The algal flora of the East Gallatin River as a contribution to the Algae of Montana
by Veda Jacobs

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Botany
Montana State University

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section of the East Gallatin Elver and its tributaries in the vicinity of Bozeman, Montana was studied in an effort to determine the species of algae present and to determine the effect of Bozeman sewage on algal growth. From systematic collections made during July and August. Cladophora, Spirogyra, and Oscillatoria were found to be the dominant genera in the East Gallatin River. Bridger Creek, and Rocky Creek, while . Nostoc, Monostroma, and Bhisoclonium were the dominant forms in Bear Creek. Oscillatoria, Stigeoclonium, Mougeotia, and Spirogyra noticeably increased in quantity of individuals as the season advanced, while Cladophora, Rhizoclonium, and Vaucheria showed no appreciable increase. Twenty-five genera including twenty-nine species and two varieties were identified eight additional species were tentatively identified, and four unknown species were described but not named. A key based on vegetative characteristics was made by which the algae in the area studied could he identified to genus. The conclusion that the Boseman sewage did not grossly pollute the East Gallatin River was based on two determinations: (1) that although the number of individual algae was decreased® the number of species was scarcely affected in the immediate area of the sewage outlet, and (2) that the notmal algal picture was resumed one and one-half miles downstream from the sewage outlet. -

THE ALGAL FLORA OF THE EAST GALLATIN RIVER AS A CONTRIBUTION TO THE ALGAE OF MONTANA

by

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ABSTRACT

A section of the East Gallatin River and its tributaries in the vicinity of Bozeman, Montana was studied in an effort to determine the species of algae present and to determine the effect of Bozeman sewage on algal growth. From systematic collections made during July and August, Cladophora, Spirogyra, and Oscillatoria were found to be the dominant genera in the East Gallatin River, Bridger Creek, and Rocky Creek, while Nostoc, Monostroma, and Rhizoclonium were the dominant forms in Bear Creek. Oscillatoria, Stigeoclonium, Mougeotia, and Spirogyra noticeably increased in quantity of individuals as the season advanced, while Cladophora, Rhizoclonium, and Vaucheria showed no appreciable increase. Twenty-five genera including twenty-nine species and two varieties were identified, eight additional species were tentatively identified, and four unknown species were described but not named. A key based on vegetative characteristics was made by which the algae in the area studied could be identified to genus. The conclusion that the Bozeman sewage did not grossly pollute the East Gallatin River was based on two determinations: (1) that although the number of individual algae was decreased, the number of species was scarcely affected in the immediate area of the sewage outlet, and (2) that the normal algal picture was resumed one and one-half miles downstream from the sewage outlet.

INTRODUCTION

Since at the present time very little study has been made of the algal flora of Montana from a taxonomic standpoint, there is a vast field open for determinative and comparative work. That we have a wealth of algal forms which are in common with many parts of the world is expected. That we have species remaining to be discovered, described and published is very probable. A systematic survey has never been made, although isolated collections of algae are reported by several collectors. This paper is a very meager beginning of an investigation of the species of algae found in our state. It is hoped that when a study of the algae of Montana is undertaken that this report of the algae of the East Gallatin River and its tributaries will be a helpful contribution to the all-inclusive work, an aid to a greater study. This paper is merely a preliminary report; the list of species is by no means complete. Seasonal scarcity of many species is caused by the comparatively short length of time the field work was carried on. The East Gallatin River would furnish additional species if studied at different seasons of the year.

In the following pages will be given an account of the species of algae found and identified. The study is predominantly that of Chlorophyceae, with Myxophyceae being represented by three genera. One genus each of Heterokontae and Rhodo-

phyceae are listed. Bacillarieae are not classified because of the lack of time for investigation.

The author is grateful to Dean F. B. Cotner of Montana State College for suggesting this study and for his valuable assistance during its progress.

MATERIALS AND METHODS

The East Gallatin River is formed by the junction of Bear Creek with Rocky Creek. During the summer when a large percent of the waters of Bear Creek are taken out for irrigation at Mt. Ellis Academy, Rocky Creek is the main tributary of the river. No noticeable change in appearance occurs after the waters of Rocky Creek are joined by Bear Creek. Small Kelly Creek joins these combined waters one mile farther west, while Bridger and Bozeman Creeks add their flow to make the river north of Bozeman much larger. The East Gallatin is not a turbulent one; its shallow waters flow quietly with occasional deeper pools or contrasting rippling stretches.

The area selected for study included the stretch of river from its point of formation four miles east of Bozeman to a bridge three and six tenths miles northwest of the city. Ten collecting stations were established at intervals on the river. These were determined by their accessibility and by their positions near points which were expected to influence the

algal picture. These stations were visited at frequent intervals, each one at least twice per week during an eight-week period. Others, as stations B, D, E, and G (see map, p. 71), being very rich in many species, were studied an average of four times a week. During certain periods daily collections were made at these points. Collections were not confined to the ten main stations. The map shows additional collecting areas. As the work progressed, Bear Creek became increasingly interesting as a source of material and much time was spent collecting specimens from it.

Specimens were studied in the laboratory and preserved in Transeau's solution[1] suggested by Tiffany (1938). Water samples from nine stations (see Chart I) were analysed for carbonate and bicarbonate content by use of the Alkalinity Method (Ellis, 1948) while pH values of the water samples were determined by means of the Beckman Glass Electrode pH Meter.

Identification of genera was made by consulting Smith (1933). Further identification of Chlorophyceae, Rhodophyceae, and Heterokontae to species was done with the aid of Wolle (1887), De Toni (1889), and Wood (1972). Tilden (1910) and Wolle were the authorities for Myxophyceae species.

Drawings of undetermined genera were made with the aid of a camera lucida and are included with this report.

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[1]Transeau's solution: water, 6 parts; 95% alcohol, 3 parts; 40% formalin, 1 part; a little copper sulfate.

VEGETATIVE KEY TO THE GENERA OF FRESH WATER ALGAE OF THE EAST GALLATIN RIVER

A. Cells grass green or yellowish green
  Cells spherical or oval — page
    Cells free-swimming; solitary ..... Chlamydomonas (20)
    Cells united in colonies
      Colony in gelatinous matrix ..... Tetraspora (21)
      Colony not gelatinous
        Cells extremely variable in size ..... Chlorococcum (35)
        Cells not conspicuously different in size ..... Protococcus (28)
  Cells rectangular, elongate or lunate
    Cells solitary
      Cells rigid, lunate; no eye spot ..... Closterium (44)
      Cells not rigid, changing shape easily; red eye spot ..... Euglena (46)
    Cells in colonies
      Cells not seriately united in filaments
        Thallus a hollow tube ..... Enteromorpha (33)
        Thallus a bright green sheet ..... Monostroma (34)
      Cells seriately arranged in branched or unbranched filaments
        Filaments branched
          Filaments without cross walls ..... Vaucheria (36)
          Filaments with cross walls
            Macroscopic colony a firm jelly, green, size of pea or cherry ... Chaetophora (27)
            Macroscopic colony not a firm jelly
              Branch ends broadly rounded, cell membrane thick ..... Cladophora (29)
              Branch ends pointed, cell membrane thin
                Branches in lateral clusters; stem cells much more broad than branch cells ... Draparnaldia (27)
                Branches not in lateral clusters; stem and branch cells approximately same width ..... Stigeoclonium (26)
        Filaments unbranched
          Filaments without transverse walls ..... Vaucheria (36)
          Filaments with transverse walls
            Walls of some cells with transverse striations ..... Oedogonium (32)
            Walls of cells with no transverse striations

Chloroplast or chloroplasts
axial
Chloroplasts irregularly
lobed, two to a cell.....Zygnema(39)
Chloroplast an axial ribbon.....Mougeotia(38)
Chloroplast or chloroplasts
parietal
Chloroplast a spiral ribbon.....Spirogyra(40)
Chloroplast not a spiral
ribbon
Chloroplast girdle-shaped
encircling most of
cell.....Ulothrix(24)
Chloroplast entirely
encircling cell
Cell wall not composed
of H-pieces.....Rhizoclonium(31)
Cell wall composed of
interlocked
H-pieces
Cells barrel-shaped,
10.5 mic. wide;
walls of stout
H-pieces.....Tribonema(18)
Cells cylindrical,
17.5 mic. wide;
walls of delicate
H-pieces.....Microspora(25)

A'. Cells not grass green or yellowish green
Cells solitary.....Diatoms
Cells united in filaments
Filaments unbranched
Filaments of spherical cells;
heterocysts present.....Nostoc(14)
Filaments of rectangular cells;
no heterocysts present
Cell pigment blue-green; not
contained in chromatophores.....Oscillatoria(11)
Cell pigment golden brown;
contained in chromatophores.....Diatoms
Filaments branched
Filaments brown; cells multiseriate;
branching irregular.....Stigonema(15)
Filaments bluish-green or olive;
cells uniseriate; branches
in dense clusters.....Batrachospermum(17)

DESCRIPTION AND CLASSIFICATION OF SPECIES

The confusion which arises when identification to species is attempted is often frustrating to the worker. The differences of opinion among authorities is extremely discouraging. Hazen (1902) gives Microspora as an example, saying that Rabenhorst, Kuetzing and others describe its diameter as 7.5-10 mic.; Cook and Wolle increase it to 14-17 or 18 mic.; while De Toni combines these making the diameter 10-18 mic. The East Gallatin specimens were uniformly 17.5 mic. Hazen says much confusion has resulted in the incorrect determination of specimens in forcing a given form into a certain species, i.e., stretching a specific diagnosis so as to include specimens varying in what is believed to be unimportant details to avoid burdening literature with new species. He adds: "The evil results of De Toni's wholesale grouping of species of ill-defined character may be seen in the very unreliable determinations of species by certain American writers who seem to have pinned their faith to his work."

Collins (1928) supplemented his book with two papers in which he listed so many substitutions, insertions, cancellations and additions that Tiffany's remarks seemed most appropriate. Tiffany reflected that scientists must organize and reorganize, classify and reclassify, correlate and recorrelate factual and inferential material.

Hazen deplores the use of cell measurements to separate species and says its use has been resorted to in a much greater degree than he had expected. Collins emphasizes this in his discussion of Spirogyra when he says dimensions of filaments are too uncertain to have much weight except when associated uniformly with other characteristics. In the books of Hazen, Collins, Croasdale (1935) and Setchell-Gardner (1903) can be found decisions that previously identified species were not correct. Criticism of others' work Hazen calls essential in causing improvement. Some species in this paper likewise will come in for later critical questioning. Thus classifying and reclassification has its place in the advancement of science.

MYXOPHYCEAE

This class includes the organisms commonly known as the blue-green algae. All species of this category contain the blue pigment phycocyanin in addition to chlorophyll and carotinoids. This group of plants also differs from other algae in that the pigments are distributed throughout the entire peripheral part of the cell without the presence of definite chromatophores. The nuclear material is not enclosed within a nuclear membrane.

HORMOGONALES

This order includes those plants in which the organization of the thallus is multicellular and filamentous. The filaments or trichomes may break into few-celled segments or hormogones.

OSCILLATORIACEAE

The filaments (trichomes) of this family are always uniseriate, unbranched, and except for apical and immediately adjacent cells, are of the same diameter throughout.

OSCILLATORIA

This genus was, according to Tilden, described by Vaucher in 1803. It includes species with free somewhat motile cylindrical trichomes without a sheath or rarely enclosed in a thin mucous sheath.

Oscillatoria chlorina Kuetzing.

Trichomes 3 mic. wide, not constricted at joints, apex very slightly curved; cytoplasm almost colorless, filled with blackish granules; transverse walls pellucid; filaments constantly moving slowly and steadily through the water.

Tilden and Croasdale both mention the plant mass of yellow-green. This feature was not observed in this study as specimens found were not in pure colonies but were mixed with O. tenuis Ag. at stations E, G, and V.

For illustrations see Tilden (1910) plate 4, figure 22; Wood (1872) plate 1, figure 1.

Oscillatoria cruenta Grunow.

Very similar in appearance in color and other characteristics to O. natans Kuetz. with the following differences: filaments slightly narrower, 6 mic. wide with articulations about 4 mic.; filaments looped, coiled or curved instead of straight; apex smoothly convex.

Found associated with Tetraspora gelatinosa (Vauch.) Desv. being observed microscopically when samples of T. gelatinosa were being studied. This Oscillatoria species was never observed by itself but only in the gelatinous mass of the T. gelatinosa colonies. Wolle mentions this relationship and notes a purplish tint which was not noted here. The color of the gelatinous mass was yellow-green.

For illustrations see Wolle (1887) plate CCVI, figure 5, and plate CCVII, figures 4-7.

Oscillatoria limosa Agardh.

Trichomes straight, not constricted at joints, cells 14-17.5 mic. wide, 3-7 mic. long; apex of trichome curved convexly; transverse walls paralleled by rows of dots which are cyanophycin granules; cells more brownish than the usual blue-green color of other species.

Found only sparingly in early part of summer mixed with O. tenuis. A pure stand found in August under the bridge at station G was a dark brown colony rising from the mud, standing

approximately 3 cm high. This is the largest Oscillatoria species found in the area studied.

For illustrations see Tilden (1910) plate 4, figure 6; West (1916) page 42, figure 29a.

Oscillatoria natans Kuetzing.

Trichomes straight or curved, cells 7 mic. wide, 7 mic. long; cells blue-green; apex of many trichomes definitely tapering to a knob, but other trichomes with exactly the same appearance and measurements otherwise, have a convex apex. Found very commonly at all stations appearing in bluish-green to blackish masses coating rocks rather than mud.

For illustration see Wolle (1887) plate CCVI, figure 19.

Oscillatoria tenuis Agardh.

Trichomes straight or slightly curved; cells 3.5 mic. wide, not quite so long as broad; apex of trichome convex, not tapering; cells light blue-green, contents finely granular, almost homogeneous. Pure stands varying from bright to dark green were very common at all stations in the river on mud at shore, or on muddy bottom of river where water was 2 or 3 feet deep and flowing slowly.

For illustration see Tilden (1910) plate 4, figures 17-18.

NOSTOCACEAE

Filaments of this family regularly form heterocysts. The

filaments are unbranched and uniseriate and are always surrounded by a homogeneous sheath. Akinetes are a frequent occurrence in all genera.

NOSTOC

The gelatinous thallus surrounding the intertwined trichomes of this genus is of firm consistency. It may be solid or hollow, often reaching a diameter of several inches. Trichomes possess intercalary heterocysts.

Nostoc comminutum Kuetzing.

Thallus approximately 0.3 cm - 2 cm in diameter, usually 1 cm, gelatinous, hollow, yellowish-brown, sometimes tinged with green; gelatin very soft, thin, easily torn; trichomes only fairly densely entangled; cells 4 mic. in diameter, spherical, often depressed spherical and closely connected; heterocysts spherical, 6 mic. in diameter, intercalary. Plant mass attached to rocks in Bear Creek, station R.

Nostoc parmilioides Kuetzing.

Colonies disk-shaped, quite hard, up to 1 cm in diameter; brownish out of water, but dark blue-grey irridescent under water; attached to stones with thallus standing usually perpendicular to article of attachment; trichomes very densely packed and interwoven; spherical cells 4 mic. wide, heterocysts 6 mic. spherical, intercalary. Found only in upper Bear Creek, very numerous just below Cooper Reservoir, gradually giving way to

N. verrucosum (Linn.) Vauch. down stream and not appearing after about 3 miles down stream from Cooper Reservoir.

For illustration see Tilden (1910) plate 8, figure 20.

Nostoc verrucosum (Linnaeus) Vaucher.

Thalli of varying sizes 5 mm in diameter to 8 cm x 3 cm; small thalli dark brown, firm, solid; larger ones hollow, more easily torn, with tinge of green; trichomes densely packed, cells 3.5 mic. in diameter, a bit subspherical, closely connected; heterocysts intercalary, spherical, 7 mic. in diameter. Very common in Bear Creek and Meadow Creek, station V. No colonies noted in the East Gallatin River.

For illustrations see Tilden (1910) plate 8, figures 11-16.

STIGONEMATACEAE

Trichomes of this family exhibit true branching which is not shown by any other family in the Hormogonales. Heterocysts are formed by all genera.

STIGONEMA

The main axes of trichomes of this genus are multiseriate. Branches may be either multiseriate or uniseriate. The sheaths around the trichomes are of firm texture and if colored, are yellowish to brown or black.

Stigonema informe Kuetzing.

Filaments brownish, somewhat mucous; small filaments 1 mm wide, 2-10 cm long, unbranched or with very short fuzz-like branches; older filaments with many branches giving feathery appearance; branches 30-40 mic. wide, cells 10-14 mic. in diameter, spherical; trichomes of several rows of cells both in main filaments and in branchlets. Found only in Bear Creek and New World Gulch Creek, stations P and Q.

For illustrations see Wood (1872) plate 8, figure 4; Tilden (1910) plate 15, figure 21.

RHODOPHYCEAE

All organisms of this class contain the red pigment, phycoerythrin, in addition to chlorophyll and the carotinoids. Phycocyanin is sometimes present also. These pigments are localized in plastids. The reserve food is stored in the form of "floridean starch". Motile reproductive cells are lacking. Sexual reproduction is practically universal in this class, and is never isogamous. Red algae played a great part in geologic ages in the building up of rocks and reefs, a process which is still going on in tropic seas today.

NEMALIONALES

Members of this order are all fresh water organisms. Alternation of generations occurs, with the plants being haploid. Growth of the thallus is always terminal from apical

cells. In the sexual reproduction the carpogones (female organs) have conspicuous trichogynes (long slender structures through which male nuclei pass).

BATRACHOSPERMACEAE

Organisms of this family are characterized by a distinct main axis from which much smaller lateral branches are borne in whorls. Carpogones and antherids are produced by mature plants only, with juvenile plants forming monospores.

BATRACHOSPERMUM (batracho, frog; spermum, seed)

Members of this genus are fairly common in fresh water of temperate regions, favoring cool shaded areas and swiftly running streams. The thallus is freely branched and gelatinous in texture with a bluish or olive color. Specimens obtained from deeper water are more red in color due to a difference in the intensity of light which reaches them.

Batrachospermum moniliforme Roth.

Soft thick gelatinous thallus of branched, bead-like threads, blue-grey or olive in color; main filaments of large axial cells 350 mic. wide, with whorls of densely-branched lateral ramuli appearing at intervals; branches moniliform, cells 7 mic. wide, 17.5-20 mic. long; some branch ends setigerous. Found in Bear Creek, station Q at only one spot, attached to rocks in middle of stream.

For illustration see Chapman (1941) page 220, figure 144.