Proc. 3rd Int. Symp. Biol. Control Weeds
Montpellier, France, 1973

INSECTS AND OTHER ORGANISMS ASSOCIATED WITH *HYDRILLA VERTICILLATA* (L. f.) L. C. (HYDROCHARITACEA) IN PAKISTAN

G. M. Baloch and Sana-Ullah*

INTRODUCTION

Hydrilla verticillata (L. f.) L. C. is an aquatic plant with a high reproductive potential and wide ecological tolerance. It reproduces both vegetatively and by seeds. In mud broken stem-pieces or shoots develop into new plants. Plants also produce subterranean shoots with long-lived tubers.

The noxious characteristics of *H. verticillata*, interference with waterflow, boating, fishing, swimming, etc. far outweigh in importance its limited use as an aquarium plant or as manure.

Because of its persistent nature and vegetative reproduction, *H. verticillata* is difficult to suppress by herbicides or other conventional methods. Therefore, work on the possibilities of biocontrol by natural enemies was initiated in early 1971 under a U.S.D.A. P.L. 480 programme and is being continued.

Natural enemies recorded

So far eight insects and two snails have been found in association with the weed. These are: *Bagous* sp., *Bagous* sp. nr. *argillaceus* Gyll., *B.* sp. nr. *argillaceus inceratus* Gyll., *B.* sp. nr. *limosus* (Gyll.), *B.* sp. nr. *lutulosus* Gyll., (Coleop., Curculionidae); *Hydrellia* sp. (Dipt., Ephydridae); *Rhopalosiphum nymphaeae* L. (Hem., Aphididae); *Nymphula diminutalis* Snell. (Lep., Pyralidae); *Limnaea luteola* Lamarck and *Gyraulus convexiusculus* (Hutton) (Mollusca). Of these, only *Hydrellia* sp., *N. diminutalis* and *B.* sp. nr. *limosus* appear to be promising bicontrol agents and, therefore, have been investigated in some detail.

Hydrellia sp.

Hydrellia is a large genus in the family Ephydridae, subfamily Notiphilinae, tribe Hydrelliini. Of the many genera of Ephydridae, only *Hydrellia* and *Lemnaphila*

*Pakistan Station, Commonwealth Institute of Biological Control, Rawalpindi, Pakistan.

are known as leaf-miners. There are about 134 known species in *Hydrellia* which feed mainly in plants of Potamogetonaceae, Alismataceae and Hydrocharitaceae except *Hydrellia griseola* (Fallen) and *H. ischiaca* Loew which attack Graminaceous crops like rice, barley, oats and other grasses (Deonier, 1971).

In Pakistan the genus *Hydrellia* has been reared from the leaves of *Potamogeton indicus* Roxb., *P. perfoliatus* L. and *Vallisneria spiralis* L. in addition to *H. verticillata*. Sankaran and Rao (1972) also recorded it from the weeds *Salvinia* and *Alternanthera* in India. However, it appears that in Pakistan the species mining leaves of *Hydrilla* is distinct from others, though this has not yet been confirmed.

Hydrellia is widely distributed in areas of its host's occurrence. It remains active for most of the year where fresh and tender leaves are available though its activity greatly decreases during November-March in cooler areas. Complete cessation of activity occurs in winter only in those areas where leaves become stiff and new growth is stopped. Deonier (1971) expressed a similar opinion when he remarked that oviposition in *Hydrellia* is restricted to sheltered and eutrophic habitats and that "the newest plant growth is generally most susceptible to infestation and is more severely damaged". Populations start building up in April and the insect remains most active till October.

Accounts of the biology and ecology of *Hydrellia* spp. have been given by Berg (1950 a) and Deonier (1971). In the present studies (23°C $\pm$ 1°) mating commenced shortly after emergence and lasted 2 to 3 minutes. Oviposition started a day after mating and a female laid a maximum of 38 eggs in her life. Eggs were laid singly or in groups of 3 or 4 on either side of floating leaves and hatched in 3-4 days. Larvae entered leaves directly after hatching and started mining. After finishing one leaf they entered another in the same whorl and when all the leaves of a whorl were destroyed, they mined through the stem to reach another whorl. In this way a single larva was found to damage 10-17 (average 12) leaves before reaching maturity. The larval and pupal stages occupied 9-16 and 6-11 days, respectively.

Hydrellia sp. was parasitized by the Braconid *Ademon decrescens* Nees, a larval-pupal parasite, to the extent of more than 50% during its active period.

Preliminary host-specificity tests have been made on *Oryza sativa* L., *Trapa bispinosa* Roxb. *P. perfoliatus*, *P. crispus* L., *V. spiralis* and *Nasturtium officinale* R. Br. Although oviposition took place on all the test plants and the host, the hatching larvae did not feed on the test plants except *P. crispus* where about 25% larvae (4 out of 16) developed to the adult stage. On the host *Hydrilla* the development per cent was 50-80. It may be mentioned here that *P. crispus* leaves resemble those of *Hydrilla* in some respects such as texture, width, etc. Thus, from these preliminary tests it appears that *Hydrellia* sp. infesting *Hydrilla* leaves is possibly a restricted feeder and distinct from other species.

Nymphula diminutalis Snell.

The genus *Nymphula* contains many species, most of which are aquatic and some semi-aquatic. The species which are known as pests are: *N. depunctalis* Guen., *N. vittalis* Bremer on paddy, and *N. nymphaeata* L. on paddy and lilies (Fletcher, 1919; Maxwell-Lefroy, 1909; Berg, 1950 b; and McGaha, 1954). Sankaran and Rao (1972) mentioned *Najas indica* (Willd.) Cham., *Nymphaea nouchali* Burm, *Potamogeton crispus* and *P. nodosus* Poir as host-plants of *N. diminutalis* in India. In Pakistan in addition to *H. verticillata*, *N. diminutalis* has also been recorded from *P. indicus*, *P. perfoliatus*, *P. crispus* and *Vallisneria spiralis*.

N. diminutalis overwinters in the larval stage. Pupation of the overwintered population occurs during February-March and the adult emergence is completed by mid-March to mid-April. About 5-6 overlapping generations are completed from April to October. Adults usually remain hidden under vegetation during the day and become active after dusk.

At 23°C $\pm$ 2°, mating occurred a day after emergence and oviposition 1 to 4 days after mating. Eggs were laid in groups on both sides of floating leaves. These hatched in 4-5 days. The hatching larvae fed on the epidermis of leaves on the first day, while on the second they started constructing small cases by stitching leaf-fragments cut during feeding. As the larvae grew bigger new cases were made, and in reaching maturity a larva built 4-5 cases. When full-grown, the larva attached the blind end of the case to the stem, closed the open end with silk and pupated. The entire larval and pupal periods occupied 28-46 days. Pupation usually occurred under water but in a few instances where pupal—cases were stuck to the walls of rearing jars outside water, no emergence of adults took place. In the field, pupae were found sticking to the plants to a depth of 1 foot below the water-surface. For studies on the biology, ecology and behaviour of *Nymphula* spp. see Welch (1916 & 1924); Berg (1950 b) and McGaha (1954).

Although no parasites have yet been reared from any stage of *N. diminutalis*, a high morality of larvae and pupae was encountered in the laboratory rearings. This was possibly due to some disease the causal organism of which has not yet been determined.

Preliminary screening tests have been made with 10 freshly hatched larvae on *Nasturtium officinale*, *Trapa bispinosa*, *Nymphaea* sp., *Polygonum caespitosum* Blume., *Oryza sativa*, *Vallisneria spiralis*, *P. perfoliatus*, *P. indicus* and *P. crispus*. No feeding was observed on the first four plants and the larvae died within 4 days, while slight nibbling occurred on rice but the larvae failed to construct cases and ultimately died. However, development was completed to the adult stage on *V. spiralis* and *Potamogeton* spp. as well as the host.

Thus, it appears that *N. diminutalis* is restricted to weedy aquatic plants. Rice and water-chestnut, the two economic plants tested, do not seem to be acceptable. However, results of the tests as well as host-records of *N. diminutalis* indicate the euryphagous nature of this Pyralid. Therefore, this insect may not prove to be particularly useful for the biocontrol of *Hydrilla*.

Bagous sp. nr. *limosus* (Gyll.)

This weevil is also distributed in most areas of the hosts' occurrence in standing water. The adults live under water feeding on leaves and stems. Oviposition also occurs in submersed stems and the larvae feed as borers or miners of stems. However, the pupal stage has not so far been found either in stems or in the soil of the ponds or on the banks.

Bagous spp. are known from many aquatic plants other than *Hydrilla* such as *Myriophyllum*, *Najas*, *Nymphaea*, *Nymphoides* and *Salvinia* (Habib-ur-Rehman *et al.*, 1969; Lekic and Minhajlovic, 1970; and Sankaran and Rao, 1972). However, none is definitely known to feed as a borer in submerged stems. Also, *B.* sp. nr. *limosus* is the only one of the five *Bagous* spp. associated with *Hydrilla* which feeds and breeds on submersed parts of the weed.

Field-collected, reproductively active females when released in aquaria in the laboratory, laid eggs in submersed stems of *Hydrilla*. The eggs hatched and the larvae fed inside stems but failed to pupate either in the stem or in the soil at the bottom. However, when the larvae that had fed and matured inside submerged stems were taken out along with the stem-sections and put on moist soil in dishes, they left the stems and entered the soil for pupation and adults emerged. Rearing, even of young larvae, in this manner was quite successful. At 24°C the incubation, larval and pupal stages occupied on average 5.5, 12 and 8.5 days, respectively.

Field observations indicated that the maximum larval populations occurred near the banks of ponds. This information was obtained when samples of *Hydrilla* plants were taken from a distance of 3, 10 and 20 ft. from the pond banks at five localities (maximum population of 410 larvae from 3 ft. distance, 110 from 10 ft. and 90 from 20 ft.). Therefore, it seems reasonable to assume that under natural conditions after reaching maturity the larvae leave the stems and in some way reach the banks to pupate in soil. However, this has not yet been confirmed.

No natural enemy from any stage of *B.* sp. nr. *limosus* has been obtained. This species has not yet been tested for host-specificity. However, its larvae have been recorded boring stems of *P. crispus* at places where this weed had overgrown *H. verticillata*.

SUMMARY AND CONCLUSIONS

Eight insects and two snails are associated with *Hydrilla verticillata* in Pakistan. Of these, only two, a Curculionid *Bagous* sp. nr. *limosus* and an Ephydrid *Hydrellia* sp. are stenophagous and promising biocontrol agents. The Pyralid *Nymphula diminutalis*, though not a pest of any economic plant and with a good destructive capability, has a comparatively wider host range within the aquatic weed plants.

Although the genus *Hydrellia* has been reared from the aquatic weed genera *Potamogeton* and *Vallisneria* in addition to *Hydrilla*, the species infesting *H. verticillata* is apparently distinct and stenophagous. This has a potentially good destructive ability (an average of 12 leaves per larva) but is also heavily parasitized by *Ademon decrescens* during its active season.

N. diminutalis also has a potentially good destructive ability but its damage to *Hydrilla* is not usually well pronounced possibly due to the fact that it feeds on a number of aquatic weeds other than *Hydrilla*. Reasonably high larval populations of *Bagous* sp. nr. *limosus* occur only near the banks of *Hydrilla*—infested ponds probably due to the need for pupation in moist soil. This may be a limiting factor to its spread to areas of ponds far beyond the banks.

Thus, studies conducted so far indicate that *Hydrellia* sp. and *B.* sp. nr. *limosus* might prove to be useful biocontrol agents for *Hydrilla*. Further studies are being continued to assess their destructive capabilities.

ACKNOWLEDGEMENTS

This research has been financed in part by a grant made by the United States Department of Agriculture under PL-480. Sincere thanks are due to Dr. M. A. Ghani, Entomologist-in-charge, Pakistan Station, Commonwealth Institute of Biological Control, and Dr. F. J. Simmonds, Director, C.I.B.C. for their guidance and encouragement during the course of work and for reviewing the manuscript.

REFERENCES

Berg, C. O.	1950a	*Hydrellia* (Ephydridae) and some other Acalyptate Diptera reared from *Potamogeton*. Ann. Ent. Soc. Amer., **43**:374-398.
Berg C. O.	1950b	Biology of certain aquatic caterpillars (Pyralidae—*Nymphula* spp.) which feed on *Potamogeton*. Trans. Amer. Micros. Soc., **59** : 254-266.
Deonier, D. L.	1971	A systematic and ecological study of Nearctic *Hydrellia* (Diptera-Ephydridae). Smithsonian contributions to zoology No. 68. Smithsonian Institution Press, City of Washington: pp 1-47.

Fletcher, T. B.	1919	Report of the Proceedings of the Third Entomological Meeting. p. 126. Supdt. Govt. Printing, India, Calcutta.
Habib-ur-Rehman, Mushtaque, M., Baloch, G. M. & Ghani, M.A.	1969	Preliminary observations on the biological control of watermilfoils (*Myriophyllum* spp.–Haloragidaceae). Tech. Bull. Commonw. Inst. Biol. Control, **11** : 165-171.
Lekic, M. & Minhajlovic, Lj.	1970	Entomofauna of *Myriophyllum spicatum* L. (Haloragidaceae), an aquatic weed on Yugoslava Territory. J. Sci. Agric. Res., **23** (82) : 59-74.
Maxwell-Lefroy, H.	1909	Indian Insect Life. A manual of the insects of the plains (Tropical India). p. 515. W. Thacker and Co., 2., Greed Lane, London.
McGaha, Y. I.	1954	Contribution to the biology of some Lepidoptera which feed on certain aquatic flowering plants. Trans. Amer. Micros. Soc., **73** : 167-177.
Sankaran, T. & Rao, V. P.	1972	An annotated list of insects attacking some terrestrial and aquatic weeds in India, with records of some parasites of the phytophagous insects. Tech. Bull. Commonw. Inst. Biol. Control, **15** : 131-157.
Welch, P. S.	1916	Contribution to the biology of certain aquatic Lepidoptera. Ann. Ent. Soc. Amer., **9** : 159-187.
Welch, P. S.	1924	Observations on the early larval activity of *Nymphula maculalis* Clemens (Lepidoptera). Ann. Ent. Soc. Amer., **17** : 395-402.