CHAPTER 11-8
AQUATIC INSECTS: HOLOMETABOLA – NEUROPTERA AND MEGALOPTERA

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Figure 1. ***Nigronia serricornis*** larva (**Megaloptera**), a species that sometimes pupates in mosses. Photo by Jason Neuswanger, with permission.

HOLOMETABOLA

The **holometabolous** insects are those with a complete life cycle – egg/embryo > larva > pupa > adult. These insects typically spend only part of the life cycle in the water. Some lay their eggs near water and larvae develop in the water. Some have eggs, larvae, and pupae in the water, but their emerging adults break through the water surface and climb onto land to emerge. For most, adult life and mating occur on land.

NEUROPTERA – Net-winged Insects

Neuroptera literally means nerve wings, so-named because of the prominent wing veins of the adults. This order is not well represented among bryophytes, and only the larvae are associated with aquatic habitats.

Osmylidae

On continents other than North America a small family, the **Osmylidae** (Figure 2-Figure 6), occurs among mosses and organic matter in and near streams (Flint 1977). ***Osmylus fulvicephalus*** (Figure 2) is the only species known in the UK, likewise living among mosses of streambanks (Elliott *et al*. 1996) and seeking food there (NatureSpot 2015). The adults (Figure 3; 25 mm long including wings) don't stray far from water but are not aquatic. The females lay their eggs on overhanging plants, tree trunks, or stones (Osmylidae 2014), and especially on mosses (Elliott *et al*. 1996) near water, laying about 30 eggs either singly or in pairs. Larvae leave the egg site within 1-3 days to burrow into mosses. Larvae may live in or out of water, but pupation is on land, lasting 7-18 days. If the larvae are submersed, they crawl out of the water (Ward 1965). If the moss is submersed, they burrow deeply into it, but within 8-28 days of submersion they die. Adults live two weeks to three months, depending on species and location.

Figure 2. ***Osmylus fulvicephalus*** larva, a species that lives among mosses on streambanks and feeds there. Photo by Walter Pfliegler, with permission.

Figure 3. ***Osmylus fulvicephalus*** adult that lays its eggs on overhanging vegetation. Larvae live among streambank mosses. Photo through Creative Commons.

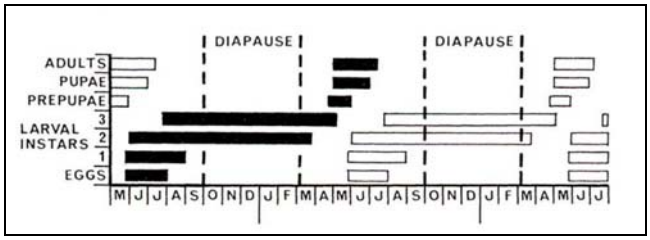

Figure 4. Phenological events (cyclic and seasonal natural phenomena, especially in relation to climate) of the life cycle of ***Osmylus fulvicephalus***. From Elliott *et al*. 1996.

Osmylus fulvicephalus (Figure 3) is controversial in that its larvae live in wet mosses, but drown in 8-28 days of submersion (Elliott *et al*. 1996). Nevertheless, they do enter the water in search of food. It seems safe to say, however, that their relationship with mosses is damp, but not aquatic. The larva feeds among these mosses. When movement is detected, it jabs at it with the long proboscis, then injects it with a salivary secretion that paralyzes it. A chironomid larva is paralyzed within 10 seconds. The ***O. fulvicephalus*** then sucks out the interior of the prey. The larvae stop eating during mid autumn and burrow down to the moss rhizoids to hibernate for the winter. Fortunately, in this state they can survive occasional submersion in water, thus surviving **spates** (sudden flood in a river, especially one caused by heavy rains or melting snow). In spring they spin a silken cocoon, sometimes incorporating bits of moss in the cocoon. Just before pupation the long jaws break off (Figure 5). The pupa becomes immobile during pupation. It grows a pair of mandibles that it uses to cut its way out of the cocoon.

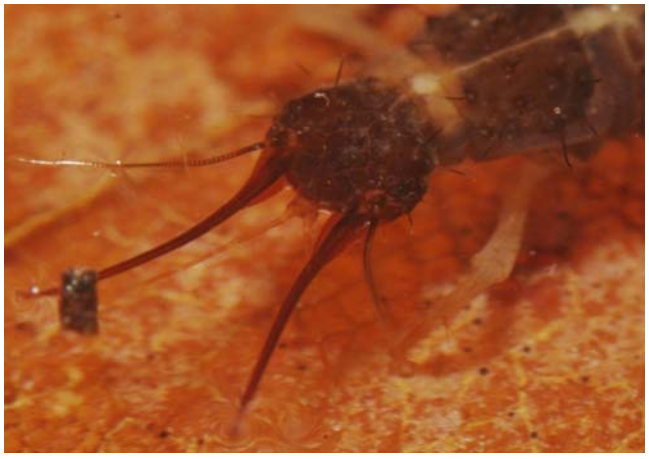

Figure 5. ***Osmylus fulvicephalus*** larva showing large jaws. Photo by Walter Pfliegler, with permission.

Like ***Osmylus fulvicephalus*** (Figure 2-Figure 5), ***Kempynus*** sp. (Figure 6) in the Southern Alps of New Zealand is somewhat amphibious, living at the edge between water and land (Cowie & Winterbourn 1979). In springbrooks it lives in clumps of the mosses ***Acrophyllum quadrifarium*** (=*Pterygophyllum quadrifarium*; Figure 7) and ***Cratoneuropsis relaxa*** (Figure 8).

Figure 6. ***Kempynus*** sp larva, member of the small family **Osmylidae** that inhabits mosses near streams. Photo by Stephen Moore, Landcare Research NZ, with permission.

Figure 7. ***Pterygophyllum quadrifarium***, a moss habitat for ***Kempynus*** sp. at stream borders and in springbrooks in New Zealand. Photo by Bill and Nancy Malcolm, with permission.

Figure 8. ***Cratoneuropsis relaxa***, a moss habitat for ***Kempynus*** sp. at stream borders and in springbrooks in New Zealand. Photo by Tom Thekathyil, with permission.

Chrysopidae

There are a number of reports of the larvae of the green lacewing ***Leucochrysa pavida*** (Figure 9-Figure 12) using bits of lichen as camouflage (Tauber *et al.* 2009; Moskowitz & Golden 2012). In fact, Wilson and Methven (1997) found that the larvae at their Illinois, USA, site were somewhat specific in the species of lichens they chose. But Slocum and Lawrey (1976) found that this insect was not totally specific. In addition to the lichens, it also includes pieces of bark, angiosperm pollen, fungal spores, insect debris, and (of course) bryophyte gametophytes. Slocum and Lawrey demonstrated that the lichens, at least, are still alive and that they have photosynthetic rates equal or greater than those same lichen species still growing on a bark substrate. Furthermore, these lichen propagules are still viable when the cocoons are attached to the bark, giving the lichens the opportunity and establish in this new location. Unfortunately, there are no similar studies on the bryophytes in this camouflage arrangement, but it at least provides the possibility for a means of dispersal.

Figure 9. ***Leucochrysa pavida*** larva with lichen back pack, showing its camouflage against tree bark lichens. Photo by Jim McCormac, with permission.

Figure 10. ***Leucochrysa pavida*** larva with lichen back pack, showing the legs and mandibles of the larva. Photo by Jim McCormac, with permission.

Figure 11. ***Leucochrysa pavida*** larva showing ventral side. Photo by Jim McCormac, with permission.

Figure 12. ***Leucochrysa pavida*** larva showing head and large mandibles of this carnivore. Photo by Jim McCormac, with permission.

MEGALOPTERA – Dobsonflies and Alderflies

Megaloptera means large wing; one adult is known with a wingspan of 21 cm, the largest of any aquatic insect in the world (Megaloptera 2014). The order is relatively small, and is close to the **Neuroptera**. Its members have

aquatic larvae, but they pupate on land in damp soil or under logs. The pupae are fully mobile and can defend themselves against predators with their large mandibles. Female adults lay 1000's of eggs on overhanging vegetation where larvae can drop into the water (Figure 13). The adults often live only a few hours and usually don't eat.

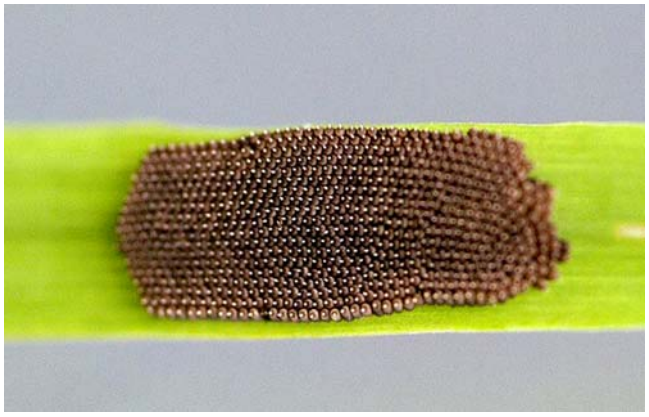

Figure 13. ***Sialis fuliginosa*** eggs. Photo by James K. Lindsey, with permission.

Sialidae – Alderflies

This is a small family that can be up to 25 mm long (Alderfly 2014). They occur sparsely worldwide with a concentration of known species in Europe (Sialidae 2015).

I have only found reference to one genus of bryophyte dwellers, ***Sialis*** (Figure 13-Figure 17) (Lithner *et al*. 1995). I likewise found this genus occasionally among bryophytes in Appalachian Mountain, USA, streams (Glime 1968). It has aquatic larvae, but adults are terrestrial and lay eggs near water (Alderfly 2014). Fully grown larvae of ***Sialis*** pupate in soil, mosses, under stones, and other locations, usually near water. In Canada, after about one month the adults appear. ***Sialis nigripes*** prefers mosses for egg laying (Elliott *et al*. 1996). ***Sialis lutaria*** (Figure 15-Figure 17) was used in a study comparing heavy metal accumulation in mosses (***Fontinalis*** spp.; **Error! Reference source not found.**), insects, and fish (Lithner *et al*. 1995).

Figure 14. ***Sialis*** adult, a genus that sometimes pupates and lays eggs among streamside bryophytes. Photo by Patrick Coin, through Wikimedia Commons.

Figure 15. ***Sialis lutaria*** larva, the aquatic stage that migrates into the water, sometimes from streamside bryophytes. Photo by André Karwath, through Creative Commons.

Figure 16. ***Sialis lutaria*** adult. Photo ©entomart, through Creative Commons.

Figure 17. ***Sialis lutaria*** adults mating. Photo by James K. Lindsey, with permission.

On the South African Cape, pupae of **Sialidae** along streams or waterfalls live in ***Sphagnum*** (Figure 18) and other mosses (Barnard 1931). These pupae require a wet, but not submersed, habitat, so the mosses must be soaking wet.

Figure 18. ***Sphagnum fimbriatum***, a genus that lives in Africa and is a potential home for pupae of **Sialidae**. Photo by Blanka Shaw, with permission.

Figure 19. ***Fontinalis antipyretica***, home to numerous kinds of insects and useful for comparing heavy metal accumulation. Photo by Malcolm Storey, through Creative Commons.

Corydalidae- Dobsonflies and Fishflies

This family occurs mostly in the Northern Hemisphere and in South America, including both temperate and tropics (Corydalidae 2014). Their body size is usually greater than 25 mm and ranges up to 80 mm (Penny *et al*. 1997; Bartlett 2004). The larvae are aquatic, are called hellgrammites, and are predators.

Nigronia, an aquatic member of the **Corydalidae**, is not typically a moss inhabitant, although I did occasionally find larvae of this genus among Appalachian Mountain stream bryophytes (Glime 1968). But like many other aquatic insects, ***Nigronia serricornis*** (Figure 20-Figure 21) pupates among mosses as well as under stones and logs (Needham *et al*. 1901). Likewise, ***Chauliodes pectinocornis*** (Figure 22) and ***C. rastricornis*** (Figure 24-Figure 24) pupate in these habitats. Pupation lasts about 2 weeks in these **Corydalidae**.

Figure 20. ***Nigronia serricornis*** larva showing powerful jaws. The aquatic larva often crawls into mosses to pupate. Photo by Jason Neuswanger, with permission.

Figure 21. ***Nigronia serricornis*** adult. Pupae of this insect often reside in mosses. Photo by Phil Myers, through Creative Commons.

Figure 22. ***Chauliodes pectinicornis*** adult, a species that lives in the water as larvae and pupates among mosses. Photo by Stephen Cresswell, with permission.

Figure 23. ***Chauliodes rastricornis*** larva, a species that may move to mosses to pupate. Photo by Tom Murray, through Creative Commons.

Figure 24. ***Chauliodes rastricornis*** adult, a species that lives in the water as larvae and pupates among mosses. Photo by Stephen Cresswell, with permission.

Summary

The **Holometabola** have a complete life cycle with egg, larva, pupa, and adult.

The **Neuroptera** are represented among aquatic bryophytes by only one family, the **Osmylidae**. The larvae of ***Osmylus*** may live among bryophytes in streams or on streambanks and obtain food there. Some species lay their eggs on mosses that overhang streams. Larvae bore into mosses in or out of the water. ***Kempynus*** species often live among mosses in springbrooks.

The **Megaloptera**, like the **Neuroptera**, have few aquatic bryophyte dwellers. ***Sialis*** (**Sialidae**) larvae occasionally occur among stream bryophytes; the pupae are often among terrestrial mosses. Some species lay eggs among mosses. Wet ***Sphagnum*** along streams or near waterfalls serves as a home for some **Sialidae**. Some members of ***Nigronia*** and ***Chauliodes***, both in the **Corydalidae**, pupate among mosses.

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