Control or No Control: A Comparison of the Feeding Strategies of Two Salvinia Weevils

D.P.A. Sands and M. Schotz
CSIRO Division of Entomology, Long Pocket Laboratories, Private Bag No. 3, Indooroopilly, Queensland 4068, Australia.

Abstract

The feeding behaviour of two Cyrtobagous spp. can be used to explain their different potential as biological control agents of salvinia (Salvinia molesta). In laboratory experiments, adults of Cyrtobagous salviniae fed mainly on buds whereas C. singularis fed extensively on other parts of the plant, leaving more buds intact. Larvae of C. salviniae tunneled into rhizomes, destroying the vascular bundles; larvae of C. singularis mainly fed externally on buds and other exposed tissues of the plants. The greater effect of C. salviniae on salvinia by destroying rhizomes and more buds, may explain its success as a biological control agent of salvinia where C. singularis had previously failed.

Efficacité des Agents Biologiques: Comparaison des Stratégies d'Alimentation de Deux Charançons de Salvinia

Deux Cyrtobagous spp. ont un potentiel différent comme agents de lutte biologique contre la plante nuisible Salvinia molesta en raison de leurs habitudes alimentaires distinctes. Les adultes de Cyrtobagous salviniae se nourrissent principalement de bourgeois, tandis que C. singularis s'alimente principalement d'autres parties de la plante, détruisant ainsi moins de bourgeois. Les larves de C. salviniae pénètrent dans les rhizomes, où ils détruisent le faisceau libéro-ligneux, tandis que les larves de C. singularis mangent principalement des bourgeois et d'autres tissus exposés des plantes. C. salviniae est sans doute un agent biologique plus efficace dans la lutte contre salvinia que C. singularis parce qu'il détruit les rhizomes et de plus grandes quantités de bourgeois.

Introduction

When biological control of the water weed salvinia (Salvinia molesta D.S. Mitchell; Salviiniaeae) was achieved in Australia, the success was attributed to introduction of a biotype of Cyrtobagous singularis Hustache (Coleoptera: Curculionidae), which was specially adapted to S. molesta (Room et al. 1981; Forno et al. 1983). Failure to control the weed in several other countries (Julien 1982) was thought to be due to introduction of a biotype collected from a different plant species, S. auriculata Aublet.

Studies were carried out on weevils originating from Trinidad (collected from S. auriculata) and Brazil (collected from S. molesta) to determine if the existence of the biotypes could be identified experimentally. Morphological studies of the two populations subsequently confirmed that they were different species (Sands 1983). The weevil introduced into Australia for biological control of S. molesta was not C. singularis, but represented the closely-related species C. salviniae Calder & Sands (Calder and Sands 1985).
Feeding by larvae of *C. salviniae* was investigated by Sands *et al.* (1983) who reported that the destruction of salvinia was primarily due to tunnelling by larvae within the rhizomes. In this paper we describe a series of experiments in which we compared the feeding characteristics of the two *Cyrtobagous* spp. and discuss their potential as biological control agents for *S. molesta*.

**Materials and Methods**

**The Salvinia Plant**

Salvinia plants are free-floating ferns. Their submerged rhizomes consist of nodes interconnected by internodes, each node bearing two floating leaves and a submerged, modified leaf referred to as a root, a leaf bud at the apical growing point, and buds at the base of leaves where branching commences.

The histology of the salvinia stem (the rhizome) was shown by Croxdale (1981) to be similar to that of the leaf petiole. In cross section the salvinia rhizome contains a central core of vascular bundles or protostele, surrounded first by an endodermis, then a spongy, air-filled aerenchyma which in turn is surrounded by a thin-walled layer of epidermal cells. The protostele branches at nodes, entering the leaf and root petioles and branches again as it enters the lamina of the leaf or the branches of root.

**Experiments with Weevils**

Experiments with *C. salviniae* collected from Mt. Isa, Queensland, but originating from Joinville, Brazil (on *S. molesta*), and *C. singularis* from Manzanilla, Trinidad (on *S. auriculata*), were carried out in a quarantine insectary using the culture methods described by Forno *et al.* (1983). All experiments were carried out on *S. molesta* after it was confirmed that *C. singularis* had similar feeding characteristics on its native host, *S. auriculata* (unpubl. data). Comparative studies of both *Cyrtobagous* spp. were made at 25°C in controlled-temperature cabinets. The insects were provided with secondary- or tertiary-stage plants of *S. molesta* grown in a nutrient solution containing 3.0 mg/l equivalent of nitrogen (as in Sands *et al.* 1983). To compare feeding by larvae, 10 newly-emerged larvae of each species were placed within an apical bud of a rhizome of *S. molesta* using the method described by Sands *et al.* (1983). Observations and measurements were made every 3 days until pupation took place.

In experiments with adults, 10 females of each weevil species were provided with four rhizomes of *S. molesta* which were replaced every 3 days. The numbers of primordial buds (buds beginning to swell) totally destroyed were compared since advanced buds usually continued to develop following attack (unpubl. data). Observations and measurements were made every 3 days for 15 days.

**Results and Discussion**

**Larval Damage**

Larvae of both *Cyrtobagous* spp. after hatching, begin to feed on roots and buds of salvinia. Within a few days larvae of *C. salviniae* begin to tunnel into the rhizomes where they progressively destroy the nodes, internodes and sometimes damage the roots (Sands *et al.* 1983).

Damage resulting from tunnelling by larvae of *C. salviniae* varied according to stage and toughness of the salvinia plant. When feeding in primary- or secondary-stage plants...
(defined by Mitchell and Thomas 1972), larvae consumed the protostele, endoderm, meristems and much of the aerenchyma (Fig. 1A), but when tunnelling in tertiary-stage plants, feeding was confined mainly to the endoderm, meristems and aerenchyma, leaving some of the tough protostele intact (Fig. 1C). When larvae of *C. salviniae* tunnelled into nodes, adjoining leaves and internodes usually separated, turned brown and eventually disintegrated. Each larva is known to destroy from 1.2–2.4 rhizome sections (Sands *et al.* 1983), including nodes, from which regrowth could otherwise have taken place. In contrast, larvae of *C. singularis* did not tunnel within rhizomes but moved from one site to another, feeding mainly externally on the submerged parts of the plant, particularly on buds, rhizome aerenchyma, and leaf petioles (Fig. 1B, 1D).

![Diagram A](image1)

![Diagram C](image2)

![Diagram B](image3)

![Diagram D](image4)

Fig. 1. Feeding sites of *Cyrtobagous* spp. larvae on *Salvinia molesta* D.S. Mitchell: (A, C) by *C. salviniae* Calder & Sands, (B, D) by *C. singularis* Hustache; (A, B) lateral view of rhizome, secondary stage; (C, D) transverse section of rhizome, tertiary stage.

In these experiments, each *C. salviniae* larva destroyed only one bud before tunnelling into the rhizome, but each larva of *C. singularis* destroyed an average of three buds and fed at many separate sites on the rhizome. While they sometimes tunnelled into the leaf petioles and fed on the aerenchyma of the rhizomes, larvae of *C. singularis*
did not destroy the protostele in nodes of secondary-stage plants, nor the endoderm of tertiary-stage plants. Large larvae have never been observed totally encased in the rhizome, whereas this is the usual feeding site for similar stages of *C. salviniae*.

The effects on plants attacked by larvae of the two *Cyrtobagous* spp. differed considerably. Plants attacked by *C. singularis* became discoloured and the apical buds disintegrated. However, sections of rhizomes including nodes, survived attack by this species and retained the capacity for regrowth. In contrast, attack by larvae of *C. salviniae* resulted in death and sinking of rhizome sections.

![Diagram](image)

**Fig. 2.** Feeding scars of *Cyrtobagous* spp. adults on *Salvinia molesta* D.S. Mitchell: (A, C) by *C. salviniae* Calder & Sands, (B, D) by *C. singularis* Hustache; (A, B) secondary-stage plants, (C, D) tertiary-stage plants.

**Adult Damage**

*C. salviniae* feed almost exclusively on buds of tertiary-stage salvinia but will attack terminal leaves of primary- and secondary-stage plants (Forno *et al.* 1983). Sites of feeding on primary- and secondary-stage plants by both *Cyrtobagous* spp. vary, but in this study *C. salviniae* preferred buds to apical leaves (Figs. 2A, 2C) while *C. singularis* preferred apical leaves (Figs. 2B, 2D). Adult *C. salviniae* destroyed nearly twice as many buds as *C. singularis*, while *C. singularis* produced more than three times the number of scars on leaves as *C. salviniae* (Table 1). Moreover, while *C. salviniae* confined their attack on leaves to the apical pair, *C. singularis* frequently attacked pairs 2, 3 and sometimes 4 and 5. Further, while adult *C. salviniae* rarely fed on leaf petioles, *C. singularis* frequently did so, and produced a chain of scars in the aerenchyma of the internodes.
The Potential of Two Cyrtobagous spp. as Biological Control Agents

Harris (1981) stated that most agents used for the biological control of weeds stress, but do not kill the target weed. In this study the stress resulting from feeding by adults and larvae of the two Cyrtobagous spp. differed considerably. Room (1984) predicted that 50–75% destruction of buds of salvinia should halt growth of the weed, suggesting that adults alone, of both Cyrtobagous spp. are capable of affecting control. However, we suggest that the greater effect of C. salviniae from larvae destroying rhizomes and adults destroying more buds, may explain its success as a biological control agent for salvinia, where stress from attack by C. singularis has been relatively ineffective.

Table 1. Comparison of feeding by two Cyrtobagous spp. on Salvinia molesta (secondary stage).

<table>
<thead>
<tr>
<th>Insect stage</th>
<th>Damage</th>
<th>C. salviniae (No./♀/day±SE)</th>
<th>C. singularis (No./♀/day±SE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adults (n = 10/sp.)</td>
<td>Buds destroyed</td>
<td>0.77±0.18</td>
<td>0.42±0.06</td>
</tr>
<tr>
<td></td>
<td>Internode scars</td>
<td>0.63±0.24</td>
<td>4.32±0.48</td>
</tr>
<tr>
<td></td>
<td>Leaf scars (&lt;1mm)</td>
<td>3.13±0.78</td>
<td>11.40±1.55</td>
</tr>
<tr>
<td>Larvae (n = 30/sp.)</td>
<td>Buds destroyed</td>
<td>1.18±0.10</td>
<td>3.05±0.20</td>
</tr>
<tr>
<td></td>
<td>Separately feeding sites</td>
<td>1.25±0.14</td>
<td>4.28±0.30</td>
</tr>
</tbody>
</table>

1 Scars >1 mm result from attack on expanding buds.

Fig. 3. Distribution of two Cyrtobagous spp.: 1984.

The two species share a common distribution over part of their natural range in South America (Calder and Sands 1985) and are now established on salvinia in several other countries (Fig. 3). When C. singularis was introduced to Botswana and Zimbabwe for control of salvinia (Bennett 1975), control of the weed was not achieved even though
the weevil is now known to have established on S. molesta in the Caprivi region of southern Africa (Procter 1984). When contrasted with the success of C. salviniae in Australia (Room et al. 1981), we believe the performance of the two weevils can be attributed to subtle differences in their feeding behaviour. This study, which began to compare two populations thought to be biotypes, resulted in the discovery of two separate species, with different biological characteristics and potentials as biological control agents.

Acknowledgments

We thank Drs. F.D. Bennett and I.W. Forno for providing the original stocks of Cyrtobagous spp.

References


