HISTORY AND ECOLOGY IN NORTH AMERICA

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Agasicles hygrophila
Alligatorweed flea beatle

Agasicles hygrophila is a biological control agent approved in the USA for release against alligatorweed.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Chrysomelidae	Leaf beetles
Genus	*Agasicles*	
Species	*Agasicles hygrophila* Selman & Vogt	Alligatorweed flea beetle

DESCRIPTION

Eggs are cylindrical and pale yellow at first (**Fig. 1a**), but the head capsules of larvae become visible when they are close to hatching. Larvae are yellow initially (**Fig. 1b**), turning dark gray or nearly black as they age (**Fig. 1c,d**). Larvae can be up to 6 mm long and have brown or black head capsules. Pupae are cream-colored initially but darken with age. Adults are 4–6 mm long and black with four yellow-gold longitudinal stripes (two on each elytra; **Fig. 1e**). Adults have enlarged hind femurs (**Fig. 1f**), enabling them to jump large distances. Females are slightly larger than males.

LIFE CYCLE

Adults emerge in early spring and begin mating and ovipositing; females lay an average of 1,100 eggs during their lifetime. Eggs are deposited in two rows (12–54 eggs per cluster) on the undersides of alligatorweed leaves (**Fig. 1a**). Larvae feed on leaf tissue, often leaving transparent feeding "windows" (**Fig. 2a**). Larvae develop through three instars prior to chewing into alligatorweed stems (**Fig. 2b**). Pupation occurs within the plant stems. Adults emerge and feed on alligatorweed leaves and stems (**Fig. 2c**). There are 4–6 generations per year. Last generation adults overwinter among roots and stems of alligatorweed along water body margins.

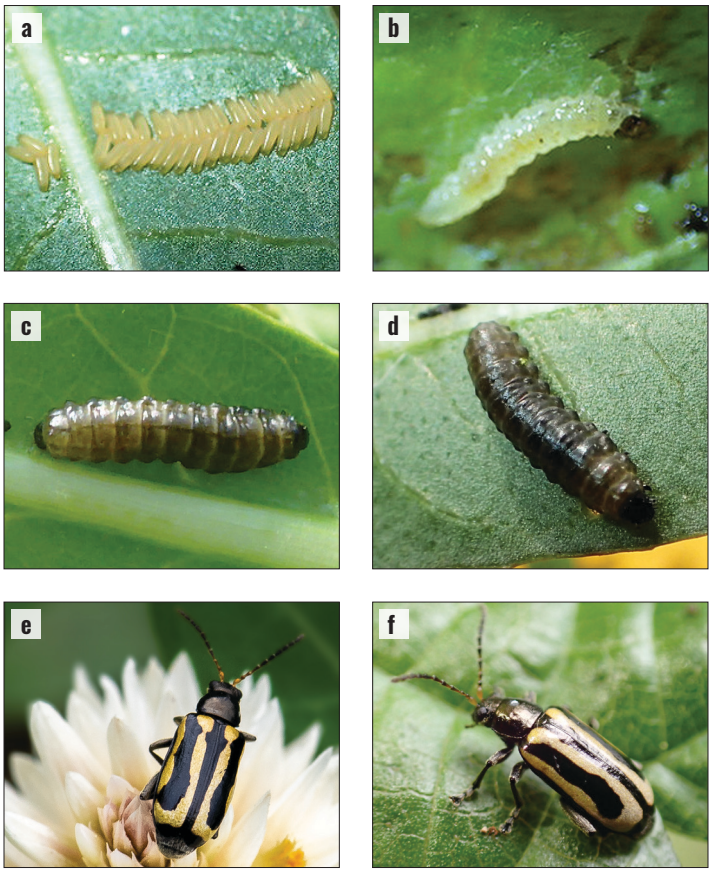

Figure 1. *Agasicles hygrophila* (a) eggs; (b) early-instar yellow larva; (c) middle-instar gray larva; (d) late-instar dark gray larva; (e) pupa; (f) adult (a–d: Marylyn Feaver, iNaturalist.org CC BY 4.0; e: Joan Costanza, iNaturalist.org CC BY 4.0; f: Orange_papa, iNaturalist.org CC BY-NC 4.0)

DAMAGE

Larval and adult feeding on leaves and stems is often severe (**Fig. 2d,e**), leading to eventual submergence of the floating mat and clearing waterways.

FIELD IDENTIFICATION

Adult *A. hygrophila* flea beetles are the most easily recognizable stage and are conspicuous with their black bodies with yellow-gold longitudinal striping (**Fig. 1e,f**). Where established, they

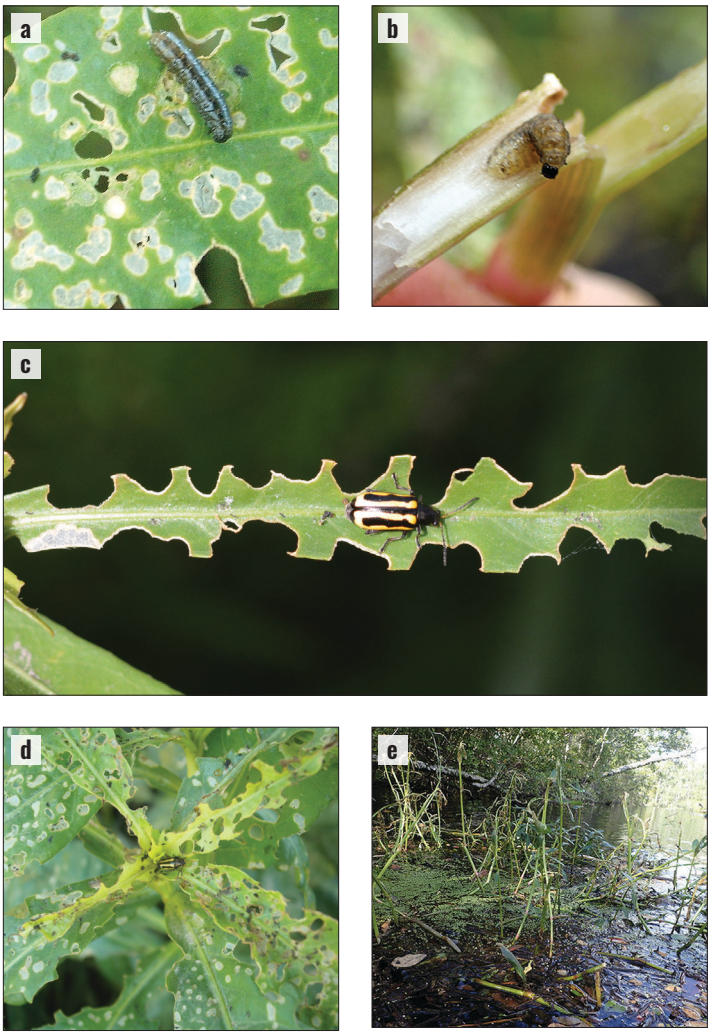

Figure 2. *Agasicles hygrophila* (a) larval leaf-feeding damage; (b) larva mining stem; (c) adult feeding damage; (d,e) combined larval and adult feeding damage (a,b,e: Marylyn Feaver; c: Amber M. King [a,b,c,e: iNaturalist.org CC BY 4.0]; d: Stephen Thorp, iNaturalist.org CC BY-NC 4.0)

can be observed feeding and ovipositing on alligatorweed foliage from spring through fall. Larvae can also be observed feeding on alligatorweed during this time period. Two other approved biological control agents are established on alligatorweed in the USA (the moth *Macrorrhinia endonephele* and the thrips *Amynothrips andersoni*), though both can be readily differentiated from the flea beetle in all life stages and by their distinctive feeding damage. Although early instars of both the flea beetle (**Fig. 1b**) and the moth (**Fig. 6b**) are yellowish, the moth larvae are much larger. In later instars, the flea beetle larvae are nearly black (**Fig. 1d**) while the moth larvae are brown with several longitudinal wavy stripes (**Fig. 6c**). The thrips is less than 2 mm long and should not be confused with either. The damage of all three species is distinct. Plants attacked by the flea beetle will show heavy feeding damage in the form of "windows" and chew holes (**Fig. 2a,c,d**). Those heavily attacked by the moth will wilt and turn yellow as they die (**Fig. 7**), eventually sinking. Plants attacked by the thrips are stunted and have deformed leaves and tips (**Fig. 4c**), but they lack the obvious feeding windows and large chew holes caused by the flea beetle.

PREFERRED HABITAT

Agasicles hygrophila attacks both forms of alligatorweed, though pupation is often limited on the terrestrial form because of its smaller, denser stems. The beetle overwinters only in warmer locations, but it extends its range into colder locations during summer and autumn. Hot, dry summers reduce beetle populations at some locations.

HISTORY AND CURRENT STATUS

Agasicles hygrophila is native to South America. Beetles from Uruguay and Argentina were released on alligatorweed in California and the southeastern USA beginning in 1964. Beetles sourced from the southernmost part of the species' range in Argentina were later released in the southeastern USA in 1979 in an attempt to increase cold tolerance.

Agasicles hygrophila failed to establish in California. Releases in the southeastern USA successfully established, but there is no evidence that beetles from the later release have performed any better than those released initially. Although *A. hygrophila* has been recorded in nine states (**Fig. 3**), its overall abundance varies by location and season. Releases at more northern sites in North Carolina, Arkansas, and Tennessee all failed to establish. Records of *A. hygrophila* being present at northern sites are due to annual reintroductions from Florida stock and from beetles migrating from warmer overwintering sites at southern locations each spring. Throughout its established range, populations peak early in the season then decline due to reduced fecundity associated with high temperatures and decreasing foliar nitrogen in host plants. The impact of *A. hygrophila* is likewise variable. It is highly successful in northern Florida and warmer coastal areas where insects can

Figure 3. *Agasicles hygrophila* reported distribution in North America (Winston et al. 2021)

overwinter, but populations are variable elsewhere. It is not effective against the terrestrial form of alligatorweed.

NONTARGET EFFECTS

None reported in North America

Amynothrips andersoni
Alligatorweed thrips

Amynothrips andersoni is a biological control agent approved in North America for release against alligatorweed.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Thysanoptera	Thrips
Family	Phlaeothripidae	
Genus	*Amynothrips*	
Species	*Amynothrips andersoni* O'Neill	Alligatorweed thrips

DESCRIPTION

Eggs are elongated and yellow at first but turn reddish with age. Nymphs are up to 2 mm long. The first nymphal stage is pale yellow, but nymphs turn increasingly orange to red with black legs through subsequent stages (**Fig. 4a**). Adults can be either wing-less or winged (with fringed wings). Most winged forms have only short wings and are flightless; long-winged forms are uncommon. Adults are 2 mm long and black with black legs and antennae (**Fig. 4b**).

LIFE CYCLE

Eggs are laid singly (an average of 200 per female) on hairs at alligatorweed stem nodes. Unmated females produce all males, but females that are fertilized produce equal amounts of male and female progeny. Adults and nymphs feed on new growth of alligatorweed leaves and stems. There are multiple overlapping generations per year; 4–5 generations have been observed in the native range. All stages can overwinter, though the most common overwintering stage is adult.

DAMAGE

Nymphs and adults puncture alligatorweed leaves and stems and suck out cell contents. Feeding causes leaf and tip deformation (**Fig. 4c**) which stunts plants. This typically does not kill plants so the overall impact is not severe.

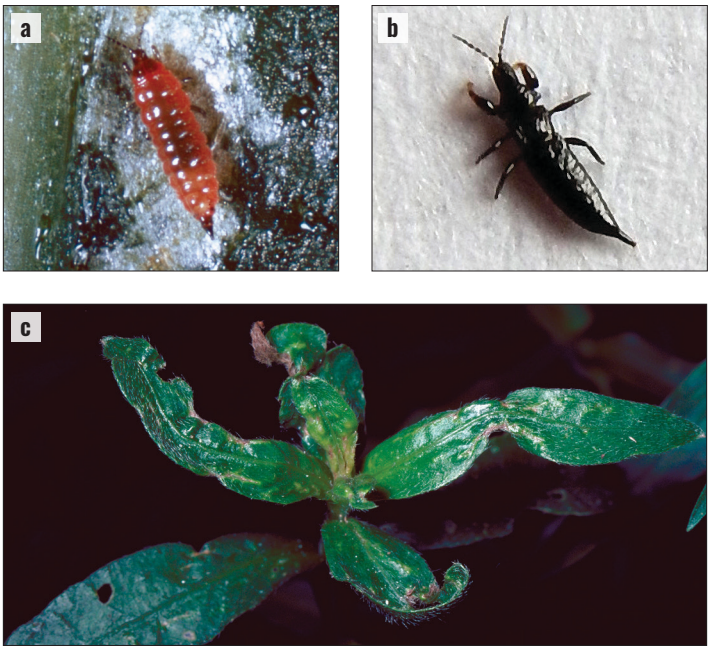

Figure 4. *Amynothrips andersoni* (a) second-instar nymph; (b) adult; (c) feeding damage (a: USDA ARS, Bugwood.org CC BY-3.0 US; b: Drashash, iNaturalist.org CC BY-NC 4.0; c: Gary Buckingham USDA ARS, Bugwood.org CC BY-3.0 US)

FIELD IDENTIFICATION

Two other approved biological control agents are established on alligatorweed in the USA (*Agasicles hygrophila* and *Macrorrhinia endonephele*), though adults of both can be readily differentiated from *A. andersoni* by being flea beetles and moths, respectively. Nymphs and adults of the thrips are tiny (≤2 mm long) with very slender bodies while the larvae of the flea beetle (**Fig. 1b–d**) and moth (**Fig. 6b,c**) are much larger. The damage of all three species is distinct. Plants attacked by the flea beetle will show heavy feeding damage in the form of "windows" and chew holes (**Fig. 2a,c,d**). Those heavily attacked by the moth will wilt and turn yellow as they die (**Fig. 7**), eventually sinking. Plants attacked by the thrips are stunted and have deformed leaves and tips (**Fig. 4c**), but they lack the obvious feeding windows and large chew holes caused by the flea beetle.

PREFERRED HABITAT

This thrips attacks both the aquatic and terrestrial forms of alligatorweed and is the most cold tolerant of established alligatorweed biocontrol agents. Thrips populations are highest where *Agasicles hygrophila* beetle populations are low.

HISTORY AND CURRENT STATUS

Amynothrips andersoni is native to South America. Thrips from Argentina were released on alligatorweed in several southeastern states in the USA beginning in 1967 and the species has since been recorded established in nine states (**Fig. 5**). It was initially the least widespread of the three alligatorweed biocontrol agents released in the USA but has

always been the most cold tolerant and the only species to impact the terrestrial form of alligatorweed. Competition from the flea beetle limits populations and impacts in southern and/or warmer climates. In northern and/or colder climates where flea beetles do not thrive, thrips populations are higher, leading to significant control of alligatorweed at some sites. Predation limits populations at some locations.

NONTARGET EFFECTS

None reported

Figure 5. *Amynothrips andersoni* reported distribution in the USA (Winston et al. 2021)

Macrorrhinia endonephele

Alligatorweed stem borer

Macrorrhinia endonephele is a biological control agent approved in the USA for release against alligatorweed.

SYNONYMS

Arcola malloi (Pastrana), *Vogtia malloi* Pastrana

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Lepidoptera	Moths and butterflies
Family	Pyralidae	Snout moths
Genus	*Macrorrhinia*	
Species	*Macrorrhinia endonephele* (Hampson)	Alligatorweed stem borer

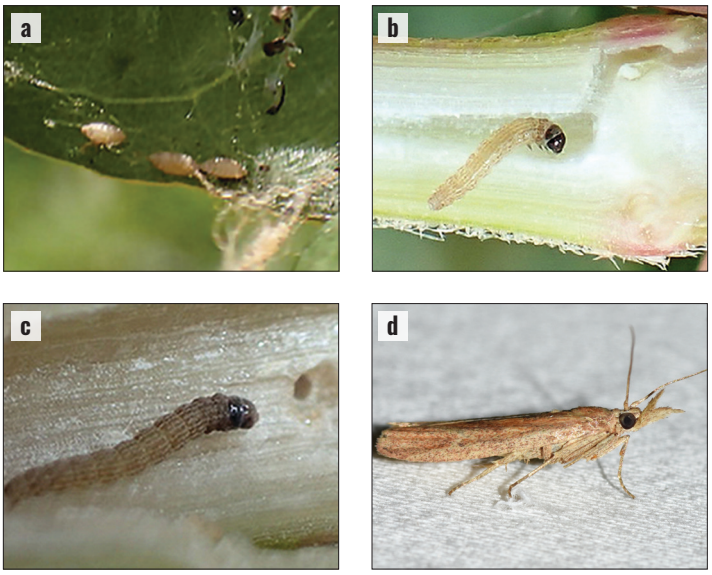

Figure 6. *Macrorrhinia endonephele* (a) eggs; (b) early-instar yellow larva; (c) late-instar brown larva; (d) adult (a–c: Marylyn Feaver, iNaturalist.org CC BY 4.0; d: Erik Johnson, iNaturalist.org CC BY-NC 4.0)

DESCRIPTION

Eggs are white and oval-shaped (**Fig. 6a**). Larvae are white to yellow initially (**Fig. 6b**), appearing brown at maturity because of several tan, longitudinal, wavy stripes (**Fig. 6c**). Final instars are up to 14 mm long. Pupae are found in silken cocoons and turn from yellow to dark brown with age. Adult moths hold their wings tightly against their bodies; they are 13–14 mm long with a wingspan of 20 mm. Forewings are tan to brown with mottled markings (**Fig. 6d**). Adults have large "snouts" covered in scales as well as large dark eyes.

LIFE CYCLE

Adults emerge in spring, and females lay eggs singly at leaf axils or on the undersides of alligatorweed leaves (**Fig. 6a**). A single female may lay an average of 260 eggs in her lifetime. Larvae bore into stem tips and mine downwards, feeding on stem tissue through five instars (**Fig. 6b**). At maturity, larvae plug stem nodes beneath them with chewed tissue in order to seal out water and prepare adult exit "windows" by chewing stem tissue but leaving the epidermis intact. Larvae spin cocoons in which to pupate, and adults emerge through exit windows. In North America, the number of generations per year is unknown; 3–4 generations per year have been observed in the native range. Last generation larvae overwinter in alligatorweed stems and pupate the following spring.

DAMAGE

Larval mining causes stems to wilt (**Fig. 7a**) and eventually die, turning yellow as they do so (**Fig. 7b**). Entire mats often turn yellow and sink (**Fig. 7c**).

Figure 7. *Macrorrhinia endonephele* stem mining causes alligatorweed plants to (a,b) wilt and (c) turn yellow as they die. Attacked mats eventually sink (a: Marylyn Feaver, iNaturalist.org CC BY 4.0; b,c: USDA ARS, Bugwood.org CC BY-3.0 US)

FIELD IDENTIFICATION

Adult *M. endonephele* are the most easily recognizable stage and are conspicuous moths with their tan wings and bodies, large snouts, and large dark eyes (**Fig. 6d**). Where established, they can be observed ovipositing on alligatorweed foliage from spring through fall. Larvae can also be observed feeding on alligatorweed during this time period, though feeding is internal (**Fig. 6b**) so stems must be dissected. Two other approved biological control agents are established on alligatorweed in the USA (the flea beetle *Agasicles hygrophila* and the thrips *Amynothrips andersoni*), though both can be readily differentiated from the moth in all life stages and by their distinctive feeding damage. Although early instars of both the moth (**Fig. 6b**) and the flea beetle (**Fig. 1b**) are yellowish, the moth larvae are much larger. In later instars, flea beetle larvae are nearly black (**Fig. 1d**) while the moth larvae are brown with several longitudinal wavy stripes (**Fig. 6c**). The thrips is less than 2 mm long and should not be confused with either of the other species. The damage of all three species is distinct. Plants heavily attacked by the moth will wilt and turn yellow as they die (**Fig. 7**), eventually sinking. Plants attacked by the flea beetle will show heavy feeding damage in the form of "windows" and chew holes (**Fig. 2a,c,d**). Those attacked by the thrips are stunted and have deformed leaves and tips (**Fig. 4c**), but they lack the obvious feeding windows and large chew holes caused by the flea beetle.

PREFERRED HABITAT

Macrorrhinia endonephele is most commonly found on mats of the aquatic form of alligatorweed, though plants of the terrestrial form are also occasionally attacked. It overwinters only in warmer locations but extends its range into colder locations during summer and autumn.

HISTORY AND CURRENT STATUS

Macrorrhinia endonephele is native to South America. Moths from Argentina were released on alligatorweed in a handful of southeastern states in the USA beginning in 1971. After establishment, they dispersed naturally to neighboring states and have since been recorded in nine total (**Fig. 8**). Larval burrowing causes stem collapse and waterlogging. The moth is a useful adjunct to (but possibly not as good a competitor as) the flea beetle *Agasicles hygrophila*. The moth contributes effectively to control in Mississippi and Florida, as well as in Texas when populations are not limited by adverse conditions. It has an excellent potential for spread, as individual dispersal has been observed up to 620 miles (1,000 km) in a single year. It most likely overwinters in warmer coastal areas and migrates to inland infestations. This moth is most effective against floating plant mats; damage to the terrestrial form is minimal.

Figure 8. *Macrorrhinia endonephele* reported distribution in the USA (Winston et al. 2021)

NONTARGET EFFECTS

Though alligatorweed is the primary host of this moth, late-instar larvae may occasionally feed on the native *Blutaparon vermiculare* and the native *Alternanthera flavescens*.

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SUGGESTED CITATION

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