

SESSION 5

*Weeds of Aquatic Systems
and Wetlands*

The Herbivorous Insect Fauna of a Submersed Weed, *Hydrilla verticillata* (Alismatales: Hydrocharitaceae)

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Abstract

Although relatively few insects have been reported to feed on submersed aquatic plants, field surveys on *Hydrilla verticillata* (L. F.) Royle for biological control agents have demonstrated that insect herbivores should be expected when surveying submersed aquatic plants in the native ranges. Beetles, or Coleoptera, especially the weevils (Curculionidae), are important herbivores. Weevils attack submersed plant species both when water is present and when water is absent during dry periods which leave the plants exposed. Pupal success appears to be the major determinant of weevil life cycle strategies. Donaciine leaf beetles (Chrysomelidae) attack the roots or crowns of submersed species, but their feeding and damage is difficult to determine. Leaf-mining *Hydrellia* flies (Diptera: Ephydriidae) are diverse and common on submersed species. Other flies, the midges (Chironomidae), are also common on submersed species, but many utilize the plants only for shelter. However, midge larvae ate the apical meristems on the tips of hydrilla stems. Aquatic caterpillars (Lepidoptera: Pyralidae) are the herbivores most easily observed on submersed species because of their large size and conspicuous damage, but their host ranges might be too broad for use as biological control agents. More research is needed on the field biologies of aquatic insect herbivores. Field surveys should be conducted on submersed aquatic weeds even in the absence of literature reports of insect herbivores. Until a reasonable database of herbivores and their host plants is assembled, it is difficult to evaluate the suitability of biological control for a submersed aquatic weed.

Keywords: Biological control, *Bagous*, *Macrolea*, *Hydrellia*, *Parapoynx*, midges

Introduction

Little is known or reported about herbivorous insect faunas associated with submersed aquatic plants. Research on insect feeding on aquatic plants has generally been lacking except for the few aquatic weed biological control programs. Insects do eat aquatic plants (Newman 1991) and more effort must be put into field collections to establish an extensive database. The known insect fauna of *Hydrilla verticillata* (L. F.) Royle, an invasive submersed weed (Langeland 1996), provides an example for potential programs on other submersed weeds. Native to Africa, Asia, Australia, and portions of Europe, hydrilla has quickly spread throughout much of the United States since its introduction into Florida in the 1950's. Initially, nothing was known about the insect fauna associated with the plant. In 1971, the United States Department of Agriculture, Agricultural Research Service, con-

tracted for surveys for natural enemies of hydrilla in India and Pakistan (Center *et al.* 1990). Limited surveys in Malaysia and Africa soon followed. In 1981, the search for insects began throughout the Indo-Pacific range of hydrilla (Balciunas, 1985). In the 1990's, surveys were made in the People's Republic of China, Korea, Japan, Thailand and Vietnam by various researchers.

The surveys in the native range of hydrilla discovered over 25 species of herbivorous insects from 5 orders identified to at least 11 genera. Not all of these species were good candidates for biological control and only 4 were released in the United States. Although the program has not yet been successful, the surveys demonstrated that a fauna existed even though none was reported. It is not unreasonable to expect similar results with other submersed aquatic weed species. The submersed Eurasian watermilfoil, *Myriophyllum spicatum* L., has also been surveyed extensively for possible biological control and has a fauna similar to hydrilla's (Buckingham 1994). Some of the other submersed plant species that are listed as important invasive weeds in various countries are *Aponogeton distachyos* L. f., *Ceratophyllum demersum* L., *Egeria densa* Plach., *Elodea canadensis* Michx., *Hygrophila polysperma* (Roxb.) Anderson, *Lagarosiphon major* Ridley, *Limnophila sessiflora* Bl., *Myriophyllum aquaticum* (Vell.) Verdc., *Najas minor* All., *Potamogeton crispus* L., *P. nodosus* Poir., and *P. pectinatus* L. (Holm *et al.* 1979). We hope that our experience with the hydrilla insect fauna discussed below will stimulate research on many of these other species.

Coleoptera

The most important insect herbivores found on hydrilla were the beetles. Eight species of *Bagous* weevils (Curculionidae) found in 4 different countries have been identified. Two species, *Bagous hydrillae* O'Brien and *B. affinis* Hustache, were released against hydrilla in the United States, but neither appears to have established. The genus *Bagous* includes well over 250 species (Askevold *et al.* 1994), many of which will undoubtedly be found on submersed plants. Various other weevil genera with fewer species also attack submersed aquatic plants. Unidentified donaciine leaf beetle larvae (Chrysomelidae, subfamily Donaciinae) have been found feeding on hydrilla in 2 different countries. Larval herbivory in the Donaciinae has been little studied because of technical difficulties maintaining colonies. Larvae are found attached to roots of submersed plants, but a feeding relationship is often not obvious.

Adults and larvae of the Australian stem-boring weevil, *B. hydrillae*, feed on submersed hydrilla at or near the water surface. Adults do not swim but crawl along the stems underwater. Eggs are laid in the stem, usually at the nodes, and the larvae tunnel in the stem. Both larval and adult feeding severs the stem, which then floats to shore (Balciunas and Purcell 1991). Mature larvae pupate in stranded hydrilla along shore or in the soil beneath the hydrilla. Larvae mature in submersed stems but do not pupate until the hydrilla is exposed on soil. The complete life cycle takes 12-14 d at 25C (Balciunas and Purcell 1991).

J. K. Balciunas first collected *B. hydrillae* in northern Australia during a worldwide survey for biological control agents of hydrilla (Balciunas 1985, Balciunas and Purcell 1991). Heavy feeding by high populations of *B. hydrillae* produced a mowing effect on hydrilla at the water surface. The weevil appeared to be restricted to sites where hydrilla was present, but occasionally adults and larvae were collected from *Vallisneria* and a few other aquatic plants when hydrilla was not available. (Balciunas and Purcell 1991).

Two other species, *B. latepunctatus* Pic and *B. affaber* Faust are similar in general appearance and biology to *B. hydrillae*, although they are good underwater swimmers. They range from the Middle East to Pakistan, India, and Bangladesh (O'Brien and Askevold 1995) with *B. latepunctatus* continuing to Thailand. Neither species is specific to hydrilla.

Adults and larvae of *B. vicinus* Hustache feed on exposed stems of hydrilla in drying water bodies or on pieces of the plant stranded on shore in India and Pakistan (Baloch *et al.* 1980, Buckingham 1994). They do not attack submersed stems as did the preceding species. Larvae bore the stems but pupate in the soil. Large numbers were collected in India (Bennett 1986). It was also reared from *Myriophyllum spicatum* L. in Pakistan (Baloch *et al.* 1972)

Adults of *B. subvittatus* O'Brien and Morimoto and *Bagous* n.sp. feed externally, apparently on stems and leaves of hydrilla stranded on shore, while the larvae of both species tunnel in the stems. We were unable to rear either species in the laboratory on submersed hydrilla plants although we found a few young larvae in submersed stems. We reared them easily on hydrilla in moist cages. Mature larvae exit the stems but those of *B. subvittatus* form cocoons by rolling the leaves together while those of *Bagous* n.sp. pupate in the soil. The range of *B. subvittatus* includes Ryukyu Islands (Japan) (O'Brien *et al.* 1994) and Thailand.

An Indian tuber-feeding weevil *B. affinis* attacks tubers in drying soil. The adults feed on stems at the water surface or along shore and in the laboratory on exposed leaves, stems, turions, and tubers (Bennett and Buckingham 1991). Females oviposited in the laboratory in moist, soft wood, in exposed stems, and in the soil. Larvae burrowed through the soil to find a tuber. Pupation occurs inside the tuber or in the soil when multiple larvae heavily damage the tuber. *Bagous affinis* ranges from Pakistan through India to Thailand (O'Brien and Askevold 1995). At one site in Pakistan, almost 100% of the tubers had been attacked during the dry season by *B. affinis* (Baloch *et al.* 1980).

The biology of another Indian tuber weevil, *B. laevigatus* O'Brien and Pajni, was essentially the same as that of *B. affinis* except that in the laboratory, the larvae fed on tubers of hydrilla but preferentially on tubers of *Potamogeton pectinatus* L. The primary larval host in the field is still unknown (Bennett and Buckingham 1991). Pupation occurs inside the tuber or in the soil. The native range includes India and Pakistan (O'Brien and Askevold 1995).

Donaciine leaf beetle larvae attached to the roots of hydrilla have been collected in China and Vietnam. Little information at this time is known about the identity and biology of these insects and the damage they might cause to hydrilla. In China, hydrilla plants heavily attacked by *Macrolea* sp. were discolored, spindly, and stunted. A European species, *M. (=Haemonia) appendiculata* Panzer, whose larvae bore in the stems of a *Potamogeton* and a *Myriophyllum*, kills heavily damaged stems (Grillas 1988).

DIPTERA

The 2 families of flies found feeding on hydrilla are the shore flies, Ephydriidae and the midges, Chironomidae. Six species of leaf-mining *Hydrellia* shore flies have been identified from 9 countries. Four species of midges have been identified from two countries. Many other midges have been collected from several countries but have not been further identified or their effect on hydrilla has not been determined.

Adults of *Hydrellia pakistanae* Deonier are small, black flies with shiny gold, or

sometimes silver, faces. Eggs, which hatch in 2-3 days, are laid on emergent and floating leaves. Larvae mine 8-12 leaves then move to the base of a leaf, insert their spiracular spines into the stem, and pupate. The spiracular spines allow the pupa to obtain oxygen from the stem. Adults emerge in approximately 2-3 days. The complete life cycle takes 18 to 28 days at 27 C. The native range of *H. pakistanae* extends from Pakistan to northeast China (Deonier 1993). *H. pakistanae* is specific to hydrilla (Buckingham *et al.* 1989) and it was released in Florida in 1987 (Buckingham 1994). It has widely established.

Adults of the Australian *Hydrellia balciunasi* Bock are similar in appearance to *H. pakistanae*. The biology is also similar (Buckingham *et al.* 1991). In Australia, *H. balciunasi* is highly specific to hydrilla (Balciunas and Burrows 1996). It was released in Florida in 1989 (Buckingham 1994).

Three other species in the *pakistanae*-species group are similar in appearance and biology to the preceding species. D. L. Deonier (1993) described *Hydrellia sarahae sarahae* Deonier from northern and eastern China and *H. sarahae laticapsula* Deonier from southern India and northern Pakistan. Krishnaswamy and Chacko (1990) reported on the biology of *H. sarahae sarahae* as *Hydrellia sp.* Larvae of both subspecies feed on hydrilla, however, we collected a few larvae and puparia of *H. sarahae sarahae* on several species of *Potamogeton*. *Hydrellia bogorae* Deonier is described from hydrilla collected in Indonesia (Deonier 1993). The third species, *H. wirthiana* Deonier is a new species from hydrilla in Korea (Deonier 1997).

Four species of **chironomid midges** have been reported feeding on hydrilla in its native range. Larvae of *Polypedilum dewulfi* Goetghebuer and *Polypedilum wittae* (Freeman) eat the apical meristems of hydrilla stems in Africa (Buckingham 1994, Pemberton 1980). The larvae bore holes into the tips and into the stems below the tips, which causes the tips to fall off. Plants are stunted, multi-branched and do not reach the water surface (Pemberton 1980). Little is known about their biologies or host plants in their native range of western Africa from Sudan to South Africa. Sixty-five percent or more of the buds examined by Pemberton (1980) at Lake Tanganyika, Tanzania, was damaged. Buckingham (1994) reported damage to hydrilla in China and Korea similar to that in Africa. The midges found in China are members of the *Cricotopus sylvestris* L.-group and an unidentified *Polypedilum sp.*

Both shore flies and midges can be expected to be found on other submersed plant species and the shore flies should be considered excellent candidates for biological control. Too little is known about midge host ranges to determine their potential at this time.

LEPIDOPTERA

At least 7 species of Lepidoptera have been found feeding on hydrilla in 7 different countries. Adults of the most common species, the case-making caterpillar *Parapoynx diminutalis* (Snellen) (Pylalidae), are small moths with white wings that have black and tan markings. Eggs are laid on leaves and stems at the water surface (Buckingham and Bennett 1996). Larvae are whitish or yellowish with spotted heads and rows of branched gills along both sides of their bodies. Larvae feed on the leaves of hydrilla from a portable tubular case made by tying leaves together with silk. Heavy feeding can defoliate the stems, but usually only stems in the warm water just below the water surface. The native range includes Kenya, South Africa, Pakistan to Southeast Asia, and Australia. *P. diminutalis* is an immigrant in Florida and also in Panama and Honduras (Buckingham 1994). It feeds primarily on hydrilla in its native range, but it has a broad laboratory host range

(Buckingham and Bennett 1989).

Similar species that are also not specific to hydrilla are *P. fluctuosalis* Zeller and *P. crisonalis* (Walker), which is common in China. Unidentified species of *Paraponyx* and some polyphagous species in other genera have been collected in association with hydrilla in Australia and Asia (Balciunas 1985).

Ambia ptolycusalis (Walker) (Pyralidae), *Margarosticha reptitalis* (Warren) (Pyralidae) and *Theila siennata* (Warren) (Pyralidae) are three species of aquatic moths that attack leaves and stems of hydrilla in streams in Australia (Balciunas *et al.* 1989). In their native range in Australia, they have been collected on hydrilla, *Blyxa octandra* (Roxb.) Planchon and *Vallisneria gracilis* F. M. Bailey (Balciunas and Center 1988).

Lepidoptera are the most noticeable insect herbivores on submersed aquatic plants, but most appear to have host ranges too broad for a biological control agent. However, we know very little about the biologies of most aquatic species. It is thus premature to make informed generalizations about their value.

Minor Herbivores

Few other insects are reported in the literature as feeding on hydrilla. Varghese and Singh (1976) reported the waterlily aphid *Rhopalosiphum nymphaeae* (L.) (Homoptera: Aphididae) in association with hydrilla in their holding ponds in Malaysia. *R. nymphaeae* is a cosmopolitan species found on emerged hydrilla leaves and stems at the water surface and on many other species of aquatic plants.

Pemberton, (1980) reported mayfly nymphs, *Povilla adusta* Navas (Ephemeroptera: Polymitaecidae) inside hydrilla stems from Lake Tanganyika, Tanzania.

Several interesting herbivores have been found on hydrilla in the introduced localities. Larvae of a caddisfly, *Nectopsyche tavana* Ross (Trichoptera: Leptoceridae) were reported feeding on hydrilla along with several other aquatic plants in two Florida lakes (Daigle and Haddock 1981). Several nematodes were found on hydrilla in Florida (Gerber *et al.* 1986).

Conclusions

Submersed weeds should be considered potential candidates for biological control. We should not let the lack of success of the hydrilla program prevent efforts on other weed species. Even in the absence of literature records of insect herbivores, field surveys should be conducted with special attention given to weevils and ephydrid shore flies. Not until more programs have been conducted will we be able to judge the potential of biological control of weeds with insects beneath the water surface.

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Footnotes

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