CHAPTER 4-7a

INVERTEBRATES: ROTIFER TAXA – MONOGONONTA

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Figure 1. ***Keratella*** sp. among ***Sphagnum*** leaves. Photo by Marek Mis <www.mismicrophoto.com>, with permission.

CLASS MONOGONONTA

This is the largest of the two classes of rotifers, comprised of ~1570 species, ~1488 of which are free-living in fresh water of limnoterrestrial habitats (Segers 2008). It differs from the **Bdelloidea** in having two sexes and having only one ovary. Nevertheless, asexual reproduction occurs over and over until environmental conditions, often related to crowding, trigger the reproduction to become sexual (Welch 2008). At this time, the eggs of the **amictic** (non-sexual) females hatch into **mictic** females that produce their eggs by meiosis. The **haploid** eggs that are not fertilized develop into much smaller males and fertilization of a female by these males produces **diploid** eggs that become resting eggs.

The monogonont rotifers mostly eat small particles and organisms by filtering them, some actually seize them, and some are parasitic.

ORDER COLLOTHECACEA

Many members of this order are **sessile** (attached) and some are colonial. These rotifers have a foot that lacks toes, but they possess many foot glands that are used for adhesion. The females are predominantly sessile, but males and immature rotifers are free-living.. The rotary apparatus surrounds a funnel-like **invagination**. Many are surrounded with a jelly sheath.

Collothecidae

Many members of the Collothecidae are plant and algal inhabitants. The **Collothecidae** provide us with evidence of adaptive strategies embodied in reproduction. An examination of 65 species of rotifers, including this family, revealed that egg volume of rotifers increased as body volume increased, but the relative size of eggs actually decreased as body size increased (Wallace *et al*.

1998). This means that smaller species, typical among planktonic species and bryophytes, invest the most in egg production. The **Flosculariidae** (**Floscullariacea**) species are of intermediate size and their relative investment in egg mass is likewise intermediate. The **Collothecidae** family has the largest species and the lowest relative biomass of egg production among those examined by Wallace *et al*.

Collotheca

Collotheca (Figure 2-Figure 8) is a common genus in peatlands, living in ***Sphagnum*** pools (Figure 5) and on ***Sphagnum*** (Figure 2, Figure 21, Figure 61-Figure 62).

Figure 2. ***Collotheca*** on ***Sphagnum***. Photo by Marek Mis <www.mismicrophoto.com>, with permission.

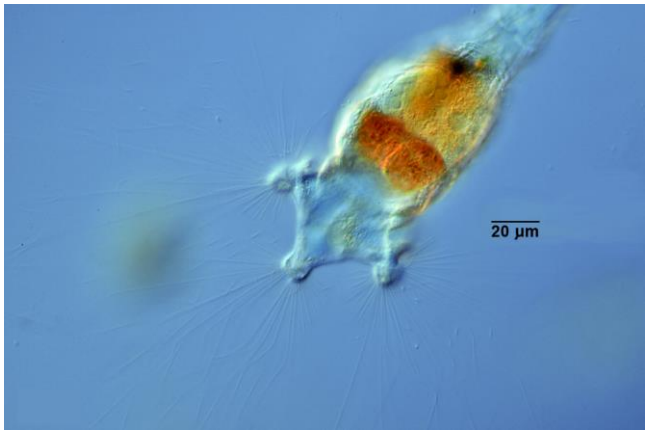

Figure 3. ***Collotheca***, a common genus on ***Sphagnum***. Photo by Proyecto Agua Water Project through Creative Commons.

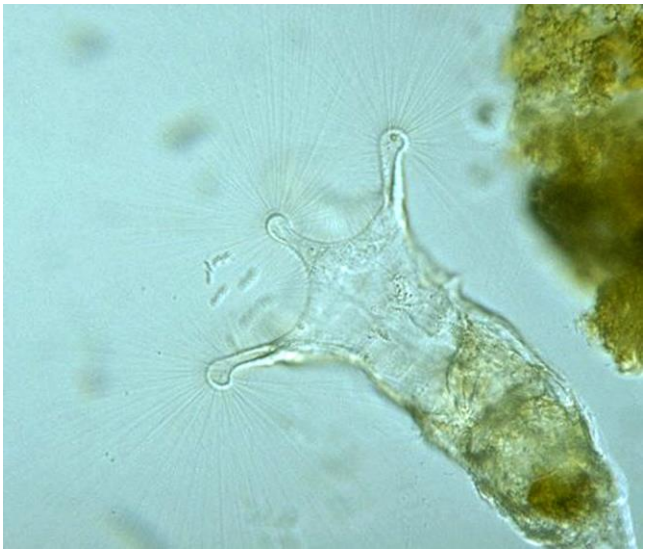

Figure 4. ***Collotheca*** sp., a common genus on ***Sphagnum***. Photo by Yuuji Tsukii, with permission.

Figure 5. ***Sphagnum*** pond, home for rotifers. Photo by Michael Luth.

Collotheca campanulata occurs on wet mosses as well as in the plankton on Svalbard (De Smet 1993). The relationships of this species to aquatic flowering plants can instruct us on relationships to look for among bryophytes. ***Collotheca campanulata*** (***gracilipes***) (Figure 6) is selective in its location on its aquatic plant substrate (Wallace & Edmondson 1986). On plants such as *Elodea canadensis*, it selected (98%) the lower (**abaxial**) surfaces of the leaves. When given equal opportunities for four plant species, it selected *Lemna minor* over *Elodea canadensis*, but in the field more were found on *Elodea canadensis*, with densities reaching more than six individuals per mm^2. Light made a difference, with 91% of the rotifers selecting the **adaxial** (upper) surface in continuous light, but showing no preference in continuous darkness. **Alpha amylase** appears to be the chemical that helps them to identify a plant substrate. Those rotifers that were induced to settle on the abaxial surface produced more eggs than those that were induced to settle on the adaxial surface. It would be interesting to see if these relationships persist on liverworts like ***Riccia fluitans*** (Figure 9) and ***Ricciocarpos natans*** (Figure 10). But what would they do on mosses like ***Fontinalis*** (Figure 11)? They are also known from bog

pools where they attach to ***Sphagnum*** (Figure 2, Figure 21, Figure 61-Figure 62) and algae (Figure 8).

Figure 6. ***Collotheca campanulata***, a rotifer that takes up residence on aquatic plants, ***Sphagnum***, and algae. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 7. ***Collotheca campanulata***, a species that is known as sessile on ***Sphagnum*** and occurs in bog pools. Photo by Yuuji Tsukii, with permission.

Figure 8. ***Collotheca campanulata***, a species that is known as sessile on ***Sphagnum*** in bogs and occurs in bog pools. Photo by Jersabek *et al.* 2003, with permission.

Figure 9. ***Riccia fluitans***, a substrate for rotifers, stranded here above water. Photo by Janice Glime.

Figure 10. ***Ricciocarpos natans***, potential home for rotifers. Photo by Janice Glime.

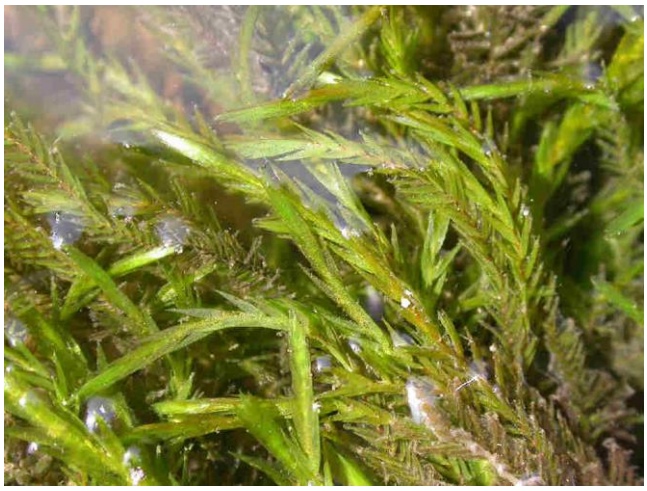

Figure 11. ***Fontinalis antipyretica*** var. ***gracilis***, home for rotifers that are able to feed on the associated detritus. Photo by David T. Holyoak, with permission.

Sphagnum peatlands (Figure 61) are home to several species of ***Collotheca***. ***Collotheca coronetta*** (Figure 12-Figure 13) and ***Collotheca ornata*** (Figure 14) live sessile on ***Sphagnum*** (Figure 21, Figure 62) (Jersabek *et al*. 2003). ***Collotheca ornata*** also occurs on wet mosses and in plankton on Svalbard. ***Collotheca crateriformis*** (Figure 15-Figure 16) and ***C. trilobata*** (Figure 17) live among ***Sphagnum*** (Figure 21). Bielańska-Grajner *et al*. (2011) reported ***C. wiszniewski*** from bogs and fens in Poland.

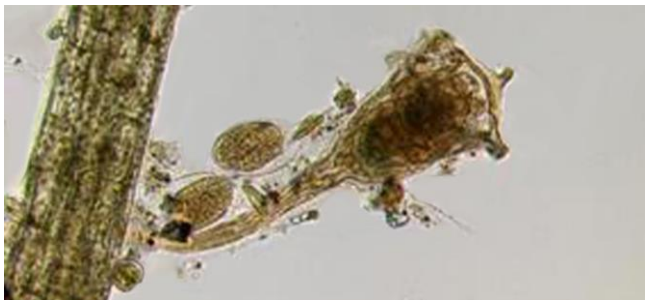

Figure 12. ***Collotheca coronetta***, a species that occurs sessile on ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

Figure 13. ***Collotheca coronetta***, a species that lives sessile on ***Sphagnum***, shown here with mucilage and resting eggs. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 14. ***Collotheca ornata***, a species that lives in bogs and is sessile on ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

Figure 15. ***Collotheca crateriformis*** from among ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

Figure 16. ***Collotheca crateriformis*** from among ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

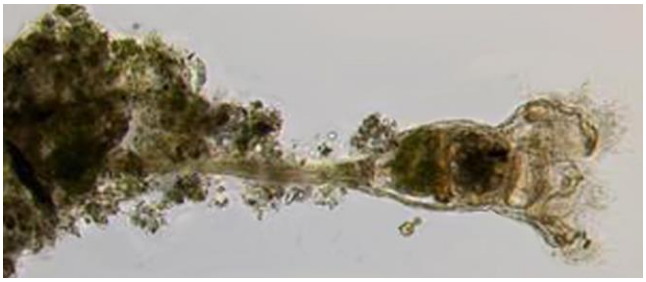

Figure 17. ***Collotheca trilobata*** from among ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

Stephanoceros

So far I have found few reports on ***Stephanoceros*** from bryophytes, but then, it is a genus with only two species (Meksuwan *et al*. 2013), both of which occur on bryophytes. And even the taxonomy is questionable, with the genus arguably belonging to ***Collotheca***. ***Stephanoceros fimbriatus*** (Figure 18-Figure 20) is a sessile species that lives on ***Sphagnum*** (Figure 21) as one of its substrates (Jersabek *et al*. 2003). ***Stephanoceros millsii*** (Figure 22) is known from bryophytes.

Figure 18. ***Stephanoceros fimbriatus***, a sessile species that can occur ln ***Sphagnum***. Photo by Wim van Egmond, with permission.

Figure 19. ***Stephanoceros fimbriatus*** with ***Sphagnum***. Photo by Marek Mis <www.mismicrophoto.com>, with permission.

Figure 20. ***Stephanoceros fimbriatus*** female, a species that occurs sessile on ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 21. ***Sphagnum cuspidatum***, potential home for a variety of rotifers. Photo by David T. Holyoak, with permission.

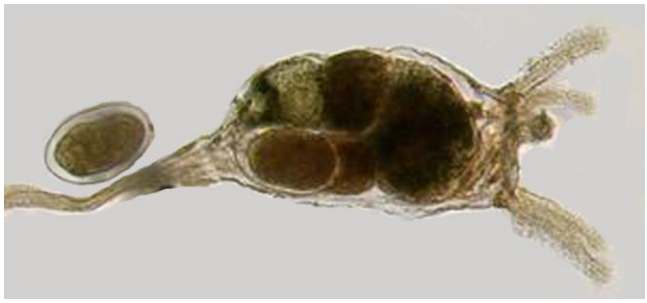

Figure 22. ***Stephanoceros millsii***, a species known from bryophytes. Note the eggs. Photo by Jersabek *et al.* 2003.

ORDER FLOSCULARIACEA

Not only do the members of this order lack toes; some of the planktonic species lack feet as well. Nevertheless, they have multiple **foot glands** to secrete glue. The rotary organ has a double ring of cilia that surrounds the anterior of its lobe-like appendages. Species may be either free-living or sessile and are suspension feeders.

Conochilidae

The species ***Conochilus hippocrepis*** (Figure 23-Figure 24) is typically planktonic in both ponds and large bodies of water, but among these habitats you can find it associated with ***Sphagnum*** (Figure 21) (Jersabek *et al.* 2003). It generally lives in a habitat with a *p*H of 6.3-8.3 and temperature range of 6.4-15.4°C (de Manuel Barrabin 2000). Its colonies can reach 30-60 members that are joined in a gelatinous case (Figure 25). Detritus and bacteria, generally abundant in the habitat, serve as food (Pourriot 1977).

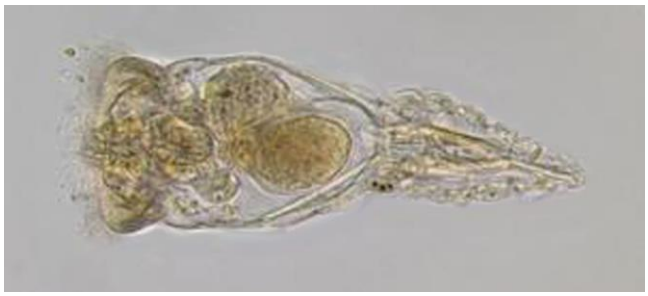

Figure 23. ***Conochilus hippocrepis*** female, member of a genus known on ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 24. ***Conochilus unicornis*** female, member of a genus known to associate with ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

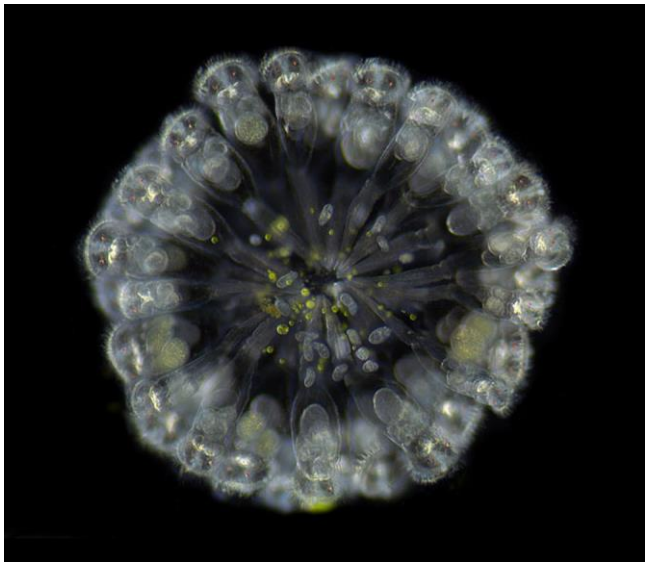

Figure 25. ***Conochilus*** sp. colony. This genus has species that are sessile on ***Sphagnum***. Photo by Wim van Egmond, with permission.

Conochilus hippocrepis (Figure 23-Figure 24) is sensitive to increasing predator pressure from the copepod ***Parabroteas sarsi*** (Figure 26) (Diéguez & Balseiro 1998). As the predator increases in size and begins to prey on the ***C. hippocrepis***, this rotifer responds by increasing its colony size (Figure 25). This seems to be the only member of this family known to associate with bryophytes, in particular ***Sphagnum*** (Figure 21).

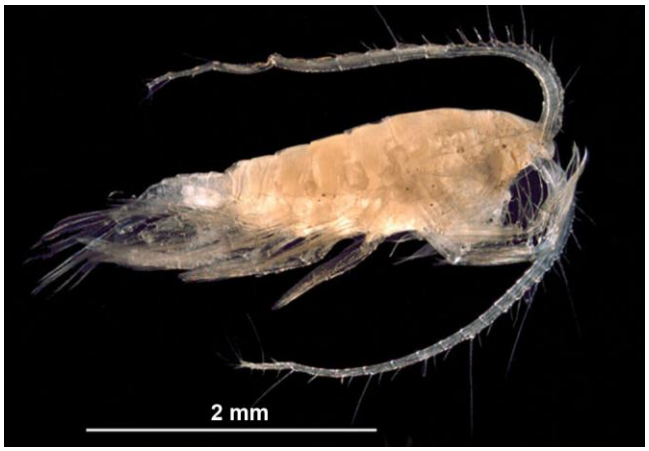

Figure 26. ***Parabroteas sarsi*** male, predator on ***Conochilus hippocrepis***. Photo by Cristián Correa Guzmán, with permission.

Flosculariidae

In this family the male is small and free-swimming, whereas the female lives in a tube and usually attaches by its modified foot. Some of these females (*e.g.* ***Ptygura linguata***) live on the bladders of species of the bladderwort ***Utricularia***. But, sadly for the rotifers, they also constitute part of the diet of these same bladderworts (Mette *et al*. 2000). This habitat affords the rotifers a special aid in getting food as it is sucked into the bladder. Bryophytes can offer no such aid, and although the genera on bryophytes are often the same because they are sessile, species differ.

Floscularia

The genus ***Floscularia*** (Figure 27-Figure 29) is a tube builder and is known to live on ***Sphagnum*** (Figure 66) (Hingley 1993). Jabez Hogg described this tube-building behavior in 1883 (*In* Rotifers 2012). The case is composed of tiny pellets. Gosse, in 1851 (*In* Rotifers 2012), reported a specimen attached to a submerged moss in a pond and observed its case-building behavior. I cannot improve upon the text provided by Hogg (1854, *In* Rotifers 2012): "In November, 1850, Mr. Gosse found a fine specimen of a ***Floscularia*** (Figure 27-Figure 29) attached to a submerged moss from a pond at Hackney; this he watched as it engaged in building its case, and at the same time discovered the use of the curious little rotatory organ on the neck. When fully expanded, the head is bent back at nearly a right angle to the body, so that the [rotary] disc (Figure 29) is placed nearly perpendicularly, instead of horizontally; the larger petals, which are the frontal ones, being above the smaller pair." The terminology has changed, but the observations still provide us with a clear picture of this rotifer on a moss. He discovered the role of these wheels of cilia by adding carmine to the water and observing its pathway.

Figure 27. ***Floscularia conifera*** female, a species that occurs sessile on ***Sphagnum*** and in bog pools. Photo by Jersabek *et al*. 2003, with permission.

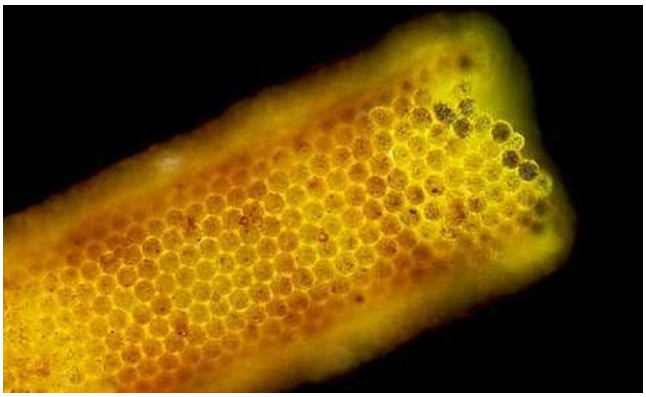

Figure 28. ***Floscularia ringens*** tube. Photo with online permission from <http://www.micrographia.com/>.

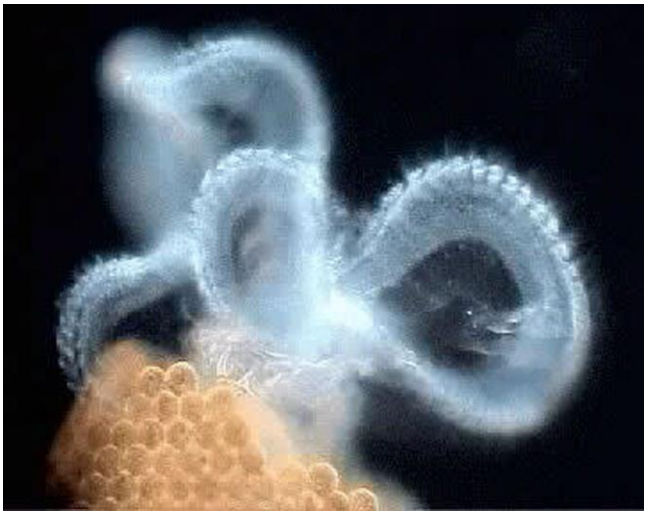

Figure 29. Tip of case of ***Floscularia ringens***, showing the geometric arrangement of pellets and the rotary apparatus. Photo by Martin Mach, with permission.

Gosse (1851 *In* Rotifers 2012) provided a charming description of the feeding as well: "If the atoms be few, we see them swiftly glide along the facial surface, following the irregularities of outline with beautiful precision, dash round the projecting chin like a fleet of boats doubling a bold headland, and lodge themselves, one after another, in the little cup-like receptacle beneath." But these were not used as food. Rather, they were eventually emptied from the cup, which was bent down to the margin of the case and the pellet, mixed with "salivary secretion," added to the margin of the case (Figure 29). Each pellet required 2-3 minutes to be gathered and deposited.

Fontaneto *et al.* (2003) added detail to tube building in ***Floscularia***. They observed that each pellet in the tube has a hole in the middle. The pellets are cemented together with "glue bundles" and the tube is lined with mucus.

Ptygura

As I read through account after account of rotifer sampling, I can't help but wonder if more attention should be given to the bryophyte habitat for locating new rotifer species, especially for sessile groups like this one. A number of these species are sessile on ***Sphagnum*** (Figure 66) and feed on associated algae. De Smet (1990) reported an unidentified species from wet mosses on Svalbard.

Ptygura rotifer (Figure 30) is a free-swimming rotifer (Michael Plewka, pers. comm. 6 August 2016), but Hingley (1993) collected them among ***Sphagnum*** (Figure 66) as well and reported them as sessile there.

Ptygura brachiata (Figure 31-Figure 32) and ***P. velata*** (Figure 33) likewise are species that live on ***Sphagnum*** (Figure 66) (Jersabek *et al*. 2003; Opitz 2016). In addition, a number of species live on other bryophytes as well as living in bogs. For example, ***Ptygura crystallina*** (Figure 34) lives on bryophytes and in bogs in the Pocono Mountains, Pennsylvania, USA. ***Ptygura melicerta*** (Figure 35-Figure 38) forms colonies (Figure 35) in a lake in Wisconsin, USA, but it is also present on bryophytes and in bog pools. It is common among colonies of the **Cyanobacterium *Gloeotrichia*** (Figure 38) (Plewka 2016).

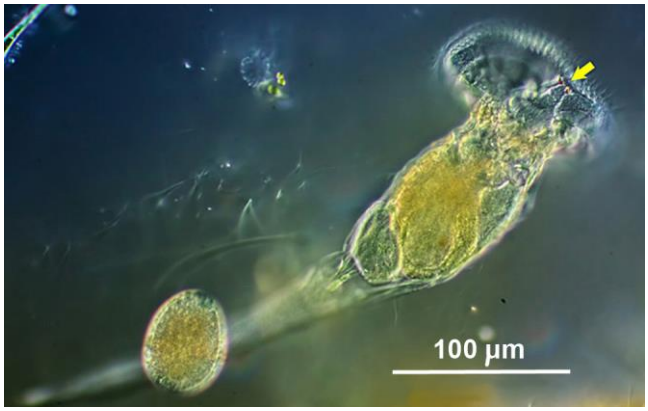

Figure 30. ***Ptygura rotifer***, a species of submersed moss in ponds. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 31. ***Ptygura brachiata*** female, known to be sessile on ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 32. ***Ptygura brachiata***, a species known to be sessile on ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 33. ***Ptygura velata***, typically living on ***Ceratophyllum***, occurs in bogs. Photo by Michael Plewka <www.plingfactory.de>, with permission.

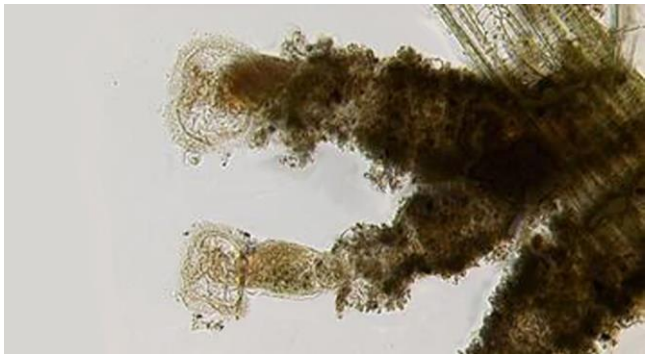

Figure 34. ***Ptygura crystallina*** female, a species from bryophytes and can occur in bogs. Photo by Jersabek *et al.* 2003, with permission.

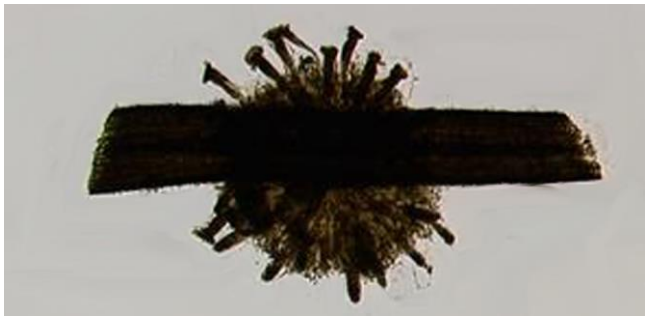

Figure 35. ***Ptygura melicerta*** colony in a lake in Wisconsin, USA. This species can occur among bryophytes and in bog pools. Photo by Jersabek *et al.* 2003, with permission.

Figure 36. ***Ptygura melicerta*** female from a lake in Connecticut, USA. Here it is among **Cyanobacteria**; it can occur among bryophytes. Photo by Jersabek *et al.* 2003, with permission.

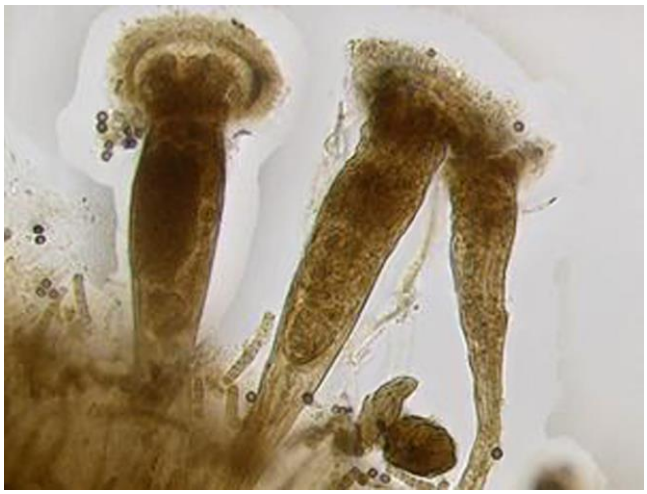

Figure 37. ***Ptygura melicerta*** colony in a lake in Wisconsin, USA. This species is known from bryophytes and bog pools. Photo by Jersabek *et al.* 2003, with permission.

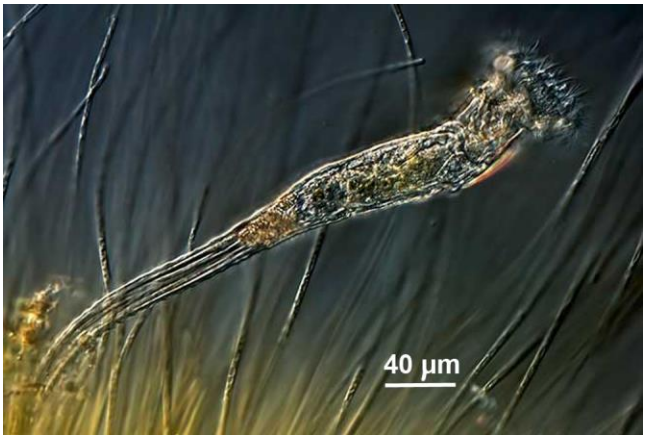

Figure 38. ***Ptygura melicerta*** with ***Gloeotrichia***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Ptygura pilula (Figure 39) seems to be more commonly a moss dweller, including ***Sphagnum*** (Figure 40), where it passes dry periods with a gelatinous covering (Plewka 2016). It incorporates feces (Figure 39-Figure 41) into this tubular housing, further adding to its protection. It also produces resting eggs (Figure 42) that help it to survive dry periods. ***Ptygura stygis*** is also known from submerged mosses (Ptygura 2016).

Figure 39. ***Ptygura pilula*** with feces in gelatinous housing. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 40. ***Ptygura pilula*** female sessile on a ***Sphagnum*** leaf; it also occurs in bog pools. Photo by Jersabek *et al.* 2003, with permission.

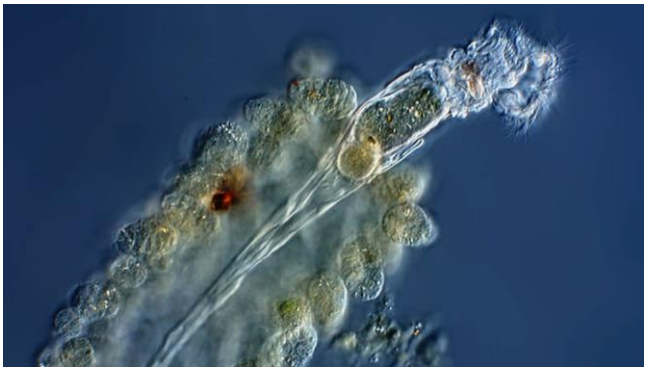

Figure 41. ***Ptygura pilula*** in case, an aquatic moss inhabitant. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 42. ***Ptygura pilula*** resting egg. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Hexarthridae

In a study of a Turkish lake, Gülle *et al*. (2010) found that rotifers were most abundant from June through August and disappeared from November through April. It was a member of the **Hexarthridae**, *Hexarthra fennica*, that was one of the dominant taxa – 51% of the zooplankton. The rotifers were most dense at a depth of 5 m. But it seems that bryophyte dwellers are few. I found only ***Hexarthra mira*** (Figure 43-Figure 44) reported as a bog and occasional bryophyte dweller, but this species is likewise planktonic. It most likely occurred among mosses accidentally from open water. Its amictic eggs become resting eggs (Figure 45-Figure 46), helping to permit its survival as its habitat dries.

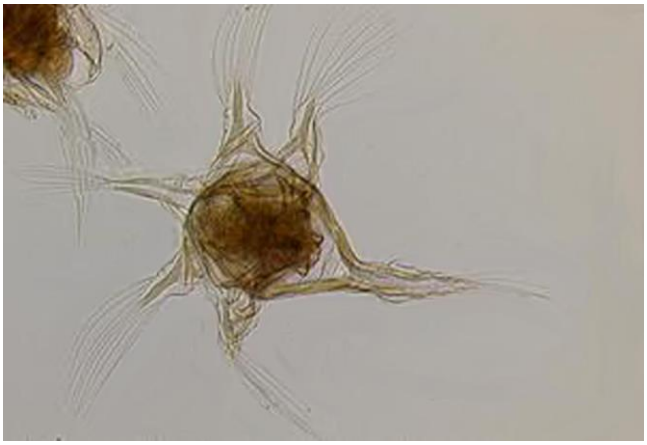

Figure 43. ***Hexarthra mira***, a typically planktonic species known from bryophytes and bogs. Photo by Jersabek *et al.* 2003, with permission.

Figure 44. ***Hexarthra mira*** female from Mexico. This planktonic species is sometimes found among bryophytes and in bogs. Photo by Jersabek *et al.* 2003, with permission.

Figure 45. ***Hexarthra mira*** with amictic egg. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 46. ***Hexarthra mira*** resting egg. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Testudinellidae

The family **Testudinellidae** includes both saltwater and freshwater species. It is characterized by having dorsal and ventral plates of the lorica that are completely fused laterally. The body is greatly flattened dorsi-ventrally (top-bottom). The foot is long and retractile (see Figure 49 and Figure 50) with a tuft of cilia at its tip. These rotifers are free swimming, typically in the littoral zone, but members of ***Testudinella*** (Figure 48-Figure 59) may also occur on bryophytes and in ***Sphagnum*** pools (Figure 5) as well as on other macrophytes. There are three genera, but only ***Testudinella*** seems to be represented on bryophytes.

Myers (1942) provided one of the more detailed texts on rotifer habitats. Among these are a number of species that live on or among ***Sphagnum*** (Figure 21) or in pools (Figure 5) among the peatlands. One such species is ***Testudinella armiger*** (Figure 47), a species that lives on the emergent species ***Sphagnum cuspidatum*** (Figure 21).

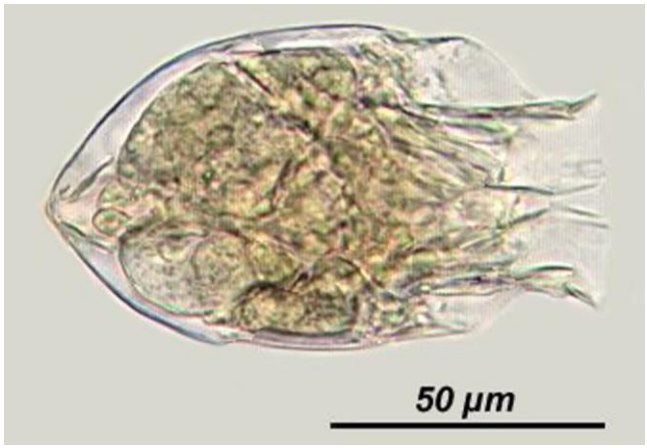

Figure 47. ***Testudinella armiger***, an inhabitant of ***Sphagnum cuspidatum***. Photo by Jersabek *et al.* 2003, with permission.

The records for ***Sphagnum*** (Figure 21) associates include ***Testudinella aspis***, ***T. emarginula*** (Figure 48), ***T. epicopta*** (Figure 49), ***T. tridentata*** (Figure 50-Figure 51), and ***T. truncata*** (Figure 52) (Myers 1942; Jersabek *et al.* 2003). ***Testudinella emarginula*** occurs in ***Sphagnum*** bogs (Figure 66) (Jersabek *et al.* 2003). This cosmopolitan species lives on plant surfaces, although it occasionally occurs in the plankton (de Manuel Barrabin 2000). It is a cold-water species (7.7-7.8°C) with a circumneutral *p*H preference (*p*H 6..8-7.5) and wide alkalinity range.

Figure 48. ***Testudinella emarginula*** from a ***Sphagnum*** bog. Photo by Jersabek *et al.* 2003, with permission.

Figure 49. ***Testudinella epicopta*** from among ***Sphagnum***. Photo by Jersabek *et al. 2003*, with permission.

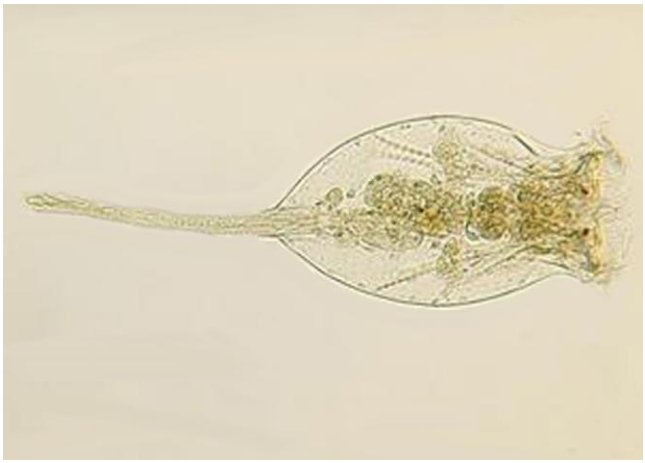

Figure 50. ***Testudinella tridentata*** subsp. ***dicella*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

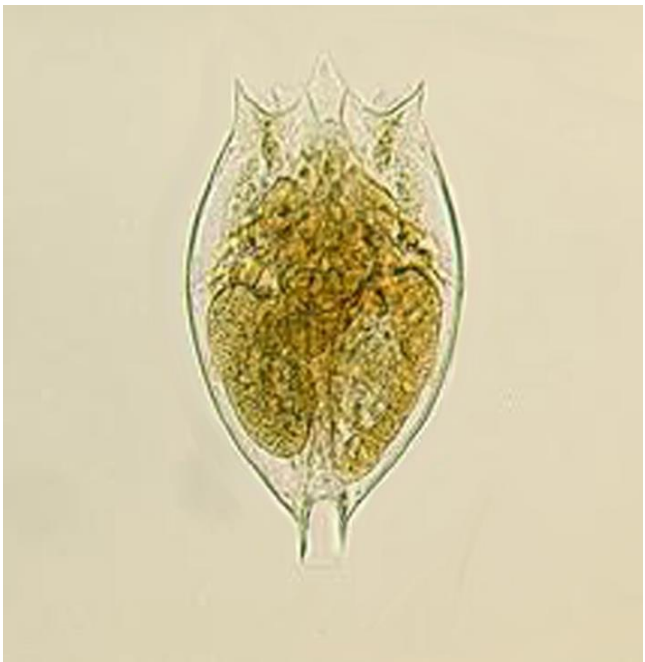

Figure 51. ***Testudinella tridentata*** subsp ***dicella*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

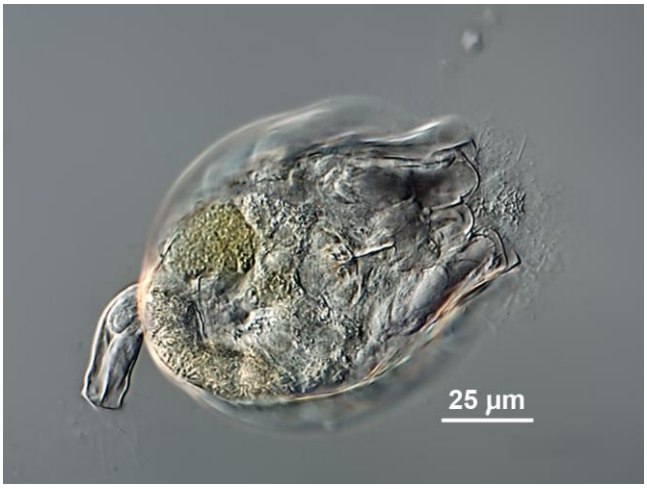

Figure 52. ***Testudinella truncata***, a ***Sphagnum*** dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Testudinella incisa (Figure 53) is typically a plankton species (Plewka 2016), but it also occurs in association with ***Sphagnum*** (Figure 54) (Jersabek *et al*. 2003). The former subspecies, ***T. incisa emarginula***, is now considered a separate species, ***T. emarginula***, so it is possible that the reference to the planktonic ***T. incisa*** really belongs to ***T. emarginula***.

Figure 53. ***Testudinella incisa***, a species sometimes associated with ***Sphagnum***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

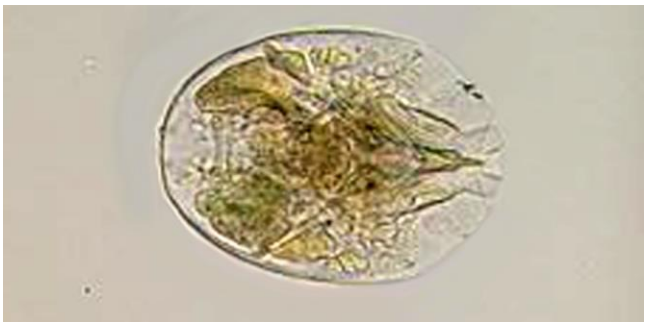

Figure 54. ***Testudinella emarginula*** from a ***Sphagnum*** bog. Photo by Jersabek *et al.* 2003, with permission.

Some members of ***Testudinella*** (Figure 55) are known from bryophytes outside of bogs. Others, such as ***Testudinella elliptica*** (Figure 56-Figure 57), live among both bog bryophytes and non-bog bryophytes.

Figure 55. ***Testudinella patina***, a genus that occurs on bryophytes. Note the complete retraction of the foot. Photo by Wim van Egmond, with permission.

Figure 56. ***Testudinella elliptica***, a species that lives on both ***Sphagnum*** and other bryophytes. Photo by Michael Plewka <www.plingfactory.de>.

Figure 57. ***Testudinella elliptica***, a species that lives on both ***Sphagnum*** and other bryophytes. Photo by Michael Plewka <www.plingfactory.de>.

Testudinella patina (Figure 58-Figure 59) is a planktonic species that likes small bodies of water where aquatic plants are abundant (de Manuel Barrabin 2000), but it is also known from peatlands (bogs or fens) in Poland (Bielańska-Grajner *et al*. 2011). Bryophytes are among the aquatic plants in some associations where it has been found. The aquatic plant area provides it with its preferred foods of the green alga ***Chlorella*** (Figure 64) and diatoms (Figure 60). It tolerates high salinity and lives in a *p*H range of 6.3-8.89. It enjoys a wide temperature range of 9.5-24.3°C. Some occur on mosses in Antarctica (Figure 59).

Figure 58. ***Testudinella patina*** female, a species that sometimes is associated with aquatic bryophytes. Here its cilia are withdrawn. Photo by Jersabek *et al.* 2003, with permission.

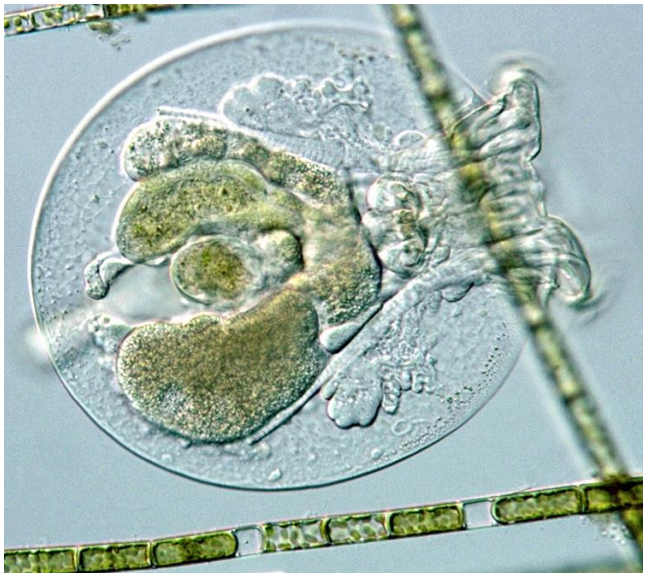

Figure 59. ***Testudinella patina***; some members of this genus are Antarctic moss dwellers. Photo by Yuuji Tsukii, with permission.

Figure 60. Diatoms that can be found among bryophytes, some serving as food for rotifers living there. Photo by Damian H. Zanette, through Public Domain.

ORDER PLOIMIDA

This order has the most families. But are these species ones likely to be on bryophytes? Myers (1942) reported 52 species of ploimate rotifers among ***Sphagnum subsecundum*** (Figure 61-Figure 62) from collections in 1941.

Figure 61. ***Sphagnum subsecundum*** in its habitat, home of ***Pedipartia gracilis***. Photo by Michael Lüth, with permission.

Figure 62. ***Sphagnum subsecundum***, home of ***Pedipartia gracilis***. Photo by Michael Lüth, with permission.

Wallace *et al*. (2008) asked if "everything is everywhere?" They answered this question in the Chihuahua Desert pools in Mexico. They found that indeed the specialized, warm-water habitat of the desert did not support "everything." The microinvertebrate fauna was dominated by rotifer families that are also common on bryophytes: **Brachionidae**, **Lecanidae**, **Lepadellidae**, and **Notommatidae**. Both habitats dry up. The full statement for "everything is everywhere" includes "but the environment selects." The desert pools are actually a similar environment to that of bryophytes that dry out between rain events.

Trochosphaeridae

Cryptic species, morphologically indistinguishable biological groups incapable of interbreeding, are not uncommon in many rotifer families. ***Filinia*** species of **Trochosphaeridae** are highly variable and likely comprise a number cryptic species (Ruttner-Kolisko 1989). This is at least in part due to the parthenogenetic reproduction that can quickly lead to a clone of genetically identical individuals in a **founder population** in a lake or other habitat. This is furthermore complicated by the absence of many good morphological characters by which to distinguish species. In the ***Filinia terminalis-longiseta*** group, ecological properties differ and suggest the existence of these microspecies, or perhaps sister species. Only two members of the **Trochosphaeridae** seem to be known from bryophytes: ***Filinia longiseta*** (Figure 63) and ***F. terminalis*** (Figure 65).

Filinia longiseta (Figure 63) is known from bryophytes in England and Ireland. This is typically a cosmopolitan planktonic species of lakes, ponds, moorland waters, and even brackish water (de Manuel Barrabin 2000). It lives in a wide range of warm temperatures (7.7-26.2°C) and *p*H (6.3-9.9). It is a filter feeder on detritus, bacteria, and small algae like ***Chlorella*** (Figure 64) in a size range of 10-12 µm (Pourriot 1965) and most likely competes for its food with members of the rotifer genus ***Conochilus*** (Figure 23-Figure 25).

Figure 63. ***Filinia longiseta***, a bryophyte dweller in lakes, ponds, and moorland waters. Photo by Jersabek *et al*. 2003, with permission.

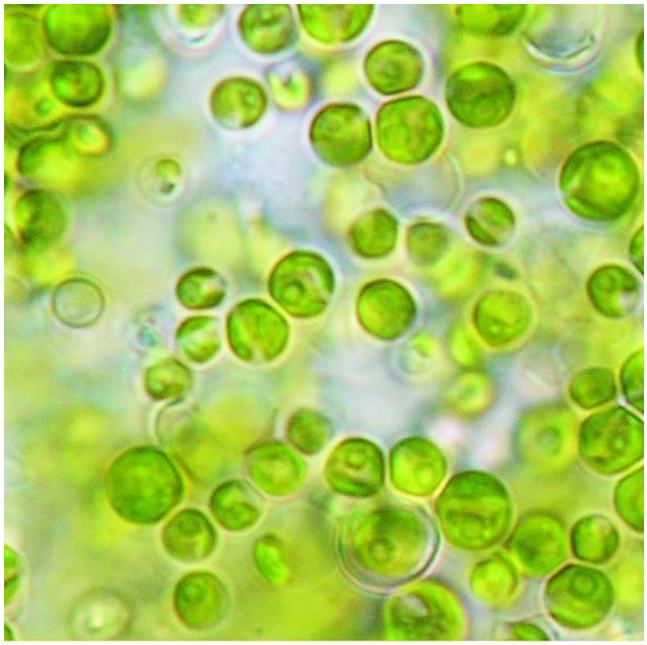

Figure 64. ***Chlorella vulgaris***, a green alga that is often associate with ***Sphagnum*** and that provides food for ***Testudinella patina***. Photo by Sarah Duff, through Creative Commons.

Filinia terminalis (Figure 65) is morphologically variable but seems to occupy a narrow and well-defined niche (Ruttner-Kolisko 1980). At an oxygen content of less than 2 mg L^{-1}, it can reach as many as 1000 individuals per liter. Not surprisingly, it is facultatively anaerobic. Its food sources include bacteria that are chemosynthetic or that decompose plankton.

Figure 65. ***Filinia terminalis*** female, Photo by Jersabek *et al*. 2003, with permission.

Although ***Filinia terminalis*** (Figure 65) is a cosmopolitan, planktonic species, it is known from bryophytes and ***Sphagnum*** bogs (Figure 66) (de Manuel Barrabin 2000). Its preferred conditions are mesotrophic to eutrophic in a *p*H range of 6.64-8.22. Its temperature range is relatively wide: 7.3-22.8°C, although de Manuel Barrabin considers it to be a species of the cool **hypolimnion** (bottom layer of deep lake or ocean; temperature never goes below 4°C). Ruttner-Kolisko (1980) found that it prefers temperatures below 12-15°C.

Figure 66. ***Sphagnum papillosum***, a bog moss. Photo by James K. Lindsey, with permission.

Brachionidae

This is a family dominated by planktonic species and was the family with the most species represented in Spanish reservoirs (de Manuel Barrabin 2000), but a few seem to spend time among bryophytes, perhaps as a place to avoid predation, or just dropped there by moving water. An interesting study by Stenson (1982) demonstrated, however, that an experimental reduction of the fish population led to an increase in larger rotifers and a decrease in the smaller filter-feeding species such as ***Keratella cochlearis*** (Figure 79), a member of the **Brachionidae**. Stenson attributed this to a change in competition for food from rotifers such as ***Polyarthra*** (**Synchaetidae**; Figure 67).

Figure 67. ***Polyarthra major***, a large rotifer that eats smaller rotifers. Note the feather-like blades that are used like paddles in swimming. Photo by Wim van Egmond, with permission.

Anuraeopsis

Anuraeopsis fissa (Figure 68-Figure 71) has been reported from a pond in Pennsylvania, USA (Jersabek *et al.* 2003). This is a planktonic rotifer that has been found among bryophytes and in bog pools. It prefers warm water and a **eutrophic** (nutrient-rich) habitat (Margalef 1955). It frequents small water bodies (de Manuel Barrabin 2000). Its food includes bacteria and detritus (Pourriot 1977) and it may become food for the rotifer ***Asplanchna*** (Figure 72) (Guiset 1977).

Figure 68. ***Anuraeopsis fissa*** with an emerging juvenile from a pond in Pennsylvania, USA. Photo by Jersabek *et al.* 2003, with permission.

Figure 69. ***Anuraeopsis fissa*** showing toes and red eyespot. Photo by Michael Pewka <www.plingfatory.de>, with permission.

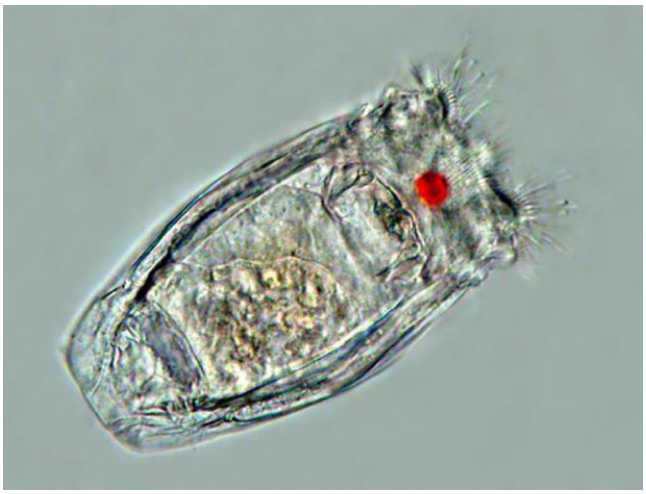

Figure 70. ***Anuraeopsis fissa*** showing a single, light-sensitive red eyespot and cilia, but with toes retracted. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 71. ***Anuraeopsis fissa*** with amictic eggs. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 72. ***Asplanchna***, in this case with a gut of ***Keratella***. It is also a predator on ***Anuraeopsis fissa***. Photo by Wim van Egmond, with permission.

Brachionus

Brachionus urceolaris (Figure 73) is planktonic, common in small, alkaline bodies of water (*p*H 7.25-9) (de Manuel Barrabin 2000). It can occur in moving water and is relatively tolerant of high salinity. It is a cosmopolitan species with a wide temperature tolerance (7.35-24.3°C). Despite its alkaline preference, Hingley (1993) found it closely associated with ***Sphagnum*** (Figure 21) in a bog.

Figure 73. ***Brachionus urceolaris***, a species that is closely associated with bog ***Sphagnum***. Photo from Proyecto Agua, with permission.

Brachionus urceolaris (Figure 74), and probably others, has a survival trick against predation. The eggs survive consumption by predators such as the cladoceran *Leptodora kindtii* (Figure 75) without harm (Nagata *et al*. 2011). Often the cladocerans would eject the eggs, and they typically ejected the lorica while digesting the living contents. There was a negative correlation between the portion of unconsumed (ejected) eggs and the length of the predator. That is, longer predators ejected fewer eggs. Nevertheless, hatching success seemed to be independent of the predator's body length. As many as 75% of the undigested eggs hatched successfully.

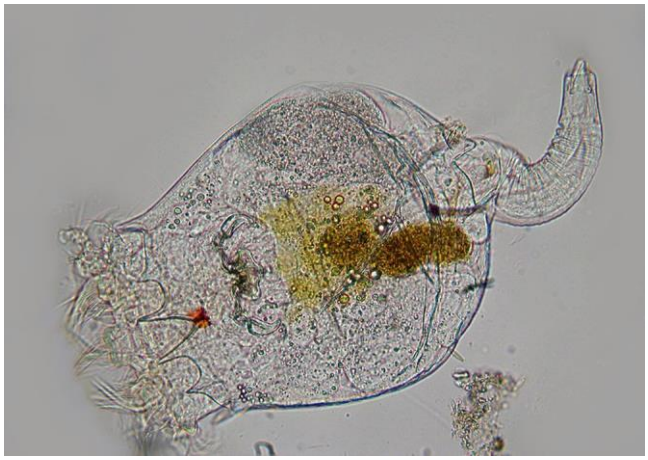

Figure 74. ***Brachionus urceolaris***, a planktonic species that can occur in a ***Sphagnum*** bog. Photo by Michael Verolet, with permission.

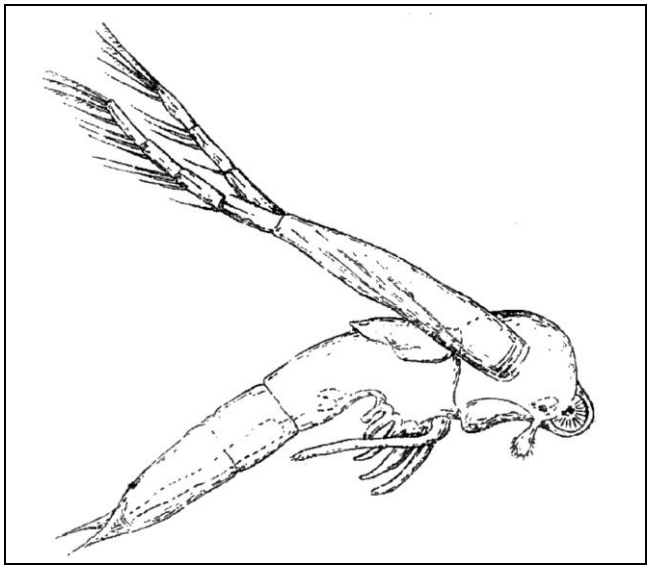

Figure 75. ***Leptodora kindtii***, a large cladoceran that is a predator on ***Brachionus urceolaris***. Drawing by A. Milnes Marshall, through Public Domain.

Kellicottia

Kellicottia is a genus with only two species (Segers 2007). ***Kellicottia longispina*** (Figure 76-Figure 77) is a central European species known from bryophytes, but it is actually typically a planktonic species (Plewka 2016). Its long spines no doubt help to protect it from predation (see Barnhisel 1991), but Madaliński (1961) suggested they

may help attach it to bryophytes. It is active year-round as an inhabitant of oligotrophic lakes with a rather narrow *p*H range of 8.2-8.5, but as expected its temperature range is broad (10.6-21.8°C) and it does not occur in small bodies of water (de Manuel Barrabin 2000). Its food is primarily chrysomonads and centric diatoms (Pourriot 1977).

Figure 76. ***Kellicottia longispina*** female, a planktonic species that has also been found with bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Figure 77. ***Kellicottia longispina*** demonstrating spines that may help in attaching it to bryophytes. Photos by Michael Plewka <www.plingfactory.de>, with permission.

Figure 78. ***Kellicottia longispina*** demonstrating spines that probably protect it from predation. Photos by Michael Plewka <www.plingfactory.de>, with permission.

Keratella

Feeding rates are inversely related to the density of food organisms in ***Keratella cochlearis*** (Figure 79), as well as in the planktonic, but occasional bryophyte-dweller, ***Polyarthra vulgaris*** (**Synchaetidae**), and *Polyarthra dolichoptera* (Bogdan & Gilbert 1982). ***Keratella cochlearis*** preferred the alga ***Chlamydomonas*** (Figure 80) to all other foods offered, perhaps explaining the rarity of this rotifer among mosses, where ***Chlamydomonas*** also is uncommon (pers. obs.). Nevertheless, ***K. cochlearis*** lives in bog/fen habitats (Bielańska-Grajner *et al.* 2011) where some species of ***Chlamydomonas*** occur (Struder-Kypke & Schonborn 1999).

Figure 79. ***Keratella cochlearis*** showing lorica, a species that is mostly planktonic but also occurs in bog/fen peatlands. Photo by Michael Plewka <www.plingfactory.de>, with permission.

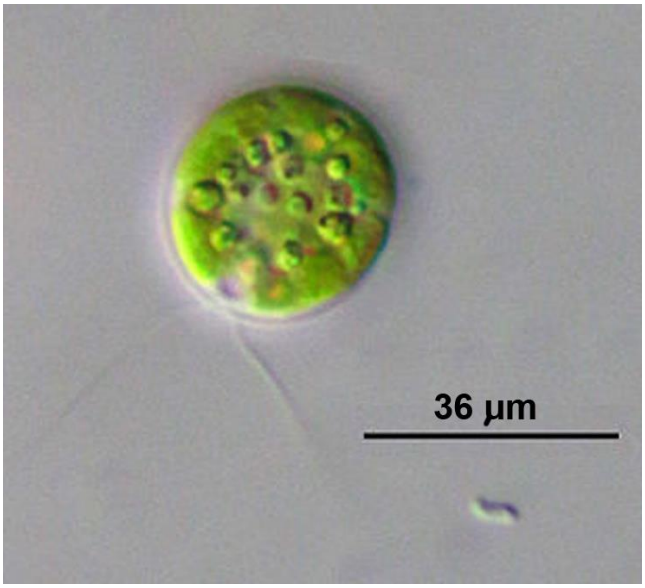

Figure 80. ***Chlamydomonas*** *globosa*, a genus that is food for ***Keratella cochlearis***. Photo by Picturepest, through Creative Commons.

Nevertheless, a number of species of ***Keratella*** live among bryophytes. ***Keratella mixta*** (Figure 81) lives among ***Sphagnum*** (Figure 62) (Jersabek *et al*. 2003). Others live in peatlands (bogs or fens), including ***K. paludosa*** (Figure 82) (Bielańska-Grajner *et al.* 2011).

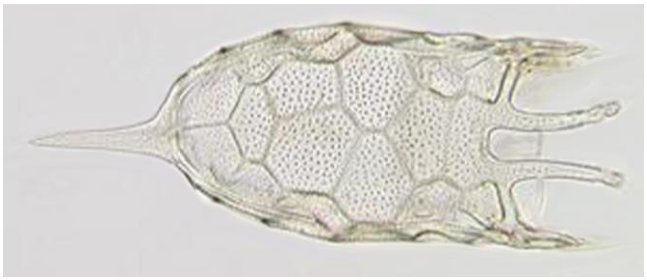

Figure 81. ***Keratella mixta*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 82. ***Keratella paludosa*** from ***Sphagnum***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Keratella quadrata (Figure 83-Figure 85) is a species known from bryophytes. This is also a cosmopolitan species that is active all year round (de Manuel Barrabin 2000). It is tolerant of mineralization and survives a wide *p*H range of 6.64-10.19. Its temperature range is likewise wide (6.4-26.1°C), as expected for a perennial species. It has broad food preferences, including detritus, bacteria, and algae in the Chlorococcales, Volvocales, Euglenales, Chrysophyceae, and diatoms (Pourriot 1977). As is typical among rotifers, females are larger than males (Figure 84). Resting eggs (Figure 85) help it to survive in this changeable habitat.

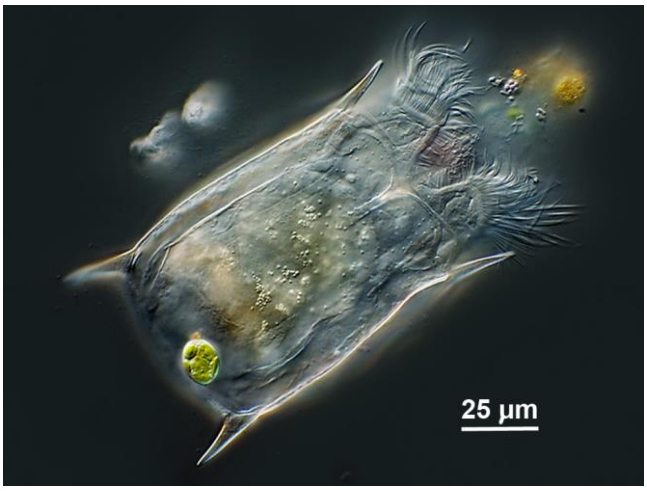

Figure 83. ***Keratella quadrata*** showing lorica and cilia. Photo by Michael Plewka <www.plingfactory.de>, with permission.

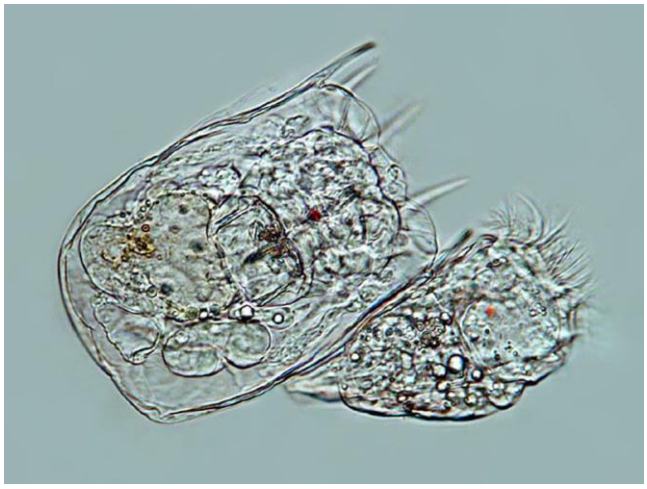

Figure 84. ***Keratella quadrata*** female (larger) and male (smaller), a species known from bryophytes. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 85. ***Keratella quadrata*** resting eggs. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Keratella serrulata (Figure 86-Figure 88) is the only planktonic brachionid that is a specialist of acid water, particularly water from bogs with ***Sphagnum*** (Figure 21) (Bērziņš & Pejler 1987; Bielańska-Grajner *et al*. 2011). Its known *p*H is around 6.6 and temperature around 18.6°C (de Manuel Barrabin 2000). It feeds on algae in the Chrysophyceae and Volvocales (Pourriot 1977). ***Sphagnum*** is important in creating its acid habitat – it lives especially in the outflow of ***Sphagnum*** bogs and poor fens (Jersabek *et al*. 2003).

Figure 86. ***Keratella serrulata***, an inhabitant of acid bog outflow water. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 87. ***Keratella serrulata***, a ***Sphagnum*** dweller, showing its ventral surface. Photo by Michael Plewka <www.plingfactory.de>, with permission.

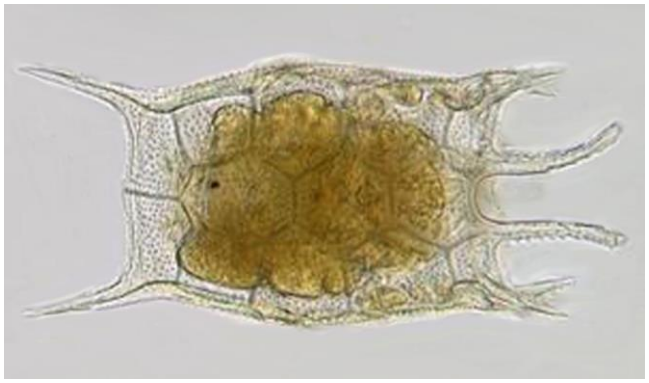

Figure 88. ***Keratella serrulata***, a species known from ***Sphagnum*** bogs and poor fen waters. Photo by Jersabek *et al.* 2003, with permission.

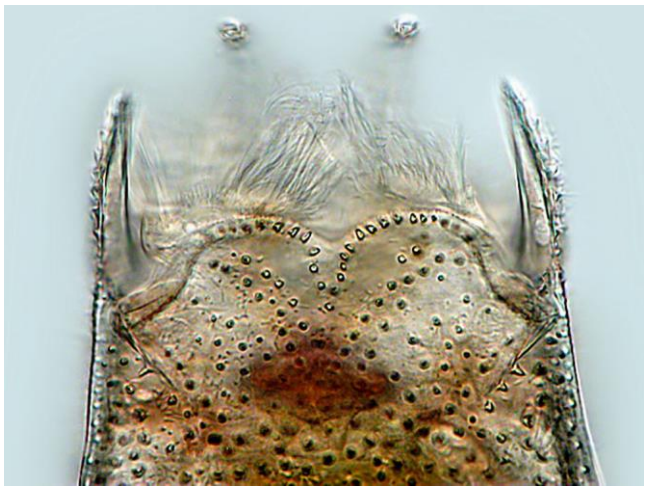

Figure 89. ***Keratella serrulata*** showing rotary cilia. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Keratella also can occur among wet mosses in waterfalls. Savatenalinton and Segers (2008) found ***Keratella cochlearis*** (Figure 79) and ***Keratella tropica*** (Figure 90) in a waterfall in Thailand, but it is likely that these planktonic species were carried there from open water (De Smet, per. comm. 3 November 2016).

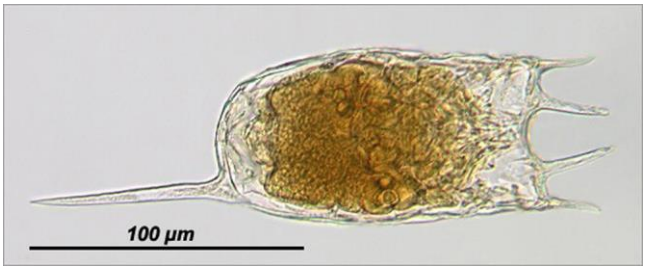

Figure 90. ***Keratella tropica***, a waterfall moss dweller. Photo by Jersabek *et al.* 2003, with permission.

Notholca

Although ***Notholca*** is a relatively large genus, only three species seem to be bryophyte dwellers. ***Notholca foliacea*** (Figure 91) occurs on mosses (Plewka 2016). ***Notholca latistyla*** is restricted to the Arctic and occurs on submerged mosses (De Smet 1990). ***Notholca squamula*** likewise occurs on submerged mosses on Svalbard.

Figure 91. ***Notholca foliacea*** from moss. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Dicranophoridae

The **Dicranophoridae** are predators and are agile in pursuing and capturing their prey (Pejler & Bērziņš 1993a). Unlike many rotifers, the **Dicranophoridae** are not planktonic – other predatory rotifers exist among the plankton – and they avoid the sediments where their prey organisms are not sufficiently abundant. Unlike many rotifers, these have been documented on two species of bryophytes through a study of their substrata. ***Albertia naidis*** (Figure 92), ***Aspelta angusta*** (Figure 97), ***A. aper*** (Figure 95), ***A. circinator*** (Figure 96), ***Dicranophorus forcipatus*** (Figure 117-Figure 118), ***D. haueri***, ***D. robustus*** (Figure 113-Figure 114), ***Encentrum eurycephalum***, ***E. fluviatile***, ***E. lupus***, and ***E. mustela*** (Figure 134), and ***E. uncinatum*** (Figure 131), were all present on 1-10% of the 122 collections of ***Fontinalis*** (Figure 11). ***Aspelta aper***, ***A. circinator***, ***Dicranophorus epicharis*** (Figure 107), ***D. luetkeni*** (Figure 110-Figure 112), ***Encentrum arvicola***, ***E. elongatum***, ***E. incisum*** (Figure 127), ***E. lupus***, ***E. sutor***, ***E. sutoroides***, ***E. tyrphos***, and ***Wierzejsklella velox*** (Figure

139-Figure 140) were all present on 1-10% of the 194 collections of ***Sphagnum*** (Figure 21). The species differ, but only the genus ***Albertia*** is present exclusively on ***Fontinalis***, and only ***Wierzejsklella*** is present exclusively on ***Sphagnum*** in this comparison. Both sets of bryophyte dwellers occur on a wide variety of other plant substrata – none was specific to bryophytes.

Albertia

Only one species of this relatively small genus is associated with bryophytes. ***Albertia naidis*** (Figure 92) not only occurs among ***Sphagnum*** (Figure 5) and ***Fontinalis*** (Figure 11), but it also is parasitic on ***Stylaria lacustris*** (Figure 93), an oligochaete (segmented worm) (Jersabek 2003).

Figure 92. ***Albertia naidis*** subsp ***intrusor*** from among ***Sphagnum*** and parasitic on ***Stylaria lacustris***. This species is also known from the aquatic moss ***Fontinalis***. Photo by Jersabek *et al.* 2003, with permission.

Figure 93. ***Stylaria lacustris***, an annelid that is parasitized by ***Albertia naidis***. Photo by Niels Sloth, with permission.

Aspelta

Several species of ***Aspelta*** live among ***Sphagnum*** (Figure 5) (*e.g.* ***A. beltista***, Figure 94) (Jersabek *et al.* 2003). Others occur not only with ***Sphagnum***, but also occur with the aquatic moss ***Fontinalis*** (Figure 11). These are ***Aspelta aper*** (Figure 95) (Pejler & Bērziņš 1993a) and ***A. circinator*** (Figure 96) (Plewka 2016). ***Aspelta angustus*** (Figure 97) occurs among mosses on rock and also among the periphyton on ***Sphagnum*** (Figure 21) (Plewka 2016).

Figure 94. ***Aspelta beltista*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 95. ***Aspelta aper***, a rotifer that occurs on both ***Fontinalis*** and ***Sphagnum*** species. Photo by Jersabek *et al.* 2003, with permission.

Figure 96. ***Aspelta cf circinator***, a species of ***Sphagnum*** ponds, but also occurs with ***Fontinalis***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

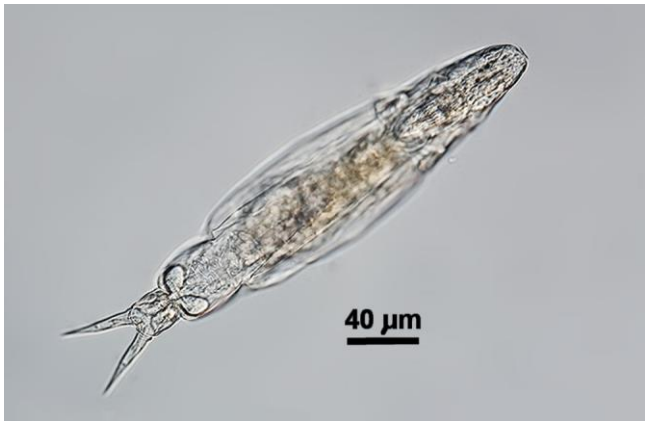

Figure 97. ***Aspelta angusta*** from among mosses on rock but also among the periphyton on ***Sphagnum***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Aspelta chorista (Figure 98) lives among the moss ***Warnstorfia exannulata*** (Figure 99-Figure 100) (Myers 1942; Jersabek *et al.* 2003).

Figure 98. ***Aspelta chorista*** from among the moss ***Warnstorfia exannulata***. Photo by Jersabek *et al.* 2003, with permission.

Figure 99. ***Warnstorfia exannulata*** habitat where one might find ***Aspelta chorista***. Photo by J. C. Schou, with permission.

One known species of ***Aspelta*** is more terrestrial. ***Aspelta secreta*** is characteristic of mosses on sandstone rocks in firewood habitats (De Smet & Verolet 2009).

Figure 100. ***Warnstorfia exannulata***, home for ***Aspelta chorista***. Photo by J. C. Schou, with permission.

Dicranophorus

Sphagnum (Figure 21) seems to be a common habitat for a number of species of ***Dicranophorus***. These include ***Dicranophorus alcimus*** (Figure 101; Jersabek *et al*. 2003), ***D. artamus*** (Figure 102; Jersabek *et al*. 2003), ***D. biastis*** (Figure 103; Jersabek *et al*. 2003), ***D. capucinus*** (Figure 104-Figure 105; Jersabek *et al*. 2003; Bielańska-Grajner *et al*. 2011), ***D. colastes*** (Figure 106; Jersabek *et al*. 2003), ***D. epicharis*** (Figure 107; Pejler & Bērziņš 1993a), ***D. facinus*** (Figure 108; Myers 1942), ***D. hercules*** (Bielańska-Grajner *et al*. 2011), ***D. isothes*** (Figure 109; Jersabek *et al.* 2003), ***D. luetkeni*** (Figure 110-Figure 112; Jersabek *et al*. 2003; Bielańska-Grajner *et al*. 2011), and ***D. proclastes*** (Myers 1942).

Figure 101. ***Dicranophorus alcimus*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

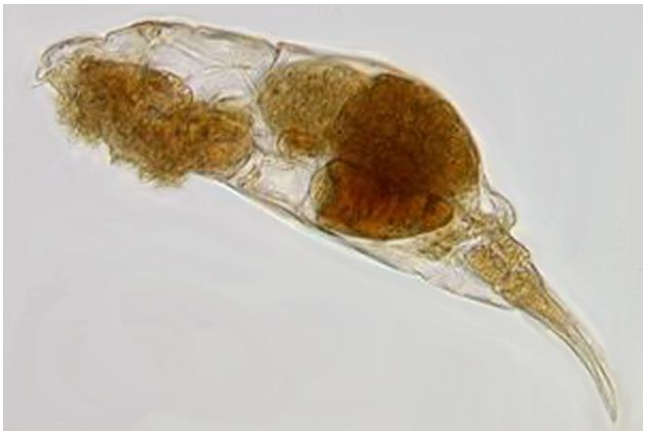

Figure 102. ***Dicranophorus artamus*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 103. ***Dicranophorus biastis*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

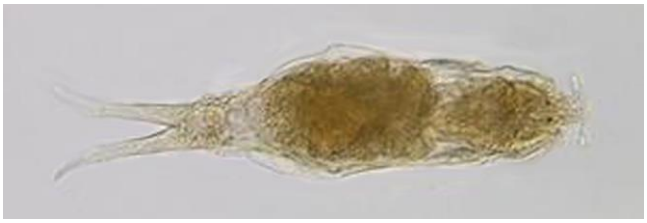

Figure 104. ***Dicranophorus capucinus*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 105. ***Dicranophorus capucinus*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 106. ***Dicranophorus colastes*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

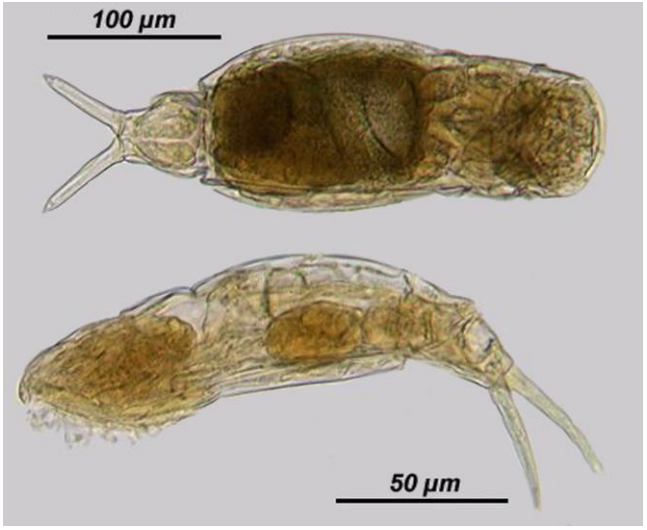

Figure 107. ***Dicranophorus epicharis***, a ***Sphagnum*** dweller. Photo by Jersabek *et al.* 2003, with permission.

Figure 108. ***Dicranophorus facinus*** lives among ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

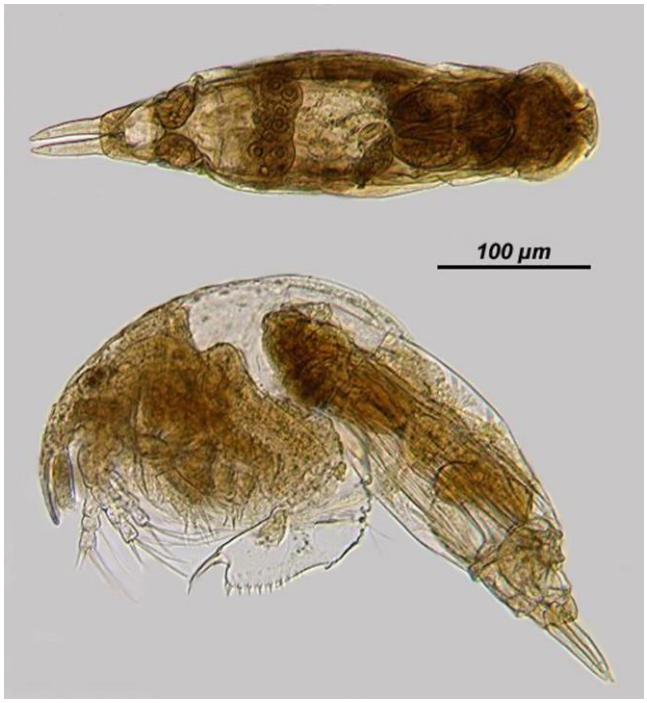

Figure 109. ***Dicranophorus isothes***, a ***Sphagnum*** dweller. Photo by Jersabek *et al*. 2003, with permission.

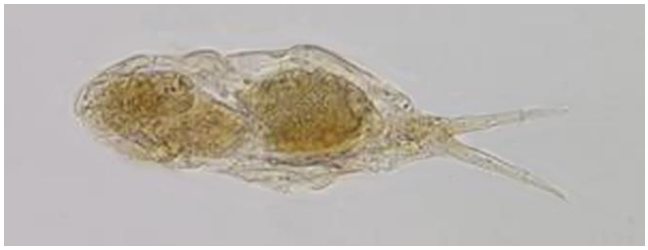

Figure 110. ***Dicranophorus luetkeni*** female, a species known from ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 111. ***Dicranophorus luetkeni*** male, a species known from ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 112. ***Dicranophorus luetkeni*** female with egg. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Dicranophorus robustus (Figure 113-Figure 114), like several other members of the **Dicranophoridae**, occurs on both the bog moss ***Sphagnum*** (Figure 21) and the brook moss ***Fontinalis*** (Figure 11) (Hingley 1993; Pejler & Bērziņš 1993a). It commonly ingests members of the rotifer genus ***Lecane*** (Figure 115), a very large genus that is abundant on bryophytes (Jersabek *et al*. 2003). This dual habitat of ***Sphagnum*** and ***Fontinalis*** also works for ***D. rostratus*** (Figure 116; Hingley 1993; Jersabek *et al.* 2003).

Figure 113. ***Dicranophorus robustus*** from *Aufwuchs*, a species found with bryophytes, including ***Sphagnum*** and ***Fontinalis***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

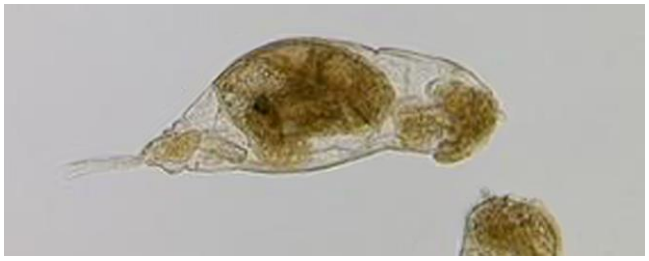

Figure 114. ***Dicranophorus robustus*** female, a species that is known to live among bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Figure 115. ***Lecane clara***, without stiffened lorica. Members of ***Lecane*** serve as food for ***Dicranophorus robustus***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 116. ***Dicranophorus rostratus*** female, a species known from ***Sphagnum*** (Myers 1942) and ***Fontinalis***. Photo by Jersabek *et al.* 2003, with permission.

Some species are known thus far only from ***Fontinalis*** (Figure 11). Among these is ***Dicranophorus forcipatus*** (Figure 117-Figure 118) (Pejler & Bērziņš 1993a; Plewka 2016), including its occurrence on Svalbard exclusively on submerged mosses (De Smet 1993).

Figure 117. ***Dicranophorus forcipatus***, a rotifer found among bryophytes in several studies, including ***Fontinalis***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 118. ***Dicranophorus forcipatus***, a rotifer found among bryophytes in several studies, shown here feeding on the surfacce of ***Spirogyra*** sp. Photo by Michael Plewka <www.plingfactory.de>, with permission.

The aquatic ***Dicranophorus hercules*** (Figure 119) is known from bryophytes (Jersabek *et al*. 2003), but its typical habitat is in the **psammon** (interstitial community among sand grains in fresh water) (Ruttner-Kolisko 1954; Pejler & Bērziņš 1993b). In fact, Wizsniewski (1934, 1937) considered this species to be exclusive to the psammon. Nevertheless, Bielańska-Grajner *et al*. (2011) found it among the peatland bryophytes in Poland.

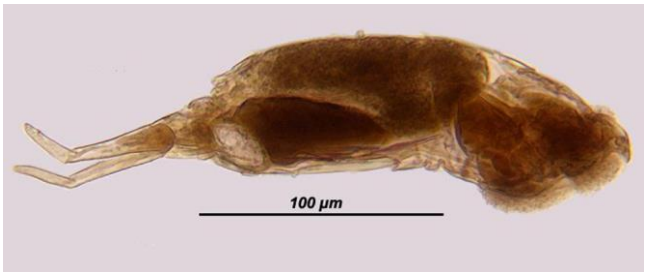

Figure 119. ***Dicranophorus hercules***, a species known from bryophytes. Photo by Jersabek *et al*. 2003, with permission.

Dorria

Dorria dalecarlica (Figure 121) is the only species in the genus (Segers 2007) and is a moss dweller in aquatic habitats, where it lives on dripping and submersed ***Fontinalis dalecarlica*** (Figure 11) (Myers 1942).

Figure 120. ***Dorria dalecarlica***, a species that can occur on submerged mosses in streams. Photos by Jersabek *et al*. 2003, with permission.

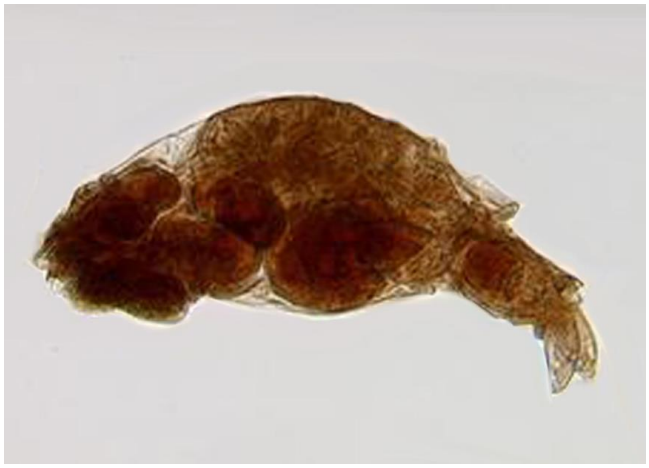

Figure 121. ***Dorria dalecarlica***, a species that can occur on submerged mosses in streams. Photos by Jersabek *et al*. 2003, with permission.

Encentrum

The genus ***Encentrum*** is a large genus with a number of species that live on bryophytes. ***Sphagnum*** (Figure 21, Figure 66) dwellers include ***E. aquilus*** (Figure 122; Jersabek *et al*. 2003), ***E. arvicola*** (Pejler & Bērziņš 1993a), ***E. carlini*** (Figure 123; Jersabek *et al*. 2003), ***E. elongatum*** (Pejler & Bērziņš 1993a), ***E. felis*** (Figure 124-Figure 125; Hingley 1993; Jersabek *et al*. 2003), ***E. glaucum*** (Figure 126; Hingley 1993), ***E. incisum*** (Figure 127; Pejler & Bērziņš 1993a), ***E. saundersiae*** (Figure 128; Myers 1942), ***E. sutor*** (Pejler & Bērziņš 1993a), ***E. sutoroides*** (Pejler & Bērziņš 1993a), ***E. tobyhannaense*** (Figure 129; Jersabek *et al*. 2003), and ***E. tyrphos*** (Pejler & Bērziņš 1993a).

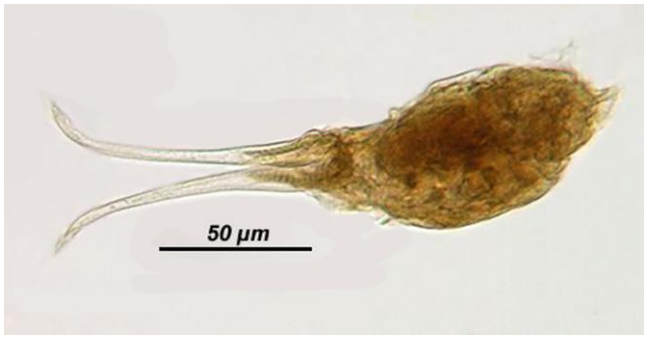

Figure 122. ***Encentrum aquilus***, a ***Sphagnum*** dweller. Photo by Jersabek *et al*. 2003, with permission.

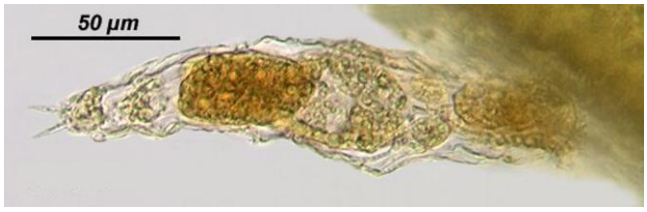

Figure 123. ***Encentrum carlini***, a ***Sphagnum*** dweller. Photo by Jersabek *et al*. 2003, with permission.

Figure 124. ***Encentrum felis*** with protruding forcipate trophi. Photo by Michael Plewka <www.plingfactory.de>, with permission.

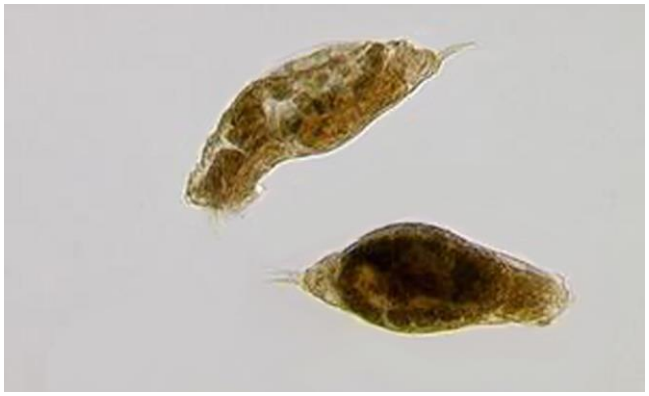

Figure 125. ***Encentrum felis***, a species known from bryophytes, including ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 126. ***Encentrum glaucum*** female, a species known from bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Figure 127. ***Encentrum oxyodon/E. incisum***, a ***Sphagnum*** dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

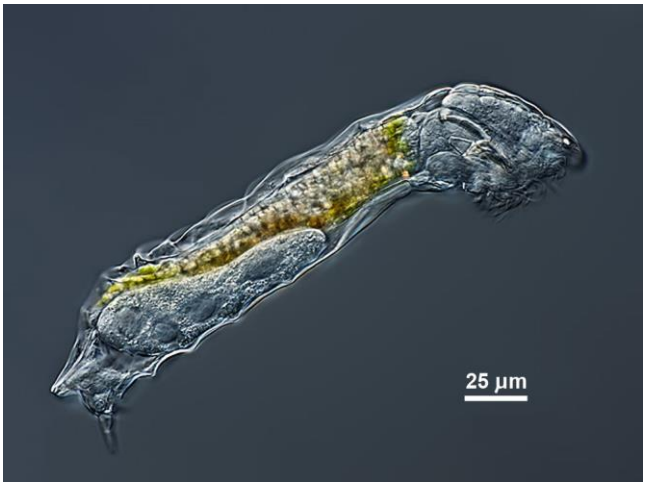

Figure 128. ***Encentrum saundersiae*** lateral view, a ***Sphagnum*** dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 129. Trophus of ***Encentrum tobyhannaensis*** from among ***Sphagnum***. Often this is the only structure that can be recognized in old collections. Photo by Jersabek *et al.* 2003, with permission.

As seems to be a common feature of this family, several species live on both ***Sphagnum*** (Figure 21, Figure 66) and ***Fontinalis*** (Figure 11). These are ***Encentrum lupus*** (Pejler & Bērziņš 1993a), ***E. mustela*** (Figure 130) (Hingley 1993; Pejler & Bērziņš 1993a), and ***E. uncinatum*** (Figure 131; Horkan 1981; Hingley 1993; Pejler & Bērziņš 1993a; Plewka 2016). ***Encentrum eurycephalum*** and ***E. fluviatile***, on the other hand, are only known from ***Fontinalis*** (Pejler & Bērziņš 1993a). ***Encentrum mucronatum*** and ***E. uncinatum*** live on submerged mosses on Svalbard, where the former is one of the most frequent species (De Smet 1990); ***E.*** cf. ***marinum*** (Figure 132) lives exclusively among submerged mosses on Svalbard, whereas ***E. mustela*** occurs on submerged mosses and in the plankton (De Smet 1993).

Figure 130. ***Encentrum mustela***, a species that occurs on both ***Sphagnum*** and ***Fontinalis***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 131. ***Encentrum uncinatum*** swimming. This species is known from the brook moss ***Fontinalis*** and the bog moss ***Sphagnum***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 132. ***Encentrum marinum***, a species that occurs exclusively among submerged mosses on Svalbard. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Encentrum lutra (Figure 133) also lives in the unpredictable habitat of epiphytic mosses (Plewka 2016). The habitat of ***E. permolle*** (Figure 134) is on moss (Plewka 2016) in Antarctic islands (Fontaneto *et al*. 2015).

Figure 133. ***Encentrum lutra***, a species that lives among epiphytic mosses. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 134. ***Encentrum permolle***, a moss dweller in the Antarctic. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Pedipartia

Pedipartia is a genus with only one species, ***P. gracilis*** (Figure 135) (Segers 2007). This rotifer species is known from just one species of ***Sphagnum***, ***S. subsecundum*** (Figure 61-Figure 62) (Myers 1942; Jersabek *et al*. 2003).

Figure 135. ***Pedipartia gracilis*** from among ***Sphagnum subsecundum***. Photo by Jersabek *et al*. 2003, with permission.

Streptognatha

Streptognatha is another genus known by only one species (Segers 2007). ***Streptognatha lepta*** (Figure 136-Figure 137), a species reported in Great Britain and elsewhere, occurs on ***Sphagnum*** (Figure 21, Figure 66) (Jersabek *et al*. 2003).

Figure 136. ***Streptognatha lepta*** female, lateral view, a species known from ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

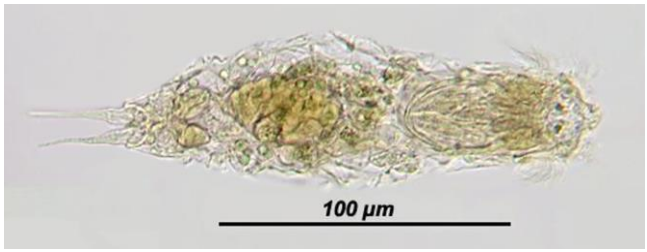

Figure 137. ***Streptognatha lepta*** female, a rotifer known to associate with ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Wierzejskiella

Of the eight species (Segers 2007) of ***Wierzejskiella***, three are known bryophyte dwellers. And all three live on ***Sphagnum*** (Figure 21, Figure 66). ***Wierzejskiella elongata*** (Figure 138) lives among ***Sphagnum*** (Myers 1942). ***Wierzejskiella velox*** (Figure 139-Figure 140) occurs both among ***Sphagnum*** and in ***Sphagnum*** pools (Myers 1942).

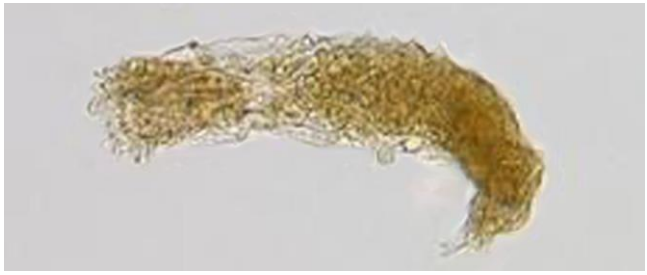

Figure 138. ***Wierzejskiella elongata*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

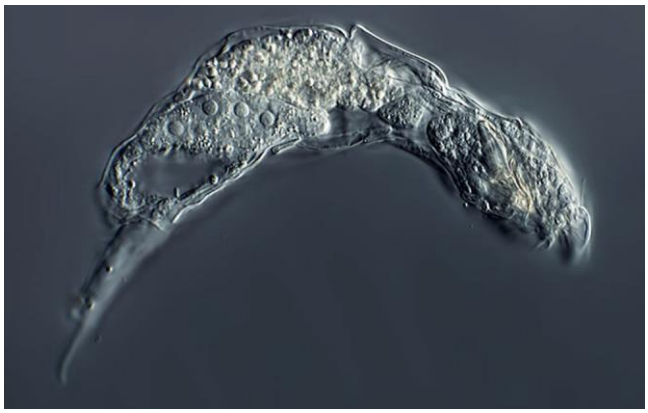

Figure 139. ***Wierzejskiella velox***, a species from ***Sphagnum*** and ***Sphagnum*** pools (Myers 1942). Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 140. ***Wierzejskiella velox*** from ***Sphagnum***, shown here with its forcipate trophi extruded as it approaches the desmid food item.. Photo by Mark Plewka <www.plingfatory.de>, with permission.

Epiphanidae

This family has rotifers that are usually planktonic, so like most of the rotifers on bryophytes, it is likely that the bryophyte is a temporary refuge. Many of the members of this family are marine (Koste 1978; Fontaneto *et al*. 2006, 2008), where no bryophytes are known.

Cyrtonia

Cyrtonia is another genus with only one species (Segers 2007), and that species is a moss dweller – ***C. tuba*** (Figure 141-Figure 142). It is known from ponds, but it has also been collected from mosses (Jersabek *et al*. 2003).

Figure 141. ***Cyrtonia tuba***, a pond and moss dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

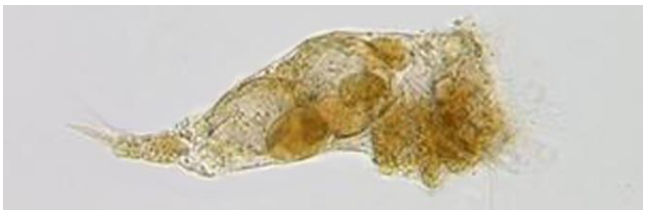

Figure 142. ***Cyrtonia tuba*** from a pond in Ohio, USA. This species has been collected from mosses. Photo by Jersabek *et al.* 2003, with permission.

Epiphanes

This genus of nine species seems to have only one that lives with bryophytes. ***Epiphanes brachionus*** (Figure 143)

lives in ***Sphagnum*** (Figure 21, Figure 66) bogs (Plewka 2016).

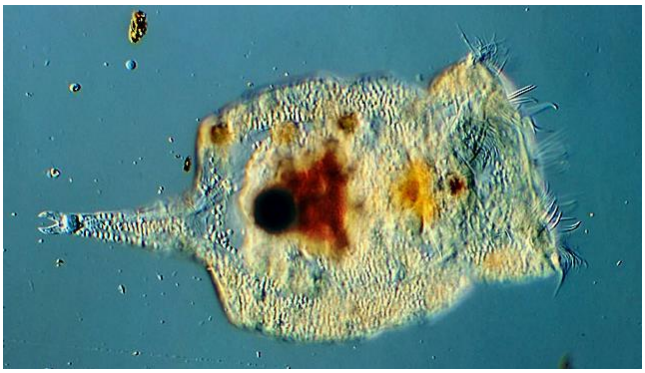

Figure 143. ***Epiphanes brachionus*** from a ***Sphagnum*** bog. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Mikrocodides

Mikrocodides, a genus of three species (Segers 2007), typically occurs in the plankton and among the periphyton. One species, ***Mikrocodides chlaena*** (Figure 144-Figure 146), however, lives among mosses and in bog pools (Plewka 2016).

Figure 144. ***Mikrocodides chlaena***, a species that occurs among mosses and in bog pools. Photo by Michael Plewka <www.plingfactory.de>, with permission.

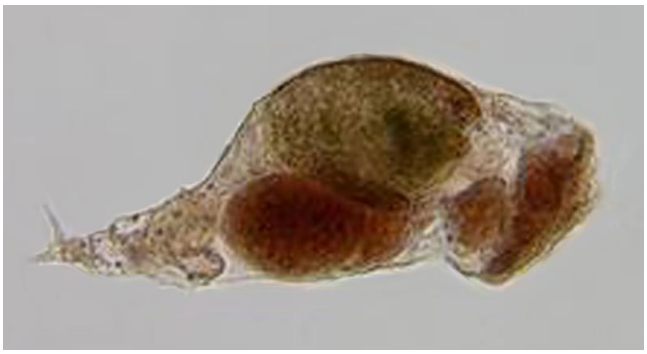

Figure 145. ***Mikrocodides chlaena*** female from New Jersey, USA. This species has been collected from mosses and from bog pools. Photos by Jersabek *et al.* 2003, with permission.

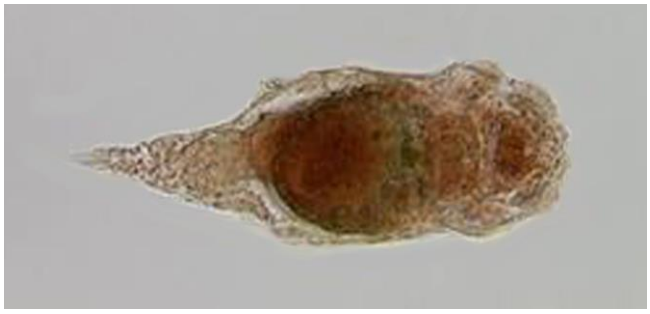

Figure 146. ***Mikrocodides chlaena*** female from New Jersey, USA. This species has been collected from mosses and from bog pools. Photos by Jersabek *et al.* 2003, with permission.

Euchlanidae

This family is characterized by a lorica consisting of connected plates (Koste & Shiel 1989). The toes are elongated. Of the five genera in the family, only ***Euchlanis*** is known from mosses.

Sphagnum (Figure 21, Figure 66), as usual, is a common substrate, with a number of species of ***Euchlanis*** associated with it. These include ***E. callysta*** (Figure 147), ***E. calpidia*** (Figure 148-Figure 149, ***E. dilatata*** (Figure 156-Figure 157), ***E. incisa*** (Figure 150) and ***E. triquetra*** (Figure 151-Figure 155) (Błedzki & Ellison 2003; Jersabek *et al*. 2003).

Figure 147. ***Euchlanis callysta*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 148. ***Euchlanis calpidia*** from among ***Sphagnum***. Photo by Jersabek *et al*. 2003, with permission.

Figure 149. ***Euchlanis calpidia*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 150. ***Euchlanis incisa*** from ***Fontinalis***. Photo by Michael Plewka <www. plingfactory.de>, with permission.

Figure 151. ***Euchlanis triquetra*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 152. ***Euchlanis triquetra*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

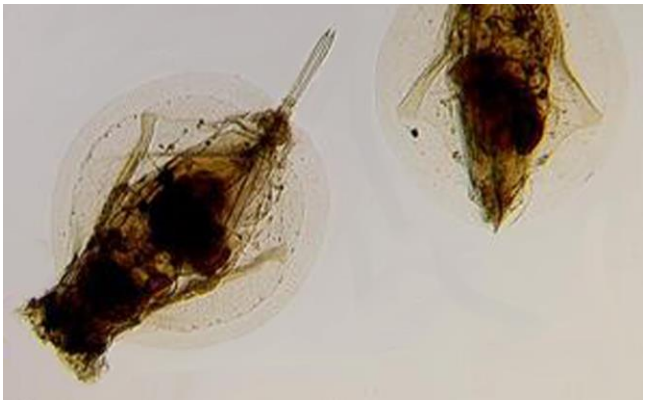

Figure 153. ***Euchlanis triquetra*** from among ***Sphagnum***. Photo by Jersabek *et al.* 2003, with permission.

Figure 154. ***Euchlanis triquetra***, a species known from ***Sphagnum*** bogs. Photo by Mark Plewka <www.plingfactory.de>, with permission.

Figure 155. ***Euchlanis triquetra*** with expelled resting egg. Photo by Michael Plewka <www.plingfactory.de>, with permission.

There seems to be a paucity of studies on rotifers beyond listing the taxa present in various water bodies. But in the **Euchlanidae**, at least one species that is known from ***Sphagnum*** (Figure 21, Figure 66) seems to have been the subject of several kinds of biological studies. For example, ***Euchlanis dilatata*** (Figure 156-Figure 157) has proven its ability to serve as a sensitive biomonitor (Sarma *et al.*

2001). In an experiment on herbicides, this species experienced a significant reduction in population density and rate of population increase in the presence of methyl parathion. These responses were exacerbated as the concentration of methyl parathion increased, regardless of food (***Chlorella vulgaris*** – Figure 64) concentration. However, higher food concentrations served to mediate the effect on the rate of population increase.

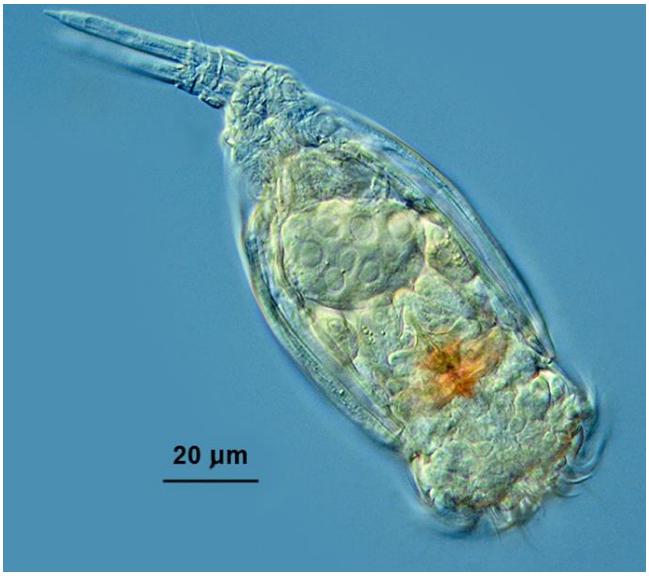

Figure 156. ***Euchlanis dilatata***, a species that can occur on bryophytes and other macrophytes. Photo by Proyecto Agua Water Project, through Creative Commons.

Figure 157. ***Euchlanis dilatata***, a species that has been collected from bryophytes. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Euchlanis dilatata (Figure 156-Figure 157) is a benthic-periphytic species known from littoral zones of small bodies of eutrophic waters (de Manuel Barrabin 2000), but can occur on bryophytes (Jersabek 2016) and other macrophytes (Plewka 2016). On Svalbard, it occurs exclusively on submerged mosses, along with ***E. deflexa*** (Figure 159) and ***E. meneta*** (Figure 158) (De Smet 1988, 1993). ***Euchlanis dilatata*** occurs in both fresh water and brackish water, preferring water rich in nutrients, especially those favoring **Cyanobacteria** (de Manuel Barrabin 2000). These waters generally have a *p*H range of 6.3-9.6 and a temperature range of 6.4-24°C. Although only 200 µm long, this species is consumed by damselfly naiads (Ejsmont-Karabin *et al*. 1993). In the lab, it is able to survive on **Cyanobacteria** [***Limnothrix*** *redekei* (Figure 160), ***Oscillatoria***. *limnetica* (Figure 161), ***Aphanizomenon*** *flos-aquae* (Figure 162), ***Anabaena*** sp. (Figure 163)], all genera that can be found with ***Sphagnum***, and a prochlorophyte (*Prochlorothrix hollandica*) (Gulati *et al*. 1993). In the field ***E. dilatata*** consumes detritus, bacteria, **Cyanobacteria**, and the diatom ***Cyclotella*** (Figure 164) (Carlin 1943), all likewise present among ***Sphagnum***. It often benefits from the convenience of attaching to planktonic algae colonies (Pejler 1962).

Figure 158. ***Euchlanis meneta***, a species known from bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Figure 159. ***Euchlanis deflexa***, an occupier of submerged mosses on Svalbard. Photo by Jersabek *et al*., with permission.

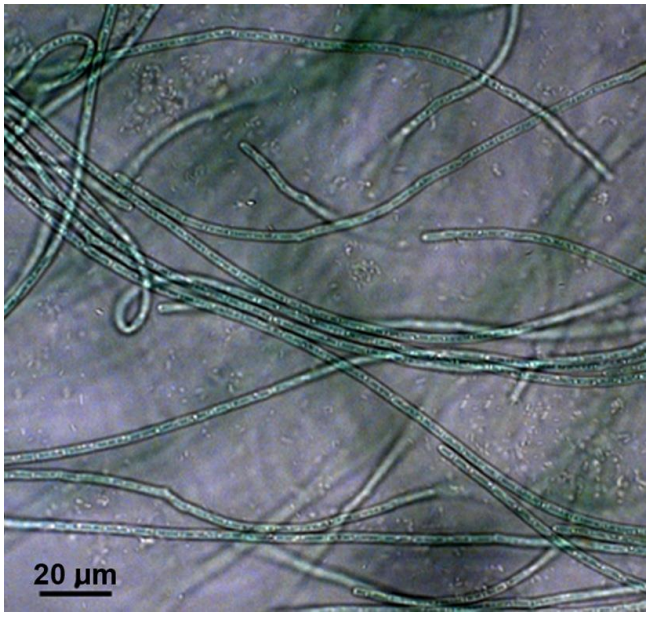

Figure 160. ***Limnothrix redekei***, food for ***Euchlanis dilatata***. Photo by Matt Pano, through Creative Commons.

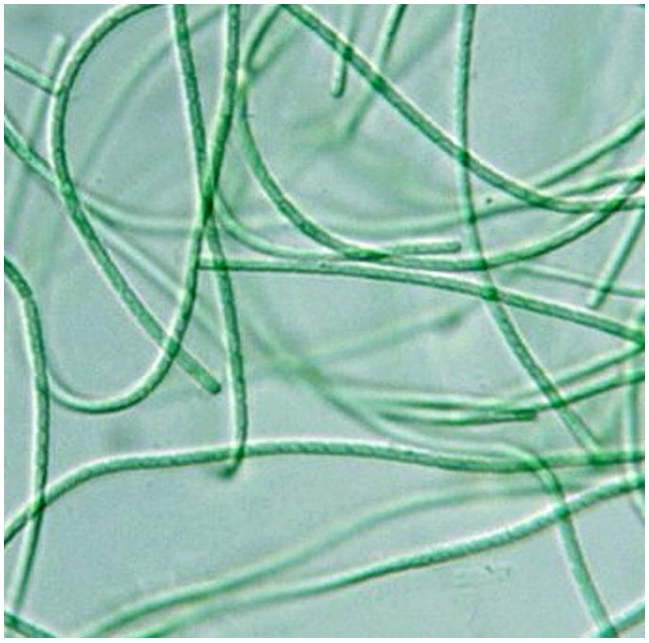

Figure 161. ***Oscillatoria limnetica***, food for ***Euchlanis dilatata***. Photo by Yuuji Tsukii, with permission.

Figure 162. ***Aphanizomenon flos-aquae***, food for ***Euchlanis dilatata***. Photo by Nordic Microalgae <www.nordicmicroalgae.org>, with online permission.

Figure 163. ***Anabaena***, food for ***Euchlanis dilatata***. Photo by Jason Oyadomari, with permission.

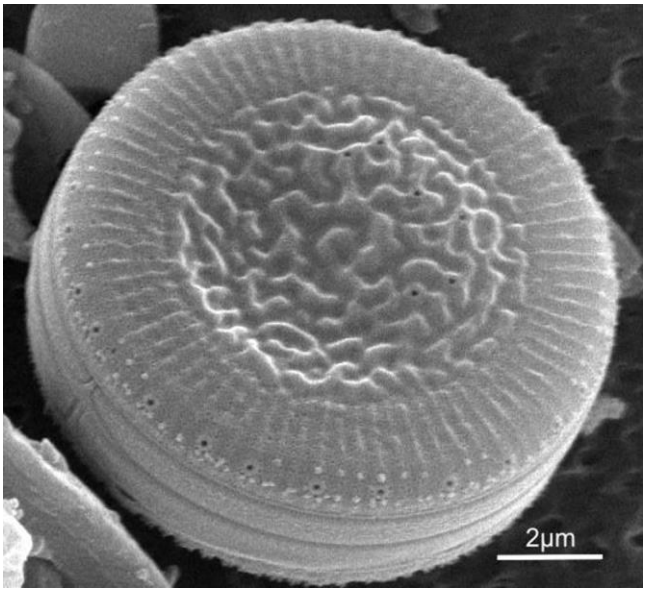

Figure 164. ***Cyclotella caspia***, food for ***Euchlanis dilatata***. Photo by Janina Kownacka, Nordic Microalgae <www.nordicmicroalgae.org>, with online permission.

Euchlanis incisa (Figure 165-Figure 167) is likewise a ***Sphagnum*** (Figure 21-Figure 66) dweller, in the northeastern USA (Błedzki & Ellison 2003), but it is also known from the non-bog aquatic moss ***Fontinalis*** (Figure 11) (Plewka 2016).

Figure 165. ***Euchlanis incisa*** female, a species known from bryophytes. Photo by Jersabek *et al*. 2003, with permission.

Figure 166. ***Euchlanis incisa***, a species known from bryophytes, including ***Fontinalis***. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 167. ***Euchlanis incisa***, a species known from bryophytes. Photo by Jersabek *et al*. 2003, with permission.

In addition to ***Sphagnum***, other bryophytes may be substrates for members of ***Euchlanis***. ***Euchlanis meneta*** (Figure 158-Figure 168) is among the dominant rotifers on mosses on Devon Island, Baffin Bay, Canada (De Smet & Beyens 1995). This species is also known from the other end of the Earth, from New Zealand (Shiel & Green 1996).

Figure 168. ***Euchlanis meneta*** female, a species known from bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Euchlanis oropha (Figure 169) is a widespread **rheophilic** (loving flowing water) species that can occur on mosses, among other substrates.

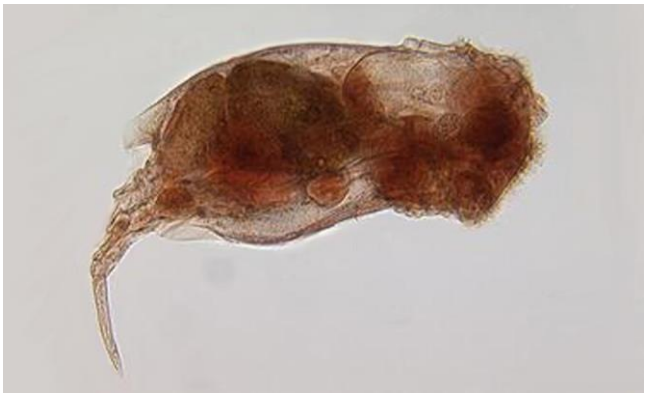

Figure 169. ***Euchlanis oropha*** female, a species known from bryophytes. Photo by Jersabek *et al.* 2003, with permission.

Gastropodidae

This family is distinguished by its oval shape and sac-like or compressed body plan. It has a thin shell that surrounds the entire body with only a small opening for the head and ventrally located foot (Figure 170-Figure 173) that is sometimes absent. The family occurs primarily in fresh water, with few marine species. There are two genera, but only members of ***Gastropus*** seem to have been collected from bryophytes. Of the three species in this genus, two are known bryophyte dwellers: ***G. hyptopus*** (Figure 170-Figure 171) and ***G. minor*** (Figure 172) (Plewka 2016). ***Gastropus stylifer*** lives on submerged mosses in trenches of Alaskan polygons (Segers *et al.* 1996).

Figure 170. ***Gastropus hyptopus***, a moss dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 171. ***Gastropus hyptopus***, a species known from bryophytes and from bog pools. Photo by Jersabek *et al.* 2003, with permission.

Figure 172. ***Gastropus minor*** lateral view, a bryophyte dweller. Photo by Michael Plewka <www.plingfactory.de>, with permission.

Figure 173. ***Gastropus minor*** female, a species known from ***Sphagnum*** bogs. Note the ventral foot. Photo by Jersabek *et al.* 2003, with permission.

Summary

The rotifers in **Monogononta** are often represented on bryophytes, especially in peatlands. The Class **Monogononta** has three orders and is the largest class of rotifers. Many members of order **Collothecacea** are sessile. Some members of family **Collothecidae** are known from ***Riccia fluitans***, ***Sphagnum***, and other bryophytes. Members of the order **Flosculariacea** are suspension feeders, and known bryophyte dwellers include members of **Conochilidae**, **Filiniidae**, **Flosculariidae**, **Hexarthriidae**, and **Testudinellidae**. The order **Ploimida** includes both planktonic and non-planktonic families that are known from bryophytes. Those included in this subchapter are **Brachionidae**, **Dicranophoridae**, **Epiphanidae**, **Euchlanidae**, and **Gastropodidae.** Additional families are in the next sub-chapters.

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