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Algae of the St. Maries River in Idaho[1]

Algae flora is one of the least studied components of the numerous aquatic environments in Idaho. This study, conducted in conjunction with a mayfly (Ephemeroptera) study on the St. Maries River in northern Idaho, represents one of the first attempts at determining the algae of a major drainage system. Since species determination of many of the algae requires mature reproductive stages obtained by intensive field sampling and laboratory-grown cultures, this study was limited to the classification of genera. The purpose of this paper is to present a check list of the algae genera of the St. Maries River with notes on their distribution and habitats.

No check lists are available for Idaho algae. Taxonomic references by Smith (1950), Prescott (1962) and Flowers (unpublished) served as the basis for identification.

Materials and Methods

Algae were collected from 28 stations on the St. Maries River and major tributaries. Stations were selected on the basis of being representative of the various riffles and pools of the river.

Algae samples were systematically collected three times during the summer of 1967 and spring of 1968 using a standard diatom net for free-floating forms and a scraping technique for the attached forms found on rocks, logs, and submergent and emergent vegetation. Samples were placed in loosely capped vials half-filled with water. These were stored at 35° F. in an illuminated refrigerator until identifications were completed, usually requiring three to four days. During this interval there was little or no deterioration of taxonomic characteristics. Water chemistry analysis was performed for pH, alkalinity, total hardness and turbidity using a Hach testing kit.[2]

Drainage System

The St. Maries River (Figure 1) is an artery of the Spokane River Basin. It drains an area of about 437 square miles and has an average stream discharge of about 520 cubic ft./sec. (Travis, et al. 1964). The St. Maries River has its origin at two

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[2] Hach Chemical Company, Ames, Iowa.

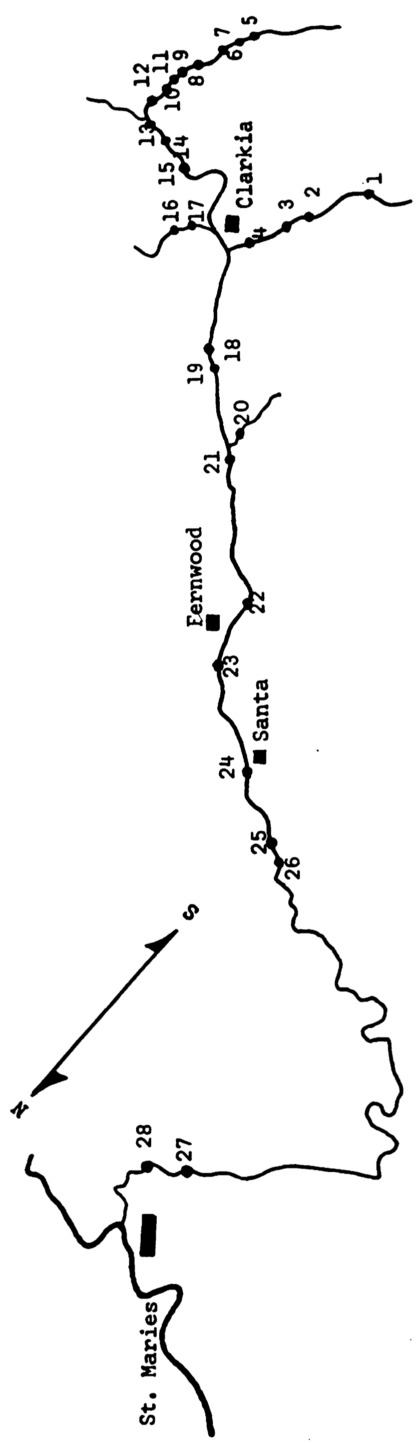

Figure 1. St. Maries River drainage and collection stations.

forks, the Middle Fork and West Fork, which join near Clarkia. The river meanders northwest along a narrow valley floor and is confluent with the St. Joe River at the city of St. Maries. Drainage waters subsequently flow into Coeur d'Alene Lake which in turn is drained via the Spokane River.

In order to effectively study the algae, the St. Maries River was divided into three regions: 1) the upper St. Maries, which includes the Middle and West Forks; 2) middle St. Maries, from Clarkia to the beginning of slack waters; and, 3) lower St. Maries, slack waters beginning approximately six miles southwest of St. Maries and extending to its confluence with the St. Joe River (Figure 1).

The headwaters of the West and Middle Forks of the St. Maries River are the result of underground seepage and surface runoff. The stream channels are five to eight feet wide at the headwaters, gradually widening to 30-40 feet near their confluence (Plate I, A-F). Both forks have numerous shallow riffles and pools, the latter ranging from two to three feet deep. Moderate to heavy siltation is in evidence through much of the West Fork; the Middle Fork is lightly silted. The bottom type is principally cobble on the Middle Fork; pebble is prevalent on the West Fork. Considerable deadfall is in or spans the upper reaches of the two forks and provides numerous collection sites for attached algae.

The size and character of the middle St. Maries is appreciably different from the upper forks with the addition of waters from numerous small tributaries. It averages 30-50 feet wide through much of its extent, occasionally widening to 80 feet (Plate I, G-H). Riffles of eight to 20 inches deep and pools of three to five feet deep characterize this portion of the river. The bottom type is principally cobble and boulder.

The lower St. Maries is characterized by slack waters. The channel averages approximately 100 feet wide and nine to 16 feet deep. The bottom is silt-mud with a moderate accumulation of decaying plant matter.

The St. Maries River has several sources of pollution. These occur principally from logging, road construction, sawmill wastes, pasture runoff and sewage effluents. Organic enrichment is in evidence by the increased abundance of algae particularly from the middle and lower St. Maries.

Results and Discussion

The St. Maries River has numerous habitats which promote the establishment of algae. Basically the river is divisible into pools and riffles which manifest numerous microhabitats as influenced by a variety of substrates, current speed, water depth, shade, etc. Table 1 reflects in a composite manner a check list of genera, distribution, general habitat and microhabitats of the algae. For reference in subsequent discussion, stations 1-4 were located on the West Fork, 5-17 on the Middle Fork, 18-26 on the middle St. Maries and 27-28 on the lower St. Maries.

Diatom net samples were taken only for key stations to reflect spatial distribution; net samples were not taken for stations 6, 7, 8, 12, 14, 19, and 26, since they were in close proximity to other stations. For both attached and nonattached algae, it is conceivable that their distribution can be greatly extended as a natural function of drift. In the former, filaments may become broken off and transported. Their presence, therefore, in downstream stations may not reflect their place of origin or principal

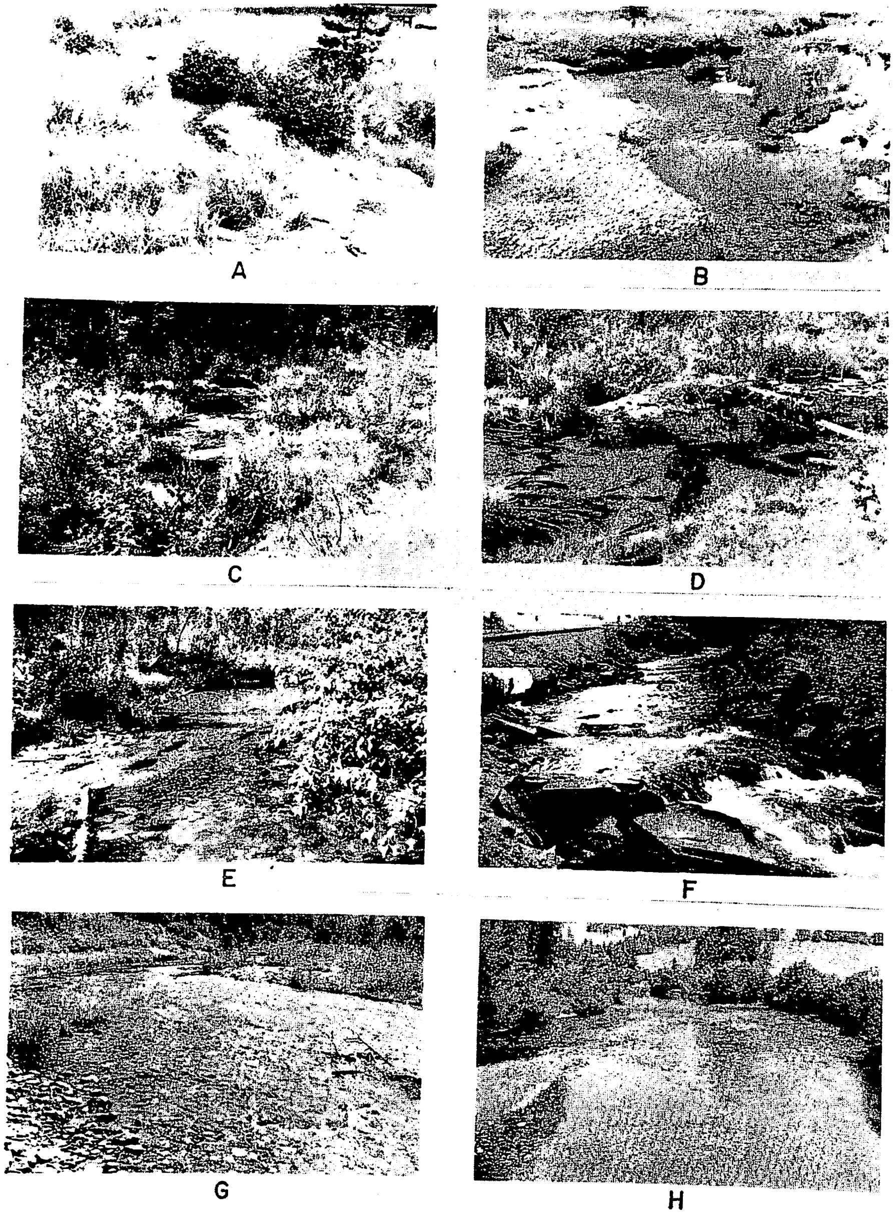

PLATE I. A. Headwater pool, Station 1; B. Slow riffle, Station 4; C. Headwater riffle, Station 7; D. Pool, Station 5; E. Moderate riffle, Station G; F. White-water riffle, Station 10; G. Moderate riffle, Station 18; and H. Moderate riffle, Station 24.

TABLE I. Distribution, habitat, and place of collection of algae on the St. Maries River.

ALGAE	1^c	2^a	3^c	4^a	5^c	6^a	7^a	8^b	9^a	10^a	11^b	12^c	13^b	14^a	15^a	16^c	17^a	18^b	19^c	20^a	21^b	22^a	23^b	24^a	25^b	26^d	27^d	28^d
Division Chlorophyta																												
Chaetophora sp.		1,2,3	1,4	1,3,4		1							1		1					1	1		1	1	1			
Characium sp.	3	1	4	1													1											
Chlamydomonas sp.	4																											
Chlorella sp.		1																										
Closteriopsis sp.	2																											
Closterium sp.	1,2,3	1,2,3	1	3,4	3	2			2,3							1	1,3	3	1	3	3	1,3	1,2,3,4	1	1			
Cosmarium sp.	1,3	1,2,3	1,3,4	1						2			3			1		3	1	1	1,3,4	1,3	1,2,3,4	1,3	1,3		4	
Draparnaldia sp.																1	1		1		1		1,2	1			2	2
Gloeocystis sp.				3								1	1											3				
Hormidium sp.																							2,4	1,3				
Microspora sp.				3																							4	
Microthamnion sp.								1		1							1		1				3					
Mougeotia sp.	1	2	3	3										1		1,3				3							2,4	
Mougeotiopsis sp.										2																		
Oedogonium sp.		2		3												1									3		2	2
Prasiola sp.							1		2	1	1,2	1,2	1	1	1		1	1										
Scenedesmus sp.									1															3				
Selenastrum sp.	2																										2	
Spirogyra sp.		1,2	3	1,3		1,2		1,2	3		1			1	1	1	3	1	1	1,3	1,4	1,3	1,2,3,4	1	1,3		2,4	1,4
Stigeoclonium sp.	1,2	3	1,3	1													1						1,2,3	1	1		2	
Tetraspora sp.				4		1,2	1		2		1	2	3									1						
Ulothrix sp.								1	1	1,2	3		1	1	1		1	1	1		1	1	1,3	1	1			
Zygnema sp.															1	1												
Division Chrysophyta																												
Bumilleria sp.				3					1,2,3	2	2									3			2					
Characiopsis sp.																			1									
Diatoms	1,2,3	1,2,3	1,3,4	1,3,4	1,2,3	1,2	1	1	1,2,3	1,3	1,3	1,2	1,3	1	1,3	1,3	1,3	1,3	1		1,3,4	1,3	1,2,3,4	1,3	1,3	2	2,3,4	3
Synura sp.	4															3	3											
Tribonema sp.	2,3,4								2							3												
Vaucheria sp.																			1									
Division Cyanophyta																												
Anabaena sp.	1	2		1												1			1			3						
Calothrix sp.					1												1	3	1		1	1,3	3	3				
Nostoc sp.	1,2	2	1	1	1			1		1	1		1	1	1	1,3	1	1	1	1,3		1	3,4	3		1	2,4	
Oscillatoria sp.	1,3	1,3	1,3,4	3	1,2,3	1,2	1	1,2	2,3	1	1,2	1,2	1,3	1	1		1	1,3	1	3	1	1	3	1,3	3		2	2
Tolypothrix sp.					1				3					1	1				1	1,3	1	1,3	3		3			
Division Rhodophyta																												
Batrachospermum sp.				1				1	3	1,3	3		1				1	1				1	1					

Station Classification:
a: Slow-moderate riffle (0.5-2.0 ft./sec.)
b: Fast riffle (above 2.0 ft./sec.)
c: Slow run or pool
d: Slack water

Place of Collection:
1. Rock and sediments
2. Logs
3. Free floating (net sample)
4. Submerged vegetation

habitat. It is significant that lotic waters afford a natural means for gross dissemination and establishment of algae to downstream areas. The attached forms gleaned from substrate scrapings, on the other hand, reflect to a reasonably high degree fidelity to specific habitats.

Spirogyra was one of the most common filamentous algae in the river, occurring in 21 stations. It was most common along the margins of slower riffles, pools and slack waters. Another common filamentous form, *Oscillatoria,* occurred in numerous habitats and was collected from 26 of the 28 stations. In addition, *Nostoc, Stigeoclonium,* and *Cosmarium* showed general distribution throughout the drainage. Blum (1959) indicated these genera reach their best development in organically enriched waters. Pasture runoff, mill wastes and sewage were definable pollution sources along the river.

Chlamydomonas, Chlorella, and *Closteriopsis* were collected only from the headwaters of the West Fork. They occurred in slow-moving riffles and pools with pebble or sandy bottoms. In addition, appreciable amounts of emergent vegetation and partially submerged logs were present to provide places for attachment and collection. With the exception of station 17, *Characium* reflected similar distribution, occurring in four of the five stations on the West Fork. During April and May, *Batrachospermum,* a red algae, was abundant on many riffles on the upper and middle St. Maries. During July and August, however, it was collected only from a few fast, shaded riffles on the Middle Fork. Whitford (1959) indicated that light intensity may be an important factor limiting its distribution. By and large, the Middle Fork is much more shaded than the West Fork, which courses through a relatively flat, open valley. Abrupt slopes and large conifers shade the Middle Fork, particularly that portion of the river above Gold Center Creek.

The middle St. Maries, from Clarkia to the start of slack waters, generally supports algae common to the upper forks. Although the river increases in size and volume, no unique forms were collected. An appreciable increase in algae was noted, however, particularly through the middle and lower portions, and was probably due to organic enrichment.

Like the middle St. Maries, the lower slack water did not support forms unique to its area although it was physically much different. Current was scarcely perceptible; depths varied from nine to 16 feet through much of the channel. Algae reached their greatest development along the margins attached to bottom substrate, logs and submergent vegetation.

No attempt was made to identify the diatom genera in this study, and are referred to as "diatoms" under the Division Chrysophyta. They were of universal distribution occurring at all stations on the river sampled with a diatom net.

Water chemistry was determined for the four regions of the St. Maries River, the West Fork, Middle Fork, middle St. Maries, and lower St. Maries (Table 2). The midsummer analysis indicated relatively consistent readings for the various parts of the river. Alkalinity showed a slight decrease through the middle and lower portions, but was not believed significant in influencing the algae distribution. With the exception of the West Fork, readings for total hardness were consistent. Dissolved O_2 and pH, likewise, were reasonably consistent. Wider disparities in dissolved O_2 might occur locally in eddies or slack waters below sewage or sawmill effluents. However, tests made immediately below effluents in moving water produced only slight changes for this character. Turbidity is not a problem in the river, although a slight discoloration was detected in the lower slack waters. The river runs clear for most of the year except during spring runoff, flash floods and from effluents.

TABLE 2. Water chemistry for four sections of the St. Maries River.[1]

	West Fork	Middle Fork	Middle St. Maries	Lower St. Maries
Alkalinity (ppm)	30	30	20	25
Total Hardness (ppm)	10	20	20	20
Dissolved O_2 (ppm)	9	8	9	8
pH	8.9	8.9	8.9	8.8
Turbidity (J.T.U.)[2]	0	0	0	15

[1] Water chemistry analysis made 8/18/67.
[2] Measured in Jackson Turbidity Units.

Summary

Algae were collected from 28 stations on the St. Maries River. Four Divisions and 34 genera were represented (number does not include diatom complex). Chlorophyta was the most widely represented. Many algae showed wide distribution in the drainage. However, *Chlamydomonas, Chlorella,* and *Closteriopsis* were collected only from the headwaters of the West Fork.

Characteristics of the habitat as riffles, pools, current speed, bottom type, submerged logs and vegetation influenced distribution.

No positive correlation could be made between algae distribution and pH, alkalinity, total hardness, dissolved oxygen or turbidity. An increase in abundance of algae was noted through the middle and lower portions of the river and was probably due to organic enrichment.

Literature Cited

Blum, J. L. 1960. Algae Populations in Flowing Waters. (In Ecology of Algae. Special Pub. No. 2.) Pymatuning Laboratory of Field Biology, Univ. of Pittsburgh. pp. 11-20.

Flowers, S. Undated. The Algae of Utah. Unpublished Manual. Dept. of Botany, Univ. of Utah. 70 p.

Prescott, G. W. 1962. Algae of the Western Great Lakes Area. Wm. C. Brown, Co., Dubuque, Iowa. 977 p.

Smith, G. M. 1950. The Fresh-Water Algae of the United States. McGraw-Hill Book Company, Inc., New York. 719 p.

Travis, W. I., H. A. Waite and J. F. Santos. 1964. Water Resources. (In Mineral and Water Resources of Idaho.) U.S. Government Printing Office, Washington, D.C. pp. 255-335.

Whitford, L. A. 1960. Ecological Distribution of Fresh-Water Algae. (In Ecology of Algae, Special Pub. No. 2.) Pymatuning Laboratory of Field Biology, Univ. of Pittsburgh. pp. 2-7.

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Photoelastic Study of Stresses in a Composite Material

Interest in stress transfer mechanisms in composite materials has been high during the past few years. This interest has been expressed as a study of the stress field surrounding the stiffener in the composite material while the material is subjected to tensile loads. Various investigators have taken different approaches to the problem depending on their background. Although the techniques used by the metallurgist, the theoretical elastician, the experimental elastician, and other investigators differ, each makes its own unique contribution and each has certain limitations. The work of one investigator usually supplements or clarifies the work of a previous investigator.

Usually the difficulties and uncertainties encountered in the study of whisker-stiffened composite materials occur in the mathematical or physical model selected for analysis. The mathematical model requires that certain simplifying assumptions be made in order to arrive at a solution. These assumptions often prevent the evaluation of the stress field at the region of the extreme stress—the region of interest to the engineer. Experimental analysis using prototype materials is handicapped by the small size of the whisker and the opacity of the matrix. In a scaled up macroscopic model there has always been a question of what factors can be successfully handled in the scaling process. For example, investigators working with the prototype materials are quite concerned with the interfacial energies associated with the boundary between the stiffener and the matrix. It is questionable whether such a factor can be successfully scaled up and used in a photoelastic experiment.

An engineer using composite materials would be interested in certain design aspects of the material. The magnitude of the stresses is of prime concern to the engineer, especially if the material is to undergo cyclic loading. High stress concentrations could lead to fatigue failure. The designer is also concerned with the ineffective or transfer length of the stiffener and the range of influence that the stiffener has on the stress field extending into the matrix. The last two quantities aid the designer in selecting the volume fraction of stiffener necessary to achieve adequate strength in the composite material.

A starting point for the above quantities is the behavior of a single stiffener, uniaxially loaded, and surrounded by a quantity of matrix so sufficient that the edge effects may be neglected. The model selected may be visualized as a cylindrical stiffener embedded concentrically in a cylindrical matrix. Loads are applied to the