Charophytes of Crooked Lake, Saskatchewan*

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Six charophyte taxa are reported from Crooked Lake, Saskatchewan and its immediate drainage system. In addition to the ubiquitous *Chara globularis*, two varieties in the *Chara vulgaris* complex not previously distinguished from Saskatchewan, *C. vulgaris* var. *longibracteata* and a *C. contraria* variant are recorded. *Tolypella glomerata* and *T. prolifera* also inhabit the lake and one *Nitella* species was located in the area. Taxonomically important features are described and illustrated for these taxa and general ecological parameters are provided as well as North American distribution ranges. Other species known to inhabit Saskatchewan are listed.

Key Words: Charophytes, Stoneworts, *Chara*, *Nitella*, *Tolypella*, Saskatchewan, distributions.

Even though stoneworts are common in most fresh and moderately saline waters, the charophyte flora of Canada is poorly described and documented. Only two regional surveys have been attempted, one from British Columbia (Allen 1951) and the other from insular Newfoundland (Mann 1989) and both of these are far from comprehensive. The major Canadian collection of Charophytes housed in the Phycological Herbarium of the Canadian Museum of Nature, Ottawa (CANA) indicates that the prairie region centered in Saskatchewan is only sporadically represented. The few prairie specimens are mostly incidental collections, those of John Macoun from the late nineteenth and early twentieth centuries being the most numerous, best known, and most widely distributed in other herbaria. Many species recorded from the area are only represented in the literature by a single collection, at most several, so information on their distribution and frequency is almost totally lacking. Numerous studies carried out on the sloughs, freshwater and saline lakes often totally omit mention of the Charophyte flora or only refer to them at the generic level; very few have identified specimens to the specific level (Rawson and Moore 1944; Hammer and Heseltine 1988). In almost all cases no descriptive information on which identifications were based is included with literature reports.

Wood's (1965) monograph of the Characeae, while being a monumental and extremely valuable work, nevertheless has produced at least one major problem for students of Charophyte taxonomy and phytogeography. His classification based mainly on morphology combines numerous taxa into large "species groups" which encourages the reporting of "groups" rather than recognizably described "species", especially by individuals not thoroughly acquainted with Charophyte taxonomy and its historical development. For example, two groups well represented in Canada include the "*Chara globularis* complex" and the "*Chara vulgaris* complex". Most, if not all, of Wood's eight varieties of *Chara globularis* Thuill. and many of the over two dozen forms are undoubtedly not conspecific (Proctor 1971, 1975; Bhatnagar 1989; John et al 1990). Yet the most commonly used key to the Charophytes of North America (Wood 1967) readily identifies all of these taxa as *C. globularis* Thuill. without further distinction. Therefore, it is not possible to determine from a literature report whether taxonomically correct variety *globularis* form *globularis* (= *C. fragilis* Desv.) is intended or whether the collective sense is being employed when this name is cited. Consequently many existing literature citations are of no use to a phytogeographer unless voucher specimens can be examined and these are not often available. A similar, but more complex and less understood situation occurs in the "*Chara vulgaris* complex" where many more varieties and forms appear to exist. This problem has previously been reiterated in a different context by Proctor (1971, 1975, 1980) but is here stressed so that future reports can be made more meaningful. If Wood's (1965) system is employed, taxa must be identified to variety and form to provide maximum information and preferably the key characters stated on which the determination was based. In much of Canada where Charophyte variations and distributions are poorly known, detailed documentation as provided in this paper is required, locality by locality, region by region, until the broad picture emerges.

This report describes the Charophyte flora of a single southeastern Saskatchewan lake basin and provides some additional general observations of distributions across the Canadian prairies. Possibly

*This paper is dedicated to Professor M.V.S. Raju, University of Regina, upon his retirement.

botanists and naturalists will recognize from the paucity of available data that much challenging opportunity exists for the collection and study of this commonly occurring and interesting group. A good understanding of the group's variations, distributions and northern limits awaits the basic information provided by such local and regional studies.

Study Area

The Qu'Appelle Basin drains an area of approximately 50 000 km^2 of south-central and south-eastern Saskatchewan via the Qu'Appelle River into the Assiniboine River as part of the Hudson Bay drainage system (Anonymous 1972). The Qu'Appelle Valley and its branches pass through gently undulating agricultural lands which are intensively cultivated and grazed. Of the eight major lakes, Crooked Lake, the second last in the chain, is located approximately 30 km northeast of Grenfell, Saskatchewan. The sigmoid shaped lake is 9 km in length and 0.8 - 1.6 km in width covering an area of 14.6 km^2. Maximum depth is 16.5 m with a mean depth of 7.9 m.

The Qu'Appelle lakes are highly eutrophic, supporting much aquatic plant growth and high fish populations (Atton and Johnson 1962) and planktonic blooms of the blue-greens *Aphanizomenon* and *Anabaena* are common in the summer months (Hammer 1970). High loading rates of nutrients such as nitrogen and phosphorous are due to agricultural runoff, shoreline cottage development, and sewage effuents entering the system from two major centers, Regina and Moose Jaw. In general, the waters of the Qu'Appelle system are highly mineralized, very hard, high in alkalines and sulphates and at times very turbid (Anonymous 1971). Turbidity is largely due to a combination of factors including runoff, wind/wave action and planktonic blooms. The climate of the entire drainage area is semi-arid receiving an average of 39 cm of precipitation annually resulting in low flow and flushing rates, further exacerbating the eutrophic nature of the system.

Because of the considerable seasonal variation of factors such as runoff, flow rates, temperature, aquatic growth, agricultural activity and cottage activity, the water chemistry also fluctuates seasonally. Conductivity measured in the Qu'Appelle River at the outflow of Crooked Lake varied from 1400 µmhos/cm in April to 1800 in October 1970 and pH ranged from 8.7 to 8.5 during the same period (Anonymous 1971). Atton and Johnson (1962) record pH values in Crooked Lake itself as 8.0 on the bottom to 8.5 at the surface. One set of surface water measurements were taken in Crooked Lake on 18 July 1993 with a conductivity of 1700 µmhos/cm and a pH of 8.9. The waters of Crooked Lake can therefore be classified as slightly brackish using the scale of Stewart and Kantrud (1971).

Crooked Lake has extensive areas of plant growth including vasculars, charophytes and other benthic and planktonic algae. A several meter zone from the shore affected by wave action is generally free of macrophytes to a depth of 2 m. Often a narrow zone of open growing macrophytes such as *Zannichellia palustris* L. and charophytes mixed with mats of *Cladophora* sp. borders the shoreward side of the dense "weed" beds which extend to depths of about 6 m maximum. The most common constituents of these vascular beds are *Ceratophyllum demersum* L., *Myriophyllum spicatum* L., *Potamogeton pectinatus* L., *P. richardsonii* (Ar. Benn.) Rydb., *Ruppia maritima* L., and *Zannichellia palustris* L., all species tolerant of high salinities. The vascular "weed line" does not extend beyond the 6 m water depth contour probably because of low light penetration and possibly oxygen depletion during the growing season at depths greater than this. Inside the weed line a narrow zone of *Cladophora* and *Tolypella* quickly gives way to the vegetation-less zone with increased depth.

Methods

Collections were made in July and August of 1989 and again in July of 1993. Charophytes were obtained by hand or with a long-handled rake in small and shallow water bodies. A heavy toothed metal two-edged rake bar on a long rope was also thrown into deeper water from shore. Most sampling within Crooked Lake proper was done from a boat using either a very long-handled rake or a heavy toothed drag on a rope. Specimens were preserved in 5% formalin, some also being pressed and dried as herbarium sheets.

Although the charophyte species of Crooked Lake could be found throughout their ecological zones, considerable collection was often necessary to find good vigorously growing and fruiting representative material. Every effort was made to sample broadly and to select the best material possible for liquid preservation. Even though dried charophytes are easier and safer to store, they often present difficulties in morphological interpretation and measurement if not carefully prepared. Care was taken to avoid fragmentary, mixed, senescent or dilapidated material, or that which was ecologically and therefore morphologically unrepresentative of the taxon. As with vascular plants, taxonomy must be based on well chosen and highly representative material and fragmentary collections must be viewed with some reservation.

Measurements of gametangial and oospore features are provided for all taxa as is the common practice when describing charophytes. Sometimes differences are distinct and measurements are useful in delimiting taxa, but often intergradation occurs and

they are of only limited value. A variety of complicating factors associated with measurements suggest that literature citations should probably best be interpreted only in the broadest and most general terms unless methodology is precisely explained. Oogonia, antheridia, and oospores continue to enlarge as they mature and there is often no easy way to determine when these are fully mature so selection of material can bias results. Choosing fully ripe oospores is probably the least subjective and therefore also probably one of the most consistent and useful measurements when comparing literature reports of different authors. Also it can often not be determined from some citations how the measurements were actually taken, whether the coronula was included, whether oospore ridges, claws and cages were included, whether fossae widths were taken from intact oospores or from crushed, flattened membranes, and so on. Whether abiotic factors (water depth, nutrients, temperature, etc.) and growth cycle stages can produce significant size variation in the gametangia and spores of a particular genotype is not clear. Counts such as the number of striae (ridges) on the oospore or the number of spiral cell convolutions of the oogonium as seen laterally are also subject to interpretation and certainly individual counts should be interpreted as "plus or minus one" in most cases.

In the present study attempts were made to choose gametangia and spores that appeared fully mature and hence at the upper end of the size range. In all cases at least 12 measurements were made, often 20 - 30. Oogonial length includes the coronula; coronula height is given separately. Width of the oogonia was measured at the greatest distance across when viewed laterally. The number of spiral cell convolutions were also counted from oogonia viewed laterally. Oospore length measurements do not include claws or cage, but width does include the ridges; fossae width was measured on intact spores. All measurements were made with a compound microscope at 100 X using a calibrated eyepiece. Oospore membranes were studied at 400 X.

Drawings were made with a Zeiss Technival stereomicroscope fitted with a drawing tube or by projecting the image of liquid preserved material onto a paper surface with a normal 35 mm slide projector utilizing "micro-observational cells" available from Ward's Natural Science Ltd. and other biological suppliers. The drawings are therefore essentially microscopic tracings of actual selected specimens and as such accurately portray size and proportion. In each of the plates, except that for *Nitella*, the plant "habit" diagram is a photocopy of an actual pressed herbarium specimen, slightly retouched in a few cases so the image would copy clearly. All drawings except the habit photocopy were made from decalcified material preserved in 5% formalin. For specimens of the genus *Chara* it was especially important to examine and illustrate younger internodes before much growth had obscured the fundamental cortication pattern and before spine cells absciss.

Conductivity measurements were taken with a Myron L DS (Model EP-10) conductivity meter while pH readings were obtained with a Cole-Parmer digital meter (pHep$^+$). These values were corroborated with a color indicator solution (La Motte wide range comparator).

Crooked Lake and the entire surrounding area involved in this study is included on the Canadian Topographical Map 62 L/10 "Crooked Lake", Edition 3 published in 1987 by Energy, Mines and Resources Canada. Locations are recorded using the one thousand meter Universal Transverse Mercator (U.T.M) Grid co-ordinates.

Voucher specimens are housed in the Sir Wilfred Grenfell College Herbarium (SWGC) as liquid preserved material and/or dried herbarium sheets. Duplicate sheets of the *Chara* and *Tolypella* species described in this study have been deposited with (CANA), the Phycological Herbarium of the Canadian Museum of Nature, Ottawa (Mann No. 107, No. 108, No. 188, No. 190, No. 191, No. 192B). Herbarium abbreviations are listed in Holmgren et al. (1990) except for the Sir Wilfred Grenfell College Herbarium (SWGC) which is not yet listed.

Species Accounts

1. *Chara vulgaris* L. var. *longibracteata* (Kütz.) J. Groves and Bullock-Webster
[= *C. vulgaris* var. *vulgaris* f. *longibracteata* (Kütz.) H. and J. Groves]. [Figure 1]

The thallus of this vigorous species measures up to 45 cm in length with axes up to 936 μm in diameter. Cortication is diplostichous and distinctly aulacanthous, spine cells being small, attached singly and often lying appressed to the stem in the furrows created by the narrower primary cortical cells (Figure 1b). Stipulode cells are short, round tipped and equal in both tiers. Branchlets are usually of 7 segments, the lower 3 - 4 being corticated and the end of 3 - 4 ecorticated cells often quite elongate. Gametangia occur at the lowest 3 - 4 corticated nodes. The length of the bracteoles and anterior bract cells is characteristic, these being very long, often in excess of 6000 μm and up to 14 times the length of a mature oogonium. In this collection the two bracteoles are always shorter than the anterior bract cells, both becoming progressively longer at the fertile nodes closer to the branchlet tip. Considerable variation occurs within this material, Figure 1c illustrating bract and bracteole lengths almost falling within ranges of those normally reported for the species (var. *vulgaris*) to the frequently extreme lengths characteristic of var. *longibracteata* (Figure 1d).

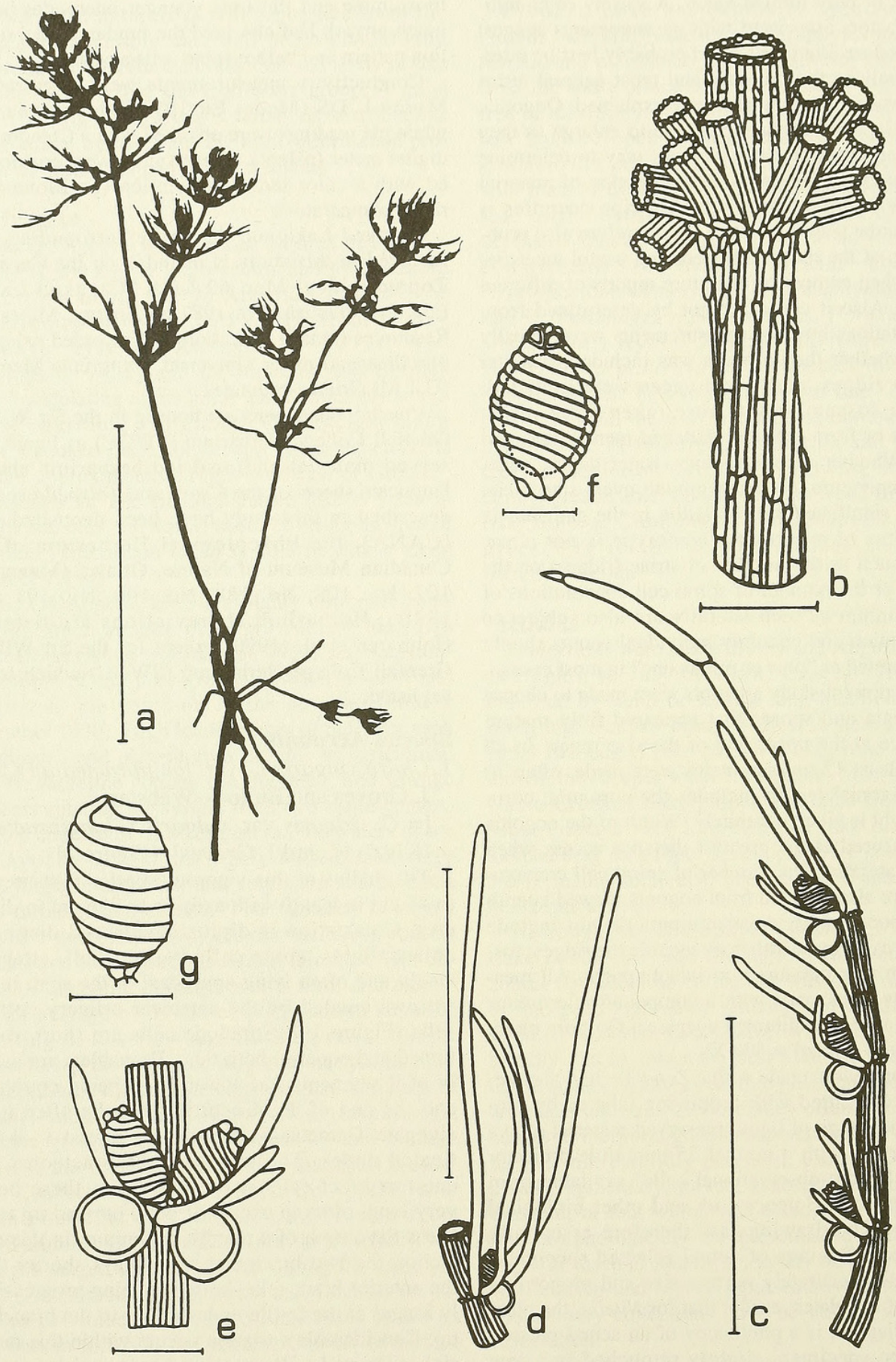

FIGURE 1. *Chara vulgaris* var. *longibracteata*. a: plant habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged portion of axis and node, scale bar = 1000 μm; c: a branchlet, scale bar = 3000 μm; d: a branchlet node showing very long bracteoles and bract cells, scale bar = 5000 μm; e: a branchlet node with geminate antheridia and archegonia, scale bar = 500 μm; f: oogonium, scale bar = 300 μm; g: oospore, scale bar = 300 μm.

Table 1 provides gametangial and oospore measurements. The geminate condition of both antheridia and oogonia occurs (Figure 1e) but not with great frequency. Coronula cells are connivent with rounded tips (Figure 1f). Oospores are bronze to brown and appear translucent under reflected light. Prominent claws with a basal cage are present (Figure 1g). At 400 X the oospore membrane appears pale orange-brown with a moderately coarse, but loosely granulate ornamentation.

The species group *Chara vulgaris* is here being separated from the species group *C. contraria* in the traditional sense, *C. vulgaris* being aulacanthous, cells of the two stipulode tiers being equal in size, bracteoles and anterior bract cells often being several times as long as mature oogonia, and mature oospores being brown in color. *Chara contraria*, on the other hand, is tylacanthous, the upper tier of stipulode cells are often somewhat larger than the lower and more tapering and pointed than in *vulgaris*, bracteoles and anterior bract cells are usually shorter than those of *vulgaris*, and mature oospores are black. The initial basic distinction is the aulacanthous/tylacanthous feature. This seems to be the most practical approach at the moment since evidence exists that the two taxa groups are almost certainly not conspecific (Grant and Proctor 1972; John et al. 1990). Until future thorough studies of the "*C. vulgaris* complex" produce additional evidence, it seems fruitless to debate this issue especially when experienced workers have little difficulty in distinguishing these two groups when good representative material is available. Both *C. vulgaris* and *C. contraria* have numerous reported varieties and forms.

Chara vulgaris is a common, widespread and cosmopolitan species found throughout most of North America. Although not separating aulacanthous *vulgaris* from tylacanthous *contraria*, Wood's (1967) map is probably reasonably accurate for both taxa if one considers the northern boundary to be approximate. However, both taxa are common in Newfoundland (Mann 1989) which is omitted on the map. Wood (1965) records f. *longibracteata* only from Europe citing no North American records. Allen (1950) observes that of the four common varieties, var. *longibracteata* is the most frequently encountered in Britain. Halsted (1879) mentions it from New Mexico, Iowa, and New York, but his descriptions are vague and appear to fall within the normal var. *vulgaris* range. Allen (1951) records a specimen from the Bow Lakes, Banff, Alberta. I saw only one aulacanthous specimen from Saskatchewan at the Canadian Museum of Nature collection (CANA 28831) from a stagnant pool 19.2 km south of Indian Head (Jones and Ledingham No. 770, 1968). It appears to be similar to the Ekapo Creek material, having well-developed anterior bracts and bracteoles.

The *Chara vulgaris* var. *longibracteata* material here described was collected from Ekapo Creek which empties into the Qu'Appelle River through a broad coulee at the eastern end of Crooked Lake. The creek carries meltwater in spring, but normally ceases to flow during the dry summers of most years, only the deeper pools retain water for the entire year. This collection was from such a small stagnant pool (Cowessess Golf Course, Green No. 5) with a muddy substrate and water of 1 m in depth. Vascular aquatics included *Ceratophyllum* sp., *Sagittaria* sp., *Myriophyllum* sp., *Utricularia* sp., and *Lemna minor* L. A thick mat of *Chara* occurred in the open water at the center of the pool where competing vasculars were scarce or absent. Unfortunately water parameters such as pH and conductivity are not available for this site, however, recorded data from the mouth of Ekapo Creek (Anonymous 1971) report conductivity at 700 µmhos/cm in April/May to 1100 in June/July 1970, considerably less than the Qu'Appelle River at 1400 and 1650 µmhos/cm during the same period.

TABLE 1. Gametangial and oospore features of *Chara* species. Measurements are presented as means (µm) with range values in parentheses.

	C. vulgaris	*C. contraria*	*C. globularis*
Oogonium			
length	691(639-721)	906(845-1009)	785(752-834)
width	426(412-443)	573(525-628)	451(422-484)
coronula height	80	116	155
convolutions	(12-14)	(11-12)	(12-14)
Oospore			
length	500(484-536)	614(587-649)	559(515-618)
width	306(268-330)	423(391-453)	381(340-412)
No. of ridges	(9-11)	(9-11)	(9-11)
fossae width	57	74	62
Antheridium			
diameter	387(350-412)	385(361-453)	341(309-361)

Hydrogen ion values ranged from pH 7.8 - 8.1 as compared to river values of pH 8.6 - 8.7.

2. *Chara contraria* A. Braun ex Kütz. [= *C. vulgaris* var. *vulgaris* f. *contraria* (A. Braun ex Kütz.) Wood]. [Figure 2]

This Crooked Lake *Chara* has a thallus length from 30 - 50 cm and axes of up to 832 µm in diameter. The olive to golden-brown axes are moderately to heavily encrusted, diplostichous and strongly tylacanthous (Figure 2b). In older axes the cortication may become irregular by overlapping growth of ends of the narrower secondary cells, sometimes developing an almost triplostichous arrangement. Tiny, almost globular spine cells are produced singly at the primary cortex nodes. Two tiers of small stipulode cells are present, the cells of the upper tier often slightly larger than those of the lower tier.

Branchlets are very long, up to 50 mm, most of the length due to three ecorticate end segments (Figure 2c). The tip cell is small, conical and pointed, the penultimate cell is of intermediate length and the ecorticate basal cell is much elongated. Three or four, occasionally two or five, short basal branchlet internodes are regularly corticated, gametangia being borne at all corticated nodes. Bracteoles and anterior bract cells are very short, less than mature oogonial length, while posterior bract cells are tiny, often obscure.

Male and female gametangia are conjoined at the nodes, the geminate condition of both antheridia and oogonia being very common. Antheridia are orange in color, mature oogonia being either orange like the antheridia or of a greenish color. Coronula cells have connivent rounded tips (Figure 2d), occasionally slightly spreading. Oospores are dark brown to black with short basal claws and thin finger-like processes at the coronula end (Figure 2e). Crushed oospore membranes appear finely granular at 400 X and are brown in color. Table 1 lists gametangial and oospore measurements.

This variant of *Chara contraria* differs from the typical in several ways; it has very long whip-like ecorticate branchlet ends, the bracteoles and anterior bract cells are very short, the geminate condition is common, and the oospore usually features elongated finger-like processes at the coronula end. Migula (1897) mentions a rare form (f. *capillacea*) with elongated branchlet ends, but in habit and other structural features it is not like the present variety. Likewise, Wood's (1965) var. *nitelloides* from South America shows some similarities, but differences as well. Corillion (1957) mentions the geminate condition occurs sometimes in *C. contraria* as well as *C. vulgaris*. Although individually most of the characteristic features of the Crooked Lake material have been reported before in *C. contraria*, their occurrence together in such robust plants apparently has not been previously noted. I have not encountered reference to the peculiar prominent apical projections on the oospore. Even so, at present this taxon will simply be regarded as an extreme variant of *C. contraria* without according it any special taxonomic status.

Chara contraria is a cosmopolitan taxon occurring throughout most of North America. Four collections of tylacanthous material from southern and central Saskatchewan were seen in the Canadian Museum of Nature (CANA) but these have not been critically assessed and require further study. None appear to show the combination of characters of the Crooked Lake material.

This taxon is ubiquitous throughout Crooked Lake preferring the shallower water between the wave affected margins and the dense vascular "weed" zone. Here it grows at a depth of 1.5 - 3.0 m intermixed with the common coarse filamentous alga *Cladophora* and open growing vasculars such as *Zannichellia*. It extends into the edge of the vascular beds, but has not been found growing within the beds or beyond the beds in deeper water. In one area where extensive Beaver (*Castor canadensis*) activity had cleared a large area which would have normally contained dense vascular growth, this *Chara* produced thick mats of especially luxuriant growth on the muddy substrate among the Beaver runs in 1 - 3 m of water. Both Olsen (1944) and Langangen (1974) characterize *C. contraria* as a species of alkaline freshwaters of high calcium content, *C. vulgaris* having very similar preferences.

3. *Chara globularis* Thuill. (= *C. fragilis* Desv., = *C. globularis* Thuill. var. *globularis* form *globularis* Wood). [Figure 3]

Chara globularis produces stout axes 30 - 50 cm in length and up to 730 µm in diameter. The main axis (Figure 3b) exhibits triplostichous cortication and cells of the primary and secondary rows are about the same diameter (isostichous). Spine cells are rudimentary and globular as are the two tiers of stipulodes. All parts of the thallus are moderately encrusted. Branchlets usually have eight corticated segments plus two short ecorticate end segments (Figure 3c). The lowest three, sometimes four, nodes from the base exhibit conjoined gametangia. Bracteoles and anterior bract cells are shorter than the mature oogonia while posterior bract cells are rudimentary. Coronula cells are connivent with the tips separated, sometimes slightly spreading (Figure 3d). Mature oogonia including the coronula cells are pale green to pale orange and antheridia are deep bright orange in living material. Intact oospores exhibit prominent basal claws and appear dark brown to black with reflected light (Figure 3e). Table 1 lists gametangial and oospore measurements which fall within the traditionally reported values (Corillion 1957; Wood 1965; Moore 1986).

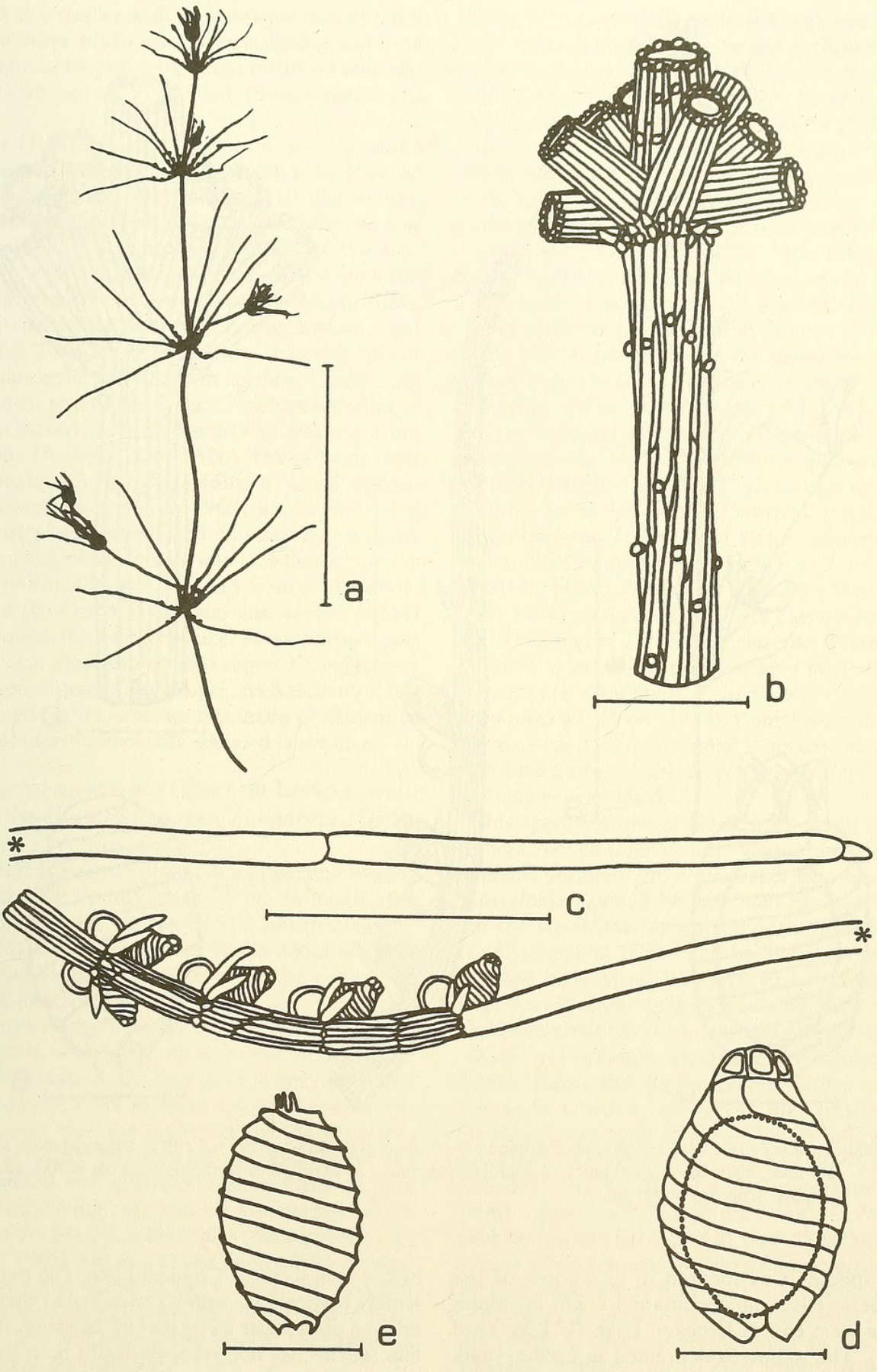

FIGURE 2. *Chara contraria*. a: plant habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged portion of axis and node, scale bar = 1000 μm; c: branchlet, scale bar = 3000 μm; d: oogonium, scale bar = 500 μm; e: oospore, scale bar = 400 μm.

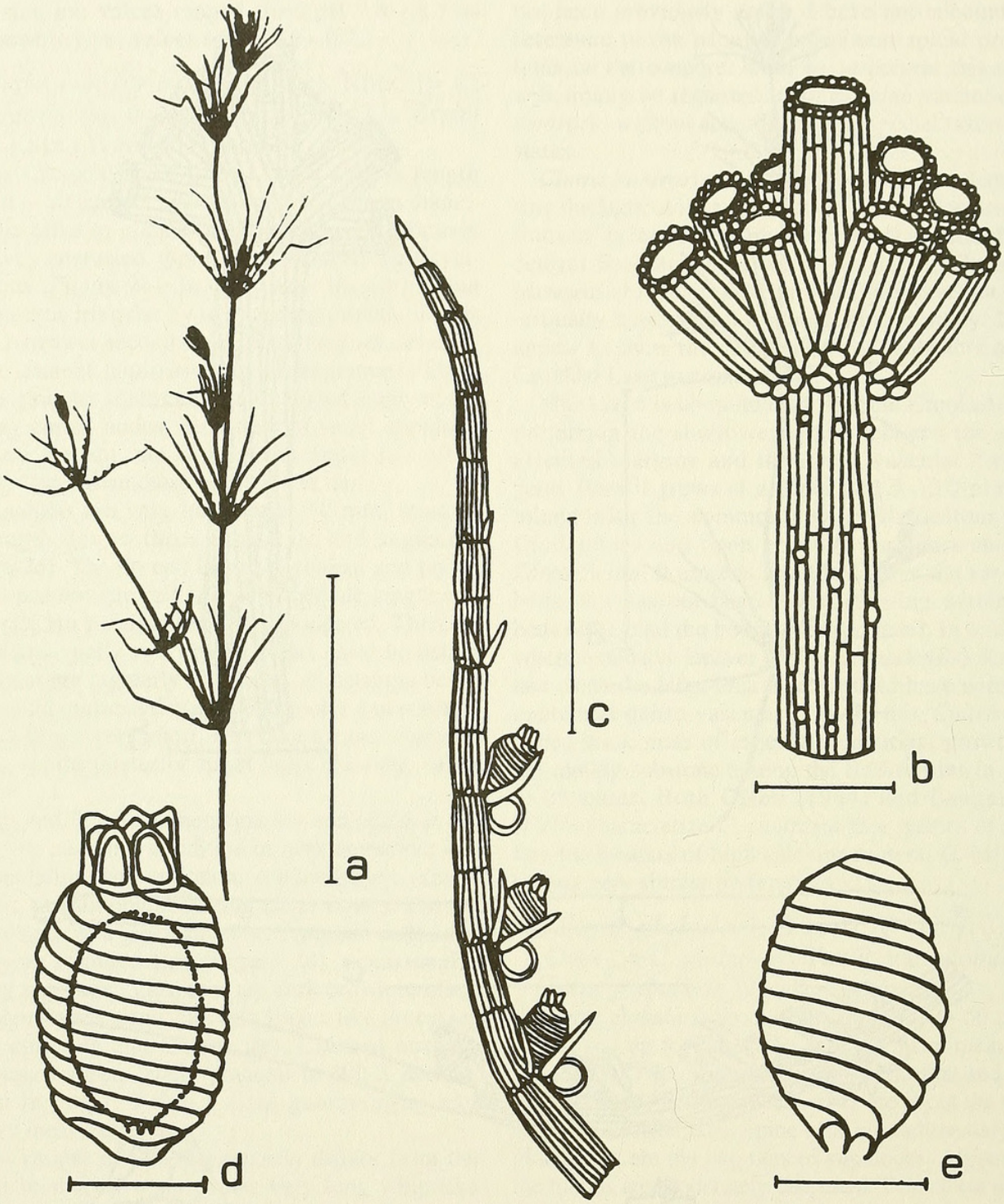

FIGURE 3. *Chara globularis*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged main axis and node, scale bar = 1000 μm; c: branchlet, scale bar = 2000 μm; d: oogonium, scale bar = 300 μm; e: oospore, scale bar = 300 μm.

This species was located in an oxbow of the Qu'Appelle River approximately 6 km upstream from the west end of Crooked Lake (U.T.M. Grid 508115). The oxbow was created in earlier years from a section of the meandering river that had been mechanically straightened for flood control purposes. *Chara globularis* covered the entire bottom in a thick carpet rooted in a fine muddy clay in 1 - 1.5 m of clear stagnant water. Conductivity measured 2500 μmhos/cm and pH was 9.1, values somewhat higher than those of Crooked Lake. The oxbow was largely bordered by willows with *Typha* encroaching into the open water along part of the shore. Although this species has not yet specifically been located in Crooked Lake, its presence in the upstream drainage system and its general ubiquitous distribution suggest it may also be found in the lake. I also located it in a roadside borrow pit in agricultural country 9 km south of the Qu'Appelle Valley rim on provincial highway number 47 (U.T.M. Grid 007473). It is

recorded as a species with a great range of ecological tolerance, from mildly acid to very alkaline and from fresh oligotrophic waters to those distinctly eutrophic, brackish, or saline (Olsen 1944; Langangen 1974).

Wood (1965) does not mention any Canadian specimens, only stating that this taxon is widespread in North America and elsewhere. His distribution map (Wood 1967) combines all his varieties so it is not possible to distinguish this taxon from it. However, sufficient Canadian collections exist (CANA) from Newfoundland, across southern Canada to British Columbia, the Yukon, and Northwest Territories to indicate it is one of our most widespread and common species. I have seen two regional specimens at the Canadian Museum of Nature (CANA) from Saskatchewan and one from Manitoba. These include CANA 15924 from Bear Lake, mile 63 of the Hansen Lake Road, Saskatchewan (B. de Vries 1962) which contains a mixture of *C. globularis* and *C. contraria*, CANA 5930 from Henzel, Saskatchewan (J. Macoun and W. Herriot 1906) and CANA 29333 from Fort Whyte, Manitoba (C. Garton). Rawson and Moore (1944) cite *C. fragilis* from Stoney Lake, Saskatchewan, and Hammer and Heseltine (1988) report *C. globularis* Thuill. from saline Wakaw Lake, Saskatchewan, but as discussed earlier, whether this taxon or another in the *C. globularis* complex is intended is not clear.

4. *Tolypella glomerata* (Desv. in Lois.) Leonh. [= *Tolypella nidifica* var. *glomerata* (Desv. in Lois.) Wood]. [Figure 4]

Tolypella glomerata produces a branching moderately encrusted thallus up to 35 cm in length, the axes being slender and up to 800 μm in diameter (Figure 4a). Branchlets at non-fertile nodes are simple and undivided. Fertile branchlets are compacted into dense heads usually less than 1 cm in diameter near the tips of the branches (Figure 4b). Branchlets of the fertile whorls are mostly once divided in a monopodial fashion, the 3 - 4 laterals only produced at the first node from the base are smaller in length and diameter than the main axis of the branchlet (Figure 4c). Characteristic of the species are the large allantoid end cells with rounded tips on both the main branchlet axis and on the laterals which place it in the Section *Obtusifolia* (Section *Tolypella* of Wood, 1965). Often a single antheridium flanked by two oogonia occur at the base of the laterals, however, up to five oogonia in a cluster have been observed here and also at the base of the branchlet where it joins the main axis.

Table 2 lists reproductive structure measurements. The Crooked Lake material exhibits most of the characteristic features of the species as documented in the standard references (Groves and Bullock-Webster 1920; Corillion 1957; Wood 1965; Moore 1986) with several variations. Antheridial diameter is the largest recorded for this taxon, approaching that of *Tolypella nidifica* of Europe. Oospore size also appears to be somewhat greater than that normally recorded for the species. The coarse linear membrane decoration pattern, which has long been recognized as a major feature of the taxon, is present but the lines often separate leaving smooth patches, sometimes extensively so, across the fossae (Figure 4f). This differs from Newfoundland material and European reports which seem to indicate that the coarse linear pattern occurs more or less uniformly across the fossae. Frame (1977) reiterates that the membrane decoration of *T. glomerata* and closely related *T. nidifica* of Europe differ significantly with the scanning electron microscope and that differences exist even between North America and European members of the morphological species *T. glomerata* as well as differences within North American populations. Ripe oospores of Crooked Lake specimens are orange-brown with reflected light.

Earlier North American workers (Allen 1883; Allen 1954) recognized two taxa closely related to, and in addition to *Tolypella glomerata*, *T. longicoma* Br. and *T. comosa* Allen. These were merged with *T. glomerata* as a variety of *T. nidifica* (*T. nidifica* var. *glomerata*) by Wood (1965). Considering the variation associated with this group it appears that a thorough reappraisal of the *T. glomerata/nidifica* complex may be warranted.

This species grows at the greatest depth recorded for the Crooked Lake charophytes. Although vascular plants normally grow no deeper than 6 m, *Tolypella glomerata* can be collected in deeper water near the weed line intermixed with the ubiquitous lake *Cladophora*. It was also collected in "holes" in the weed beds where the thick vascular vegetation cover was broken, again associated with mats of *Cladophora*, but never amongst the dense vasculars.

Wood's (1967) map which does not separate related taxa, shows that the *Tolypella nidifica* complex extends in a broad belt across the United States entering Canada only in the Canadian prairies. The only Canadian citation by Wood (1965) is of J. Macoun's (1879) collection var. *glomerata* from a "pond west of Saskatchewan". Whether "Saskatchewan" here should read "Saskatoon" or whether this is actually an Alberta report is not clear. The Canadian Museum of Nature contains a single specimen of *T. glomerata* from the region (CANA 5910) from a "shallow prairie pond 16 km east of Canmore, Alberta, on Banff-Calgary Highway" (A. E. Porsild 18151A, 11 July 1951). I have recently reported (Mann, in press) a collection of *T. glomerata* from the tip of the Great Northern Peninsula in Newfoundland and this together with the prairie reports constitute the most northerly records in North

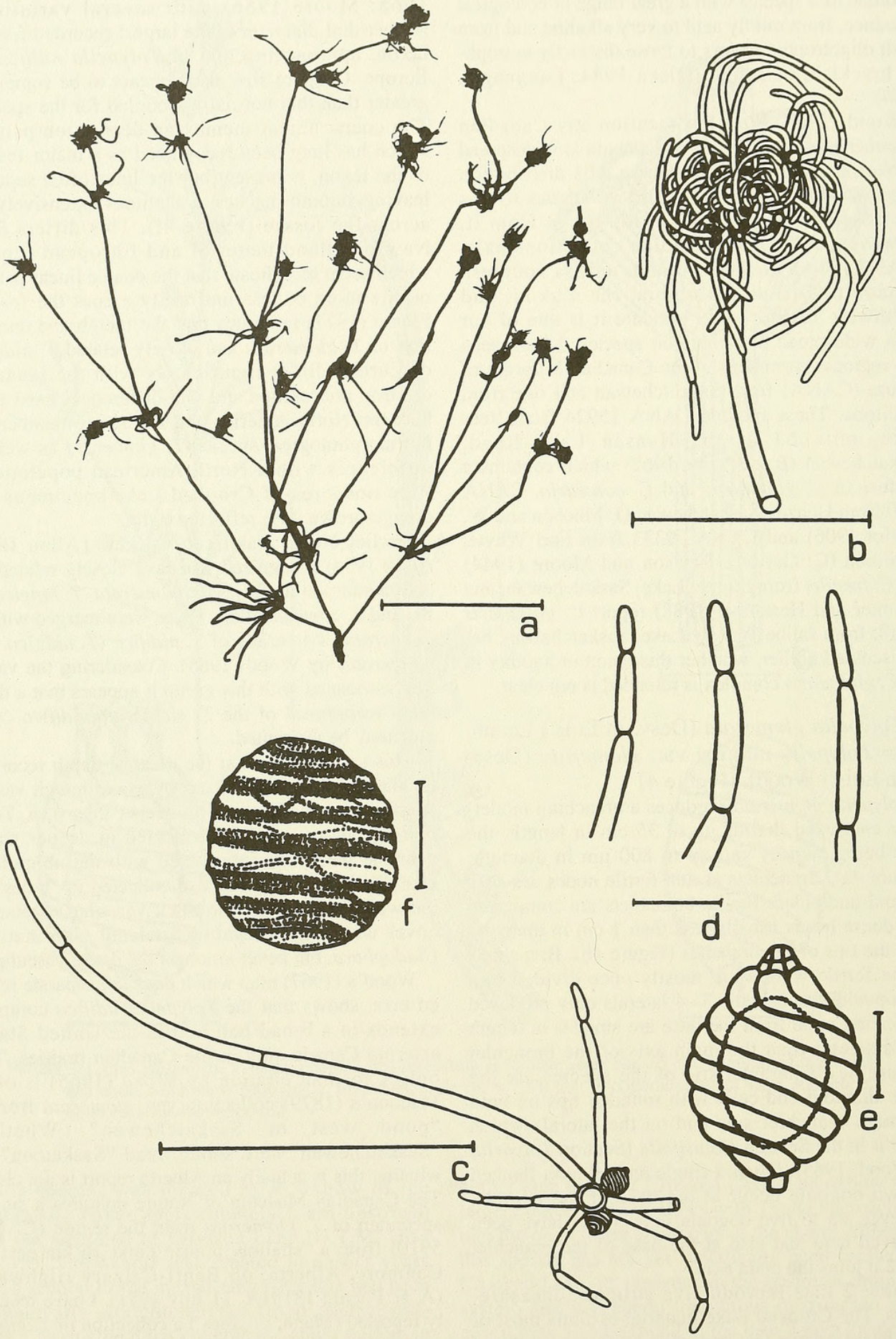

FIGURE 4. *Tolypella glomerata*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: enlarged terminal "head", scale bar = 1 cm; c: branchlet with four laterals, scale bar = 5000 µm; d: variations in terminal cells, scale bar = 1000 µm; e: oogonium, scale bar = 200 µm; f: oospore showing linear ornamentation, scale bar = 200 µm.

TABLE 2. Gametangial and oospore features of *Tolypella* species. Measurements are presented as means (μm) with range values in parentheses.

	T. glomerata	*T. prolifera*
Oogonium		
length	557(474-618)	573(515-618)
width	444(391-474)	424(381-453)
coronula height	50	50
convolutions	(9-11)	(11-12)
Oospore		
length	409(371-433)	409(370-433)
width	334(319-350)	336(319-350)
No. of ridges	(7-8)	(8-10)
fossae width	62	57
Antheridium		
diameter	469(402-515)	267(216-288)

America. The Newfoundland and Crooked Lake specimens show some differences in growth habit, gametangial size and oospore membrane decoration, but how significant these are is not understood at present.

5. *Tolypella prolifera* (Ziz. ex A. Braun) Leonh. [= *Tolypella intricata* var. *intricata* form *prolifera* (Ziz. ex A. Braun) Wood]. [Figure 5]

Crooked Lake *Tolypella prolifera* is a stouter plant than *T. glomerata* with axes up to 1050 μm in diameter, with longer simple sterile branchlets and fewer but larger fertile heads (Figure 5a). Actively growing axes are lightly to moderately encrusted and have a brighter grass green color compared to the olive green of older more encrusted axes and those of *T. glomerata*. Branchlets of the dense fertile "birds-nest" heads usually bear laterals at two nodes above the base in a monopodial fashion, the laterals often again branching (Figure 5b). Very characteristic of the section to which it belongs, Section *Acutifolia* (Section *Rothia* of Wood 1965), are the tapering branchlet and lateral axes, with each cell closer to the tip becoming progressively smaller, the end cell producing a small sharp conical tip (Figure 5c). In almost all morphological respects it exhibits the features normally used to distinguish this taxon (Groves and Bullock-Webster 1920; Corillion 1957; Wood 1965).

Gametangial and oospore measurements are given in Table 2. Coronulas remain attached as oospores mature, the upper tier of five coronula cells are approximately twice the height of the lower tier (Figure 5d). Intact mature oospores are dull brown in color with reflected light as are the crushed spore membranes with transmitted light. Oospore membranes are more or less smooth or at least only very indistinctly and irregularly ornamented at 400 X except for a narrow band of irregular coarse granules on either side of the ridges. I can find no reference to these narrow granular strips in any of the traditional light microscope literature or in more recent scanning electron studies.

Unlike *Tolypella glomerata*, *T. prolifera* tends to grow among the vascular macrophytes where their growth is not excessively dense. Crum (1975) noted that *Ceratophyllum demersum* L. because of its dense stands, was a negative indicator of *T. prolifera* and *T. intricata*, but that more open growing species like *Potamogeton* and *Myriophyllum* were positive indicators of presence. Observations in Crooked Lake also support this relationship. In Britain, *T. prolifera* is listed in the Red Data Books as a potentially endangered species, its habitat specified as "... exclusively a plant of small alkaline water bodies such as ditches, rivers, canals or peat pits. It prefers slow-moving water and tends to grow in deeper water than other members of the genus" (Stewart and Church 1992).

Although Wood (1965) considers this taxon a form of *Tolypella intricata*, earlier workers and a number of modern authorities treat it at the species level (Corillion 1957; Sawa 1973; Blazencic et al. 1990). This taxon appears to be distributed across most of the United States and southern Canada excluding the maritimes and Newfoundland. Wood (1965) only lists two Canadian records, one from Quebec and one from Saskatchewan. Allen (1954) notes records from British Columbia, Saskatchewan, Lake Huron and Lake Ontario. Also, a collection at the Canadian Museum of Nature (CANA) occurs from Bolton Creek, near Bennett Lake, Ontario. Curiously enough, even though Wood (1965) lists its occurrence in Saskatchewan, his distribution map (Wood 1967) totally excludes this taxon from the entire Canadian prairies and north-central United States. *Tolypella prolifera* is relatively well represented in the national collection (CANA) from southern Saskatchewan and Alberta with a total of

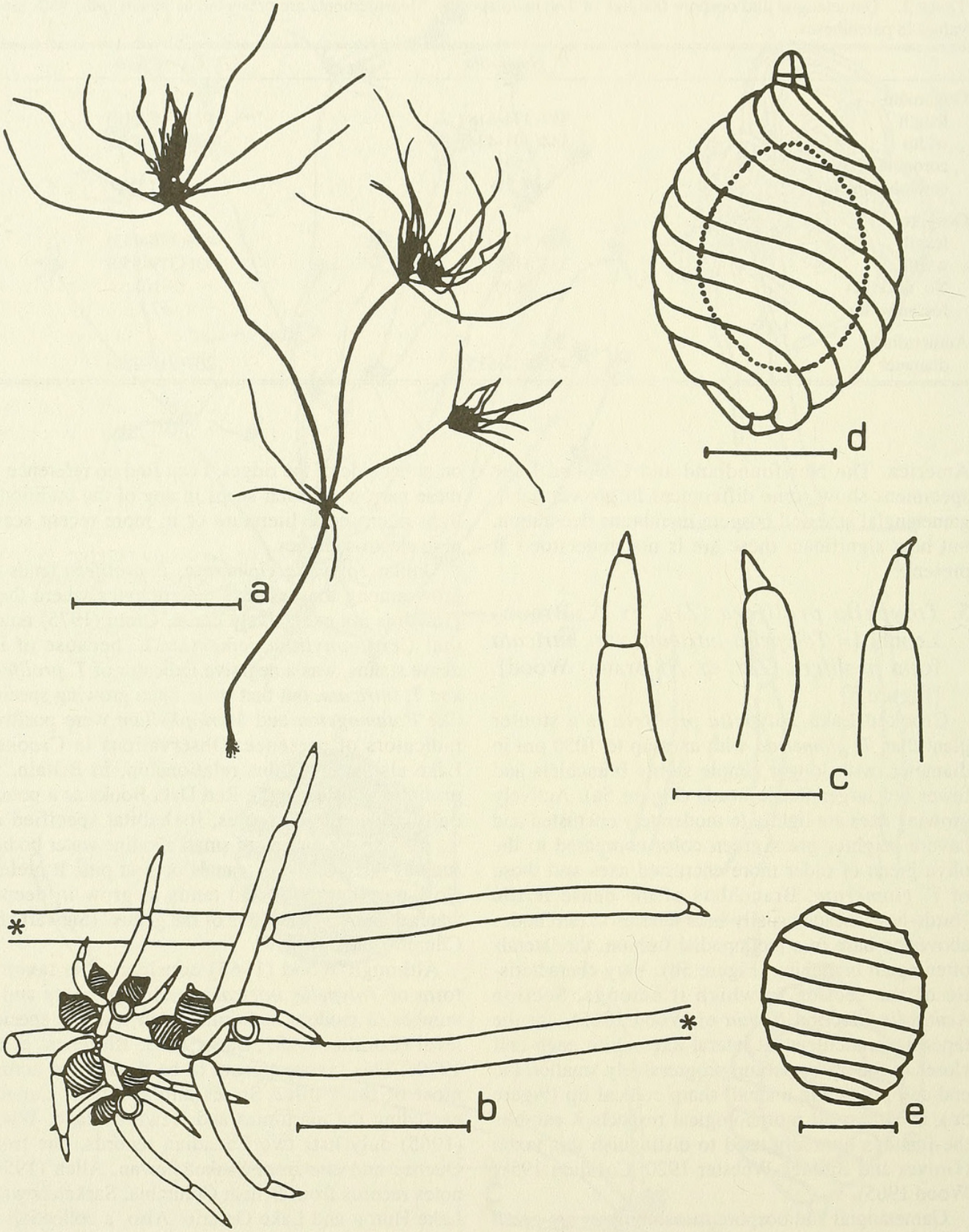

FIGURE 5. *Tolypella prolifera*. a: habit, photocopied herbarium specimen, scale bar = 5 cm; b: branchlet, scale bar = 2000 µm; c: variation in branchlet end cells, scale bar = 500 µm; d: oogonium, scale bar = 200 µm; e: oospore, scale bar = 200 µm.

seven specimens. Saskatchewan collections are listed from pools and lakes in the Moose Jaw, Regina, and Yorkton areas and the Alberta collection from Pot Hole Creek.

6. *Nitella* sp. [Figure 6]

When examining the *Chara vulgaris* material from Ekapo Creek, a single stem of *Nitella* was found, its anchoring rhizoidal mass still intertwined with those

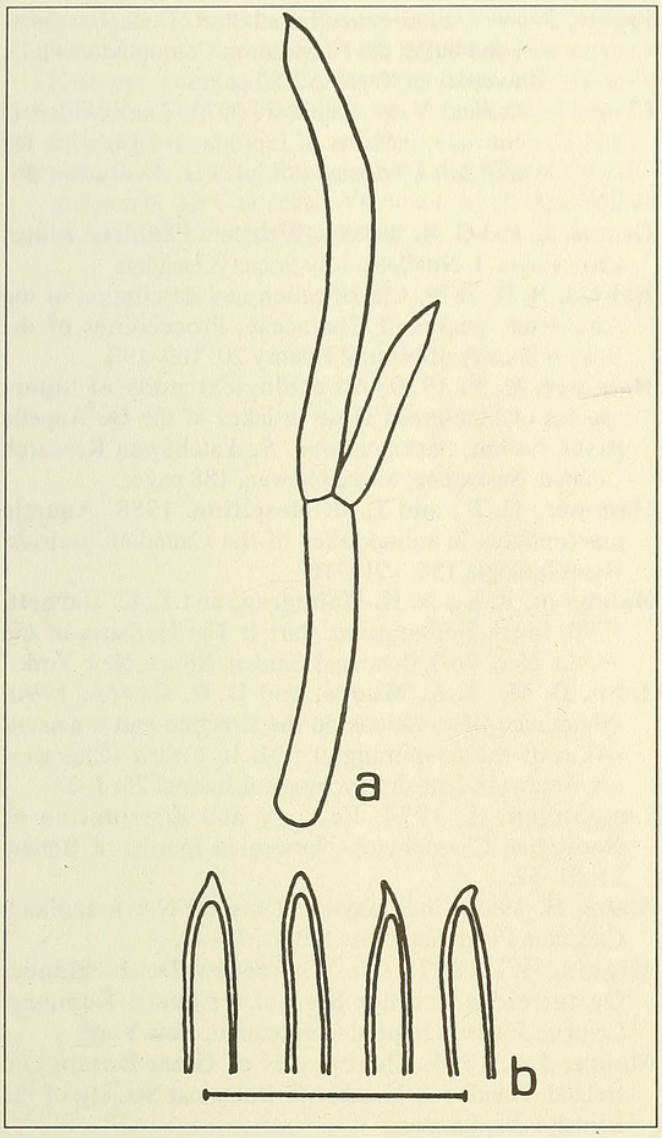

FIGURE 6. *Nitella* sp. a: typical branchlet; b: variation in branchlet apices, scale bar = 1000 μm.

of some *Chara* axes. A thorough search of all collections made from this site turned up no further *Nitella* specimens. The plant was entirely sterile, no gametangia were present. The thallus axis is very slender, only 215 μm in diameter and 20 cm in length with six branchlets per node. Dactyl apices are mostly acute or acute-apiculate as described and illustrated in Wood (1965) and Wood and Imahori (1964) (Figure 6b). From its once furcate branchlets, single-celled dactyls and acute dactyl apices, it most likely is *Nitella flexilis* or a closely related form. Dactyls are of unequal size as illustrated in Figure 6a.

Both monoecious *Nitella flexilis* and dioecious *N. opaca* are cosmopolitan species and among the most commonly collected Nitellas. Because members of the *N. flexilis* complex can flourish over an extremely broad range of environmental parameters (Olsen 1944; Langangen 1974), they should be frequently encountered throughout the area, especially so in the more oligotrophic northern lakes. Even though Wood (1965, 1967) treats these two as a single taxon, this approach may no longer be tenable and monoecious and dioecious taxa should be distinguished whenever possible (Sawa 1965; Proctor 1975, 1980). If the opportunity arises, this site should again be thoroughly sampled in an attempt to obtain additional material on which to base a more sound taxonomic judgement.

Other Charophytes Recorded From Saskatchewan

The following records of Saskatchewan charophytes are those for which specimens are known to exist or which are otherwise considered to be well documented. The information may be of use to others involved in charophyte studies or in more general aquatic studies where charophytes are only one of the components being investigated. If taxonomic identity of these or other collections not thoroughly described in the literature is critical, then it would be prudent for investigators to check the actual specimens, if possible, to verify original determinations.

Specimens housed in the Phycological Herbarium of the Canadian Museum of Nature, Ottawa are listed as CANA followed by accession number, collector, date of collection in brackets and approximate location. Scattered unreported specimens possibly also occur in prairie herbaria or larger collections such as (NY), (US) and others, especially specimens obtained since the early nineteen-sixties.

Chara canescens Desv. & Lois. in Lois. (= *C. evoluta* T.F. Allen. All CANA specimens are monoecious)
— CANA 5943, 5944 J. Macoun (1879) "Saskatchewan"
— CANA 5873, 5933 J. Macoun (1896) Park Beg, Saskatchewan
— CANA 29327 J. Hudson (1955) Mortlach, Saskatchewan
— citation in Hammer and Heseltine (1988) Wakaw Lake, Saskatchewan

Chara globularis var. *virgata* (Kütz.) R. D. Wood (= *C. delicatula* Agardh)
— citation in Wood (1965), J. Macoun (1879) "Ponds west of Saskatchewan"

Chara aspera Deth. ex Willd. [*C. globularis* var. *aspera* (Deth. ex Willd.) Wood]
— CANA 5951 J. Macoun (1879) "Saskatchewan"
— CANA 5926, 5929 J. Macoun and W. Herriot (1906) Henzel, W. of Yorkton, Saskatchewan
— CANA 5927, 5928 J. Macoun and W. Herriot (1906) French, W. of Saskatoon, Saskatchewan
— CANA 28830 G. Ledingham (1987) Hudson Bay, Saskatchewan

Chara aspera var. *macounii* Allen [*C. macounii* (Allen) Robinson, *C. globularis* var. *virgata* f. *macounii* (Allen) Wood]
— citation in Robinson (1906) and Wood (1965), J. Macoun (1879) Long Lake, Saskatchewan

Chara braunii Gm. (*C. coronata* Ziz. ex Bischoff)
— CANA 28837 G. Ledingham and B. Rever (1960) W. of Regina, Saskatchewan
— CANA 5937, 5938, 5952 J. Macoun (?) "Canada". No specific location given.

Chara buckellii G.O. Allen
— cited in Hammer and Heseltine (1988) Waldsea Lake, Saskatchewan

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Literature Cited

Allen, G. O. 1950. British Stoneworts (Charophyta). The Haslemere Natural History Society, Surrey, England.

Allen, G. O. 1951. Notes on Charophytes from British Columbia. Proceedings of the Linnean Society 162: 148–152.

Allen, G. O. 1954. An annotated key to the Nitelleae of North America. Bulletin of the Torrey Botanical Club 81(1): 35–60.

Allen, T. F. 1883. Notes on the American species of *Tolypella*. Bulletin of the Torrey Botanical Club 10 (10–11): 109–117.

Anonymous. 1971. Qu'Appelle Basin Study Report on qualitative study of surface waters. Canadian Department of Environment, Inland Waters Branch, Water Quality Division, Regina, Saskatchewan. 36 pages.

Anonymous. 1972. Report of the Qu'Appelle Basin Study Board. Queen's Printer, Legislative Building, Regina, Saskatchewan. 65 pages.

Atton, F. M., and **R. P. Johnson.** 1962. Report on the limnology and fisheries of six lakes of the lower Qu'Appelle Valley in southern Saskatchewan. Saskatchewan Fisheries Laboratory, Department of Natural Resources, Saskatoon, Saskatchewan. 123 pages.

Bhatnagar, S. K. 1989. Cytological perspectives of Charophyta. 1. *Chara globularis* complex. Phykos 28 (1 & 2): 156–165.

Blazencic, J., Z. Blazencic, M. Cvijan, and **B. Stevanovic.** 1990. Systematic and biogeographic studies of Charophytes in Yugoslavia. Cryptogamie Algolgie 11(4): 249–256.

Corillion, R. 1957. Les Charophycées de France et d'Europe Occidentale. Travaux du Laboratoire de Botanique de la Faculté des sciences d'Angers, Fascicules 11–12.

Crum, G. H. 1975. Distribution, taxonomy and ecology of Charophytes in Iowa. Ph.D. thesis, Iowa State University, Ames, Iowa. 152 pages.

Frame, P. 1977. Fine structural studies of oospore ornamentation and bulbil development in Charophytes. Ph.D. thesis, University of Toronto. 182 pages.

Grant, M. C., and **V. W. Proctor.** 1972. *Chara vulgaris* and *C. contraria*: patterns of reproductive isolation for two cosmopolitan species complexes. Evolution 26: 267–281.

Groves, J., and **G. R. Bullock-Webster.** 1920. The British Charophyta. I. Nitelleae. Ray Society, London.

Halsted, B. D. 1879. Classification and description of the American species of Characeae. Proceedings of the Boston Society of Natural History 20: 169–190.

Hammer, U. T. 1970. An ecological study of bloom species of blue-green algae in lakes of the Qu'Appelle River system, Saskatchewan. Saskatchewan Research Council, Saskatoon, Saskatchewan. 188 pages.

Hammer, U. T., and **J. M. Heseltine.** 1988. Aquatic macrophytes in saline lakes of the Canadian prairies. Hydrobiologia 158: 101–116.

Holmgren, P. K., N. H. Holmgren, and **L. C. Barnett.** 1990. Index Herbariorum, Part I: The Herbaria of the World. New York Botanical Garden, Bronx, New York.

John, D. M., J. A. Moore, and **D. R. Green.** 1990. Preliminary observations on the structure and ornamentation of the oosporangial wall in *Chara* (Charales, Chlorophyta). British Phycological Journal 25: 1–24.

Langangen, A. 1974. Ecology and distribution of Norwegian Charophytes. Norwegian Journal of Botany 21: 31–52.

Mann, H. 1989. Charophytes of insular Newfoundland. Canadian Field-Naturalist 103(1): 34–42.

Migula, W. 1897. Die Characeen Deutschlands, Oesterreichs und der Schweiz. Eduard Kummer, Leipzig. Johnson Reprint Corporation, New York.

Moore, J.A. 1986. Charophytes of Great Britain and Ireland. Handbook Number 5. Botanical Society of the British Isles, London.

Olsen, S. 1944. Danish Charophyta: chorological, ecological and biological investigations. Det Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter 3(1): 1–240.

Proctor, V. W. 1971. *Chara globularis* Thuillier (= C. fragilis Desvaux): breeding patterns within a cosmopolitan complex. Limnology and Oceanography 16(2): 422–436.

Proctor, V. W. 1975. The nature of Charophyta species. Phycologia 14(2): 97–113.

Proctor, V. W. 1980. Historical biogeography of *Chara* (Charophyta): an appraisal of the Braun-Wood classification plus a falsifiable alternative for future consideration. Journal of Phycology 16: 218–233.

Rawson, D. S., and **J. E. Moore.** 1944. The saline lakes of Saskatchewan. Canadian Journal of Research, Section D, Zoological Sciences 22: 141–201.

Robinson, C. B. 1906. The Chareae of North America. Bulletin of the New York Botanical Garden 4(13): 244–308.

Sawa, T. 1965. Cytotaxonomy of the Characeae: karyotype analysis of *Nitella opaca* and *Nitella flexilis*. American Journal of Botany 52(9): 962–970.

Sawa, T. 1973. Two new species of *Tolypella* (Characeae) from North America. Journal of Phycology 9: 472–482.

Stewart. N. F., and **J. M. Church.** 1992. Red Data Books of Britain and Ireland: Stoneworts. The Joint Nature Conservation Committee, Peterborough.

Stewart, R. E., and **H. A. Kantrud.** 1971. Classification of natural ponds and lakes in the glaciated prairie region. Resource publication 92, Bureau of Sport fisheries and Wildlife, Fish and Wildlife Service, Washington D.C. 15 pages.

Wood, R. D. 1965. Monograph of the Characeae. *In* A revision of the Characeae, Volume I. *By* R. D. Wood and K. Imahori. Cramer, Weinheim.

Wood, R. D. 1967. Charophytes of North America. Stella's Printing, West Kingston, Rhode Island.

Wood, R. D., and **K. Imahori.** 1964. Iconograph of the Characeae. *In* A revision of the Characeae, Volume II. *By* R. D. Wood and K. Imahori. Cramer, Weinheim.

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