

CHAPTER 4-2

INVERTEBRATES: SPONGES, GASTROTRICHS, AND FLATWORMS



Figure 1. This planarian is navigating a mat of the liverwort *Lepidozia cordulifera*. Photo by Filipe Osorio.

Porifera – Sponges

Sponges don't seem to have any particular appreciation of bryophytes, being unknown from that habitat. However, it appears that the moss genus *Fissidens* has a special fondness for sponges. I know of no other bryophyte genus that finds this a suitable habitat, but *Fissidens fontanus* (Figure 2) in Europe is epizootic on sponges (Sowter 1972) and *F. brachypus* lives only on freshwater sponges in the Amazon (Buck & Pursell 1980). *Fissidens* seems to like animal habitats, living on the openings of wombat holes, termite mounds, and in this case, on a sponge.

Although a moss-sponge combination in nature is rare, humans seem to have found this combination useful. A patent application by Albert G. Morey, dated 13 October 1968, for an "improved mattress" extols the virtues of placing a large sponge (mattress) over a layer of only slightly spongy material such as moss. A three-layer mattress is considered to be superior, with the lower layer of moss sustaining the middle layer of woody fiber or excelsior, again with a layer of elastic sponge on top. It appears that this was a real sponge (or lots of them) and predates the use of cellulose sponges. The improvement

seems to have been the addition of the moss and fibrous layers.

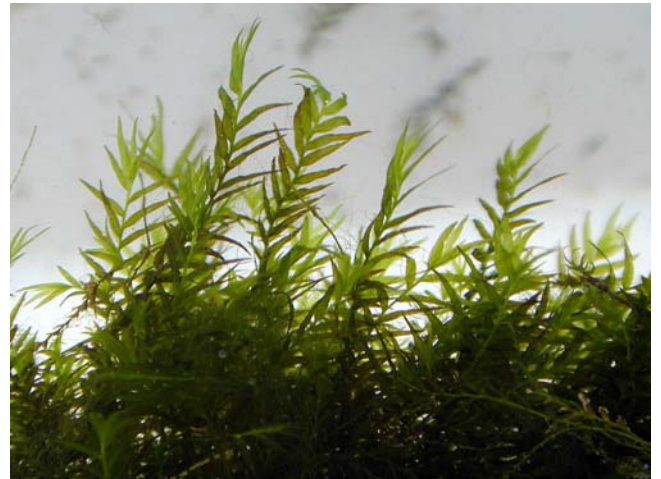


Figure 2. *Fissidens* (= *Octodiceras*) *fontanus*, a species that can be epizootic on sponges. Photo by Michael Lüth.

Gastrotrichs

These small animals with "hairs on their stomachs" use them to beat against such surfaces as moss leaves to glide forward (Figure 3-Figure 9; Hingley 1993). They lack a coelom, like flatworms, and move in a similar motion. Like nematodes, rotifers, and tardigrades, freshwater gastrotrichs are all **parthenogenetic**, producing viable unfertilized eggs. Adults are unable to go dormant, but when unfavorable conditions arise, they produce larger eggs with heavier shells that survive not only desiccation, but also low and high temperatures. They adhere using cement glands in two terminal projections (Gastrotrich 2009). One of the glands conveniently secretes a de-adhesion to release them.

They may be found occasionally on aquatic mosses. The Dichaeturidae is a rare family that has been found in cisterns, in underground water, and among mosses (Remane 1935-1936; Ruttner-Kolisko 1955). In the Czech Republic, Vlčková *et al.* (2002) reported 2823 of these invertebrates on 100 ml of the aquatic moss *Fontinalis antipyretica* in Bystřice, whereas in Mlýnský náhon there were only 371 per 100 ml. In Bystřice the mosses held a food source of organic matter in the size range of 30-100 μm . Linhart *et al.* (2002) found that abundance was negatively influenced by flow velocity in both of these streams, and the gastrotrichs were significantly fewer in riffles, suggesting that mosses could act as refugia in areas of high flow. On the other hand, sediment also was reduced in areas of high velocity, resulting in more available food in low velocity areas.

In a peatland complex in northern Italy, Balsamo and Todaro (1993) identified 21 species of gastrotrichs. Hingley (1993) found the following gastrotrichs among the peatlands mosses in her study of the British Isles:

<i>Chaetonotus heterocanthus</i>	<i>Chaetonotus zelinkai</i>
<i>Chaetonotus maximus</i>	<i>Heterolepidoderma ocellatum</i>
<i>Chaetonotus ophiogaster</i>	<i>Ichthyidium forcipatum</i>
<i>Chaetonotus polyspinosus</i>	<i>Lepidodermella squamatum</i>
<i>Chaetonotus voighti</i>	<i>Stylochaeta fusiformis</i>

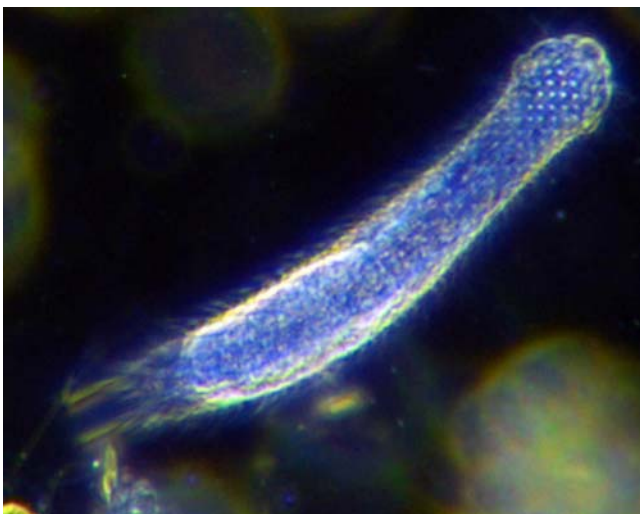


Figure 3. Gastrotrich showing two tails and cilia. Photo by Jasper Nance through Wikimedia Commons.



Figure 4. Gastrotrichs awakened from dry soil. Photos by Paul G. Davison.



Figure 5. *Chaetonotus cordiformis*. Photo by Yuuji Tsukii.

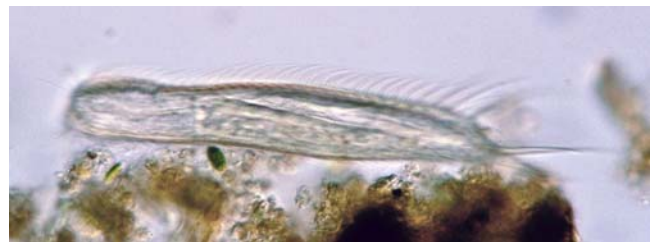


Figure 6. *Chaetonotus zelinkai*, a moss-dwelling gastrotrich. Photo by Yuuji Tsukii.



Figure 7. *Chaetonotus zelinkai*, a peatland gastrotrich. Photo by Yuuji Tsukii.



Figure 8. *Heterolepiderma*, a genus that has moss-dwelling gastrotrichs. Photo by Yuuji Tsukii.

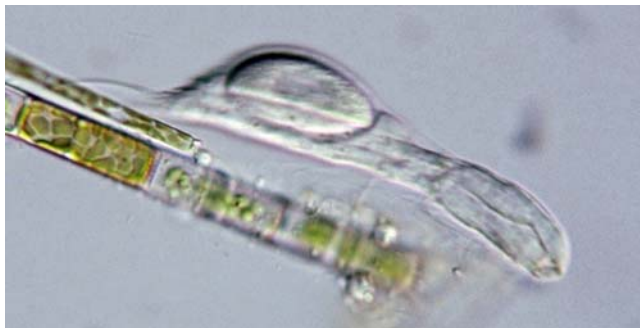


Figure 9. *Ichthyidium forficula*, a member of a genus that can occupy peatlands. Photo by Yuuji Tsukii.

Platyhelminthes – Flat Worms

The Turbellaria (Figure 1) are shaped like a large ciliate and actually have a covering of cilia that permits them to glide (Hingley 1993). But they are multicellular, mostly **not** flat, sporting a simple digestive system, nervous system, and excretory system. They even have eyespots and a simple brain. Reproduction may be by simple division, whereas others are hermaphrodites and have sexual reproduction. Their eggs are thin-shelled in summer and hatch as soon as they are laid, but winter eggs are thick-shelled and may be dormant. These thick-shelled eggs can survive desiccation, whereas mature individuals might migrate to more moist deeper levels.

Desiccation Tolerance

If there is a niche, there is most likely an organism to fill it. And eventually, there is most likely a biologist to study it, but for moss-dwelling bryophytes, this has been a long time coming. Although flatworms, known to most of us as human parasites and freshwater organisms, can be quite abundant among bryophytes, their presence there is barely known (Paul Davison, personal communication, 8

August 2007). Unlike the rhizopods and other kinds of protozoa, the moss-dwelling flatworms are not known to enter a state of cryptobiosis. Davison has collected several that he has taken to room-dry conditions and then revived (Figure 11). These relatively unknown members of the bryophyte community do form cysts and resistant eggs (Figure 10) that permit them to survive the alternate wet and dry conditions found among bryophytes, especially those on tree trunks, despite the thinness of their mucous covering.

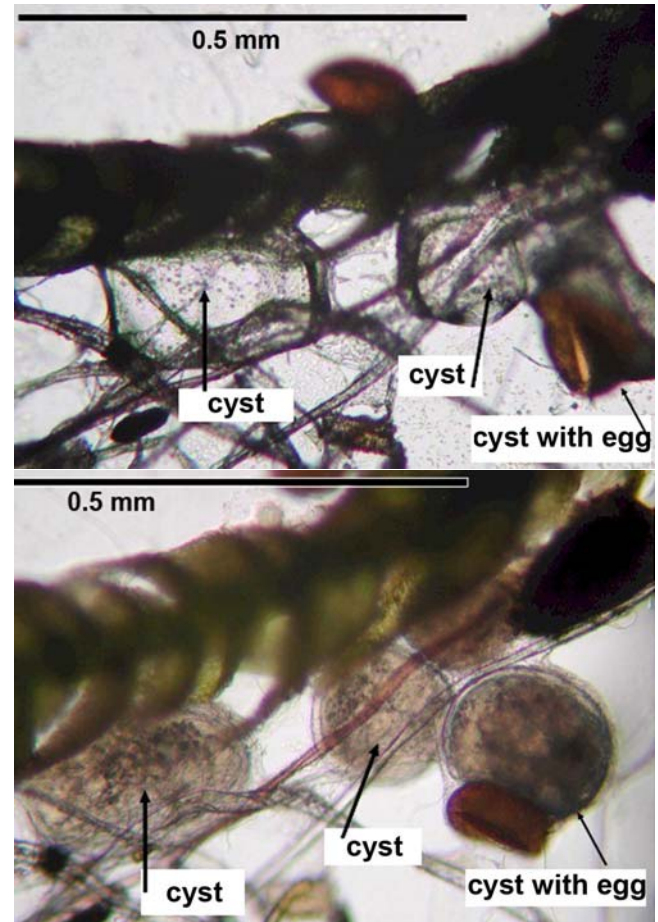


Figure 10. Cysts of flatworms on a moss. **Upper:** Cysts in desiccated state. **Lower:** Cysts after rehydration. Photos by Paul G. Davison.



Figure 11. Recently excysted turbellarian and empty cyst. The dark brown eggs formed during encystment, providing a second means of surviving. These flatworms were living in the moss *Entodon seductrix* (Figure 12) from a concrete block wall in Florence, Alabama, induced to encyst on a glass slide, then brought back to an active state. Photo by Paul G. Davison.



Figure 12. *Entodon seductrix*, a moss where flatworms are known to encyst. Photo by Robert Klips.

Bryophytes as a Habitat

Most of the non-parasitic flatworms (Turbellaria) are known from aquatic habitats. Stern and Stern (1969) found numbers among cold springbrook mosses (*Fontinalis antipyretica*) in Tennessee to be similar to those on stones, ranging 1-5 per 0.1 m² on stones and 1-4 per 0.1 m² among the moss-algae associations. Frost (1942) found less than 0.1% of the fauna to be turbellarians among mosses [mostly *Fontinalis squamosa* (Figure 13), *F. antipyretica*, and *Platyhypnidium riparioides*] in her River Liffey Survey, Ireland. They are not generally a dominant component of the stream bryophyte fauna.



Figure 13. *Fontinalis squamosa*, a common habitat for stream fauna, including flatworms. Photo by Michael Lüth.

The well-known planarian *Dugesia dorotocephala* finds "moss and sand quite acceptable," preferring them over silt, but less than rocks or leaves (Figure 14; Speight & Chandler 1980). *Phagocata gracilis*, a moss-preferring species, selected temperatures of 4-22°C, preferring 14.8°C on rocks and 12.6°C on moss. *Phagocata velata*, on the other hand, preferred living on rocks and migrated mostly to a temperature range of 16.0-20.5°C, with a temperature preference of 17.8°C.

One mossy habitat where these microturbellarians seem to be quite rare, however, is in the Antarctic. Nevertheless, Schwarz *et al.* (1993) did find one catenulid flatworm inhabiting the mosses of flushes near the Canada Glacier on continental Antarctica.



Figure 14. *Dugesia* in its rock habitat, which is usually preferred to mosses. Photo by Janice Glime.

Epiphyte Dwellers

The microturbellarians are those free-living flatworms (Platyhelminthes) generally <1 mm in length (Figure 15; Paul Davison, pers. comm. 12 January 2008). They typically live in water films, making them essentially aquatic. Any bryologist would immediately identify bryophytes as one such habitat, so it is no real surprise to us that they (Rhabdocoela, Typhloplanidae) are common 1-2 m above ground among epiphytic mosses. Such is a fertile microturbellarian habitat in the southeastern US where Davison, Robison, Steenkiste, and Artois (in prep.) sampled in longleaf pine-mixed hardwoods, *Juniperus* in limestone cedar glades, northern hardwoods above 1600 m elevation, dwarf oak forest, upland hardwoods-pine, and planted roadside pecan trees. They found that the tree trunk dwellers are rare in cool, mossy stream ravines but are common in areas prone to rapid drying following rainfall – mosses on tree trunks fit this need well. Their common moss habitats are *Leucodon julaceus* and *Clasmatodon parvulus* on trees of open, urban habitats, including *Catalpa* sp., *Celtis* sp., *Cornus florida*, *Fraxinus* sp., *Liquidambar*, *Magnolia grandiflora*, *Paulownia*, *Quercus* spp., and *Ulmus* spp. They survive these habitats by forming thin-coated transparent mucous cysts, a mechanism not familiar in other habitats.

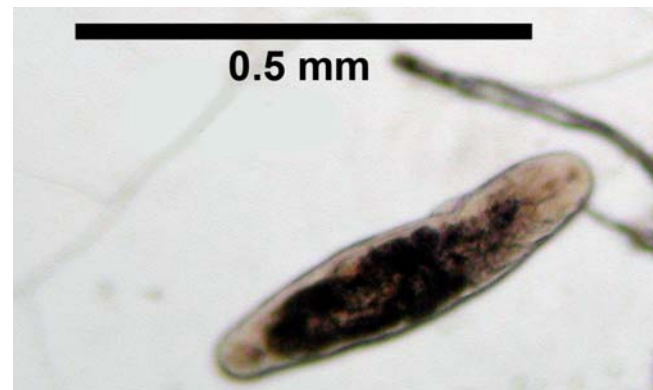


Figure 15. Moss flatworm, a microturbellarian. Photo by Paul G. Davison.

Davison has found that flatworms are quite common in association with mosses on hackberries and other trees in Florence, Alabama, USA. These include *Clasmatodon* on *Paulownia tomentosa* and *Leucodon julaceus* (Figure 16) on *Cornus florida*, all at least 0.3 m above ground.

Davison later collected flatworms from mosses on two white oaks in northern Tennessee, suggesting that they may be widespread, at least in these south temperate areas. The collections were from *Foerstroemia* and *Haplohymenium* growing 1.7-2 m above the ground. Although these had 10 and 6 turbellarians, a sample of *Hypnum curvifolium* from the tree base produced only one worm. Davison suggests that the water bears are important determinants of the location of the turbellarians, and water bears were less abundant at the tree base.



Figure 16. Epiphytic *Leucodon julaceus*, a known habitat for flatworms. Photo by Janice Glime.

Although flatworms are known from dry mosses on rocks, these observations by Davison appear to be the first discovery of their living among epiphytic bryophytes. There is at least one report of moss-dwelling turbellarians (on *Stokesiella oregana*) on a wet log (Merrifield & Ingham 1998), but that is hardly similar to the dry habitat of a tree trunk. The flatworms are seldom abundant, with four or fewer from a clump being common. However, they can be as abundant as 20 in a palm-sized patch of moss. Although they are not abundant, they are frequent, despite the apparent dispersal problems they are likely to have.

Food Sources

When active, flatworms feed on protozoa, nematodes, rotifers, tardigrades, insect larvae (Figure 17), and algae (Kolasa 1991) with which they share their mossy home. As suggested by Davison, it appears that one attraction for the flatworms in moss communities is the available tardigrades (Figure 18). Flatworms are also known to eat mosquito larvae (Figure 17), so it is likely that they are able to eat Chironomidae (midge) larvae that live among the leaves of aquatic mosses and liverworts. Some microturbellarians are known to house green algae as symbionts (Kolasa 1991), presumably contributing to oxygen, but possibly also contributing carbohydrates. Such a relationship is unknown among moss-dwellers, but certainly it would be worthwhile to search for such symbionts.



Figure 17. Flatworm feeding on a mosquito larva. Photo by Paul G. Davison.



Figure 18. Flatworm eating tardigrade. Photo by Paul G. Davison.

Summary

Fissidens fontanus and *F. brachypus* can grow epizootically on sponges. Humans may enjoy a mattress made with mosses and sponges.

Gastrotrichs survive the dry stages of mosses by producing larger eggs that survive due to heavier shells. They seem to prefer lower velocity areas where sediments can accumulate and can be relatively common in peatlands.

Flatworms are mostly from aquatic habitats where they are known from *Fontinalis antipyretica*, *F. squamosa*, and *Platyhypnidium riparioides*. They survive winter and dry periods like the gastrotrichs, as thick-shelled eggs, but they can also form cysts, particularly among epiphytic mosses. They are actually more abundant on tree trunks that are prone to drying out than they are in cool, mossy stream ravines. These terrestrial species seem to be most abundant among the mosses where they can find tardigrades to eat. *Phagocata gracilis* actually prefers moss habitats.

Acknowledgments

Paul Davison kept me informed of new finds, which were especially important for these groups where so little is known of their bryophyte relationships. Filipe Osorio added information on tropical Platyhelminthes. Yuuji Tsukii gave me permission to use his wonderful collection of images.

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