HISTORY AND ECOLOGY IN NORTH AMERICA

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Bangasternus orientalis
Yellow starthistle bud weevil

Bangasternus orientalis is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Curculionidae	Weevils
Genus	*Bangasternus*	
Species	*Bangasternus orientalis* Capiomont	Yellow starthistle bud weevil

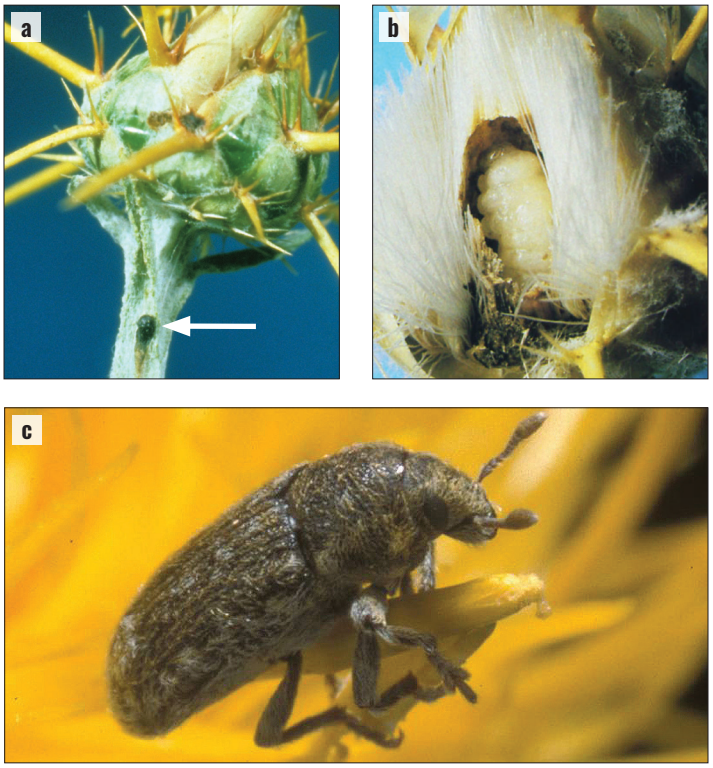

Figure 1. *Bangasternus orientalis* (a) egg on plant stem (white arrow); (b) larva in seed head; (c) adult (a: University of Idaho Archives, Bugwood.org, CC BY-3.0 US; b: California Department of Agriculture; c: Laura Parsons & Mark Schwarzländer, University of Idaho)

DESCRIPTION

Eggs are tiny yellow spheres covered with dark egg caps (**Fig. 1a**). Larvae are up to 6 mm long with white, C-shaped bodies and brown head capsules (**Fig. 1b**). Adults are 4–6 mm long with somewhat flattened, cylinder-shaped bodies and short snouts (**Fig. 1c**). Adult bodies are brown with yellow-white hairs that give them a mottled appearance.

LIFE CYCLE

Overwintering adults resume activity in spring when yellow starthistle is bolting. Females lay eggs singly on leaflets or the stem just below buds (**Fig. 1a**). They may lay up to 470 eggs in a lifetime. Eggs are covered with a dark, protective substance. Larvae hatch in late spring and tunnel through the stem to reach the developing flower head where they feed on bracts, receptacle tissue, and developing seeds. Larvae grow through four instars; the first instar mines the stem and bracts of the

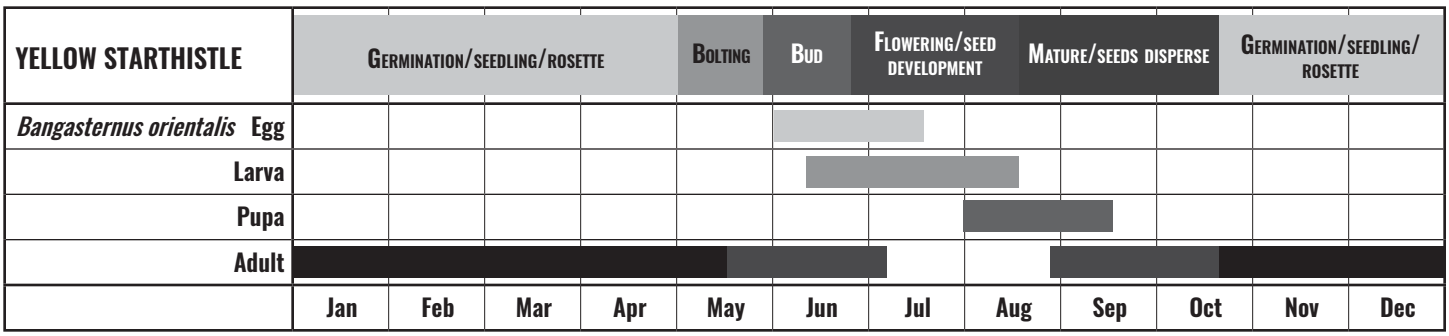

Figure 2. Schematic life cycles of *Bangasternus orientalis* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There is typically one generation per year.

flower head while instars 2–4 occur inside the head and feed on the developing seeds. Pupation occurs within seed heads in a chamber made of damaged seed and receptacle tissue. Adults emerge in late summer and overwinter in soil litter. There is one generation per year (**Fig. 2**).

DAMAGE

Though adults feed on yellow starthistle stem wings and leaves, the feeding is superficial and does not significantly damage the plant. Larvae feed on seed head tissue and developing seeds. Seed consumption does not kill existing plants, but reduces seed production which may help decrease the rate of spread of yellow starthistle populations and may reduce infestations in some habitats.

FIELD IDENTIFICATION

Adult *Bangasternus orientalis* may be observed on yellow starthistle flower heads and stems throughout spring and early summer and again in late summer. After laying eggs at the base of yellow starthistle flower heads, females cover the eggs with a dark protective material. These covered eggs are readily visible to the naked eye (**Fig. 1a**). Larval feeding is not readily visible unless flower heads are dissected (**Fig. 1b**).

Three other introduced beetle and three introduced fly species also feed on yellow starthistle in North America. These are listed in **Table 1**, along with key diagnostic traits that help differentiate their adults from *B. orientalis* and from each other.

PREFERRED HABITAT

This weevil initially established throughout most yellow starthistle infestations in the western USA, indicating it is well adapted to a variety of conditions. It appears to do better at mid-elevation sites where the weevil *Eustenopus villosus* is not already established or abundant.

HISTORY AND CURRENT STATUS

Bangasternus orientalis is native to Europe, Western Asia, and the Mediterranean. A population sourced from Greece was released in California, USA beginning in 1985 and subsequently in other western states. Following establishment, attempts were made to redistribute the weevil to Iberian starthistle (*Centaurea iberica*) and Malta starthistle (*Centaurea melitensis*) in California in 1994; however, the weevil failed to establish on either weed species.

Bangasternus orientalis is reported to be established in five states in the western USA (**Fig. 3**). Larval feeding typically destroys 60% of seeds within attacked seed heads. It was initially the most widespread of established biocontrol agents. However, densities of the weevil have been declining since their peak a few years after their original release. The current attack rate is usually less than 15% of available seed heads. Predation, parasitism, and displacement by other established biocontrol agents limit populations in many areas.

NONTARGET EFFECTS

None reported in North America.

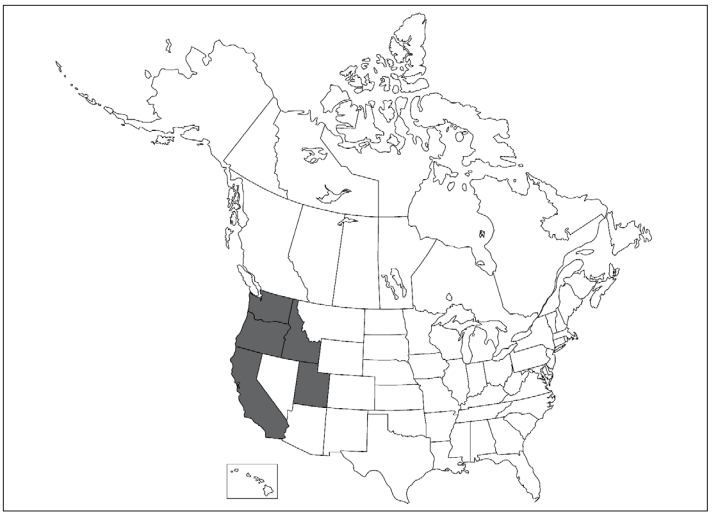

Figure 3. *Bangasternus orientalis* reported distribution in North America (Winston et al. 2023)

Ceratapion basicorne

Yellow starthistle rosette weevil

Ceratapion basicorne is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Brentidae	Weevils
Genus	*Ceratapion*	
Species	*Ceratapion basicorne* (Illiger)	Yellow starthistle rosette weevil

DESCRIPTION

Eggs are oval, smooth, and a translucent light yellow at first, turning darker with age (**Fig. 4a**). Larvae (**Fig. 4b**) are creamy white with dark brown head capsules and are typically less than 3 mm long. Adults are small (2–2½ mm long), teardrop-

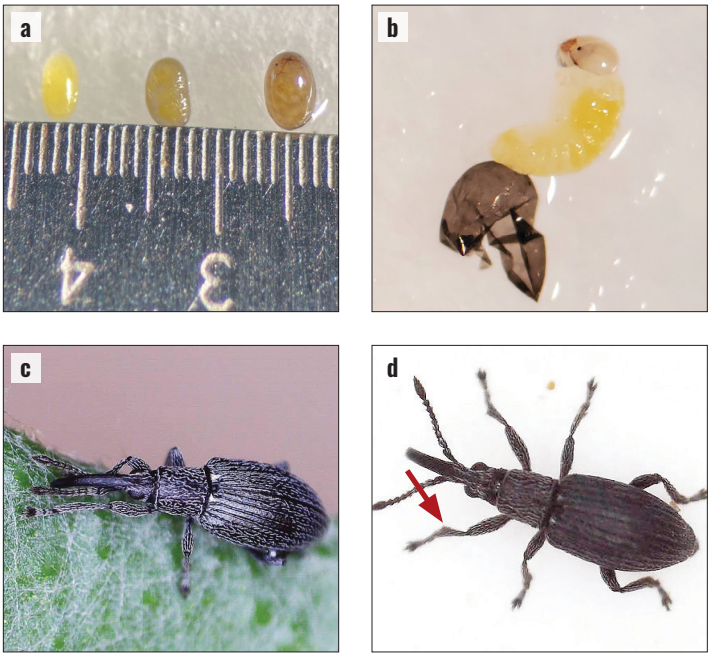

Figure 4. *Ceratapion basicorne* (a) eggs in increasing stages of development from left to right; (b) freshly hatched larva; (c) adult female; (d) adult male with an enlarged ridge or crest on the protibia (red arrow), which females lack (a–d: Kristi Gladem and Kelly Hanrahan, Colorado Department of Agriculture, Palisade Insectary)

shaped, and have long curved snouts. They are black with blue-green metallic elytra and black to reddish legs (**Fig. 4c**). Males have an enlargement on the protibia (**Fig. 4d**) which females lack.

LIFE CYCLE

Overwintering adults emerge in early spring (**Fig. 5**) and feed on yellow starthistle rosette leaves. Eggs are deposited singly inside the midrib or blade of rosette leaves. Hatching larvae tunnel down the leaf midrib into the root crown, feeding on plant tissue and developing through three instars. Pupation occurs in the root crown in late spring/early summer. Adults emerge in early summer and feed on leaves for about two weeks, then they leave the plant to overwinter in sheltered areas. There is only one generation per year. Multiple larvae have been found feeding within the same plant.

DAMAGE

Adults feeding on yellow starthistle foliage leave characteristic feeding windows in leaf blades (**Fig. 6a**). Adult damage is typically superficial and does not do any appreciable damage. Heavy larval feeding (**Fig. 6b**) can result in stunted plant growth and a reduction in seed production.

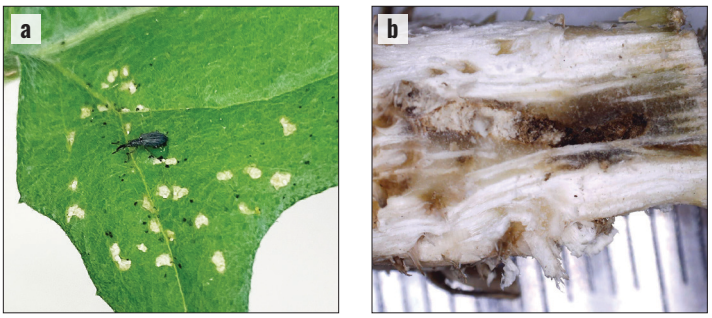

Figure 6. *Ceratapion basicorne* (a) adult feeding, leaving characteristic windows in a yellow starthistle leaf blade; (b) larval mining tunnel and pupation chamber within a yellow starthistle root crown (a,b: Kristi Gladem and Kelly Hanrahan, Colorado Department of Agriculture, Palisade Insectary)

FIELD IDENTIFICATION

Tiny black *Ceratapion basicorne* adults (**Fig. 4c,d**) can be observed resting on the undersides of yellow starthistle leaves in early spring and on bolting plants in early summer. Adult feeding windows (**Fig. 6a**) may be present on yellow starthistle leaf blades or leaf midribs. Larvae and their mining damage are not readily visible unless plant leaves and root crowns are dissected (**Fig. 6b**). Three other introduced beetle species feed on yellow starthistle in North America, but only on the flower heads or stem wings. These are listed in **Table 1**, along with key diagnostic traits that help differentiate their adults from *C. basicorne* and from each other.

PREFERRED HABITAT

Though it is too soon to determine any trends in habitat preferences of this weevil in the USA, *Ceratapion basicorne* has been considered one of the most ubiquitous and abundant species present on yellow starthistle in Europe, indicating it is well adapted to a variety of conditions.

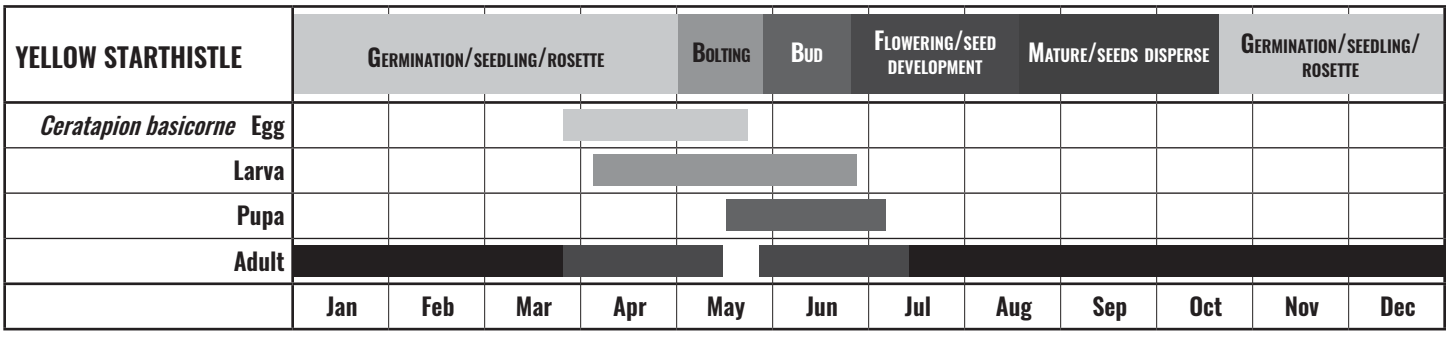

Figure 5. Schematic life cycles of *Ceratapion basicorne* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There is typically one generation per year.

HISTORY AND CURRENT STATUS

Ceratapion basicorne is native to Europe and the Mediterranean. A population sourced from Greece was released in California, USA from 2020 through 2022 and in Idaho in 2023. Although it is too early to confirm its field establishment (**Fig. 7**), early results are encouraging.

NONTARGET EFFECTS

None reported in North America.

Figure 7. *Ceratapion basicorne* was only recently (2020 and later) released in North America, and it is too early to confirm successful field establishment (Winston et al. 2023)

Chaetorellia australis
Yellow starthistle peacock fly

Chaetorellia australis is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Diptera	Flies
Family	Tephritidae	Fruit flies
Genus	*Chaetorellia*	
Species	*Chaetorellia australis* Héring	Yellow starthistle peacock fly

DESCRIPTION

Eggs are elongated and white or pale yellow. Larvae are somewhat barrel-shaped (though slightly thicker at one end) and up to 4 mm long. They are white, turning yellowish with maturity, and they lack an obvious head capsule (**Fig. 8a**). Pupae are concealed in a barrel-shaped puparium up to 3½ mm long and are pale yellow with dark ends. Adults have tan bodies with eight black spots on the thorax (**Fig. 8b**). Their eyes are multi-colored and metallic, and their wings are clear with thick brown bands (**Fig. 8b**). Males are 3–4 mm long; females are 4–6 mm, including ovipositors.

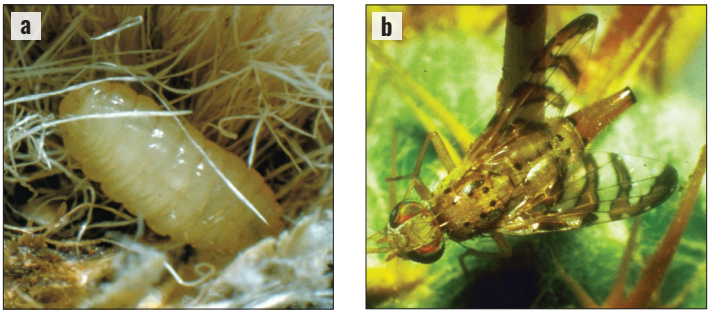

Figure 8. *Chaetorellia australis* (a) larva feeding within a yellow starthistle seed head; (b) adult (a: Gary Piper, Washington State University, Bugwood.org CC BY-3.0 US; b: Charles Turner, USDA ARS, Bugwood.org CC BY-3.0 US)

LIFE CYCLE

Adults emerge in spring before yellow starthistle has begun to bolt (**Fig. 9**). Adults often feed on nectar of vetch (*Vicia* spp.) or other plants with early developing flowers while waiting for their target plants to develop to the appropriate stage for oviposition. Adult females lay eggs singly beneath bracts of closed buds. After hatching, larvae tunnel into seed heads and feed on receptacle tissue and developing seeds through three instars. Pupation occurs in puparia within flower heads inside chambers made of pappus and chewed seeds. Adults emerge in early to midsummer, mate, and lay eggs in more starthistle buds. Mature larvae of the summer generation overwinter within yellow starthistle seed heads. There are usually two generations per year, though three generations are possible where the growing season is sufficiently long.

Chaetorellia australis will frequently oviposit in buds of the earlier-flowering invasive weed bachelor's button (*Centaurea cyanus*); adults emerging as part of the next generation will then utilize yellow starthistle.

DAMAGE

Larvae feed on developing seeds. Seed consumption does not kill existing plants, but reduces seed production which may help decrease the rate of spread of yellow starthistle populations and may reduce infestations in some habitats.

FIELD IDENTIFICATION

Adult *Chaetorellia australis* may be observed on yellow starthistle plants throughout spring and summer. Feeding

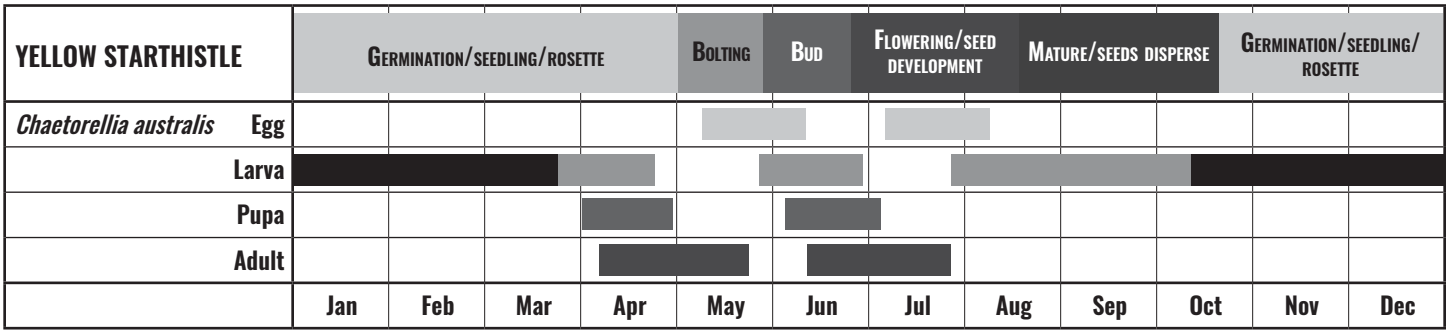

Figure 9. Schematic life cycles of *Chaetorellia australis* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There are typically two generations per year, though sometimes three where growing seasons are long.

larvae are not readily visible unless seed heads are dissected, at which point the cream-colored larvae can be observed feeding on receptacle tissue and seeds (**Fig. 8a**). Multiple larvae may be present in the same seed head.

The very closely related *Chaetorellia succinea* (see **pg. 12**) was accidentally introduced to North America along with populations of *C. australis*. *Chaetorellia succinea* is similar in nearly all aspects aside from having 10 spots on its thorax instead of the eight present on *C. australis* (**Fig. 10a,b, Fig. 25a**). The spring generation of *C. succinea* also becomes active slightly later in the season compared to *C. australis*. One other introduced fly species (*Urophora sirunaseva*) and three additional introduced beetle species feed within yellow starthistle seed heads in North America. These are listed in **Table 1**, along with key diagnostic traits that help differentiate their adults from *C. australis* and from each other.

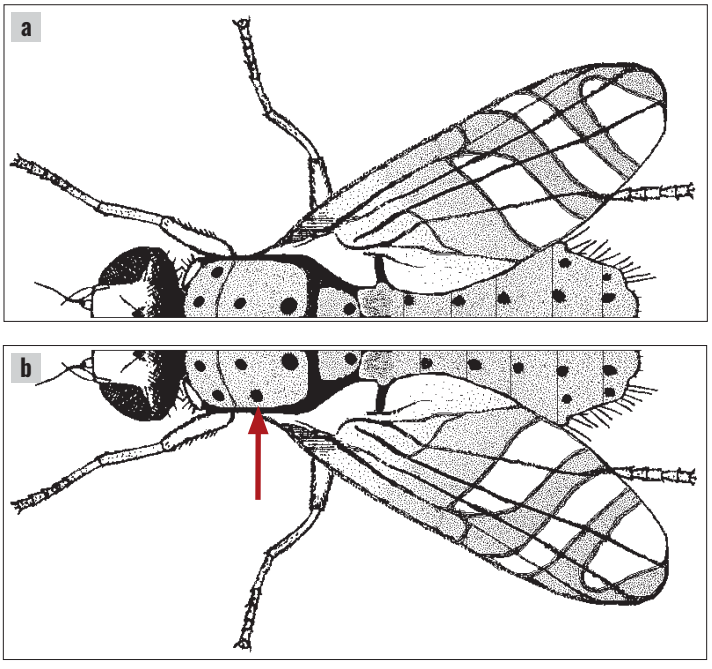

Figure 10. Line drawings of (a) *Chaetorellia australis* and (b) *C. succinea* illustrating the extra spot (red arrow) on each half of the thorax of *C. succinea* (J. Johnson, University of Idaho)

PREFERRED HABITAT

Chaetorellia australis does best where bachelor's button (*Centaurea cyanus*) co-occurs with yellow starthistle. It also prefers warm and low-elevation sites.

HISTORY AND CURRENT STATUS

Chaetorellia australis is native to Europe and the Mediterranean. A population sourced from Greece was released in California, USA beginning in 1988 and subsequently in other western states.

Chaetorellia australis is reportedly established in four states in the western USA (**Fig. 11**) and attacks both yellow starthistle and the invasive bachelor's button (*Centaurea cyanus*). The abundance of this fly varies, often in relation to bachelor's button presence. Attack rates are typically higher on bachelor's button, on which it can reduce seed production by up to 70% in Washington. Although it has been observed destroying up to 90% of seeds in attacked yellow starthistle seed heads, attack rates have typically not exceeded 10% of available seed heads, likely due to poor synchrony in spring.

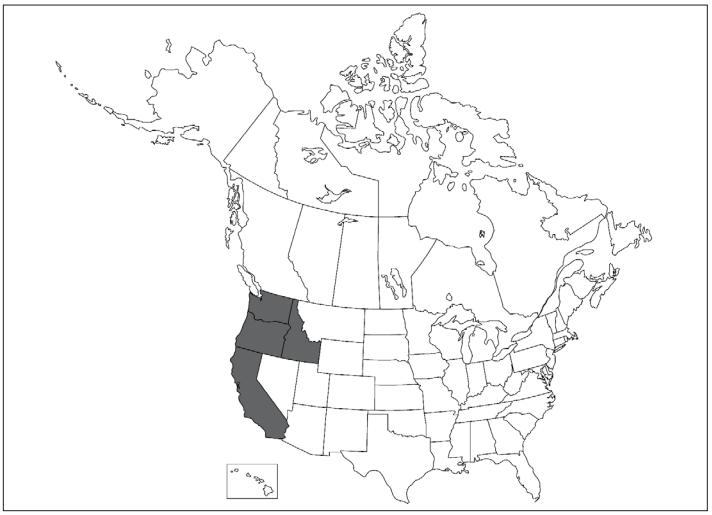

Figure 11. *Chaetorellia australis* reported distribution in North America (Winston et al. 2023)

NONTARGET EFFECTS

The first generation of *Chaetorellia australis* readily attacks the invasive weed bachelor's button (*Centaurea cyanus*) in North America.

Eustenopus villosus
Yellow starthistle hairy weevil

Eustenopus villosus is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Curculionidae	Weevils
Genus	*Eustenopus*	
Species	*Eustenopus villosus* (Boheman)	Yellow starthistle hairy weevil

DESCRIPTION

Eggs are translucent, oval, and tiny (**Fig. 12a**). Larvae are up to 6 mm long with white, C-shaped bodies and brown head capsules (**Fig. 12b**). Pupae are typically creamy white with obvious appendages and a long snout (**Fig. 12c**). Adults are 4–6 mm long with oblong, cylindrical bodies and long, slender snouts (**Fig. 12d**). Adult bodies are brown with lighter-colored longitudinal stripes and are covered with long hairs.

LIFE CYCLE

Overwintering adults emerge in spring when yellow starthistle is bolting (**Fig. 13**). They feed heavily on early immature starthistle buds. Females chew holes in the sides of mature, closed buds (pre-flower) in early to midsummer, lay eggs inside, and cap holes with a dark substance (**Fig. 14a**). Larvae hatch throughout summer and feed on developing seeds through three instars. Pupation occurs in seed heads in chambers made of damaged seed and receptacle tissue (**Fig. 14b**). Adults emerge in late summer and overwinter in soil litter. There is one generation per year.

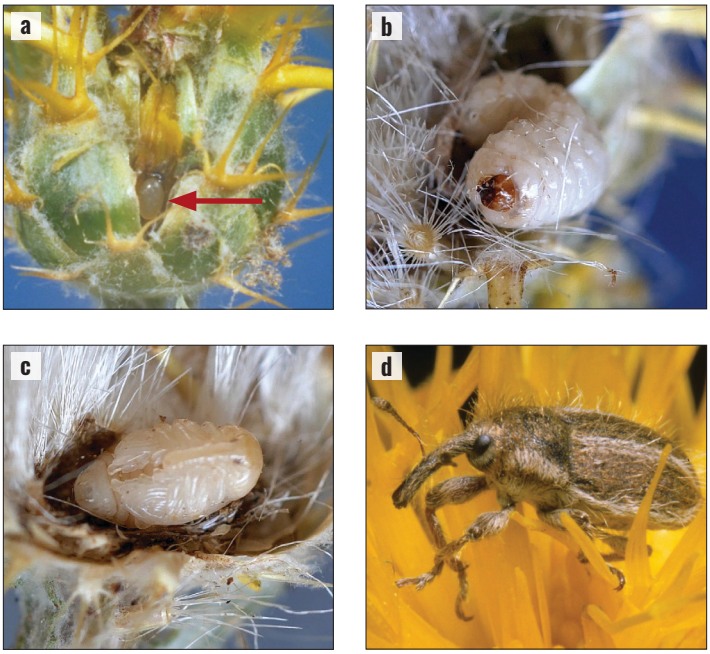

Figure 12. *Eustenopus villosus* (a) egg; (b) larva; (c) pupa; (d) adult (a: John Connett, University of Idaho; b,c: Travis McMahon, MIA Consulting; d: Laura Parsons & Mark Schwarzländer, University of Idaho, Bugwood.org CC BY-3.0 US)

DAMAGE

Larvae feed on receptacle tissue and developing seeds (**Fig. 14b**). Adult feeding can lead to a high percentage of mortality of young flower buds (**Fig. 14c**). Both forms of feeding do not kill existing plants, but reduce seed production which may help decrease the rate of spread of yellow starthistle populations and may reduce infestations in some habitats.

FIELD IDENTIFICATION

Adult *Eustenopus villosus* may be observed on yellow starthistle seed heads and stems from early to midsummer and again in

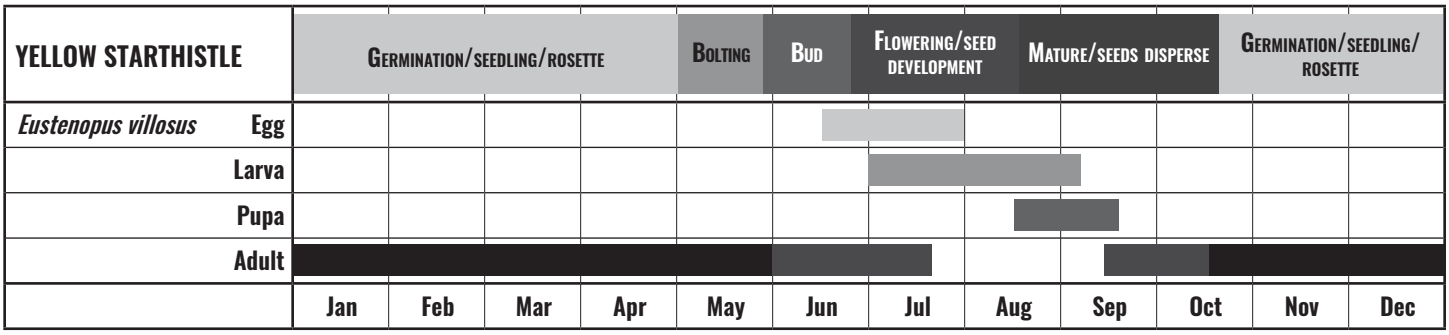

Figure 13. Schematic life cycles of *Eustenopus villosus* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There is typically one generation per year.

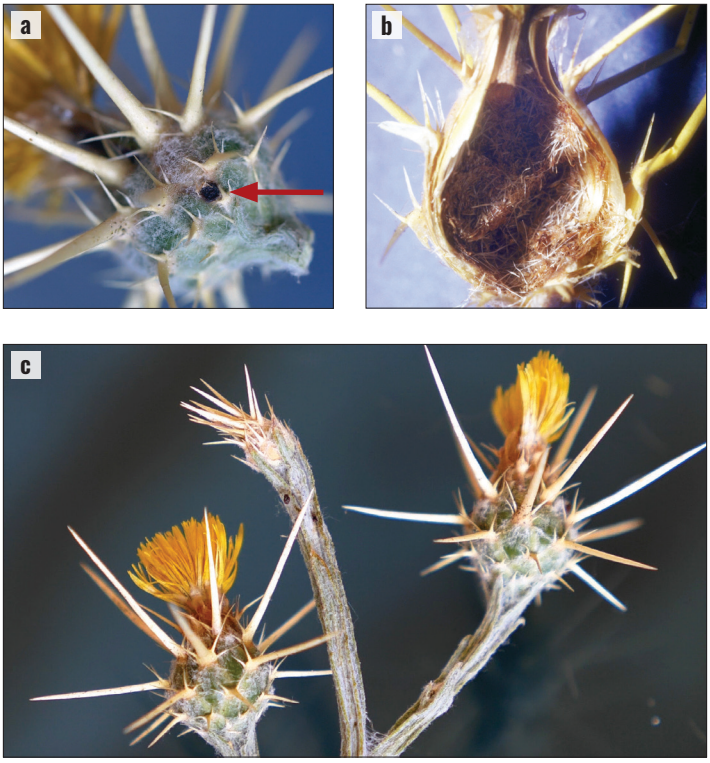

Figure 14. *Eustenopus villosus* (a) oviposition hole; (b) pupal chamber and chewed up florets, seeds, and receptacle tissue; (c) adult feeding caused the abortion of the center bud (a,c: Travis McMahon, MIA Consulting; b: Charles Turner, USDA ARS)

early fall. After chewing holes in the sides of yellow starthistle seed heads and laying eggs within, females cover the eggs with a dark protective material. These covered holes are readily visible to the naked eye (**Fig. 14a**). Larval feeding is not readily visible unless seed heads are dissected (**Fig. 14b**).

Three other introduced beetle species feed on yellow starthistle in North America, and three introduced fly species also feed within yellow starthistle seed heads. These are listed in **Table 1**, along with key diagnostic traits that help differentiate their adults from *E. villosus* and from each other.

PREFERRED HABITAT

This weevil does well throughout the majority of conditions yellow starthistle has invaded in the USA. In California, it is most common in the foothills and is less common in the Great Central Valley.

HISTORY AND CURRENT STATUS

Eustenopus villosus is native to Europe, Western Asia, and the Mediterranean. A population sourced from Greece was released in California, Idaho, Oregon, and Washington, USA beginning in 1990 and subsequently redistributed to other western states.

Eustenopus villosus has been reported established in seven states in the western USA (**Fig. 15**) where it is widespread and abundant. It is the second most abundant agent in California (after *Chaetorellia succinea*), attacking up to 80% of seed heads. Larval feeding may destroy up to 100% of seeds within attacked seed heads. Adult feeding also delays production of mature flowers 2–3 weeks and often causes abortion of attacked young flower buds. The combined effect of larval and adult feeding has the largest total impact on yellow starthistle's reproductive output compared with the other starthistle biological control insects. However, delayed flower production and mortality of the early flower buds reduces the plant's synchronicity with and attractiveness to other ovipositing seed predators.

Eustenopus villosus adults feed and lay eggs on a higher proportion of plants infected by the rust *Puccinia jacea* var. *solstitialis*, but larvae consume a lower proportion of seeds in flower heads attacked on rust-infected plants. However, seed production for plants attacked by *E. villosus* is similar whether or not plants are infected with the rust.

In conjunction with the fly *Chaetorellia succinea*, *E. villosus* can reduce seed production by >70% overall. This is believed to have contributed to significant declines of yellow starthistle populations at some sites that have no disturbance and have competition from grasses and other forbs. No declines in yellow starthistle have been observed in several other areas, especially those with high disturbance such as along roadsides. At many sites, yellow starthistle plants compensate for any decreases in density by growing larger and producing more seed heads and seeds. Parasitism and predation may reduce the impact of this weevil at some sites.

NONTARGET EFFECTS

None reported in North America.

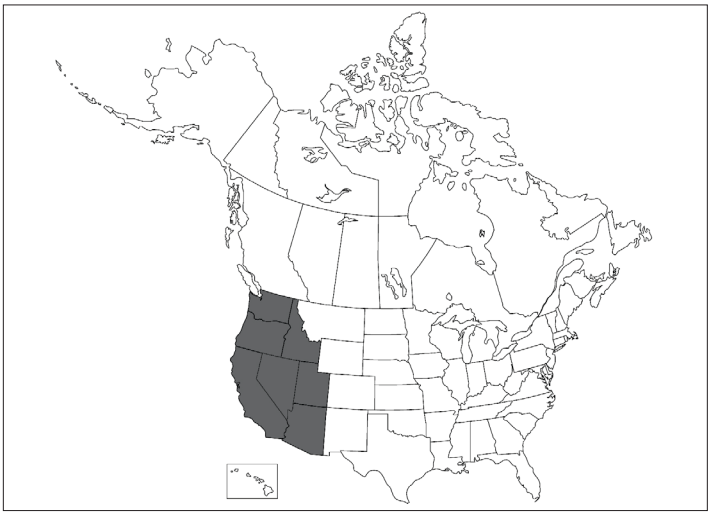

Figure 15. *Eustenopus villosus* reported distribution in North America (Winston et al. 2023; C. Randall, personal observation)

Larinus curtus
Yellow starthistle flower weevil

Larinus curtus is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Coleoptera	Beetles
Family	Curculionidae	Weevils
Genus	*Larinus*	
Species	*Larinus curtus* Hochhut	Yellow starthistle flower weevil

DESCRIPTION

Eggs are tiny, yellow, and elongate. Larvae are up to 6 mm long with white, C-shaped bodies and brown head capsules (**Fig. 16a**). Pupae are typically creamy white with obvious appendages and a medium-length snout (**Fig. 16b**). Adults are 5–6 mm long with oval-shaped bodies and medium-length snouts (**Fig. 16c**). Adult bodies are brown with white hairs that give them a mottled appearance. The body hairs are often yellowish from yellow starthistle pollen.

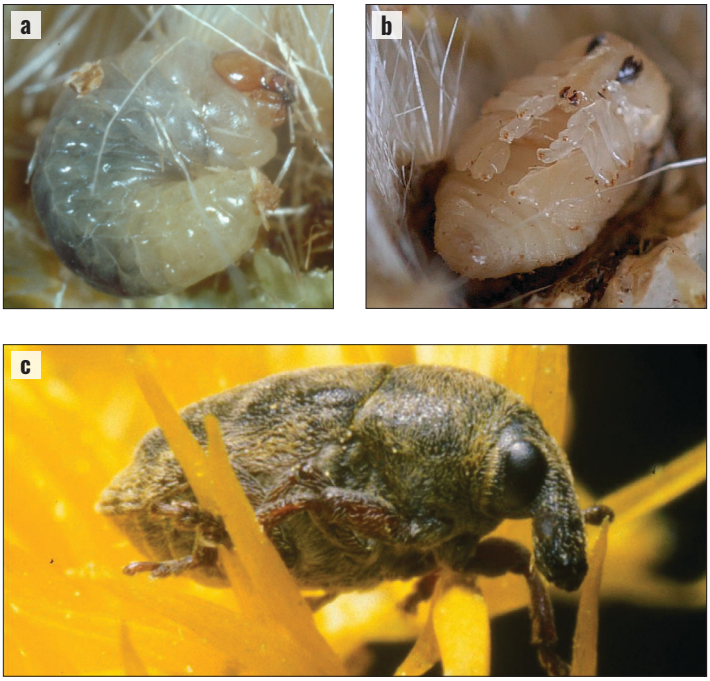

Figure 16. *Larinus curtus* (a) larva; (b) pupa; (c) adult (a: Charles Turner, USDA ARS; b: Travis McMahon, MIA Consulting; c: Laura Parsons & Mark Schwarzländer, University of Idaho, Bugwood.org CC BY-3.0 US)

LIFE CYCLE

Overwintering adults emerge in summer when yellow starthistle is in bud and flowering (**Fig. 17**), and they feed on florets and pollen. Females lay eggs singly in open flower heads at the base of florets. Larvae hatch in summer and feed on developing seeds through three instars. Pupation occurs in seed heads in chambers made of damaged seed and receptacle tissue. Adults emerge in late summer and overwinter in the soil litter. There is one generation per year.

DAMAGE

Adults feed on pollen and florets, though the impact is typically minor. Larvae feed on flower head tissue and developing seeds. Seed consumption does not kill existing plants, but reduces seed production which may help decrease the rate of spread of yellow starthistle populations and may reduce infestations in some habitats.

FIELD IDENTIFICATION

Adult *Larinus curtus* may be observed on yellow starthistle flower heads throughout summer (when they can often be found upside down burrowed into starthistle florets) and again in early fall. Eggs are laid at the base of florets so are not readily observed. Larval feeding is also not readily visible unless seed heads are dissected.

Three other introduced beetle species as well as three introduced fly species feed on yellow starthistle in North America. These are listed in **Table 1**, along with key diagnostic traits that help differentiate their adults from *L. curtus* and from each other.

PREFERRED HABITAT

This weevil does well throughout the majority of conditions yellow starthistle has invaded in the USA.

HISTORY AND CURRENT STATUS

Larinus curtus is native to Europe, Western Asia, and the Mediterranean. A population sourced from Greece was released in California, Idaho, Oregon, and Washington, USA beginning in 1992 and redistributions were subsequently attempted in Arizona and New Mexico.

Larinus curtus is presently established in four states in the western USA (**Fig. 18**). Larval feeding destroys about 60% of seeds within attacked seed heads; however, attack rates are typically low. Abundance of this weevil plateaued within a few years of its introduction, and its current abundance varies from high in portions of Oregon, to moderate in Washington, to becoming more limited in Idaho and California (where incidence is <1%). It is less abundant than the other seed-feeding biocontrol agents.

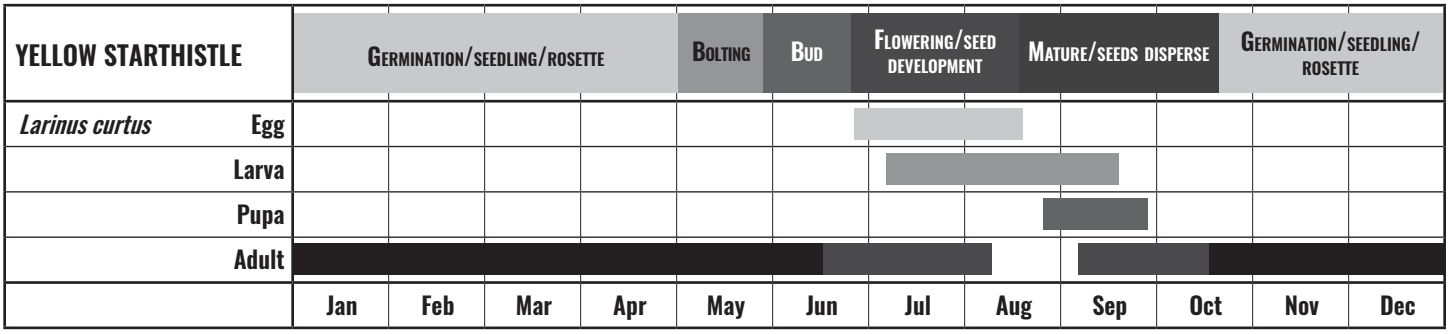

Figure 17. Schematic life cycles of *Larinus curtus* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There is typically one generation per year.

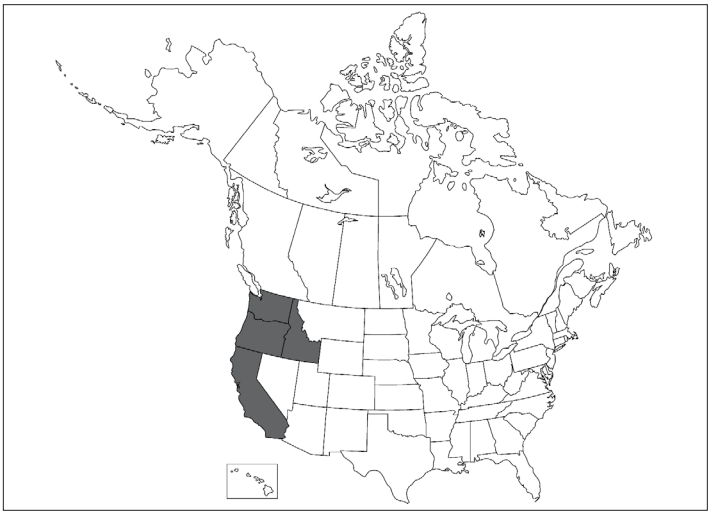

Figure 18. *Larinus curtus* reported distribution in North America (Winston et al. 2023)

Some *L. curtus* populations have been found to be infected with microsporidia (*Nosema* sp.), which is an internal parasite of the digestive tract. It has been suggested that microsporidia may reduce survivorship and fecundity of infected adults; however, population-level impacts on *L. curtus* field populations are unknown.

NONTARGET EFFECTS

Adult *L. curtus* were found feeding on open flower heads of cultivated safflower (*Carthamus tinctorius*), but no egg laying or development occurred. Consequently, there has been no impact to safflower production. It did not lay eggs in safflower in laboratory no-choice experiments.

Puccinia jaceae var. *solstitialis*
Yellow starthistle rust fungus

Puccinia jaceae var. *solstitialis* is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Fungi	Fungus
Phylum	Basidiomycota	Club fungi
Class	Pucciniomycetes	
Order	Pucciniales	Rust fungi
Family	Pucciniaceae	
Genus	*Puccinia*	
Species	*Puccinia jaceae* var. *solstitialis* Savile	Yellow starthistle rust fungus

DESCRIPTION AND LIFE CYCLE

This fungus has a complicated life cycle that includes five different spore stages throughout the year. Teliospores can withstand freezing temperatures and are the overwintering stage. In spring, these germinate to produce basidiospores that infect yellow starthistle rosette leaves. The rust then develops through two subsequent spring spore stages (pycniospores and aeciospores). Symptoms include yellowish chlorotic lesions with raised centers which turn into orangish-brown or rusty-brown pustules (**Fig. 19a–c**) that produce large amounts of urediniospores. The spores are microscopic. The urediniospores spread rapidly from plant to plant as they are easily dispersed by both wind and rain. Multiple "generations" of uredinia infection can occur during the spring and summer, with each full cycle taking two weeks to complete; however, the spores require at least 8 hours of dew to germinate.

DAMAGE

Infected plants can experience stunted growth, reduced seed production, and a higher susceptibility both to competition from other plants and attack from additional biocontrol agents.

FIELD IDENTIFICATION

Urediniospore pustules of *Puccinia jaceae* var. *solstitialis* are rust-colored to dark brown (**Fig. 19**) and can be found on leaves and stems of infected yellow starthistle plants

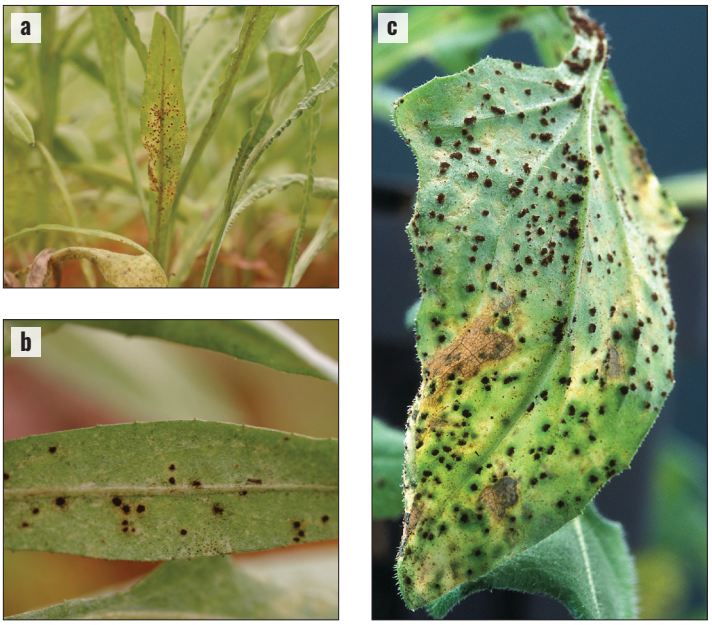

Figure 19. *Puccinia jaceae* var. *solstitialis* infecting yellow starthistle leaves (a,b: Eric Coombs, Oregon Department of Agriculture, Bugwood.org, CC BY-3.0 US; c: Stephen Ausmus, USDA ARS, Bugwood.org, CC BY-3.0 US)

throughout the growing season. No other, similar rust fungi are known to infect yellow starthistle in North America.

PREFERRED HABITAT

The yellow starthistle rust fungus requires climates with dew periods of at least 8 hours a day that result in moisture forming or collecting on starthistle foliage.

HISTORY AND CURRENT STATUS

Puccinia jaceae var. *solstitialis* is native to Europe, Western Asia, and the Mediterranean. A population sourced from Turkey was released in California, USA beginning in 2003 and in Oregon, USA beginning in 2008. It is currently established in the USA only in California and Oregon (**Fig. 20**). Under optimal conditions (moist, mild temperatures) the rust can reduce yellow starthistle biomass and the number of flower heads, especially in conjunction with high competition from other plant species. At drier sites, its impact is reduced and likely to be of only minor biological significance. Across much of yellow starthistle's range in the USA, the climatic conditions are suboptimal, preventing the rust's persistence and/or significant impact.

Figure 20. *Puccinia jaceae* var. *solstitialis* reported distribution in North America (Winston et al. 2023)

NONTARGET EFFECTS

None reported in North America.

Urophora sirunaseva
Yellow starthistle gall fly

Urophora sirunaseva is a biological control agent approved in North America for release against yellow starthistle.

CLASSIFICATION

RANKING	SCIENTIFIC NAME	COMMON NAME
Kingdom	Animalia	Animals
Phylum	Arthropoda	Arthropods
Class	Insecta	Insects
Order	Diptera	Flies
Family	Tephritidae	Fruit flies
Genus	*Urophora*	
Species	*Urophora sirunaseva* (Héring)	Yellow starthistle gall fly

DESCRIPTION

Eggs are elongated and white or pale yellow. Larvae are somewhat barrel-shaped (though slightly thicker at one end) and up to 4 mm long. They are white, turning yellowish with maturity, and they lack a head capsule but have a dark anal plate (**Fig. 21a**). Pupae are concealed in a barrel-shaped puparium up to 3½ mm long that is pale yellow with dark

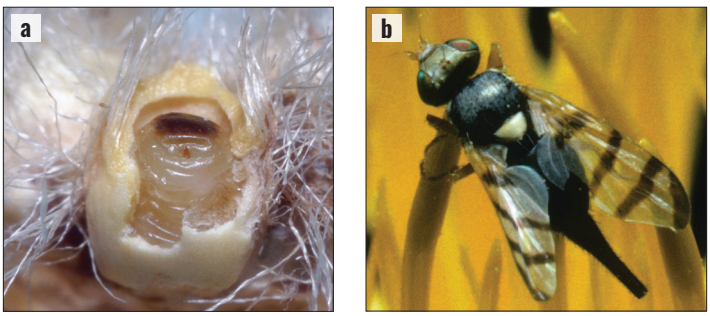

Figure 21. *Urophora sirunaseva* (a) larva in gall; (b) adult (a: Charles Turner, USDA ARS; b: Laura Parsons & Mark Schwarzländer, University of Idaho, Bugwood.org CC BY-3.0 US)

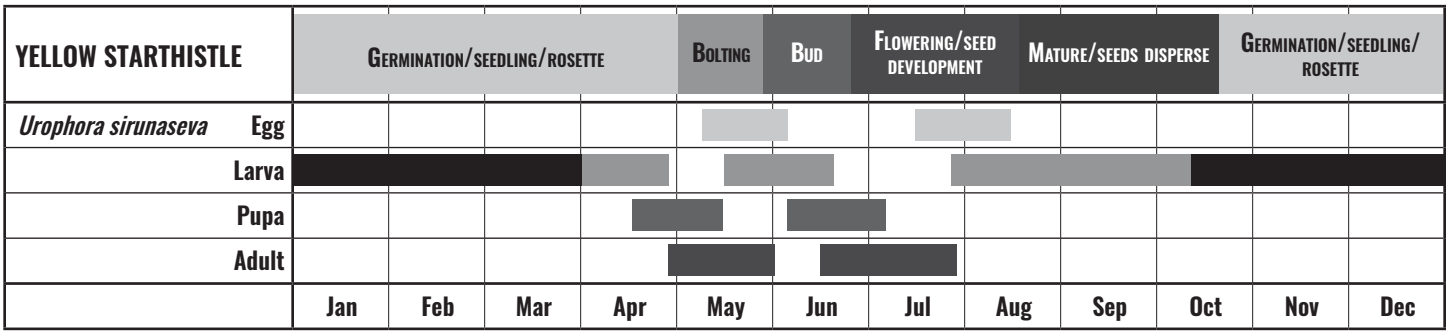

Figure 22. Schematic life cycles of *Urophora sirunaseva* and yellow starthistle in North America. Bars indicate the approximate length of activity for each life stage; dates will vary depending on local conditions. Black bars represent the inactive and/or overwintering periods. There are typically two generations per year, though sometimes three where growing seasons are long.

ends. Puparia are contained in woody galls. Adults have black bodies with a yellow spot on the rear part of the thorax. Their eyes are multi-colored and metallic, and their wings are clear with dark crossbands (**Fig. 21b**). Males are 3–4 mm long; females are 4–6 mm, including ovipositors.

LIFE CYCLE

Adults emerge in spring as yellow starthistle is bolting and starting to form buds (**Fig. 22**). Females lay eggs in immature closed buds amongst the developing florets. After hatching, the larva follows a floret tube down to the ovule at the base of the floret. The larva enters the ovule (young achene), and the plant responds by beginning the formation of a gall. Multiple galls often occur in one flower head. There are three larval instars, prior to pupation within galls. Adults emerge in early to midsummer, mate, and lay eggs in more yellow starthistle buds. Larvae of the summer generation overwinter within hard galls inside the seed heads. There are two generations per year.

DAMAGE

Floret feeding and gall formation reduce seed production. Galls (**Fig. 23**) are believed to act as nutrient sinks, diverting plant resources away from regular plant function and seed formation. This does not kill existing plants, but a reduction in seed production may help decrease the rate of spread of yellow starthistle populations and may reduce infestations in some habitats.

FIELD IDENTIFICATION

Adult *Urophora sirunaseva* may be observed on yellow starthistle plants throughout spring and summer. Feeding larvae are not readily visible unless seed heads are dissected, at which point their woody galls can be observed (**Fig. 23**). Multiple galls are often present in the same seed head.

Two other introduced fly species (*Chaetorellia australis* and *C. succinea*), and three introduced beetle species also feed in yellow starthistle seed heads in North America. These are included in **Table 1**, along with key diagnostic traits that help differentiate their adults from *Urophora sirunaseva* and from each other.

Figure 23. Multiple woody galls of *Urophora sirunaseva* in a yellow starthistle seed head (Charles Turner, USDA ARS)

PREFERRED HABITAT

Specific habitat requirements are unknown for *Urophora sirunaseva*, but this fly does not seem to do well at overly windy locations. In California, *U. sirunaseva* is more common in the coastal mountains and less common in the interior of the state.

HISTORY AND CURRENT STATUS

Urophora sirunaseva is native to Europe and the Mediterranean. The first introductions occurred on yellow starthistle in California, USA beginning in 1969 utilizing flies collected in Italy. After these failed to establish, it was determined the species introduced was in fact *Urophora jaculata*, which is specific to yellow starthistle biotypes growing only in Italy. Two additional populations of the true *U. sirunaseva* were subsequently introduced and released in the USA beginning in 1984 (from Greece into California, Idaho, Oregon, and Washington; from Turkey into Idaho). The Turkish introduction presumably did not survive.

Urophora sirunaseva is presently established in four states in the western USA (**Fig. 24**). Gall formation decreases yellow

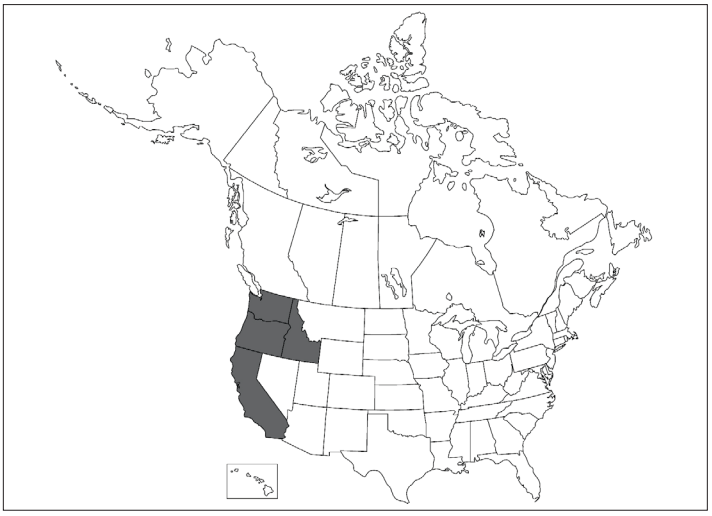

Figure 24. *Urophora sirunaseva* reported distribution in North America (Winston et al. 2023)

starthistle seed production, though multiple galls per seed head are necessary before seed reduction is significant, and such high gall densities are uncommon. While this species is widely distributed, abundance is low. Attack rates peaked at approximately 50% a few years following their successful establishment. More recently, attack rates are closer to 10% of yellow starthistle seed heads. Consequently, its overall impact is now limited. Populations at some sites are hindered by competition with other seed head biocontrol agents.

NONTARGET EFFECTS

None reported in North America.

UNAPPROVED BIOCONTROL AGENTS

One accidentally introduced species (*Chaetorellia succinea*) is established on yellow starthistle in North America. **It is illegal to intentionally move this species to new areas in the USA.** Care should be taken when transferring approved biocontrol agents, especially the very similar *Chaetorellia australis*, to ensure the unapproved *C. succinea* is not also included in transferred material.

Chaetorellia succinea

(Diptera: Tephritidae)

DESCRIPTION AND LIFE CYCLE

Adults usually emerge in spring before yellow starthistle has begun to bolt. Adults often feed on nectar of vetch (*Vicia* spp.) or other plants with early developing flowers while waiting for their target plants to develop to the appropriate stage for oviposition. Adults have tan bodies with 10 black spots on the thorax (**Fig. 10b, 25a**). Their eyes are multi-colored and metallic, and their wings are clear with thick brown bands (**Fig. 25a**). Males are 3–4 mm long; females are 4–6 mm, including ovipositors. Adult females lay eggs singly beneath bracts of closed buds. Eggs are elongated and white or pale yellow. After hatching, larvae tunnel into seed heads and feed on receptacle tissue and developing seeds through three instars. Larvae are somewhat barrel-shaped (though slightly thicker at one end) and up to 4 mm long. They are white, turning yellowish with maturity, and they lack an obvious head capsule (**Fig. 25b**). Pupation occurs in puparia within seed heads inside chambers made of pappus and chewed seeds. Puparia are barrel-shaped, up to 3½ mm long, and pale yellow with dark ends. Adults emerge in early to midsummer, mate, and lay eggs in more starthistle buds. Mature larvae of the summer generation overwinter within starthistle seed heads. There are usually two generations per year, though three generations are possible where the growing season is sufficiently long.

Chaetorellia succinea is similar in nearly all aspects to the very closely related *Chaetorellia australis*, aside from having 10 spots on its thorax instead of the eight present on *C. australis* (**Fig. 10a,b, Fig. 8b**). The spring generation of *C. succinea* also becomes active slightly later in the season compared to *C. australis*.

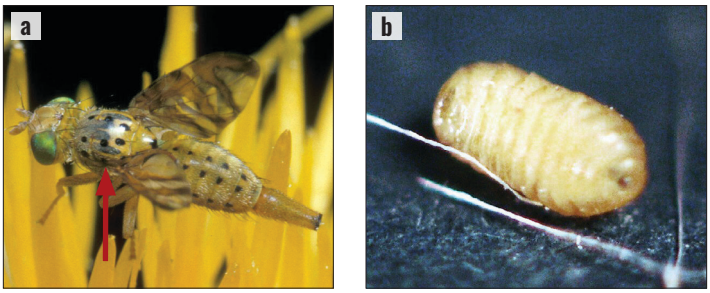

Figure 25. *Chaetorellia succinea* (a) adult with extra spot on thorax (red arrow); (b) larva (a: Laura Parsons & Mark Schwarzländer, University of Idaho, Bugwood.org CC BY-3.0 US; b: Rachel Winston, MIA Consulting)

HISTORY AND CURRENT STATUS

Chaetorellia succinea was accidentally introduced to Oregon, USA in 1991 along with populations of the intentionally introduced *C. australis*, though this was not discovered until 1995. The contaminant was unknowingly redistributed along with *C. australis* throughout California, Oregon, and Washington beginning in 1994. *Chaetorellia succinea* rapidly spread throughout the western USA and is currently widespread and abundant in five states (California, Idaho, Nevada, Oregon, and Washington).

Of the two *Chaetorellia* species, *C. succinea* is considered the more effective biocontrol agent for yellow starthistle because it is widespread and often builds up high populations

locally. Larval feeding destroys up to 80% of seeds within attacked yellow starthistle seed heads and decreases pollinator visitation. High *Eustenopus villosus* populations are associated with lower populations of *C. succinea* (and the other seed head insects), due to *E. villosus* causing delayed flower production and mortality of early flower buds, and also possibly due to *E. villosus* larvae killing larvae of other insects co-habiting the seed head. Further studies of these interactions and their outcomes are warranted. Despite this, *C. succinea* and *E. villosus* in combination can reduce yellow starthistle seed production by >70% overall. Whether this level of seed destruction results in a decline of yellow starthistle abundance depends on many factors. At many infestations, yellow starthistle plants compensate for any decreases in density by growing larger and producing more seed heads. Impact is highest at sites with significant competition from other plant species.

NONTARGET EFFECTS

Chaetorellia succinea larvae were found feeding in the heads of non-commercial safflower (*Carthamus tinctorius*) in California, though damage was minimal. Field and laboratory trials documented *C. succinea* ovipositing and developing in the flower heads of *Plectocephalus americana*, a related genus indigenous to the central and southwestern USA. An application and permit (USDA-APHIS-PPQ 526 permit) to move *C. succinea* has not been submitted, and **this species remains unauthorized for release or redistribution**. It is likely that this fly will attack *P. americana* and its other native relative *P. rothrockii* in the field if the fly should reach their geographic range (Arizona to Missouri) through its own natural dispersal. Field and laboratory trials also found *C. succinea* to oviposit and develop on the weedy and exotic Malta starthistle (*Centaurea melitensis*) and Sicilian starthistle (*C. sulphurea*).

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Table 1. Key traits for differentiating introduced natural enemies established on yellow starthistle in North America.

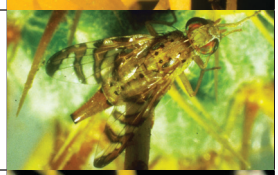
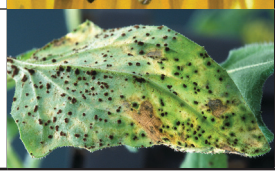
	SPECIES	APPROVAL STATUS	ATTACK	ADULT DESCRIPTION	ADULT
BEETLES	*Bangasternus orientalis*	Approved in the USA	Adults: feed on foliage, but superficially Larvae: feed on receptacle tissue and developing seeds	Cylinder-shaped, somewhat flattened, dark brown with lighter hairs, appearing mottled, short snout, 4–6 mm long	
	Ceratapion basicorne	Approved in the USA	Adults: feed on foliage, but superficially Larvae: mine root crowns	Teardrop-shaped, black with metallic hue on elytra, reddish to black legs, long snout, ≤2½ mm long	
	Eustenopus villosus	Approved in the USA	Adults: feed on early immature starthistle buds Larvae: feed on receptacle tissue and developing seeds	Oblong, cylindrical bodies, brown with lighter longitudinal stripes, covered in long hairs, very long slender snout, 4–6 mm long	
	Larinus curtus	Approved in the USA	Adults: feed on florets and pollen, but superficially Larvae: feed on receptacle tissue and developing seeds	Oval-shaped, dark brown with lighter hairs, appearing mottled, hairs often yellowish from pollen, medium snout, 5–6 mm long	
FLIES	*Chaetorellia australis*	Approved in the USA	Adults: none Larvae: feed on receptacle tissue and developing seeds	Tan bodies and legs, 8 black spots on thorax, eyes multi-colored and metallic, wings clear with thick brown bands, 3–6 mm long	
	Chaetorellia succinea	Not approved in the USA	Adults: none Larvae: feed on receptacle tissue and developing seeds	Tan bodies and legs, 10 black spots on thorax, eyes multi-colored and metallic, wings clear with thick brown bands, 3–6 mm long	
	Urophora sirunaseva	Approved in the USA	Adults: none Larvae: feed in seed heads, causing formation of galls	Black bodies, yellow spot on the rear of thorax, eyes multi-colored and metallic, wings clear with dark crossbands, males 3–4 mm, females 4–6 mm	
FUNGUS	*Puccinia jaceae* var. *solstitialis*	Approved in the USA	Urediniospore pustules infect leaves and stems	Urediniospore pustules brown to rust-colored, on both lower and upper leaf surfaces and leaf stems/wings	

Photo credits: *Bangasternus orientalis, Eustenopus villosus, Larinus curtus, Chaetorellia succinea, Urophora sirunaseva*: Laura Parsons & Mark Schwarzländer, University of Idaho; *Ceratapion basicorne*: Kristi Gladem and Kelly Hanrahan, Colorado Department of Agriculture, Palisade Insectary; *Chaetorellia australis*: Charles Turner, USDA ARS, Bugwood.org, CC BY-3.0 US; *Urophora sirunaseva*: Emanuele Santarelli, iNaturalist.org CC BY-NC-SA 4.0; *Puccinia jaceae* var. *solstitialis*: Stephen Ausmus, USDA ARS, Bugwood.org, CC BY-3.0 US

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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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