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The Biology and Ecology of the Salvinia Weevil: A Biological Control Agent for the Management of Giant Salvinia

Scientific name: *Cyrtobagous salviniae* Calder and Sands (Insecta: Coleoptera: Curculionidae)

Introduction

Giant salvinia, *Salvinia molesta* D. S. Mitchell (Salviniaceae), is an invasive free-floating fern native to southeastern Brazil that has plagued waterways of tropical and subtropical regions of the world (Figure 1). Giant salvinia was first introduced into the United States in 1995 in South Carolina through the water plant trade, but chemical treatments were used to quickly eradicate this small infestation. In 1998, giant salvinia was reported along the border of Texas and Louisiana in the Toledo Bend Reservoir, subsequently spreading uncontrollably to lakes, ponds and reservoirs throughout the southeastern United States. Vegetative reproduction, rapid growth rates and dispersion by humans and flooding are major factors in the formation of dense mats of this weed. These mats can completely cover a body of water, consequently restricting commercial and recreational boating access. The mats also crowd out native vegetation, decrease dissolved oxygen levels and cause mortality of benthic fauna. As a result, giant salvinia is widely regarded as one of the world's worst aquatic weeds.

Figure 1. Giant salvinia infestation in Bienville Parish, Louisiana, 2011. Photograph by Christopher Mudge, U.S. Army Engineer Research & Development Center.

The salvinia weevil, *Cyrtobagous salviniae* Calder and Sands (Coleoptera: Curculionidae), is a small beetle native to southeastern Brazil and northern Argentina used for the biological control of giant salvinia. The salvinia weevil was first released in Australia in the 1980's from a population collected in Brazil. Following successes in Australia, weevils have been reared and released as a biological control agent in at least 14 other countries. Weevils were first released in the United States at Toledo Bend Reservoir (Louisiana/Texas) and Lake Texana (Texas) in 2001. An ecotype of the salvinia weevil has been found in Florida since the 1960's, but giant salvinia control with this strain of the weevil has not been effective. Since the initial releases, successful control of giant salvinia has occurred in southern regions of Texas and Louisiana.

Distribution

In the United States, giant salvinia has been reported in Alabama, Arizona, California, Florida, Georgia, Hawaii, Louisiana, Mississippi, North Carolina, Oklahoma, South Carolina, Texas and Virginia (Figure 2). The largest infestations have been reported in

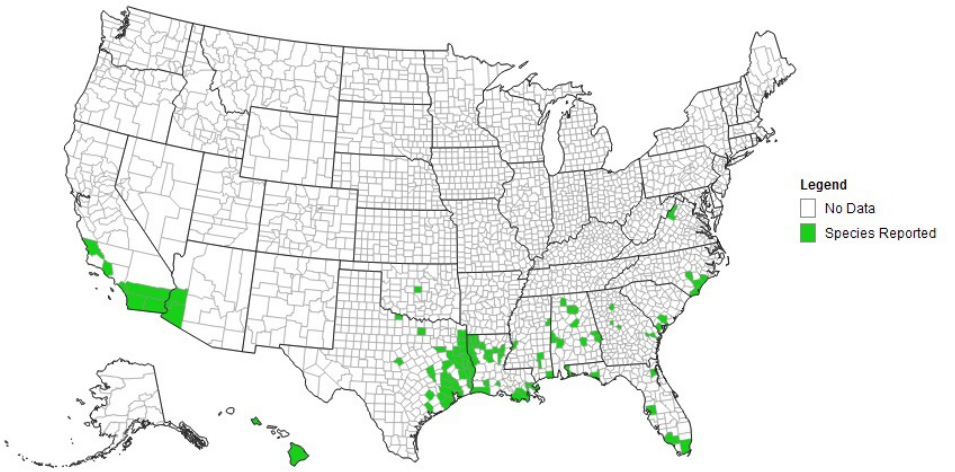

Figure 2. Distribution of Salvinia molesta in United States. Source: EDDMapS.org.

eastern Texas and Louisiana. Since 2001, weevils have been released throughout Texas and Louisiana. However, efforts to establish weevils at latitudes north of 32° N (Natchitoches, La.) have been unsuccessful, probably because of weevil mortality at freezing winter temperatures. Further research is needed to find cold tolerant strains of the weevil or develop techniques to enhance winter survival.

Description

Eggs of the salvinia weevil are 0.5 x 0.2 mm (0.02 x 0.01 inches), milky white and elliptical in shape (Figure 3).

Salvinia weevil larvae are milky white with a hard, brown head. Full grown (fifth instar) larvae are ca. 2.6 mm (0.10 inches) long, but early larvae can be as small as 1 mm (0.04 inches) (Figure 4).

Pupae are 2 x 2.6 mm (0.08 x 0.10 inches) in size and enclosed in a cocoon interwoven with the brown root hairs (Figure 5).

Adult salvinia weevils are 2- 3.5 mm (0.08- 0.14 inches) long. Newly emerged adults (teneral) have a brown coloration that changes to shiny black within a few days (Figure 6). Salvinia weevils have a long snout and hard wing covers (elytra).

Life Cycle and Ecology

At 26°C (78°F), the salvinia weevil completes development from egg to adult in 45 days. Female weevils deposit eggs singly in cavities in the plant bud or suspended in a modified frond that resembles a root mass below the water. Larvae emerge from eggs in approximately 10 days. For the first 3-to-14 days, larvae may be found feeding externally in the buds and fronds of giant salvinia. Later instars are found tunneling inside the new rhizomes, where higher levels of nitrogen promote larval development. After approximately 23 days, fifth instars exit the rhizome to molt to the pupal stage. Pupae can be found below water within the submerged frond or attached to the rhizome. Adult weevils emerge from the pupal stage after 10-to-15 days. Adults can be found on the fronds of giant salvinia and underwater in the submerged fronds. While underwater, a film of air trapped beneath the body allows the weevils to respire. Female salvinia weevils tend to be larger than males; however, it is difficult to distinguish male and female based on external morphology. Mating and oviposition initiates between five and 26 days after emergence and occurs more than once in a lifespan. Female egg production increases at higher plant nitrogen levels; a nitrogen concentration in the plant tissue of 2 percent to 3 percent is considered optimal for reproduction. Ideal temperatures for weevil reproduction range between 23° and 27°C (73 to 81°F), and negligible egg laying occurs below 21°C (70°F). Adults feed at temperatures between 13° and 33°C (55° to 91°F).

Host

Extensive host range experiments and field observations in the native range demonstrated that the salvinia weevil can only survive on plant species in the genus *Salvinia*. In the United States, the salvinia weevil feeds and reproduces exclusively on two invasive plants: giant salvinia and common salvinia (*Salvinia minima* Baker). Giant salvinia can be differentiated from common salvinia by the presence of egg beater shaped hairs on the leaf of the plant (Figure 7). Common salvinia leaf hairs do not conjoin at the tip to form the egg beater shape.

Figure 3. Egg of the salvinia weevil, located above the submerged frond. Photograph by Alana Russell, LSU AgCenter.

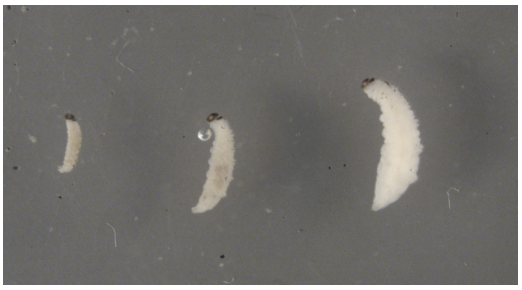

Figure 4. First, third and fifth instar larvae of the salvinia weevil. Photograph by Alana Russell, LSU AgCenter.

Figure 5. Pupa of the salvinia weevil. Photograph by Alana Russell, LSU AgCenter.

Figure 6. Adult salvinia weevils. (a) Dorsal view of a mature weevil, (b) Lateral view of a mature weevil, (c) Dorsal view of a teneral weevil, (d) Lateral view of a teneral weevil. Photographs by Alana Russell, LSU AgCenter.

Economic Importance

Salvinia weevil larvae and adults feed aggressively on giant salvinia. Adult feeding scars are easily identified by "shotgun" hole patterns in apical buds and fronds (Figure 8), whereas larval injury is characterized by browning of fronds (Figure 9a). While adult injury suppresses the growth of giant salvinia, larval injury is most important in reduction of this weed. The tunneling behavior exhibited by larvae (Figure 9b) disconnects the flow of nutrients from submersed fronds to the emergent fronds and buds, causing the plant to disintegrate and sink.

Salvinia weevils can reduce the density of giant salvinia in one to four years after establishment (Figure 10). However, this reduction could vary between sites and climatic conditions. Regions with milder winters may experience a faster weevil population growth and, consequently, faster weed control. Mechanical and chemical control can be utilized to supplement biological control; however, these technologies alone are economically costly and may require repeat applications.

Figure 7. Egg beater shaped hairs of a giant salvinia frond. Photograph by Alana Russell, LSU AgCenter.

Figure 8. Characteristic shotgun hole feeding pattern of the adult salvinia weevil on giant salvinia. Photograph by Alana Russell, LSU AgCenter.

Utilizing Weevils for Management of Giant Salvinia

Initial success using the salvinia weevil stimulated a mass rearing program to supply weevils to infested areas in Louisiana and Texas. Weevils are reared in tanks, culture boxes, or in earthen ponds and done inside a greenhouse or outside exposed to environmental conditions. Ideal climatic and water quality conditions are simulated in the rearing reservoirs, to promote maximum weevil development. Researchers assess weevil density in the plants by extracting adults using a Berlese funnel which exposes plant samples to heat from artificial light, forcing insects to move away from the heat and dried plant material to the bottom of the funnel. Insects that climb to the bottom of the funnels are collected in a reservoir containing ethanol. From these samples, the number of weevils per kg of giant salvinia can be estimated. A rearing site is considered ready for harvest when it reaches approximately 60 adults per kg of giant salvinia (30 adults/pound). Alternatively, weevil density can be estimated on a per-area basis. Here, researchers use a PVC frame of standard size (for example, 1m2) placed on the salvinia mat to determine the amount of plant material to collect from the given area. Weevils will be extracted from the plant material using Berlese funnels. Using this method, we can obtain the number of weevils per kg per unit area. This method could be useful when monitoring weevil release sites to document the impact of the weevil.

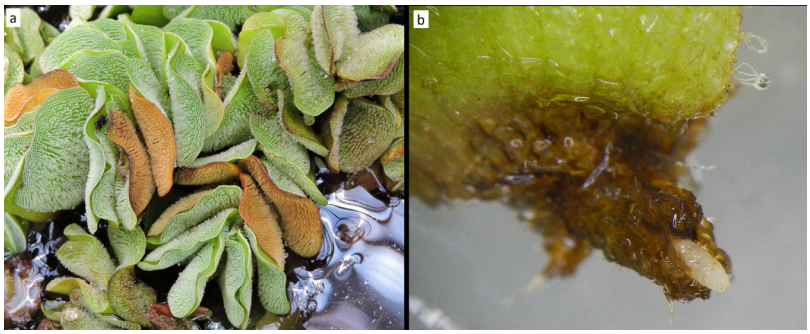

Figure 9. (a) Browning of giant salvinia fronds is indicative of feeding injury produced by the larval growth stage of the salvinia weevil. (b) Salvinia weevil larva tunneling into the rhizome of giant salvinia. Photograph by Alana Russell, LSU AgCenter.

Figure 10. Giant salvinia infestation in Lafourche Parish, Louisiana, before and after release of salvinia weevils. Photograph Wendell Lorio, LSU AgCenter.

Current research now focuses on improving the management of giant salvinia in temperate regions. Researchers have begun comparative analysis of the cold tolerance of salvinia weevils from geographically distinct populations throughout the world. Similarly, the physiology and cold tolerance of salvinia weevils collected from temperate areas of the insect's native range is being investigated. If weevils better adapted to cold winters can be isolated, researchers plan to rear and release this ecotype throughout

the temperate range of giant salvinia. Additional research is also being conducted involving other components of integrated weed management.

Once the weevil has reduced giant salvinia density, plant managers often wonder what can be done with fringe populations. This will be dependent on risk of weed reintroduction. If there is minimal chance of plants reentering the aquatic system, elimination of remaining plants is recommended; however, if plant reestablishment is likely to occur in the future, leaving weevil-infested plants is encouraged. The remnant plant population can serve as a reservoir of weevils for future outbreaks or population increases. To facilitate control efforts, plant managers should collect plants from a location (1) known to have weevils and (2) showing brown leaf coloration, and release these plants in locations with existing giant salvinia infestations.

Selected References

Forno, I.W., Bourne, A.S. 1985. Feeding by adult *Cyrtobagous salviniae* on Salvinia molesta under different regimes of temperature and nitrogen content and the effects on plant growth. Entomophaga 30: 279-286.

Forno, I.W., Sand, D.P.A., Sexton, W. 1983. Distribution, biology, and host specificity of *Cyrtobagous singularis* Hustache (Coleoptera: Curculionidae) for the biological control of *Salvinia molesta*. Bulleting of Entomological Research 73: 85-95.

Jacono, C.C. (1999). *Salvinia molesta* (Salviniaceae), new to Texas and Louisiana. Sida 18: 927-928.

Oliver, J. D. 1993. A review of the biology of giant salvinia (*Salvinia molesta* Mitchell). Journal of Aquatic Plant Management 31:227-231.

Sands, D.P.A., M. Schotz, and A.S. Bourne. 1983. The feeding characteristics and development of larvae of a salvinia weevil *Cyrtobagous* sp. Entomologia Experimentalis et Applicatta 34: 291-296.

Thomas, P.A. and P. M. Room. 1986. Taxonomy and control of *Salvinia molesta*. Nature 320:581-584.

Tipping, P.W., Center, T.D. 2003. *Cyrtobagous salviniae* (Coleoptera: Curculionidae) successfully overwinters in Texas and Louisiana. Florida Entomologist 86: 92-93.

Tipping, P.W., Martin, M.R., Center, T.D., Davern, T.M. 2008. Suppression of *Salvinia molesta* Mitchell in Texas and Louisiana by *Cyrtobagous salviniae* Calder and Sands. Aquatic Botany 88: 196-202.

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