HISTORY AND ECOLOGY IN NORTH AMERICA

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Megamelus scutellaris
Waterhyacinth planthopper

Megamelus scutellaris is a biological control agent approved in the USA for release against waterhyacinth.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Hemiptera	True bugs
Family	Delphacidae	Planthoppers
Genus	*Megamelus*	
Species	*Megamelus scutellaris* Berg	Waterhyacinth planthopper

DESCRIPTION

Eggs are elliptical and milky white when laid but turn yellowish with reddish eye spots before hatching. Nymphs are similar to wingless adults but are smaller (up to 2½ mm long). Nymphs have yellowish bodies with mottled brown markings; their coloration darkens through each instar (**Fig. 1a**). Adults can be either wingless or winged (with clear wings). Adults are typically 2½–3½ mm long and are mottled brown, gray, and yellowish (**Fig. 1b**).

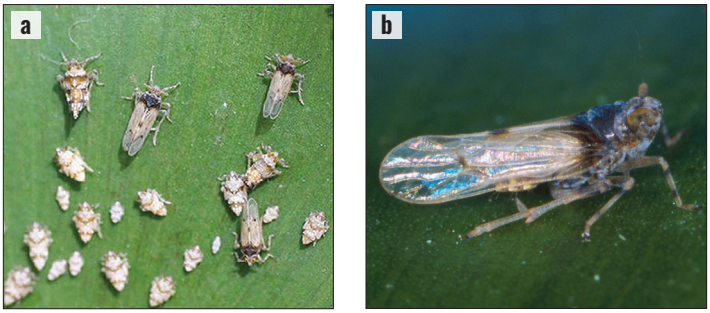

Figure 1. *Megamelus scutellaris* (a) adults and nymphs; (b) adult (a: Jason D. Stanley, USDA ARS, Bugwood.org CC BY-3.0 US; b: Philip W. Tipping, USDA-ARS Invasive Plant Research Lab)

LIFE CYCLE

At warm locations with winter temperatures above freezing, both *M. scutellaris* and waterhyacinth develop throughout the year. At cold sites, immature stages overwinter in decaying mats of waterhyacinth. Adults lay eggs within leaves of waterhyacinth in spring; oviposition scars can be recognized by three parallel marks. Nymphs develop through five instars. Nymphs and adults feed on leaves and stems of waterhyacinth. Environmental cues determine whether adults will be winged or wingless. When planthoppers are overcrowded or waterhyacinth plants are of poor quality, adults develop wings (i.e., become macropterous) that enable them to disperse to more suitable waterhyacinth plants/infestations. There are multiple overlapping generations per year.

DAMAGE

Nymphs and adults pierce waterhyacinth leaves and stems and feed on sap (**Fig. 2a**). Plants with heavy feeding produce fewer leaves and eventually wilt and die (**Fig. 2b**).

Figure 2. *Megamelus scutellaris* (a) adults and nymphs feeding on the underside of a waterhyacinth leaf; (b) adults and damage to waterhyacinth (a: Julie Coetzee, iNaturalist.org CC BY-NC 4.0; b: Philip W. Tipping, USDA-ARS Invasive Plant Research Lab)

FIELD IDENTIFICATION

Although feeding scars on waterhyacinth leaves (**Fig. 2a**) may be indicative of planthopper presence, some other waterhyacinth natural enemies established in North America may at times cause feeding damage similar in appearance (**Fig. 8b, 12**). The surest means to confirm the planthopper's presence is to observe nymphs or adults actively feeding on waterhyacinth. Because there are multiple overlapping generations of this species in the southeastern USA, nymphs and adults should be readily visible when waterhyacinth is actively growing at sites where the planthopper is established.

PREFERRED HABITAT

Megamelus scutellaris appears to do best at sites with some cover or shading. Although the reasons for this are not currently known, shading may promote increased humidity which increases survival of the planthopper.

HISTORY AND CURRENT STATUS

Megamelus scutellaris is native to the Amazon basin of South America. A population sourced from Argentina was released in Florida, Louisiana, and Texas, USA beginning in 2010 and in California beginning in 2011. The first releases were believed to have failed establishment, and a second release sourced from northern Argentina/Paraguay was released in Florida beginning in 2013 and Louisiana in 2015. It was subsequently determined both sets of releases resulted in successful establishment in Florida, and the two different populations are no longer differentiated. Establishment has also been confirmed in California (**Fig. 3**). *Megamelus scutellaris* from Florida were redistributed to Arkansas in 2021, but establishment has not yet been confirmed.

In Florida, *M. scutellaris* populations dispersed >3¾ miles (6 km) from release sites within two years of release. Although dispersal is still increasing, planthopper populations persist only at low levels at most sites. The waterhyacinth planthopper combines well with herbicides, providing significant reductions in biomass, density, and relative growth rate and reducing the necessary application rates and frequency of herbicide applications. A native parasitoid has been documented parasitizing *M. scutellaris* eggs at some Florida locations, but it is incidental and it does not limit populations.

In California, *M. scutellaris* has only recently been confirmed established. The planthopper is already decreasing live leaves/above-water biomass of waterhyacinth by upwards of 27%, although the planthopper distribution is still restricted to the original release site, and additional time is needed to determine its overall impact.

NONTARGET EFFECTS

None reported in North America.

Figure 3. *Megamelus scutellaris* reported distribution in North America (Winston et al. 2021)

Neochetina bruchi & N. eichhorniae

Chevroned & mottled waterhyacinth weevils

Neochetina bruchi & *N. eichhorniae* are closely related biological control agents approved in North America for release against waterhyacinth.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Curculionidae	Weevils
Genus	*Neochetina*	
Species	*Neochetina bruchi* Hustache *Neochetina eichhorniae* Warner	Chevroned waterhyacinth weevil Mottled waterhyacinth weevil

DESCRIPTION

These species are morphologically very similar. Eggs are white and oval. Larvae are C-shaped, white with yellow-orange heads, and up to 9 mm long (**Fig. 4a**). Pupae are white and enclosed in cocoons. Adults are somewhat rounded and have long snouts. Adult *Neochetina bruchi* are tan or brown and often have a lighter-colored V-shaped band on the lower parts of the elytra (**Fig. 4c**). Adult *N. eichhorniae* are usually a darker mottled gray and brown (**Fig. 4d**). Both species have two dark markings on their elytra. The markings are shorter

for *N. bruchi* and located midway down the elytra while the markings for *N. eichhorniae* are longer and situated closer to the weevil's head (**Fig. 4b–d**).

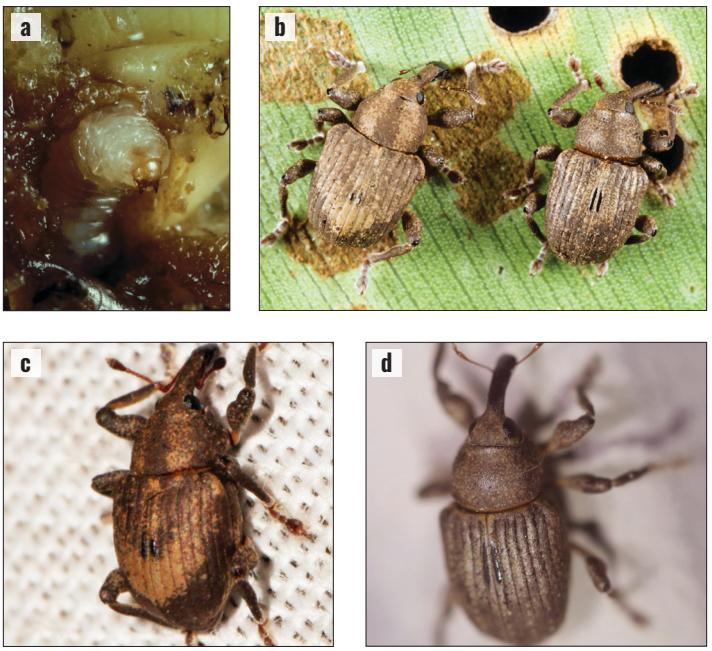

Figure 4. *Neochetina* spp. (a) larva; (b) adults (*N. bruchi* left, *N. eichhorniae* right); (c) *N. bruchi* adult; (d) *N. eichhorniae* adult (a,b: Willey Durden, USDA-ARS, Bugwood.org CC BY-3.0 US; c: Riana60, iNaturalist.org CC BY-NC 4.0; d: Joshua Doby, iNaturalist.org CC BY-NC 4.0)

LIFE CYCLE

Both species are continuously brooded, creating frequent overlap of generations. In warm areas with temperatures above freezing, all stages of the beetles can overwinter. Adults may live longer than a year and can be found year-round. Adults feed on waterhyacinth leaves and stems, producing feeding scars 2–3 mm wide (**Fig. 5**). Adults lay eggs (300–400 in a lifetime) embedded in waterhyacinth leaf and petiole tissue. *Neochetina bruchi* may deposit several eggs in the same site while *N. eichhorniae* deposits eggs singly. Larvae feed on plant tissue through three instars and mine the petioles towards the root crown. *Neochetina bruchi* larvae develop somewhat faster than *N. eichhorniae* larvae. Pupation occurs in cocoons attached to waterhyacinth roots below the water surface. Emerging adults climb on waterhyacinth tissue above the water surface to feed and mate.

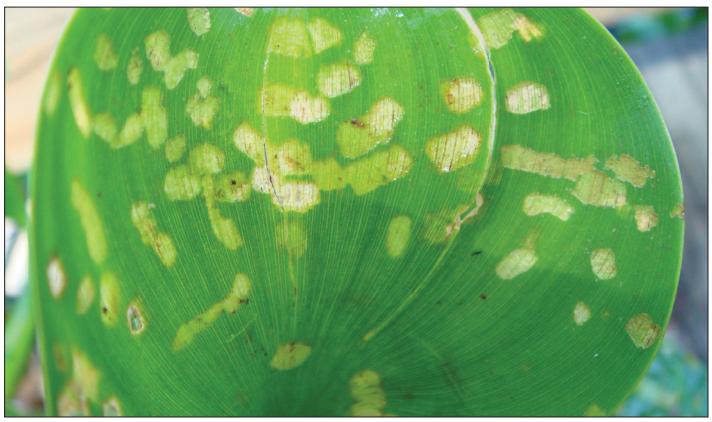

Figure 5. *Neochetina* spp. adult feeding scars on waterhyacinth (Katherine Parys, USDA-ARS, Bugwood.org CC BY-3.0 US)

DAMAGE

Adult feeding causes characteristic feeding scars on leaves and petioles (**Fig. 5**). Larval feeding produces mining tunnels in leaf petioles. Damage from adults and larvae stunts plant growth and reduces floral and vegetative reproduction. Heavy feeding and mining causes leaf petioles to become thin and brittle, and plants become waterlogged and gradually sink.

FIELD IDENTIFICATION

The 2–3 mm wide adult feeding scars on waterhyacinth leaves (**Fig. 5**) are indicative of waterhyacinth weevil presence. The other waterhyacinth natural enemies established in North America do not cause cause this characteristic external feeding damage on leaves. Old feeding scars may be observed on any waterhyacinth leaves. When scars are found on the center (newest) leaves, adults can usually be found at the base of the petiole within the leaf sheath. Mining larvae can also be dissected from petioles to confirm presence. Because there are multiple overlapping generations of this species in the southeastern USA, adults or their characteristic feeding damage should be readily visible when waterhyacinth is actively growing at sites where the weevils are established.

PREFERRED HABITAT

The specific habitat requirements of both species are unknown, although both appear to thrive wherever waterhyacinth populations remain persistent throughout the year.

HISTORY AND CURRENT STATUS

The *Neochetina* spp. are native to South America. *Neochetina eichhorniae* and *N. bruchi* sourced from Argentina were released in Florida, USA in 1972 and 1974, respectively, and were later redistributed to Texas, Louisiana, and California. Both species were also redistributed from Florida to Mexico beginning in 1976 (*N. eichhorniae*) and 1994 (*N. bruchi*), although a population of *N. eichhorniae* was found to have been inadvertently introduced to Mexico by 1967. Both species are well established in five states in the USA (**Fig. 6**) as well as in Mexico.

In the Gulf Coast region of the USA, *N. eichhorniae* is usually the dominant species. Damage between the two species is difficult to differentiate, but they likely complement each other. These weevils have been credited with reducing waterhyacinth abundance to less than ⅓ its original levels

Figure 6. *Neochetina bruchi* & *N. eichhorniae* reported distribution in the USA (both species are established in all five states; Winston et al. 2022)

in some parts of the Gulf Coast states. In managed systems, significantly less chemical controls are now needed (and much less frequently) to manage the weed. However, waterhyacinth remains a problem in other parts of this region.

In California, *N. bruchi* is the dominant species, and populations of *N. eichhorniae* are very small. However, *N. bruchi* appears to have only minor impacts in California, and populations in that region are likely limited by cold temperatures.

In Mexico, although both species are abundant, their impact is variable. In combination, they provide excellent control of waterhyacinth in some water bodies, but they have limited impact in others unless additional agents or control methods are utilized.

NONTARGET EFFECTS

Spillover attack was observed on the native pickerelweed (*Pontederia cordata*), canna lily (*Canna* spp.), and other native species intermixed with waterhyacinth in the USA, although this attack was insignificant and temporary. More recently, no nontarget attack has been observed in North America.

Niphograpta albiguttalis
Waterhyacinth moth

Niphograpta albiguttalis is a biological control agent approved in the USA for release against waterhyacinth.

SYNONYMS

Epipagis albiguttalis (Warren), *Sameodes albiguttalis* (Warren)

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Lepidoptera	Moths and butterflies
Family	Crambidae	Snout moths
Genus	*Niphograpta*	
Species	*Niphograpta albiguttalis* (Warren)	Waterhyacinth moth

DESCRIPTION

Eggs are small, spherical, and creamy-white. First-instar larvae have a brown body with dark spots and a dark brown head. Later instars are cream-colored with scattered dark brown spots and a dark orange head and can be up to 2 cm long (**Fig. 7a**). Adults are variable in coloration, and females are often darker than males. Adult forewings range from golden to brown, while the hindwings are more consistently golden. Light-colored segments make their abdomens appear ringed. There is often a distinct white spot midway along the leading edge of the forewing and a distinct dark spot near the center of the hindwing (**Fig. 7c**). Adults are typically 6–10 mm long with wingspans of 17–25 mm.

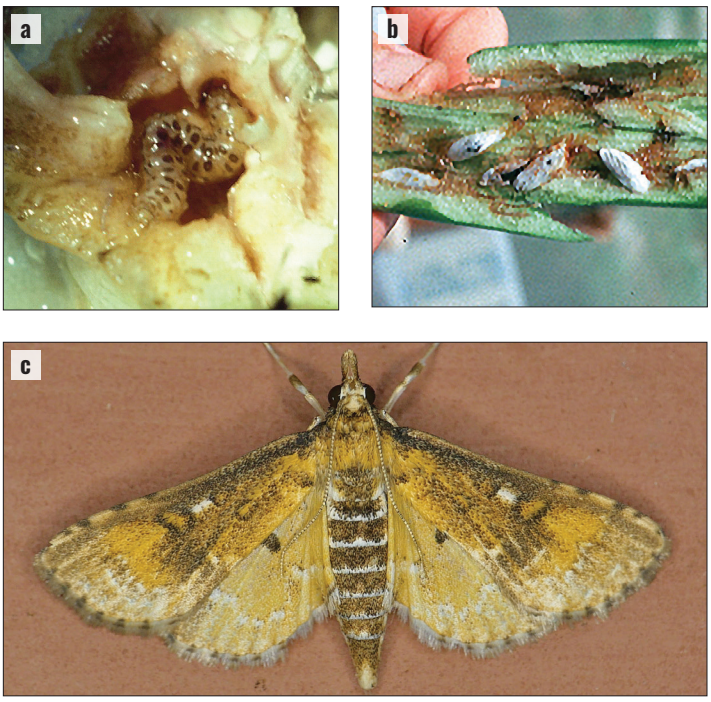

Figure 7. *Niphograpta albiguttalis* (a) larva and feeding damage; (b) pupae and larval feeding damage; (c) adult (a: Willey Durden, USDA-ARS, Bugwood.org CC BY-3.0 US; b: US Army Corps of Engineers, ERDC; c: Monica Krancevic, iNaturalist.org CC BY-NC 4.0)

LIFE CYCLE

This species is continuously brooded, creating frequent overlap of generations. In warm areas with temperatures above freezing, all stages can overwinter. Adults lay eggs (350–600 in a lifetime) singly or in small groups in leaf and petiole tissue, often in existing leaf injuries or feeding scars left by the *Neochetina* weevils. Larvae feed on leaf tissue through five instars, mining in petioles towards the root crown. Pupation occurs in cocoons within waterhyacinth petioles (**Fig. 7b**). Emerging adults are short-lived (up to 10 days), typically nocturnal, and can often be found resting on the undersides of waterhyacinth leaves. When adults emerge from leaf petioles, a glassy "window" is left covering the emergence tunnel.

DAMAGE

Larval tunneling in leaf petioles (**Fig. 8a**) causes a characteristic curling and browning of the affected leaf (**Fig. 8b**). Tunneling destroys shoot tips, preventing future growth. Attacked waterhyacinth stems often die or lose buoyancy and sink.

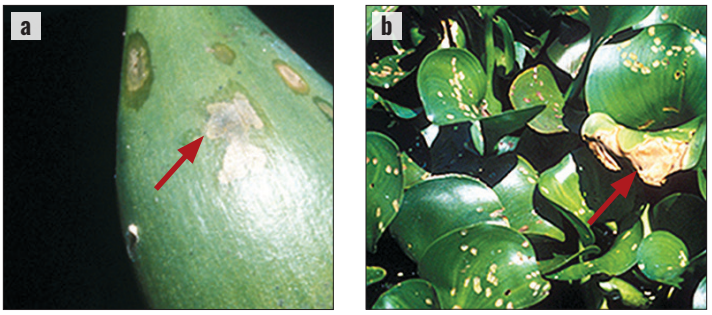

Figure 8. *Niphograpta albiguttalis* damage, red arrows (a) larval mining; (b) curling and browning of leaf caused by larval mining (a,b: US Army Corps of Engineers, ERDC)

FIELD IDENTIFICATION

Adult moths can be readily observed resting on the undersides of waterhyacinth leaves at night at sites where it is established. Alternatively, leaf petioles can be dissected to reveal the presence of mining larvae. In the absence of adults or larvae, the brown discoloration of waterhyacinth petioles (**Fig. 8a**) caused by larval mining and the resulting curling and browning of affected leaves (**Fig. 8b**) are good indications this moth is present. However, larvae of the native moth *Bellura densa* (see following section) also feed on waterhyacinth leaves and bore into stems.

PREFERRED HABITAT

The specific habitat requirements are unknown, although this species is most often observed wherever waterhyacinth populations remain persistent throughout the year. *Niphograpta albiguttalis* appears to prefer young waterhyacinth plants with bulbous petioles, as are typically found in more open infestations with less dense populations of waterhyacinth.

HISTORY AND CURRENT STATUS

Niphograpta albiguttalis is native to South America. A population sourced from Argentina was released in Florida, Louisiana, and Texas, USA beginning in 1977 and then redistributed to California in 1983. It failed to establish in California but supposedly established in the three Gulf Coast states (**Fig. 9**). The moth was first recorded in Mexico in 1993 where it was not intentionally released. Although its mode of entry to Mexico is unknown, it possibly spread naturally from neighboring Texas.

In the USA, the moth reportedly establishes quickly and causes significant damage to bulbous waterhyacinth stems locally before disappearing. However, it has rarely been observed in the most recent field surveys. Populations in Mexico were at one point regarded as high, although its impact in Mexico has never been determined.

NONTARGET EFFECTS

None reported in North America.

Figure 9. *Niphograpta albiguttalis* reported distribution in the USA (Winston et al. 2021)

NATIVE SPECIES

Bellura densa (=*Arzama densa*) (Lepidoptera: Noctuidae)

DESCRIPTION AND LIFE CYCLE

Adults are mottled tan, have a furry thorax, are up to 17 mm long, and have a wingspan of 35 mm (**Fig. 10a**). Females lay eggs in spring in masses on waterhyacinth leaves. Larvae feed on waterhyacinth leaves and bore into stems. Late instars are olive green with dark horizontal bands (**Fig. 10b**) and are

up to 5 cm long. Pupation occurs in cocoons in plant stems. There are two generations per year in southern regions. Larvae overwinter in waterhyacinth stems.

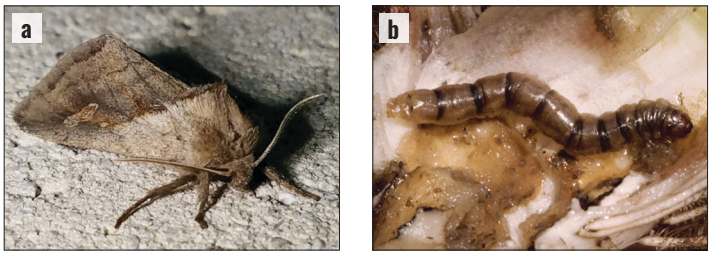

Figure 10. *Bellura densa* (a) larva; (b) adult (a: Stefan Neser, Bugwood.org, CC BY-3.0 US; b: Zoology123, iNaturalist.org CC BY-NC 4.0)

Figure 11. *Cercospora piaropi* necrotic lesions on waterhyacinth foliage (Freeman and Charudattan 1984)

HISTORY AND CURRENT STATUS

Bellura densa is native to the southeastern USA. It was redistributed in southern states in the 1970s–80s for control of waterhyacinth. High populations significantly reduce waterhyacinth cover and biomass in some ponds, but have little impact in others. Populations are greatly hindered by parasitism, predation, and disease. **This moth feeds on native or economically important species, including taro (*Colocasia esculenta*), pickerelweed (*Pontederia cordata*), and other species in the Araceae and Pontederiaceae, so it is not safe for redistribution.**

Cercospora piaropi (=*C. rodmanii*) (Dothideomycetes: Capnodiales)

DESCRIPTION

This pathogen reproduces only asexually via conidia (spores) which land on leaf surfaces and develop structures that grow inward, infecting leaf tissue. Infection sites are pale green at first but turn into dark necrotic spots as the surrounding tissue dies (**Fig. 11**). New conidia are produced on specialized structures that emerge from infected leaves, and the conidia are spread to new leaves by wind and the splashing of water. Infection kills waterhyacinth leaf tissue from the tip to the stem. New leaves are often produced to combat leaf loss. Under severe disease conditions, new leaves are killed faster than they can be replaced, and the entire plant dies. Disease symptoms can be found year-round in warm climates.

HISTORY AND CURRENT STATUS

This pathogen is native to North America and was intentionally redistributed in Florida and Louisiana in the 1970s for control of waterhyacinth. It has also been used to control waterhyacinth in reservoirs in Mexico. Extensive research was conducted on economical applications of this fungus, although it was never formally registered as a bioherbicide. In both the USA and Mexico, it is capable of decreasing waterhyacinth biomass, and in some instances has caused substantial decline of weed populations. Long-term success of this pathogen with only a single application is unlikely when waterhyacinth growth is rapid. Combined feeding by the *Neochetina* weevils and infection with this fungus has additive effects.

UNAPPROVED BIOCONTROL AGENTS

One accidentally introduced species is established on waterhyacinth in the USA. **It is not approved for use, and it is illegal to intentionally move this species to new areas in the USA.** Care should be taken when transferring approved agents to ensure that this unapproved species is not also included in transferred material.

Orthogalumna terebrantis (Acari: Galumnidae)

DESCRIPTION AND LIFE CYCLE

This species is continuously brooded, creating frequent overlap of generations. In warm areas with temperatures above freezing, all stages can overwinter. Adults lay tiny yellow eggs in damaged areas of waterhyacinth leaves. Nymphs and adults are brown, becoming shiny and nearly black with maturity (**Fig. 12**). Adults are teardrop-shaped and less than 1 mm long, appearing as small black dots on waterhyacinth leaves. Feeding mites produce characteristic feeding tunnels between leaf veins. The tunnels are long (5–10 mm) and thin (**Fig. 12**) and extend towards the tip of the leaf. There may be three generations per year.

HISTORY AND CURRENT STATUS

Orthogalumna terebrantis was recorded in Florida and Louisiana, USA by 1968. It is widespread in these states, but

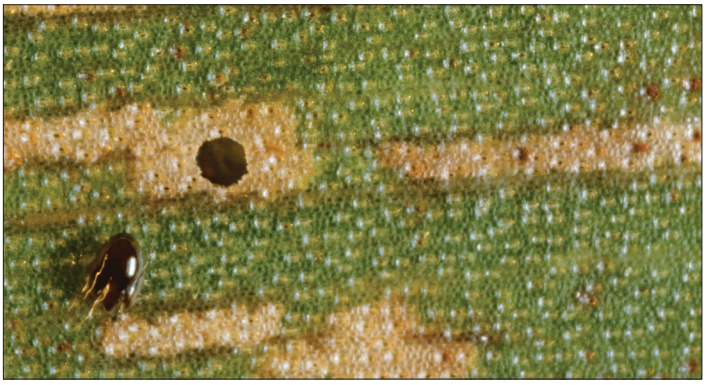

Figure 12. *Orthogalumna terebrantis* adult and characteristic feeding tunnels (Willey Durden, USDA-ARS, Bugwood.org CC BY-3.0 US)

its populations are sporadic, and it provides no substantial control on its own. However, in combination with *Neochetina eichhorniae*, the mite can significantly reduce size and density of waterhyacinth in natural situations locally. **It is not approved for redistribution in the USA.**

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NAISMA is a network of professionals challenged by invasive species: land managers, water resource managers, state, regional, and federal agency directors and staff, researchers, and nonprofit organizations. NAISMA's members are a diverse group of individuals and organizations who are involved in implementing invasive species management programs at all scales. Our mission is to support, promote, and empower invasive species prevention and management in North America. Our vision is to have North America's lands and waters protected from invasive species. NAISMA's programs aim to provide the support, training, and standards needed by the professional invasive species management community.

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