# Two biocontrol insects of invasive yellow toadflax self-established in Anchorage, Alaska: the toadflax flower-feeding beetle and the toadflax seed capsule weevil 

by Alexandria Wenninger ${ }^{1}$

Two biological control agents of the invasive plant yellow toadflax (Linaria vulgaris Miller, 1768) have established in Anchorage, Alaska without intentional introduction: the toadflax flower-feeding beetle (Brachypterolus pulicarius (Linnaeus, 1758)) and the toadflax seed capsule weevil (Rhinusa antirrhini (Paykull, 1800)). Both of these species were accidentally introduced to eastern North America in the early 1900s and are now found throughout much of the continent where yellow toadflax infestations occur; some states have intentionally redistributed these species, however no formal biocontrol introductions of these species have been made in Alaska. Despite the lack of formal introductions in Alaska, these two biocontrol species both occur in Anchorage, Alaska. Feeding by these two species reduces seed production, which may slow the spread and establishment of new populations of invasive toadflax in Alaska.

## The toadflax flower-feeding beetle, Brachypterolus pulicarius (Linnaeus) (Coleoptera: Kateretidae)

The toadflax flower-feeding beetle emerges as an adult in spring and feeds on emerging toadflax shoot tips before laying eggs into unopened flower buds (Wilson et al. 2005). Adults are brown to black in color and $\sim 2-3 \mathrm{~mm}$ in length (Figure 1). The larvae feed on flowers (ovaries, pollen, and anthers) and developing seeds before dropping to the ground to overwinter as pupae (McClay 1992). Larvae are yellow in color with a brown to black head and darkened band on the pronotum, reaching a length of $\sim 7 \mathrm{~mm}$ (Figure 2). Larval feeding can reduce a flower's seed production by as much as $\sim 75 \%-90 \%$ (Harris 1961, McClay 1992, Winston et al. 2014). Pupae are yellow in color, $\sim 2-3 \mathrm{~mm}$ in length, and feature a row of paired spines along the dorsum extending from the head to the end of the abdomen (Figure 2); the spines on the thorax project forward toward the head whereas the spines on the abdomen project back toward the rear. The adults have been reported feeding on flowers of other plant species, including strawberry and dandelion, however, the species is only known to be able to complete development on species in the genus Linaria (Hervey 1927). Only one generation is known per year in Canada, with the species overwintering as pupae, however, in Europe and some states in the US, some may eclose late in the season and overwinter as an adult (Government of British Columbia 2018).

The toadflax flower-feeding beetle is thought to have been accidentally introduced to North America in New York, USA in 1919, after which it was intentionally redistributed to various localities within the lower 48 states, however I found no evidence of intentional introductions in Alaska. The toadflax flower-feeding beetle has been released in and is established in British Columbia (Government of British Columbia 2018) though it has not yet been recorded in Yukon, Canada ${ }^{2}$. This beetle was first recorded from Alaska in 2016 when one individual was caught in a vane trap in Anchorage ${ }^{3}$. This species was found on toadflax as early in the season as 2 June 2022, and some adults were still present on flowers on 13 September. I

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Figure 1: Left: Adult Brachypterolus pulicarius, a.k.a. toadflax flower-feeding beetle on yellow toadflax shoot. Right: Adult Rhinusa antirrhini, a.k.a. toadflax seed capsule weevil on yellow toadflax flower. Photographed June 2022 in Anchorage, Alaska by A. Wenninger.
wild-collected larvae between 18-23 August to rear indoors; the beetles were able to be reared from larva to adult at room temperature $\left(\sim 70{ }^{\circ} \mathrm{F}\right)$ and the first adults emerged 12 September.

## The toadflax seed capsule weevil, Rhinusa antirrhini (Paykull) (Coleoptera: Curculionidae)

The toadflax seed capsule weevil emerges as an overwintered adult in late spring and feeds on emerging toadflax shoot tips and flowers before laying eggs into the flower's ovaries (Wilson et al. 2005). Adults are grey to black in color, setose, and $\sim 2.5-3 \mathrm{~mm}$ in length (Figures 1 and 3). Egg deposition into the host plant tissue triggers gall formation; the seeds near the egg expand beyond their typical size resulting in seed inviability (Sing et al. 2016). The developing larvae then feed on both the galled tissue as well as on other developing seeds within the capsule (Sing et al. 2016). The legless larvae are creamy white with a black head capsule, $\sim 4 \mathrm{~mm}$ in length, and feed on galled seed tissue before pupating inside the seed capsule (Figure 2). Adults emerge in late summer to early fall and will often overwinter inside the seed capsule or in plant debris (Nowierski 2004).

Rhinusa antirrhini is thought to have been accidentally introduced to the eastern United States, first recorded around 1909, and to British Columbia, Canada, first recorded in 1917, after which intentional introductions were made in various localities of both Canada and the lower 48 states (Winston et al. 2014), however I found no evidence of intentional introductions in Alaska. This beetle was previously recorded from Alaska in both Fairbanks in October $2006^{4}$ and Anchorage in July $2008^{5}$ on yellow toadflax. In 2022 this species was collected as early as 2 June and as late as 13 September.

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Figure 2: Larval, pupal, and adult stages of the two species of biocontrol beetles (not to scale). Top left: Brachypterolus pulicarius larva at base of L. vulgaris flower (flower petals have been removed to expose the larva at the base). Top middle: B. pulicarius larva, ventral and dorsal habita. Top right: Adult B. pulicarius, lateral habitus. Bottom left: Rhinusa antirrhini larva feeding inside L. vulgaris seed capsule. Bottom middle: R. antirrhini pupa inside L. vulgaris seed capsule. Bottom right: Adult R. antirrhini lateral habitus. Immatures photographed August 2022 and adults photographed June 2022 in Anchorage, Alaska by A. Wenninger.

The toadflax seed capsule weevil was previously recognized for its potential to decrease seed production of invasive toadflax in Anchorage (Lamb et al. 2009, = Gymnetron antirrhini), however, I have been unable to find any report of further surveys of the distribution of this species in Alaska since those initial discoveries. Seed reductions due to feeding by this species have been reported as high as $90 \%$ in Washington (Nowierski 2004), however most reported attack rates are lower than this (Winston et al. 2014). Previous observations in Alaska have reported $\sim 20 \%$ attack rate on yellow toadflax by an unknown weevil (Alaska Natural Heritage Program 2011), which is consistent with the $20-25 \%$ typical seed reduction observed in Canada (Nowierski 2004). Predators and parasitoids of this species may contribute to the variation seen in seed attack rates among localities. A study in Ottawa, Canada found anywhere from $4 \%$ to $85 \%$ of collected R. antirrhini larvae were parasitized (Allison 2009). Alaska is also home to the solitary predatory wasp Cerceris nigrescens, which is known to collect adult R. antirrhini as prey for nest provisioning (Krombien 1938, Scullen 1965). It is worth noting that R. antirrhini may delay oviposition in areas where it is in competition with B. pulicarius (Turner 2008), and furthermore B. pulicarius larvae have been observed predating upon R. antirrhini eggs (Jacobs and Sing 2006). Many authors report that these competitive and antagonistic interactions between B. pulicarius and R. antirrhini prevent their impact on toadflax from being additive (Harris 1961, Winston et al. 2014, Sing et al. 2016).

## Host

Yellow toadflax (Linaria vulgaris Miller) was introduced to North America in the 1600s for ornamental and medicinal purposes. By 1849 the species had spread across the eastern and mid-western United States where it became a significant agricultural weed (Saner et al. 1995, Sing et al. 2022). The species is now


Figure 3: Lateral habitus of adult R. antirrhini collected 2 June 2022 in Anchorage, Alaska. Photo by Derek S. Sikes, University of Alaska Museum of the North, Arctos record: https://arctos.database.museum/ guid/UAM:Ento:476269.
found throughout much of North America, having spread as a contaminant in crop seed and baled hay, through railway corridors and ship ballasts, and from intentional ornamental plantings (Saner et al. 1995, Sing et al. 2022). The plant produces yellow, spurred flowers with orange throats, borne in terminal clusters (Figure 4); leaves are pale green and arranged alternately on the stem (Alaska Natural Heritage Program 2011). Yellow toadflax can spread by seed or root fragments and its invasion is facilitated by disturbance. Once established, yellow toadflax can form dense colonies that suppress native grasses and perennials (Alaska Natural Heritage Program 2011). Toadflax seeds often remain viable after ingestion by wildlife and livestock (primarily ungulates and birds) which is thought to facilitate long-range dispersal as well as dispersal into wilderness areas (Sing et al. 2016, 2022).


Figure 4: Left: Closeup of the toadflax flower. Note the tiny beetle posterior hanging out of the flower, belonging to Rhinusa antirrhini. Photographed 26 June 2022. Right: Invasive toadflax flowers peppering an Anchorage roadside, photographed 29 August 2022. Photos from Anchorage, Alaska by A. Wenninger.

## 2022 Survey Results

Midtown and Northeast Anchorage were surveyed opportunistically in 2022 for existing yellow toadflax populations and for the presence of the two biocontrol beetles on toadflax (Figure 5). The locations where I surveyed toadflax in 2022 can largely be simplified into 11 distinct locations (Figure 5a); B. pulicarius was detected at all 11 of these locations (Figure 5b) and R. antirrhini was detected at 8 of the 11 locations (Figure 5c).


Figure 5: Anchorage 2022 toadflax and biocontrol beetle survey locations. a) Locations where Linaria vulgaris (yellow toadflax) occurs and was checked for biocontrol beetles in Anchorage in 2022. b) Locations where Brachypterolus pulicarius was detected on toadflax and c) locations where Rhinusa antirrhini was detected on toadflax. Maps generated using ArcGIS Online, Oceans Basemap; Basemap credits: Esri, DeLorme, NaturalVue I Kenai Peninsula Borough, Matanuska-Susitna Borough GIS, Municipality of Anchorage, State of Alaska, Esri, HERE, Garmin, SafeGraph, METI/NASA, USGS, EPA, NPS, USDA.

## Reporting

In 2023 I plan to develop protocols for involving citizen scientists in surveying for beetles on toadflax to help expand our understanding of the distribution of these beetles beyond Anchorage. Currently, infestations of yellow toadflax on public land can be reported via the mobile app 'Alaska Invasives ID' or at https:/ /alaskainvasivesreporter.org. I am especially interested in reports of the biocontrol beetles on yellow toadflax observed outside of Anchorage. Photos and location can be submitted directly to Statewide IPM Technician Alex Wenninger via email at akwenninger@alaska.edu or via our monitoring portal at https:/ /alaskapestreporter.org.

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    ${ }^{2}$ There is conflicting information in the literature about the presence of this species in western Canada. Harris (1961) states that the species had been found in all Canadian provinces by 1953, however, this species has not been recognized as being present in British Columbia nor Yukon in the first (Bousquet 1991) nor second (Bousquet et al. 2013) editions of the Checklist of the Beetles of Canada and Alaska. A publication titled 'Brachypterolus pulicarius L.' found on the Government of British Columbia website states that intentional releases of this organism as a biocontrol on Dalmatian toadflax (Linaria dalmatica L.) occurred in 1989 and 2004 and describes the species as established in British Columbia. I was unable to find any further records of this species in Yukon.
    ${ }^{3}$ https: / /arctos.database.museum/guid/UAM:Ento:351434

[^1]:    ${ }^{4} \mathrm{https}: / /$ arctos.database.museum/guid/UAM:Ento:25891, https:/ /arctos.database.museum/guid/UAM:Ento:25892, https:/ /arctos.database.museum/guid/UAM:Ento:25893, https://arctos.database.museum/guid/UAM:Ento:25974, https: / /arctos.database.museum/guid/UAM:Ento:25975, https:/ /arctos.database.museum/guid/UAM:Ento:25976
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