

A LITERATURE REVIEW OF THE FRESHWATER ALGAE OF THE CANADIAN ATLANTIC PROVINCES, QUEBEC, MAINE, AND NEW HAMPSHIRE

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A bibliography of the papers on freshwater algae of Prince Edward Island, Nova Scotia, New Brunswick, Quebec, Newfoundland, Maine, and New Hampshire is presented. All algal systematic papers from the earliest to July, 1977, are reviewed. Included is the first paper on Canadian freshwater phycology. A computer data base was generated from references up to August, 1975, as part of an algal study of the Dunk River, Prince Edward Island. A checklist (print-out), including more than 2500 taxa, was prepared from this data base under several headings, including: taxon—area—author—year; and taxa common to all areas. The checklist, together with the review, is presented for use as working tools for future related algal studies.

Introduction

In 1974 a study was conducted on the freshwater algae of the Dunk River, Prince Edward Island (Staker 1976) as part of an inter-disciplinary project initiated by the University of Prince Edward Island. A literature survey was prepared to provide background data on freshwater algal systematics from Prince Edward Island and surrounding provinces, New Brunswick, Nova Scotia, Quebec, and Newfoundland. The neighboring states of Maine and New Hampshire in the United States were also included as being part of a northeastern floristic area. A computer data base was prepared from the literature surveyed up to August 1975. Computer print-outs were prepared from the data base giving information under the following headings:

1. Taxon—area—author (by Division)
2. Checklist of algae
3. Number of species of algae by area
4. Taxa common to all areas
5. Taxa found only in one area
6. Literature cited.

Table I shows the various algal groups represented in the literature survey (August, 1975) for each province or state.

The computer print-outs (unpublished) are available from the Depository of Unpublished Data, National Science Library, National Research Council of Canada, Ottawa K1A 0S2.

The present review is based on 103 publications as used for preparing the computer data base and another 11 papers which have since appeared up to July, 1977. The review and computer print-outs are presented to provide a research aid for future algal studies of northeastern North America.

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Literature Review

Maine

The algae of Maine were discussed as early as 1888 by West, who listed 77 desmids, mainly from the Orono area. In the same state, West (1889, 1891) reported a total of 171 species. Three papers by Harvey (1888, 1889, 1892) treated the freshwater algae of the Orono-Penobscot River region of central Maine with over 100 taxa recorded. Taylor (1921) described both marine and freshwater forms of the algal flora of Mount Desert and some dozen or so algae are listed. One new species of *Spirogyra* was reported by Transeau *et al.* (1934) and Unger (1941) did a preliminary survey of the protozoa of Beaver Lake, near Salsbury Cove. Twenty-five of Unger's 92 genera of "invertebrates" are typically classified as algae by phycologists.

Four papers by Cooper (1939, 1940, 1942a, 1942b) and one by Cooper and Fuller (1945) described the general limnology of lakes in Maine. The principal algae, however, were identified to the generic level only. Wheldon (1943) has notes on algae collected and descriptions of new species from New England, including Maine, while Mackenthum, Keup, and Stewart (1968) discuss nutrients and the algae in Lake Sebasticook. The phytoplankton dominance, volumes and chlorophyll a concentrations were determined.

New Brunswick

In New Brunswick, the earliest studies appear to be those of Baxter (1903, 1905, 1907). He reported nearly 100 species of desmids and 139 forms *in toto* from the Miramichi River area. Habeeb and Drouet (1948) conducted a study in the Grand Falls area from June to mid-August, 1947, not including diatoms, desmids, *Chara*, *Oedogonium*, or *Mougeotia*. About 77 taxa were identified by Drouet. Hughes (1952) reported on the phytoplankton of 8 small lakes in the vicinity of Charlotte County. Limnetic phytoplankton identified in the study numbered 119. Klugh (1921) described a new blue-green genus, *Oligoclonium*, and 3 new species of blue-greens from the Chatham area. Geitler (1932) did not recognize this as a new genus but as a species of *Hydrocoleum*. In (1927), Klugh studied 18 sites in New Brunswick and Ontario, and reported on algal diversity and relative abundance. An *in vitro* study of microcrustacean eating habits was included.

Smith (1952) did a quantitative study of lakes in Charlotte County. The lakes were reported to be of Caledonian type with low productivity. Hughes identified the algae for Smith, finding 101 species, 40 of which were desmids. Besch *et al.* (1972) have studied the benthic diatoms in the Miramichi River, as indicators of mining pollution, recording 169 species. They found also that diatom communities could be used as reliable indicators of average pH conditions.

New Hampshire

Freshwater algal literature in New Hampshire dates back to Wood's paper (1869) on desmids from Saco Pond in the White Mountains. Hastings (1892) recorded 7 species of desmids, including notes. Cushman (1905) reported some 255 taxa of desmids from various lakes and ponds. Hoover (1937, 1938) conducted biological surveys of the Androscoggin, Saco, and Merrimack watersheds of New Hampshire. The plankton were identified by W.T. Edmondson and about 16 genera of phytoplankton were enumerated. Cole (1939) studied the plankton of the Connecticut River watershed. Identification was to the generic level only.

Wheldon (1942) recorded 83 species of algae with extensive notes, including some new species from ponds near New Durham. Blum (1943) described a new species, *Spirogyra echinospora*, from Hanover. Some freshwater algae from Louisiana and New Hampshire were studied by Flint (1948) including *Batrachospermum*, *Sirodotia*, and *Tuomeya*. Flint (1953) reported the presence of *Kyliniella*, a very rare form,

recorded only once previously and not since. The most comprehensive modern paper on algae in New Hampshire is that of Gruendling and Mathieson (1970). The authors investigated in detail, the composition, periodicity, and abundance of phytoplankton in relation to the trophic status of two New Hampshire lakes. One of the lakes, Newfound Lake, is oligotrophic, while Winnisquam Lake was considered to be in the early stages of eutrophication. A total of 185 species of phytoplankton was recorded. Gerhart and Likens (1975) compared 4 methods for determining nutrient limitation in enrichment experiments on Mirror Lake, a small oligotrophic lake. The flora was handled in a general manner and the phytoplankton assemblage consisted of many small flagellates. Kezar Lake, a small eutrophic lake, was artificially circulated during the warmer months to impede the annual bloom of bluegreen algae (Haynes 1975). Immediately after mixing was begun, *Aphanizomenon flos-aquae* bloomed.

Newfoundland

Cushman (1904) dealt with the desmids of the Rose au Rue area of Newfoundland. Some 20 taxa of desmids were reported, including critical notes. Cushman (1906b) published another paper on desmids that included some 72 species from St. Anthony's and Rose au Rue. In 1927 Hustedt described a new diatom species, *Surirella arguta*. Perhaps the most critical papers on Newfoundland algae were written by Taylor (1933, 1934). In these 2 papers, 581 algae are described with notes on the more difficult taxa. Taylor commented on the collection that, "pure myxophycean associations were very infrequent and that desmids alone characterized the flora of many of the samples." Taylor's notes include: Chlorophyceae, with some 428 forms of desmids; Myxophyceae; Euglenophyceae; Chrysophyceae, Dinophyceae; and Heterokontae. Taylor and Fogg (1927) sampled in late summer from the Bay of Islands area and reported 35 species of algae, exclusive of diatoms and desmids. Ruzicka (1949) produced a monograph on *Cosmarium hornavenense*, a quite variable species, including some forms from Newfoundland. Palmer and Black (1955) report 43 genera of algae from Argentia tap water samples claiming that the counts and algal composition indicate relatively clean water. A note by Palmer (1965) records that essentially the same succession of algal pulses occurred over a 4-yr. period, and the list of algae from Argentia had grown to 71 by the time of the report. Eight new genera from Newfoundland were included. A paper by Woodhead and Tweed (1961) from the Avalon Peninsula, reported that desmids, diatoms, and bluegreens were most abundant from their collections. Over 1000 taxa were identified, many of which were newly recorded for Canada. Davis (1972a, 1972b, 1973) studied several oligotrophic ponds on the Avalon Peninsula with relation to zoophytoplankton dynamics. Lakshminarayana (1976) found a total of 29 newly recorded algae from Newfoundland in a series of small ponds near St. John's, while O'Connell and Andrews (1977) did a seasonal and quantitative study of Long Pond. This pond receives both rural and urban runoff and has a high flushing rate. The phytoplankton were characterized by nanoplankton (particularly flagellates) and aspects of plankton ecology were discussed in relation to eutrophication.

Cedercreutz (1943) points out the similarities of the algae of Labrador and insular Newfoundland. In this paper, 229 taxa, excluding diatoms, are listed. Croasdale and Grönblad (1964) reported 24 genera and 362 species and varieties of desmids from the southeastern coastal area of Labrador. They suggest that the percentage of species of *Cosmarium* increases in the total flora with increasing latitudes. Duthie and Ostrofsky (1974) studied the plankton, chemistry, and physics of 10 lakes and reservoirs in the Churchill Falls region of western Labrador. They reported that diatoms were the most abundant group with flagellated Chrysophyta more abundant in the reservoir than in natural lakes. Specifically 28 algae were listed, but more were enumerated than those reported. The enumeration of these algae oc-

curred in Duthie and Ostrofsky (1975a, 1975b), Duthie, Ostrofsky, and Sreenivasa (1975) and Duthie, Ostrofsky, and Brown (1976). In these 4 papers the entire algal flora consisting of 545 taxa is compiled in an annotated list. Ostrofsky and Duthie (1975) used the ^{14}C method to determine the primary productivity of these bog lakes and performed enrichment experiments.

Nova Scotia

In Nova Scotia, Joshua (1885) published an annotated list of 11 desmids, 3 of which were from Pictou. A similar list of new and rare desmids was reported by Turner (1885) including 4 taxa from Nova Scotia. A summer collection by Roscoe (1931) included 2 species of freshwater *Batrachospermum* from St. Paul's Island, Victoria County. In 1938, Smith conducted a biological survey of Lake Jesse. Algae were identified by C.W. Lowe with 83 forms reported. One new genus and 5 new species were found by Hughes (1948) from a small lake near Medway River and a paper by Smith (1961) reported dystrophic conditions in Boar's Back Lake, a brown lake that had a bloom of *Peridinium limbatum*.

Prince Edward Island

Smith (1946) dealt with 5 ponds along the Prince Edward Island National Park, one pond was brackish and the others exposed to salt on occasion. The algae in Smith's (1946) study were identified by Hughes. Most of the 32 taxa were euryhaline, and most were identified to the generic level only. A study by Hughes (1950) spanned the 3 Maritime provinces with 537 taxa (excluding diatoms) reported. Of this total, 36 species from Prince Edward Island were recorded and most of these are characteristic of alkaline waters. Staker (1976) studied the algae of the Dunk River System in Prince County. His samples were taken either monthly (Sept.-April) or twice monthly during summer (May-Aug.) at 13 sampling stations. The total number of algal species recorded was 146. The algal flora of the Dunk River was described as a cyanophyte-chlorophyte type with chlorococcaceous greens dominating the large mill pond and filamentous greens dominating riffles and pools.

Québec

Some 31 studies to date have been conducted on Québec freshwater algae. The first was that of Kemp (1858), who describes a number of algae from the Montreal region. Miller (1915) recorded 54 species, mostly greens, from the Montreal island. Lowe (1927) recorded 305 taxa (40% of these being desmids) also from Montreal. Brunel (1932) studied the algal flora of Québec noting 73 species. Brunel added *Micrasterias expansa* to the Québec flora in (1940) and *Stephanodiscus binderanus* in (1956).

The desmids of the province of Québec are voluminously covered in the works of Irénée-Marie. In (1939), Irénée-Marie recorded some 527 species, varieties or forms of desmids from Montreal. The desmids of the Québec City region are discussed in several subsequent papers (1940, 1951a, 1951b, 1951c, 1952a) and for the Trois-Rivières region (1944, 1947, 1948a, 1949a, 1949b, 1954a, 1954b, 1956, 1957, 1958). Desmids of Lac Mistassini (1949c) were described including 262 taxa, and 553 forms of desmids were reported (1952b) for the region of Lac St. Jean. A new species from Grand Falls, New Brunswick, *Staurastrum hebeebense*, was described by Irénée-Marie in (1948b).

Prescott et al. (1949) described *Spirogyra pseudo-cylindrica* and *Bulbochaete glabra*, 2 new species from Gaspé Peninsula. Louis-Marie (1953) reported 71 taxa of algae, many of which were desmids, from the Laurentides. Two papers by Flint (1957a, 1957b) dealt primarily with swift-flowing streams forms including 4 species of red algae and 10 other lotic species. The phytoplankton composition and seasonality of Lac St. Francois were discussed by Cardinal (1964). Included were 153

Table 1. Orders represented in the survey with the number of taxa present in each province or state.

Division Order	ME	NB	NH	NFLD	NS	PEI	QUE
Bacillariophyta							
Centrales	1	8	9	5	1	1	21
Pennales	78	208	9	119	11	4	118
Chlorophyta							
Charales	1	0	1	0	0	0	0
Chlorococcales	40	90	50	47	58	10	106
Cladophorales	6	4	0	2	3	2	3
Oedogoniales	11	24	0	3	27	3	6
Schizogoniales	0	0	0	0	0	0	1
Tetrasporales	12	9	8	6	6	0	15
Ulotrichales	11	24	3	21	22	2	43
Ulvales	0	2	0	2	2	1	0
Volvocales	6	15	2	5	6	2	16
Zygnematales	458	497	448	1074	390	12	1457
Chrysophyta							
Chrysocapsales	0	0	0	0	0	0	1
Chryomonadales	3	18	20	12	11	0	29
Rhizochrysidales	0	0	1	1	0	0	3
Cryptophyta							
Cryptomonadales	2	0	6	2	0	0	1
Cyanophyta							
Chaemaesiphonales	1	1	0	1	1	0	3
Chroococcales	10	50	10	47	31	3	42
Oscillatoriales	11	67	9	52	51	4	67
Euglenophyta							
Colaciales	0	0	2	0	0	0	0
Euglenales	19	3	1	2	3	0	23
Pyrrophyta							
Dinocapsales	0	2	0	0	2	0	0
Dinococcales	0	0	0	0	2	0	0
Gymnodiniales	0	0	2	0	0	0	1
Peridinales	2	13	9	5	13	2	15
Rhodophyta							
Bangiales	1	0	1	0	0	0	1
Nemalionales	3	4	6	0	5	0	7
Xanthophyta							
Heterococcales	3	10	2	5	7	0	9
Heterosiphonales	4	9	0	3	6	1	8
Heterotrichales	0	1	0	6	1	1	4
Rhizochloridales	0	1	1	0	1	0	1
TOTALS	683	1060	600	1421	660	48	2001

phytoplankters, while 458 taxa were enumerated by Bourrelly (1966) for the region of the Mont Tremblant Park.

In addition to the above, there are a number of papers that concern several provinces, or several states, or a combination. Borge (1909) lists 39 algae from Québec and Nova Scotia. A total of 107 desmid taxa area reported by Brown (1930) from Maine, New Hampshire, Newfoundland, and Québec, among the other algae, most of which were from the southeastern coastal plain region of the United States. Cushman (1906a, 1907a, 1907b, 1908a, 1908b) studied extensively the desmids of New England and these papers included work on the sub-family Saccodermatae, and the genera *Pleurotaenium*, *Tetmemorus*, *Closterium*, and *Micrasterias* respectively. Collins (1909, 1912, 1918) compiled a book and two addenda to his algae of North America. The book was a comprehensive study of all known Chlorophyceae from the Arctic Ocean to the Isthmus of Panama. Both marine and freshwater forms were described with a special emphasis on New England forms. In (1942), Gustafson published on some of the freshwater algae from New England. Included were some notes on the distribution and occurrence of 35 species, predominantly from Maine and New Hampshire. Palmer (1958) speaks of the algae and other interference organisms in New England water supplies. He also discusses the relationships between New England and Newfoundland algal floras.

Discussion and Conclusions

Earlier papers from this region are often descriptive in their approach with the emphasis on algal taxonomy. Obvious examples are the works of Baxter, Collins, Cushman, Harvey, Irénée-Marie, Taylor, and West. Many of the more recent papers are ecological or even experimental in nature with the stress away from systematics. Noteworthy are the works of Besch *et al.* Gerhart and Likens, Haynes, Mackenthum *et al.* O'Connell and Andrews, and Ostrofsky and Duthie. This may be a reflection of the research trends of today with much of the effort focused on environmental studies. There are no algal systematists, like Croasdale, Irénée-Marie, or Taylor, actively working in this area now.

Floristically speaking, the desmids are the qualitative prominent form throughout this region (*cf* Table I^a). This is especially true of Quebec and Newfoundland where sphagnum bogs are commonplace. The literature review does not show Prince Edward Island to follow this trend, but this is probably due to the fact that the Dunk River, an alkaline stream, was the only body of water studied extensively.

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Addendum

A checklist of the freshwater algae of Ontario, exclusive of the Great Lakes, was recently presented by Duthie and Socha (1976) which includes some 2073 taxa.

Duthie, H.C. and Socha, R. 1976. A checklist of the freshwater algae of Ontario, exclusive of the Great Lakes. *Nat. Can.* 103: 83-110.