CHAPTER 12-6
TERRESTRIAL INSECTS: HEMIMETABOLA – HEMIPTERA (HETEROPTERA)

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Figure 1. Lacebug (**Tingidae**) with moss ***Tortula papillosa*** and lichen *Candelaria concolor*. Photo by Robert Klips, with permission.

HEMIPTERA – True Bugs

While many people call all insects bugs, there is only one order that officially carries that name. Their scientific name of **Hemiptera** revealed their most unique character, wings that are "half" membranous and "half" chitinized. But recent classification has added other groups to the **Hemiptera** that do not have this character, and some have no wings at all. The order is now divided, including the traditional "bugs" in the suborder **Heteroptera**. The **Hemiptera** are **hemimetabolous**, having a life cycle of eggs, nymphs, and adults. The overwintering stage depends on the species and may be spent among mosses.

Although most bugs feed on tracheophyte (mostly flowering plant) leaves, often specializing on one species, for many the bryophytes are important alternate hosts when the tracheophyte leaves are no longer available or no longer hospitable. But Rédei *et al*. (2003) considered the ground fauna to be under-sampled relative to the pest species that occurred above ground on plants. Using Berlese funnels for extraction (without specifying sample size) they found that the assemblages of **Hemiptera** from mosses were similar to those from soil and could occur "in great numbers" (Table 1). In fact, moss samples had higher numbers per sample than soil samples, although it is hard to know the appropriate base (weight, area, volume, *etc*.) on which to compare them. To sample **Hemiptera** among bryophytes, Marie-Claude Larivière uses a sieve technique (Figure 2).

As an example of moss hemipteran diversity, the communities among various moss species in Hungary differ little from each other, with the exception of those on ***Sphagnum*** (Figure 3; Table 1) (Rédei *et al*. 2003). On the other hand, the **Hemiptera** communities on bryophytes differ significantly ($p<0.05$) from those of tussocks and those of soil, leaf litter, and debris (Figure 4). An important factor among the bryophyte habitats is the moisture level. Mosses on the ground retain water longer

than those on tree trunks, with those on rocks retaining the least water and providing the driest habitats. Consequently, **Hemiptera** species preferring humid conditions are common among bryophytes on the ground and some tree trunk conditions but do not occur among the drier rock dwellers.

Table 1. Comparison of Hemiptera in bryological samples and non-bryological samples on the ground. From Rédei *et al*. 2003.

substrate	number of samples	numb specimens	per sample
mosses on tree trunks	225	725	3.2
mosses on stones and rocks	292	1240	4.2
mosses on ground	259	520	2.0
other mosses	117	221	1.9
Sphagnum	94	107	1.1
soil	390	159	0.4
leaf litter, debris	795	586	0.7
tussocks, tufts of sedges	287	209	0.7

Figure 2. Marie-Claude Larivière sifting moss and leaf litter in NZ to find **Hemiptera**. Photo by André Larochelle, with permission.

Figure 3. ***Sphagnum*** becoming established on *Potentilla fruticosa* as a fen becomes more moist and acidified. The fen and bog locations typically have both flowering plants and mosses, providing the two alternative hosts needed by many **Hemiptera** species. Photo by Janice Glime.

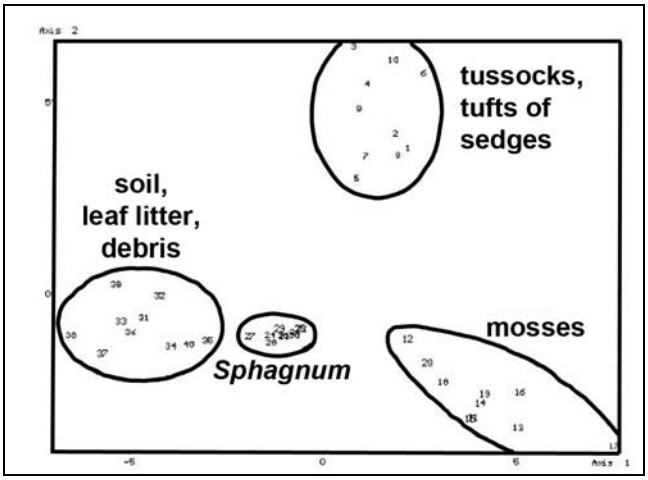

Figure 4. Similarity pattern of communities associated with the four major substrata groupings of Hungarian hemipteran ground fauna. Redrawn from Rédei *et al*. 2003.

True bugs are affected by the nutrients available to mosses. Richardson *et al*. (2002) found that moss-feeding true bugs in fertilized plots in Scandinavia diminished in number to as little as 6% of those in the unfertilized controls. The **Homoptera** on grasses, on the other hand, were more than 400% more abundant, indicating that fertilization was detrimental to the moss communities. Such a reduction could be the result of nutritional changes in the mosses or a reduction in mosses, reducing both food and cover for bryophyte-adapted bugs.

Adaptations

Most of the bugs that live among bryophytes are tiny, often only 1-2 mm in length. Their biggest adaptation is that many of the moss dwellers are able to eat mosses. This ability not only may involve differences in mouthparts, but at least sometimes requires the presence of **endosymbiotic** bacteria to help in digestion (Kuechler *et al*. 2013). But it seems that few other adaptations exist. Their coloration is often brown, and I find that the common moss-dwelling lace bugs often resemble seeds, not mosses. That's not a bad appearance if you are hiding from carnivores, but it doesn't make you invisible. Instead, the coloration of most species is adaptive for the primary host. On the other hand, mosses provide a habitat where behavior is important. Many species are able to migrate vertically within the moss mat to find suitable temperature and humidity (Marie-Claude Larivière, pers. comm. 1 September 2015).

Nutrients

Among the factors that limit **Hemiptera**, nutrients in the plants can play an important role. This can be especially important for some adapted to Arctic and sub-Arctic habitats where nutrient turnover is slow. In a dwarf shrub heath community, Richardson *et al*. (2002) manipulated nutrients and temperatures to determine responses. Nutrient addition had a strong effect on the subordinate mosses and resulting changes in the abundance of the insect herbivores. These changes had a greater impact on the insect herbivore community than those of the shrub layer. Those **Hemiptera** (**Heteroptera**) on the fertilized plots reached an abundance only 6% that of the unfertilized controls. **Homoptera** (former classification),

on the other hand, were more than 400% more abundant. The grass-eating **Delphacidae** (plant hoppers) were only present in fertilized plots.

Habitats

Forests

Forests offer a variety of habitats for bryophyte-dwelling **Hemiptera** (Lattin & Moldenke 1990). In the woodland habitats of Hungary, Rédei *et al*. (2004) found ***Acalypta carinata*** (2.5 mm; **Tingidae**; Figure 5) among the ***Sphagnum*** (Figure 3) and the moss ***Abietinella abietina*** (Figure 6), living on tree trunks or the ground. This lace bug prefers humid, shady woodland habitats. ***Acalypta musci*** (2.5-2.8 mm; Figure 7) is typically a moss dweller, but it also occurs on fungi on tree trunks and among mosses at tree bases.

Figure 5. ***Acalypta carinata*** female on moss in Germany. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission

Figure 6. ***Abietinella abietina***, a woodland home for ***Acalypta carinata.*** Photo by Janice Glime.

Figure 7. ***Acalypta musci***, a species named for its association with mosses. Photo by Boris Loboda, with permission.

The mossy forests of the temperate and Antarctic rainforests of New Zealand (Figure 8) are home to the tiny **Peloridiidae** (2-4 mm) (Burckhardt 2010; Burckhardt *et al*. 2011; Harris 2011, 2014). The **Peloridiidae** also occur in temperate forests in Australia (Grozeva *et al*. 2014). The genus ***Xenophyes*** (2.18-3.23 mm; Figure 9), a member of **Peloridiidae**, is common in the rainforests throughout the southern hemisphere, including Chile, Argentina, New Zealand, New Caledonia, and Australia (Burckhardt *et al*. 2011). ***Peloridium hammoniorum*** (3.9-4.3 mm), the only member of the family with both winged and flightless forms, was recently described as a new species from Chilean secondary forests, living among mosses, primarily on ***Polytrichadelphus magellanicus*** (Figure 10) (Shcherbakov 2014).

Figure 8. Wet Rimu (***Dacrydium***) forest in New Zealand where **Heteroptera** live among mosses. Photo by Marie-Claude Larivière, with permission.

Figure 9. ***Xenophyes rhachilophus***, member of a genus that is common among mosses in rainforests of the Southern Hemisphere. Photo by S.E. Thorpe, through Creative Commons.

Figure 10. ***Polytrichadelphus magellanicus***, home of ***Peloridium hammoniorum***. Photo by Juan Larrain, with permission.

Dikraneura aridella (5.6-6 mm; **Cicadellidae**; Figure 11) lives in moss-covered coniferous European forests, where it feeds on grasses (Söderman 2007). ***Aguriahana pictilis*** (~5 mm; **Cicadellidae**; Figure 12) likewise lives in moss-covered forests, but it feeds on blueberry (*Vaccinium myrtillus*) leaves. The importance of the mosses for these two species is unclear. Elsewhere, ***Macrocixius emeljanovi*** (0.51-0.64 mm; **Cixiidae**) and ***M. oropilus*** (0.69-0.70mm) live in high mountain mossy forests in Taiwan and Nepal (Orosz 2013). ***Melanocoryphus albomaculatus*** (~9 mm; **Lygaeidae**; Figure 13-Figure 14), a critically endangered species in the Czech Republic, lives under lichens, moss, dry leaves, stones, etc. (Kment *et al*. 2013a). Its bright orange and black color patterns seem left over from some prior host of its relatives because they do not seem adaptive to mosses or to some of its host plants like *Senecio* (Chateau Moorhen 2015). And, oddly for a moss dweller, in France it likes hot, dry places!

Figure 11. ***Dikraneura aridella***, a species that prefers moss-covered coniferous forests in Europe. Photo by Marko Mutanen, through Creative Commons.

Figure 12. ***Aguriahana pictilis***, an inhabitant of moss-covered forests. Photo by Gernot Kunz, with permission.

Figure 13. ***Melanocoryphus albomaculatus***, a critically endangered species in the Czech Republic, often living under mosses. Photo by Valter Jacinto, through Creative Commons.

Figure 14. ***Melanocoryphus albomaculatus***, a moss dweller that does not have cryptic coloration for moss dwelling. Photo by Didier Descouens, through Creative Commons.

Larivière *et al*. (2011) reported ***Oiophysa ablusa*** (**Peloridiidae**; Figure 15) from montane ***Nothofagus*** forests in New Zealand where they lived among wet mosses and leaf litter. ***Oiophysa cumberi*** (Figure 16) is a more lowland species, living in broadleaf-podocarp and ***Nothofagus*** forests among both mosses and liverworts on the ground and on trees. ***Oiophysa distincta*** is likewise in the lowland to montane podocarp and ***Nothofagus*** forests where it lives among mosses on the ground and on trees as well as in litter. This species also occurs on the pendulous moss ***Weymouthia*** sp. (Figure 17).

Figure 15. ***Oiophysa ablusa*** on leafy liverwort. Photo by E. Wachmann through M.-C. Larivière, with permission.

Epiphytes

Tree-trunk bryophytes are typically drier than those growing on the ground and some species of **Lygaeidae** prefer to live among mosses in this habitat (Rédei *et al*. 2003). Members of **Peloridiidae** (Bechly & Szwedo 2007) and **Rhyparochromidae** (Rédei *et al*. 2003) are common on tree trunk mosses in Europe. Furthermore, the genus ***Acalypta*** (**Tingidae**) is represented there by a number of species, and ***Piesma maculatum*** (2-3 mm.; **Peismatidae**; Figure 18), ***Myrmedobia exilis*** (1.3-2.2 mm; **Microphysidae**; Figure 19), ***Cryptostemma*** (2.5-2.8 mm; **Dipsocoridae**; Figure 20), and ***Ceratocombus coleoptratus*** (1.5-2.0 mm; **Ceratocombidae**; Figure 21) also prefer this tree trunk habitat, as well as ground and other substrata. Rédei *et al*. consider many terrestrial ***Hebrus*** (**Hebridae**; Figure 36-Figure 38) species, including young nymphal stages, to prefer moss on tree trunks, ground, and other surfaces. In Tasmania, ***Xenophyes cascus*** (2.48-3.10; **Peloridiidae**; Figure 22) occurs among bark mosses (Burckhardt *et al*. 2011).

Figure 16. ***Oiophysa cumberi***, a moss inhabitant. Photo by George Gibbs, with permission.

Figure 17. ***Weymouthia mollis***, home for some members of ***Oiophysa distincta***. Photo by Phil Bendle, through Creative Commons.

Figure 18. ***Piesma maculatum***, a hemipteran living among mosses on tree trunks. Photo by Joe Botting, with permission.

Figure 19. ***Myrmedobia exilis***, a tree-trunk bryophyte dweller. Photo by Mardon Erbland, through Creative Commons.

Figure 20. ***Cryptostemma*** sp.; ***Cryptostemma waltli*** lives among mosses in shaded habitats. Photo by Michael F. Schönitzer, through Creative Commons.

Figure 21. ***Ceratocombus coleoptratus***, a tree-trunk and ground moss dweller. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission

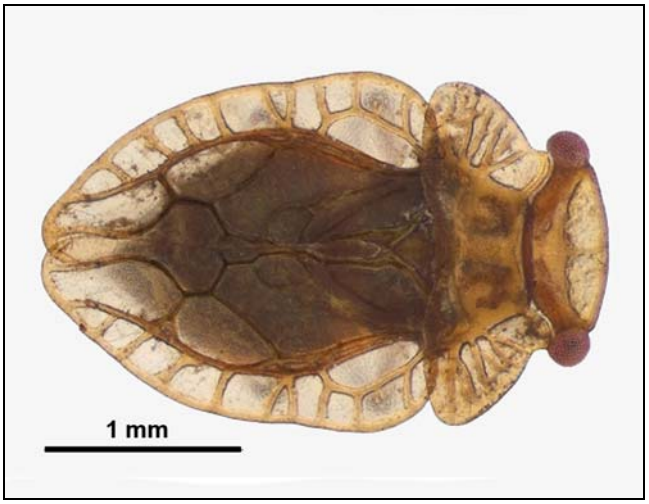

Figure 22. ***Xenophyes cascus***, a species that lives among epiphytic mosses in epiphytes. Photo by Marie-Claude Larivière, with permission.

The **Saldidae** (shore bugs; Figure 24-Figure 23) include a range of habitats from the intertidal zone to terrestrial habitats. Among these habitats is the moss on the trunks of rainforest trees (Polhemus & Chapman (1979). ***Lampracanthia crassicornis*** (1 mm; Figure 23) and ***Salda anthracina*** (Figure 24) lay their eggs between the leaves of mosses (Hungerford 1918). ***Salda anthracina*** is much like the preying mantis in its mating behavior. But unlike the preying mantis, the male initially follows the female around, keeping a safe distance (Hungerford 1919). When he decides to mate (or the opportunity is right), he pounces upon her. He exits quickly at completion lest he too, like the preying mantis male, be eaten by his mate. And sometimes he is eaten.

Figure 23. ***Lampracanthia crassicornis***, a species that lays its eggs on mosses. Photo from CNC-BIO Photography Group, Biodiversity Institute of Ontario, through Creative Commons

Figure 24. ***Salda anthracina***, a species that lays her eggs among moss leaves and will eat her mate if he doesn't leave fast enough. Photo by Tom Murray, through Creative Commons.

Sand Dunes

In dunes, bryophytes can offer respite from the dry sand. Spungis (2005) found that **Hemiptera** density was limited by available cover of mosses and lichens. Sand dunes are dry and inhospitable for insects that do not have desiccation protection. For some, that protection comes in surface waxes, hard chitin, and a reduced physiological need for water. For others, behavior is the most important adaptation, allowing the hemipterans to move to mosses when host plants become inhospitable. Spungis (2005) found that mosses provided a refuge for bugs in the coastal grey dunes (Figure 25) of Latvia. The number of species of **epigeic** (active at the soil surface) **Hemiptera** correlated with the moss-lichen cover in the dunes (p<0.01). The density of ground-dwelling species was low and both population density and species diversity were limited by available cover of lichens and mosses. ***Nysius thymi*** (3.5-4.5 mm; **Lygaeidae**; Figure 26) and members of **Miridae** (jumping tree bugs; Figure 118-Figure 123) had high population densities and were dominant compared to the grass-dwelling hemipterans. ***Sciocoris cursitans*** (4.5-6.0 mm; Figure 27) in the **Pentatomidae** dominated the soil dwellers (41%), with a high correlation (r=0.81; p<0.01) with moss and lichen cover.

Figure 25. Coastal grey dunes in The Netherlands. Similar sites in Latvia have limited **Hemiptera**-moss associations, including mostly **Miridae**. Photo by Bas Kers, through Creative Commons.

Figure 26. ***Nysius thymi*** on thyme flower. This species is dominant in sandy areas of Latvia with dense moss and lichen cover. Photo by Tristan Bantock, with permission.

Figure 27. ***Sciocoris cursitans*** adult, a soil dweller with a high correlation with mosses and lichens. Photo by Tristan Bantock, with permission.

In Hungary, Rédei *et al*. (2004) found that ***Acalypta gracilis*** (2-2.8 mm; **Tingidae**; Figure 28) preferred the Pannonic dune open grassland patches (Figure 29) over the dune-slack (Figure 30) purple moor grass meadow. ***Acalypta marginata*** (2.0-3.0 mm; Figure 31-Figure 32) was present equally in the Pannonic dune open grassland and the Pannonic sand puszta patches (Figure 33), but likewise avoided the dune-slack purple moor grass meadow. Both species are moss dwellers.

Figure 28. ***Acalypta gracilis***, a moss dweller that prefers dune open grassland in Hungary. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission.

Figure 29. Pannonic sand steppe, Hungary. Photo by Daniel Dítě in Šefferová Stanová *et al*. 2008, with authorized reproduction.

Figure 30. Dune slack and meadow in UK, a habitat that seems to be avoided by moss dwelling ***Acalypta*** species in Hungary. Photo by David Hawgood, through Creative Commons.

Figure 31. ***Acalypta marginata*** with moss, a dweller among mosses in sandy areas, including dunes. Photo by Boris Loboda, with permission.

Figure 32. ***Acalypta marginata*** disappearing into the depths of a moss. Photo by Boris Loboda, with permission.

Figure 33. Pannonic sand puszta with draw well in Hungary. Photo by Andreas Poeschek, through Creative Commons.

Streamside and Wet Habitats

This habitat group includes bugs with high moisture requirements, but that are not truly aquatic. For example, ***Macrovelia hornii*** (4.2 mm; **Macroveliidae**; Figure 34) nymphs and adults live among mosses at the water's edge but are unable to live in the water or on its surface (Usinger 1974).

Figure 34. ***Macrovelia hornii***, a moss inhabitant at water's edge. Photo by Jerry Wilson, with permission.

Hebrus concinnus (2.25-2.5 mm; **Hebridae**; Figure 35), from a genus that is dominant among **Hemiptera** in bogs and fens (see Chapter on aquatic Hemiptera in this volume), lays its eggs where they are partially concealed between moss leaves (Usinger 1974). Schuh and Slater (1995) described them as living deep in moss mats, with ***Hebrus ruficeps*** (1.3-3.7 mm; Figure 36) overwintering frozen in ice among ***Sphagnum*** (Figure 37). ***Hebrus pusillus*** (1.6-2.1 mm; Figure 38) is associated with ***Sphagnum*** and other mosses (Howe 2004) and also reproduces among mosses at the edge of water (Münch 2013). Hebrids also often lay their eggs among mosses, suggesting that early instars may develop there.

Figure 35. ***Hebrus concinnus***, a species that lays its eggs among mosses. Photo through Creative Commons.

Figure 36. ***Hebrus ruficeps*** on ***Sphagnum***, a common bog dweller that overwinters in ice among ***Sphagnum***. Photo by Ruth Ahlburg, with permission.

Figure 37. Frozen ***Sphagnum fimbriatum*** and ice habitat where ***Hebrus ruficeps*** is able to spend its winter in ice among the moss plants. Photo by Dick Haaksma, with permission.

Figure 38. ***Hebrus pusillus***, among the dominant ***Hebrus*** species in bogs and fens. Photo by Joseph Botting, with permission.

Micracanthia schuhi (2.64-3.35; **Saldidae**; see Figure 39) is a moss dweller in Oregon, USA, where it lives beside a small stream on Mt. Hood among moist mosses (Lattin 1968, 1997). It moves up and down within the moss mat to achieve the best temperature level (Lattin 1968).

Figure 39. *Micracanthia marginalis*. ***Micracanthia schuhi*** lives among mosses on Mt. Hood, Oregon, USA. Photo by Jürgen Deckert, with permission.

Cryptostemma waltli (1.2-1.5 mm; **Dipsocoridae;** Figure 20) lives in shaded wet habitats where it inhabits the mosses ***Sphagnum*** (Figure 37), ***Hypnum*** (Figure 40), ***Brachythecium*** (Figure 41), and ***Cratoneuron*** (Figure 42) (Kment *et al.* 2013b).

Figure 40. ***Hypnum lindbergii***, potential home for ***Cryptostemma waltli*** in wet, shaded habitats. Photo by Michael Lüth, with permission.

Figure 41. ***Brachythecium rutabulum*** with capsules, a genus that could be home to ***Cryptostemma waltli*** in shaded, wet habitats. Photo by Malcolm Storey through DiscoverLife.

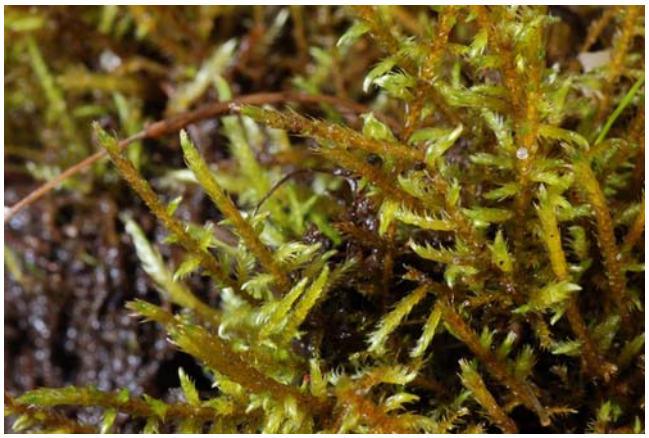

Figure 42. ***Cratoneuron filicinum***, one of the mosses that may house ***Cryptostemma waltli*** in shaded, wet habitats. Photo by J. C. Schou, with permission.

Peatlands

Peatlands are borderline between aquatic and terrestrial habitats. I have already discussed the more aquatic-leaning taxa in the chapter on Aquatic Insects, especially those living in bog pools. Here I will treat the species that use other (non-bryophyte) plants that live in the bogs, perhaps also using the mosses, but that require or benefit from the peatland habitat.

Rédei *et al*. (2003) found that the **Hemiptera** tussock community and species living among ***Sphagnum*** (Figure 3) species were comprised primarily of ubiquitous species that were able to occupy most kinds of mossy substrata. Like many other invertebrates, many of the species of **Hemiptera** are not restricted to bogs and tend to be widespread (Holzinger & Schlosser 2013).

Holzinger and Schlosser (2013) conducted a survey of the **Hemiptera** fauna of Austrian peat bogs in the Bohemian Forest. They found that the **Auchenorrhyncha** formed a considerable fauna, with 93 species among 7465 specimens in these bogs, making them one of the most abundant animal groups in peatlands (see also Holzinger 1995, 2000; Holzinger & Novotny 1998). Eleven of these species were either **tyrphobiontic** (peat bog specialist; restricted to bogs) or **tyrphophilous** (common in bogs but not restricted to them). Tyrphobiontic species in these bogs include ***Sorhoanus xanthoneurus*** (3.1-3.4 mm; **Cicadellidae**; Figure 43) and ***Stroggylocephalus livens*** (5-6.5 mm; **Cicadellidae**; Figure 44), ***Kelisia vittipennis*** (3-3.6 mm; **Delphacidae;** Figure 45), and ***Cixius similis*** (5 mm; **Cixiidae**; Figure 46) (see also Trivellone 2010). ***Cixius similis*** migrates from mosses to shrubs to feed and mate, then returns to the moss-covered ground to oviposit (Söderman 2007). Tyrphophilous species include the **Cicadellidae** ***Sorhoanus assimilis*** (often the most frequent hemipteran; 2-2.9 mm; Figure 47), ***Cicadula saturata*** (4-5.5 mm; Figure 48), and ***Macrosteles ossiannilssoni*** (Figure 49), and the **Delphacidae** ***Paradelphacodes paludosa*** (2.8-3 mm; Figure 50), ***Kelisia ribauti*** (3-4.5 mm; Figure 51), and ***Oncodelphax pullula*** (2-4 mm; Figure 52) (Holzinger & Schlosser 2013).

Figure 43. ***Sorhoanus xanthoneurus***, a restricted bog dweller. Photo by Joe Botting, with permission.

Figure 44. ***Stroggylocephalus livens***, a restricted bog species in Europe. Photo by Gernot Kunz, with permission.

Figure 45. ***Kelisia vittipennis***, a species restricted to bogs. Photo by Joe Botting, with permission.

Figure 46. ***Cixius similis***, a bog-restricted species that moves from mosses to shrubs to feed and back to mosses to oviposit. Photo by Joe Botting, with permission.

Figure 47. ***Sorhoanus assimilis*** adult, a bog-loving moss dweller. Photo by Gernot Kunz, with permission.

Figure 48. ***Cicadula*** sp. adult, a tyrphophilous species. Photo by Tristan Bantock, with permission.

Figure 49. ***Macrosteles ossiannilssoni***, a tyrphophilous bog dweller. Photo by Marko Mutanen, through Creative Commons.

Figure 50. ***Paradelphacodes paludosa*** adult, a bog-loving moss dweller. Photo by Gernot Kunz, with permission.

Figure 51. ***Kelisia ribauti***, a species that is common in bogs but that is not restricted to them. Photo by Gernot Kunz, with permission.

Figure 52. ***Oncodelphax pullula*** on Cyanobacteria, a species that is common in bogs but not restricted to them. Photo by Joe Botting, with permission.

Conomelus lorifer (**Delphacidae**; Figure 53-Figure 54) occurs in ***Sphagnum***-*Carex* associations in Switzerland (Trivellone 2010) at higher altitudes (Ökteam 2012). ***Conomelus anceps*** (4 mm; Figure 55-Figure 56) is a lower altitude species and comprised 17% of the individuals in the Austrian peat bogs and was the most common species there (Holzinger & Schlosser 2013). This species was followed by ***Muellerianella extrusa*** (3.6-4.2 mm; **Delphacidae**; Figure 57) (9.2%), ***Sorhoanus xanthoneurus*** (**Cicadellidae;** Figure 43) (7.6%), ***Jassargus pseudocellaris*** (**Cicadellidae**; Figure 58) (5.5%), and ***Macustus grisescens*** (5-6 mm; **Cicadellidae**; Figure 59) (5.2%). Most of these species are **stenoecious** (having a narrow habitat range) and specialize not only on the habitat, but also on their host plants (Nickel *et al*. 2002; Nickel 2003). The bogs have more **univoltine** (having one brood of offspring per year) **Auchenorrhyncha** species compared to other habitats in Austria and likewise more of their species in the bogs hibernate during their nymphal stage (Holzinger & Schlosser 2013). Densities of adults are low in spring (10-60 individuals per m^2), rising to a high of 180 individuals per m^2 in July.

Figure 53. ***Conomelus lorifer***, a bog dweller in Europe. Photo by Gernot Kunz, with permission.

Figure 54. ***Conomelus lorifer*** adult, a bog dweller. Photo by Gernot Kunz, with permission.

Figure 55. ***Conomelus anceps*** nymph, a bog dweller. Photo by James K. Lindsey, with permission.

Figure 56. ***Conomelus anceps*** adult, a bog dweller, with moss. Photo by Tim Faasen, with permission.

Figure 57. ***Muellerianella extrusa***, a species associated with ***Sphagnum*** in Europe. Photo by Gernot Kunz, with permission.

Figure 58. ***Jassargus pseudocellaris*** adult, a species associated with ***Sphagnum***. Photo by Tristan Bantock, with permission.

Figure 59. ***Macustus grisescens***, a ***Sphagnum*** associate in Europe. Photo by Tristan Bantock, with permission.

In Austrian peatlands, life cycle stages of the **Auchorrhyncha** represent different proportions than in the whole of the Austrian fauna (Figure 60) (Holzinger & Schlosser 2013). The number of generations tends to be fewer in peatlands than in the general fauna (Figure 60).

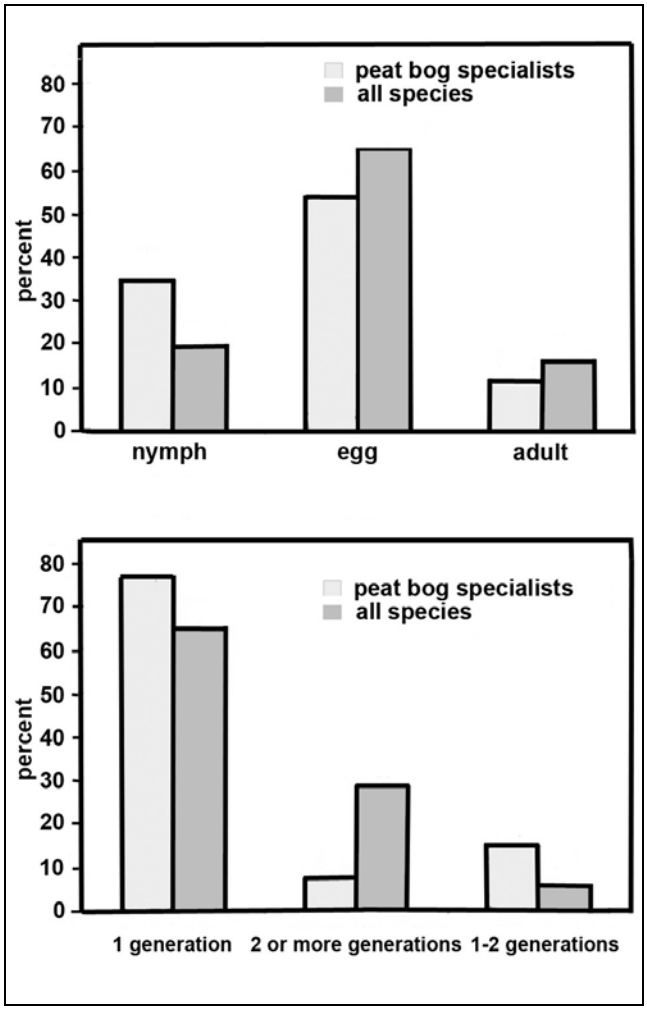

Figure 60. Comparison of generation stages and numbers of generations per year for species of **Auchenorrhyncha** in Bohemian forest peat bogs compared to those of the whole Austrian **Auchenorrhyncha** fauna. Redrawn from Holzinger & Schlosser 2013.

SUBORDER HETEROPTERA (true, typical bugs)

PENTATOMOMORPHA – STINK BUGS, FLAT BUGS, AND SEED BUGS

Thyreocoridae – Ebony Bugs

One member of this family was collected among mosses of the Cheviot Hills, UK – ***Corimelaena scaraboeoides*** was common among mosses (Champion 1871). ***Thyreocoris scarabaeoides*** (Figure 61-Figure 63) is a common moss inhabitant, measuring only 3-4 mm (British Bugs 2015a). Its black color as an adult makes it difficult to notice in the depths of the moss. (I can't find confirmation of the nomenclature for ***Corimeleana scaraboeoides***, so it may be a synonym of ***Thyreocoris scarabaeoides***.)

Figure 61. ***Thyreocoris scarabaeoides*** mid-instar nymph, a common moss inhabitant in the UK. Photo by Tristan Bantock, with permission.

Figure 62. ***Thyreocoris scarabaeoides*** late-instar nymph. Photo by Tristan Bantock, with permission.

Figure 63. ***Thyreocoris scarabaeoides*** adult. Photo by Tristan Bantock, with permission.

Cydnidae – Burrowing Bugs, Shield Bugs

Burrowing bugs don't normally inhabit bryophytes, but there are some exceptions. These include the somewhat larger ***Canthophorus impressus*** (6-7 mm; Figure 64), a rare species (British Bugs 2015b) that hibernates in groups under mosses and leaves in winter (eImageSite.net 2013). Records for ***Canthophorus dubius*** (7mm; Figure 65) are often actually ***C. impressus***, requiring dissection for certain identification (British Bugs 2015b).

Figure 64. ***Canthophorus impressus***, a species that hibernates in groups under mosses. Photo by Tristan Bantock, with permission.

Figure 65. ***Canthophorus dubius***, a winter moss inhabitant in the chalk downs of the UK. Photo by Dragiša Savić, with permission.

The shield bug ***Adomerus biguttatus*** (Figure 66-Figure 67) overwinters among bryophytes (Southwood & Leston 1959).

Figure 66. ***Adomerus biguttatus*** nymph on moss, its overwintering site. Photo by Tristan Bantok, with permission.

Figure 67. ***Adomerus biguttatus*** adult on moss, its overwintering site. Photo by Tristan Bantok, with permission.

Pentatomidae – Stink Bugs and Shield Bugs

In Hungary this family is represented in great numbers in moss mats (Rédei *et al*. 2003). In the UK Champion (1871) reported ***Rhacognathus punctatus*** (7-9 mm; Figure 68-Figure 69) among mosses in heath (Figure 70) and ***Zicrona caerulea*** (5-7 mm; Figure 71-Figure 72) as a common bug among mosses on the chalk downs (Figure 73). ***Sciocoris cursitans*** (4.5-6 mm; Figure 27) dominated the epigeic **Hemiptera** at the coastal gray dunes in Latvia (Spungis 2005) and demonstrated a significant positive correlation with the amount of moss-lichen cover. This family seems to prefer mosses for cover in relatively exposed and dry habitats. Despite the statement by Rédei *et al*. (2003) that they occur in great numbers in moss mats, there seems to be little published about the role of these relationships.

Figure 68. ***Rhacognathus punctatus*** nymph, a species that lives among mosses in heath in the UK. Photo by Tristan Bantock, with permission.

Figure 69. ***Rhacognathus punctatus*** adult, a moss dweller. Photo by James K. Lindsey, with permission.

Figure 70. Heathland where one might find ***Rhacognathus punctatus*** among mosses. Photo by James K. Lindsey, with permission.

Figure 71. ***Zicrona caerulea*** early instar, a moss inhabitant. Photo by Tristan Bantock, with permission.

Figure 72. ***Zicrona caerulea*** adult, a common bug among mosses in UK chalk grasslands. Photo from <www.entomart.be>, through Creative Commons.

Figure 73. Chalk downs at Chanctonbury Hill Chalk Pits, UK, hone to ***Zicrona caerulea*** among mosses. Photo by Malcolm Oakley, with permission.

Berytidae – Stilt Bugs

The **Berytidae** are comprised of about 100 species (Encyclopædia Britannica 2015). They are delicate looking, with slender bodies, and despite their long legs they are slow moving. They are somewhat larger (5-9 mm) than most moss dwellers, but their brown color helps them to blend somewhat with at least some mosses. All members of the family are plant feeders and they sometimes damage crop plants. A few are known moss dwellers.

Berytinus signoreti (4.5-6 mm; Figure 74-Figure 75), ***Berytinus minor*** (Figure 76), and ***Neides tipularius*** (10-11.5 mm; Figure 77) are all moss dwellers in the UK (Champion 1871). Woodroffe (1959) reported ***Berytinus signoreti*** occurring under the flower *Lotus corniculatus*, but also noted "scattered individuals" among mosses. ***Berytinus minor*** is common among mosses and grass roots in the UK (Douglas & Scott 1865). In Dorset, England, members of ***Cymus*** (2.5-5 mm; Figure 78-Figure 79) live in meadows and heathlands on rushes, but in winter this genus overwinters under moss or bark (Recording Dorset 2011).

Figure 74. ***Berytinus signoreti***, a moss dweller in the UK. Photo by Tristan Bantock, with permission.

Figure 75. ***Berytinus signoreti*** adult, a moss dweller. Photo by Tristan Bantock, with permission.

Figure 76. ***Berytinus minor***, a moss dweller in the UK. Photo by Miroslav Deml, through Creative Commons.

Figure 77. ***Neides tipularius***, a moss dweller in the UK. Note the long legs. Photo by Tristan Bantock, with permission.

Figure 78. ***Cymus glandicolor*** nymph, a moss dweller. Photo by Tristan Bantock, with permission.

Figure 79. ***Cymus glandicolor***, a species that overwinters under mosses or bark. Photo by Tristan Bantock, with permission.

Lygaeidae – Seed Bugs and Milkweed Bugs

Most of the members of this family are ill-suited for living among bryophytes. They typically feed on seeds, but some are predatory, some feed on sap, and some feed on blood (TrekNature 2011). They often exhibit bright colors (Figure 80) and are too large to move easily among most kinds of mosses.

Figure 80. ***Lygaeus creticus*** on ***Atrichum***, exhibiting a size and sharp color contrast that does not make this a safe environment. Photo by Dragiša Savić, with permission.

In Eastern Europe, Kment *et al*. (2013a) found ***Melanocoryphus albomaculatus*** (7-9.5 mm; Figure 13-Figure 14), a colorful bug, under lichens, mosses, dry leaves, and stones. They preferred sunny rocky hillsides and clearings. Perhaps its red and black warning colors are enough to scare away would-be predators, or it simply isn't seen when under the moss. ***Taphropeltus hamulatus*** (2.9-3.4 mm; Figure 81) lives in well-drained base-rich sites, particularly among the mosses in areas with loose rocks (Alexander 2008). At least its colors are less conspicuous. ***Lamproplax picea*** (4.0-5.0 mm; Figure 82) is a moss dweller in the UK and has similar dark coloration (Hallett 1916).

Figure 81. ***Taphropeltus hamulatus***, a moss dweller in well-drained, base-rich sites. Photo by Tristan Bantock, with permission.

Figure 82. ***Lamproplax picea***, a moss dweller in the UK. Photo by Joe Botting, with permission.

Piesmatidae – Ash-Grey Leaf Bugs

This is a small family of plant-eating bugs. Using the Berlese funnel to extract bugs from various substrata, Rédei *et al*. (2003) found that ***Piesma maculatum*** (2-3 mm; Figure 83) preferred to live among mosses on tree trunks, ground, and other substrata. Alexander (2008) likewise found it in moss litter in the UK. I have not found any other records for this family among bryophytes.

Figure 83. ***Piesma maculatum***, a species that "prefers" living among mosses. Photo by Joe Botting, with permission.

Rhyparochromidae – Seed Bugs

I discovered a record of this family by accident as I was searching for harvestman pictures. Naturalist Graeme Lyons (2011) of Sussex, UK, reported "beating" a clump of ***Thuidium tamariscinum*** (Figure 84) to find invertebrates. With this activity, he was able to add a new species of **Hemiptera** to his list of finds: ***Peritrechus nubilus*** (5-6 mm; Figure 85). In New Zealand, this family occurs among mosses in the forest (Figure 86).

Figure 84. ***Thuidium tamariscinum*** with capsules, home to ***Peritrechus nubilus***. Photo by Michael Lüth, with permission.

Figure 85. ***Peritrechus nubilus***, a species found in the moss ***Thuidium tamariscinum***. Photo by Tristan Bantock, with permission.

Figure 86. **Rhyparochromidae** habitat under moss in Arthur's Pass, NZ. Photo by Marie-Claude Lariviére, with permission.

Early reports of bryophyte dwellers in this family date as far back as 1871 (Champion 1871). A species of ***Peritrechus lundii*** (4-5 mm; Figure 87) along with two ***Drymus*** (Figure 97-Figure 98) species, ***Trapezonotus arenarius*** (4-4.5 mm; Figure 88-Figure 89), and ***Stygnocoris sabulosus*** (2.5-3 mm; Figure 90-Figure 91), were most common among mosses in alder (*Alnus*) woods.

Figure 87. ***Peritrechus lundii***, a moss dweller. Photo by Tristan Bantock, with permission.

Figure 88. ***Trapezonotus arenarius*** nymph, a common species among UK mosses in alder woods. Photo by Tristan Bantock, with permission.

Figure 89. ***Trapezonotus arenarius*** adult, a common species among alder woods in the UK. Photo by Tristan Bantock, with permission.

Figure 90. ***Stygnocoris sabulosus***, a moss dweller. Photo by Tristan Bantock, with permission.

Figure 91. ***Stygnocoris sabulosus*** adult at Crowle Moors, UK. Photo by Brian Eversham, with permission.

Alexander (2008) reported that ***Trapezonotus desertus*** (4-5 mm; Figure 92) nymphs occurred among dry mosses and lichens. ***Peritrechus geniculatus*** (5-6 mm; Figure 93-Figure 94) is also known from mosses and leaves on light sandy and chalky soils in Dorset, England (Alexander 2008; Recording Dorset 2011). This species overwinters as an adult, protected by the mosses. ***Eremocoris abietus*** (6-7.5 mm; Figure 95) and ***Stygnocoris rusticus*** (3-4 mm; Figure 96) likewise occur among mosses elsewhere in the UK (Champion 1871).

Figure 92. ***Trapezonotus desertus***, a species whose nymphs live among dry mosses and lichens. Photo by Tristan Bantock, with permission.

Figure 93. ***Peritrechus geniculatus*** nymph, an inhabitant of mosses and leaves on light sandy and chalky soils in the UK. Photo by Tristan Bantock, with permission.

Figure 94. ***Peritrechus geniculatus*** adult, a species that spends time among mosses in the UK. Photo by Tristan Bantock, with permission.

Figure 95. ***Eremocoris abietis***, a moss dweller in Europe. Photo by R. Altenkamp, Berlin, through Creative Commons.

Figure 96. ***Stygnocoris rusticus***, a species that lives among mosses in the UK. Photo by Tristan Bantock, with permission.

Drymus sylvaticus (Figure 97), ***D. brunneus*** (Figure 98), ***Stygnocoris sabulosus*** in a UK study occurred primarily among mosses in the alder woods. ***Canthophorus dubius*** (**Cynidae**; Figure 65) was more rare, overwintering among mosses under junipers of the chalk downs, a habitat where ***Zicrona coerulea*** (**Pentatomidae**; Figure 71-Figure 72) was common. ***Drymus brunneus*** (4-5 mm) occurs among mosses in damp, shady places; it is widespread and common (Stenhouse 2007) despite preferring damper soils than other species of ***Drymus*** (Alexander 2008). ***Drymus sylvaticus*** (4-5 mm) is one of the most common of the British ground bugs, often occurring among mosses on dry soil (Alexander 2008; Bury Wildlife 2014). This species becomes active at night, feeding on mosses and fungal hyphae (Southwood & Leston 1959; Alexander 2008). Champion (1871) reported both of these species from mosses near Cheviot Hills, UK. *Recording Dorset* (2011) reports ***D. sylvaticus*** as common, occurring in most dry habitats that have mosses. In the UK, the rare ***Drymus pilicornis*** (3.9 mm) lives mostly in moss clumps among grasses on calcareous or base-rich grassland (Alexander (2008). In France, the rare ***Drymus pilipes*** (~2 mm) lives among mosses and litter (Péricart 1999).

Figure 97. ***Drymus sylvaticus*** adult, a moss dweller on dry soil in the UK. Photo by Tristan Bantock, with permission.

Figure 98. ***Drymus brunneus***, a moss dweller in damp, shady places in Europe. Photo by Tristan Bantock, with permission.

Pterotmetus staphyliniformis (5-5.5 mm; Figure 99) is a rare species in the UK, living on moss-covered boulders on cliffs (Alexander 2008). Both ***Megalonotus praetextatus*** (4-5 mm; Figure 100) and ***M. sabulicola*** (4.5-5.5 mm; Figure 101) live in dry areas, the former where it is warm and sunny, especially in dunes and quarries, but it also lives on cliffs with mosses on partly vegetated ledges and gentle slopes. ***Megalonotus sabulicola*** is mainly coastal and is a ground-dwelling species that is most easily found among mosses. ***Megalonotus chiragra*** attaches its eggs to moss stems (Southwood & Leston 1959; Gerson 1982).

Figure 99. ***Pterotmetus staphyliniformis***, a rare species that lives on moss-covered boulders on cliffs. Photo by Gernot Kunz, with permission.

Figure 100. ***Megalonotus praetextatus***, a species that lives on cliffs with mosses on partly vegetated ledges and gentle slopes. Photo by Tristan Bantock, with permission.

Figure 101. ***Megalonotus sabulicola***, a coastal species found most easily among mosses. Photo by Tristan Bantock, with permission.

The *Recording Dorset* (2011) website notes that the tiny ***Tropistethus holosericus*** (2mm) (Figure 102) lives among the low vegetation and mosses over sand and chalk, overwintering there as adults.

Figure 102. ***Tropistethus holosericus***, a species of low vegetation and mosses. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission.

Rédei *et al*. (2003) found this family "in great numbers" in moss mats in Hungary. Abundant species included ***Plinthisus pusillus*** (1.8 mm; Figure 103) and ***Rhyparochromus vulgaris*** (7-8 mm; Figure 104). Adult members of **Rhyparochromidae** preferred mosses on tree trunks, ground, and other substrata. The seed eaters in this family search mostly on the ground, where they live among the mosses. In Hungary Rédei *et al*. (2003) found that **Stygnocorini** young nymphs (a tribe in the **Rhyparochromidae**) preferred moss mats on rocks. Other members of the family **Rhyparochromidae** seemed to prefer mosses on tree trunks, ground, and other surfaces. Within these, humidity conditions typically determined the preference.

Figure 103. ***Plinthisus pusillus***, an abundant species in moss mats in Hungary. Photo from Zoologische Staatssammlung Muenchen, SNSB, through Creative Commons.

Figure 104. ***Rhyparochromus vulgaris*** on moss, an abundant species there in Hungary. Photo by Tristan Bantock, with permission.

In Dorset, England, one can find ***Scolopostethus puberulus*** (4 mm; Figure 105) among mosses that reside with taller vegetation, especially at cliff bases and in marshy places (Champion 1871; Recording Dorset 2011). Alexander (2008) likewise found this species in damp, mossy places. The adults hibernate in mosses (Champion 1871). Other moss-dwelling members of this genus include overwintering ***S. thomsoni*** (3.5-4 mm; Figure 106) and commonly ***S. affinis*** (3.5-4.5 mm; Figure 107) (Torre-Bueon 1917).

Figure 105. ***Scolopostethus puberulus***, an inhabitant of mosses at cliff bases and other mossy places. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission.

Figure 106. ***Scolopostethus thomsoni***, a species that overwinters among mosses. Photo by Tom Murray, through Creative Commons.

Figure 107. ***Scolopostethus affinis***, a common species among mosses. Photo by Tristan Bantock, with permission.

Englund (2003) found several new species of **Rhyparochromidae** in the Austral Islands. These were mostly located by fogging mosses in the rata (*Metrosideros*) forest (Figure 108). Englund commented that his habitat had been largely overlooked.

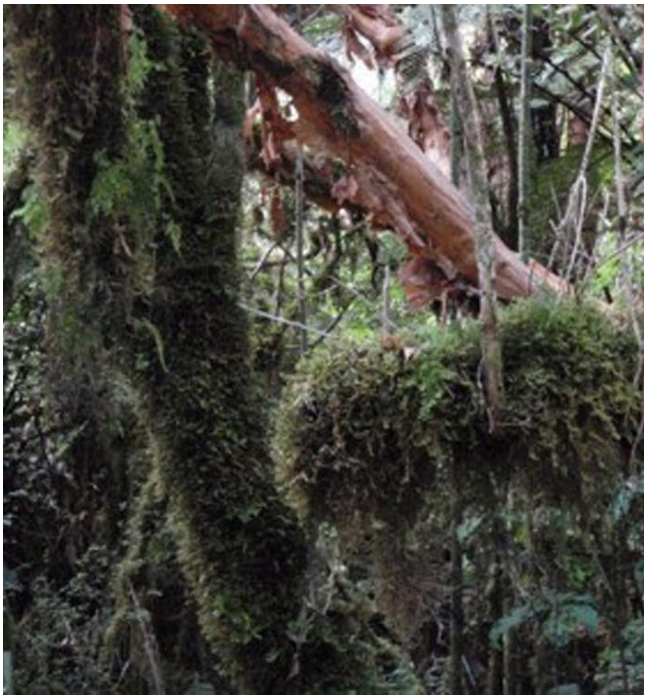

Figure 108. Rata (*Metrosideros*) forest near stream, home for Austral **Rhyparochromidae** in mosses. Photo by Marie-Claude Larivière, with permission.

Scutelleridae – Jewel Bugs

The **Scutelleridae** are rarely reported from mosses. Alexander (2008) reported the coastal species ***Odontoscelis lineola*** (4-5 mm; Figure 109), a warmth-loving species, on fairly stable sandy substrates, often with growth of mosses. This species is an active burrower. But the mosses may simply have been indicative of the habitat.

Figure 109. ***Odontoscelis lineola***, a burrowing species that often occurs with mosses in coastal regions. Photo by Tristan Bantock, with permission.

CIMICOMORPHA – BED BUGS, BAT BUGS, ASSASSIN BUGS, AND PIRATE BUGS

Anthocoridae – Minute Pirate Bugs or Flower Bugs

These are predaceous bugs that suck fluids from their prey by cutting a hole in the prey, injecting enzymes, and drinking the contents (Wikipedia 2016). In Hungary Rédei *et al*. (2003) found the **Anthocoridae** (among others) represented in great numbers in moss mats by using Berlese funnel extraction, but it is possible he was referring to those previous members of the family treated herein as **Microphysidae**.

Nevertheless, ***Anthocoris nemorum*** (3-4 mm; Figure 110) builds a **hibernaculum** (winter shelter for dormant animal) in sheltered places under bark, in leaf litter, or among mosses (Hill 1957). ***Temnostethus pusillus*** (2.5-3.1 mm; Figure 111) often occurs on branches and trunks that are overgrown with mosses (Graff 2015). Fauvel (1999) suggests that mosses and lichens on trees may help members of the **Anthocoridae** to colonize that habitat.

Figure 110. ***Anthocoris nemorum***, a species that uses mosses for its winter hibernaculum. Photo by Joe Botting, with permission.

Figure 111. ***Temnostethus pusillus***, a species that lives on branches and tree trunks overgrown with mosses. Photo by Tuomo Vainio, through Creative Commons.

Microphysidae – Minute Bladder Bugs

This is a family of tiny insects (0.5-2.4 mm long) that emit a repugnant liquid to defend themselves (Watson & Dallwitz 2003). The family **Microphysidae** (Figure 112-Figure 113) finds its food among the bryophytes (Howe 2004). They feed on booklice, aphids, and other small creatures under bark and among those lichens and mosses growing on trees.

Figure 112. ***Loricula*** sp. female, member of the family **Microphysidae**. This predominately terrestrial family feeds on organisms living among mosses. Photo by Sarefo, through Creative Commons.

Figure 113. ***Loricula*** sp. male, a predator on moss-dwelling organisms. Photo by Sarefo, through Creative Commons.

Loricula ruficeps (lichen bugs) (1.5-1.6 mm; see Figure 112-Figure 113) in Hungary is numerous in moss mats (Rédei *et al*. 2003). ***Myrmedobia exilis*** (3 mm; Figure 19) lives among mosses on tree trunks, ground, and other substrata. It is often associated with ***Polytrichum commune*** (Figure 138) or ***Rhytidiadelphus triquetrus*** (Figure 114) (EOL 2015). The good news is that it is a predator on ***Adelges*** (see **Adelgidae** in next sub-chapter on Hemiptera). Nymphs of ***Myrmedobia exilis*** live among mosses in open clearings on acid or sandy soils, but the adult females move to conifers to feed on aphids (Alexander 2008). ***Myrmedobia coleoptrata*** (0.5 mm; Figure 115) usually grows beneath the bark of various trees, especially *Picea*, but it occasionally occurs in tufts of mosses at the tree base (Alexander 2008), as well as being associated with ***Rhytidiadelphus triquetrus*** and ***Polytrichum commune*** (EOL 2015). Douglas (1861) considered it a rare species that lives with ants. Moisture is important in determining which species occur in which locations (Rédei *et al*. 2003).

Figure 114. ***Rhytidiadelphus triquetrus***, one of the homes of ***Myrmedobia exilis*** and ***M. coleoptrata***. Photo by Janice Glime.

Figure 115. ***Myrmedobia coleoptrata*** with moss, a species that occasionally lives among mosses at tree bases. Photo by Rob Ryan, with permission.

Nabidae – Damsel Bugs

In Hungary Rédei *et al*. (2003) found the **Nabidae** (among others) represented in great numbers in moss mats by using Berlese funnel extraction. The **Nabidae** were mostly 5-10 mm long. ***Nabis ferus*** (8-8.5 mm; Figure 116) lives on mossy outcrops in the relict dry acid grassland of the UK (Alexander 2008).

Figure 116. ***Nabis ferus***, a species living on mossy outcrops in dry acid grasslands in Europe. Photo by Joe Botting, with permission.

Miridae – Jumping Tree Bugs

Wheeler (2001) stated that mosses have been undocumented hosts for **Miridae** until recently. Using the Berlese funnel method, Rédei *et al*. (2003) found the **Miridae** (among others) represented in great numbers in moss mats. Humidity was important in determining locations and substrata.

Spungis (2005) found this family to have high population densities in the coastal grey dunes (Figure 25) of Latvia, dominating over grass-dwelling **Hemiptera**. These habitats suggest that these hemipterans may do best in somewhat dry habitats, but that they require the protective cover of mosses to survive there.

The predominantly North American genus ***Bothynotus*** (Figure 117) is relatively small (2.4-4.7 mm), typically brown, and densely pilose (Henry 1979), making it somewhat inconspicuous on soil or among mosses. Mosses may serve as the main habitat for the predatory ***Bothynotus pilosus*** (Figure 117) in Great Britain (Southwood & Leston 1959; Wheeler 2001). Bedwell (1930) found this species among ***Sphagnum*** and other mosses in Scotland. Later, Scudder (1995) found that it has a Nearctic distribution as well, occurring on the ground (probably among mosses) in the Yukon and British Columbia, Canada, and now it is known in China (Qi & Huo 2007). Henry (1979) considered that its association with conifers may actually be an association with the mosses that grow there, with few collectors actually finding them on the conifers. Nevertheless, the importance of bryophytes to this genus remains unknown, but ground level trapping records suggest that mosses may be an important habitat for it.

Figure 117. ***Bothynotus pilosus***, a ground dweller that might live among mosses. Photo by Petri Parkko, through Creative Commons.

In another study in Great Britain, ***Plagiognathus chrysanthemi*** (Figure 118-Figure 120) and ***Amblytylus delicatus*** (see Figure 121) occurred among mosses (Woodroffe 1959).

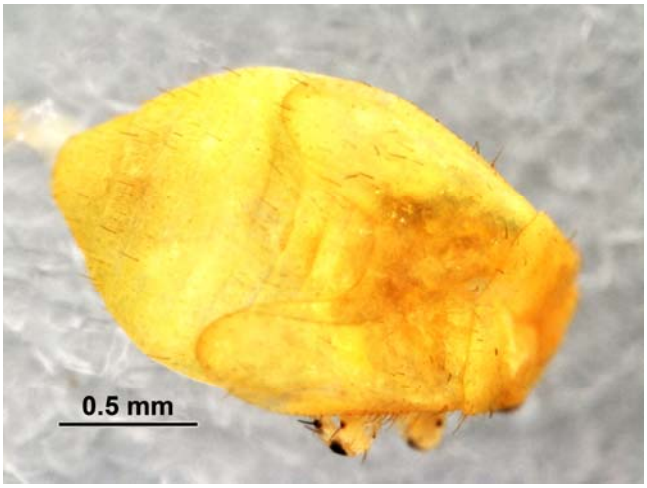

Figure 118. ***Plagiognathus chrysanthemi*** nymph, a moss dweller. Photo from BIO Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

Figure 119. ***Plagiognathus chrysanthemi*** adult, a moss dweller in Great Britain. Photo from BIO Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

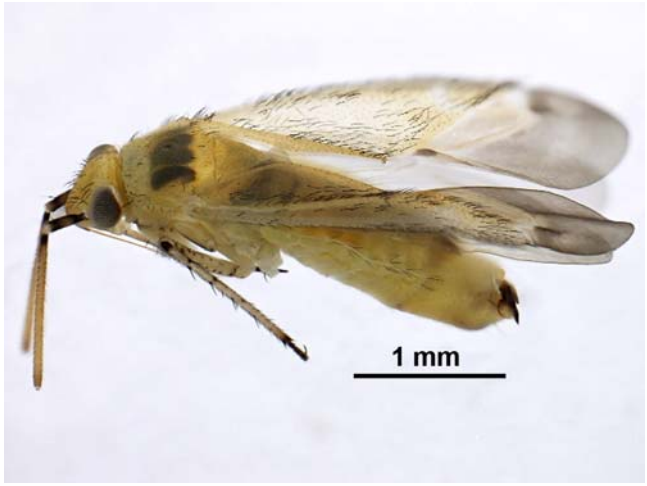

Figure 120. ***Plagiognathus chrysanthemi*** adult, a moss dweller in Great Britain. Photo from BIO Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

Figure 121. *Amblytylus nasutus* adult; ***A. delicatus*** is a moss dweller in Great Britain. Photo by Ruth Ahlburg, with permission.

In Hawaii, the endemic species ***Kamehameha lunalilo*** (Figure 122) occurs on the mosses and ferns that cover trunks and branches of a number of tree species (Zimmerman 1948). Few of the moss dwellers have long legs and antennae like this species.

Figure 122. ***Kamehameha lunalilo***, a moss dweller in Hawaii. Photo from American Museum of Natural History, through Public Domain.

Pseudoclerada (Figure 123), an endemic genus with only two species currently, is another Hawaiian **Miridae** (Asquith 1997). This genus lives in mid-elevation wet gulches and mid- to high-elevation mesic to wet forests. The species are usually solitary and live among the mosses covering tree branches.

Figure 123. ***Pseudoclerada kilaueae***, a moss dweller on tree branches. Photo from American Museum of Natural History, through Public Domain.

Tingidae – Lace Bugs

This is a family of small to mid-sized bugs (2-10 mm) with lacy wings. The **Tingidae** are primarily associated with flowering plants, but ***Acalypta*** (Figure 124-Figure 125, Figure 133-Figure 136, Figure 139, Figure 146, Figure 149) is most frequently collected from mosses (Froeschner 1976). In fact, it appears that mosses offer an alternative habitat housing a number of species.

The evolutionary history of ***Acalypta*** (Figure 124-Figure 125, Figure 133-Figure 136, Figure 139, Figure 146, Figure 149) is reflected in its occasional use of seed plants (Froeschner 1976). This seems to occur most commonly when the mosses are not in a favorable condition for lace bug development. Predictably, the genus is absent in the dry desert and plains states of the United States, but its absence along the Mississippi River is more difficult to explain. Its **brachypterous** (short) wings and recent geological history of the Mississippi flood plain may account for its continued absence there – it is dispersal limited.

Many species in ***Acalypta*** (Figure 124-Figure 125, Figure 133-Figure 136, Figure 139, Figure 146, Figure 149) live among the bryophytes (Michael Münch pers. comm. 30 October 2014). The bryophyte-dwelling members of the genus are tiny (~2 mm long) and have short (brachypterous) wings (British Bugs 2011). Some species, such as the widespread ***Acalypta parvula*** (~2 mm; Figure 124-Figure 125) (Hallett 1916), also have frequent macropterous (large or normal winged) forms. This species, the smallest of the ***Acalypta*** species, is common in the UK among short mosses, especially where soils are dry. It overwinters as an adult.

Figure 124. ***Acalypta parvula*** on moss in Germany. Photo by Michael Münch <www.insekten-sachsen.de> through GBIF, with permission.

Figure 125. ***Acalypta parvula*** amid mosses and soil. Photo by Tristan Bantock, with permission.

In the United Kingdom, five species of ***Acalypta*** feed on both capsules and vegetative parts of mosses (Howe 2004). Bailey (1951) likewise observed members of ***Acalypta*** feeding on the capsules of ***Climacium*** (Figure 126-Figure 128) after the calyptra had fallen.

Figure 126. ***Climacium dendroides*** individuals, a species whose capsules and leaves are eaten by ***Acalypta***. Photo by Michael Lüth, with permission.

Figure 127. ***Climacium dendroides***; the capsules and leaves serve as food for ***Acalypta***. Photo by Janice Glime.

Figure 128. Capsules of ***Climacium americanum*** that have shed their calyptrae and are suitable food for species of ***Acalypta***. Photo by Janice Glime.

The substrate under the moss helps to determine which ***Acalypta*** species will occur there (Rédei *et al*. 2003). ***Acalypta musci*** (2.5-2.8 mm; Figure 7) prefers mosses on stones and rocks, along with most nymphs in the ***Acalypta*** genus. In addition to living among ***Abietinella abietina*** (Figure 6), often a rock dweller, ***A. musci*** also lives on typical soil moss species such as ***Plagiomnium cuspidatum*** (Figure 129) and ***P. undulatum*** (Figure 130) (Roshko 1969; Putshkov 1974; Rédei *et al*. 2004), and frequently occurs among mosses growing at the bases of trees (Singer 1952; Jordan 1963; Wagner 1967; Rédei *et al*. 2004). In the Bükk Mountains of Hungary, Varga (1992) found ***Acalypta musci*** and ***A. gracilis*** (Figure 28) living among the protected subalpine moss species ***Plagiobryum zieri*** (Figure 131) and ***Saelania glaucescens*** (Figure 132). Nearby road traffic polluted these mosses with lead, causing a poor bryofauna, and those invertebrates living there, including the two ***Acalypta*** species, contained high concentrations of lead. ***Acalypta gracilis flaventis*** occurs in the eastern and central Palaearctic among mosses under *Ephedra* (Golub 1998). Whereas its typical habitat is among mosses, ***Acalypta*** can also occur on fungi growing on tree trunks (Rédei *et al*. 2004).

Figure 129. ***Plagiomnium cuspidatum***, home for ***Acalypta musci***. Photo by Michael Lüth, with permission.

Figure 130. ***Plagiomnium undulatum***, home for ***Acalypta musci***. Photo by Michael Lüth, with permission.

Figure 131. ***Plagiobryum zierii***, mountain home for ***Acalypta musci*** and ***A. gracilis***. Photo by Michael Lüth, with permission.

Figure 132. ***Saelania glaucescens***, mountain home for ***Acalypta musci*** and ***A. gracilis***. Photo by Michael Lüth, with permission.

Tree trunk mosses, ground, and other surfaces are preferred by ***Acalypta carinata*** (2.5 mm; Figure 5) and ***A. platycheila*** (Figure 133). ***Acalypta carinata*** occurs among ***Sphagnum*** (Figure 37), but also can be found in the drier habitat of the moss ***Abietinella abietina*** (Figure 6) in Hungary (Rédei *et al.* 2004). In southeast England, Kondorosy *et al*. (2010) found ***Acalypta platycheila*** feeding on mosses in apple orchards (Figure 134). The typical habitat of this species is humid, shady woodland.

Figure 133. ***Acalypta platycheila***, a tree-trunk moss dweller. Photo by Boris Loboda, with permission.

Figure 134. Apple orchards at Leavenheath, UK. Photo by Jonathan Billinger, through Creative Commons.

Moss mats house numerous ***Acalypta marginata*** (Figure 31) in Eurosiberia and ***A. platycheila*** (Figure 133) in Hungary (Rédei *et al*. 2003). ***Acalypta marginata*** occurs in mosses such as ***Rhytidiadelphus*** sp. (Figure 135) as well as among tracheophytes (Roshko 1969; Rédei *et al.* 2004). In these habitats it occurs throughout the year, oviposits in the mosses and litter, and overwinters as adults or older larvae (Putshkov 1974; Rédei *et al.* 2004). ***Acalypta platycheila*** and ***A. carinata*** (Figure 5) also live among mosses in the *Dryopteridi-Alnetum* (ferns and alders) (Rédei *et al.* 2004), but Alexander (2008) considered them to have a preference for mosses on rotting logs in the UK. ***Acalypta brunnea*** is most likely to occur among mosses at tree bases or on decaying stumps (Alexander 2008). These substrate preferences of both the mosses and the species of ***Acalypta*** can be explained by differences in humidity.

Figure 135. ***Rhytidiadelphus loreus***, home to ***Acalypta marginata***. Photo by David T. Holyoak, with permission.

In Scotland, Corbet (2006) reported ***Acalypta nigrina*** (Figure 136) among mosses. Moss form may play a role in the choice of habitat by some hemipterans, but for ***Acalypta nigrina*** the selected mosses have diverse forms, including the horizontal-growing (**pleurocarpous**) ***Hylocomium splendens*** (Figure 137) and upright (**acrocarpous**)

Polytrichum sp. (Figure 138) among its Hungarian habitats (Rédei *et al*. 2004). However, both moss species form deep "mats" that provide a relatively wide moisture and light range that would permit the lace bug to seek the most suitable humidity level and temperature.

Figure 136. ***Acalypta nigrina***, a moss dweller in Scotland. Photo by Johannes Skaftason, with permission.

Figure 137. ***Hylocomium splendens***, one of the diverse forms of mosses inhabited by ***Acalypta nigrina***. Photo by Michael Lüth, with permission.

Figure 138. ***Polytrichum commune***, showing upright growth form, one of the forms occupied by ***Acalypta nigrina*** (Figure 136). Photo by Bob Klips, with permission.

Acalypta saundersi (Figure 139) does seem to have a moss form preference, selecting loose-growing bryophyte forms on fallen logs (Lattin 1997). It lives only in old-growth western USA coniferous forests and its flightlessness, like that of other members of the genus, seems to correlate with its requirement for old growth (Lattin & Moldenke 1990), probably due to limited dispersal that causes a long colonization time. To find the lace bugs in this habitat, Lattin (1997) suggests gathering quantities of mosses and using a Tullgren funnel with heat and light to drive the bugs out of the moss. Sadly, this method is highly destructive if one wants to make a quantitative study and some slow-moving taxa simply die in place.

Figure 139. ***Acalypta saundersi***, a species among loose-growing mosses on logs. Photo by BIO Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

In Hungary, Rédei *et al*. (2004) found only ***A. marginata*** (Figure 31) and ***A. gracilis*** (Figure 28) among the mosses of Kiskunság National Park, both in great numbers. ***Acalypta gracilis*** occurs in typical boreal forest mosses such as ***Pleurozium schreberi*** (Figure 140) and ***Ptilium crista-castrensis*** (Figure 141), as well as in the dry habitat of exposed sites among ***Syntrichia ruralis*** (Figure 142-Figure 143) (Péricart & Golub 1996).

Figure 140. ***Pleurozium schreberi*** on sand, home in the boreal forest for ***Acalypta gracilis***. Photo by Janice Glime.

Figure 141. ***Ptilium crista-castrensis***, home for ***Acalypta gracilis*** in the boreal forest. Photo by Li Zhang, with permission.

Figure 142. ***Syntrichia ruralis*** dry, home for ***Acalypta gracilis***. Photo by Janice Glime.

Figure 143. ***Syntrichia ruralis*** wet, home for ***Acalypta gracilis***. Photo by Janice Glime.

Although most of the species of ***Acalypta*** occur in relatively moist habitats, in the Upper Columbia River Basin, western North America, ***Acalypta cooleyi*** (Figure 144) lives at the bases of sagebrush (Figure 145) and other shrubs (Lattin 1995). There it finds refuge among the mosses, which it also eats.

Figure 144. ***Acalypta cooleyi***, a species that finds refuge among mosses and eats them in sagebrush habitats. Photo by Bio Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

Figure 145. Sagebrush and moss, home for ***Acalypta cooleyi*** in western North America. Photo courtesy of Roger Rosentreter.

Acalypta barberi (1-2 mm; Figure 146) and ***A. saundersi*** (Figure 139) both feed and breed among the mosses (Drake & Lattin 1963). Interestingly, ***A. barberi*** feeds on mosses until they dry up. Then it shifts to hops (*Humulus lupulus*). Both adults and nymphs of ***A. barberi*** occurred on ***Eurhynchium oreganum*** (Figure 147) in Oregon and Washington, USA (Russell 1979). In the lab it subsisted for several weeks on this species. This widespread lace bug caused a shipment of nursery stock from Japan to be halted at quarantine in New York because of the danger of importing it among the mosses and introducing it where it can damage crops (Drake & Lattin 1963). In Arkansas, ***A. susanae*** (1.9 mm) was described as a new species from a log where it lived with mosses and slime molds (Allen *et al*. 1988). This species also eats mosses.

Figure 146. ***Acalypta barberi***, a species that feeds on and breeds among mosses. Photo by Gary Griswold, with permission.

Figure 147. ***Eurhynchium oreganum***, home and food for ***Acalypta barberi***. Photo by Matt Goff, with permission.

Bryophytes are often used as packing material for house plants and garden plants. Froeschner (1991) suggested that the new species ***Acalypta laurae*** (2 mm) was almost introduced to the United States from Mexico in the mosses used for packing the house plant *Tillandsia inoantha* (Figure 148).

Figure 148. *Tillandsia ionantha*, a species that is packed in mosses for shipment. These mosses could introduce ***Acalypta laurae*** from Mexico to the US. Photo by Cliff, through Creative Commons.

Wheeler and Reeves (2004) searched for members of ***Acalypta*** in the southeastern United States. In North Carolina they found one nymph and one adult of ***Acalypta duryi*** (Figure 149) associated with the moss ***Dicranum scoparium*** (an acrocarpous moss; Figure 150). In Tennessee they found both nymphs and one adult of this species associated with ***Hylocomiastrum umbratum*** (a pleurocarpous moss; Figure 151) and adults from ***Anomodon rostratus*** (a pleurocarpous moss; Figure 152). ***Acalypta lillianis*** (~2.2 mm; Figure 153) occurred with ***Polytrichum commune*** (acrocarpous; Figure 138) and ***P. juniperinum*** (Figure 154) in the southeastern states, including new records for Alabama and South Carolina. Bailey (1951) observed ***A. lillianis*** feeding on mosses. These tiny insects are hard to find and require destructive collecting techniques to be thorough. Both ***Acalypta lillianis*** and ***A. mera*** are bryophagous in northwestern USA.

Figure 149. ***Acalypta duryi***, a species that has been found among several moss species in the southeastern United States. Photo by Nancy Lowe, through Discover Life.

Figure 150. ***Dicranum scoparium*** (acrocarpous), one of the several moss species where ***Acalypta duryi*** lives. Photo by Janice Glime.

Figure 151. ***Hylocomiastrum umbratum*** (pleurocarpous), one of the several moss species where ***Acalypta duryi*** lives. Photo by Michael Lüth, with permission.

Figure 152. ***Anomodon rostratus***, one of the several moss species where ***Acalypta duryi*** lives. Photo by Bob Klips, with permission.

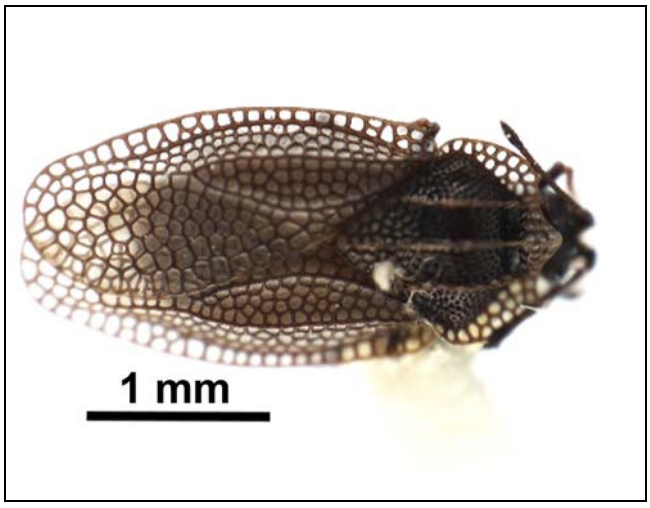

Figure 153. ***Acalypta lillianis***, a moss-eating species in northern North America. Photo by Bio Photography Group, Biodiversity Institute of Ontario, through Creative Commons.

Figure 154. ***Polytrichum juniperinum***, one of the several moss species where ***Acalypta lillianis*** lives. Photo by Janice Glime.

But other genera of **Tingidae** do occur among mosses. Alexander (2008) described the habitat of ***Campylosteira verna*** (Figure 155) in the UK as one among mosses on hot, dry slopes, usually in calcareous grassland. ***Campylosteira*** and ***Acalypta*** (Figure 124-Figure 125, Figure 133-Figure 136, Figure 139, Figure 146, Figure 149) are **phytophagous** (plant-eating) bugs and subsist mostly on moss mats or stems of various herbaceous plants (Rédei *et al*. 2003). In their Hungarian study, Rédei *et al*. (2003) found more ***Acalypta*** species on mosses than on any other substrate. But for ***Campylosteira verna***, only 16.2% were collected on moss, whereas 61.6% were collected among leaf litter. Based on their studies in Hungary, Redei *et al.* considered members of ***Acalypta*** to be **muscicolous** (growing best among mosses). The other **Tingidae** genera found among mosses seem to have wider preferences.

Figure 155. ***Campylosteira verna***, a species that lives among mosses and elsewhere in hot, dry, calcareous grassland in the UK, often eating the mosses. Photo by Boris Loboda, with permission.

In West Virginia, USA, Torres-Miller (1995) found a different representative of this family. She was able to extract ***Leptoypha mutica*** (2.7-3.0 mm; Figure 156-Figure 157) from mosses with a Berlese funnel. ***Derephysia foliacea*** (foliaceous lace bug) (3-3.5 mm; Figure 158) hibernates as adults among mosses in the Ukraine

(Putshkov 1974; Lattin 2009). Thomas (1938) found that the uncommon species ***Catoplatus fabricii*** (3.8-4.5 mm; Figure 159) was located more easily among mosses, where it could even be abundant; Woodroffe (1959) reaffirmed that it was most frequently collected among mosses.

Figure 156. ***Leptoypha mutica*** nymph, a moss dweller in West Virginia, USA. Photo by Claude Pilon, with permission.

Figure 157. ***Leptoypha mutica*** adult, a moss dweller in West Virginia, USA. Photo by Tom Murray, through Creative Commons.

Figure 158. ***Derephysia foliacea***, a foliaceous lace bug that hibernates among mosses in winter in the Ukraine. Photo by Tristan Bantock, with permission.

Drake and Buhoff (1959) reported a moss-feeding member of the **Tingidae** from Mexico. Lis (2000b) recently described ***Paraphatnomella tamasi*** (2.35 mm) as a new genus and species from India, likewise a moss dweller.

Figure 159. ***Catoplatus fabricii*** adult, a species found mostly among mosses in Great Britain. Photo by Boris Loboda, with permission.

Cantacaderidae

This family is a segregate of the **Tingidae**. And like some **Tingidae**, some members of **Cantacaderidae** are bryophyte eaters. Moir and Brennan (2007) point out that the more primitive bug families like these two feed on fungi, lichens, mosses, and underground roots. In Australia, ***Carldrakeana tingalei*** feeds on mosses and lichens (Hacker 1928). More recently, Lis (2000a) described a new Australian species, ***C. pallida*** (2.04-2.52 mm), also a moss feeder.

Reduviidae

There's always one! A beetle, a lizard, a mantid, and now a bug! These are all animals that cultivate bryophytes on their exterior. These are not just idle passengers using free transportation. The bryophytes actually grow on these animals. But unlike the other bryophyte gardeners, nymphs of ***Reduvius personatus*** (masked bug; Figure 160) actually place soil and various objects, sometimes including bryophytes (Figure 160), on their bodies as camouflage (Harz 1952; Weirauch 2006). Members of the genus ***Reduvius*** are only 9-14 mm in length (Wygodzinsky & Usinger 1964), so the kinds of plants that can grow on them are limited to those no bigger than bryophytes – small bryophytes.

Figure 160. ***Reduvius personatus*** with liverwort and insect camouflage. Photo compliments of Kurt (Hock Ping Guek) <orionmystery.blogspot.com>.

Reduvius personatus (Figure 160) builds two layers of camouflage. The first layer is made from soil, often called a **dust coat** (Brandt & Mahsberg 2002) or **natural camouflaging** (Figure 161) (Ambrose 1999). This was originally thought to be a product of dust in the habitat, but instead it is accumulated by an active process of kicking it there with the hind legs (Weber 1930; Immel 1955), using the **tarsal fan** (Weirauch 2006). This dust layer is present in all the reduviids that use this form of camouflage.

Figure 161. ***Reduvius personatus*** nymph with only the first layer of cover, the dust coat. Note the flatness typical of the nymph in spring. Photo by Whitney Cranshaw, through Creative Commons.

The second layer is more variable among the individuals. It typically contains coarser particles, including such objects as corpses of insects the reduviid nymph has eaten (Figure 161). This habit has earned this layer the name of **corpse camouflaging** (Ambrose 1999) or **backpack** (Brandt & Mahsberg 2002). It is this layer that sometimes has bryophytes in it (Figure 161). The question remains whether these bryophytes were placed there deliberately, or if they arrived as spores or fragments and grew there. I have seen pictures with protonemata growing on the soil layer. This entire camouflage apparatus must be replaced each time the insect molts. Nevertheless, I have seen pictures of liverworts with branches fully developed. Javahery (2013) reported that third instars were dormant during the first winter and the fifth instar was dormant during the second winter, with the life cycle being completed in two years. With the right climate and timing, this could permit the observed growth from a spore.

Reduvius personatus has multiple means of holding the soil particles there. Short setae help trap the dust and hold the first layer in place (Weirauch 2006). There are short-projection trichomes and long-projection trichomes that help to hold the outer layer. At least in some species, short-projection trichomes appear to be responsible for the fastening of the camouflaging layer close to the integument, whereas long-projection trichomes may hold the outer layer of camouflaging material in place. Both short-projection trichomes and long-projection trichomes, as well as grouped trichomes, secrete a sticky substance that helps to affix such items as smooth-bodied insect carcasses (Weirauch 2006; Javahery 2013).

The nymph becomes engorged before entering winter dormancy and does not eat during the entire winter (Readio 1931). By the time warm weather returns, the body is thin and flat (Figure 161). Nevertheless, it has enough energy remaining to once again eat and be active. This dormancy behavior appears to be due to a biological clock and is not altered when the insect is maintained over winter in a warm environment with a supply of its normal food.

Other members of the **Reduviidae** in West Africa likewise adorn themselves with soil and the "backpack" materials. ***Paredocla*** and ***Acanthaspis*** (Figure 162) species add larger objects to the second layer, including prey corpses and plant parts (Brandt & Mahsberg 2002). In these species, the dust covering masks the chemical and tactile cues that are recognized by the worker ants that they often eat, making it easier for the reduviid nymphs to hunt. On the other hand, the second layer, the backpack, seems to play only a minor role in deterring the ants from approaching and being caught.

The predators on West African ***Paredocla*** and ***Acanthaspis*** (Figure 162) species include spiders, geckos, and centipedes (Brandt & Mahsberg 2002). In experiments using these three predators, the bug nymphs were more likely to survive with full camouflage than were the ones denuded of their covering. Not only did the backpack layer confuse the visually oriented predators, it also could be shed to distract the enemy while the reduviid nymph ran away, working much like the detached lizard's tail. In a different set of experiments in East Africa, Jackson and Pollard (2007) demonstrated that three species of the spider family **Salticidae** (*Hyllus* sp., *Plexippus* sp., and *Thyene* sp.) responded as predators to the naked ***Acanthaspis petax*** (Figure 162) (back packs removed) significantly more often than they responded to the masked bugs.

Figure 162. ***Acanthaspis petax*** nymph with ant carcass camouflage. This one is also eating an ant. Photo by Orionmystery, through Wikimedia Creative Commons.

DIPSOCOMORPHA

Dipsocoridae

Cryptostemma (Figure 20) in Hungary seems to prefer living among mosses on tree trunks, ground, and other surfaces (Rédei *et al*. 2003).

Ceratocombidae

Rédei *et al*. (2003) used Berlese funnels to assess the **epigeic** (ground-living) Hemiptera in Hungary. The

Ceratocombidae are not common among mosses, with only one species represented. ***Ceratocombus coleoptratus*** (1.5-2 mm; Figure 21) prefers mosses on tree trunks, ground, and other substrata as well as mosses in swampy meadows (Alexander 2008; Münch 2012). Edwards (1874) considered it to be rare in Norfolk, UK.

Ceratocombus vagans (3.8-4.5; Figure 163) is predaceous, eating such small arthropods as oribatid mites and springtails that frequently occur among bryophytes (Lattin 1997). In northern Michigan, USA, it lays its eggs at the end of the summer, inserting them into the tissues of ***Sphagnum*** (Figure 37) with its well-developed ovipositor.

Figure 163. ***Ceratocombus vagans*** nymph, a species that preys on small organisms among bryophytes and lays its eggs among ***Sphagnum***. Photo by Jim McClarin, with permission.

Schizopteridae – Jumping Soil Bugs

This is a relatively small, mostly tropical family, but it has bryophyte dwellers among its species. Members of the family are suitable for moss-dwelling by their small size (0.5-2 mm). They eat small invertebrates, so bryophytes should provide suitable hunting grounds.

In New Zealand, ***Hypselosoma acantheen*** (Figure 164) lives mostly in forests among litter and mosses (Hill 1999). In New Caledonia, one can find ***Hypselosoma rembaiensis***, another recently described species, among mosses (Hill 2013). In Australia, new species of ***Kaimon*** were described from mosses (***K. polysperes***, ***K. thorntonensis***, ***K. webbensis***) (Hill 2004).

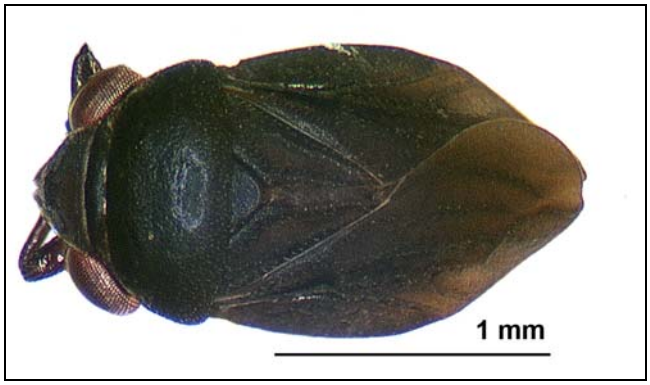

Figure 164. ***Hypselosoma acantheen***, an inhabitant of forest mosses and litter. Photo by Marie-Claude Lariviere, through Landare Research, with permission.

India likewise has newly discovered moss dwellers in this family. Rédei (2008) described ***Kikeshia stysi*** from sifted mosses in West Bengal.

GERROMORPHA – SEMIAQUATIC BUGS OR SHORE-INHABITING BUGS

Mesoveliidae – Water Treaders

Although most of these species live on floating plants, some live in forest leaf litter and damp moss (DiTerlizzi 2004).

Gerridae

"Aquatic insects" are only aquatic for part of their lives, so many of the species discussed earlier as aquatic insects may also appear here as terrestrial insects. Among the amphibious species is ***Gerris lacustris*** (Figure 165). It skates on the water and does not live among mosses in the water, but when it hibernates it may seek out the protection and moisture of terrestrial mosses near its pond (Butler 1886).

Figure 165. ***Gerris lacustris*** adult in its aquatic, surface-dwelling stage. It may seek mosses on land to spend the winter. Photo by Jakub Rom, through EOL Public Domain.

NEPOMORPHA

Aphelocheiridae

I found only one record of this family associated with mosses. Alexander (2008) reported ***Aphelocheirus aestivalis*** (8.5-10.5 mm; Figure 166) among the UK fauna, living where there is overhanging vegetation or on moss-covered rocks.

Figure 166. ***Aphelocheirus aestivalis***, a species one can find on moss-covered rocks. Photo by Niels Sloth, with permission.

Summary

Several orders of insects have been lumped into the current order **Hemiptera**. The suborder **Heteroptera** contains those members that were traditionally **Hemiptera**. Among these are a number of moss dwellers. The Hemiptera have a life cycle of egg – nymph – adult.

Some members of **Hemiptera** use bryophytes as a habitat, an egg-laying site, a food source, an overwintering site, and a hunting site. Most of the faithful species are tiny but seem to lack any special resemblance to bryophytes. They benefit from the moisture and protection while often finding food there among algae, slime molds, fungi, bryophyte leaves, and invertebrate fauna.

The most common habitats of moss dwellers include forest floor and epiphytic bryophytes, sand dunes, streamside and other wet mosses, and peatlands. Some aquatic bugs leave the water to spend the winter under mosses.

The most primitive **Hemiptera** are typically moss dwellers, especially the **Tingidae** and closely related families. Members of the genus ***Acalypta*** are typically moss dwellers, eat mosses, and have many species among mosses. Many of the species have limited distribution.

The **Miridae** most likely have bryophyte dwellers that are yet to be discovered, with evidence suggested by ground traps. In some parts of the world, **Rhyparochromidae** are common among mosses. A number of families have lesser representation than those just mentioned.

Some members of the **Reduviidae** include bryophytes among the camouflage items they carry on their backs. Such "back packs" are known to discourage would-be predators.

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