CHAPTER 12-5
TERRESTRIAL INSECTS:
HEMIMETABOLA – NOTOPTERA
AND PSOCOPTERA

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Figure 1. Example of Mantophasmatodea, a subgroup of the Notoptera. Photo by Michael F. Schönitzer through Creative Commons.

NOTOPTERA

The order Notoptera perhaps deserves its own chapter simply because the smallest chapter is appropriate for the smallest order (<30 species) of insects (Ando & Machida 1987). But alas, for practical reasons, I have included the Psocoptera here as well, a much larger order but rare among bryophytes. The order Notoptera is poorly known and has limited, but widespread, distribution. Nevertheless, it is important in our understanding of insect evolution (Vrsansky et al. 2001). And mosses seem to play a role for at least some of their lives.

The order Notoptera is relict (survived from an earlier time period) (Vrsansky et al. 2001; Schoville & Kim 2011) and in addition to the two living families, it is known from fossils in middle Eocene (Lutetian) Baltic amber (Arillo & Engel 2006) and the Lower Permian (Aristov 2004), suggesting that it has been widespread in time and space. The living Notoptera are known only from Canada (Walker 1914), western United States (Caudell & King 1924; Kamp 1963, 1970), Russia (Bey-Bienko 1951; Kevan 1979), Korea (Storozhenko & Park 2002; Kim & Lee 2007), China (Wang 1987), and northern Japan (Schoville 2010). Genetic isolation in parts of Asia may have resulted from geologic events in which islands fragmented and collided, causing mountain uplifts in Japan (Schoville et al. 2013). The remaining taxa appear to be a "poorly dispersing, cold-adapted terrestrial insect lineage" that occupies Japan, Korea, and Russia. The island fragmentation events have created a number of endemic species. In the western US, several Grylloblattidae and Gryllacrididae returned to the devastated Mt. St. Helens within three years after its eruption in 1980 (Sugg & Edwards 1998), suggestion that it has some means of dispersal.

The order Notoptera was named in 1915 but was largely overlooked (Wikipedia 2016a). More recently, it was somewhat resurrected and joined with the Grylloblattodea, placing both of them in the order Notoptera.

These insects resemble mantids, but never have wings (Ando & Machida 1987). They live under stones and in
caves in the alpine areas (Schoville & Kim 2011). They are well adapted to cold conditions (Pritchard & Scholefield 1978; Kevan 1979; Jarvis & Whiting 2006). Many retreat deep below the surface to escape surface temperatures ranging -35 to +45°C (Kevan 1979).

**Grylloblattodea – Ice Crawlers**

The Grylloblattodea are predominately nocturnal and feed on detritus (Wikipedia 2015). They are wingless and have either reduced eyes or no eyes (Figure 2). There is only one family and it is comprised of only 5 genera and 34 species that live mostly in leaf litter and under stones of extremely cold environments of higher elevations.

![Figure 2. Member of Grylloblattidae on snow, a small family that may lay eggs in mosses. Photo by Alex Wild through Creative Commons.](image)

When temperatures are cold enough for ice crystals to form in the body, the Grylloblattidae retreat under the snow pack near the soil (Grimaldi & Engel 2005). They feed mostly on arthropod carcasses, but if these are insufficient they rely on plant material (Wikipedia 2015). At least one member deposits its eggs among mosses (Richards & Davies 1977).

**Grylloblattidae – Ice Crawlers**

The North American ice crawlers are known for their adaptations to cold, whereas the Asian members are the most diverse (Jarvis 2005; Jarvis & Whiting 2006). They are rarely encountered, but this may be due to their seclusive habit of going underground or hiding among mosses. Bai et al. (2010) suggested that they lost their wings and became adapted to living under rocks or hidden in mosses in cold areas.

Most members of this family are carrion feeders, but they will also eat plant material, fungi, and detritus (Bai et al. 2010).

The modern (extant) members of this family are 14-34 mm long, pale, wingless, and avoid light (nocturnal or living in caves) (Bai et al. 2010).

**Galloisiana**

Galloisiana nipponensis (Figure 3) was first described by Caudell and King in 1924 from Japan. This was the introduction of a new genus and new family, the Grylloblattidae. This species occurs on the ground under stones and in moss (Memim Encyclopedia 2015). To date, no eggs have been found among mosses in G. nipponensis (Rentz & Ingrisch 2009).

![Figure 3. Galloisiana nipponensis, an extant member of the Notoptera in northern Japan. Photo by Obsidian Soul through Creative Commons, with modified background.](image)

Three quarters of a century later, Galloisiana olgae is a recently described species occurring in a small area on the banks of the Vasilkovka River in southeastern Russia (Vrsansky et al. 2001). The genus has also spread to Korea (Schoville & Kim 2011) and China (Wang 1987). It inhabits wet soil and is found under rocks that are covered with mosses. This raises an interesting question. What is the importance of the mosses on those rocks. I venture a guess. This and all members of the order are omnivores, often feeding on carcasses of other arthropods (Wikipedia 2015). Rocks with mosses provide easy access for these wingless insects to hunt for food among the mosses at night (or whenever they feed).

**Grylloblatta**

In North America, 13 species of Grylloblatta (Figure 4) have been described, but Schoville and Graening (2013) considered that another 16 are awaiting description and publication. Its known distribution in western North America (Caudell & King 1924) includes California, USA (Caudell 1923; Schoville & Roderick 2010; Schoville 2012), to British Columbia, Canada (Gregson 1938; Kamp 1979; Huggard & Klenner 2003). This is a genus with high endemism and small species ranges.

Bai et al. (2010) considered temperature to be the primary limiting factors in their distributions. This does not bode well for them in the face of global warming. A species of Grylloblatta (Figure 4) on Mt. Rainier, Washington, USA, is active on the snow in summer, where it forages at night (Edwards 1982). But they have behavioral strategies that enable them to avoid freezing, as seen in this Grylloblatta. This species lacks the usual means to survive freezing (cryoprotectants, supercooling) and dies at a mere -6.5°C (Edwards 1987). On the other hand, it experiences heat convulsions at temperatures of 14°C. Morrissey and Edwards (1979) similarly found that the Mt. Rainier species suffers lethal heat convulsions at 15-20°C and speculated that unsaturated fatty acids might be important in their low-temperature adaptations. Could it
be that arachidonic acid, a polyunsaturated fatty acid in
mosses, might contribute to this cold tolerance? Neverthe-
less, it migrates downward to overwinter among the
rocks under deep snow where it is assured of
temperatures above its -6.5°C lethal temperature (Edwards
1987). Henson (1957) was able to maintain nymphs of
Grylloblatta campodeiformis (Figure 4) at 4.5°C for six
months.

Members of Grylloblatta (Figure 4) possess sensilla
(McIver & Sutcliffe 1982), a series of branched hairs
protected by cuticle near the tip of the mandibles. Baker
(1982) suggests they may be used to sense the pressure
being exerted on the mandible tips, perhaps avoiding
damage to the muscles.

Grylloblattella

Grylloblattella cheni was described as the second
species in this genus, occurring in China (Bai et al. 2010).
It is known from only one specimen, collected in the
primary boreal coniferous forest near a lake. It was under
the bark of a log near the summer snow line. This and
other extant species have a shorter meso- and metathorax
than prothorax, the opposite of the fossil species where the
prothorax is shorter. They suggest this may be due to the
loss of wings in the extant species.

PSOCOPTERA – Booklice, Barklice, Barkflies

This order is considered the most primitive of
hemipteroids (Wikipedia 2016b). These are small
insects(1-10 mm long). The barklice are harmless to
the trees where they live, eating mostly algae and lichens.
Their small size apparently makes scraping their food
somewhat hazardous; their chewing mandibles are
accompanied by a slender rod modified from the central
lobe of the maxilla. This modified rod is used to brace
them while they scrape their food with their mandibles.
Some can spin silk, covering large areas of the bark (Hoell
et al. 1998).

Most of the Psocoptera feed on detritus, epiphytes,
fungi, and some on leaves (Baz 2008). They have a thin
cuticle and thus are susceptible to desiccation. They
are able to take up moisture from the atmosphere and obtain
some of their water from food, but rarely by drinking.

Bryopsocus (Bryopsocidae) is associated with trees
and mosses in wet forests (New & Lienhard 2007). This
genus is endemic to New Zealand. Only two species occur
there, both associated with mosses: Bryopsocus angulatus
and B. townsendi, ranging 2-3 mm long (Bess & Johnson
2009). Likewise in New Zealand, Echmepteryx
madagascariensis (Lepidopsocidae; Figure 5) lives on
mosses that grow on the horizontal trunks of Metrosideros
(Figure 6) (Smithers 1973). Smithers (1974) also collected
Spilopsocus avius (Elipsocidae) from mosses in the
subAntarctic islands of New Zealand.
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Figure 6. *Metrosideros umbellata* (rata) showing horizontal trunks with mosses where one might find *Echmepteryx madagascariensis*. Photo by John Barkla, with permission.

Evidence of members of *Psocoptera* eating bryophytes is limited. Valle *et al.* (1977) reported one that feeds on mosses and lichens growing on citrus in Cuba.

Lucking (2000) pointed out that the *Psocoptera* are among the insects that feed on epiphyllous bryophytes, as well as other organisms (algae, fungi, lichens) that grow on the leaves. Unlike the *Lepidoptera* feeding there, the *Psocoptera* are generalists, eating whatever is available on the leaf. They typically lay their eggs on the lower leaf surfaces. The young juveniles are protected by their mothers. Lucking concluded that although they did considerable damage to the leaf habitat, they positively influenced the diversity of the lichen and bryophyte community.

Schmidt and New (2008) recorded other *Psocoptera* in association with mosses in Tasmania. *Lepinotus patruelis* (*Trogiidae*; Figure 7) was among mosses on a log; *Liposcelis* (*Liposcelidae*; Figure 8) occurs among mosses on logs and living trees.

Some members of this order are known from mossy forests, but the role of the mosses is unclear. García Aldrete (2009) reported several species from this habitat in Argentina: *Polypsocus jujuyensis*, *Polypsocus selenius* (*Amphisocidae*), *Lachesilla dividiproctus*, *Lachesilla peckorum*, and *Lachesilla cuala* (*Lachesillidae*). On the other hand, Thornton (1985) found that the numbers and diversity of *Psocoptera* decreased on mountain tops with wet conditions and epiphytic mosses in many areas of the Pacific.

Some *Psocoptera* are restricted to caves. The neotenous (retaining juvenile characteristics in adults) *Cyptophania pakaratii* (Figure 9) seems to be limited to the fern-moss "gardens" in the cave entrances (Figure 10) in the Pacific basin (Mockford & Wynne 2013). These habitats serve as relict habitats of the last glacial maximum, supporting species that are restricted to the conditions they offer (Benedict 1979; Northup & Welbourn 1997; Wynne 2013; Wynne *et al.* 2014).

Figure 7. *Lepinotus patruelis*, a moss dweller on logs and trees in Tasmania. Photo from <www.aphotofauna.com>, with permission.

Figure 8. *Liposcelis* sp. hiding under bark. Photo by Peter J. Bryant, with permission.

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Figure 9. *Cyptophania pakaratii*, a species apparently restricted to the fern-moss patches in cave entrances. Photo by Jut Wynne, with permission.
Figure 10. Relict fern-moss garden in cave at Rapa Nui National Park, Easter Island, Chile. Photo by Jut Wynne, with permission.

Summary

The Notoptera is a small order of relict insects, due in part to absence of wings and dispersal limitations. The Grylloblattodea (ice crawlers) are mostly nocturnal detritus feeders. Some can use mosses for oviposition. Members of Grylloblattidae may live under mosses in cold regions. Grylloblatta campodeiformis is often associated with mossy old-growth forests and deposits her eggs on the mosses.

Few species of Psocoptera are moss inhabitants, but their small size permits some of them to live there. The genus Bryopsocus is known only from mossy habitats in New Zealand. Some may feed on bryophytes, including epiphyllous bryophytes. Some are restricted to cave entrances where they live among mosses and ferns.

Acknowledgments

Thank you to Wikipedia as a free source of basic information on so many taxa. Those who have placed their images in the public domain or given me permission have made this chapter more interesting for the readers.

Literature Cited


