Phenology, Biology, And Host-Specificity of Some Stenophagous Insects Attacking *Myriophyllum* spp. in Pakistan

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INTRODUCTION

In a preliminary report on the natural enemies of water milfoil (*Myriophyllum* spp.), Habib-ur-Rehman *et al.* (1969) mentioned three Curculinonids (*Bagous geniculatus* Huchhuth, *B. vicinus* Hust. and *Phytobius* sp.) and a Gelechiid (*Aristotelia* sp.) as being apparently promising enemies of water milfoil in Pakistan. Further studies on the biology, phenology and host-specificity of these insects were carried out and are reported here. The investigations were mainly confined to Baluchistan (West Pakistan) for *Bagous* spp. and to East Pakistan for *Phytobius* sp. and *Aristotelia* sp.

1. BAGOUS GENICULATUS HUCHHUTH

In view of the failure to find in nature the immature stages of *B. geniculatus* in either submersed or emersed parts of water milfoil (Habib-ur-Rehman *et al.*, 1969), different breeding techniques were tried in the laboratory. Adults collected in the field mated readily but did not oviposit when left on stem sections of the host in glass jars filled with water. This suggested that perhaps oviposition was not usually possible under water. Consequently, females which had mated were exposed to water milfoil stem sections on moist substrates and this elicited an immediate oviposition response.

ECOLOGY AND PHENOLOGY

Consequent upon the laboratory breeding experience, further search for immature stages in the field was concentrated on water milfoil growing in moist conditions such as banks of lakes and ponds. A strip 10 ft long and 3 ft wide on the edge of the water at Band Khushdil Khan (Baluchistan) was examined in May, 1969 with the results as shown in Table 1.

The presence, at the time of the examination, of early stages near the edge of the water and of mature stages farther away, indicates that oviposition occurs near the lake shores.

Habib-ur-Rheman *et al.* (1969) could not account for the low populations of *B. geniculatus* since no immature stages were found. However, in view of the breeding behaviour now discovered, it appears that the major factor contributing towards low populations is the fluctuation in water levels (a regular feature of water milfoil habitat in Pakistan), entailing heavy mortality of larval and pupal stages due to rising water.

Under normal conditions where both water and the weed are present, *B. geniculatus* becomes active in the last week of April, and oviposition commences possibly in early May. Larval and pupal stages are present from mid-May to September and from the end of June to October, respectively. Only the adults overwinter, adhering to the basal portions of the plants under water. During abnormal years, when the lakes and ponds dry up, adults overwinter within dried up stubbles in the soil and reproductive activity in the next season may be delayed as late as August due to the retarded growth of the weed. There is possibly

TABLE 1. STAGES OF *B. geniculatus* FOUND ON WATER MILFOIL PLANTS AT VARIOUS DISTANCES FROM THE EDGE OF THE WATER

Distance from the edge of the water (ft)	Stages recovered		
	Larvae	Pupae	Adults
0-2		Not checked	
2-4	8	Nil	Nil
4-6	14	4	Nil
6-8	4	5	6
8-10	Nil	Nil	Nil

only one generation a year. No natural enemies of *B. geniculatus* have been found.

BIOLOGY

For mating in the laboratory, stem sections of water milfoil in water and bright sunlight were essential. Oviposition started 4 days after mating and continued throughout most of the life of the female. Eggs were laid close to the feeding punctures.

At a mean temperature of 61 F ± 5, the incubation period varied from 6 to 8 days. On hatching the grubs fed inside the stems and passed through four instars lasting from 61 to 69 days. Pupation occurred in the soil and the adults emerged in 10 to 12 days. As adults may live 2 years or longer, fecundity was not ascertained. The maximum deposition in 1 day by a female was 43 eggs.

Under field conditions, mating pairs were seen in shallow waters. Eggs were found only in the basal portions of stems of plants growing on the banks and not in the water. Adults were also observed in the morning leaving the water for plants on the banks, possibly for oviposition, and returning to the original sites in the afternoon. The larvae bore downward within the stems, finally entering the soil for pupation.

HOST-SPECIFICITY

In feeding and oviposition tests, four to ten copulating pairs were placed on each test plant and the test was replicated three times. They were placed for 1 day on stem sections of the test plant in glass jars filled with water and kept in sunlight and then transferred to stem sections on a moist substrate. Stem sections were replaced periodically. Observations were continued until oviposition occurred or until all the adults had died. Tests were considered valid only when feeding and oviposition occurred on watermilfoil.

The plants tested were: water lettuce (*Pistia stratiotes* L.); coontail (*Ceratophyllum demersum* L.); stonewort (*Chara* sp.); a gentian (*Limnanthemum cristatum* Griseb.); a grass (*Hygroryza aristata* (Retz.) Nees); wild rice (*Oryza rufipogon* Griff.); rice (*Oryza sativa* L.); water chestnut (*Trapa bispinosa* Roxb.); hydrilla (*Hydrilla verticillata* Casp.); trefoil (*Lotus* sp.); bushy pondweed (*Najas minor* All.); water lilies (*Nymphaea nouchali* Burm. and *N. stellata* Willd.); false loosestrifes (*Ludwigia* sp., *L. perrinus* Burm. and *L. suffruticosa* Walt.); water pepper (*Polygonum hydropiper* L.); dock (*Rumex maritimus* L.); water hyacinth (*Eichhornia crassipes* (Mart.) Solms.); clasping-leaf pondweed (*Potamogeton perfoliatus* L.); sharp buttercup (*Ranunculus muricatus* L.); cattail (*Typha* sp.); pennywort (*Hydrocotyle asiatica* L.); water dropwort (*Oenanthe stolonifera* Wall.).

None of the plants tested was accepted for oviposition but appreciable feeding took place on clasping-leaf pondweed and bushy pondweed. Irregular feeding also occurred on coontail, water chestnut, hydrilla and water lilies. Thus, for oviposition *B. geniculatus* is apparently specific to water milfoils but some feeding will occur on some other aquatic plants.

2. BAGOUS VICINUS HUST.

Ecology and phenology

The ecological requirements of this weevil are quite similar to those of *B. geniculatus*. Adults feed on both submersed and emersed parts of the plants, mainly the latter. Breeding occurs in emersed plants. Populations of *B. vicinus* also suffer from fluctuations in water levels.

In Baluchistan reproductively active females are present from April to September and in East Pakistan from October to April. Adults in Baluchistan overwinter within water milfoil stubbles from October to March, while in East Pakistan *B. vicinus* passes the monsoon period (May to September) on vegetation near the water. The number of generations per year is not known, but it is probably multivoltine because the development period (oviposition to adult stage) in Baluchistan is 11 to 17 days. No parasites or predators have been recorded for this weevil.

Biology

As with *B. geniculatus*, oviposition of *B. vicinus* also occurs in plants growing on the banks and not in the water. Eggs are laid either singly or in pairs in feeding pits* at the basal portions of stems. The grubs bore downwards through the stems and pupate in the soil up to a depth of 2 in.

At a mean temperature of 84 F ± 7, the incubation, larval and pupal periods lasted for 2, 6 to 10 (average 7.1) and 3 to 5 (average 3.6) days, respectively. The maximum number of eggs laid in a day by a female was 40.

Host-specificity

The procedures adopted for the feeding and oviposition tests with *B. geniculatus* were also used for this species. The plants tested were: coontail; stonewort; rice; water chestnut; hydrilla; lotus (*Nelumbo nucifera Graetn.*); water lily; false loosestrifes (*Ludwigia repens* Forst. and *L. suffruticosa*); sago pondweed (*Potamogeton pectinatus* L.); cattail.

Both feeding and oviposition occurred on hydrilla, sago pondweed and water lily. It was not determined whether development of immature stages on these plants could take place. Although these plants are of common occurrence in water milfoil habitats where this weevil is present, the immature stages have never been found in them. Thus, while these plants were attacked in captivity, they are unlikely to serve as hosts in nature.

3. PHYTOBIUS SP.

Ecology and phenology

This weevil is found only in East Pakistan where its larvae attack the emersed leaves and flowers of *Myriophyllum indicum* and *M. tuberculatum* growing in rice fields, road-side ditches, and ponds. Oviposition commences in October and high populations of all stages are present in January when the water level has decreased considerably.

Although adults of *Phytobius* sp. are present throughout the year, there is apparently no breeding in the monsoon season when the adults remain confined to water pepper, a semi-aquatic plant growing on banks. During the rest of the season, breeding continues on emersed parts of water milfoil growing both on banks and inside water. However, at times, the infestation is confined only to host plants growing in elevated moist soils when the fields are flooded or when the rice plants crowd out the water milfoil.

It is surprising that, although adults are present on

*Holes made in the stems by weevil's snout for feeding purposes.

water pepper growing around water milfoil during the monsoon, they do not breed on this plant nor do they move back to water milfoil when it becomes available above water. Adults collected from water pepper during this season oviposited freely on water milfoil in the laboratory. There are four to five generations per year in East Pakistan. No natural enemies were recorded for this weevil.

Host-specificity

To test feeding and oviposition response, five to ten pairs of adults reared in the laboratory were placed on the distal parts of water milfoil on moist blotting paper in dishes. With the commencement of oviposition, the adults were transferred to similar pieces of test plants in similar containers. Observations were continued till oviposition commenced or all the adults died.

The following plants were tested: arrow-heads (*Sagittaria guayanensis* Kunth. and *S. sagittifolia* L.); joyweed (*Alternanthera sessilis* (L.) R. Br.); spiny pigweed (*Amaranthus spinosus* L.); water lettuce; coontail; spreading sneezeweed (*Centipeda minima* (L.) A. Br. and Aschers); conyza (*Conyza* sp.); snakeroot (*Eupatorium ayapana* Vent.); sunflower (*Helianthus annuus* L.); potato-vine (*Ipomoea aquatica* Forsk.); morning glory (*Ipomoea repens* Lam.); water cress (*Rorippa indica* (L.) Hiern.); spurge (*Euphorbia* sp.); a gentian; a grass; wild rice; sensative plant (*Mimosa pudica* L.); water lily; false loosestrifes (*Ludwigia palustris* (L.), *L. prostrata* Roxb., *L. perrinus* and *L. repens*); water pepper; small knotweed (*Polygonum plebium* R. Br.); smartweed (*Polygonum* sp.); dock; water hyacinth; sharp buttercup; spurry (*Oldenlandia paniculata* L.); figwort (*Limnophylla heterophylla* Benth.); pennywort; frog-fruit (*Lippia nodiflora* (L.) Michx.).

Feeding and oviposition occurred on water pepper and only slight nibbling on smartweed was recorded. Of the 20 larvae from the eggs deposited on water pepper, six completed development and adults emerged after 24 to 36 days while 14 out of 18 completed development, the adults emerging after 16 to 20 days on water milfoil. The long developmental period on water pepper in the laboratory and the absence of immature stages in the field indicate that this plant probably could not be a suitable host in nature.

4. ARISTOTELIA SP.

Ecology and phenology

Aristotelia sp. attacks *M. indicum* and *M. tuberculatum* in East Pakistan where it is mainly present in Boro[1] rice fields but occasionally also in ponds.

Oviposition by this Gelechiid starts at the end of the monsoon period, usually by about late October. The larvae feed on the floral parts only. Populations increase gradually reaching a peak in March. However, during late March populations are drastically reduced due to heavy rains. A further reduction is brought about in April when water milfoil is pulled out of rice fields during harvesting. *Aristotelia* sp. hibernates as full-grown larva within cocoons and remains attached to the flower-stalks of the host during the monsoon period. It is multivoltine.

Larvae were found to be parasitized by an unidentified Ichneumonid in January and by a Braconid in June; the level of parasitism being 1% and 16.6%, respectively.

Host-specificity

For oviposition tests, two to ten reproductively active females were released in a cage (18″ by 18″ by 18″) containing water milfoil and the plant to be tested. For larval feeding, 30 to 60 newly hatched larvae (in batches of ten) were offered to stems with flowers and leaves of a test plant. Plants included in this test for oviposition were: arrowheads; joyweed; spiny pigweed; coontail; conyza; snakeroot; potato-vine; morning glory; water cress; spurge; a gentian; a grass; rice water chestnut; hydrilla; sensitive plant; lotus; false loosestrifes *L. repens* and *L. suffruticosa*; water pepper; dock; sharp buttercup; figwort; pennywort. For larval feeding, the plants used were: rice; water chestnut; lotus; water lily; pickerelweed (*Monochoria hastata* Solmn.).

No oviposition occurred on any of the plants tested while egg-laying continued on water milfoil in each test. Slight larval feeding took place on pickerelweed and four out of thirty larvae completed development on water chestnut. This plant in some regions is an economic crop.

While the absence of oviposition on water chestnut is encouraging, field trials on feeding and oviposition with this plant should be undertaken. However, in nature, this insect has not been found to breed on either water chestnut or any plant other than water milfoils.

SUMMARY AND CONCLUSIONS

Adults of *Bagous geniculatus*, and to some extent also those of *B. vicinus*, feed on submersed plants of *Myriophyllum spicatum* in West Pakistan and *M. indicum* and *M. tuberculatum* in East Pakistan, and breeding takes place only in water milfoil growing on banks and not in the water. *Phytobius* sp. and *Aristotelia* sp. feed and breed on aerial flower stalks of submersed and emersed plants of *M. indicum* and *M. tuberculatum*.

Bagous spp. oviposit in the basal parts of stems and the larvae bore downwards, finally entering the soil for pupation. *Phytobius* sp. larvae feed on leaves and flowers and those of *Aristotelia* sp. on floral parts only. Pupation in both these species takes place on stalks above the water. *B. geniculatus* is univoltine, whereas the other three species are multivoltine. Populations of all four are greatly affected by the fluctuation in water levels of water milfoil habitats in Pakistan.

Although the immature stages of these four insects could not be found in nature on any plant other than water milfoil, adults of *B. geniculatus* and *Phytobius* sp. feed on clasping-leaf pondweed and water pepper, respectively. *B. geniculatus* failed to lay eggs in clasping-leaf pondweed in the laboratory tests. *Phytobius* sp. oviposited on water pepper in captivity, but the percentage of larval development was about 50% less and the development period about 2 weeks longer than that on water milfoil. Thus, water pepper is unlikely to serve as a host in nature.

In the laboratory, feeding and oviposition by *B. vicinus* took place on hydrilla, clasping-leaf pondweed and water lily. However, these plants, though quite abundant in water milfoil habitats, apparently were not attacked by *B. vicinus* in the field. *Aristotelia* sp. did not oviposit on any of the plants tested, including water chestnut on which 12% of the larvae had completed development in one test.

[1]Rice crop in East Pakistan falls in three groups: (i) Aus (Autumn rice), (ii) Aman (Winter rice) and (iii) Boro (Summer rice).

All four species apparently seem to be specific to water milfoil as indicated by laboratory and field observation studies. Their populations in Pakistan are adversely affected by frequent water fluctuations. Thus, the insects seldom build up populations high enough to affect the abundance of water milfoil. Moreover, since *Bagous* spp. breed only in plants growing outside water on moist banks, there is very little chance of their establishment in areas lacking suitable breeding sites.

As *Phytobius* sp. and *Aristotelia* sp. occur only in East Pakistan on *M. indicum* and *M. tuberculatum*, their usefulness may be restricted ecologically, or to the species of the host, or by both of these factors. Furthermore, since their breeding and feeding is confined to emersed parts of water milfoil, submersed parts would remain unaffected.

However, if breeding sites for *Bagous* spp., stable water milfoil habitats, suitable ecological conditions and host species of *Phytobius* sp. and *Aristotelia* sp. are available, trial introductions of the four species would be worthwhile. If they were introduced simultaneously, through their combined action of damaging submersed parts and reducing seed production, these insects might possible be helpful in retarding the rate of growth and spread of *Myriophyllum* spp.

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