Taxonomy, distribution and ecology of the freshwater sponges (Porifera: Spongillidae) and bryozoans (Ectoprocta) of Eastern Canada

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ABSTRACT

Specimens of freshwater bryozoans (Ectoprocta) and sponges (Porifera: Spongillidae), two of the most poorly known faunal groups in Canada, were obtained from various locations in Ontario, Quebec, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland. A total of 14 species of bryozoans and 15 species of sponges were identified. In 31 cases, these species were recorded from a province for the first time. Species new to Canada include the bryozoans Lophopodella carteri, Plumatella orbisperma, and Pottsiella erecta, and the sponges Radiospongilla crateriformis, Spongilla aspinosa, and Trochospongilla horrida. The morphology, taxonomy, distribution, and ecology of each species are examined. Several taxonomic revisions are made. Eunapius mackayi and Plumatella orbisperma are redescribed. Spongilla heterosclerifera, considered an endangered species, is shown to be a species mixture. Taxonomic keys to Eastern Canadian species of freshwater bryozoans and sponges are presented. New limits of tolerance to pH, calcium and magnesium levels, and water temperature are established for several species.

RÉSUMÉ

Les Bryozoaires (Ectoprocta) et les Eponges (Porifera: Spongillidae) d'eau douce sont deux des groupes les moins connus de la faune canadienne. Des spécimens en ont éte preleves à divers endroits en Ontario, au Quebec, au Nouveaux-Brunswick, en Nouvelle-Ecosse, a l'Ile du Prince Edouard et a Terre-Neuve. J'ai identifié, en tout, 14 especes de Bryozoaires et 15 espèces d'Éponges. Dans 31 cas, ces especes etaient signalees pour la première fois dans ces provinces. Parmi les especes nouvellement reperees au Canada, on retrouve chez les Bryozoaires: Lophopodella carteri, Plumatella orbisperma, Pottsiella erecta, et chez les Eponges: Radiospongilla crateriformis, Spongilla aspinosa et Trochospongilla horrida. Ma recherche a porté sur la morphologie, la taxonomie, la distribution, et l'ecologie de chaque espece. La classification a été révisee dans plusieurs cas. Eunapius mackayi et Plumatella orbisperma ont fait l'objet d'une nouvelle description. Selon mes résultats, Spongilla heterosclerifera, qui est considérée comme une espèce en voie d'extinction, est en fait une association de deux espèces. Je propose une clé d'identification pour les Bryozoaires et les Éponges d'eau douce de l'Est du Canada et je donne également, pour plusieurs espèces, de nouveaux seuils de tolerance au pH, aux taux de calcium et de magnésium, ainsi qu'à la temperature de l'eau.

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Note Regarding Authorship

Each chapter in this thesis is intended for publication, and was written and prepared by the candidate. The entire study was conceived, and the results were interpreted, by the candidate, with the following exceptions: For Chapter II, Dr. Timothy S. Wood prepared the SEM photographs, and aided in the interpretation of the results. For Chapter III, Dr. Henry M. Reiswig prepared the figures, and for Chapter IV, Dr. Reiswig helped prepare many specimens for examination.

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Chapter I

GENERAL INTRODUCTION

Freshwater bryozoans (Ectoprocta) and sponges (Porifera) comprise approximately 2% of the total known species of their predominantly marine phyla. These sessile, colonial invertebrates commonly occur in a wide range of inland waters, colonizing submerged surfaces and feeding on suspended material. In Eastern Canada, as well as in other regions in North America (Frost 1991; Wood 1991), bryozoans and sponges are found attached to submerged objects in almost every unpolluted lake or stream.

Freshwater bryozoans are widely distributed (Bushnell 1973), occasionally dominate epibenthic and littoral communities in biomass (Bushnell et al. 1987; Raddum and Johnsen 1983) and contribute significantly to the recycling of phosphorus and nitrogen in small lentic habitats (Job 1976; Sorensen et al. 1986). They are preyed upon by various invertebrates and fish (Bushnell 1966); however, the coelomic fluid of some bryozoan species is selectively toxic to certain fish and larval salamanders (Collins et al. 1966; Tenney and Woolcott 1964). The prolific growth of encrusting bryozoan colonies may foul boats, fishnets (Jonasson 1963), and fish culture cages such that water exchange is impeded and fish growth is significantly reduced (Greenland et al. 1988). Encrusting colonies may also obstruct pipes and conduits of water supplies (Shrivastava and Rao 1985) and nuclear power installations (Aprosi 1988; Pourcher and d'Hondt 1987). There are currently 24 described species of freshwater bryozoans in North America (Wood 1991).

Freshwater sponges are common and widely distributed (Penney and Racek 1968), and represent an important food source for certain invertebrates (Resh 1976) and waterfowl (McAuley and Longcore 1988). Because of their

capacity to remove and process large amounts of suspended material from the water column (Francis and Poirrier 1986), they may contribute significantly to the nutrient cycling of small aquatic habitats (Frost 1978). Occasionally, their prolific growth has been reported to obstruct water pipes and conduits (Pennak 1989) There are 29 described species of freshwater sponges in North America whose taxonomic status is either currently accepted or unresolved (Frost 1991; Harrison 1974; Jewell 1959).

On a regional scale, the distributions of freshwater bryozoans (Bushnell 1966, 1974; Geimer and Massard 1986; Rao et al. 1985) and sponges (Harrison 1974) have been correlated with specific water quality conditions. Many species have narrow limnological requirements ard are sensitive to environmental pollution (Cooper 1988; Francis and Harrison 1988; Malchow 1978; Mundy 1981; Mysing-Gubala and Poirrier 1981), while others are tolerant of highly polluted conditions (Bushnell 1974; Henry et al. 1989). Since both phyletic groups have resistant structures or life stages (i.e., siliceous sponge spicules, sponge gemmules, bry zoan statoblasts) which are well preserved in lake sediments, they have been used in paleolimnological studies (Crisman et al. 1986; Harrison 1988; Harrison and Warner 1986; Kratz et al. 1991; Kuc 1973).

Despite their common occurrence and potential value as biological indicators of water quality, there is a paucity of published information concerning the distribution and ecology of freshwater bryozoans and sponges in Canada. I attribute this largely to difficulties in species identification due to the lack of useful taxonomic information. Much of the species-level taxonomy of both groups has historically been in a state of confusion, and this has caused them to be generally ignored in limnological studies and faunal surveys throughout North America. Consequently, the ecology and taxonomic status of several North American species remains

poorly known. A thorough understanding of the ecology of bryozoans and sponges is essential for their effective use as indicators in bioassay studies, water quality monitoring, and paleolimnological research, and for controlling their fouling growth. Proper species identification is necessary in such studies since large biological differences often exist among species within a family, or even within a genus (Resh and Unzicker 1975). Improper identification can therefore lead to an erroneous assessment of an organism's response. Unfortunately, there are very few reliable features by which species of freshwater Ectoprocta and Porifera may be identified; both groups contain species which exhibit a high degree of ecomorphic variation, a factor which is not given sufficient consideration in most taxonomic descriptions. An additional problem for Canadian biologists is that the available taxonomic and distributional information for North American freshwater bryozoans and sponges is based almost entirely on specimens collected within the United States.

The objectives of my research are to (1) identify and describe the freshwater bryozoans and sponges which occur in Eastern Canada, (2) determine the environmental factors which limit their distribution, and (3) re-examine the taxonomic status of certain problematic species. The purpose of this work is to provide fundamental knowledge to facilitate the use of these common freshwater organisms in bioassay studies, biological monitoring, and environmental impact assessment of freshwater ecosystems in Canada.

Chapters II and III examine the taxonomic status of two problematic species which are known or expected to occur in Eastern Canada. Chapters IV and V discuss the taxonomy, distribution, and ecology of 15 species of freshwater sponges and 14 species (2 classes, 6 families) of freshwater bryozoans occurring in Eastern Canada. Taxonomic keys are presented for both

groups. Emphasis has been placed on species occurring in southern Quebec, since most of the specimens were collected from this region. The other regions in Eastern Canada from which specimens were obtained include Ontario, New Brunswick, Nova Scotia, Prince Edward Island, and Newfoundland.

References Cited

APROSI, G. 1988. Bryozoans in the cooling water circuits of a power plant. Verh. Int. Verein. Limnol. 23: 1542-1547.

BUSHNELL, J.H. 1966. Environmental relations of Michigan Ectoprocta and dynamics of natural populations of Plumatella repens. Ecol. Monogr. 36: 95-123.

BUSHNELL, J.H. 1973. The freshwater Ectoprocta: a zoogeographical discussion. In Living and fossil Bryozoa: recent advances in research. Edited by G.P. Larwood and M.B. Abbott. Academic Press, London. pp. 75-92.

BUSHNELL, J.H. 1974. Bryozoans (Ectoprocta). In Pollution ecology of freshwater invertebrates. Edited by C.W. Hart and S.L.H. Fuller. Academic Press, N.Y. pp. 157-194.

BUSHNELL, J.H., FOSTER, S.Q. and WAHLE, B.M. 1987. Annotated inventory of invertebrate populations in an alpine lake and stream chain in Colorado. Great Basin Nat. 47: 500-511.

COLLINS, E.J., TENNEY, W.R. and WOOLCOTT, W.S. 1966. Histological effects of the poison of Lophopodella carteri (Hyatt) in the gills of Carassius auratus (Linnaeus) and larval Ambystoma opacum (Gravenhorst). Va. J. Sci. (n. ser.) 17: 155-161.

COOPER, C.M. 1988. The toxicity of suspended sediments on selected freshwater invertebrates. Verh. Int. Verein. Limnol. 23: 1619-1625.

CRISMAN, T.L., CRISMAN, U.A.M., and BINFORD, M.W. 1986. Interpretation of bryozoan microfossils in lacustrine sediment cores. Hydrobiol. 143: 113-118.

FRANCIS, J.C. and HARRISON, F.W. 1988. Copper and zinc toxicity in Ephydatia fluviatilis (Porifera: Spongillidae). Trans. Am. Micros. Soc. 107: 67-78.

FRANCIS, J.C. and POIRRIER, M.A. 1986. Particle uptake in two fresh-water sponge species, Ephydatia fluviatilis and Spongilla alba (Porifera: Spongillidae). Trans. Am. Microsc. Soc. 105: 11-20.

FROST, T.M. 1978. The impact of the freshwater sponge Spongilla lacustris on a sphagnum bog-pond. Verh. Int. Verein. Limnol. 20: 2368-2371.

FROST, T.M. 1991. Porifera. In Ecology and classification of North American freshwater invertebrates. Edited by J.H. Thorp and A.P. Covich. Academic Press, N.Y. pp. 95-124.

GEIMER, G. and MASSARD, J.A. 1986. Les bryozoaires du Grand-duche de Luxembourg et des régions limitrophes. Trav. Scient. Mus. Hist. nat. lux. VII. 188p.

GREENLAND, D.C., NEWTON, S.H. and FAUCETTE, Jr., R.F. 1988. Effects of cage encrustation by the bryozoan Plumatella casmiana on production of channel catfish. Prog. Fish-Cult. 50: 42-45.

HARRISON, F.W. 1974. Sponges (Porifera: Spongillidae). In Pollution ecology of freshwater invertebrates. Edited by C.W. Hart and S.L.H. Fuller. Academic Press, N.Y. pp. 29-66.

HARRISON, F.W. 1988. Utilization of freshwater sponges in paleolimnological studies. Palaeogeogr. Palaeoclimatol. Palaeoecol. 62: 387-397.

HARRISON, F.W. and WARNER, B.C. 1986. Fossil fresh-water sponges (Porifera: Spongillidae) from western Canada: an overlooked group of Quaternary paleoecological indicators. Trans. Am. Microsc. Soc. 105: 110 120.

HENRY, V., BUSSERS, J.C., BOUQUEGNEAU, J.M., and THOME, J.P. 1989. Heavy metal and PCB contamination of bryozoan colonies in the River Meuse (Belgium). Hydrobiol. 202: 147-152.

JEWELL, M.E. 1959. Porifera. In Fresh-water biology. 2nd ed. Edited by W.T. Edmondson. J. Wiley and Sons, N.Y. pp. 298-312.

JOB, P. 1976. Intervention des populations de Plumatella fungosa (Pallas) (Bryozoaire Phylactoleme) dans l'autopuration des eaux d'un etang et d'un ruisseau. Hydrobiol. 48: 257-261.

JONASSON, P.M. 1963. The growth of Plumatella repens and P. fungosa (Bryozoa Ectoprocta). Oikos 14(2): 121-137.

KRATZ, T.K., FROST, T.M., ELIAS, J.E., and COOK, R.B. 1991. Reconstruction of a regional, 12,000-yr silica decline in lakes by means of fossil sponge spicules. Limnol. Oceanogr. 36: 1244-1249.

KUC, M. 1973. Fossil statoblasts of Cristatella mucedo Cuvier in the Beaufort Formation and in interglacial and postglacial deposits of the Canadian arctic. Geol. Surv. Canada Pap. 72-28. Ottawa. 12p.

MALCHOW, C.P. 1978. Der Verdauungstrakt von Plumatella repens (L) (Bryozoa, Phylactolaemata). I. Ultrastruktur und funktionelle Zusammenhange. II. Strukturveranderungen als Indikator fur Wasserverschmutzung. Zoologische Beitrage 24: 365-394.

McAULEY, D.G. and LONGCORE, J.R. 1988. Foods of juvenile ring-necked ducks: relationship to wetland pH. J. Wildl. Management 52: 177-185.

MUNDY, S.P. 1981. Some effects of low concentrations of copper ions on Cristatella mucedo (Bryozoa: Phylactolaemata). In Recent and fossil Bryozoa. Edited by G.P. Larwood and C. Nielsen. Olsen and Olsen, Fredensborg. pp.177-184.

MYSING-GUBALA, M. and POIRRIER, M.A. 1981. The effects of cadmium and mercury on gemmule formation and gemmosclere morphology in Ephydatia fluviatilis (Porifera: Spongillidae). Hydrobiol. 76: 145-148.

PENNAK, R.W. 1989. Fresh-water invertebrates of the United States. 3rd Ed. Protozoa to Mollusca. J. Wiley and Sons. N.Y. 628p.

PENNEY, J. T. and RACEK, A.A. 1968. Comprehensive revision of a worldwide collection of freshwater sponges (Porifera: Spongillidae). U.S. Nat. Mus. Bull. 272: 1-184.

POURCHER, A.-M. and d'HONDT, J.-L. 1987. Étude ultrastructurale du sessoblaste et du flottoblaste chez Plumatella fungosa (Pallas, 1768) (Bryozoaires, Phylactolaemates). Ann. Sc. Nat., Zool. 13 ser., 8: 209-216.

RADDUM, G.G. and JOHNSEN, T.M. 1983. Growth and feeding of Fredericella sultana (Bryozoa) in the outlet of a humic acid lake. Hydrobiol. 101: 115-120.

RAO, K.S., AGRAWAL, V., and DIWAN, A.P. 1985 Studies on water quality monitoring with freshwater Ectoprocta as indicator organisms. In Bryozoa: Ordovician to recent. Edited by C. Nielsen and G.P. Larwood. Olsen and Olsen, Fredensborg. pp. 348-349.

RESH, V.H. 1976. Life cycles of of invertebrate predators of freshwater sponge. In Aspects of sponge biology. Edited by F.W. Harrison and R.R. Cowden. Academic Press, New York. pp. 299-314.

RESH, V.H. and UNZICKER, J.D. 1975. Water quality monitoring and aquatic organisms: the importance of species identification. J. Wat. Poll. Contr. Fed. 47: 9-19.

SHRIVASTAVA, P. and RAO, K.S. 1985. Ecology of Plumatella emarginata (Ectoprocta: Phylactolaemata) in the surface waters of Madhya Pradesh with a note on its occurrence in the protected waterworks of Bhopal (India). Environ. Poll. (ser. A) 39: 123-130.

SORENSEN, J.P., RIBER, H.H. and KOWALCZEWSKI, A. 1986. Soluble reactive phosphorus release from bryozoan dominated periphyton. Hydrobiol. 132: 145-148.

TENNEY, W.R. and WOOLCOTT, W.S. 1964. A comparison of the responses of some species of fishes to the toxic effect of the bryozoan Lophopodella carteri (Hyatt). Va. J. Sci. (n. ser.) 15: 16-20.

WOOD, T.S. 1991. Bryozoans. In Ecology and classification of North American freshwater invertebrates. Edited by J.H. Thorp and A.P. Covich. Academic Press, N.Y. pp. 95-124.

Chapter II

STATOBLAST MORPHOLOGY AND SYSTEMATICS OF THE FRESHWATER BRYOZOAN, HYALINELLA ORBISPERMA (KELLICOTT 1882)

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Abstract

The freshwater bryozoan Hyalinella orbisperma (Ectoprocta: Phylactolaemata), previously known only from Michigan, is added to the list of Canadian fauna from a specimen collected at Georgian Bay, Ontario. Floatoblasts match the appearance of those described from Michigan. The sessoblast of this species is recorded and illustrated for the first time. Scanning-electron microscopy of the floatoblast and sessoblast reveals a raised reticulation with interstitial tubercles covering the capsule periblast, suggesting a close phylogenetic relationship with certain Plumatella species. The case for other species with sessoblasts in the genus Hyalinella is extremely weak. It is proposed that H. orbisperma be reassigned to the genus Plumatella.

Introduction

Like many aquatic invertebrates, the bryozoans (Ectoprocta) offer few reliable features by which species may be distinguished. For the class Phylactolaemata, taxonomists rely heavily on the morphology of encapsulated buds (statoblasts) which are a unique characteristic of this exclusively freshwater group of bryozoans. Statoblasts are sclerotized, dormant structures produced asexually by all phylactolaemate species, and can survive freezing, desiccation, and other environmental stresses (Bushnell and Rao 1974). A statoblast consists of a yolky, germinal mass enclosed by two chitinous valves; the valves form an inner capsule surrounded by an outer periblast. Most bryozoans produce buoyant statoblasts (floatoblasts) with a peripheral annulus of gas-filled cells; they may also produce adherent, nonfloating statoblasts (sessoblasts) which are cemented through the colony wall to a firm substrate. The annulus of a sessoblast is reduced to a thin lamella. The surface patterning of the statoblast is often species-specific (Mundy 1980). These and other morphological characteristics of statoblasts are considered to be important diagnostic criteria in the identification of phylactolaemate bryozoan species, and have been used to elucidate their phylogenetic relationships (Lacourt 1968; Mukai 1990; Oda and Mukai 1985; Smith 1988; Toriumi 1950; Wood 1979).

Hyalinella orbisperma (Kellicott) (Phylactolaemata: Plumatellidae) is a freshwater bryozoan previously known only from a few scattered ponds in Michigan (Bushnell 1965; Kellicott 1882). Kellicott (1882) provided a limited description of the new form which he tentatively designated Plumatella orbisperma, and was undecided as to whether it represented a new species, or simply a variety of either "Plumatella arethusa" [=P. repens (Linnaeus)] or "Plumatella vesicularis" [=Hyalinella punctata (Hancock)]. In

a detailed study of the Michigan freshwater bryozoans, Bushnell (1965) distinguished P. orbisperma from other Plumatella species primarily by the shape of the floatoblast, lack of a sessoblast, and certain colonial features, and reassigned the species to the genus Hyalinella. Lacourt (1968), apparently unaware of Bushnell's study, doubted the validity of Hyalinella (Plumatella) orbisperma since the original description by Kellicott (1882) was inadequate and no specimens were known to exist. However, from an examination of Bushnell's specimens, Wiebach (1973) considered H. orbisperma to be a valid species.

Recently, a review of bryozoans in the collection of the Royal Ontario Museum (Toronto, Canada) revealed Hyalinella orbisperma from a specimen (ROM No. K-13) misidentified as Plumatella fungosa (Pallas), collected by A.G. Huntsman (date unknown) at Go Home Lake, Georgian Bay, Ontario. The species is thus added to the list of Canadian fauna. Based on other specimens obtained by Huntsman from the same location, the Georgian Bay specimen was probably collected around 1910. The specimen matches Bushnell's (1965) description quite closely, except for the presence of sessoblasts. In this study, the fine surface structure of both types of statoblasts in the Georgian Bay specimen was examined to evaluate the systematic position of Hyalinella orbisperma (Kellicott).

Materials and Methods

The Georgian Bay Hyalinella orbisperma specimen (ROM No. K-13) is preserved in alcohol and consists of a small amount of fragmented colony on unidentified plant material. Statoblasts were examined and photographed in a Philips 500 scanning electron microscope. In order to conserve material for future examination, only a small number of statoblasts (6 floatoblasts and 3

sessoblasts) were extracted from the specimen. Prior to scanning electron microscopy (SEM), the statoblasts were dehydrated in an acetone series, subjected to critical-point drying with carbon dioxide (to prevent distortion of the capsule), and then sputter-coated in gold.

For comparative study, a specimen of Hyalinella vaihiriae was obtained from the Rogick collection (specimen no. 1) at the United States National Museum, and the statoblasts were examined following the procedure given above.

Results and Discussion

Colony description of Hyalinella orbisperma:

The Georgian Bay colony is recumbent and dichotomously branched. The ectocyst (in the preserved condition) is soft, translucent, swollen, without encrustation, and lacking the white spots that are often observed in H. punctata. Septation, keeling, and emargination are absent. Zooids are arranged both linearly and in clusters of 2 to 7 polypides. The polypide orifices are oriented vertically to the substrate. The polypides are retracted due to poor fixation, thus making tentacle counts impossible. Each zooid may contain 1-2 sessoblasts, and an aggregation of 10-20 floatoblasts.

Floatoblast morphology:

The floatoblasts of the Georgian Bay specimen are circular in outline, or nearly so (mean length to width ratio=1.11), biconvex and generally symmetrical in lateral view, and have a thin annulus which widens slightly at the poles (Figure 1). The ventral (deutoplasmic) surface is somewhat

pointed, as was described for Michigan specimens (Bushnell 1965).

The floatoblast dimensions of the Georgian Bay specimen are slightly smaller than those given by Kellicott (1882) and Bushnell (1965), but the length to width ratios compare favorably (Table 1). White (1915) provides the only published records of bryozoans from Georgian Bay, and briefly describes specimens identified as Plumatella fungosa collected from pond weeds (Pontederia sp.). These had round statoblasts with length to width ratios of 1.2, and may actually have been H. orbisperma.

Scanning electron microscopy of the floatoblast reveals a raised hexagonal reticulation on both valves which does not extend onto the annulus (Figure 1; Figure 2). A similar reticulation was illustrated in SEM photographs of H. orbisperma by Bushnell and Rao (1979), and by Rao (in Pennak 1989, p.276). Prominent tubercles occur along the region where annulus and fenestra meet (Figure 1); they become much less distinct toward the center of the fenestra, and are absent from the rest of the annulus. A median cord between floatoblast valves is lacking, and the suture line is slightly serrated. The valves have begun to separate (Figure 3), possibly due to the specimen's prolonged storage in alcohol.

Floatoblasts of H. orbisperma and H. punctata differ greatly in shape and surface detail. The length to width ratios reported for H. orbisperma floatoblasts (1.07-1.11; Table 1) do not overlap those reported for H. punctata, which vary from 1.31 to 1.77 (Massard and Geimer 1991). Bushnell (1965) noted that the larger, broader floatoblasts of H. punctata have proportionately greater float area than the smaller, rounder floatoblasts of H. orbisperma. In the Georgian Bay specimen, the maximum width of the annulus is less than 18% of the length of the floatoblast (Table 1). Bushnell (1965) also emphasized that although both floatoblast capsules of H. punctata are convex, they are not as inflated as those of H. orbisperma,

and the ventral capsule is not pointed. In both species, the suture line between the floatoblast valves is serrated, but the discontinuous medial rib (a linear arrangement of sutural knobs) described for H. punctata (Bushnell and Rao 1979; Massard and Geimer 1991) is absent in H. orbisperma. Finally, the fenestra of H. punctata floatoblasts bears generally larger tubercles than that of H. orbisperma, without any raised reticulation (Bushnell and Rao 1979; Geimer and Massard 1986; Massard and Geimer 1991).

Sessoblast morphology:

The sessoblast of H. orbisperma (Figure 4) is described here for the first time. It is circular in outline. Lengths and widths (in micrometers) of three sessoblasts are: 528 X 410, 544 X 430, and 576 X 448. with a mean length to width ratio of 1.2. The lamella is reticulated and its edges are serrate. Tubercles on the frontal periblast are small and low, disappearing towards the center, but extending onto the lamella. Tubercles near the lamella are enclosed in a raised reticulation which is very faint but otherwise identical to that which appears on the floatoblast.

The sessoblast problem in Hyalinella:

The existence of a sessoblast in Hyalinella has been questioned since Jullien's (1885) original description of the genus precluded sessoblasts. Toriumi (1956), noting the overlap in colonial morphology between specimens of Plumatella and Hyalinella, suggested that the difference between the two genera is the absence of a sessoblast in the latter. However, Lacourt (1968) expanded the definition of the genus Hyalinella to include certain species with sessoblasts. In his revision of Hyalinella, Wiebach (1973) accepted the

validity of four species previously reported to produce sessoblasts: H. punctata, H. africana Wiebach, H. indica (Annandale) and H. minuta (Toriumi).

A brief review of each of these species reveals considerable uncertainty on the issue of sessoblasts in Hyalinella. Annandale (1915) found no sessoblasts in the type material of H. indica. Lacourt (1968) described sessoblasts from a specimen which he identified as H. indica (No. SMF-836 in the Senckenberg Museum, Frankfurt), but the same specimen is considered by Wiebach (1973) to be a species of Plumatella.

In his original work on Hyalinella minuta, Toriumi (1941a, 1955) confirmed the absence of sessoblasts. Later, he reported collecting colonies with a few sessoblasts, allowing that these may be formed in a "special case" (Toriumi 1972). These sessoblasts were never described, and no specimens are known to exist. Furthermore, Rao (1973) did not find sessoblasts in any of the Indian specimens of H. minuta that he had examined. Until more convincing evidence is presented, the existence of sessoblasts in this species should be considered doubtful.

Hyalinella africana is known from only two small specimens from Zimbabwe (Wiebach 1964). On the basis of statoblast morphology, Lacourt (1968) considered this species to be a Plumatella, and Wiebach (1973) later admitted the possibility that H. africana is a synonym of Plumatella longigemmis (Annandale).

For the most common (and possibly the only undisputed) member of the genus, Hyalinella punctata, Lacourt (1968) provided a description of "rarely found" sessoblasts without reference to any particular specimen or locality. Grančarova (1968) reported sessoblasts in Bulgarian colonies, but Wiebach (1973) was unable to confirm her finding from an examination of the same material. Toriumi (1972) noted that a number of European specimens of P.

repens have been erroneously identified as H. punctata, and Massard and Geimer (1991) suggested that reports of sessoblasts in H. punctata were the result of previous workers confusing this species with the hyaline forms of P. repens and P. fungosa.

Rao et al. (1985) mentions the occurrence of sessoblasts in certain specimens of H. punctata collected from central India, but previous collections of this species in India (Annandale 1910; Rao 1976) contained no sessoblasts. Sessoblasts were not found in H. punctata collected in Luxembourg (Geimer and Massard 1986), nor were they found in Japan, Korea and Taiwan (Toriumi 1941a, 1941b, 1942), nor in any of the detailed regional North American studies from Lake Erie (Rogick, 1935), Michigan (Bushnell 1965), Massachusetts (Smith 1989), Ohio (Wood 1989), and Quebec (Ricciardi, In preparation). Sessoblasts were similarly absent from laboratory reared colonies reported by Rogick (1945), Mukai et al. (1987), and by Toriumi (1972) in 13 generations. The possibility that sessoblast formation in H. punctata occurs within a narrow range of environmental conditions must be considered unlikely given the absence of sessoblasts from the wide range of natural and experimental populations described above.

The environmental factors controlling sessoblast formation, and the functional differences between floatoblasts and sessoblasts, have not been fully established. In many phylactolaemate species (e.g., Plumatellidae), it is likely that floatoblasts are primarily dissemules and that larger sessoblasts serve mainly in seasonal recruitment of new colonies (Pourcher and d'Hondt 1987; Karlson 1991). With ample yolk reserves, a large statoblast capsule may more easily survive prolonged periods of seasonal drought or cold weather. In those species (e.g., Lophopodidae) known to form only floatoblasts, the capsule is always relatively large, similar in size to a normal sessoblast. Such floatoblasts must serve dual roles of

dissemination and seasonal recruitment. In Hyalinella punctata, the large floatoblast size, (maximum 765 μm length X 489 μm width, Wood 1989) suggests that it, too, serves these dual functions. Therefore, it would be surprising to discover sessoblasts in this species.

Hyalinella vaihiriae Hastings is the only North American Hyalinella species previously reported to produce sessoblasts (Rogick and Brown 1942). The statoblasts of H. vaihiriae are remarkably different from those of any other known species of Hyalinella. The floatoblasts are oval, acutely pointed at the poles, and asymmetric in lateral view. Sessoblasts reported by Rogick and Brown (1942) from a specimen collected at Bear River, Utah, have a distinct reticulation (Figure 5), similar to that which covers the floatoblast capsule (Cazzaniga 1988). The reticulation consists of a uniform network of ridges enclosing hexagonal pits without any visible interstitial tubercles, unlike that which occurs on H. orbisperma statoblasts.

Much of the confusion regarding the existence of sessoblasts in Hyalinella is clearly the result of a broad morphological overlap among described species of Plumatella and Hyalinella (Torium 1956, 1972; Wiebach 1973). With the exception of the Bear Creek H. vaihiriae, every one of the Hyalinella species mentioned above has been placed in the genus Plumatella at some time, and there has not been a single undisputed specimen of Hyalinella in which the production of sessoblasts could be confirmed. The discovery of sessoblasts in H. orbisperma, far from settling the issue, raises the question of whether this species properly belongs in the genus Plumatella.

Comparison with Stephanella hina Oka:

Because of apparent similarities of floatoblast shape and certain colonial features, Bushnell (1965) advocated a comparative study of H. orbisperma and Stephanella hina in the event that sessoblasts be found in H. orbisperma colonies. Floatoblasts of both species are round, but those of S. hina have a sharply reticulated surface without tubercles (Mukai 1990, Smith 1988), while those of H. orbisperma have tubercles combined interstitially with small reticulations (Figure 2). Furthermore, one of the valves of the S. hina floatoblast consistently bears a distinctive central projection (Mukai 1990; Smith 1988; Wood 1979) which is lacking in H. orbisperma. Smith (1988) noted that the small lophophore, low tentacle number, and statoblast fine structure of S. hina were sufficient to distinguish it from the genera Hyalinella and Plumatella. Recently, Mukai (1990) has shown from Japanese specimens of S. hina that the developing floatoblast acquires a unique orientation with respect to the funiculus, making unlikely a close affinity with any other known species. Because of the wide morphological differences between Stephanella and the other genera of phylactolaemate bryozoans, it has been proposed that the genus be placed in its own family (Mukai 1990). These considerations argue against linking H. orbisperma with S. hina.

Comparison with Plumatella species:

Specimens of P. repens and P. fungosa may have round floatoblasts with a pointedly convex ventral capsule, quite similar to that of H. orbisperma, although the annulus is typically much wider. A characteristic feature of Plumatella floatoblasts is a lightly raised fenestral reticulation with a

small tubercle in the center of each defined cell; this feature is found in every Plumatella species (except P. fruticosa Allman) recorded in Europe and North America, but is absent in virtually all other species (Bushnell and Rao 1979; Geimer and Massard 1986; Mundy 1980; Wood, 1979). Sessoblasts of European and North American Plumatella species bear prominent tubercles on the frontal valve. Tubercles on the sessoblasts of P. repens, P. fungosa, and P. coralloides Allman, illustrated in SEM photographs by Geimer and Massard (1986), are enclosed in a faint reticulation of the same type which occurs on the floatoblast. The capsular surface of the H. orbisperma floatoblast (Figure 2) and sessoblast (Figure 5) clearly shows the reticulation and tubercles of a typical Plumatella. This finding is persuasive evidence of a strong Plumatella affinity, and implies that H. orbisperma is a species closely related to the repens-fungosa-coralloides group. On the basis of the morphological evidence presented above, we suggest that the species be returned to its original name, Plumatella orbisperma Kellicott.

Acknowledgments

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References Cited

ANNANDALE, N. 1910. Materials for a revision of the phylactolaematous Polyzoa of India. Rec. Ind. Mus. 3: 373-374.

--------- 1915. The genus Australella and some allied species of phylactolaematous Polyzoa. J. Proc. Asiatic Soc. Bengal 11: 163-169.

BUSHNELL, J.H. 1965. On the taxonomy and distribution of freshwater Ectoprocta in Michigan. III. Trans. Amer. Micros. Soc. 84(4):529-548.

BUSHNELL, J.H. and RAO, K.S. 1974. Dormant or quiescent stages and structures among the Ectoprocta: physical and chemical factors affecting viability and germination of statoblasts. Trans. Amer. Micros. Soc. 93:524 543.

BUSHNELL, J.H. and RAO, K.S. 1979. Freshwater Bryozoa: micro-architecture of statoblasts and some aufwuchs animal associations. In Advances in Bryozoology. Edited by G.P. Larwood and M.B. Abbott. Academic Press, London. pp. 75-92.

CAZZANIGA, N.J. 1988. Hyalinella vaihiriae (Ectoprocta: Phylactolaemata) en la provincia de San Juan (Argentina). Rev. Asoc. Lienc. Nat. Litoral 19:205 208.

GEIMER, G. and MASSARD, J. 1986. Les bryozoaires du Grand-Duché de Luxembourg et des régions limitrophes. Travaux Scient. Mus. Hist. nat. Luxembourg. VII. 188p.

GRANČAROVA, T. 1968. Novi briozoi za faunata na Balgarija. Bull. Inst. Zool. Mus. Acad. Bulg. Sci. 28: 197-204.

JULLIEN, J. 1885. Monographie des bryozoaires d'eau douce. Bull. Soc. Zool. France 10: 91-207.

KARLSON, R.H. 1991. Recruitment and local persistence of a freshwater bryozoan in stream riffles. Hydrobiologia (in press).

KELLICOTT, D.S. 1882. Polyzoa. Observations on species detected near Buffalo, N.Y. Proc. Amer. Soc. Microscopists 4: 217-229.

LACOURT, A.W. 1968. A monograph of the freshwater Bryozoa--Phylactolaemata. Zool. Verhandl. 93: 1-159.

MASSARD, J.A. and GEIMER, G. 1991. Note sur les Bryozoaires d'eau douce trouvé en diverses stations luxembourgeoises et belges, avec des considérations sur la bryozoofaune de la Sûre et des remarques concernant les statoblastes de Hyalinella punctata (Hancock, 1850). Bull. Soc. Nat. Luxembourgeois 92: 131-148.

MUKAI, H. 1990. Systematic position of Stephanella hina (Bryozoa: Phylactolaemata) with special reference to the budding site and the attachment of sessoblasts. Zool. Sci. 7: 947-954.

MUKAI, H., FUKUSHIMA, M. and JINBO, Y. 1987. Characterization of the form and growth pattern of colonies in several freshwater bryozoans. J. Morph. 192:161-179.

MUNDY, S.P. 1980. Stereoscan studies of phylactolaemate bryozoan statoblasts including a key to the statoblasts of the British and European Phylactolaemata. J. Zool. Lond. 192: 511-530.

ODA, S. and MUKAI, H. 1985. Fine surface structure of the statoblasts of higher phylactolaemate bryozoans. In Bryozoa: Ordovician to recent. Edited by C. Nielsen and G.P. Larwood. Olsen and Olsen, Fredensborg. pp. 233-244.

PENNAK, R.W. 1989. Freshwater invertebrates of the United States. 3rd edition. Protozoa to Mollusca. J. Wiley and Sons. New York. 628p.

POURCHER, A.-M. and d'HONDT, J.-L. 1987. Étude ultrastructurale du sessoblaste et du flottoblaste chez Plumatella fungosa (Pallas, 1768) (Bryozoaires, Phylactolaemates). Ann. Sc. Nat., Zool. 13 Ser., 8: 209-216.

RAO, K.S. 1973. Studies on freshwater Bryozoa III. The Bryozoa of the Narmada River system. In Living and fossil Bryozoa: recent advances in research. Edited by G.P. Larwood. Academic Press, London. pp. 529-537.

-------- 1976. Studies on the freshwater Bryozoa IV. The Bryozoa of Rajasthan, India. Rec. Zool. Surv. India 69: 329-345.

RAO, K.S., AGRAWAL, V., DIWAN, A.P., and SHRIVASTAVA, P. 1985. Studies on freshwater Bryozoa V. Observations on central Indian materials. In Bryozoa: Ordovician to recent. Edited by C. Nielsen and G.P. Larwood. Olsen and Olsen, Fredensborg. pp. 257-264.

ROGICK, M.D. 1935. Studies on the freshwater Bryozoa. II. The Bryozoa of Lake Erie. Trans. Amer. Microsc. Soc. 54(3): 245-263.

--------- 1945. Studies on the freshwater Bryozoa XV. Hyalinella punctata growth data. Ohio J. Sci. 45: 55-79.

ROGICK, M.D. and BROWN, C.J.D 1942. Studies on freshwater Bryozoa XII. A collection from various sources. Ann. N.Y. Acad. Sci. 43: 123-144.

SMITH, D.G. 1988. Stephanella hina (Ectoprocta: Phylactolaemata) in North America, with notes on its morphology and systematics. J. N. Amer. Benthol. Soc. 7: 253-259.

--------- 1989. Keys to the freshwater macroinvertebrates of Massachusetts. No. 4: Benthic colonial phyla. Mass. Dept. Env. Qual. Eng., Div. Wat. Poll. Contr. Westborough, Mass. 48pp.

TORIUMI, M. 1941a. Studies on freshwater Bryozoa of Japan. I. Sci. Rep. Tohoku Imp. Univ. (4) 16:413-425.

--------- 1941b. Studies on freshwater Bryozoa of Japan II. Freshwater Bryozoa of Tyosen (Korea). Sci. Rep. Tohoku Imp. Univ. (4) 16: 413-425.

--------- 1942. Studies on freshwater Bryozoa of Japan. IV. Freshwater Bryozoa of Taiwan (Formosa). Sci. Rep. Tohoku Imp. Univ. (4) 17: 207-214.

--------- 1955. Taxonomical study on freshwater Bryozoa. XII. On Plumatella repens var. minuta Toriumi, 1941. Sci. Rep. Tohoku Univ. (4) 21: 137-143.

--------- 1956. Taxonomical study on freshwater Bryozoa. XVII. General consideration: interspecific relation of described species and phylogenetic consideration. Sci. Rep. Tohoku Univ. (4) 22: 57-88.

--------- 1972. Additional observations on Plumatella repens (L.) (a freshwater bryozoan) VII. Re-examination on the materials labelled Plumatella punctata. Bull. Mar. Biol. Stn. Asamushi 14: 155-167.

WHITE, H.T. 1915. Bryozoa of the Georgian Bay region. Contrib. Can. Biol. (1911-1914) 2: 195-199.

WIEBACH, F. 1964. Untersuchungen an Susswasser-Bryozoen aus Brasilien und Zentralafrika. Ann. Mus. Afr. Centrale, Sci. Zool. 129: 1-42.

--------- 1973. Preliminary notes on a revision of the genus Hyalinella. In Living and fossil Bryozoa. Edited by G.P. Larwood. Academic Press, London and New York. pp. 539-547.

WOOD, T.S. 1979. Significance of morphological features in bryozoan statoblasts. In Advances in Bryozoology. Edited by G.P. Larwood and M.B. Abbott. Academic Press, London. pp. 59-74.

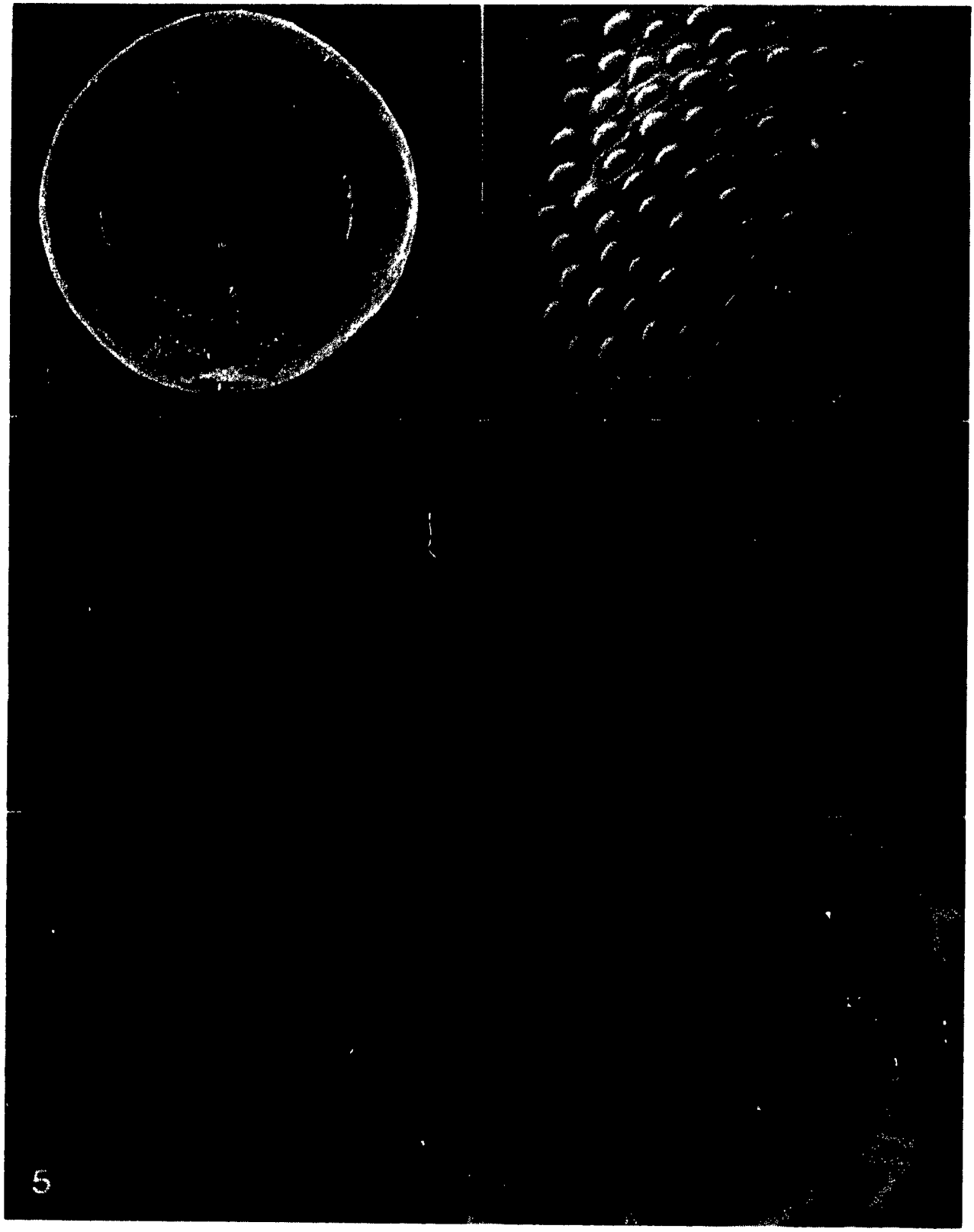
--------- 1989. Ectoproct bryozoans of Ohio. Bull. Ohio Biol. Surv. (n. ser.) 8 (2): 70p.

Table 1. Floatoblast dimensions (in μm) of Hyalinella orbisperma (mean values in parentheses).

	SOURCE		
	Present study	Bushnell 1965	Kellicott 1882
NUMBER OF MEASUREMENTS	6	156	---
OVERALL LENGTH	320-(332)-336	300-(340)-370	343
OVERALL WIDTH	288-(300)-304	280-(310)-350	320
MEAN OVERALL L/W	1.11	1.08	1.07
DORSAL FENESTRA LENGTH	192-(213)-240	225	
DORSAL FENESTRA WIDTH	192-(203)-208	215	
DORSAL FENESTRA L/W	1.05	1.05	
VENTRAL FENESTRA LENGTH	240-(257)-272	250	
VENTRAL FENESTRA WIDTH	224-(232)-256	240	
VENTRAL FENESTRA L/W	1.11	1.04	

(L/W = length to width ratio)

FIGURES 1-5: Scanning-electron micrographs of Hyalinella orbisperma statoblasts. Fig. 1: Dorsal (cystigenic) surface of floatoblast (scale bar = 100 μm). Fig. 2: Detail of surface floatoblast showing reticulation and tubercles (scale bar = 20 μm). Fig. 3: Suture zone of floatoblast (scale bar = 100 μm). Fig. 4: Frontal view of sessoblast (scale bar = 100 μm). Fig. 5: Detail of frontal sessoblast valve, showing surface pattern (scale bar = 20 μm). Figure 6: Hyalinella vaihiriae sessoblast, frontal view (scale bar= 100 μm).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CONNECTING STATEMENT

In Chapter II, statoblast morphology was used to evaluate the taxonomic status of the freshwater bryozoan Hyalinella orbisperma. This rare species is apparently restricted to isolated areas in the Great Lakes region. It was shown that H. orbisperma properly belongs in the genus Plumatella, and that it is closely related to Plumatella repens, P. fungosa, and P. coralloides.

The taxonomic status of another rare and possibly endangered species, the freshwater sponge Spongilla heterosclerifera, is examined in Chapter III.

Chapter III

SPONGILLA HETEROSCLERIFERA SMITH, 1918 IS AN INTERSPECIFIC FRESHWATER SPONGE MIXTURE (PORIFERA, SPONGILLIDAE)

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Ricciardi, A. and H.M. Reiswig. Spongilla heterosclerifera Smith, 1918 is an interspecific freshwater sponge mixture (Porifera, Spongillidae).

Abstract

A freshwater sponge classified as Spongilla heterosclerifera Smith 1918 and reported only from Oneida Lake, New York, was considered to be an endangered species. Examination of the holotype specimen reveals that it is actually an interspecific mixture of two widely distributed sponges, Ephydatia muelleri (Lieberkuhn) and Eunapius fragilis (Leidy). Spongilla heterosclerifera is therefore a junior synonym, in part, of both of these distinct species. Similar erroneous taxonomic interpretations of species mixtures have been documented and illustrate the importance of recognizing the possibility of species mixing when identifying freshwater sponge taxa.

Introduction

Spongilla heterosclerifera, a freshwater sponge (Porifera: Spongillidae), was described by Smith (1918) from specimens collected at Oneida Lake, New York. It was subsequently reported sixty years later from Oneida Lake by Harrison and Harrison (1979) who considered it to be a taxonomically valid, environmentally restricted species on the verge of extinction. No other records of S. heterosclerifera exist for Oneida Lake or for any other locality. Spongilla heterosclerifera has been added to the IUCN Invertebrate Red Data Book as an endangered species (Wells 1983) and has been considered for listing in the U.S. List of Endangered and Threatened Wildlife (U.S. Fish and Wildlife Service 1989). Although S. heterosclerifera has been included in various North American spongillid checklists and keys (Frost 1991, Harrison 1974, Penney 1960, Jewell 1959, Pennak 1953, Wurtz 1950), it has not been examined in any taxonomic revision of freshwater sponges (e.g., Penney and Racek 1968). Smith's (1918) description remains the only detailed diagnosis of the species. Furthermore, the taxonomic status of S. heterosclerifera is unclear: Frost (1991) noted that the species may be placed in either the genus Spongilla or the genus Eunapius, depending on how its spicular characteristics are interpreted.

During an ongoing survey of the freshwater sponges of southern Quebec, efforts were made to locate species known to occur in adjacent areas (such as New York state) since the ranges of some of these species may extend into Quebec. Attempts to locate S. heterosclerifera were unsuccessful. Specimens which approached Smith's (1918) description were collected, but under close scrutiny were discovered to be interspecific sponge mixtures. It was then considered necessary to evaluate the taxonomic validity of S. heterosclerifera.

Materials and Methods

Holotype materials of Spongilla heterosclerifera Smith (USNM No. 9190) were obtained from the United States National Museum of Natural History. The specimen consisted of dried patches of sponge on a single rock and 5 accompanying slides, presumably of fragments taken from patches on the rock. There are apparently no other type materials. Despite Smith's (1918) claim that paratypes were deposited in the collection of the College of Environmental Sciences and Forestry, New York State University (formerly the New York State College of Forestry), there are no type specimens or species-identified freshwater sponges in the college collection (R. Norton, personal communication). The holotype materials were examined and photographed using light microscopy. Several additional slides were made from samples taken from various locations on the holotype rock; these have been deposited in the USNM collection. Dr. F.W. Harrison kindly provided specimens collected during his 1977 visit to Oneida Lake (Harrison and Harrison 1979) for similar detailed analysis.

Results and Discussion

Smith (1918) gave the following description of the spicules and gemmules of S. heterosclerifera:

"Skeleton spicules are commonly fairly stout, slightly curved, sharp pointed, and rather closely crowded with small spines except on the smooth terminal parts which are of variable extent, but each of which is usually one-sixth of the entire length of the spicule. There are no true flesh or dermal spicules. Gemmule spicules (are) of various types ranging between stout, cylindrical, strongly spined amphistrongyli; long, slender amphistrongyli; and slender, smooth or sparsely spined amphioxi. The first mentioned cover the foraminal side of the gemmules and the others are associated with the other side which is next to the substratum. Gemmules are

abundant and form a pavement layer on the substratum and are surrounded and bound together into a firm crust by a cellular pneumatic layer which is closely crowded with spicules of which the majority are of the short, stout amphistrongylous type."

The gemmoscleres (gemmule spicules) and the arrangement of the gemmules described by Smith (1918) are indistinguishable from those of Eunapius fragilis (Leidy), a common cosmopolitan species. Similarly, the megascleres (skeleton spicules) match those of Ephydatia muelleri (Lieberkuhn), another widely distributed species (Penney and Racek 1968).

None of the specimens provided by F.W. Harrison contained the combination of features described by Smith (1918), but instead were identifiable as pure examples of Eunapius fragilis, Spongilla lacustris (Linnaeus), Ephydatia muelleri, and Trochospongilla horrida Weltner; these specimens are presently in the collection of the Redpath Museum, McGill University. On the basis of this material, we were unable to verify Harrison and Harrison's (1979) claim that S. heterosclerifera is a taxonomically valid species.

A detailed survey of the holotype rock revealed eighteen individual sponge patches. These consisted of nine patches of Eunapius fragilis gemmule pavement (Fig.1), with a few megascleres (smooth amphioxea) enclosed in the spongin matrix, and nine patches of Ephydatia muelleri, three of which contained gemmules (Fig.2); these had the birotulate gemmoscleres typical of the species (Fig.3). Included among the gemmoscleres of E. fragilis are the transitional gemmosclere/megasclere spicules (amphioxea intermediate in length between the two spicule classes and bearing only a few short spines near the tips) commonly found in specimens from northeastern North America (Smith 1990; Ricciardi and Reiswig, personal observation). These were considered by Smith (1918, p.240) to be a characteristic distinguishing S.

heterosclerifera from E. fragilis. Most of the sponge patches on the holotype rock are separate, but in one location a vegetative Ephydatia muelleri patch is confluent with a Eunapius fragilis gemmule pavement layer (Fig.1). Several of these patches may have once been confluent, or even overgrowing one another, but after sampling and abrasion have become relatively distinct entities. Two of the five original holotype slides contain gemmule fragments and birotulate spicules typical of Ephydatia muelleri (Fig.4). The remaining slides contain Eunapius fragilis gemmule fragments, including gemmoscleres, mixed with spinous megascleres indistinguishable from those of Ephydatia muelleri.

We conclude that there is absolutely no material or evidence to support the distinct species status of Spongilla heterosclerifera; it is clearly an erroneous interpretation of a mixture of two common species, Ephydatia muelleri and Eunapius fragilis. It must therefore be considered a junior synonym, in part, of both of the valid names of its components. Its inclusion in the IUCN Invertebrate Red Data Book and in the U.S. List of Endangered and Threatened Wildlife is thus no longer justified.

There are several examples in the taxonomic literature of erroneous interpretations of sponge mixtures. Spongilla discoides Penney, known from only a single specimen, was shown by Penney and Racek (1968) to be a mixture of Anheteromeyenia ryderi (Potts) and adventitious spicules of Corvomeyenia everetti (Mills). A specimen reported from Louisiana as Spongilla (Eunapius) fragilis by Moore (1953), and listed as a new state record, was later found to be a colony of Ephydatia fluviatilis (Linnaeus) growing over gemmules of Spongilla lacustris (Poirrier 1969). Smith (1976) described a stratified sponge mixture from a museum specimen in which A. ryderi formed a colony overgrowing E. fragilis, with gemmules of both species abundant in a common basal layer. In our collections, we have encountered species mixtures

resulting from both confluent and epizoic growth, including the following combinations: S. lacustris X E. fragilis (gemmule pavement), S. lacustris X A. ryderi, a tripartite combination of S. lacustris X Eunapius fragilis X Ephydatia muelleri, and several Ephydatia muelleri X Eunapius fragilis (e.g., Redpath Museum specimens RMI-3464 and RMI-3478). These particular species have overlapping environmental tolerances and are often found in the same habitat (Ricciardi and Reiswig, personal observation), therefore their combinations may simply be chance occurrences; it is not known whether they demonstrate an affinity for forming confluent colonies or stratified mixtures. The gemmule pavement exposed after the deterioration of colonies of Eunapius fragilis, for example, may often serve as a substrate for colonization by other species. These examples illustrate the importance in recognizing the possibility of species mixing when identifying freshwater sponge taxa.

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References cited

FROST, T.H. 1991. Porifera. In Ecology and classification of North American freshwater invertebrates. Edited by J.H. Thorp and A.P. Covich. pp.95-124.

HARRISON, F.W. 1974. Sponges (Porifera: Spongillidae). In Pollution ecology of freshwater invertebrates. Edited by C.W. Hart and S. Fuller. Academic Press, N.Y. pp. 29-66.

HARRISON, F.W. and HARRISON, M.B. 1979. The taxonomic and ecological status of the environmentally restricted spongillid species of North America. IV. Spongilla heterosclerifera Smith 1918. Hydrobiol. 62: 107-111.

JEWELL, M.E. 1959. Porifera. In Fresh-water biology, 2nd ed. Edited by W.T. Edmondson. J. Wiley and Sons, N.Y. pp. 298-312.

MOORE, W.G. 1953. Louisiana fresh-water sponges, with ecological observations on certain sponges of the New Orleans area. Trans. Amer. Microsc. Soc. 72: 24-32.

PENNAK, R.W. 1953. Porifera. In Fresh-water invertebrates of the United States. Ronald Press Co. New York. pp. 77-97.

PENNEY, J.T. 1960. Distribution and bibliography (1892-1957) of the freshwater sponges (Porifera: Spongillidae). Univ. So. Carolina Publ. Ser. III. Biol. 3: 1-97.

PENNEY, J.T. and RACEK, A.A. 1968. Comprehensive revision of a worldwide collection of freshwater sponges (Porifera: Spongillidae). U.S. Nat. Mus. Bull. 272: 1-84.

POIRRIER, M.A. 1969. Louisiana fresh-water sponges: taxonomy, ecology and distribution. Ph.D. Dissertation. Louisiana State University. New Orleans, Louisiana. Univ. Microfilms No. 70-9083.

SMITH, D.G. 1976. An intergeneric fresh-water sponge mixture (Demospongiae: Spongillidae). Trans. Amer. Microsc. Soc. 95: 235-236.

SMITH, D.G. 1990. Keys to the freshwater macroinvertebrates of Massachusetts. No.5. Porifera Spongillidae. Mass. Dept. Env. Qual. Eng., Div. Wat. Poll. Contr. Westborough, Mass. 49p.

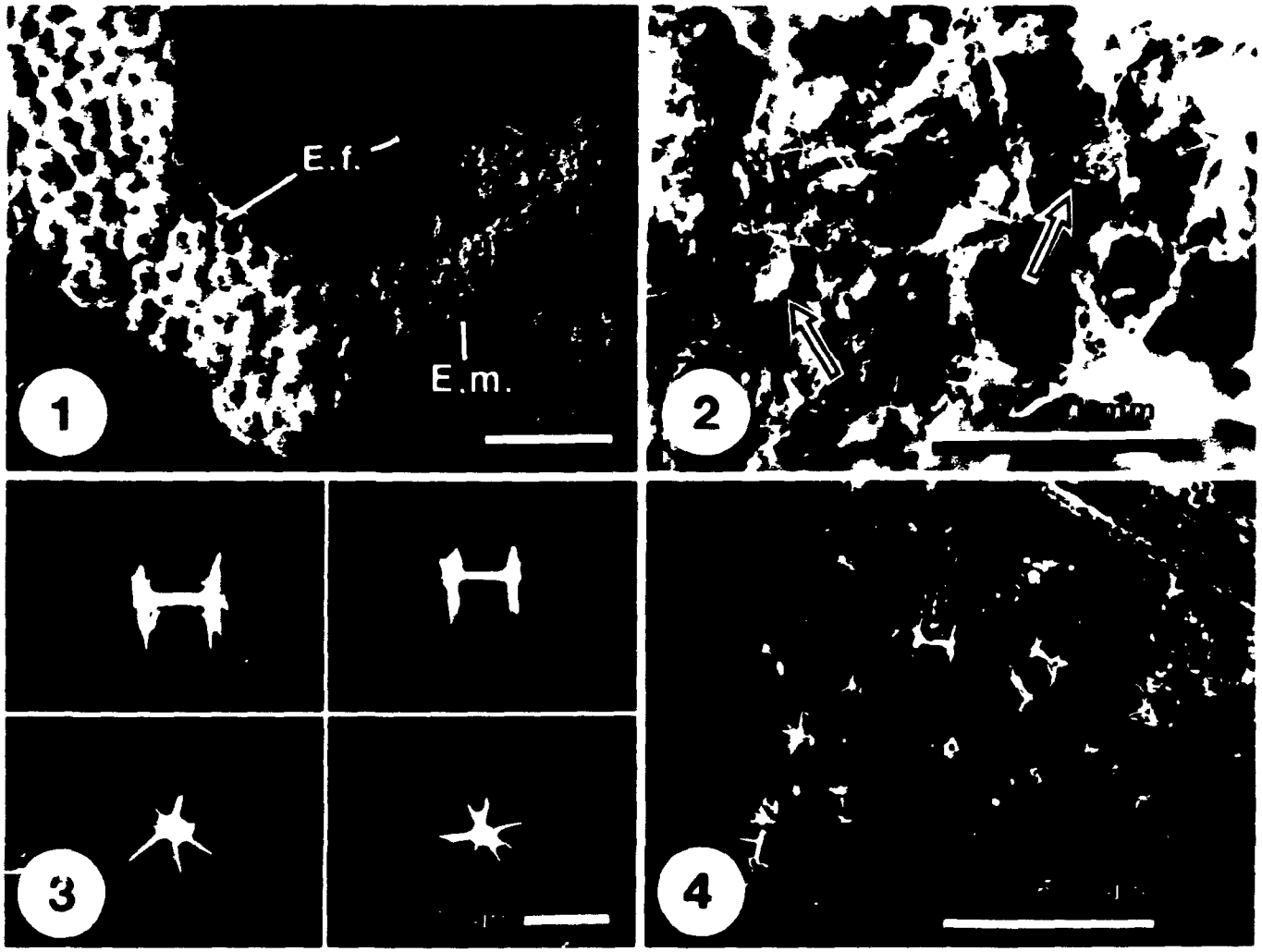
SMITH, F. 1918. A new species of Spongilla from Oneida Lake, New York. Cornell Univ., N.Y. State College of Forestry Appl. Technol. Publ. 9: 239-243.

U.S. Fish and Wildlife Service. 1989. Sponges (Porifera). Federal Register 54: 564.

WELLS, S.M. 1983. Porifera. In The IUCN Invertebrate Red Data Book. Edited by S.M. Wells, R.M. Pyle and N.M. Collins. IUCN, Gland, Switzerland. pp. 9-19.

WURTZ, C.B. 1950. Fresh-water sponges from Pennsylvania and adjacent states. Not. Natur. Acad. Natur. Sci. Phil. 228: 1-10.

FIGURES 1-4. Components of the holotype specimen of "Spongilla heterosclerifera" (USNM 9190). **Fig. 1.** Patches of Eunapius fragilis gemmule pavement (E.f.) confluent with a colony of Ephydatia muelleri (E.m.). **Fig. 2.** Gemmules of Ephydatia muelleri (arrows) embedded in the sponge colony. **Fig. 3.** Gemmoscleres from the Ephydatia muelleri gemmules (transverse and axial views). **Fig. 4.** An Ephydatia muelleri gemmule fragment with gemmoscleres (from one of the original holotype slides).


E.f.
E.m.
1
2
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4

CONNECTING STATEMENT

In Chapter III, species mixtures were shown to be potential sources of error in the identification of freshwater sponge taxa. Spongilla heterosclerifera Smith, included in recent invertebrate checklists and taxonomic keys as a rare and endangered species, was shown to be an interspecific mixture of two common sponges.

Chapter IV presents the results of a survey of freshwater sponges occurring in Eastern Canada. In this chapter, the taxonomy, morphology, distribution, and ecology of Eastern Canadian species of freshwater sponges are examined.

CHAPTER IV

Taxonomy, distribution and ecology of the freshwater sponges (Porifera: Spongillidae) of Eastern Canada

Abstract

A recent survey of the freshwater sponges of Eastern Canada (from Ontario to Newfoundland) recorded 15 species in the region, representing 50% of the total number of species known from North America. The sponges Radiospongilla crateriformis, Spongilla aspinosa and Trochospongilla horrida are reported from Canada for the first time. Detailed notes on the taxonomy, morphology, distribution, and ecology of each Eastern Canadian species are given. Corvospongilla novaeterrae, a problematic species known only from the Maritime region, is examined in detail. Eunapius mackayi, which is widely distributed in Eastern Canada, is described. New limits of tolerance to pH, calcium and magnesium levels, and water temperature are established for several species. A taxonomic key to the freshwater sponges of Eastern Canada is presented.

Introduction

Freshwater sponges are colonial filter-feeding organisms found attached to submerged surfaces in almost every unpolluted lake or stream. They are often a dominant component of benthic communities, and may contribute significantly to nutrient cycling (Francis and Poirrier 1986; Frost 1978) and primary production (Frost 1978; Frost and Williamson 1980) in small aquatic habitats. However, they have received very little attention and are among the most poorly known faunal groups in Canada. This may be largely due to difficulties in species identification, and the lack of useful taxonomic and ecological information on species occurring in Canadian waters.

There are 29 described species of freshwater sponges in North America whose taxonomic status is generally accepted or has not been seriously questioned (Frost 1991; Harrison 1974; Jewell 1959; Penney and Racek 1968). It was expected that a diverse group of freshwater sponges would be found in Eastern Canada, due to the diversity and abundance of freshwater habitats and the wide range of ecological conditions in the region. To test this hypothesis, a large number of specimens were obtained from various parts of Ontario, Quebec, New Brunswick, Nova Scotia, and Newfoundland, representing a general survey of the spongillid fauna of Eastern Canada. This survey included a detailed examination of the morphology, taxonomy, distribution, and ecology of each identified species.

Materials and Methods

I collected specimens from May to November, 1989-1991, primarily from southern Quebec and eastern Ontario. During this period, additional specimens from these and other provinces were obtained from the collections of several museums and universities. The sources are listed below, and

abbreviations are given where applicable, for future reference to specimens from these collections:

Academy of Natural Sciences of Philadelphia (ANSP)

British Museum (BM)

Canadian Museum of Nature (formerly National Museum of Canada) (CMN; NMC)

Department of Entomology (Lac St-Louis collection), McGill University

New Brunswick Museum (NBM)

Nova Scotia Museum (NSM)

Redpath Museum, McGill University (RMI; HMR)

Royal Ontario Museum (ROM)

United States National Museum of Natural History (USNM)

Specimens in my own collection have been given the prefix "AR". In total, over 1300 specimens from Eastern Canada were examined. I measured water quality of most habitats in Quebec and Ontario; temperature and pH were measured on site, using a Fisher mercury thermometer and a Cole-Parmer digital pH meter (model 05941-20), respectively. Water samples were transported back to a lab or field station to measure calcium and magnesium hardness (as $CaCO_3$ and $MgCO_3$, respectively), using a chemical test kit (LaMotte Chemical Products Co.). Water quality data from New Brunswick were obtained from D.F. McAlpine (New Brunswick Museum). Water quality data from Nova Scotia were obtained from J. Kerekes (Canadian Wildlife Service, Atlantic Region), and from published studies (Freedman et al. 1989; Kerekes et al. 1978).

Freshwater sponge taxonomy is based on the morphology and arrangement of spicules (siliceous, needlelike structures which comprise the mineral skeleton) and gemmules (resistant resting bodies). Spicules are divided into three general classes: (1) large spicules which make up the main skeleton

(megascleres), (2) smaller spicules which support certain tissues (microscleres), and (3) spicules which surround the gemmule and form part of its resistant coat (gemmoscleres). In this study, spicule preparations for sponge identification were obtained as follows: temporary preparations (for rapid or preliminary identification) were made by heating a mixture of sponge spicules and bleach ($HClO_4$) on a microscope slide. Permanent spicule preparations were made using the membrane filter technique described by Reiswig and Browman (1987); these preparations were used for spicule measurements. Spicule and gemmule measurements were made using a Numonics 2200 digitizing tablet and SigmaScan (version 3.92, Jandel Scientific) software.

Results and Discussion

In total, 15 species of freshwater sponges were collected from various regions in Eastern Canada (Table 1; Table 2). These species comprise 52% of the total number of described species in North America, demonstrating that freshwater sponges are a well represented and much more diverse group in Eastern Canada than previous records would indicate. Further collection would very likely add to this list of species since there are large areas of Eastern Canada whose aquatic invertebrate fauna have been poorly investigated.

Table 1. Classification of freshwater sponges occurring in Eastern Canada

Phylum Porifera
Class Demospongiae
Order Haplosclerida
Family Spongillidae

1 Anheteromeyenia argyrosperma (Potts 1880)
2 Anheteromeyenia ryderi (Potts 1882)
3 Corvomeyenia everetti (Mills 1884)
4 Corvospongilla novaeterrae (Potts 1886)
5 Ephydatia fluviatilis (Linnaeus 1758)
6 Ephydatia muelleri (Lieberkuhn 1856)
7 Eunapius fragilis (Leidy 1851)
8 Eunapius mackayi (Carter 1885)
9 Heteromeyenia baileyi (Bowerbank 1863)
10 Heteromeyenia tubisperma (Potts 1881)
11 Radiospongilla crateriformis (Potts 1882)
12 Spongilla aspinosa Potts 1880
13 Spongilla lacustris (Linnaeus 1758)
14 Trochospongilla horrida Weltner 1893
15 Trochospongilla pennsylvanica (Potts 1882)

Table 2. Distribution of Eastern Canadian freshwater sponges*

	Species codes														
Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Ontario	*					*	*			*			*		*
Quebec	*	*	*		*	*	*	*	*	*	*		*	*	*
New Brunswick	*	*				*	*	*	*				*		*
Nova Scotia	*	*	*	*		*	*	*	*			*	*		*
Newfoundland		*	*	*		*	*	*					*		*

(* Species codes refer to numbered species in Table 1.)

A full description of each species, including notes on taxonomy, ecology, and distribution in Eastern Canada are presented below. A key to Eastern Canadian species follows afterward. Figures are provided; in some

cases, individual figures may apply to two or more species which share the same illustrated character. Synonyms given for each species generally follow Penney and Racek (1968), and are limited to those published for Eastern Canada. Water quality data is provided for active (vegetative) colonies, rather than the more resistant gemmule phase, since active colonies are more sensitive to environmental change (Harrison 1977).

Anheteromeyenia argyrosperma (Potts 1880)

Pl.I, Figs.5-6; Pl.IV, Fig.4

Heteromeyenia argyrosperma Mackay 1886b, 1889; Gee 1937

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), flat, with a generally smooth surface. Megascleres slender amphioxea, sparsely covered with procurved spines; megasclere length=250-(284)-304 μm (50 counts, std. dev.=16), width=10-(12)-15 μm (50 counts, std. dev.=0.5). Microscleres absent.

Gemmules yellow, spherical; diameter=558-(649)-686 (20 counts, std. dev.=39.2); foramen simple. Gemmoscleres birotulates of two length groups, similar in shape and somewhat transitional; rotules consist of a few long, strongly recurved rays; shaft bears recurved spines. Shorter birotulates are more abundant, shaft densely spined; length=65-(81)-89 μm. Larger birotulates are less abundant, shaft sparsely spined; length=114-(130)-160 μm.

Taxonomy

In many specimens, the two size classes of gemmoscleres are so intergrading that it is impossible to distinguish them. However, the large gemmosclere length range (65-160 μm) is characteristic of the species.

Habitat and general ecology

Anheteromeyenia argyrosperma is found in both lentic and lotic habitats, typically in slightly acidic waters of low to moderate alkalinity and high conductivity (Harrison 1974; Poirrier 1969). Colonies are found on upper (exposed) and lower surfaces of various substrates with an apparent preference for wood substrates. The species is generally uncommon in Eastern Canada, but may be locally abundant in certain habitats, and occurs in the following range of water quality conditions: temperature=9-23°C, pH=6.8-7.4, calcium=20-40 mg/L, magnesium=22-50 mg/L. Small green colonies with gemmules were found epiphytic on Fontinalis sp. in a water temperature of 9°C, at Lac Magnan (north of Montreal, Quebec); this is the lowest recorded temperature at which A. argyrosperma has been collected (Harrison 1974).

Distribution in Eastern Canada

Ontario (Gee 1937), Quebec (Gee 1937), New Brunswick, Nova Scotia (Mackay 1886b, 1889).

Anheteromeyenia argyrosperma is recorded from New Brunswick from a specimen (NBM, uncatalogued) collected at Beaver Lake, Gloucester Co., N.B. (47°33'N, 66°11'W) on 11 July 1991.

Anheteromeyenia ryderi (Potts 1882)

Pl.I, Figs.5-6; Pl.IV, Figs.5-7

Heteromeyenia ryderi Mackay 1886b, 1889; Smith 1930; Gee 1937

Heteromeyenia pictouensis Potts 1885, Mackay 1886b, 1889; Smith 1930

Heteromeyenia macouni Mackay 1900; Gee 1931

Description of Eastern Canadian specimens

Sponge green (due to the presence of symbiotic algae), brown or white,

forming small hemispherical colonies in running water, and massive, irregular, ramose or papillate colonies in calm, standing water. Megascleres are highly variable; in the typical ryderi form, megascleres are slender amphioxea sparsely covered with short, procurved spines except at the tips; in the pictouensis form, megascleres are short, robust amphistrongyla, densely covered to the tips with recurved spines; in the macouni form, megascleres are extremely thin amphioxea, sparsely covered with minute procurved spines, except at the tips. Intergrading types of all three of these forms may be found. Overall, the range of megasclere length is from 141 to 279 μm, and width is from 1 to 21 μm. In the typical form, megasclere length=194-(220)-253 (30 counts, std. dev.=14.8), width=7-(11)-14 (30 counts, std. dev.=1.7). Microscleres are absent.

Gemmules yellow, roughly spherical, usually not present in abundance; diameter=300-400 μm. Gemmoscleres birotulates of two distinct classes; gemmoscleres of the shorter class have umbonate disklike rotules with serrated margins, the shaft is either smooth, or bears 1-3 spines; length of the shorter class= 28-(34)-41 μm (20 counts, std. dev.=2.7), shaft width= 3-(4)-5 μm (20 counts, std. dev.=0.5), rotule diameter=20-(23)-28 μm (30 counts, std. dev.=2); gemmoscleres of the longer class have rotules composed of recurved rays, the shaft may bear several recurved spines; length of the longer class=46-(56)-64 μm (20 counts, std.dev.=6), shaft width=4-(7)-8.5 μm (20 counts, std.dev.=1.1), rotule diameter=17 (21)-23 μm (20 counts, std.dev.=1.7).

Taxonomy

The pictouensis form of this species was originally considered to be a distinct species, Heteromeyenia pictouensis Potts, but differed from the typical form of ryderi only in the robustness and dense spination of its

megascleres. The great variation of A. ryderi's megascleres is apparently ecomorphic (Okland and Okland 1989, Poirrier 1977), and pictouensis is only one of many ecological variants of the species.

An unusual ecomorph of A. ryderi, the macouni form (formerly Hetermeyenia macouni Mackay), deserves special mention. It is found on Sable Island, a crescentic sandy shoal in the Atlantic Ocean (44°N 60°W), 160 Km southeast of Nova Scotia. The island is about 35 Km long and less than 2 Km wide, and holds several brackish and freshwater ponds which regularly receive inputs of saltwater carried from the sea by rain (Wright 1989). Heteromeyenia macouni was described by Mackay (1900), and relegated to a synonym of Anheteromeyenia (Heteromeyenia) ryderi by Gee (1931). In the type specimen of H. macouni (NSM 899-Z-2-1), the megascleres are long, very thin, and microspined; length=141-(176)-242 μm (50 counts, std.dev.=21.4), width=1-(2)-7 μm (50 counts, std.dev.=1.5). The birotulates are similar in shape. The shorter birotulates have generally smooth, slender shafts, and deeply incised, umbonate rotules; length=22-(25)-28 μm (50 counts, std.dev.=1.5), shaft width=1-(1.5)-2 μm (50 counts, std.dev.=0.4), rotule diameter=8.5-(14)-18.5 (50 counts, std.dev.=2.3); the longer birotulates have smooth, slender shafts, and umbonate rotules composed of 3-5 rays with recurved tips; length=35-(46)-55 μm (50 counts, std.dev.=3.9), shaft width=1-(2)-4 μm (50 counts, std.dev.=0.6), rotule diameter=9-(12)-15 μm (50 counts, std.dev.-2). Gemmules are large, spherical, orange or brown, ranging from 400 to 800 μm in diameter.

Gee (1931) synonymized H. macouni with A. ryderi var. baleni, a variety characterized by its thin spicules. Comparing the type specimen of baleni (ANSP 4766) with that of macouni shows that spicules of the baleni variety (megasclere width=2-[5]-8 μm, gemmosclere width=2-[3]-6 μm) are generally not as thin those of macouni. The macouni and pictouensis forms

represent the two extremes in a continuous series of morphological types of A. ryderi.

Habitat and general ecology

The macouni form of A. ryderi is known to occur in two of the 13 ponds on Sable Island: Lily Pond (NSM 899-Z-2-1; NSM 953-Z-1-1; NMC 1900-0491), and Pond #3 (Wright 1989), south of the Met station. Both ponds have the lowest conductivity (ranging from 124 to 245 μmho/cm) among ponds whose conductivities are as high as 39,000 μmho/cm (J. Kerekes, unpublished data). The following water quality conditions have been recorded for the two ponds:

Lily Pond: temperature=14-17°C, pH=5.5-6.0, conductivity=168-200 μmho/cm, total phosphorus=28.9-35.6 mg P/m^3, chlorophyll [a]=1.6-5.1 mg/m^3.

Pond #3: temperature=18-19°C, pH=6.0-6.6, conductivity=124-245 μmho/cm, total phosphorus=27.6-33.8 mg P/m^3, chlorophyll [a]=1.3-1.4 mg/m^3.

I have also identified specimens of A. ryderi macouni from Yudle Cove Pond, Terra Nova National Park, Newfoundland (CMN slides #62, #65 and #66). Okland and Okland (1989) collected specimens of A. ryderi, from lakes on the western coast of Norway, which had slender spicules apparently identical to those of the macouni form. The common feature of all of the habitats in which A. ryderi macouni occurs is that they receive significant atmospheric inputs of sea salts in the form of aerosols. The occurrence of this ecomorphic form of A. ryderi in coastal lakes might therefore be attributable to the influence of sea spray.

In general, Anheteromeyenia ryderi is known to occur in the following range of water quality conditions in Eastern Canada: temperature=12-24°C, pH=4.8-8.9, calcium=0.5-9.0 mg/L, magnesium=0.3-2.0 mg/L, conductivity=31-245 μmho/cm.

Distribution in Eastern Canada

Quebec (Gee 1937), New Brunswick (Smith 1930), Nova Scotia (Mackay 1886b, 1889, 1900), Newfoundland (Smith 1930).

This species is distributed throughout eastern North America (Penney and Racek 1968), and is particularly common in Eastern Canada. It likely occurs on Prince Edward Island.

Corvomeyenia everetti (Mills 1884)

Pl.III, Fig.3: Pl.IV, Fig.10

Meyenia everetti Mackay 1885, 1886a, 1886b, 1889

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae) or brown, with a distinctly hispid surface, and growing as a flat encrustation often with several long, thin, projecting branches (about 2 mm in diameter). Megascleres slender amphioxea, usually entirely smooth but some may bear a few small spines; megasclere length=143-(218)-260 μm (100 counts, std.dev.=21.1), width=3.5-(8)-14 μm (100 counts, std.dev.=3). Microscleres small birotulates, shaft normally smooth, rotules dome-shaped and composed of 3-6 recurved spines; microsclere length=14-(18)-26 μm (100 counts, std.dev.=2.5), shaft width=1-(2)-3.5 μm (100 counts, std.dev.=0.5), rotule diameter=3.5-(5)-7 μm (100 counts, std.dev.-0.5).

Gemmules large (diameter=710-[800]-902 μm, 14 counts, std.dev.=66), and not very abundant. Gemmoscleres are birotulates of variable lengths (33-[59]-78 μm, 50 counts, std.dev.=10), with a smooth, slender shaft (width=3-[4]-6 μm, 50 counts, std.dev.=1); rotules distinctly umbonate, consisting of several recurved spines; rotule diameter=10-(20)-26 μm (50 counts, std.dev.=3). Like most birotulates, the gemmoscleres are arranged

radially in a single layer in the gemmule crust.

Taxonomy

Volkmer-Ribeiro (1986) erected a new freshwater sponge family, the Metaniidae (order Poecilosclerida), and placed C. everetti into this family, based on a hypothesized phylogenetic relationship between the genus Corvomeyenia and a marine poeciloscerid genus. However, until more substantial evidence is presented to support this relationship, C. everetti should be maintained in the family Spongillidae.

The spicular components of Corvomeyenia everetti (excluding gemmoscleres) are very similar to those of Corvospongilla novaeterrae, a problematic species which may actually be an ecomorphic variant of Corvomeyenia everetti. While Corvomeyenia everetti is found as far west as the Quebec-Ontario border, Corvospongilla novaeterrae is known only from a few coastal localities in Newfoundland and Nova Scotia, and is probably confined to the Maritime region. The distinct birotulate gemmoscleres of Corvomeyenia everetti, with their well-defined rotules and smooth, slender shafts, clearly differentiate the species from Corvospongilla novaeterrae. Even in the absence of gemmules, gemmoscleres are sometimes present in the tissues of Corvomeyenia everetti and Corvospongilla novaeterrae, and specimens may be distinguished in such instances.

Habitat and general ecology

Corvomeyenia everetti is limited to moderately acidic (pH=5.0-6.6), lentic habitats, with transparent waters low in calcium (0-4mg/L) and magnesium (0-3 mg/L) (Harrison 1974; Jewell 1935). Aquatic plants and woody debris are apparently the preferred substrates. It is often found associated with two other acidophilic sponges, Eunapius mackayi and Trochospongilla

pennsylvanica.

Distribution in Eastern Canada

Quebec, Nova Scotia (Mackay 1885, 1886a, 1886b, 1889), Newfoundland.

Specimens from Quebec were obtained from Petit Lac Long near Ste-Agathe-des-Monts (HMR 84-8-5.2), Lac Bourgeois near La Tuque (ROM B-18), and Lac Welly in Parc Mastigouche (AR459S); these represent the only known collections of the species from the province. In Newfoundland, C. everetti is known from White Point Pond, Terra Nova National Park (NMC1900-0489).

Corvospongilla novaeterrae (Potts 1886)

Pl.III, Fig.3; Pl.IV, Fig.11

Spongilla novaeterrae Potts 1886; Mackay 1889; Traxler 1898; Annandale 1911; Ord and Cameron 1950; Penney and Racek 1968

Ephydatia novaeterrae Weltner 1895

Corvospongilla novaeterrae Jewell 1952; Volkmer-Ribeiro and Traveset 1987

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), thin, encrusting; slender branches may project from the surface. Megascleres relatively scarce, generally smooth amphioxea, commonly with some canal erosion; a few sparsely spined forms, and forms transitional with gemmoscleres, are usually present; megasclere length=112-(154)-170 μm (130 counts, std.dev.=14.5), width=4-(8)-13 μm (130 counts, std.dev.=2.5). Microscleres abundant, minute birotulates of variable size; rotules dome-shaped and composed of 3-6 spines; shafts generally smooth; microsclere length=13-(21)-32 μm (130 counts, std.dev.=5.5), shaft width=1-(2)-3.5 (70 counts, std.dev.=3.5).

Gemmules spherical, large, free in the skeleton or attached to the

substrate; gemmule diameter=820-(1083)-1418 μm (65 counts, std.dev.= 129); pneumatic layer very thin, almost completely absent; foramen simple; 3-8 foraminal pores are found on each gemmule (on average, 6 per gemmule). Gemmoscleres highly variable, abundant, short, robust amphistrongyla or amphioxea, bearing a variable number of large recurved spines which tend to aggregate near the ends of the shaft, occasionally giving the spicule a birotulate appearance; gemmosclere length=21-(39)-63 μm (130 counts, std.dev.=8.0), shaft width (excluding spines)=3-(6)-9 μm (120 counts, std.dev.=4.2); gemmoscleres are generally arranged tangentially in the gemmule crust, although several of the more "birotulate" forms are found projecting radially from the surface.

Taxonomy

Corvospongilla novaeterrae is remarkably similar to Corvomeyenia everetti in that (1) they have nearly identical growth forms; (2) they have similar birotulate microscleres; (3) the megascleres of both species are smooth or microspined amphioxea, with overlapping size ranges; (4) the gemmules of both species are large (mean diameter > 1000 μm) and spherical, with simple foramina.

However, the two species differ in the following ways: (1) the gemmoscleres of Corvospongilla novaeterrae are generally short, robust rod-shaped spicules, often heavily spined, while those of Corvomeyenia everetti are elongate birotulates with smooth, slender shafts; (2) the pneumatic layer is well-developed in the everetti gemmule, but is extremely reduced in the novaeterrae gemmule; (3) their distributions overlap in parts of the Maritime region (Nova Scotia and Newfoundland), but the distribution of novaeterrae is apparently restricted to this region, while everetti is distributed over northeastern North America as far inland as Wisconsin

(Jewell 1935, 1939).

On the basis of its birotulate microscleres, tangentially arranged rod-shaped gemmoscleres, and large gemmules with reduced pneumatic layer, Spongilla novaeterrae Potts is assignable to the genus Corvospongilla Annandale, a taxonomic interpretation made by Jewell (1959) and later reinforced by Volmer-Ribeiro and Traveset (1987). However, both Annandale (1911) and Weltner (1895) maintained that the gemmoscleres of S. novaeterrae were simply malformed birotulates. The highly variable gemmoscleres are clearly the most problematic character of C. novaeterrae. The distal aggregation of spines on the spicule and the tendency for the more "birotulate" gemmoscleres to assume radial positions in the gemmule crust indicates their intermediate character between rod-shaped and birotulate forms. There is a similarity between the gemmoscleres of C. novaeterrae and malformed birotulates of Ephydatia muelleri or Anheteromeyenia ryderi, which leads to the possibility that novaeterrae may simply be an aberrant form of Corvomeyenia everetti. Traxler (1898) and Penney and Racek (1968) considered Corvospongilla novaeterrae to be a sexual hybrid of Corvomeyenia everetti and some other genus. Most authors follow Penney and Racek (1968) and omit C. novaeterrae from their taxonomic keys. Traxler (1898) and Penney and Racek (1968) had based their interpretation on Potts' type material: a presumably syntypic group of specimens on 7 stones (ANSP 4521, 4522, 4545-4549) and 2 accompanying slides. Upon examining this material, I have found it mixed with specimens clearly identifiable as Eunapius mackayi. ANSP specimens 4545, 4546, 4547, and 4549, which are all part of Potts' collection from the type locality in Newfoundland and considered paralectotypes (Volkmer-Ribeiro and Traveset 1987), are comprised almost exclusively of E. mackayi spicules and a few gemmules. Valid specimens of C. novaeterrae (ANSP 4521, 4522, and 4528) were often mixed with E. mackayi,

both species usually encrusting the same stone. The lectotype (ANSP 4521) designated by Volkmer-Ribeiro and Traveset (1987) is the specimen the least contaminated with E. mackayi spicules. Potts (1886) apparently recognized these foreign spicules in his type material and therefore did not include them in his illustration of novaeterrae. I have recently identified a pure specimen of C. novaeterrae from Warren Lake, Nova Scotia (NSM 1976-Z-324-1), which has no spicules resembling those of E. mackayi, and closely fits Potts' (1886) original description.

The assumption of sexual hybridization is based on an erroneous interpretation of the spicule mixture and C. novaeterrae's unusual gemmoscleres. Such a hybridization would presumably have intermediate characteristics of both parent species, but the characteristics of the Warren Lake specimen cannot be confidently assigned to any other North American species. Furthermore, hybridization should be equally likely to occur throughout the overlapping range of both parent species. While C. everetti, E. mackayi, and most other species have relatively extensive ranges in eastern North America, Corvospongilla novaeterrae is known only from coastal regions of Nova Scotia and Newfoundland. Therefore, there remain only two acceptable hypotheses concerning the status of C. novaeterrae: (1) it is a valid species of Corvospongilla; (2) it is an ecomorphic form of Corvomeyenia everetti.

The large gemmules with simple foramina and a weakly developed pneumatic layer, the size and shape of the birotulate microscleres, and the predominantly rod-shaped gemmoscleres are characteristics shared by most Corvospongilla species. Highly variable gemmoscleres, including some obviously tending toward birotulate form, are found in two South American species whose taxonomic status has not been challenged: Corvospongilla seckti and C. volkmeri (Rosa-Barbosa 1988); both of these species differ

from C. novaeterrae primarily by their densely spined amphistrongyle megascleres. If the taxonomic validity of Corvospongilla novaeterrae depends solely on the interpretation of its highly variable gemmoscleres, then the acceptance of Corvospongilla seckti and C. volkmeri support the validity of C. novaeterrae and its inclusion in the genus Corvospongilla. In each of these species (as well as in certain other genera, e.g., Radiospongilla; Pectispongilla) the gemmoscleres may be natural evolutionary intermediates between amphioxea and birotulates.

Conversely, the irregular gemmoscleres of C. novaeterrae may simply be ecomorphic. The loss of birotulate form may be associated with the reduction of the gemmule pneumatic layer, which in turn may be an ecophenotypic response to a particular environmental factor. Given that each of the sites at which C. novaeterrae has been collected is located very close to the ocean (Warren Lake, for example, is less than 3 Km from the coast), this factor might be salinity. The same aerosol influence that is the likely cause of the macouni ecomorph of A. ryderi could conceivably result in a highly aberrant form of C. everetti.

The status of Corvospongilla novaeterrae can only be fully resolved by the rearing of living colonies under different water quality conditions. Until such a conclusive examination is made, it seems best to maintain C. novaeterrae as a distinct species.

Habitat and general ecology

Corvospongilla novaeterrae has been collected from clear, shallow water in lakes located along coastal regions, and was found in the following water quality conditions at Warren Lake (Kerekes et al. 1978): pH=5.2-6.3, conductivity=26-37 μmho/cm, color=30-70 Hazen units, turbidity= 0.1-0.2 APHA, phosphorus=3.5-9.6 mg/m^3, chlorophyll [a]=0.3-2.1 mg/m^3.

Distribution in Eastern Canada

Nova Scotia, Newfoundland.

In Nova Scotia, C. novaeterrae occurs in Bluff Lake and Eagle Lake, Halifax Co. (Ord and Cameron 1950), and in Warren Lake, Cape Breton Highlands National Park. In Newfoundland, it was collected at Heart's Content, Trinity Bay (approx. 48°N) (Potts 1886). It may occur in lakes near the coastal areas of Prince Edward Island and New Brunswick.

Ephydatia fluviatilis (Linnaeus 1758)

Pl.IV, Fig.1

Ephydatia fluviatilis Smith 1921, Gee 1937

Description of Eastern Canadian specimens

Megascleres amphioxea, generally smooth, a few may be microspined; megasclere length=253-(316)-355 μm (50 counts, std.dev=2.0), width=9-(14)-17 μm (50 counts, std.dev.=2.0). Microscleres absent.

Gemmules abundant, spherical, normally 400 to 600 μm in diameter. Gemmoscleres birotulates of one type; rotules disklike, not deeply incised, margins serrated with numerous (often more than 20) teeth; shaft smooth, or bearing 1-4 large spines; gemmosclere length always greater than rotule diameter; gemmosclere length=21-(23)-25 μm (32 counts, std.dev.=1.2), width (at center)=2-(3)-4 μm (32 counts, std.dev.=0.5); rotule diameter=13-(19)-24 μm (32 counts, std.dev.=2.5).

Taxonomy

This species has historically been confused with its congener, Ephydatia muelleri (Lieberkuhn), since original descriptions treated both forms as the same species. However, they may be consistently separated by

their gemmosclere morphology. The length of the gemmosclere is always greater than the rotule diameter in E. fluviatilis, and always less than or equal to the rotule diameter in E. muelleri. The rotules of E. muelleri are more deeply incised and composed of far fewer teeth (normally 12 or less) than those of E. fluviatilis. Although most North American keys have employed these characteristics to separate E. fluviatilis and E. muelleri since the early part of this century, the taxonomic confusion surrounding the two species has persisted for quite some time; this is particularly true for Canada where most species records were established before 1940. Gee (1937) could not find a single valid specimen of E. fluviatilis from collections of previous workers, despite numerous records of its occurrence. Ephydatia muelleri is far more common in northeastern North America than is E. fluviatilis; consequently, the majority of records referring to E. fluviatilis in Canada actually belong to E. muelleri.

Habitat and general ecology

Ephydatia fluviatilis is found in alkaline waters (Harrison 1974; Poirrier 1974), particularly waters rich in calcium (Francis et al. 1982). The single specimen (AR486S) that I have collected was found as a brown encrustation on the underside of a rock in a shallow, sluggish stream (temperature=17°C, pH=8.4, calcium=68 mg/L, magnesium=28 mg/L).

Ephydatia fluviatilis has been shown to be sensitive to low concentrations of heavy metals. Exposure to 0.001 mg/L of cadmium or mercury causes distinct gemmosclere malformations and may inhibit gemmule formation (Mysing-Gubala and Poirrier 1981). Copper and zinc are toxic to the sponge cells at micromolar concentrations (Francis and Harrison 1988).

Distribution in Eastern Canada

This species is rare in Eastern Canada, although apparently common in the western regions of Canada. Valid specimens of E. fluviatilis have been collected from Wabamum Lake, Alberta (NMC1900-0587B), and from a small pond near Minnedosa, Manitoba (ROM, uncatalogued). The only valid specimen obtained in Eastern Canada is from a tributary of the Chateauguay River near Huntington, Quebec (AR486S).

Ephydatia muelleri (Lieberkuhn 1856)

Pl.I, Fig.3; Pl.IV, Figs.2-3

Spongilla stagnalis Dawson 1878

Spongilla asperrima Dawson 1878

Meyenia fluviatilis Mackay 1889

Ephydatia muelleri Smith 1921, 1930; Gee 1937; Benfey and Reiswig 1982; Barbeau et al. 1989; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), brown or grey; surface irregular and papillose. Megascleres stout or slender amphioxea, usually densely covered with short conical spines, except near the tips; in rare cases, megascleres are entirely smooth; both smooth and variably spined forms are often present in the same specimen; megasclere length=171-(245)-311 μm (259 counts, std.dev.=26.4), width=5-(11)-23 μm (220 counts, std.dev.=3.7). Microscleres absent.

Gemmules yellow, spherical, abundant and scattered throughout the sponge, ranging from 300-400 μm in diameter. Gemmoscleres birotulates of one class; rotules flat, umbonate, deeply and irregularly incised into no more than 12 long rays; shaft normally smooth, rarely with 1 or 2 spines; gemmosclere length never greater than rotule diameter; malformations are

common, often resulting in a loss of birotulate form; gemmosclere length= 8-(17)-28 μm (250 counts, std.dev=3.8), shaft width=1-(4)-9 μm (137 counts, std.dev.=1.3), rotule diameter=8-(15)-27 μm (270 counts, std.dev.=3.5).

Taxonomy

As mentioned previously, E. muelleri is consistently separated from its congener E. fluviatilis by gemmosclere morphology. In E. muelleri, the length of the gemmosclere is never greater than the diameter of the rotules, and the margins of the rotules are deeply incised to form no more than 12 long rays; in E. fluviatilis, the length of the gemmosclere is always greater than the diameter of the rotules, and the rotule margin is usually weakly incised to form 13-20 or more short teeth. Eastern Canadian records of Ephydatia fluviatilis dated prior to 1930 are likely referring to E. muelleri.

Habitat and general ecology

Specimens of Ephydatia muelleri were collected from the following range of water quality conditions in Eastern Canada: temperature=9-24°C, pH=5.9-9.1, calcium=18-78 mg/L, magnesium=12-70 mg/L. Colonies were most often associated with the sponges Spongilla lacustris and Eunapius fragilis, and the bryozoans Cristatella mucedo and Pectinatella magnifica. Active green colonies were collected in 9°C at Lac Magnan (near Lachute, Quebec); this temperature represents a new tolerance limit for the vegetative phase of the species. Benfey and Reiswig (1982) found that the gemmules of E. muelleri were sensitive to decreases in pH, and that exposure to relatively low pH (5.8-6.5) resulted in reduced gemmule hatchability. Gemmules of this species may withstand long-term exposure to temperatures as low as -80°C without loss of hatchability (Barbeau et al. 1989).

Distribution in Eastern Canada

Ontario (Dawson 1878; Gee 1937), Quebec (Dawson 1878; Gee 1937; Benfey and Reiswig 1982; Barbeau et al. 1989; Ricciardi and Lewis 1991), New Brunswick, Nova Scotia (Mackay 1889), Newfoundland (Mackay 1889).

Ephydatia muelleri is one of the most widely distributed and frequently encountered sponges in Eastern Canada. It is common in subarctic lakes (approx. 55°N) near Schefferville, Quebec. Although previously unreported for New Brunswick, specimens of E. muelleri were collected from the Hammond and Miramichi Rivers (NBM, uncatalogued).

Eunapius fragilis (Leidy 1851)

Pl.I, Fig.1; Pl.IV, Figs.8-9

Spongilla ottawaensis Dawson 1878

Spongilla fragilis Mackay 1886b, 1889; Huntsman 1913; Smith 1930; Gee 1937

Eunapius fragilis Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), grey, or brown, normally forming thick hemispherical masses with conspicuously large pores. Megascleres smooth amphioxea, length=165-(189)-261 μm (150 counts, std.dev.=19.8), width=4-(10)-14 μm (150 counts, std.dev.=1.7). Microscleres absent.

Mature gemmules are enclosed in a common brown coat, forming a pavement layer cemented to the substrate, or individual clusters of 2-4; foramina extend through the coat as short tubes, always directed upward from the pavement layer, or outward from the cluster. Gemmoscleres are of one class, normally amphistrongyle, densely covered with spines which tend to be especially concentrated at the tips; length=32-(57)-121 μm (100 counts,

std.dev.=12.6), width=3-(5)-8 μm (100 counts, std.dev.=1.1); a small number of spicules transitional between gemmoscleres and megascleres (long, mostly smooth amphioxea, bearing a few spines at the tips) are usually present in the gemmule coat.

Taxonomy

This species is easily distinguished from its congener, Eunapius mackayi, which has spiny megascleres and hemispherical gemmule clusters in which the foramina are always directed inward or towards the substrate.

Habitat and general ecology

Eunapius fragilis occurs in both lentic and lotic habitats, often in great abundance, and is the most common sponge found in alkaline, calcium-rich habitats in Eastern Canada. Vegetative (active) colonies were collected from the following range of water quality conditions: temperature=9-26°C, pH=6.8-9.4, calcium=8-130 mg/L, magnesium=0.5-150 mg/L.

Eunapius fragilis often occurs with other sponges, Spongilla lacustris and Ephydatia muelleri, and bryozoans, Paludicella articulata and Pectinatella magnifica. In the St. Lawrence River (Quebec), it is associated with recently established populations of the zebra mussel, Dreissena polymorpha (Bivalvia: Dreissenidae); both of these filter-feeding organisms appear to have similar habitat preferences. Eunapius fragilis is also one of the most common epizoic organisms on unionid mussels. The shells of over 30% of living mussels, Elliptio complanata and Lampsilis radiata, collected from the north shore of Ile Perrot during the summer of 1991, were encrusted with colonies or gemmule pavement of E. fragilis. The sponge grows predominantly on the siphonal end of the mussel, where it benefits from the suspended food particles drawn toward it by the siphonal current. The growth may become so

luxuriant that it apparently interferes with the protrusion of the siphon. In muddy or sandy areas, the exposed siphonal end of mussel shells may offer the only firm substrate available for sponge colonization. Since a single mussel may live for several years, it could provide a substrate for several successive generations of a sponge which produces a gemmule pavement. It is not known whether sponge larvae preferentially colonize living mussels.

The life history strategy of Eunapius fragilis in Eastern Canada is based on the simultaneous hatching of the entire gemmule pavement at low temperature (4-5°C; Fell 1990), and subsequent rapid growth. This results in a large, confluent colony early in the year, and appears to be a successful strategy in the competition with other colonial organisms for substrate, especially on limited surfaces (e.g., on mussel shells). The gemmules exist solely for overwintering and conserving the substrate for a new colony early in the spring. Dispersal is accomplished primarily through the production of motile larvae.

Distribution in Eastern Canada

Ontario (Huntsman 1913; Gee 1937), Quebec (Dawson 1878; Gee 1937; Ricciardi and Lewis 1991), New Brunswick, Nova Scotia (Mackay 1886b, 1889, Smith 1930), Newfoundland (Mackay 1889).

Eunapius fragilis is one of the most common and widely distributed sponges in Eastern Canada. Its occurrence in New Brunswick is recorded here for the first time from specimens collected from the Hammond River and various lakes in Saint John, Gloucester, and Restigouche Counties (NBM, uncatalogued specimens). It likely occurs on Prince Edward Island.

Eunapius mackayi (Carter 1885)

Pl.II, Figs.1-4

Spongilla mackayi Carter 1885; Mackay 1885, 1886b, 1886c, 1889

Spongilla johansenı Smıth 1930

Spongılla ıgloviformıs Gee 1937

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae) or brown, thin, encrusting, with a slightly hıspıd surface. Megascleres relatively scarce, long, straight or slightly curved, spined amphioxea or amphistrongyla; spines procurved, more abundant and prominent near the tips of the spicule; megasclere length=177-(200)-302 μm (204 counts, std.dev.=23), width (excluding spines)=7-(12)-18 μm (204 counts, std.dev.=3), maximum spine length=1-(3.5)-7 μm (41 counts, std.dev.=1.2).

Gemmules occur near the substratum in compact hemispherical clusters of 7-20 or more, with the concavity oriented toward the substratum, and with foramina directed inward; in some cases, the cluster is a pavement layer, slightly concave against the substrate, with foramina directed downward. The gemmule cluster is enclosed by a common pneumatic coat and a dense, nestlike arrangement of spicules (gemmoscleres). Individual gemmules are green or yellow, subspherıcal, somewhat flattened around the region of the foramen; the foramen has a short flaring collar; gemmule diameter=263-(421)-841 μm (75 counts, std.dev.=73). Gemmoscleres are straight amphioxea or amphıstrongyla, densely spined; spines long, pointed, strongly recurved near the tips of the spicule, perpendicular near the center of the spicule; gemmosclere length=79-(156)-267 μm (287 counts, std.dev.=30), width (excluding spines)=2-(8)-20 μm (287 counts, std.dev.=1.2), maximum spine length=1-(4)-9 μm (287 counts, std.dev.=1.5); gemmoscleres tangentially

embedded in the pneumatic layer enclosing the gemmule cluster, but absent around the foramina.

Spicules identical to gemmoscleres are found in abundance in the sponge tissue, regardless of whether gemmules are present. They differ morphologically from the megascleres by their relatively short length, and dense covering of prominant, recurved spines, but these distinctions are sometimes complicated by the presence of intergrading forms. They differ functionally from the megascleres by their position and arrangement in the sponge tissue. Megascleres line the sponge canals and form weak fascicles, but are otherwise scarce. Spicules identical to gemmoscleres are abundantly distributed throughout the sponge tissue, except locally around the canals; they do not form fascicles, and are not more abundant in any particular region of the tissue except in the vicinity of gemmules. Therefore, they appear to have the functional roles of both microscleres and gemmoscleres.

Taxonomy

The multifunctional role of the tissue/gemmule spicules in Eunapius mackayi is not unique. The same situation occurs in the sponge Radiospongilla cerebellata (Bowerbank), where regular microscleres are put to use in the construction of the gemmule (Saller 1990c). Trochospongilla horrida has two classes of megascleres differing in size and function; the longer class composes the sponge skeleton, while spicules of the smaller class support the pinacoderm and are also embedded in the coat which binds the gemmules together in a pavement layer (Saller 1990a,b); however, the individual gemmule coats have their own birotulate gemmoscleres.

Based on their similar species descriptions, Poirrier (1969) asserted that Spongilla igloviformis (Potts 1887) and Spongilla mackayi (Carter 1885) are synonymous. I have examined the type specimens of S. igloviformis (ANSP

4523) and S. mackayi (BM 1890-1-9-279) and have found them to be almost identical in spicule morphology and in the form and arrangement of their gemmules; they are undoubtedly the same species. Since the earliest description of the species was provided by Carter (1885), the name Spongilla mackayi Carter is given priority. Penney and Racek (1968) assigned the species to the genus Eunapius, based on the rod-shaped gemmoscleres, the tendency for gemmules to form coherent groups, and the assumed absence of microscleres. The presence of two classes of tissue spicules warrants further examination of the systematic position of E. mackayi, and may result in the reassignment of this species to another genus.

The spicule morphology of E. mackayi appears to be highly ecomorphic. While the typical procurved and recurved spination of the megascleres and the microsclere-gemmoscleres is present in specimens collected from slightly acidic habitats, it is often indistinct in specimens from strongly acidic habitats (pH<=5.0), which are probably deficient in silica. These specimens have thin, poorly-developed spicules covered with minute, perpendicular spines which tend to be more abundant near the spicule tips. Nevertheless, although characteristic differences in spination may be lost, two size classes of spicules are usually discernible, and another feature which remains constant is the tendency for gemmules to form hemispherical clusters with inwardly-directed foramina.

Spongilla johanseni, a species described by Smith (1930) from a bog lake near Shippigan, New Brunswick, has the characteristics of E. mackayi collected from highly acidic habitats. The holotype of S. johanseni (USNM 30782) has very thin, straight spicules with minute, perpendicular spines. In some spicules, the spines are distinctly aggregated near the spicule tips. The gemmules are in hemispherical clusters with their foramina directed inward. The gemmoscleres are almost indistinguishable from the

spicules which are found in the tissue; gemmosclere length=79-(114) 162 μm (80 counts, std.dev.=20). The tissue spicules have a similar size range, but are longer (on average); length=96-(141)-180 (80 counts, std.dev.=21). Based on the above characters, Spongilla johanseni should be considered a junior synonym of Eunapius mackayi.

Habitat and general ecology

Eunapius mackayi is restricted to acidic or dystrophic, standing waters with a pH range of 4.7 to 6.2. It normally occurs as a thin encrustation on twigs and branches, and is commonly associated with two other acidophilic sponges, Corvomeyenia everetti and Trochospongilla pennsylvanica. I have collected E. mackayi from water of pH=4.7 and a temperature of 4°C at Lac Stevens (Parc Mastigouche, Quebec) in November, 1991. The lake was covered by a few centimeters of ice. Green colonies with numerous green gemmules were attached to dead tree branches; the colonies were rapidly deteriorating, and overwintering was likely carried out exclusively by the gemmules. The spicule morphology of these specimens (AR492S) closely resembles that of S. johanseni. One other sponge, T. pennsylvanica, was collected from the lake, but on that occasion was found only as gemmule pavement and clearly was not as abundant as E. mackayi. I have obtained green colonies of E. mackayi from other acidic lakes in Parc Mastigouche (Quebec), and the Adirondack Mountains (New York), although previous accounts of this species (e.g., Moore 1953, Neidhoefer 1940, Old 1932, Poirrier 1969) fail to mention the presence of symbiotic algae in the colony or gemmules.

The formation of hemispherical gemmule clusters with inwardly-directed foramina likely has adaptive significance. The inward orientation of the foramina may be designed to avoid fouling or siltation. With synchronous

hatching, this orientation may also aid in the rapid fusion of germinal material from each gemmule, resulting in a larger, more viable ancestrula. The concave gemmule cluster may conserve substrate (e.g., by preventing colonization by periphyton) for the ancestrula, and may shield the ancestrula from harmful ultraviolet light during its early stages of development.

Distribution in Eastern Canada

Quebec (Gee 1937), New Brunswick (Smith 1930), Nova Scotia (Carter 1885, Mackay 1885, 1886b, 1886c, 1889), Newfoundland (Mackay 1886c, 1889)

This species is known from New Brunswick from specimens collected at Shippigan ("S. johanseni", USNM 30782) and Williams Lake, Kings Co. (NBM, uncatalogued). It has been reported from Alger County, Michigan, near Lake Superior, therefore it probably occurs in southern Ontario.

Heteromeyenia baileyi (Bowerbank 1863)

Pl.I,Fig.2; Pl.III,Figs.5,12

Heteromeyenia repens Smith 1930

Heteromeyenia baileyi var. repens Gee 1937

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae) or pale yellow, thin, encrusting; surface hispid. Megascleres amphioxea, smooth or sparsely spined; spines minute, blunt and rosettelike; megasclere length=216-(247)-320 μm (30 counts, std.dev.=18.9), width=5-(8)-13 μm (30 counts, std.dev.=1.7). Microscleres amphioxea, densely covered with spines which have terminal knobs; spines increasing in length toward the center of the

spicule, sometimes leaning obliquely, maximum spine length greater than maximum spicule width; microsclere length=53-(67)-83 μm (30 counts, std.dev.=6.5), width (excluding spines)=1-(2.5)-4 μm (30 counts, std.dev.=0.5).

Gemmules yellow, spherical, generally less than 500 μm in diameter; foramen slightly raised, without terminal cirri. Gemmoscleres are of two intergrading classes: (1) short birotulates with flat, serrated rotules; spicule length=38-(44)-51 μm (30 counts, std.dev.=2.7), shaft width=3-(5)-7 μm (30 counts, std.dev.=1.1), rotule diameter=13-(18)-22 (30 counts, std.dev.=2.3); (2) long birotulates with rotules composed of long recurved hooks, giving the rotule an umbrella-like appearance; hooks often with blunt tips; spicule length= 49-(70)-86 μm (30 counts, std.dev.=9.8), shaft width=3-(5)-7 μm (30 counts, std.dev.=1.0), rotule diameter=18-(22)-28 μm (30 counts, std.dev.=2.0).

Taxonomy

Heteromeyenia baileyi is readily separated from its congener H. tubisperma by the foraminal structure of its gemmule: the foramen of H. tubisperma is an extended tube, whose length is at least half of the diameter of the gemmule, and which bears several terminal cirri or tendrils; the foramen of H. baileyi is short and lacks terminal appendages. The umbrella-like rotules on the longer gemmosclere class are fairly distinctive of H. baileyi. Megascleres of both species are quite similar. In the absence of gemmules or gemmoscleres, the morphology of the microscleres is often useful in distinguishing the two species. Microscleres of H. baileyi are generally shorter in length (53-[67]-83 μm) than those of H. tubisperma (73-[100]-118 μm). Microscleres of H. tubisperma are more densely spined; the spines near the ends of the spicule are distinctly recurved, but become

perpendicular and larger toward the center of the spicule. Spines on the H. baileyi microsclere are more or less perpendicular throughout; they are disproportionately long near the center of the spicule, and their maximum length is, on average, greater than the width of the spicule. Spines on the H. tubisperma microsclere are never longer than the width of the spicule.

Habitat and general ecology

Heteromeyenia baileyi is found encrusting stones or vegetation in lakes and sluggish streams. It is most commonly associated with the sponges Anheteromeyenia argyrosperma and Eunapius fragilis. In Eastern Canada, specimens are known from the following range of water quality conditions: pH=5.9-8.2, water temperature=15-26°C, calcium=20-130 mg/L, magnesium=20-150 mg/L. The values of 130 mg/L and 150 mg/L were recorded from a creek on Ile Perrot (Quebec) and represent new tolerance limits to calcium (as $CaCO_3$) and magnesium (as $MgCO_3$) levels, respectively, for H. baileyi.

Distribution in Eastern Canada

Quebec (Gee 1937), New Brunswick, Nova Scotia (Smith 1930).

Heteromeyenia baileyi is locally abundant in some lake outflows in the Laurentian region, north of Montreal (Quebec), but is generally uncommon. In New Brunswick, the species occurs in Oak Bay, Charlotte Co. (45°14'N, 67°12'W) (NBM, uncatalogued).

Heteromeyenia tubisperma (Potts 1881)

Pl.I,Fig.2; Pl.III,Figs.4,6,11

Carterius tubisperma Huntsman 1913; Gee 1937

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), brown or white, papillose and encrusting. Megascleres smooth or very sparsely microspined; length= 238-(290)-337 μm (80 counts, std.dev=20), width=9-(12)-15 μm (80 counts, std.dev.=1.5). Microscleres long slender amphioxea, densely spined; spines small and recurved near the spicule tips, but near the center of the spicule the spines are larger, straight, and with terminal knobs; spine length not greater than the width of the spicule; microsclere length=73-(100)-118 μm (80 counts, std.dev.=9.5), width (excluding spines)=2-(3)-4.5 μm (80 counts, std.dev.=0.6).

Gemmoscleres birotulates of two roughly defined size classes of similar shape; rotules flat, with numerous recurved hooks; shafts sparsely spined; gemmosclere length (of combined classes)=33-(44)-62 μm (80 counts, std.dev.=7), width=2-(4)-6 μm (80 counts, std.dev.=0.7), rotule diameter= 12-(19)-25 μm (80 counts, std.dev.=2.3).

Gemmules yellow, spherical, free, abundant in the basal portion of mature sponge; diameter=534-(585)-661 μm (10 counts, std.dev.=47); foramen an extended tube, length at least half of gemmule diameter; foraminal length=216-(291)-355 μm (10 counts, std.dev.=58), width=48-(57) 65 μm (10 counts, std.dev.=7); normally bearing 4-8 terminal tendrils (90-200 μm in length, 4-14 μm in width).

Taxonomy

This sponge is distinguished from all other species by the long

foraminal tube and tendrils on its gemmule, which can be observed with a hand lens. In the absence of gemmules, microsclere morphology may help distinguish this species from its congener, Heteromeyenia baileyi, which has shorter microscleres with longer spines.

Habitat and general ecology

Heteromeyenia tubisperma is found in alkaline waters ranging from clear to green and very turbid, in both lentic and lotic habitats. Eastern Canadian specimens were collected from the following water quality conditions: temperature=11-26°C, pH=7.1-9.0, calcium=12-130 mg/L, magnesium=22-150 mg/L. The upper limits for pH, calcium, and magnesium represent new tolerance limits for H. tubisperma. Species commonly found in association with H. tubisperma include the sponges, Spongilla lacustris, Eunapius fragilis, and Ephydatia muelleri, and the bryozoans, Paludicella articulata and Plumatella emarginata.

The long foraminal tendrils on the gemmule are likely adapted for dispersal (e.g., by waterfowl).

Distribution in Eastern Canada

Ontario (Huntsman 1913; Gee 1937), Quebec.

This species was previously reported from southern Ontario near Lake St. Clair (Gee 1937) and near Toronto (Huntsman 1913). I have collected it from a creek near North Lancaster, Ontario (AR438S). It is probably widespread throughout the Great Lakes region. Although previously unreported in Quebec, it is fairly common in Lac St-Louis (St. Lawrence River), and in lakes and streams throughout the southern part of the province.

Radiospongilla crateriformis (Potts 1882)

Pl.I,Fig.5; Pl.III,Fig.10

Description of Eastern Canadian specimens

Sponge brown or white, small, thin, flat, encrusting. Megascleres slender amphioxea, sparsely microspined; spines procurved, generally absent from the tips of the spicule; megasclere length=254-(278)-298 μm (35 counts, std.dev.=11.7), width=9-(11)-14 μm (35 counts, std.dev.=1.1).

Gemmules white, small, spherical, free; gemmule diameter=261-(383)-520 μm (10 counts, std.dev.=93.2). Foramen raised, cone-like. Gemmoscleres arranged radially around the gemmule, except in the immediate vicinity of the foramen, where they lean away to form a crater-like depression around the micropyle. Gemmoscleres with distal aggregations of recurved spines, giving the spicule a birotulate appearance; gemmosclere length=60 (71)-80 μm (60 counts, std.dev.=4.5), shaft width=2.5-(4)-6 μm (60 counts, std.dev.=0.7), rotule diameter=8-(11)-13.5 μm (60 counts, std.dev.=1.2). Free gemmoscleres are always present in the sponge tissue, even in the absence of gemmules.

Taxonomy

In most species of Radiospongilla, spicules identical to gemmoscleres are commonly found free in the sponge tissue regardless of whether gemmules are present. Penney and Racek (1968) referred to these as "immature gemmoscleres", but for at least one species, R. cerebellata (Saller 1990c), they appear to be regular microscleres that are used in constructing the gemmule. This may also be true for R. crateriformis.

The distal recurved spines on the gemmosclere are highly variable in length; short spines give the gemmosclere an amphistrongyle appearance, longer spines give it a birotulate appearance. Unlike most birotulates, the

overall length of the gemmosclere is several times longer than the rotule diameter; like most birotulates, however, the gemmoscleres are arranged radially on the gemmule.

Habitat and general ecology

Radiospongilla crateriformis prefers stagnant, turbid, alkaline waters (Harrison 1974; Poirrier 1969). In Canada, the species is known only from Ile Perrot (Ottawa River, Quebec). Specimens were collected in late July and early August, 1991, from a shallow creek (< 50 cm depth), a backpool of the Ottawa River subject to annual drying. Water quality conditions were as follows: temperature 23-26°C, pH=7.9-8.2, calcium=130 mg/L, magnesium= 150 mg/L. Other sponges collected on these occasions were Heteromeyenia tubisperma and H. baileyi.

Distribution in Eastern Canada

Ile Perrot, Quebec (AR422S, AR432S).

Mackay (1886a) collected a few "large hooked birotulates" which he assumed to be "Meyenia crateriforma" (=R. crateriformis) from lake sediments in Nova Scotia, but no slides or specimens exist; it is very unlikely that a confident identification could be made from such limited material, therefore I consider this record to be doubtful.

Spongilla aspinosa Potts 1880

Pl.I,Fig.1; Pl.III,Fig.2

Description of Eastern Canadian specimens

Sponge green, thin, with long slender branches. Megascleres smooth, straight amphioxea, length=222-(274)-338 μm (110 counts, std.dev.=28),

width=5-(10)-15 μm (110 counts, std.dev.=2). Microscleres abundant, smooth or very sparsely microspined, thin, needle-like, and predominantly straight: length=21-(50)-78 μm (120 counts, std.dev.=15), width=0.4-(1.5)-3.2 μm (110 counts, std.dev.=0.5).

Gemmules scarce, occurring in clusters of various sizes, with foramina oriented toward the substrate; gemmoscleres abundant and enclose each gemmule in a nest-like capsule, but are not embedded in the gemmule pneumatic layer; individual gemmules large, thick-coated, diameter=603-(660)-809 μm (16 counts, std.dev.=63); foramen simple. Gemmoscleres smooth amphioxea, resembling smaller megascleres; length=129-(247)-306 μm (50 counts, std.dev.=34), width=6-(9)-15 μm (50 counts, std.dev.=2.5).

Taxonomy

Historically, this species has been distinguished from its congener, Spongilla lacustris, by its smooth microscleres. However, as shown by Volkmer-Ribeiro and Traveset (1987) through scanning-electron microscopy, the microscleres of S. aspinosa are sparsely covered with minute spines, except near the tips. The spines are often discernible under regular light microscopy. Microscleres of S. lacustris differ by being more densely and conspicuously spined, particularly near the tips (however, microscleres from silica-poor habitats may be so thin that the spines are hardly visible). The most consistent differences between both species is in the arrangement of the gemmules and their gemmoscleres. The thick-coated gemmules of S aspinosa are organized into small clusters with their foramina oriented toward the substrate. Gemmules of S. lacustris may be either thin- or thick-coated, are far more abundant than those of S. aspinosa, and are never organized into clusters. The gemmule spicules of S. aspinosa are smooth amphioxea (essentially small megascleres), are always present in abundance,

but are not embedded in the pneumatic layer of the gemmule; gemmoscleres of S. lacustris are not always present, rarely abundant, are always embedded in the gemmule pneumatic layer, and are often densely spined.

Habitat and general ecology

Ecological data for S. aspinosa is scarce. Previous reports (Eshleman 1950; Jewell and Brown 1929; Potts 1887) indicate that the species occurs in clear, acidic, lentic habitats. In Nova Scotia, it has been found in the following water quality conditions: temperature=24°C, pH=4.8-5.4, conductivity=87 μmho/cm, turbidity=0.14 APHA, color=50-90 Hazen, calcium=0.4 mg/L, magnesium=0.4 mg/L.

Potts (1887) attributed the scarcity of gemmules in S. aspinosa to a perennial existence which places minimal importance on the production of overwintering structures; the gemmules likely serve only as insurance against adverse environmental conditions. The significance of the substrate-directed orientation of the foramina is unknown, since this feature has not been previously described. As in the case of Eunapius mackayi, this orientation may be chiefly designed to protect the foraminal openings from siltation or fouling.

Distribution in Eastern Canada

Nova Scotia.

This species has not been previously reported from Canada. I have identified specimens of S. aspinosa collected from Jigging Cove Lake, Cape Breton Highlands National Park (NSM 1976-Z-321-1; NSM 1976-Z-319-7), and Little Peskowesk Lake, Kejimkujik National Park (NSM 1972-Z-591-4), in Nova Scotia.

Spongilla lacustris (Linnaeus 1758)

Pl.I,Fig.1; Pl.III,Figs.1,9

Spongilla dawsoni Dawson 1878

Spongilla flexispina Dawson 1878

Spongilla lacustroides Mackay 1886a

Spongilla lacustris var. dawsoni Mackay 1885, 1886b

Spongilla lacustris Mackay 1889; Huntsman 1913; Smith 1921, 1930; Gee 1937; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae), brown, or white; mature colonies with long, cylindrical branches (up to 8 mm diameter) projecting from a central encrusting base. Megascleres smooth amphioxea, length 158 (254)-362 μm (200 counts, std.dev.=28.9), width=4 (10)-17 μm (200 counts, std.dev.=2.9). Microscleres spined amphioxea, slightly to strongly curved; densely covered with small spines, especially near the tips; microsclere length=32-(61)-94 μm (200 counts, std.dev.=12.5), width=1.0 (3.5) 7.5 μm (200 counts, std.dev.=1.4).

Gemmules green or brown, abundant in base and branches of mature sponge; pneumatic coat thin, thick, or absent; foramen simple or with a short peripheral collar; 1-4 foramina may be present; gemmule diameter=290 (425)-842 μm (50 counts, std.dev.=71.3). Gemmoscleres present or absent, usually scarce, slightly to strongly curved amphioxea or amphistrongyla; covered with a variable number of recurved spines, usually aggregated near the tips; gemmosclere length=18-(32)-58 μm (50 counts, std.dev.=9.2), width=3-(5)-7 μm (50 counts, std.dev.=1.0).

Taxonomy

This highly variable species is usually easily distinguished from its

congener, S. aspinosa, which has smooth or sparsely spined microscleres (lacking spines near the tips), thick-coated gemmules occurring in clusters, and smooth gemmoscleres.

Habitat and general ecology

Spongilla lacustris is a light-positive species found in a wide range of water quality conditions and in a wide range of lentic and lotic habitats. Colonies grow more luxuriently in clear, permanent, standing waters. Eastern Canadian specimens were found in the following range of water quality conditions: temperature=4-25°C, pH=4.8-9.0, calcium=0.4-60 mg/L, magnesium=0.4-64 mg/L. Specimens were collected from Little Peskowesk Lake, Kejimkujik National Park, Nova Scotia (NSM 1972-Z-591-2) which has a pH of 4.8, the lowest recorded pH value for the species.
Spongilla lacustris is most commonly associated with the sponges, Eunapius fragilis and Ephydatia muelleri, and the bryozoan Paludicella articulata. Like Eunapius fragilis, S. lacustris commonly grows on the shells of living unionid clams.

Frost et al. (1982) observed that S. lacustris rapidly colonizes substrate which it contacts, and suggested that its branching growth form aids its local dispersal. In shallow waters, I have found individual colonies interconnected by one or two stoloniferous branches; this mode of propagation is similar to that of macrophytes and probably serves more as a form of recruitment than of dispersal. Simpson (1980) noted the lack of evidence supporting the idea that gemmules may serve as dispersal agents. luxuriant branching colonies of S. lacustris in the lower Ottawa River (Quebec) have an annual mode of dispersal involving gemmules. In this region, S. lacustris overwinters as a mass of gemmules enclosed in its original sponge skeleton. The onset of spring flooding in the Ottawa River

valley causes fragmentation of the buoyant, gemmule-laden branches, which are then carried downstream by the current. For two successive years, during periods of spring flooding, I have collected fragments of these branches directly from the current, or in bays where they had become entrained along the lower Ottawa River.

In addition to aiding dispersal, the branching growth form of S. lacustris may alleviate the effects of siltation and substrate competition (Manconi and Pronzato 1991), allow the colony to escape anoxic bottom sediments (Frost et al. 1982), and increase feeding efficiency by providing a higher surface/volume ratio (Frost and Williamson 1980)

Due to the activity of its algal symbionts, S lacustris may contribute significantly to the primary production of small lentic habitats (Frost 1991). In clear, softwater lakes where macrophytes are scarce or lacking, the green branching form of S. lacustris appears to assume the functional role of a macrophyte as a primary producer.

Distribution in Eastern Canada

Ontario (Dawson 1878; Mackay 1889; Huntsman 1913; Gee 1937), Quebec (Dawson 1878; Gee 1937; Ricciardi and Lewis 1991), New Brunswick (Smith 1930; Gee 1937), Nova Scotia (Mackay 1885, 1886a,b, 1889; Smith 1930; Gee 1937), Newfoundland (Mackay 1889; Smith 1930).

Spongilla lacustris is the most common and widely distributed freshwater sponge in Eastern Canada.

Trochospongilla horrida Weltner 1893

Pl.I,Fig.4; Pl.III,Fig.7

Description of Eastern Canadian specimens

Sponge green (due to symbiotic algae) or brown, flat, encrusting. Megascleres amphioxea (rarely amphistrongyla), densely covered with blunt, truncated spines typical of the genus, megasclere tips usually acerate and sparsely spined, sometimes densely spined; megasclere length=155-(187)-250 μm (30 counts, std.dev =10). Microscleres absent.

Gemmules yellow or brown, spherical, normally cemented to the substrate in a pavement layer, with foramina directed upward; gemmule diameter=324-(380)-537 μm (15 counts, std.dev.=54). Gemmoscleres small birotulates; rotules disklike, with smooth margins, and nearly equal in diameter; length of gemmosclere is never larger than diameter of smaller rotule; gemmosclere length=8-(9)-10 (30 counts, std.dev.=0.5); diameter of smaller rotule=10-(12) 13 (30 counts, std.dev.=1.2); diameter of larger rotule=13 (14)-16 (30 counts, std.dev.=1.0).

Taxonomy

A recent redescription of this species is provided by Saller (1990a). Most taxonomic keys separate I. horrida from its congener, I. pennsylvanica, by the relative sizes of the gemmosclere rotules; in I. horrida, the rotules are nearly equal in diameter, whereas in typical specimens of I. pennsylvanica, one rotule is disproportionately larger than the other. In some specimens of I. pennsylvanica, the rotules are equal (or nearly equal) in diameter. Because of the apparent morphological overlap, Poirrier (1969) considered I. horrida to be an ecomorphic variant of I. pennsylvanica. However, both species can consistently be separated by comparing the length of the gemmosclere with the diameter of the smaller rotule (similar to the

criterion which separates Ephydatia muelleri and E. fluviatilis). For T. horrida, the length of the gemmosclere is, on average, less than the diameter of the smaller rotule; for T. pennsylvanica, the length of the gemmosclere is greater than (or, in rare cases, equal to) the diameter of the smaller rotule. Furthermore, in specimens of T. pennsylvanica which have equibirotulate gemmoscleres, there are usually a few typical pennsylvanica birotulates present by which the species can be immediately recognized.

Habitat and general ecology

In Quebec, Trochospongilla horrida is rare and has been found only in alkaline, lotic habitats, on the underside of rocks in slowly flowing water. The following water quality conditions were recorded: temperature=20-22°C, pH=7.4-8.1, calcium=10-60 mg/L, magnesium=30-50 mg/L.

Distribution in Eastern Canada

Quebec (ARIS; HMR 90-9-8.7; HMR 90-9-8.17)

Trochospongilla horrida has not been previously recorded in Canada. It is known only from the lower Ottawa and St. Lawrence Rivers in the vicinity of the Island of Montreal.

Trochospongilla pennsylvanica (Potts 1882)

Pl.I,Fig.4; Pl.III,Fig.8

Tubella pennsylvanica Mackay 1886b, 1889; Smith 1930

Trochospongilla pennsylvanica Gee 1937

Description of Eastern Canadian specimens

Sponge small, flat, encrusting; color brown, grey, or green (due to symbiotic algae). Megascleres amphistrongyla or amphioxea, densely covered

to the tips with spines; spines are straight and predominantly blunt or truncated: megasclere length=100-(253)-432 μm (144 counts, std.dev.=88.5), width=6 (13) 25 μm (144 counts, std.dev.=4.0). Microscleres absent.

Gemmules yellow, spherical; normally in a pavement layer, with foramina oriented upward; gemmule diameter=310-(350)-396 (25 counts, std.dev.=27.0). Gemmoscleres birotulates; rotules disklike, normally with smooth margins, and normally strongly unequal in diameter; the lower rotule, which lies next to the gemmule, is typically disproportionately larger than the upper rotule, which is often rudimentary; in rare cases, the rotules are almost equal in diameter; the length of the gemmosclere, on average, is greater than or equal to diameter of the smaller (upper) rotule; gemmosclere length=11-(17) 41 μm (134 counts, std.dev.=4.9); diameter of upper rotule=3.5-(9) 23 μm (134 counts, std.dev.=4); diameter of lower rotule= 13-(24)-41 μm (134 counts, std.dev.=8.1).

Taxonomy

As mentioned previously, I. pennsylvanica gemmoscleres having nearly equal rotules are distinguished from those of I. horrida by comparing the length of the gemmosclere to the diameter of the smaller rotule; if the gemmosclere length is, on average, greater than or equal to the diameter of the smaller rotule, then the specimen is likely to be I. pennsylvanica.

Some I. pennsylvanica specimens from acid lakes (pH<5.0) have malformed gemmoscleres in which both rotules are deeply incised into 4-6 distinct rays; this may be the result of silica deficiency associated with the acidic habitat.

Habitat and general ecology

Trochospongilla pennsylvanica is found as small, thin patches on the

underside of submerged objects in acidic to weakly alkaline waters of lentic and lotic habitats. In acid lakes, it is often found associated with Eunapius mackayi and Corvomeyenia everetti. Specimens have been collected from the following water quality conditions: temperature 9-24°C, pH=5.0-7.2, calcium=0-20 mg/L, magnesium=0-10 mg/L. Specimens found in 9°C (at Lac Magnan, near Lachute, Quebec), a new tolerance limit for I. pennsylvanica, were brown in color, and showed little sign of deterioration. Gemmules of the species were collected from Lac Stevens (Parc Mastigouche, Quebec) in a pH of 4.7, but no colonies were found.

Distribution in Eastern Canada

Ontario (Gee 1937), Quebec (Gee 1937), New Brunswick, Nova Scotia (Mackay 1886b, 1889), Newfoundland (Mackay 1889; Smith 1930)

I have identified a specimen of I. pennsylvanica from Lucky Lake, Restigouche Co., New Brunswick (47°34'N 66°13'W) (NBM, uncatalogued), which represents a new record for the province.

KEY TO THE FRESHWATER SPONGES OF EASTERN CANADA

1a Microscleres present 2
1b Microscleres absent 8

2a Microscleres birotulate. 3
2b Microscleres rod-shaped 4

3a Gemmoscleres birotulate. . . . . Corvomeyenia everetti
3b Gemmoscleres rod-shaped . . . . . Corvospongilla novaeterrae

4a Gemmoscleres birotulate, microsclere spines with terminal knobs . . . . . Heteromeyenia, 5
4b Gemmoscleres rod-shaped or absent, microsclere spines without terminal knobs 6

5a Foraminal tube of mature gemmule extended (average length at least half of gemmule diameter) and bearing terminal tendrils, maximum length of central spines on microsclere generally smaller than maximum width of spicule, microsclere length ranging from 73 to 118 μm . Heteromeyenia tubisperma
5b Foraminal tube of mature gemmule very short and lacking terminal tendrils, central spines on microscleres disproportionately long, maximum spine length greater than maximum spicule width, microsclere length ranging from 53 to 83 μm Heteromeyenia baileyi

6a Megascleres spined, mature gemmules usually in hemispherical clusters, with foramina directed inward or toward the substrate, colony thin and unbranched . . . . . Eunapius mackayi*
6b Megascleres smooth, gemmules not in hemispherical clusters, colony often with long, fingerlike branches . . . . . Spongilla, 7

7a Microscleres smooth or sparsely spined; gemmules thick-coated, occurring in clusters with foramina directed toward the substrate; gemmoscleres smooth, identical to megascleres. . . . . Spongilla aspinosa
7b Microscleres densely spined, especially at the tips, gemmules not in clusters; gemmoscleres, when present, are spined . . . . . Spongilla lacustris

8a Gemmoscleres rod-shaped, mature gemmules fixed in groups and enclosed in a common coat. . . . . Eunapius, 9
8b. Gemmoscleres birotulate, or with blunt ends somewhat resembling rotules; gemmules not as above. 10

9a. Foramina of gemmules directed outward or away from the substrate, megascleres smooth . . . . . Eunapius fragilis
9b Foramina of gemmules directed inward or toward the substrate, megascleres spined. . . . . Eunapius mackayi*

10a. Megascleres densely covered with blunt or truncated spines, mature gemmules in a pavement layer cemented to the substrate, gemmoscleie rotules normally with smooth margins — Trochospongilla, 11

10b Megascleres with pointed spines, or completely smooth, mature gemmules not as above, gemmoscleie rotules with incised or serrated margins — 12

11a. Gemmoscleie rotules normally strongly unequal in diameter, on average, gemmoscleie length greater than or equal to diameter of smaller rotule — Trochospongilla pennsylvanica

11b. Gemmoscleie rotules almost equal in diameter, gemmoscleie length less than the diameter of smaller rotule — Trochospongilla horrida

12a Gemmoscleres of two distinct size classes or forms — Anheteromeyenia, 13

12b. Gemmoscleres of one size class and form — 14

13a. Gemmoscleres of the smaller class having flat disclike rotules with incised margins, gemmoscleie length ranging from 22 to 64 μm — Anheteromeyenia ryderi

13b. Gemmoscleie rotules composed of a few large, recurved hooks, gemmoscleie length ranging from 65 to 160 μm — Anheteromeyenia argyrosperma

14a Gemmoscleie length greater than 60 μm, rotule diameter several times smaller than spicule length, rotules with recurved hooks, megascleres covered with distinctly procurved spines, foramen of gemmule centered within a crater-like depression formed by slanting gemmoscleres — Radiospongilla crateriformis

14b Gemmoscleie length less than 30 μm, rotule diameter almost as large as spicule length, rotules without recurved hooks, megascleres smooth or spined, spines not procurved, gemmule not as above — Ephydatia, 15

15a Gemmoscleie length less than or equal to rotule diameter, rotules deeply incised to form no more than 12 long rays . . . . . — Ephydatia muelleri

15b Gemmoscleie length greater than rotule diameter, rotules normally weakly incised, forming 13 or more serrations . . . . . — Ephydatia fluviatilis

*Note that in Eunapius mackayi, the shorter class of spicules can be interpreted as both microscleres and gemmoscleres. The spicules are indistinguishable from those surrounding the gemmule, but are always present in the absence of gemmules and are distributed throughout the sponge tissue. Therefore, they may be correctly interpreted as regular microscleres which are also used in the construction of the gemmule.

Key to spicules (excluding gemmoscleres) of freshwater sponges occurring in Eastern Canada

1a Megascleres smooth 2
1b Megascleres spined. 5

2a Microscleres present 3
2b Microscleres absent . . *Eunapius fragilis* & *Ephydatia* spp

3a Microscleres rod-shaped. . . . . *Spongilla*, 4
3b Microscleres birotulate . . . . . *Corvomeyenia everetti* & *Corvospongilla novaeterrae*

4a Microscleres smooth or sparsely spined, needle-like, and predominantly straight . . *Spongilla aspinosa*
4b Microscleres densely spined, especially at the tips, straight or curved. . . . . *Spongilla lacustris*

5a Microscleres present* 6
5b Microscleres absent 8

6a Microsclere spines with terminal knobs; microsclere length ranging from 53 to 118 μm. . . . *Heteromeyenia*, 7
6b Microsclere spines pointed, usually strongly recurved, microsclere length ranging from 114 to 270 μm . *Eunapius mackayi**

7a Microsclere spines disproportionately long at the center of the spicule, maximum spine length greater than or equal to maximum spicule width, microsclere length ranging from 53 to 83 μm . . . *Heteromeyenia baileyi*
7b Microsclere spines not disproportionately long, maximum spine length less than maximum spicule width, spines distinctly recurved near the tips of the spicule, microsclere length ranging from 73 to 118 μm . . . *Heteromeyenia tubisperma*

8a Spines pointed and curved, usually sparse or absent near the tips of the spicule 9
8b Spines blunt or truncated, and generally straight, often densely cover the tips of the spicule *Trochospongilla* spp.

9a Spines procurved *Radiospongilla crateriformis* & *Anheteromeyenia* spp
9b Spines not procurved, both smooth and variably spined megascleres often present in the same specimen . . . . . *Ephydatia* spp.

*Note that the microscleres of *Eunapius mackayi* occur as a second class of spicules which are shorter, more densely spined, and more abundant than the megascleres, although transitional forms may be present

PLATES I-IV: Freshwater sponge spicules

PLATE I:

Figures 1-4. Megascleres of freshwater sponges (Scale bar=20 μm)

Fig.1, *Eunapius fragilis* and *Spongilla* spp.; Fig.2, *Heteromeyenia* spp.;

Fig.3, *Ephydatia muelleri*; Fig.4, *Trochospongilla* spp.;

Fig.5, *Anheteromeyenia* spp. and *Radiospongilla crateriformis*;

Fig.6, *Anheteromeyenia ryderi pictouensis*.

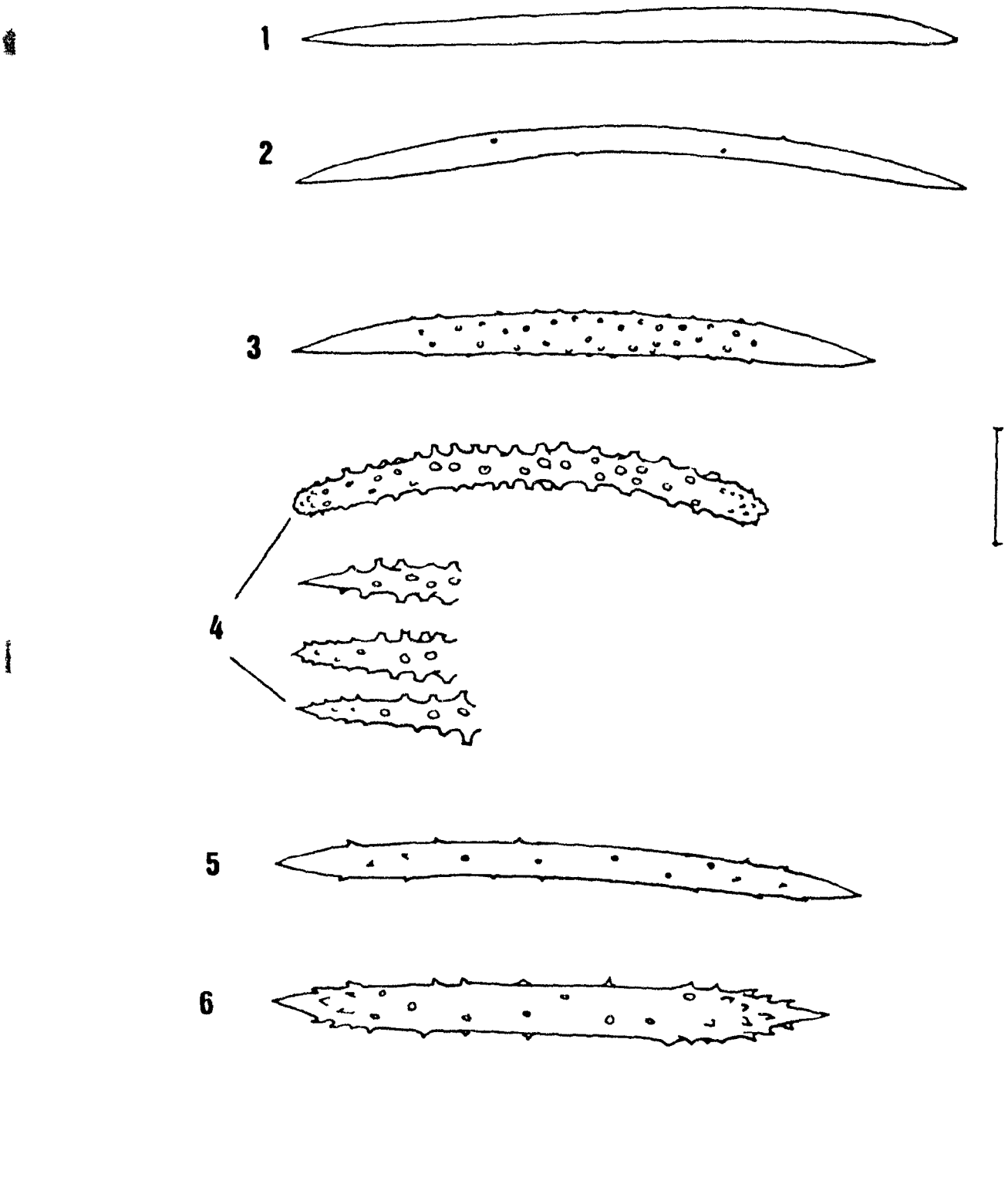
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PLATE II:

Figures 1-4. Eunapius mackayi spicules (Scale bar=30 μm).

Figs.1-2, Typical megascleres; Fig.3, "Spongilla johanseni" spicules; Fig.4, Microsclere-gemmoscleres.

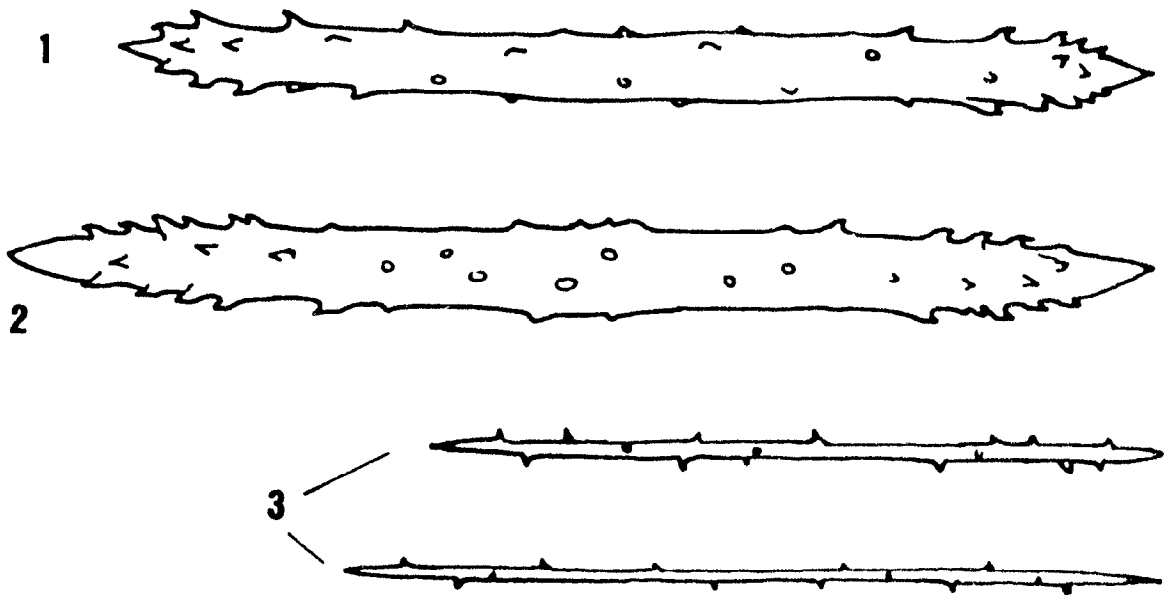
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PLATE III:

Figures 1-5. Microscleres of freshwater sponges (Scale bar=20 μm).
Fig.1, Spongilla lacustris; Fig.2, Spongilla aspinosa; Fig.3, Corvomeyenia everetti and Corvospongilla novaeterrae; Fig.4, Heteromeyenia tubisperma; Fig.5, Heteromeyenia baileyi.
Figure 6. Foramen of Heteromeyenia tubisperma gemmule (Scale bar=100 μm).

Figures 7-12. Gemmoscleres of freshwater sponges. Fig.7, Trochospongilla horrida (Scale bar=20 μm); Fig.8. Trochospongilla pennsylvanica (scale bar=20 μm); Fig.9, Spongilla lacustris (Scale bar=10 μm);
Fig.10, Radiospongilla crateriformis (Scale bar=10 μm);
Fig.11, Heteromeyenia tubisperma (Scale bar=20 μm); Fig.12, Heteromeyenia baileyi (Scale bar=20 μm).

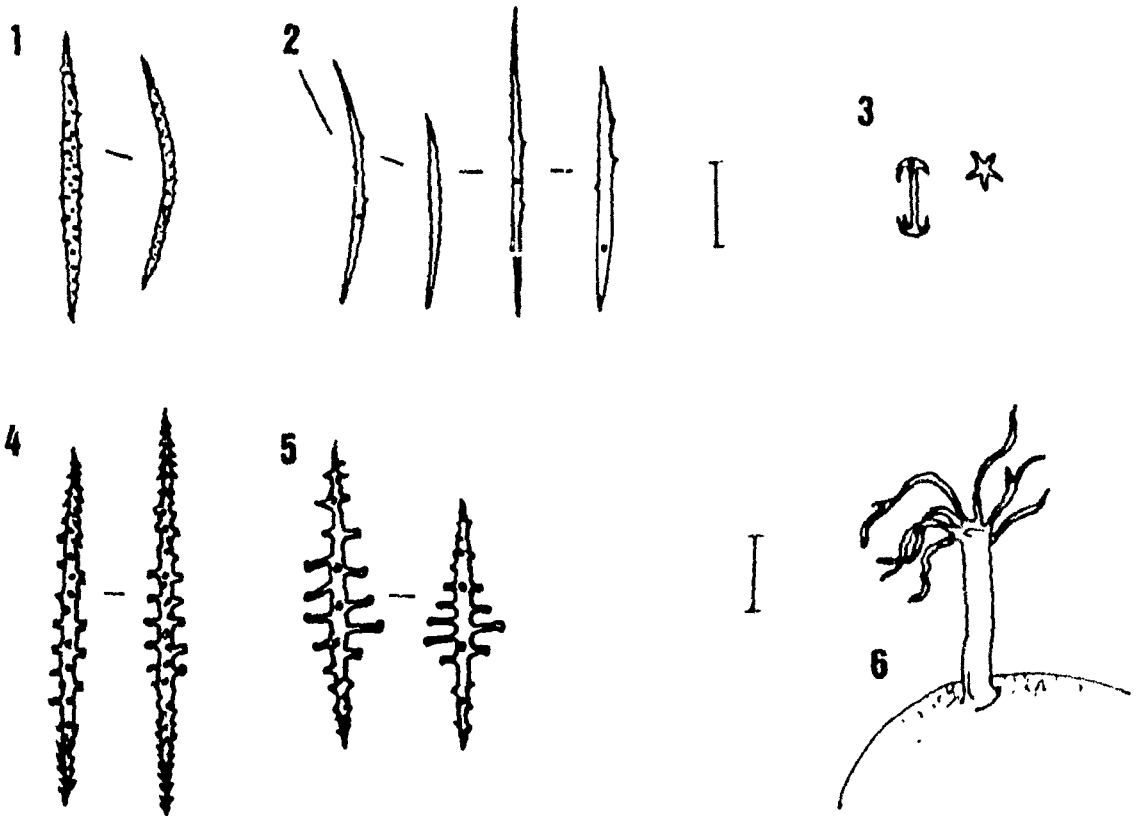
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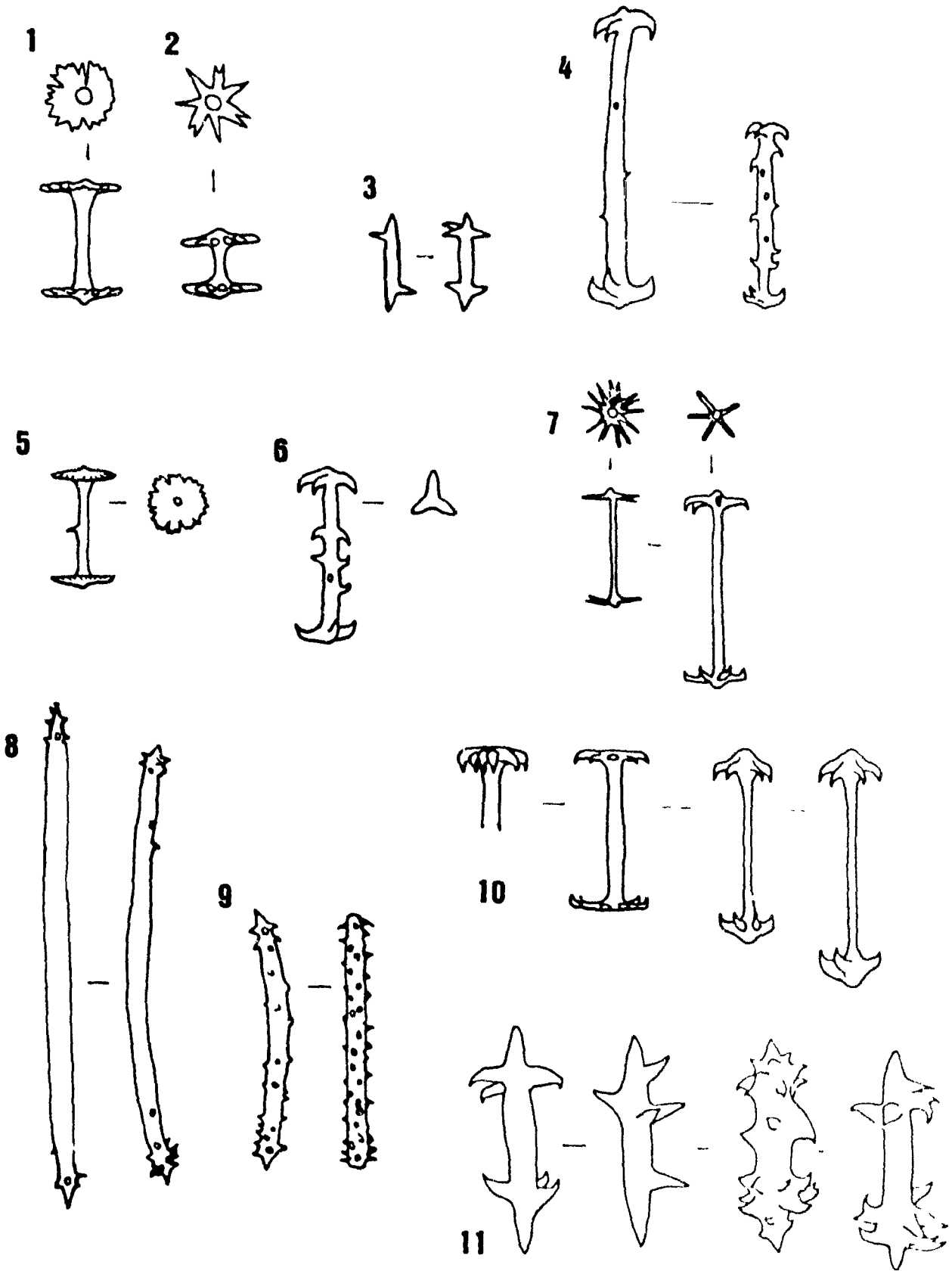
PLATE IV:

Figures 1-11. Gemmoscleres of freshwater sponges. Fig.1, Ephydatia fluviatilis (Scale bar=20 μm); Fig.2, Ephydatia muelleri (Scale bar=20 μm); Fig.3, Malformed gemmoscleres of E. muelleri (Scale bar=20 μm); Fig.4, Anheteromeyenia argyrosperma (Scale bar=50 μm);

Figures 5-7. Anheteromeyenia ryderi gemmoscleres (Scale bar=30 μm). Fig.5, Short birotulate; Fig.6, Long birotulate; Fig.7, A. ryderi macouni, short and long birotulates;

Figures 8-9. Eunapius fragilis gemmoscleres (Scale bar=20 μm). Fig.8, Transitional gemmosclere-megasclere; Fig.9, typical gemmoscleres; Fig.10, Corvomeyenia everetti gemmoscleres (Scale bar=20 μm); Fig.11, Corvospongilla novaeterrae gemmoscleres (Scale bar=20 μm).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References Cited

ANNANDALE, N. 1911. Fresh water sponges, Hydroids and Polyzoa. In: The Fauna of British India including Ceylon and Burma. London. p.122.

BARBEAU, M.A., REISWIG, H.M. and RATH, L.C. 1989. Hatching of freshwater sponge gemmules after low temperature exposure: Ephydatia muelleri (Porifera: Spongillidae). J. Therm. Biol. 14: 225-231.

BENEY, T J. and REISWIG, H.M. 1982. Temperature, pH, and photoperiod effects upon gemmule hatching in the freshwater sponge, Ephydatia muelleri (Porifera, Spongillidae). J. Exp. Zool. 221: 13-21

BOWERBANK, J.S. 1863. A monograph of the Spongillidae. Proc. Zool. Soc. London 1863: 440-472.

CARTER, H.J. 1885. Note on Spongilla fragilis, Leidy, and a new species of Spongilla from Nova Scotia. Ann. Mag. Nat. Hist. (5) 15: 19-20.

DAWSON, G.M. 1878. On some Canadian species of Spongilla. Can. Nat. 8: 1-5.

ESHLEMAN, S K. 1950. A key to Florida's fresh-water sponges, with descriptive notes. Quart. J. Fla. Acad. Sci. 12: 36-44.

FELL, P.E. 1990. Environmental factors affecting dormancy in the freshwater sponge Eunapius fragilis (Leidy). Invert. Repr. Dev. 18: 213-219.

FRANCIS, J.C. and HARRISON F.W. 1988. Copper and zinc toxicity in Ephydatia fluviatilis (Porifera: Spongillidae). Trans. Am. Micros. Soc. 107: 67-78.

FRANCIS, J. C. and POIRRIER, M.A. 1986. Particle uptake intwo fresh-water sponge species, Ephydatia fluviatilis and Spongilla alba (Porifera: Spongillidae). Trans. Am. Microsc. Soc. 105: 11-20.

FRANCIS, J.C., POIRRIER, M.A. and LABICHE, R.A. 1982. Effects of calcium and salinity on the growth rate of Ephydatia fluviatilis (Porifera: Spongillidae). Hydrobiol. 89: 225-229.

FREEDMAN, B., KEREKES, J. and HOWELL, G. 1989. Patterns of water chemistry among twenty-seven oligotrophic lakes in Kejimkujik National Park, Nova Scotia. Water, Air and Soil Poll. 46: 119-130.

FROST, T.M. 1978. The impact of the freshwater sponge Spongilla lacustris on a sphagnum bog-pond. Verh. Int. Verein. Limnol. 20: 2368-2371.

FROST, T.M. 1991. Porifera. In Ecology and classification of North American freshwater invertebrates. Edited by J.H. Thorp and A.P. Covich. Academic Press, N.Y. pp. 95-124.

FROST, T.M., DENAGY, G.S., and GILBERT, J.J. 1982. Population dynamics and standing biomass of the freshwater sponge, Spongilla lacustris. Ecol. 63: 1203-1210.

FROST, T.M. and WILLIAMSON, C.E. 1980. In situ determination of the effect of symbiotic algae on the growth of the freshwater sponge Spongilla lacustris. Ecology 61: 1361-1370.

GEE, N.G. 1931. A contribution toward an alphabetical list of the known fresh-water sponges. Bull. Peking Soc Nat. Hist. 5: 31-52.

GEE, N.G. 1937. Canadian freshwater sponges Trans. Roy. Can Inst. 21:285 296.

HARRISON, F.W. 1974. Sponges (Porifera: Spongillidae) In Pollution Ecology of freshwater invertebrates. Edited by C W Hart and S.L.H. Fuller Academic Press, N.Y. pp. 29-66.

HARRISON, F.W. 1977. The taxonomic and ecological status of the environmentally restricted spongillid species of North America. 3 Corvomeyenia carolinensis Harrison, 1971. Hydrobiol 56 187 190.

HUNTSMAN, A.G. 1913. Invertebrates other than insects and mollusks. In The natural history of the Toronto region. Edited by J.H. Faull. Can. Inst. Toronto. Pp. 272-287.

JEWELL, M.E. 1935. An ecological study of the freshwater sponges of northern Wisconsin. Ecol. Monogr. 5: 461-504.

JEWELL, M.E. 1939. An ecological study of the freshwater sponges of Wisconsin. II. The influence of calcium. Ecology 20. 11 28.

JEWELL, M.E. 1952. The genera of North American fresh water sponges, Parameyenia, new genus. Trans. Kansas Acad. Sci. 55. 445 457.

JEWELL, M.E. 1959. Porifera In Freshwater biology, 2nd ed., Edited by W.I. Edmondson. Wiley and Sons, N.Y. pp 298-312.

JEWELL, M.E. and BROWN, H.W. 1929. Studies on Northern Michigan Bog Lakes. Ecology 10: 427-475.

KEREKES, J., SCHWINGHAMER, P., and SCOTT, R. 1978. Aquatic resources inventory, Cape Breton Highlands National Park, Nova Scotia. Part 3. Selected limnological measurements in 62 lakes. Environment Canada, Canadian Wildlife Service. 225p.

LEIDY, J. 1851. Spongilla fragilis. Proc. Acad. Nat. Sci. Phila. 5: 278.

LIEBERKUHN, N. 1856. Zusatze zur Entwickleungsgeschichte der Spongillen. Arch. Anat Physio. (Mueller) 1856: 496-514.

LINNAEUS, C. 1758. Systema naturae. 10th ed. J. Cramer, Weinheim.

MACKAY, A.H. 1885. Organic siliceous remains in the lake deposits of Nova Scotia. Canadian Rec. Sci. 1: 236-244.

MACKAY, A.H. 1886a. Notes on Nova Scotia fresh-water sponges. Proc. Trans. Nova Scotia Inst. Nat. Sci. 6: 145-148.

MACKAY, A.H. 1886b. Notes on the fresh-water sponges of Nova Scotia. Proc. Trans. Nova Scotia Inst. Nat. Sci. 6: 233-240.

MACKAY, A.H. 1886c. New freshwater sponges from Nova Scotia and Newfoundland. Canadian Rec. Sci. 2: 19-22.

MACKAY, A.H. 1889. Fresh-water sponges of Canada and Newfoundland. Proc. Trans. Roy. Soc. Canada 7: 84-95.

MACKAY, A.H. 1900. A fresh water sponge from Sable Island. Proc. Trans. Nova Scotia Inst Nat. Sci. 10: 319-322.

MANCONI, R and PRONZATO, R. 1991. Life cycle of Spongilla lacustris (Porifera, Spongillidae): a cue for environment-dependent phenotype. Hydrobiol. 220: 155-160.

MILLS, H. 1884. Thoughts on the Spongidae, with reference to the American sponges of the fresh-water group with some account of them in detail. Proc. Am. Soc. Micr. 1884 131-147.

MOORE, W.G. 1953. Louisiana fresh-water sponges, with ecological observations on certain sponges of the New Orleans area. Trans. Amer. Micr. Soc. 72: 24 32.

MYSING-GUBALA, M.S. and POIRRIER, M.A. 1981. The effects of cadmium and mercury on gemmule formation and gemmosclere morphology in Ephydatia fluviatilis (Porifera: Spongillidae). Hydrobiol. 76: 145-148.

NEIDHOEFER, J.R. 1940. The fresh-water sponges of Wisconsin. Trans. Wisc. Acad. Sci. Lett. Arts 32: 177-197.

OKLAND, K.A. and OKLAND, J. 1989. The amphiatlantic freshwater sponge Aheteromeyenia ryderi, (Porifera, Spongillidae) taxonomic-geographic implications of records from Norway. Hydrobiol. 17: 177-188.

OLD, M.C. 1932. Taxonomy and distribution of the fresh-water sponges (Spongillidae) of Michigan. Pap. Mich. Acad. Sci. Arts Lett. 15: 439-477.

ORD, M.J. and CAMERON, M.L. 1950. Spongilla nova terrae Potts, a fresh-water sponge new to Nova Scotia. Proc. Nova Scotia Inst. Sci. 22:8-13.

PENNEY, J.T. and RACEK, A.A. 1968. Comprehensive revision of a worldwide collection of freshwater sponges (Porifera: Spongillidae). U.S. Nat. Mus Bull. 272: 1-184.

POIRRIER, M.A. 1969. Louisiana fresh-water sponges: taxonomy, ecology and distribution. Louisiana State University. Ph.D. Dissertation. Univ. Microfilms No. 70-9083.

POIRRIER, M.A. 1974. Ecomorphic variation in gemmoscleres of Edphydatia fluviatilis Linnaeus (Porifera: Spongillidae) with comments upon its systematics and ecology. Hydrobiol. 44: 337-347.

POIRRIER, M.A. 1977. Systematic and ecological studies of Anheteromeyenia ryderi (Porifera: Spongillidae) in Louisiana. Trans. Amer. Microsc. Soc. 96: 62-67.

POTTS, E. 1880. On freshwater sponges. Proc. Acad. Nat. Sci. Phil. 1880: 356-357.

POTTS, E. 1881. Some new genera of freshwater sponges. Proc. Acad. Nat. Sci. Phil. 1881: 149-150.

POTTS, E. 1882. Three more freshwater sponges. Proc. Acad. Nat. Sci. Phil 1882: 12-14.

POTTS, E. 1885. A new freshwater sponge from Nova Scotia. Ann. Mag. Nat. Hist. (5) 15: 425-426.

POTTS, E. 1886. Freshwater sponges from Newfoundland: a new species. Ann. Mag. N. H. ser 5, 18: 243-246.

POTTS, E. 1887. Contributions towards a synopsis of the American forms of freshwater sponges with descriptions of those named by other authors and from all parts of the world. Proc. Acad. Nat Sci. Phil 1887 158 279

REISWIG, H M. and BROWMAN. 1987. Use of membrane filters for microscopic preparations of sponge spicules. Trans. Am. Micr. Soc 106 10 20.

RICCIARDI, A. and LEWIS, D.J. 1991. Occurrence and ecology of Lophopodella carteri (Hyatt) and other freshwater Bryozoa in the lower Ottawa River near Montreal, Quebec. Can. J. Zool. 69: 1401 1404.

ROSA-BARBOSA, R. de 1988. Corvospongilla volkmeri sp n. e registro de Corvospongilla seckti Bonetto & Ezcurra de Drago, 1966 no Brasil (Porifera, Spongillidae). Iheringia Ser. Zool. (67): 109-122.

SALLER, U. 1990a. A redescription of the freshwater sponge Trochospongilla horrida (Porifera, Spongillidae). Abh. Naturwiss. Ver. Hamburg (NF) 31/32 163-174.

SALLER, U. 1990b. The formation of gemmule shells in the freshwater sponge Trochospongilla horrida (Porifera, Spongillidae). Zool. Jb. Anat. 120: 239 250.

SALLER, U. 1990c. Formation and construction of asexual buds of the freshwater sponge Radiospongilla cerebellata (Porifera, Spongillidae). Zoomorph. 109: 295-301.

SIMPSON, T.L. 1980. Reproductive processes in sponges: a critical evaluation of current data and views. Int. J. Invert. Reprod 2: 251 269.

SMITH, F. 1921. Distribution of the fresh-water sponges of North America. Illinois Dept. Regist. Educ. Nat. Hist. Survey, Bull. 14: 9 22.

SMITH, F. 1930. Some recent collections of Canadian freshwater sponges. Can. Field-Nat. 44: 182-185.

TRAXLER, L. 1898. Beitrage zur Kenntnis der Spongilla novae terrae Potts. Termesz Fuzetek 21: 314-324.

VOLKMER-RIBEIRO, C. 1986. Evolutionary study of the freshwater sponge genus Metania Gray, 1867: III. Metaniidae, new family. Amazoniana 9(4): 493-509

VOLKMER-RIBEIRO, C. and TRAVESET, A. 1987. Annotated catalog of the type specimens of Pott's species of freshwater sponges. Proc. Acad. Nat. Sci. Phila. 139: 223-242.

WELTNER, W. 1893. Uber die Autorenbezeichnung von Spongilla erinaceus. Sitz. Ber. Ges. Naturf. Freunde, Berlin 1893: 7-13.

WELTNER, W. 1895. Spongillidenstudien III. Katalog und Verbreitung der bekannten Susswasserschwamme. Arch. fur Naturg. 66: 114-144.

WRIGHT, B. 1989. The fauna of Sable Island. N.S. Mus. Cur. Rept. 68: 93p.

CONNECTING STATEMENT

In Chapter IV, the results of a comprehensive study of the freshwater sponge fauna of Eastern Canada were presented. Freshwater sponges were found to be a much more common and diverse group than was indicated by extant species records, but this was expected given (1) the lack of previous aquatic invertebrate surveys, and (2) the wide range of habitats and ecological conditions existing within the region.

Chapter V examines the ectoproct bryozoan fauna occurring in Eastern Canadian inland waters. Like the spongillids, this group has received very little attention, and relatively few Canadian records exist. This chapter presents new information concerning the taxonomy, morphology, distribution, and ecology of Eastern Canadian freshwater bryozoans

CHAPTER V

Taxonomy, distribution and ecology of the freshwater bryozoans (Ectoprocta) of Eastern Canada

Abstract

A recent survey of the freshwater ectoproct bryozoans of Eastern Canada (from Ontario to Newfoundland) recorded 14 species in the region, representing almost 60% of the total number of species known from North America. The bryozoans Lophopodella carteri and Pottsiella erecta are new to Canada. Plumatella fruticosa is recorded from Eastern Canada for the first time. Detailed notes on the taxonomy, morphology, distribution and ecology of each Eastern Canadian species are given. A taxonomic key to the Eastern Canadian freshwater bryozoans, including a key to statoblasts, is presented.

Introduction

Freshwater bryozoans (Ectoprocta) are common, sessile, filter-feeding organisms found attached to submerged surfaces in a wide variety of inland water habitats. As a group, they are widely distributed (Bushnell 1973), may dominate epibenthic and littoral communities in biomass (Bushnell et al. 1987; Raddum and Johnsen 1983), and contribute significantly to the recycling of phosphorus and nitrogen in small lentic habitats (Job 1976; Sorensen et al. 1986). Encrusting bryozoan colonies may foul boats, fishnets (Jonasson 1963), and fish culture cages (Greenland et al. 1988), and obstruct the pipes and conduits of water supplies (Shrivastava and Rao 1985) and nuclear power installations (Aprosi 1988; Pourcher and d'Hondt 1987). However, they have received little attention and are among the poorest known faunal groups in Canada. This may be largely due to difficulties in species identification, and the lack of useful taxonomic and ecological information on species occurring in Canadian waters.

There are about 24 described species of freshwater bryozoans in North America (Wood 1991). It was expected that a diverse group of freshwater bryozoans would be found in Eastern Canada, due to the diversity and abundance of freshwater habitats and the wide range of ecological conditions in the region. To test this hypothesis, specimens were obtained from various parts of Ontario, Quebec, New Brunswick, Prince Edward Island, and Newfoundland, representing a general survey of the freshwater bryozoan fauna of Eastern Canada. This survey involved a detailed examination of the morphology, taxonomy, distribution, and ecology of each identified species. Preliminary results obtained from Quebec have already been reported elsewhere (Ricciardi and Lewis 1991).

Materials and Methods

I collected specimens from May to November, 1989-1991, from various localities in southern Quebec and eastern Ontario. Additional specimens were obtained from the collections of museums and universities. The sources are listed below, and abbreviations are given, where applicable, for future reference to specimens from these collections:

Canadian Museum of Nature (formerly National Museum of Canada) (CMN; NMC)

Department of Entomology (Lac St-Louis collection), McGill University

New Brunswick Museum (NBM)

Redpath Museum, McGill University

Royal Ontario Museum (ROM)

Specimens in my personal collection have been given the prefix "AR". In total, approximately 500 specimens from Eastern Canada were examined. I measured water quality of most of the collection sites in Quebec and Ontario; temperature and pH were measured on site, using a Fisher mercury thermometer and a Cole-Parmer digital pH meter (model 05941-20), respectively. Water samples were transported back to a lab or field station to measure calcium and magnesium hardness (as $CaCO_3$ and $MgCO_3$, respectively), using a chemical test kit (LaMotte Chemical Products Co.). Water quality data from New Brunswick were obtained from D.F. McAlpine (New Brunswick Museum).

Methods of preservation and preparation generally follow Wood (1989). Statoblast and zooecial measurements were made using a Numonics 2200 digitizing tablet and SigmaScan (version 3.92, Jandel Scientific) software.

Results and Discussion

In total, 14 species of freshwater bryozoans, representing 2 classes and 6 families, were collected from various regions in Eastern Canada (Table

1; Table 2). These species comprise 58% of the total number of described species in North America, indicating that freshwater bryozoans are a well-represented and much more diverse group in Eastern Canada than previous records would indicate. This is by no means a definitive picture of the bryozoan fauna of Eastern Canada. Given annual and seasonal population fluctuations, as well as large areas in Eastern Canada whose aquatic invertebrate fauna has generally been poorly surveyed, further investigation would certainly reveal more species throughout the region.

Table 1: Classification of freshwater bryozoans occurring in Eastern Canada.

Phylum Ectoprocta

Class Phylactolaemata

Family Fredericellidae

1 *Fredericella indica* Annandale 1909

Family Plumatellidae

2 *Plumatella casmiana* Oka 1907
3 *Plumatella emarginata* Allman 1844
4 *Plumatella fruticosa* Allman 1844
5 *Plumatella fungosa* (Pallas 1768)
6 *Plumatella orbisperma* Kellicott 1882
7 *Plumatella repens* (Linnaeus 1758)
8 *Plumatella reticulata* Wood 1988
9 *Hyalinella punctata* (Hancock 1850)

Family Lophopodidae

10 *Lophopodella carteri* (Hyatt 1866)

Family Pectinatellidae

11 *Pectinatella magnifica* (Leidy 1851)

Family Cristatellidae

12 *Cristatella mucedo* Cuvier 1798

Class Gymnolaemata

Order Ctenostomata

Family Paludicellidae

13 *Paludicella articulata* (Ehrenberg 1831)
14 *Pottsiella erecta* (Potts 1884)

Table 2. Distribution of Eastern Canadian freshwater bryozoans*

	Species codes													
Province	1	2	3	4	5	6	7	8	9	10	11	12	13	14
Ontario	*	*	*		*	*	*	*	*		*	*	*	
Quebec	*	*	*	*	*		*	*	*	*	*	*	*	*
New Brunswick				*	*		*				*	*		
Prince Edward Island			*		*									
Newfoundland												*		

(* Species codes refer to numbered species in Table 1.)

A full description of each species, including notes on taxonomy, ecology, and distribution in Eastern Canada, is presented below. A key to Eastern Canadian species follows. Figures are provided; in some cases, individual figures may apply to two or more species which share the same illustrated characters. Synonyms are limited to those published for Eastern Canada. Water quality data is provided for active, living colonies, rather than for the more resistant statoblast phase.

Fredericella indica Annandale 1909

Pl.I,Fig.3; Pl.IV,Figs.7-9

Fredericella regina Odell 1899

Fredericella sultana Huntsman 1913; White 1915; Rogick 1937

Fredericella indica Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Colony dendritic with recumbent, or free and erect antler-shaped branches (Pl.I, Fig.3); recumbent branches are keeled; erect branches are

without a keel. Ectocyst brown or grey, lightly to heavily encrusted. Extended lophophore circular in outline. Statoblasts without annulus, non-buoyant, elongated-oval or kidney-shaped in outline (Pl.IV, Figs.7-9); surfaces of both valves are marked extensively with a uniform pattern of small hexagonal pits (resembling the surface of a golf ball) clearly visible when a dried valve is examined under a microscope; in some specimens, the pitting is reduced in size or depth, or is replaced by a light reticulation. Statoblasts occur in both free and adherent branches; 1-3 statoblasts may be present in each zooid; statoblast length=413-500-550 μm (25 counts, std.dev.=38.6), width=149-204-278 μm (25 counts, std.dev.=33.8).

Taxonomy

Wood and Backus (1991) have presented morphological and genetic evidence that North American and European forms of Fredericella sultana are different species. Both forms are easily separated by the surface patterning of the statoblast. Fredericella indica has a pitted or reticulated statoblast, whereas F. sultana has a smooth statoblast without any distinct surface marking. The surface pattern of the F. indica statoblast is best observed on a dried valve, since the valve may appear smooth when wetted. Some specimens from Ile Perrot, Quebec (AR21B, AR32B, AR122B) have lightly reticulated valves without any pitting. These specimens grow in the same habitat as, and sometimes in the immediate vicinity of, colonies which have pitted statoblasts.

All known Canadian specimens of Fredericella have the characteristic statoblasts of F. indica.

Habitat and general ecology

Fredericella indica was found to occur in lentic and lotic habitats in

the following water quality conditions: temperature=4-26°C, pH=6.1-9.4, calcium=0-78 mg/L, magnesium=2-70 mg/L. The species is clearly eurytopic with respect to water temperature and pH. Living colonies have been found to tolerate temperatures of 1.5-2°C under an ice-covered lake throughout the winter (Bushnell 1966). The highest temperature recorded for the species is 32°C (Everitt 1975). I have collected several living colonies from water of pH=9.4 in the St. Lawrence River near Ile Perrot, representing a new tolerance limit for the species. Fredericella indica has been found in pH as low as 4.7 (Everitt 1975).

In Quebec, Fredericella indica is commonly associated with the bryozoans Plumatella reticulata and Paludicella articulata, and the sponges Eunapius fragilis and Ephydatia muelleri. It is one of the most common epizoic species on bivalves (Bushnell 1966; Curry et al. 1981), and occurs on the shells of up to 70% of living unionid mussels, Elliptio complanata, in some lakes in southern Quebec.

The erect growth form of F. indica has several ecological advantages: (1) it allows the colony to escape fouling and siltation, e.g., from their own fecal wastes; (2) it may lessen competition for space and food; (3) it allows colonization of a greater variety of substrates, e.g., the muddy bottom sediments of lakes (Bushnell 1966), and (4) it allows dispersal by fragmentation (Wood 1973). These advantages are shared by other bryozoans (e.g., Paludicella articulata) and sponges (e.g., Spongilla lacustris) which have erect or free-branching growth forms.

Distribution in Eastern Canada

Ontario (Odell 1899; Huntsman 1913; White 1915; Rogick 1937), Quebec (Ricciardi and Lewis 1991).

Fredericella indica is one of the most common and widespread bryozoans

in Quebec and Ontario, and can be expected to occur throughout the Eastern Canadian region.

Plumatella casmiana Oka 1907

Pl.I,Fig.2; Pl.III,Figs.1-5; Pl.IV,Fig.4

Plumatella casmiana Rogick 1943

Description of Eastern Canadian specimens

Colony compact, dendritic, entirely recumbent; colonial branches tend to radiate from a common point of origin. Ectocyst brown or grey, semi-translucent or opaque, normally heavily encrusted and somewhat brittle, strongly keeled, furrowed at zooecial tips (Pl.I, Fig.2). Zooids crowded, often partially fused; septa usually present.

Floatoblasts of two types may be present: the first type is thick-walled, buoyant, and often has a pointedly-convex ventral capsule (Pl.III, Figs.1-3); the second type, termed a leptoblast, is thin-walled, non-buoyant, has a uniformly thin annulus, and is twice as long as wide (Pl.III, Figs.4-5). Both types are symmetrical in lateral outline, and have extensive, oval fenestrae; the fenestral length is at least 1.5 times its width. Measurements of the thick-walled floatoblast are as follows: length=297-(323)-340 μm (15 counts, std.dev.=14.3), width=184-(202)-222 μm (15 counts, std.dev.=9.0), dorsal fenestra length=167-(191)-213 μm (15 counts, std.dev.=13.0), width=114-(127)-140 μm (15 counts, std.dev.=8.3); ventral fenestra length=179-(235)-271 μm (15 counts, std.dev.=23.0), width=138-(158)-177 μm (15 counts, std.dev.=12.0). Leptoblasts were not found in the few Eastern Canadian specimens that were collected. Bushnell (1965) gives the following measurements for Michigan P. casmiana leptoblasts: length=340-430 μm, width=160-220 μm.

Sessoblasts are round or oval (Pl.IV, Fig.4); the frontal valve is mostly smooth, but sometimes has a conspicuous, central raised tubercle; lamella typically very thin, normally less than 40 μm in width, and oriented perpendicular to the substrate; sessoblast length (including lamella)= 441-(463)-478 μm (15 counts, std.dev.=19.8), width (including lamella)=272 (321)-366 μm (15 counts, std.dev.=47.1), lamella width=24 (35) 47 μm (19 counts, std.dev.=8.0).

Bushnell and Wood (1971) describe honeycomblike P. casmiana colonies derived from the fusion of erect, densely crowded zooids; these colonies have not yet been found among Eastern Canadian specimens of this species.

Taxonomy

The presence of leptoblasts, found in no other bryozoan, insures correct identification of P. casmiana. The extensive, oval fenestrae of the floatoblasts, with an average length/width ratio of at least 1.5, is a key feature of the species (Wood 1991).

Habitat and general ecology

Luxuriant colonies of P. casmiana have been reported to foul fish culture cages, impeding water flow and thus adversely affecting fish growth (Greenland et al. 1988). The species is found in both lentic and lotic habitats, with a preference for alkaline waters (Bushnell 1968). In Quebec, colonies occur on limestone channel markers in the St. Lawrence River, in areas where the pH is as high as 9.0.

In most plumatellid bryozoans, floatoblasts serve as dispersal agents and sessoblasts have both overwintering and recruitment functions (Karlson 1991; Pourcher and d'Hondt 1987; Raddum 1981). However, P. casmiana sessoblasts are formed only in response to adverse environmental conditions;

they often complete development when the parent colony has deteriorated, and conserve favorable substrate during unfavourable periods for future generations (Wood 1973). The functions of dispersal and recruitment are divided among both types of P. casmiana's floatoblasts. The thick-walled, buoyant floatoblast has dispersal capability; the thin-walled, non-buoyant leptoblast is produced in the early part of the growing season (Rogick 1943) and germinates immediately after release from the colony (Mukai et al. 1983), thereby serving as a mechanism of colonial recruitment during favourable periods.

Distribution in Eastern Canada

Ontario (Rogick 1943), Quebec.

In Ontario, P. casmiana has been collected from Lake Erie (Rogick 1943) and the Grand River at Caledonia (ROM K-5). In Quebec, where it was previously unrecorded, P. casmiana is rare and occurs in the St. Lawrence River near the Island of Montreal (AR11B; AR25B).

Plumatella emarginata Allman 1844

Pl.I,Fig.2; Pl.III,Figs.15-17; Pl.IV,Figs.2,6

Plumatella diffusa Osler 1883

Plumatella princeps var. emarginata Davenport 1904

Plumatella repens var. emarginata Rogick 1937

Plumatella emarginata Huntsman 1913; White 1915

Description of Eastern Canadian specimens

Colony dendritic, zooids recumbent or erect; ectocyst brown or grey, translucent to opaque, lightly to heavily encrusted; recumbent branches usually keeled (Pl.I, Fig.2); septa present at the junction of every branch;

branches may be fused; in rare cases, the upright tips of many branches are fused together to form a honeycomblike mass. Floatoblasts (Pl.III, Figs.15-17) oval, with a distinctly flattened dorsal valve and a concave ventral valve, giving the floatoblast a strongly asymmetrical lateral outline; dorsal annulus is extensive, leaving only a small fenestra uncovered, maximum width of dorsal annulus is at least as great as the length of the dorsal fenestra; annulus often with a silvery sheen, less commonly with a bronze sheen; floatoblast length=382-(422)-460 μm (25 counts, std.dev.=18.3), width=200-(237)-258 μm (25 counts, std.dev.=13.7); dorsal fenestra length=84-(126)-150 μm, width=58-(95)-123 μm (25 counts, std.dev.=16.2); ventral fenestra length=196-(223)-250 μm (25 counts, std.dev.=13), width=169-(188)-210 μm (25 counts, std.dev.=11.4).

Sessoblasts (Pl.IV, Figs.2,6) round or oval; frontal valve uniformly granular, densely covered with large dorsal tubercles visible under high magnification (40X); lamella of highly variable width; sessoblast length (including lamella)=401-(453)-513 μm (10 counts, std.dev.=52.3), width (including lamella)=264-(354)-414 μm (10 counts, std.dev.=52.3); lamella width=33-(52)-60 μm (10 counts, std.dev.=10.7).

Taxonomy

Plumatella emarginata closely resembles its congener P. reticulata, but emarginata's strongly asymmetrical floatoblast and smooth sessoblast (lacking the network of ridges present on P. reticulata's sessoblast) clearly distinguishes the species.

Habitat and general ecology

Plumatella emarginata is found predominantly in streams or waveswept areas of lakes. It often grows luxuriantly on the tops of rocks in fast-

slowing streams. In calm, lentic habitats, P. emarginata grows on the underside of submerged surfaces, even in shaded areas; since the colony commonly occupies upper, exposed surfaces in running water (with fecal wastes and other debris being washed away by the current), the preferred position on the substrate is likely designed to avoid fouling or siltation, rather than to avoid light or competition with periphyton.

Specimens of P. emarginata were collected from the following water quality conditions: temperature=14-21°C, pH=7.0-8.4, calcium=20-68 mg/L, magnesium=20-28 mg/L.

Distribution in Eastern Canada

Ontario (Davenport 1904; Huntsman 1913; White 1915; Rogick 1937), Quebec, Prince Edward Island.

Plumatella emarginata has not been previously recorded from Quebec or Prince Edward Island. In Quebec, I collected several specimens from lake outflows in the Laurentian region near Morin Heights, and as far south as the Chateauguay River near Huntington. I have also obtained a specimen from a pond at Southport, Prince Edward Island.

Plumatella fruticosa Allman 1844

Pl.I,Figs.3; Pl.III,Figs.12-14; Pl.IV,Figs.1,5

Plumatella repens var. fruticosa Rogick 1935

Description of Eastern Canadian specimens

Colony dendritic; zooecial branches recumbent with upright tips or growing free of the substrate (Pl.I, Fig.3); ectocyst lightly to moderately encrusted; recumbent branches with keel; no visible septa; zooecial diameter ranges from 250-(339)-460 μm (14 counts, std.dev.=59.0). Both floatoblasts

(Pl.III, Figs.12-14) and sessoblasts (Pl.IV, Figs.1,5) are long and narrow, and strongly asymmetric in lateral view; statoblast length is usually greater than twice the width. The dorsal surface of the floatoblast is flattened or even slightly concave, the dorsal fenestra is very narrow; the ventral surface is convex, and the ventral fenestra is long and oval; both dorsal and ventral fenestrae have a length/width ratio greater than 2. The annulus is covered with either a bronze or silvery sheen. Statoblast length=385-(443)-563 μm (20 counts, std.dev.=51), width-179 (200) 226 μm (20 counts, std.dev.=42.9); dorsal fenestra length=191-(232) 349 μm (16 counts, std.dev.=35.5 μm), width=54-(78)-128 μm (16 counts, std.dev.=18); ventral fenestra length=277-(290)-378 μm (20 counts, std.dev.=39), width=96-(138)-163 μm (20 counts, std.dev.=17.3).

Sessoblasts are broadly oval, almost rectangular; the frontal valve is covered with irregular tubercles, sometimes giving it a reticulated appearance; the lamella is sclerotized and conspicuously reticulated, has wavy serrated margins, and widens at the poles; sessoblast length (including lamella)=445-(504)-582 μm (20 counts, std.dev.=30.7), width (including lamella)=236-(273)-315 μm (20 counts, std.dev.=20.3); lamella width=32-(67) 97 μm (20 counts, std.dev.=11.2).

Taxonomy

The zooecia of this species resemble those of Fredericella indica, but the statoblasts, with their distinct annulus, are easily distinguished from those of F. indica. The combined statoblast characteristics (large length/width ratio, strong asymmetry of floatoblast and sessoblast, narrow fenestra on dorsal floatoblast valve) distinguish P. fruticosa from all other species.

Some authors consider the presence of serrated zooecial branches

in P. fruticosa to be taxonomically important; the serrations result from the budding and successive shedding of newly formed zooids. This feature is not seen in Quebec specimens, and is apparently uncommon in North America (Bushnell 1968).

Habitat and general ecology

Plumatella fruticosa was collected from two Quebec lake outflows of pH=6.1-6.3 in a temperature of 10°C, where it was associated with other bryozoans, Cristatella mucedo and Fredericella indica, and the sponge Spongilla lacustris. The species was also found in a northern New Brunswick lake in the following water quality conditions: temperature=18.5-21.5°C, pH=7.7-8.5, calcium=7.7-8.1 mg/L, magnesium=1.0-1.2 mg/L, potassium=0.3 mg/L, sodium=1.6-1.7 mg/L; also occurring in this lake were Plumatella fungosa and P. repens.

Plumatella fruticosa occurs primarily in cold, holarctic lakes and streams, particularly in montane regions (Bushnell 1968), in pH as low as 5.7 (Bushnell 1966).

Distribution in Eastern Canada

Quebec, New Brunswick

Plumatella fruticosa is reported from Eastern Canada for the first time. The only other record of this species in Canada is from Vancouver Island (Carl 1943). Rogick (1935) reported the species from the western basin of Lake Erie. The species is known from Lac Demarest (AR145B) and Lac Minette, in Parc Mastigouche, Quebec, and from Mecormack Lake, Restigouche County, New Brunswick (AR162B).

Plumatella fungosa Pallas 1768

Pl.I,Fig.5; Pl.III,Figs.6-7,9; Pl.IV,Figs.2,6

Plumatella fungosa White 1915

Description of Eastern Canadian specimens

Mature colony compact; branches fused throughout their length; often growing as an erect honeycomblike or fungoid mass (Pl.I, Fig.3). Ectocyst brown or colorless, transparent to opaque, normally only lightly encrusted; conspicuous dark septa usually present; recumbent branches may be weakly keeled. Floatoblasts (Pl.III, Figs.6-7) are round to oval, and strongly asymmetric in lateral view due to an inflated ventral capsule, which is often pointed; floatoblast length=270-(327)-388 μm (40 counts, std.dev.=17.5), width=211-(240)-273 μm (40 counts, std.dev.=11.6); dorsal fenestra length=106-(154)-202 μm (40 counts, std.dev.=11.9), width=100-(147)-183 μm, (40 counts, std.dev.=13.8); ventral fenestra length=167-(216)-252 μm (40 counts, std.dev.=12.0), width=139-(182)-227 μm (40 counts, std.dev.=13.3).

Sessoblasts are round to oval (Pl.IV, Figs.2,6), normally with a wide lamella; sessoblast length (including lamella)=391-(445)-502 μm (14 counts, std.dev.=23.3), width (including lamella)=277-(335)-411 μm (14 counts, std.dev.=30.2), lamella width=29-(46)-64 μm (14 counts, std.dev.=6.0). The surface of both the sessoblast and the floatoblast is covered with a raised reticulation and interstitial tubercles (Geimer and Massard 1986; Mundy 1980) very similar to that which occurs on the statoblasts of Plumatella repens and P. orbisperma (Ricciardi and Wood 1992; Chapter II), and discernible only under high magnification.

Taxonomy

The conspicuous fungoid mass of adherent zooids is a characteristic feature of Plumatella fungosa; only P. casmiana and P. emarginata are known to occasionally produce similar colonies. In such cases, statoblast features may easily distinguish the species.

Habitat and general ecology

Plumatella fungosa is found primarily on firm substrates in stagnant, eutrophic waters. Eastern Canadian specimens are known from the following water quality conditions: temperature=15-23°C, pH=7.1-8.6, calcium=7.7-7.8 mg/L, magnesium=1.0-70.0 mg/L. Plumatella fungosa grows very prolifically with biomass densities up to 1600 g/m^2 (Job 1976, Jonasson 1963), and plays a significant role in the removal of nitrogen (Job 1976) and the release of phosphorus (Sorensen et al. 1986) in the water column of small lakes. It can tolerate highly polluted conditions, including exposure to extensive heavy metal and PCB contamination (Henry et al. 1989). Large encrustations of P. fungosa foul boats and fishnets (Jonassen 1963), and obstruct the cooling circuits of nuclear power stations in Europe (Aprosi 1988; Pourcher and d'Hondt 1987). In Lac St-Louis (St. Lawrence River, Quebec), P. fungosa is associated with recently established populations of zebra mussels, Dreissena polymorpha (Bivalvia: Dreissenidae).

Distribution in Eastern Canada

Ontario (White 1915), Quebec, New Brunswick, Prince Edward Island.

The only published record of Plumatella fungosa in Eastern Canada is from Georgian Bay, Ontario (White 1915). I have obtained a specimen (AR161B) from Wolf Island (St. Lawrence River) near Kingston, Ontario. In Quebec, I have collected specimens from the following locations: Lac Macdonald and Lac

Carruther (AR60B), near Lachute; Ile Perrot (AR105B,106B) and Lac St-Louis (AR128B,129B), near the Island of Montreal; Lac Hertel (AR139B) near Mt. St-Hilaire; and Parc d'Avignon (AR154B) near Huntington. In New Brunswick, the species occurs in Mecormack Lake (Restigouche Co.) (AR163B). The species is also found in a pond at Southport, Prince Edward Island (AR141B).

Plumatella orbisperma Kellicott 1882

Pl.II, Fig.1; Pl.III, Figs.3,10-11

Plumatella orbisperma Ricciardi and Wood 1992

Description of Eastern Canadian specimens

Colony dichotomously branched, mostly recumbent; polypides in erect clusters of 2 to 7 (Pl.II, Fig.1), usually connected by only a narrow stolon. Ectocyst soft, gelatinous, transparent, swollen, without keeling or encrustation; septa absent. Floatoblasts are circular (length/width ratio=1.07-1.11), biconvex and generally symmetrical in lateral view; the ventral capsule is pointed (Pl.III, Fig.3). The annulus is thin on both the dorsal and ventral surfaces (Pl.III, Figs.10-11); the average dorsal and ventral annulus width are less than 18% and 11% of the floatoblast length, respectively. Floatoblast length=320-(332)-336 μm (6 counts, std.dev.=6.1), width=288-(300)-304 (6 counts, std.dev.=6.1); dorsal fenestra length=192-(213)-240 μm (6 counts, std.dev.=17.7), width=192-(203)-208 μm (6 counts, std.dev.=7.5); ventral fenestra length=240-(257)-272 μm (6 counts, std.dev.=9.7), width=224-(232)-256 μm (6 counts, std.dev.=12.2). Sessoblasts are circular; sessoblast length (including lamella)=528-(549)-576 μm (3 counts), width (including lamella)=410-(429)-448 μm (3 counts); average length/width ratio=1.2.

The dorsal and ventral fenestrae of the floatoblast and the frontal

valve of the sessoblast are covered with tubercles which are prominent near the periphery, but disappear toward the center. The tubercles are enclosed in a lightly raised reticulation, visible with scanning-electron microscopy, very similar to that which occurs on the statoblasts of certain other Plumatella species.

Taxonomy

This species is closely allied with Plumatella repens and P. fungosa (Ricciardi and Wood 1992; Chapter II). The soft, swollen ectocyst resembles that of Hyalinella punctata, but the floatoblasts easily distinguish the species, and sessoblasts are absent in H. punctata. The lateral symmetry of the floatoblast and the lack of zooecial septa in P. orbisperma easily separate it from hyaline forms of P. fungosa. The combination of erect, clustered polypides, and the round floatoblast with its thin annulus and pointed ventral capsule distinguish P. orbisperma from hyaline forms of P. repens.

Habitat and general ecology

Plumatella orbisperma has only been found in calm, standing waters rich in macrophytes, algae, and organic material (Bushnell 1974), with a mean pH of 7.3 (Bushnell 1966).

Distribution in Eastern Canada

Ontario (Ricciardi and Wood 1992).

In Canada, Plumatella orbisperma is known only from Go Home Lake, Georgian Bay, Ontario (ROM K-13). It is probably much more widespread than scanty records would indicate, and may occur in a large number of scattered eutrophic ponds and lakes throughout the Great Lakes region.

Plumatella repens (Linnaeus 1758)

Pl.I,Fig.1; Pl.III,Figs.6-7,8; Pl.IV,Figs.2,6

Plumatella arethusa Osler 1883; Davenport 1904

Plumatella repens Odell 1899; Huntsman 1913; White 1915; Rogick 1937; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Colony recumbent and dendritic, forming large, flat, spreading masses; in rare cases, branches are closely appressed and partially fused; ectocyst translucent to opaque, colorless or colored reddish-brown, normally unencrusted, sometimes lightly (never heavily) encrusted; a faint keel may be present; zooids usually filled with numerous floatoblasts. Floatoblasts round to broadly oval (Pl.III, Figs.6-7); valves symmetric in lateral view (Pl.III, Fig.8); minute tubercles interstitially enclosed in a raised reticulation (visible under high magnification) cover the dorsal and ventral fenestrae, and are prominent where the annulus and fenestra meet (Geimer and Massard 1986; Wood 1979). The dorsal fenestra is either round or slightly truncated, and variable in size. The ventral fenestra is roughly circular and relatively large. Floatoblast length=312-(367)-391 μm (20 counts, std.dev.=21.5), width=237-(251)-270 μm (20 counts, std.dev.=7.4); dorsal fenestra length=128-(147)-157 μm (20 counts, std.dev.=10.3), width=137-(149)-165 μm (20 counts, std.dev.=10.0); ventral fenestra length=206-(227)-241 μm (20 counts, std.dev.=13.3), width=191-(199)-209 μm (20 counts, std.dev.=7.0).

Sessoblasts round to oval (Pl.IV, Figs.2,6); lamella wide and usually parallel to the substrate; tubercles on the frontal valve are enclosed in a faint reticulation similar to that which appears on the floatoblast, but only discernible with scanning-electron microscopy. Sessoblast length (including lamella)=347-(462)-474 μm (10 counts, std.dev.=16.8), width

(including lamella)=336-(364)-392 μm (10 counts, std.dev.=40.0); lamella width=49-(52)-54 μm (10 counts, std.dev.=2.4).

Taxonomy

The absence of septa, the generally unfused branches, and the symmetric floatoblast valves of Plumatella repens distinguish it P. fungosa. Hyaline forms of P. repens have a clear, transparent ectocyst, and may produce a round floatoblast with a thin dorsal and ventral annulus. These forms of P. repens are distinguished from P. orbisperma by the following differences: (1) the polypides of P. repens are not arranged into erect clusters, unlike those of P. orbisperma; (2) the ventral floatoblast capsule is not as inflated or pointed as in P. orbisperma; (3) the floatoblast annulus, especially on the dorsal surface, is not as thin as in P. orbisperma. On average, the dorsal annulus width is greater than 20% of the floatoblast length for P. repens, but is less than 18% of the floatoblast length for P. orbisperma.

Habitat and general ecology

Colonies of Plumatella repens are found from early May until late October in Eastern Canada, and have been collected from the following water quality conditions: temperature=17-23°C, pH=7.2-8.5, calcium=7.7-120.0 mg/L, magnesium=1.0-90.0 mg/L. Plumatella repens is most often found associated with the bryozoans P. fungosa, P. emarginata, and P. reticulata, the sponge Eunapius fragilis, as well as larval caddisflies, Ceraclea nepha (Trichoptera: Leptoceridae), which are common predators of P. repens in southern Quebec (Ricciardi and Lewis 1991). Colonies of P. repens are found growing on a variety of substrates, including macrophytes, Vallisneria americana, Nymphaea tuberosa, Nuphar variegatum, Pontederia sp., and

Potamogeton sp. Like many other bryozoans, P. repens grows preferentially on the underside of submerged surfaces to escape fouling from periphyton, seston, and their own fecal wastes (Raddum 1981).

Distribution in Eastern Canada

Ontario (Odell 1899; Davenport 1904; Huntsman 1913; White 1915; Rogick 1937), Quebec (Ricciardi and Lewis 1991), New Brunswick.

I have obtained a specimen of P. repens from Mecormack Lake, Restigouche Co., New Brunswick (AR164B), which represents the first collection of this species from the province.

Plumatella repens is widespread and common in North America (Bushnell 1973), and can be expected to occur throughout Eastern Canada.

Plumatella reticulata Wood 1988

Pl.III, Figs.22-23; Pl.IV, Fig.3

Description of Eastern Canadian specimens

Colony recumbent, with upright zooecial tips. Ectocyst dark brown, heavily sclerotized, translucent to opaque, lightly to heavily encrusted, distinctly keeled. Dark, conspicuous septa occur at the junction of each branch. Zooecial tips are furrowed. Crowded branches may be fused along a portion of their length. Floatoblasts oval to broadly oval, valves approximately symmetrical in lateral view (Pl.III, Fig.23), float coverage on dorsal surface (Pl.III, Fig. 22) far more extensive than on ventral surface. Floatoblast length=273-(348)-389 μm (34 counts, std.dev.=17.0), width=177-(209)-225 μm (34 counts, std.dev.=22); dorsal fenestra length=67-(123)-136 μm (34 counts, std.dev.=17.3), width=55-(103)-125 μm (34 counts, std.dev.=20.8); ventral fenestra length=112-(146)-211 μm (17 counts,

std.dev.=31.0), width=108-(127)-156 μm (34 counts, std.dev.=21.0).

Sessoblasts oval; frontal valve of mature sessoblasts is marked with thick, dark reticulating ridges (Pl.IV, Fig.3), clearly visible under low magnification (40X). Sessoblast length (including lamella)=340-(397)-460 μm, (10 counts, std.dev.=31.5), width (including lamella)=208-(278)-328 μm (10 counts, std.dev.=33.0), lamella width=23-(33)-40 μm (10 counts, std.dev.=6).

Taxonomy

The distinctly reticulated sessoblast and the symmetric floatoblast valves clearly distinguish Plumatella reticulata from its congener P. emarginata, which is otherwise similar in appearance. Identification may be complicated by two factors:

(1) The reticulation is not always visible on immature sessoblasts, and its development is apparently a function of age; young colonies will usually have smooth or only faintly reticulated sessoblasts. A few unreticulated sessoblasts are often found in the extremities (i.e., the younger portion) of a mature colony, whereas the reticulated sessoblasts are found near the central (older) portion of the colony.

(2) A previously undescribed form of P. reticulata (AR104B) found in the lower Ottawa River (Quebec) has floatoblasts which are laterally curved or bent, and therefore appear asymmetrical in lateral view (although the valves are equally convex); in this colony, there are no floatoblasts of the normal type, but typical sessoblasts are present in abundance. Normal Plumatella reticulata colonies occurred in the same habitat.

Habitat and general ecology

In Eastern Canada, P. reticulata occurs primarily in calm, alkaline waters. It has been collected from the following range of water quality

conditions: temperature=20-26°C, pH=7.5-9.4, calcium=16-63 mg/l, magnesium=30-65 mg/L. Colonies of P. reticulata are sometimes overgrown by freshwater sponges (Eunapius fragilis, Spongilla lacustris), are often associated with the bryozoans Fredericella indica and Paludicella articulata, and have Aufwuchs communities predominantly composed of attached tubicolous rotifers (Limnias spp.). Colonies are locally abundant along the lower Ottawa River, reaching densities of up to 65 individual colonies (size >1 cm^2) per square meter.

Distribution in Eastern Canada

Ontario (Wood 1988), Quebec.

In Ontario, this species has been recorded from East Sister Island in the western basin of Lake Erie (Wood 1988), and occurs in the Grand River, Caledonia (ROM K-5). In Quebec, this species occurs in abundance in the Ottawa and St. Lawrence Rivers, and has also been found in Lac Carruther (approx. 45°40'N, 74°20'W) in the Laurentian region, which represents the northern limit of its known range.

Hyalinella punctata (Hancock 1850)

Pl.I,Fig.4; Pl.III,Figs.18-21

Plumatella punctata Davenport 1904; Huntsman 1913; White 1915

Hyalinella punctata Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Young colonies consist of recumbent, stoloniferous strings of contiguous zooids; mature colonies consist of flat, compact gelatinous masses formed by the agglutination of zooecial branches; most colonies have at least one long, linear branch. Ectocyst soft, swollen, gelatinous,

transparent, colorless or yellowish, unencrusted, and without septation or keeling; minute white spots (present in over 50% of Quebec specimens) are often visible on the ectocyst of younger portions of the colony. Floatoblasts are large, broadly oval, rounded or truncated at the poles, and asymmetrical in lateral view; dorsal and ventral fenestrae are broadly oval; the outline of the floatoblast capsule is clearly visible through the annulus; a conspicuous central nodule occurs on the floatoblast ventral capsule (Pl.III, Fig.20) in about 80% of Quebec specimens, but not all floatoblasts in a specimen may possess it. Floatoblast length=542-(586)-617 μm (40 counts, std.dev.=15), width=315-(408)-411 μm (40 counts, std.dev.=13); capsule length=365-(382)-403 μm (10 counts, std.dev.=12), width=270-(281)-295 μm (10 counts, std.dev.=8). Sessoblasts are absent.

Taxonomy

Some European authors (e.g., Lacourt 1968) report sessoblasts in Hyalinella punctata, but no confirmed specimens bearing sessoblasts exist. These reports are probably based on erroneous identifications of hyaline forms of Plumatella repens (Massard and Geimer 1991; Toriumi 1972). Ricciardi and Wood (1992; Chapter II) and Massard and Geimer (1991) discuss the sessoblast problem of H. punctata in detail.

The occurrence of a central nodule on the ventral floatoblast capsule is of unknown taxonomic significance, and may simply be ecomorphic. A similar structure has only been observed once in other Eastern Canadian species; 10% of the floatoblasts in a specimen of Plumatella repens (AR42B) from a creek on Ile Perrot, Quebec, had a similar nodule. Smith (1988) mentioned a "centrally located circular region" on the floatoblast capsules of H. punctata and P. fungosa, and Wood (1979) illustrated a small raised central tubercle on the ventral capsular valve of P. emarginata, but these

structures are rare and apparently not as well developed as those in Quebec specimens of H. punctata.

Habitat and general ecology

In southern Quebec, H. punctata has been collected from the following water quality conditions: temperature=14-26°C, pH=7.4-9.0, calcium=20-78 mg/L, magnesium=20-70 mg/L. Bushnell (1974) describes H. punctata as having preferences for alkaline, mesotrophic or eutrophic waters, and sometimes collected in pH>9.0. Wood (1991) associates H. punctata with very still waters; however, luxuriant colonies occur in great abundance in some riffle streams in southern Quebec. In lake outflows and tributaries of the Chateauguay River near Huntington, compact gelatinous colonies blanket the undersides of rocks in densities of 180 cm^2 of colony per m^2 of substrate. In southern Quebec, colonies first appear in early June when the water temperature exceeds 20°C. In late July, small (<1 cm) linear strings of zooids are found in sudden abundance (20-30 colonies/m^2) on the undersides of rocks and branches, when water temperatures range from 23-26°C. These colonies consistently lack the statoblast valves that are normally present at the point of origin of a colony, suggesting that the colonies (often too spatially separated to have resulted from fission) are larvally derived and that sexual reproduction and larval release occurs in early July. Statoblasts are formed in August.

A feature apparently associated with the absence of sessoblasts in H. punctata is its large floatoblast, similar in size to a normal sessoblast. Although having extensive float coverage, the H. punctata floatoblast is initially non-buoyant upon release from the colony. The larger floatoblast capsule should contain more yolk reserve, and therefore is probably better designed to survive prolonged unfavourable periods. These statoblasts may

serve to produce new generations of colonies in the same habitat after overwintering, as would a typical sessoblast. Upon drying, the statoblast becomes buoyant (Wood 1989), and presumably attains the dispersal capability of a typical floatoblast.

Distribution in Eastern Canada

Ontario (Davenport 1904; Huntsman 1913; White 1915), Quebec (Ricciardi and Lewis 1991).

This species is widely distributed in eastern North America (Bushnell 1973), and is expected to occur throughout Eastern Canada.

Lophopodella carteri (Hyatt 1866)

Pl.II,Fig.2; Pl.IV,Fig.10

Lophopodella carteri (Ricciardi and Lewis 1991)

Description of Eastern Canadian specimens

Colony yellow, gelatinous, transparent, globular and lobate, rarely greater than 1 cm in diameter (Pl.III, Fig.2). Ectocyst soft, without any encrustation. Polypides withdraw into a common coelomic cavity.

Only one type of statoblast is produced (Pl.IV, Fig.10). It is broadly oval and saddle-shaped, with a series of 8-13 spiny, marginal projections at both poles; statoblast length (with spines)=1150-(1121)-1126 μm (20 counts, std.dev.=30), width=904-(948)-979 μm (20 counts, std.dev.=20); spine length=200-(264)-357 μm (20 counts, std.dev.=20).

Taxonomy

As Wood (1989) noted, the unpigmented mouth region of the L. carteri lophophore distinguishes young colonies (without statoblasts) from those of

Pectinatella magnifica, which has a conspicuous red pigment. The yellowish coloration and lobate form of L. carteri colonies separates them from similar young colonies of Cristatella mucedo.

Habitat and general ecology

Lophopodella carteri is apparently restricted to alkaline waters (Bushnell 1966). In southern Quebec, the species has been recorded from the following water quality conditions: temperature=9-26°C, pH=7.4 9.4, calcium=18-30 mg/L, magnesium=20-30 mg/L. Colonies commonly occur on the stems and leaves of macrophytes, Ceratophyllum demersum, Elodea canadensis, Najas flexilis, Nymphaea tuberosa, Vallisneria americana, and are often found in association with bryozoans, C. mucedo and P. magnifica.

The coelomic fluid of L. carteri colonies is highly toxic to certain fish (Tenney and Woolcott 1964) and larval salamanders (Collins et al. 1966). The fluid damages the gill epithelium; animals lacking gills are apparently unaffected. The coelomic fluid may somehow be discharged into the water to discourage predation by fish. However, in southern Quebec, L. carteri is commonly preyed upon by larval caddisflies, Ceraclea nepha and C. submacula. Extensive predation of laboratory colonies by microturbellarians, Stenostomum sp. (Turbellaria: Catenulida), has also been observed (Ricciardi and Lewis 1991).

The Ottawa River population of L. carteri typically forms statoblasts in early July when water temperatures exceed 20°C. Colonies reach their greatest abundance in mid-summer in water temperatures of 23-25°C. A population density of 230 colonies/m^2 was observed in a stagnant pool (temperature=25°C, calcium=20 mg/L, magnesium=20mg/L, pH=9.4) near Ile Perrot, in July 1991.

Several living colonies were removed from unionid mussels (Elliptio

complanata) collected from the St. Lawrence River (at Iles de Boucherville, near the Island of Montreal), from a water temperature of 9°C, on November 3, 1991. These small (<5mm diameter), yellowish, lobate colonies had all of the features typical of L. carteri, but lacked statoblasts. The lowest recorded temperature at which living colonies have been collected is 8°C (Tenney and Woolcott 1962).

Distribution in Eastern Canada

Quebec (Ricciardi and Wood 1991).

In Eastern Canada, Lophopodella carteri is known only from the lower Ottawa River (Ricciardi and Lewis 1991) and the St. Lawrence River, near the Island of Montreal; this general area represents the northern limit of its known range. Previously unidentified specimens collected from the lower Ottawa River indicate that the species has been present at that location since at least 1982. Lophopodella carteri is uncommon and known from scattered localities in eastern North America (Wood 1991; Bushnell 1973).

Pectinatella magnifica (Leidy 1851)

Pl.II,Figs.3-4; Pl.IV,Fig.12

Pectinatella magnifica Goadby and Bovell 1855; Osler 1883; Odell 1899; Huntsman 1913; White 1915; Geiser 1934; Tanton 1935; Judd 1950; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Colony gelatinous, transparent; young colonies small (1-3 cm diameter) and lobed in outline (Pl.II, Fig.4); mature colonies occurring as contiguous rosettelike patches on a common gelatinous base or core, often growing as large, firm gelatinous masses several centimeters in diameter (Pl.II, Fig.3). Lophophore with a conspicuous red pigment around the mouth region.

Statoblasts of one type only, roughly circular, with a single row of 12-17 flattened, hooked spines around entire periphery (Pl.IV, Fig.12); statoblast diameter (including spines)=1209-(1275)-1322 μm (20 counts, std.dev.=32.6).

Taxonomy

No other bryozoan produces large, compound gelatinous colonies reaching several centimeters in diameter; Tanton (1935) and Judd (1950) report colonies measuring 30-50 cm in diameter from various localities in Ontario. Young, individual colonies of P. magnifica may be distinguished from all other bryozoans by the red pigment on the mouth region of the lophophore.

Habitat and general ecology

Colonies of P. magnifica occur in lentic areas and lake outflows in Eastern Canada from June to late October, normally produce statoblasts in July, and have been recorded from the following water quality conditions: temperature=9-26°C, pH=6.8-9.4, calcium=20-130 mg/L, magnesium=20-150 mg/L. Large compound colonies tend to occur in warm, shallow water, predominantly in shaded areas. While the most luxurient growth occurs at warm temperatures, several active colonies were collected from a water temperature of 9°C at Lac Papineau (near Lachute, Quebec), which is, to my knowledge, the lowest recorded temperature at which colonies have been collected.

Pectinatella magnifica is commonly associated with the bryozoan Cristatella mucedo, and the freshwater sponge Eunapius fragilis, and preyed upon by larval caddisflies, Ceraclea submacula (Trichoptera: Leptoceridae).

Distribution in Eastern Canada

Ontario (Goadby and Bovell 1855; Osler 1883; Odell 1899; Huntsman 1913; White 1915; Geiser 1934; Tanton 1935; Judd 1950), Quebec (Osler 1883; Ricciardi and Lewis 1991), New Brunswick (Osler 1883).

Pectinatella magnifica is very common and widespread throughout most of the Eastern Canadian region.

Cristatella mucedo Cuvier 1798

Pl.IV., Fig.11

Cristatella ophidoidea Osler 1883

Cristatella idae Odell 1899

Cristatella mucedo Davenport 1904; Huntsman 1913; White 1915; Rogick 1937; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Colony soft, transparent, gelatinous, smooth in outline, without lobes or branches, round when young, elongate and caterpillarlike when mature; usually no more than 1 cm in width and 2-5 cm in length, but occasionally much longer. Mature colonies have 3 marginal rows of polypides enclosing a clear, central space. Statoblasts are of one type (Pl.IV, Fig.11), circular, with a complete row of slender, cylindrical hooked spines (18-38) on the periphery of each capsule; statoblast diameter (without spines)=995-(1085)-1143 μm (25 counts, std.dev.=56), spine length=279-(373)-489 μm (15 counts, std.dev.=54).

Taxonomy

Young, round colonies of C. mucedo are normally distinguished from those of P. magnifica by the red coloration on the P. magnifica lophophores. In some instances, this coloration may not be clearly seen, or has not yet

developed in young colonies of P. magnifica, and an alternative method of identification must be used. The symmetrical arrangement of polypides in C. mucedo colonies separates them from the random arrangement of P. magnifica polypides (Smith 1991). Colonies of C. mucedo consist of marginal rows of polypides enclosing a clear central space, which is discernible even in young colonies; such an arrangement is absent in P. magnifica colonies.

Habitat and general ecology

Colonies of C. mucedo were collected from the following water quality conditions: temperature=4-26°C, pH=5.9-9.4, calcium=2-60 mg/L, magnesium=10-64 mg/L. Cristatella mucedo is clearly eurytopic with respect to its temperature and pH tolerance. Colonies were collected from Lake Sir John (near Lachute, Quebec) on September 15, 1990, in a pH of 5.9. Colonies were also found in a temperature of 4°C and a pH of 6.1 at the outflow of Lac St. Bernard, in Parc Mastigouche, Quebec, on November 10, 1991. To my knowledge, the lower limits for temperature (4°C) and pH (5.9 and 6.1) are the lowest recorded for the species. Bushnell (1966) collected colonies in water temperatures of 6-32°C, and a pH as high as 9.8.

In southern Quebec, C. mucedo is found from late May until mid-November; statoblasts are usually produced in late June. Colonies of C. mucedo are most often associated with P. magnifica, and the sponges Eunapius fragilis and Ephydatia muelleri.

Distribution in Eastern Canada

Ontario (Osler 1883; Odell 1899; Huntsman 1913; White 1915; Rogick 1937), Quebec (Osler 1883; Ricciardi and Lewis 1991), New Brunswick, Newfoundland.

This holarctic species is widespread throughout Eastern Canada.

Statoblasts from White Point Pond, in Terra Nova National Park, Newfoundland (NMC 1977-0501B), and from the Hammond River, New Brunswick (NBM, uncatalogued), represent the first records of this species in these provinces.

Paludicella articulata (Ehrenberg 1831)

Plate II, Fig.5

Paludicella ehrenbergii Odell 1899

Paludicella articulata Huntsman 1913; White 1915; Rogick 1937; Ricciardi and Lewis 1991

Description of Eastern Canadian specimens

Colony threadlike, with both free and recumbent branches (Pl.II, Fig.5); zooids club-shaped, growing contiguously in a linear sequence and divided by septa; branching occurs at nearly right angles; ectocyst yellow or brown, firm, often shiny, with little or no encrustation, never keeled; zooecial orifice square, located subterminally; extended lophophore circular. Zooecial length=1384-(1652)-1974 μm (20 counts, std.dev.=141), maximum width=179-(229)-355 μm (20 counts, std.dev.=40.1).

External sclerotized buds, termed hibernacula, are produced instead of statoblasts; these are highly variable and often irregular in outline, although club-shaped forms resembling zooids often occur.

Taxonomy

Due to its small size, this species is easily overlooked or mistaken for filamentous algae. Closer examination, however, reveals a colonial form which is distinct from all other North American bryozoans. The sequential arrangement of the zooids, and the subterminal, 4-sided zooecial orifice readily distinguish the species from its closest relative, Pottsiella

erecta.

Habitat and general ecology

Paludicella articulata is a eurytopic species found in both lentic and lotic habitats, but occurs predominantly in streams and in the waveswept areas of lakes and rivers. Active colonies were found in the following range of water quality conditions: temperature=5-26°C, pH=5.9-9.4, calcium=10-130 mg/L, magnesium=22-150 mg/L. Bushnell (1974) states that 5°C is the lower limit of temperature tolerance for the species.

Although P. articulata was found on one occasion in a habitat of pH=5.9 (Lake Sir John, Quebec), it is most often collected in alkaline water of pH>7.0. This species was conspicuously absent from lakes and streams of pH=4.7-6.5 in the Parc Mastigouche region (Quebec), although it was fairly abundant in one lake (Lac Vert) of pH=7.0, and other bryozoans (Plumatella repens, P. fruticosa, C. mucedo, F. indica) were found in pH as low as 6.1 in the same region.

Paludicella articulata is most often associated with Plumatella reticulata and Fredericella indica, and the sponge Eunapius fragilis, which occasionally overgrows the Paludicella colony.

Distribution in Eastern Canada

Ontario (Odell 1899; Huntsman 1913; White 1915; Rogick 1937), Quebec (Ricciardi and Lewis 1991).

This species is very common in the Great Lakes region and southern Quebec. It likely occurs throughout the Eastern Canadian region, but its diminutive size has caused it to be generally overlooked.

Pottsiella erecta (Potts 1884)

Plate II, Figs. 6-7

Description of Eastern Canadian specimens

Colony consisting of individual, erect, cylindrical zooids, joined by a narrow recumbent stolon (Pl.II, Fig.6). Ectocyst firm, translucent, unencrusted. Extended lophophore is circular. Zooecial orifice, located terminally, takes on a 5-sided shape when lophophore is retracted (Pl.II, Fig.7); the pentagonal shape is supported by lightly sclerotized ridges extending from the apices of the orifice down to about a one-third of the length of the zooid. Each zooid is slightly constricted at the base. Branching and hibernacula occur only from the stolon.

Material for this study (AR147B) consisted of only four zooids attached to fragments of stolon removed from the basal portion of a freshwater sponge (Eunapius fragilis). Zooid length=1680-(1780)-1900 μm (4 counts, std.dev.=98); maximum orifice width=1090-(1250)-1510 μm (4 counts, std.dev.=19.5); stolon width=50-(51)-53 μm (4 counts, std.dev.=1.4).

Taxonomy

This gymnolaematous species is distinguished from its closest relative, Paludicella articulata, primarily by its growth form (zooids connected by a stolon, rather than contiguously) and the form and position of its zooecial orifice (located terminally rather than subterminally, and being 5-sided rather than 4-sided).

Habitat and general ecology

Relatively little ecological information exists for Pottsiella erecta. It is found in both lentic and lotic habitats, and frequently grows in close

association with other suspension feeders, including other bryozoans, sponges, rotifers, cnidarians, and bivalves (Curry et al. 1981; Maciorowski 1974; Smith 1985). Everitt (1975) reported P. erecta from the following water quality conditions: temperature=12-35°C, pH=6.4-8.6, conductivity=38-3400 μmho/cm.

Distribution in Eastern Canada

Quebec.

Pottsiella erecta has been collected from a single location in the lower Ottawa River, at the southwestern tip of the Island of Montreal, which represents the northern limit of its known range.

KEY TO THE FRESHWATER BRYOZOANS OF EASTERN CANADA

1a. Colony soft, gelatinous, transparent, smooth or lobed in outline, never dendritic; statoblasts with peripheral spines.....2

1b. Colony transparent to opaque, dendritic, with distinct zooecial tubes; statoblasts without spines.....4

2a. Lophophore with red pigment around mouth region; young colony lobate and rosettelike; mature colonies occurring as contiguous patches on a common gelatinous base or core, often growing as large gelatinous masses several centimeters in diameter; statoblasts with a single row of flattened, hooked spines around entire periphery ..... Pectinatella magnifica

2b. Lophophore without red pigment; colonies and statoblasts not as above.....3

3a. Mature colony smooth in outline, elongated and caterpillarlike, averaging 2 to 5 cm in length but occasionally much longer, normally with a cloudy white color; statoblasts circular, with two rows of cylindrical hooked spines, one row projecting from the periphery of each capsule..... Cristatella mucedo

3b. Colony globular, lobate, yellow in color, less than 1.5 cm in diameter; statoblasts broadly oval, with spines projecting only from the margins of the poles..... Lophopodella carteri

4a. Extended lophophore circular or elliptical in outline; statoblasts, if present, are sessoblasts only.....5

4b. Extended lophophore U-shaped in outline; both floatoblasts and sessoblasts may be present..... Plumatellidae, 7

5a. Zooecial orifice round; ectocyst normally encrusted with tiny particles; adherent branches with a dorsal keel; statoblasts are produced ..... Fredericella indica

5b. Zooecial orifice square or pentagonal (when lophophore is retracted); zooids club-shaped; colonial branches thin, threadlike or stoloniferous; ectocyst normally unencrusted, never keeled; colony producing external buds (hibernacula) rather than statoblasts..... Gymnolaemata, Paludicellidae, 6

6a Orifice subterminal, square; zooids growing in a linear sequence.. ..... Paludicella articulata

6b Orifice terminal, pentagonal when lophophore is retracted; zooids upright, connected by a stolon.. . .. . Pottsiella erecta

7a. Ectocyst soft, swollen, gelatinous, translucent, colorless or yellowish, not encrusted, occasionally covered with minute white spots; keel and septa absent, colony entirely recumbent, forming either a flat compact mass or a long dendritic string of adherent zooids, floatoblasts broadly oval, rounded or truncated at the poles, asymmetric in lateral view, average length greater than 500 μm, ventral capsule often bearing a conspicuous central nodule; sessoblasts absent ... Hyalinella punctata

7b. Ectocyst firm, not gelatinous, often encrusted, brownish, translucent to opaque, keel or septa may be present, white spots very rare; colony dendritic, occasionally erect; floatoblasts round to oval, symmetric or asymmetric in lateral view, average length usually less than 500 μm; floatoblast capsule round to oval, ventral capsule rarely bearing a central nodule, sessoblasts may be present..... Plumatella, 8

8a. Floatoblast capsule covered by annulus much more dorsally than ventrally, maximum width of dorsal annulus greater than or equal to length of dorsal fenestra 9

8b. Floatoblast capsule covered by annulus only slightly more dorsally than ventrally, maximum width of dorsal annulus less than length of dorsal fenestra. 10

9a. Dorsal and ventral floatoblast valves nearly equally convex, symmetric in lateral view; frontal valve of mature sessoblast with a dark netlike pattern of ridges..... Plumatella reticulata

9b. Floatoblast dorsal surface flattened, valves strongly asymmetric in lateral view; frontal valve of mature sessoblast not as above. ..... Plumatella emarginata

10a. Average length of floatoblast and sessoblast more than twice width, floatoblast asymmetric in lateral view, colonial branches never fused..... Plumatella fruticosa

10b. Floatoblast or sessoblast length less than twice width; floatoblast either symmetric or asymmetric in lateral view; colonial branches may be fused along a portion of their length..... 11

11a. Floatoblast dorsal fenestra length greater than 1 5 times width; more than one type of floatoblast may be present, ectocyst generally opaque, encrusted and strongly keeled in mature colonies; sessoblast lamella width normally less than 40 μm, frontal valve sometimes bearing a conspicuous central raised tubercle..... Plumatella casmiana

11b. Floatoblast dorsal fenestra length less than 1 5 times width; floatoblasts of one type only; ectocyst translucent or opaque, seldom encrusted or keeled; sessoblast lamella width normally greater than 40 μm in width, frontal valve not as above..... 12

12a Floatoblast strongly asymmetric in lateral view; colonial branches fused along most of their length, usually forming thick erect masses in mature colonies; septa usually present..... Plumatella fungosa

12b. Floatoblast symmetric in lateral view; colonial branches seldom fused; septa absent.....13

13a Average width of dorsal annulus less than 18% floatoblast length; floatoblast round, length/width ratio less than 1.1, ventral capsule pointed; ectocyst swollen, transparent, never encrusted or keeled; polypides in erect clusters of 2 to 7 and connected by a narrow stolon in recumbent colonies..... Plumatella orbisperma

13b. Average width of dorsal annulus greater than 18% floatoblast length; floatoblast round to oval, length/width ratio normally greater than 1.1, ventral capsule not pointed; ectocyst transparent to opaque, not swollen, sometimes lightly encrusted and keeled; polypides not as above..... Plumatella repens

Key to the statoblasts of phylactolaemate bryozoans of Eastern Canada

1a. Statoblast with hooked spines 2
1b. Statoblast without hooked spines 4

2a. Statoblast with a single peripheral row of dorsoventrally flattened hooked spines 3
2b. Statoblast with two rows of cylindrical, hooked spines, one row on each valve ..... *Cristatella mucedo*

3a. Spines with serrated edges, confined to the margins at the poles; statoblast broadly oval in outline ..... *Lophopodella carteri*
3b. Spines with smooth edges, arranged around entire periphery; statoblast roughly circular in outline ..... *Pectinatella magnifica*

4a. Statoblast with air-filled annulus, buoyant when dried (floatoblast) 5
4b. Statoblast annulus reduced to a lamella, or absent (sessoblast) 13

5a. Average floatoblast length at least twice width 6
5b. Average floatoblast length less than twice width 7

6a. Floatoblast symmetric in lateral view, average length less than 400 μm; dorsal fenestra broadly oval; floatoblast may be thin-walled and transparent. *Plumatella casmiana*
6b. Floatoblast asymmetric in lateral view, thick-walled and opaque; dorsal fenestra very narrow; average floatoblast length more than 400 μm ..... *Plumatella fruticosa*

7a. Floatoblast capsule covered by annulus disproportionately more dorsally than ventrally, maximum width of annulus on dorsal surface greater than or equal to length of dorsal fenestra 8
7b. Floatoblast capsule covered by annulus only slightly more dorsally than ventrally, maximum width of annulus on dorsal surface less than length of dorsal fenestra 9

8a. Dorsal floatoblast surface flattened, floatoblast strongly asymmetric in lateral view; annulus normally with a silvery sheen ..... *Plumatella emarginata*
8b. Dorsal and ventral floatoblast surfaces nearly equally convex, floatoblast symmetric in lateral view, annulus normally with a bronze sheen ..... *Plumatella reticulata*

9a. Floatoblast large and broadly oval, rounded or truncated at the poles, average length greater than 500 μm; ventral capsule sometimes bearing a conspicuous central nodule; fenestra (viewed under high magnification) covered with large tubercles, without any raised reticulation ..... *Hyalinella punctata*
9b. Floatoblast round to oval, average length less than 500 μm; ventral capsule without a central nodule, fenestra (viewed under high magnification) having a raised reticulation with interstitial tubercles 10

10a. Dorsal fenestra length less than 1.5 times width.....11
10b Dorsal fenestra length more than 1.5 times width.. Plumatella casmiana

11a. Floatoblast symmetric in lateral view.....12
11b Floatoblast strongly asymmetric in lateral view.... Plumatella fungosa

12a. Average width of dorsal annulus less than 18% floatoblast length; floatoblast round, length/width ratio less than 1.1; ventral capsule pointed..... Plumatella orbisperma
12b. Average width of dorsal annulus greater than 18% floatoblast length; floatoblast round to oval, length/width ratio greater than 1.1; ventral capsule rarely pointed .... Plumatella repens

13a. Lamella present; capsule covered with ridges or tubercles..... ....Sessoblasts, 14
13b. Lamella absent; capsule normally covered with hexagonal pits..... Fredericella indica

14a. Sessoblast length at least twice width..... Plumatella fruticosa
14b. Sessoblast length less than twice width.....15

15a. Frontal valve of mature sessoblast with a dark netlike pattern of ridges clearly visible under low (50X) magnification..... ..... Plumatella reticulata
15b. Sessoblast not as above.....16

16a. Sessoblast lamella normally less than 40 μm in width, oriented perpendicularly to the substrate; frontal valve mostly smooth, sometimes bearing a conspicuous central raised tubercle..... Plumatella casmiana
16b. Sessoblast lamella normally greater than 40 μm in width, oriented at variable angles to the substrate; frontal valve (viewed under high magnification) distinctly tubercolated to varying degrees, with or without a lightly raised reticulation; central raised tubercle absent*... Plumatella emarginata
Plumatella repens
Plumatella fungosa
Plumatella orbisperma

* These species cannot be confidently separated on the basis of sessoblast morphology alone.

Plates I-IV. Bryozoan colonies and statoblasts

PLATE I:

Figures 1-5. Bryozoan colonial form, dorsal view (Scale bar=1 mm).

Fig.1, *Plumatella repens*;

Fig.2, *P. emarginata* or *P. casmiana*;

Fig.3, *Fredericella indica* or *Plumatella fruticosa*, erect and recumbent branches.

Fig.4, *Hyalinella punctata*;

Fig.5, *Plumatella fungosa*.

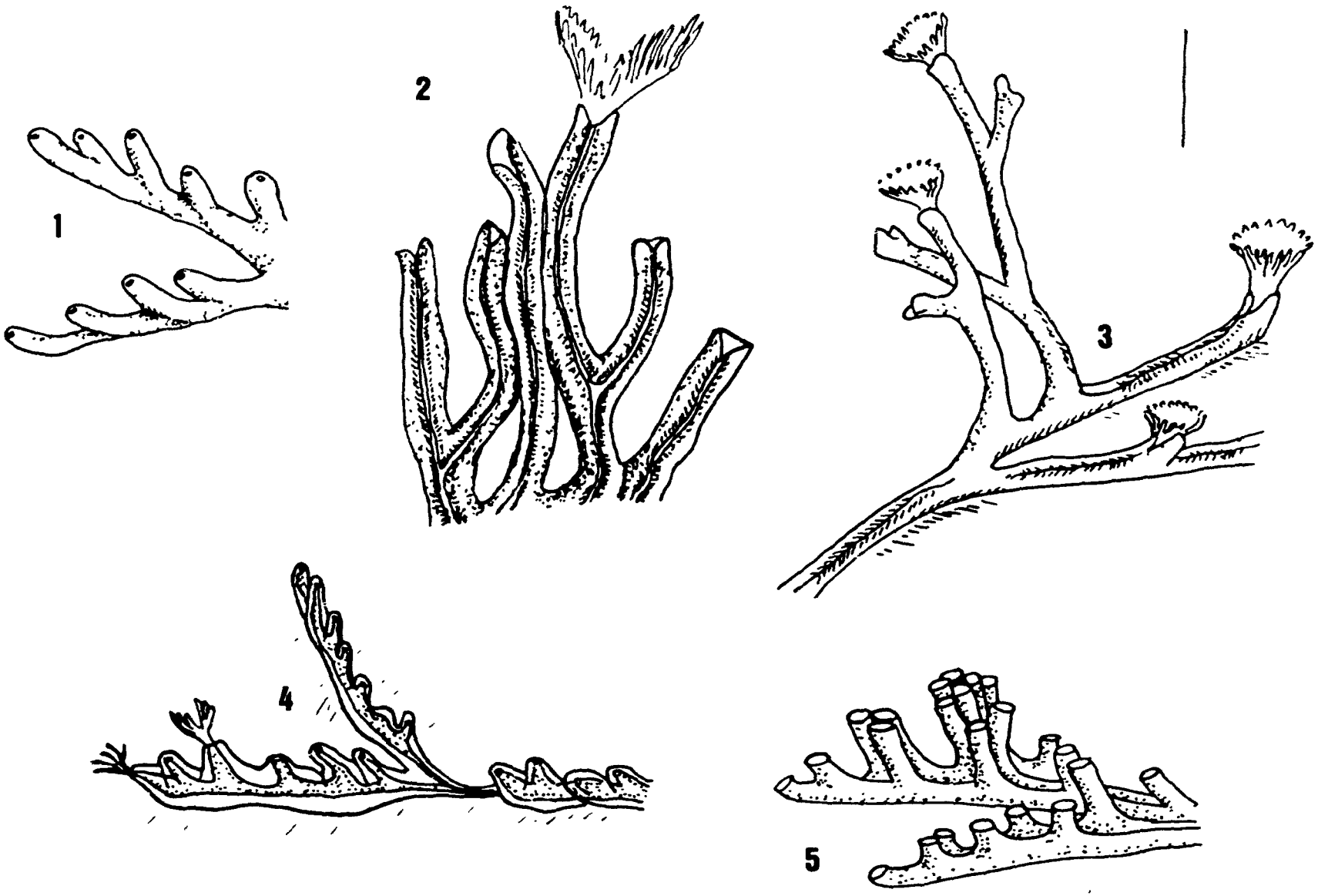
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PLATE II:

Fig.1, Plumatella orbisperma (Scale bar=1 mm);

Fig.2, Lophopodella carteri, a=statoblast (Scale bar=1 mm);

Fig.3, Pectinatella magnifica, compound colony (Scale bar=5 cm);

Fig.4, Individual P. magnifica colony, with statoblasts (Scale bar=5 mm);

Fig.5, Paludicella articulata, a=hibernacula (Scale bar=1 mm);

Fig.6, Pottsiella erecta (Scale bar=1 mm);

Fig.7, P. erecta, zooecial orifice (Scale bar=125 μm).

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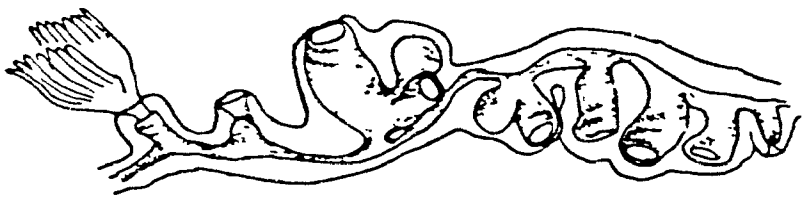

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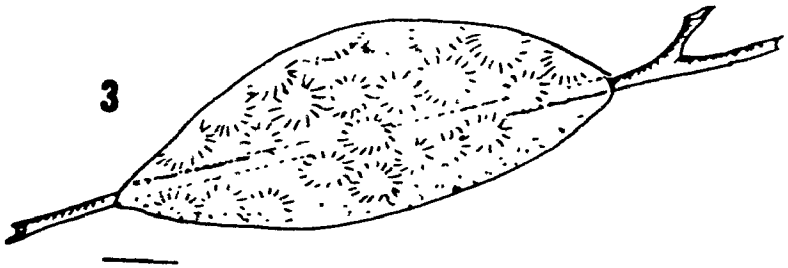

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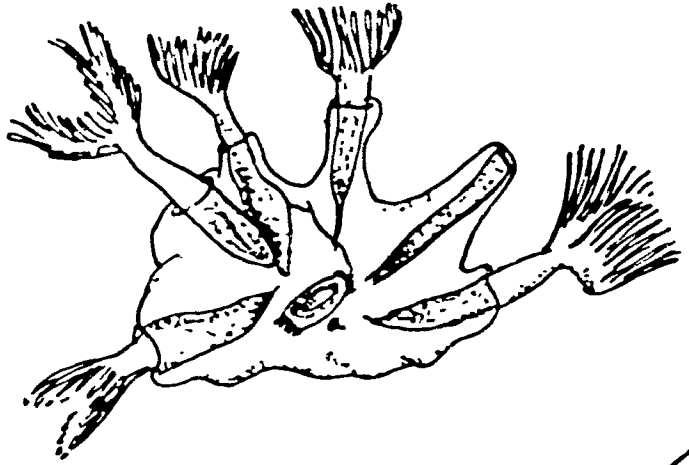

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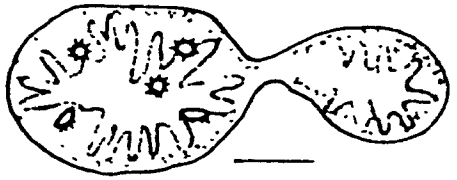

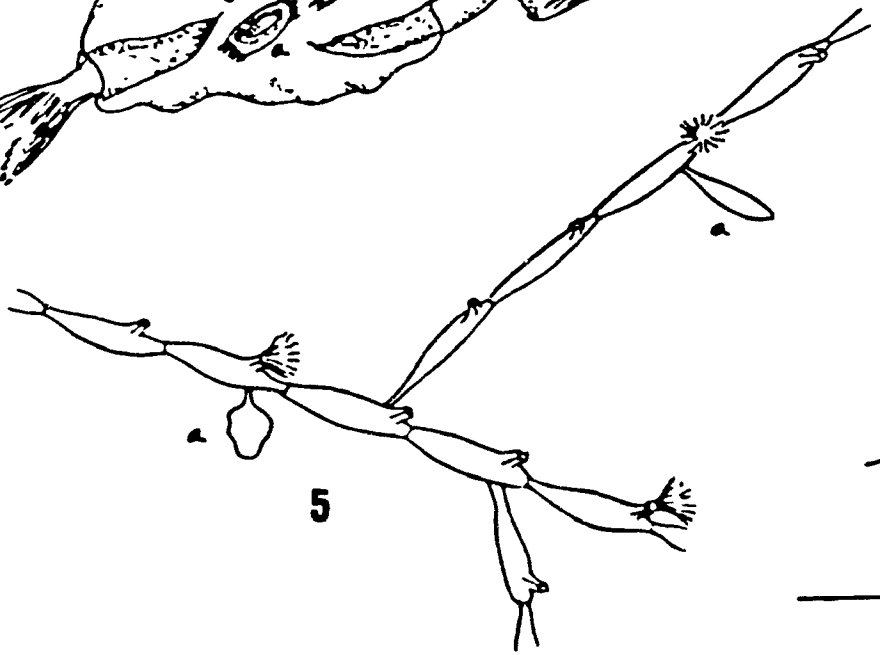

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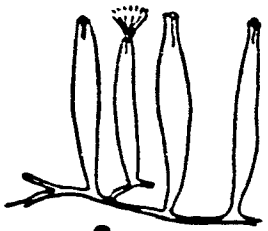

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PLATE III:

Figures 1-23. Floatoblasts of freshwater bryozoans.

Figs.1-17, 22-23: Scale bar=100 μm; Figs.18-21: Scale bar=200 μm.

Figs.1-2, Plumatella casmiana, thick-walled floatoblast. Fig.1, ventral valve. Fig.2, dorsal valve.

Fig.3, P. orbisperma or P. casmiana, lateral view.

Figs.4-5, P. casmiana leptoblast. Fig.4, ventral valve. Fig.5, dorsal valve.

Figs.6-7, Plumatella repens or P. fungosa. Fig.6, ventral valve. Fig.7 dorsal valve.

Fig.8, P. repens, lateral view. Fig.9, P. fungosa, lateral view.

Figs.10-11, Plumatella orbisperma. Fig.10, ventral valve. Fig.11, dorsal valve.

Figs.12-14, Plumatella fruticosa. Fig.12, dorsal valve. Fig.13, ventral valve. Fig.14, lateral view.

Figs.15-17, Plumatella emarginata. Fig.15, ventral valve. Fig.16, dorsal valve. Fig.17, lateral view.

Figs.18-21, Hyalinella punctata. Fig.18, ventral valve. Fig.19, dorsal valve. Fig.20, ventral valve with central nodule. Fig.21, lateral view.

Figs.22-23, Plumatella reticulata. Fig.22, dorsal valve. Fig.23, lateral view.

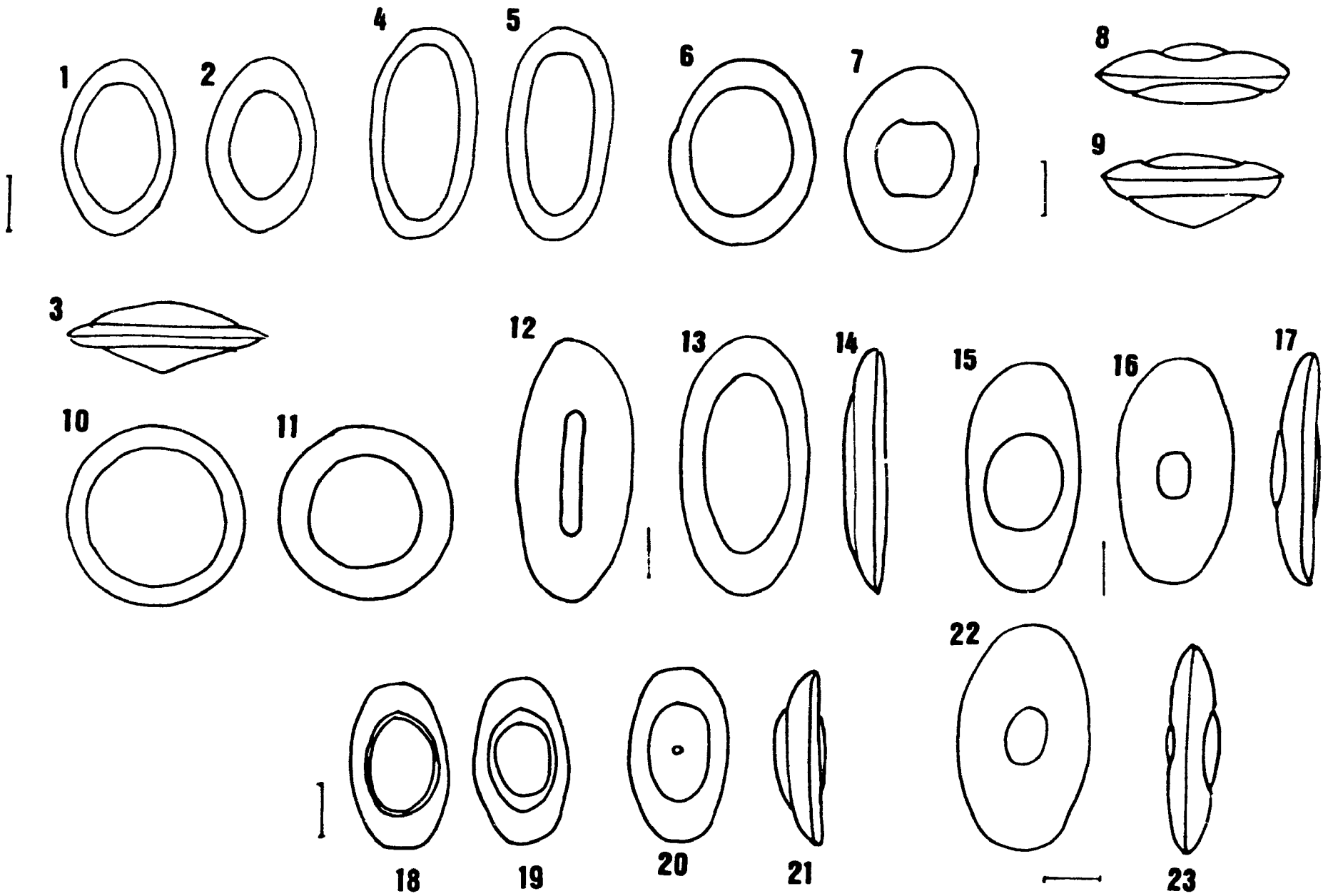
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PLATE IV:

Figures 1-9. Bryozoan sessoblasts. Figs.1-6, Scale bar=200 μm; Figs.7-9, Scale bar=100 μm.

Fig.1, Plumatella fruticosa, frontal valve.

Fig.2, P. repens or P. fungosa or P. emarginata, frontal valve.

Fig.3, P. reticulata, frontal valve.

Fig.4, P. casmiana, frontal valve.

Fig.5, P. fruticosa, lateral view.

Fig.6, P. repens, emarginata, or fungosa, lateral view.

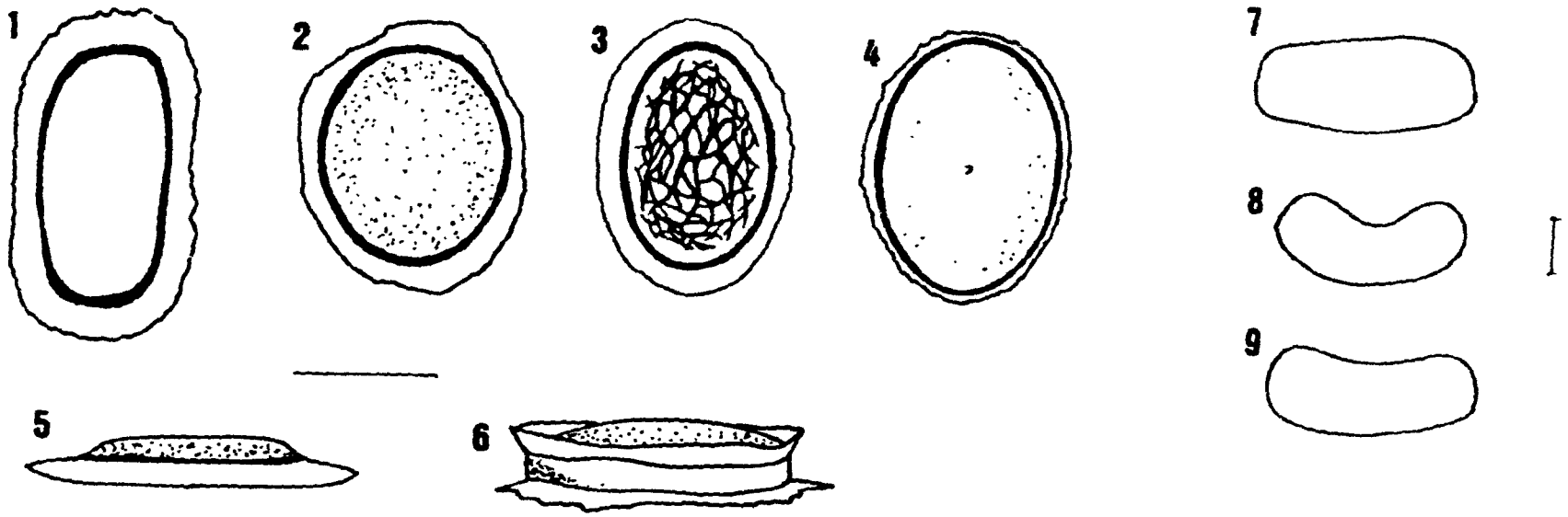
Figs.7-9, Outline of Fredericella indica statoblasts.

Figures 10-12. Bryozoan statoblasts. Scale bar=500 μm.

Fig.10, Lophopodella carteri.

Fig.11, Cristatella mucedo.

Fig.12, Pectinatella magnifica.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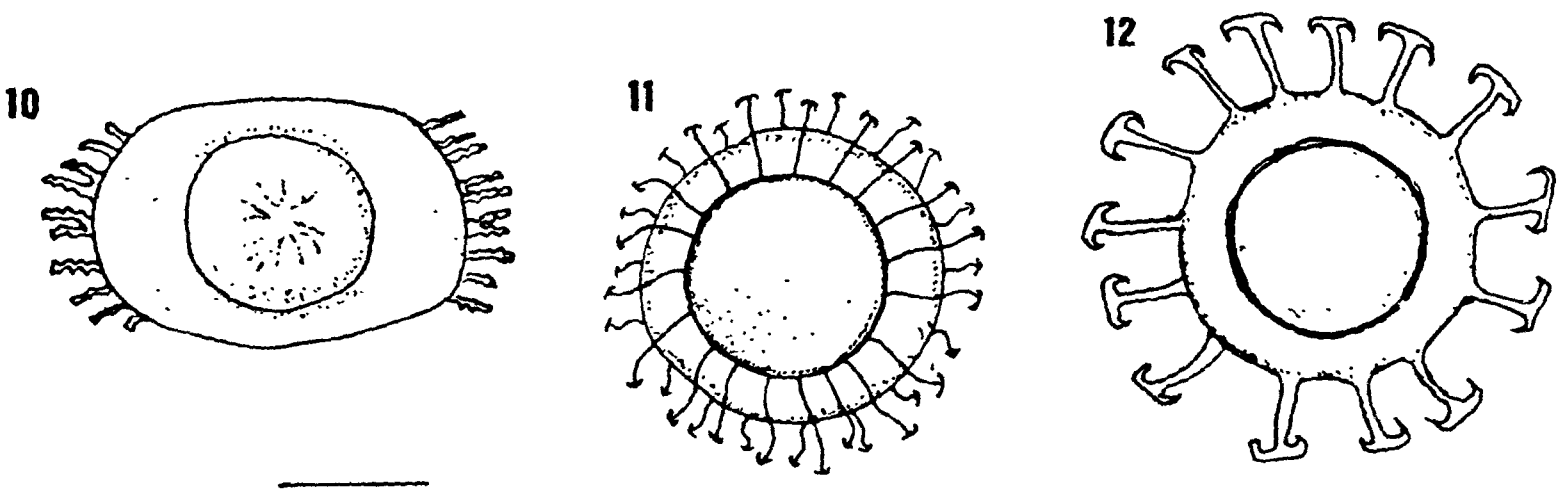
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References Cited

ALLMAN, G.J. 1844. On Plumatella repens. Rep. Brit. Assn. Adv. Sci. 13: 74-76.

ANNANDALE, N. 1909. A new species of Fredericella from the Indian lakes. Rec. Ind. Mus. 3: 373-374.

APROSI, G. 1988. Bryozoans in the cooling water circuits of a power plant. Verh. Int. Verein. Limnol. 23: 1542-1547.

BUSHNELL, J.H. 1965. On the taxonomy and distribution of freshwater Ectoprocta in Michigan. III. Trans. Amer. Microsc. Soc. 84: 529-548.

BUSHNELL, J.H. 1966. Environmental relations of Michigan Ectoprocta and dynamics of natural populations of Plumatella repens. Ecol. Monogr. 36: 95 123.

BUSHNELL, J.H. 1968. Aspects of architecture, ecology, and zoogeography of freshwater Ectoprocta. Atti. Soc. Ital. Sci. Nat. Mus. Civ. Stor. Nat. Milano 108: 129-151.

BUSHNELL, J.H. 1973. The freshwater Ectoprocta: a zoogeographical discussion. In Living and fossil Bryozoa: recent advances in research. Edited by G.P. Larwood and M.B. Abbott. Academic Press, London. pp. 75-92.

BUSHNELL, J.H. 1974. Bryozoans (Ectoprocta). In Pollution ecology of freshwater invertebrates. Edited by C.W. Hart and S.L.H. Fuller. Academic Press, N.Y. pp. 157-194.

BUSHNELL, J.H., FOSTER, S.Q. and WAHLE, B.M. 1987. Annotated inventory of invertebrate populations in an alpine lake and stream chain in Colorado. Great Basin Nat. 47: 500-511.

BUSHNELL, J.H. and WOOD, T.S. 1971. Honeycomb colonies of Plumatella casmiana Oka (Ectoprocta: Phylactolaemata). Trans. Amer. Micros. Soc. 90: 229-231.

CARL, G.C. 1943. Natural history of the Forbidden Plateau area, Vancouver Island, British Columbia. Rep. Prov. Mus. nat. Hist. Victoria, B.C. 1943:18 40.

COLLINS, E.J., TENNEY, W.R. and WOOLCOTT, W.S. 1966. Histological effects of the poison of Lophopodella carteri (Hyatt) in the gills of Carassius auratus (Linnaeus) and larval Ambystoma opacum (Gravenhorst). Va. J. Sci. (n. ser.) 17: 155-161.

CURRY, M.G., EVERITT, B. and VIDRINE, M.F. 1981. Haptobenthos on shells of living freshwater clams in Louisiana. Wasmann J. Biol. 39: 56-62.

CUVIER, G. 1798. Tableau elémentaire de l'histoire naturelle des animaux. 710p.

DAVENPORT, C.B. 1904. Report on the fresh-water Bryozoa of the United States. Proc. U.S. Nat. Museum. 27: 211-221.

EHRENBERG, C.G. 1831. Phytozoa polypi. Symbolae physicaem etc. Animalia evertebrata 1: 831.

EVERITT, B. 1975. Freshwater Ectoprocta: distribution and ecology of five species in southeastern Louisiana. Trans. Amer. Micros. Soc. 94: 130-134.

GEIMER, G. and MASSARD, J.A. 1986. Les bryozoaires du Grand-Duché de Luxembourg et des régions limitrophes. Trav. Sci. Mus. Hist. Nat. Lux. VII. 188p.

GEISER, S.W. 1934. The distribution of Pectinatella magnifica in the United States. Field and Lab. 2: 56-59.

GOADBY, Dr. and BOVELL, J. 1855. Passing visits to the Rice Lake, Humber River, Grenadier's Pond, and the Island. Canadian J. Ind. Sci. Art. 3: 201-203.

GREENLAND, D.C., NEWTON, S.H. and FAUCETTE, Jr., R.F. 1988. Effects of cage encrustation by the bryozoan Plumatella casmiana on production of channel catfish. Prog. Fish-Cult. 50: 42-45.

HANCOCK, A. 1850. On the anatomy of the fresh-water Bryozoa, with descriptions of three new species. Ann. Mag. Nat. Hist. (2) 5: 175-202.

HENRY, V., BUSSERS, J.C., BOUQUEGNEAU, J.M., and THOMÉ, J.P. 1989. Heavy metal and PCB contamination of bryozoan colonies in the River Meuse (Belgium). Hydrobiol. 202: 147-152.

HUNTSMAN, A.G. 1913. Invertebrates other than insects and mollusks. In The natural history of the Toronto region. Edited by J.H. Faull. Can. Inst. Toronto. pp. 272-287.

HYATT, A. 1866. Observations on polyzoan suborder Phylactolaemata. Comm. Essex Inst. 4: 107-228.

JOB, P. 1976. Intervention des populations de Plumatella fungosa (Pallas) (Bryozoaire Phylactoleme) dans l'autopuration des eaux d'un étang et d'un ruisseau. Hydrobiol. 48: 257-261.

JONASSON, P.M. 1963. The growth of Plumatella repens and P. fungosa (Bryozoa Ectoprocta). Oikos 14(2): 121-137.

JUDD, W.W. 1950. Pectinatella magnifica Leidy (Bryozoa) in the Dundas Marsh, Hamilton, Ontario. Can. Field-Nat. 64: 191-192.

KARLSON, R.H. 1991. Recruitment and local persistence of a freshwater bryozoan in stream riffles. Hydrobiologia (in press).

KELLICOTT, D.S. 1882. Polyzoa. Observations on species detected near Buffalo, N.Y. Proc. Amer. Soc. Microscopists 4: 217-229.

LACOURT, A.W. 1968. A monograph of the freshwater Bryozoa--Phylactolaemata. Zool. Verhandl. 93: 1-159.

LEIDY, J. 1851. On Cristatella magnifica n. sp. Proc. Acad. Nat. Sci. Phil. 5: 265-266.

LINNAEUS, C. 1758. Systema naturae. 10th ed. J. Cramer, Weinheim.

MACIOROWSKI, A.F. 1974. The occurrence of the freshwater bryozoan Pottsiella erecta (Potts) 1884 (Gymnolaemata: Paludicellidae) in Lake Erie. Ohio J. Sci. 74: 245-247.

MASSARD, J.A. and GEIMER, G. 1991. Note sur les Bryozoaires d'eau douce trouvé en diverses stations luxembourgeoises et belges, avec des considérations sur la bryozoofaune de la Sûre et des remarques concernant les statoblastes de Hyalinella punctata (Hancock, 1850). Bull. Soc. Nat. Luxembourgeois 92: 131-148.

MUKAI, H., NIWA, T., TSUCHIYA, M., and NEMOTO, T. 1983. The growth of colonies and the production of statoblasts in a freshwater bryozoan, Plumatella casmiana. Sci. Rep. Fac. Educ. Gunma Univ. 32: 55-75.

MUNDY, S.P. 1980. Stereoscan studies of phylactolaemate bryozoan statoblasts including a key to the statoblasts of the British and European Phylactolaemata. J. Zool. Lond. 192: 511-530.

ODELL, W.S. 1899. Notes on fresh-water Polyzoa. Ottawa Nat. 13: 107-113.

OKA, A. 1907. Zur Kenntnis der Susswasserbryozoen von Japan. Annot. Zool. Jap. 6: 117-123.

OSLER, W. 1883. On Canadian fresh-water Polyzoa. Can. Nat. 10: 399-406.

PALLAS, P.S. 1768. Descriptio Tubulariae-fungosae prope Wolo mense Julio 1768 observatae. Nov. Comm. Acad. Sci. Imp. Petro. 12: 565-572.

POTTS, E. 1884. On Paludicella erecta. Proc. Acad. Nat. Sci. Phil. 36: 213-214.

POURCHER, A.-M. and d'HONDT, J.-L. 1987. Étude ultrastructurale du sessoblaste et du flottoblaste chez Plumatella fungosa (Pallas, 1768) (Bryozoaires, Phylactolaemates). Ann. Sc. Nat., Zool. 13 Ser., 8: 209-216.

RADDUM, G.G. 1981. Life strategy of Plumatella repens (Bryozoa). Fauna 34: 162-166.

RADDUM, G.G. and JOHNSEN, T.M. 1983. Growth and feeding of Fredericella sultana (Bryozoa) in the outlet of a humic acid lake. Hydrobiol. 101: 115-120.

RICCIARDI, A. and LEWIS, D.J. 1991. Occurrence and ecology of Lophopodella carteri (Hyatt) and other freshwater Bryozoa in the lower Ottawa River near Montreal, Quebec. Can. J. Zool. 69: 1401-1404.

RICCIARDI, A. and WOOD, T.S. 1992. Statoblast morphology and systematics of the freshwater bryozoan, Hyalinella orbisperma (Kellicott 1882). Can. J. Zool. 70: In press.

ROGICK, M.D. 1935. Studies on the freshwater Bryozoa II. The Bryozoa of Lake Erie. Trans. Amer. Microsc. Soc. 54: 245-263.

ROGICK, M.D. 1937. Studies on the freshwater Bryozoa V. Some additions to Canadian fauna. Ohio J. Sci. 37: 99-104.

ROGICK, M.D. 1943. Studies on freshwater Bryozoa XIII. Additional Plumatella casmiana data. Trans. Amer. Microsc. Soc. 62: 265-270.

SHRIVASTAVA, P. and RAO, K.S. 1985. Ecology of Plumatella emarginata (Ectoprocta: Phylactolaemata) in the surface waters of Madhya Pradesh with a note on its occurrence in the protected waterworks of Bhopal (India). Environ. Poll. (ser. A) 39: 123-130.

SMITH, D.G. 1985. Lophopodella carteri (Hyatt), Pottsiella erecta (Potts) and other freshwater Ectoprocta in the Connecticut River (New England, U.S.A.). Ohio J. Sci. 85: 67-70.

SMITH, D.G. 1988. Stephanella hina (Ectoprocta: Phylactolaemata) in North America, with notes on its morphology and systematics. J. N. Amer. Benthol. Soc. 7: 253-259.

SMITH, D.G. 1991. The colonial hydras and moss animals. In Keys to the freshwater macroinvertebrates of Massachusetts. Mass. Dept. Env. Qual. Eng., Div. Wat. Poll. Contr. Westborough, Mass. pp.34-64.

SORENSEN, J.P., RIBER, H.H. and KOWALCZEWSKI, A. 1986. Soluble reactive phosphorus release from bryozoan dominated periphyton. Hydrobiol. 132: 145-148.

TANTON, T.L. 1935. Pectinatella in Rainy River District, Ontario. Can. Field-Nat. 49: 127-129.

TENNEY, W.R. and WOOLCOTT, W.S. 1962. First report of the bryozoan, Lophopodella carteri (Hyatt), in Virginia. Am. Midl. Nat. 68: 247-248.

TENNEY, W.R. and WOOLCOTT, W.S. 1964. A comparison of the responses of some species of fishes to the toxic effect of the bryozoan Lophopodella carteri (Hyatt). Va. J. Sci. (n. ser.) 15: 16-20.

TORIUMI, M. 1972. Additional observations on Plumatella repens (L.) (a fresh-water bryozoan) VII. Re-examination on the materials labelled Plumatella punctata. Bull. Mar. Biol. Stn. Asamushi 14: 155-167.

WHITE, H.T. 1915. Bryozoa of the Georgian Bay region. Contrib. Can. Biol. (1911-1914) 2: 195-199.

WOOD, T.S. 1973. Colony development in species of Plumatella and Fredericella (Ectoprocta: Phylactolaemata). In Development and function of animal colonoies through time. Edited by R.S. Boardman, A.H. Cheetham, and W.A. Oliver, Jr. Dowden, Hutchinson and Ross, Stroudsburg, Pennsylvania. pp. 395-432.

WOOD, T.S. 1979. Significance of morphological features in bryozoan statoblasts. In Advances in Bryozoology. Edited by G.P. Larwood and M.B. Abbott. Academic Press, London. pp. 59-74.

WOOD, T.S. 1988. Plumatella reticulata sp. nov. in Ohio (Bryozoa: Phylactolaemata). Ohio J. Sci. 88: 101-104.

WOOD, T.S. 1989. Ectoproct bryozoans of Ohio. Bull. Ohio Biol. Surv. (n. ser.) 8 (2): 70p.

WOOD, T.S. 1991. Bryozoans. In Ecology and classification of North American freshwater invertebrates. Edited by J.H. Thorp and A.P. Covich. Academic Press, N.Y. pp. 95-124.

WOOD, T.S. and BACKUS, B.T. 1991. Differentiation of North American and European forms of Fredericella sultana (Blumenbach) (Ectoprocta: Phylactolaemata). Hydrobiologia (In press).

Chapter VI

CONCLUSIONS

The freshwater bryozoan and spongillid fauna of Eastern Canada is much more diverse than is indicated by published species records. More than half of all North American species occur in Eastern Canada, reflecting a species richness that is likely correlated with the diversity of aquatic habitats and ecological conditions within the region. Freshwater bryozoans and sponges are found in almost every unpolluted lake or stream during the warm months of the year; lake outflows are the most preferred habitats. The number of species recorded within a province is clearly a function of the number of sites and specimens examined. Therefore, the paucity of published records from a province (e.g., Prince Edward Island) is more a reflection of its poorly surveyed aquatic invertebrate fauna than of any biogeographic factor. Many species thought to have limited distributions (e.g., Plumatella fruticosa) based on scanty published records may actually be widely distributed (although they may be uncommon).

As would be expected, the most common and widespread species (e.g., Spongilla lacustris, Eunapius fragilis, Ephydatia muelleri, Cristatella mucedo, Fredericella indica, Plumatella repens, Paludicella articulata and Pectinatella magnifica) are eurytopic species, tolerant of a wide range of pH, temperature, and water hardness. Conversely, certain species are clearly stenotopic. These include strongly acidophilic species such as Eunapius mackayi, Corvomeyenia everetti, Spongilla aspinosa, and Trochospongilla pennsylvanica. Species more adapted to alkaline water include the bryozoans Hyalinella punctata, Lophopodella carteri, Plumatella fungosa, and Plumatella reticulata, and the sponges Eunapius fragilis and Trochospongilla horrida.

Many freshwater bryozoans (e.g., Plumatella repens, Fredericella indica) and sponges (e.g., Spongilla lacustris, Anheteromeyenia ryderi, Trochospongilla pennsylvanica) are highly ecophenotypic, and may be identified by only a few reliable features. This is an important consideration when preparing taxonomic keys or species descriptions for regions in which a wide range of aquatic habitats and ecological conditions exist.

Since it is now clear that a diverse and abundant bryozoan and spongillid fauna exist in Eastern Canadian inland waters, and that the distribution and morphology of many of these species are linked to environmental conditions, an important area of research that warrants further investigation is their potential value as biological indicators of water quality.