

BIOLOGICAL CONTROL OF WEEDS
IN MONTANA



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FIELD GUIDE FOR THE BIOLOGICAL CONTROL OF WEEDS IN MONTANA

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GLOSSARY OF SYMBOLS

Effectiveness

- ★★★ Very Effective: Usually greatly reduces target weed density over time when released on sites that fit the biocontrol agent's ecological needs. Produces significant damage to target weeds.
 - ★★ Effective: Often reduces target weed density over time when released on sites that fit the biocontrol agent's ecological needs. Produces noticeable damage to target weeds.
 - Moderately Effective: Occasionally reduces target weed density over time when released on sites that fit the biocontrol agent's ecological needs. Produces some damage to target weeds.
 - Unknown Effectiveness: Biocontrol agent is too rare or too new to rate effectiveness in Montana.



USER Bolded words seen throughout this guide can be found in the glossary (pgs. 98-101).

GLOSSARY OF SYMBOLS

Attack Sites





Attacks Seed Heads



Attacks Leaves



Attacks Stems



Attacks Roots

Biocontrol Collection Methods



Hand Pick



Accelerator/Insect Separator



Sweep Net



Aspirator



Tapping into Pan/Bucket



Clipping



Digging



Vacuuming

INTRODUCTION

Noxious weeds are a significant problem in Montana. Integrated Weed Management (IWM) practices lead to the greatest likelihood of control. IWM combines a variety of tools to reach the desired level of control. Control methods include but are not limited to prevention, grazing, biocontrol, herbicide, cultivation, hand pulling and digging, cutting and mowing, and seeding competitive vegetation. This "toolbox" of IWM methods can be combined in different ways depending on the location, weed species, and landowner goals.

Classical biological control (biocontrol) is the practice of importing and releasing host-specific natural enemies, also known as biocontrol agents and usually insects, to control an invasive, non-native weed species. Before release, each biocontrol agent must be carefully tested to ensure it will not negatively impact plants other than the target weed. The movement of biocontrol agents is regulated by the U.S. government. An understanding of the biocontrol agents' ecological needs, life cycle, and how to correctly release them is necessary to accurately predict that they will likely survive, thrive, and suppress the target weed. If biocontrol is an appropriate weed management tool for your weed infestations, this guide will provide the information necessary to successfully implement biocontrol as part of your IWM efforts.

Pros & Cons of Biological Weed Control

Pros

- Biocontrol agents only directly affect their target weed species.
- Once established, biocontrol agents will continue to impact the target weed.

INTRODUCTION

- Biocontrol agents will often spread to new patches of their target weed.
- Biocontrol agents are inexpensive.
- Biocontrol agents are low maintenance; usually only need to make releases for 1-3 years for establishment.

Cons

- Biocontrol agents are sometimes hard to establish.
- Biocontrol is not appropriate for all sites.
- It will take a few years before the biocontrol agent's impact becomes obvious.
- Biocontrol agents seldom completely eliminate the target weed.

Biocontrol Cannot Be Used on All Montana Noxious Weeds

There are two reasons biocontrol cannot be used on all noxious weeds in Montana. First, effective and host-specific biocontrol agents have not been found for every noxious weed affecting Montana. Many noxious weeds are closely related to one or more of Montana's native or beneficial plant species, making it difficult to find biocontrol agents that will not attack these closely related native plant species. Second, biocontrol should only be used on a noxious weed that is well established in an area. Target weed infestations need to be large enough to support the population growth of the biocontrol agents. These host-specific agents only feed on their target weed and, in many cases, need the target weed to overwinter. Therefore, if the weed infestation is not large enough, the biocontrol agent population will not reach a level that is high enough to significantly impact the target weed. In areas where a noxious weed is not as well established, it is best to use other control methods.

CANADA THISTLE

CANADA THISTLE

(Cirsium arvense)

Weed Description: Herbaceous **perennial** that forms dense patches of plants connected through a root system that spreads horizontally. Leaves are irregularly **lobed** with prickly **margins**. Stems are 0.3 to 2 m (1 to 6 ft) in height. Canada thistle flowers are clustered and are typically light purple in color but can fade to white over time. This species rapidly takes over in disturbed, moist sites.



Canada thistle infestation (left); flower (top right); and leaf (bottom right).

Biological Control Agent for Canada Thistle

Canada Thistle Rust

(Puccinia punctiformis)



Unknown Effectiveness



Attack Site - Root System



Collection Method - Clipping

Joel Price, Oregon Dept of Agriculture, bugwood.org



Canada thistle rust (Puccinia punctiformis) spore stages (above); Teliospores (top) and spermagonia (bottom). Canada thistle rust in the fall (right).



Biocontrol Agent Description: A fungus that infects the root system and kills the leaves. Goldenorange colored pustules occur on leaves and stems in the spring, and brown rust colored spores in the fall.

CANADA THISTLE

Life Cycle: Canada thistle rust has a complex life cycle. In the spring and early summer, goldenorange pustules called spermagonia form on the underside of leaves. Spermagonia give way to chalky, rusty-brown aeciospores. In the fall, dark brown teliospores form on the underside of leaves. Teliospores can travel through the extensive root system spreading infection. Rust fungus can also be spread via wind to other Canada thistle patches.

Mode of Attack: Spores germinate on leaves and the fungus travels down stems to infect the root system. Once roots have been infected, nutrients cannot be drawn from the soil, thus weakening and potentially killing the plants.

How to Use: It is best to inoculate dense infestations in the fall when there is a higher dew point (after 2 P.M.), while outside temperatures range from 45 to 65°F. To inoculate, use a spray bottle to apply distilled water on newly growing rosettes that are less than 6 inches in height. Then place a ¼ teaspoon of your inoculum (infected leaves that have been dried and ground) on the damp rosette and spray more distilled water on the inoculum to ensure that it sticks on rosette leaves.

How to Collect: During fall, inspect leaves and stems for brown, rust-colored spores. Once infected plants have been identified, cut stem of plant and remove any flowers or flower buds. Allow leaves and stems to dry out, then remove leaves from stems

CANADA THISTLE

and finely grind (food processor, blender, etc.) dried leaves to create inoculum. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: In spring and/or early summer, check infestations for golden-orange pustules on underside of leaves that have an aromatic smell, similar to lilacs and/or rusty-brown spores. During fall, examine underside of leaves for rust colored spores.

In Montana: Canada thistle rust naturally occurs in Montana and, since 2017, has been intentionally moved to uninfected Canada thistle infestations. At the time of printing, there is a significant effort to inoculate and monitor approximately 100 sites in Montana to determine effectiveness and optimal site conditions for this agent. For up to date information, please visit mtbiocontrol.org.

Note: At the time of printing in 2021, Canada thistle rust is still being researched as a potential future Canada thistle biological control agent, please check with your weed coordinator or extension agent to determine if Canada thistle rust is available for general distribution.

CAL	CANADA THISTLE RUST (Puccinia punctiformis)	LE RUS	T (Puccinia _I	punctifor	mis)
Winter	Spring		Summer	er	Fall
	Golden-orange pustules form on underside of leaves.	pustules side of			
	-A	roduce ch brown s	Produce chalky, rust- brown spores.		
			Spores from diseased shoots infect neighboring plants.	diseased nfect g plants.	
					Dark brown spores from on underside of leaves.
Fungus overwinters in the root system.					Fungus moves into the root system.

(Rhaponticum repens)

Weed Description: Bushy, branched perennial with vertical and horizontal creeping roots. Blue-green lobed basal rosettes emerge in early spring, flowers develop and bloom in summer. Plants are 1/3 to 1 meter (1 to 3 ft) in height. Russian knapweed flowers are usually pink or purple with light pink to white tips on each flower head. Opaque bracts are smooth and papery without spines.

Russian knapweed (Rhaponticum repens) plant.



Biocontrol Agent for Russian Knapweed

Russian Knapweed Gall Wasp

(Aulacidea acroptilonica)



Unknown Effectiveness



Attack Site - Stem(s)



Collection Method - Clipping

*Please read notes on redistribution.





Jeff Littlefield, Montana State University

Adult Russian knapweed gall wasp (Aulacidea acroptilonica); ~ 1/8 inch in size (left). Galls made by the Russian knapweed gall wasp (Aulacidea acroptilonica) (right).

Biocontrol Agent Description: Adult wasps are around 2 mm (½ in), have dark bodies, brown slender legs, light colored transparent wings and long dark antennae. Females are slightly larger/longer than males. Larvae are milky white with a curved body and a white head capsule.

Life Cycle: Adult wasps emerge from the previous year's galls from mid-May to mid-June. Eggs are laid immediately after female wasps exit the galls. Once the larvae hatch, they begin to feed on the plant stems, forming galls. The larvae go through three developmental stages while inside the gall. The third phase goes dormant mid-summer and overwinters before pupation in the spring.

Mode of Attack: Larval feeding on plant stems initiates the development of protective plant tissue called galls. The formation of galls in response to larval feeding can negatively affect plant growth and development by allocating nutrients to the formation of the gall itself. Heavy gall production can reduce flower or seed production. Galling may weaken the plant but does not usually kill it.

How to Use: Release 50-100 galls on areas with a minimum 1 acre **infestation** (infestations of 5 or more acres are preferable) immediately after collection has occurred. There may be native insect predators that develop on them and kill wasps contained within the galls, therefore, it is best to collect galls from a local site for redistribution.

How to Collect: Collect galls in spring prior to adult emergence in mid-May. They can also be collected in the fall although it is less ideal. Clip stem several inches below gall. Galls should be mature (i.e. starting to dry out and leaves of the galls opening slightly). Place galls at the base of Russian knapweed plants in a location protected from rodents. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: Adult wasps are too small and short-lived to be easily identified. Instead, look for galls starting in early summer and throughout the year. Galls are easier to locate in fall or spring after plants have died back and leaves have fallen.

In Montana: Establishment is limited but increasing, and effectiveness is currently unknown.

Note: This recommended biocontrol agent is best used with other management strategies including additional biocontrol agents, chemical, and mechanical methods.

Due to parasitoid concerns, it is highly recommended to rear adults out of clipped galls for redistribution. This process is required for biocontrol agents moved across state lines.

RUSSIAN KNAPWEED GALL WASP (Aulacidea acroptilonica)	Summer Fall			Overwinter as Larvae in Galls	
WASP (A	Sun				
KNAPWEED GALL	Spring	Visible as Adults	Eggs Laid		Pupae
RUSSIAN	Winter				

Biocontrol Agent for Russian Knapweed

Russian Knapweed Gall Midge (Jaapiella ivannikovi)



梵 Unknown Effectiveness



Attack Site - Stem(s)



Collection Method - Clipping

*Please read notes on redistribution.





Adult Russian knapweed gall midge (Jaapiella ivannikovi); ~ 1/8 inch long (left). Galls made by the Russian knapweed gall midge (Jaapiella ivannikovi) (right).

Biocontrol Agent Description: Adult midges are light brown with transparent wings, large eyes, long slender legs, and are about 2 mm (1/8 in) long. Larvae

are white and curved with a slightly orange hue.

Life Cycle: Adult midges emerge in the spring. Females immediately lay eggs on the tips of plants. Once hatched, the larvae feed at the developing tips of stems and branches, stimulating the formation of leafy galls. There are multiple generations per year and galls can be located until the fall. The pupae are reported to overwinter in the galls before adults emerge the following spring. However, it is possible that some of the larvae drop out of the gall and overwinter as pre-pupae in the soil or soil litter (this needs further research). Several generations of the midge may occur depending upon location and climate.

Mode of Attack: Larval feeding on plant stems initiates the development of protective plant tissue called galls. The formation of galls in response to larval feeding can negatively affect plant growth and development by allocating nutrients to the formation of the gall itself. Galls on the primary stem usually prevent flower formation. Galling may weaken the plant but does not usually kill it.

How to Use: Release 50-100 galls on areas with a minimum 1 acre **infestation** (infestations of 5 or more acres are preferable) immediately after collecting. Release galls in locations where plants are still actively growing.

How to Collect: Galls may be collected from June to October. Clip the stem several inches below the gall. Galls should be mature (i.e. starting to dry out and leaves of the galls opening slightly).

Bundle galls together and place in a protective or shaded spot at the base of actively growing Russian knapweed plants. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: The adults are too small and short-lived to be easily located or identified. Instead, look for galls on Russian knapweed stems from June to October. Galls have a grey- whitish appearance due to gall hairs making them easy to locate. Galls are located at the tips of stems and branches.

In Montana: Midge establishment is limited but increasing in Montana. Effectiveness is unknown.

Note: To increase the chances of establishment, cut (mow, weed-eat, clip) a 30+ square foot area of the Russian knapweed about 2 weeks prior to the planned release. This will stimulate the production of new stems which the insects prefer. This biocontrol agent does not do well at drier sites or during dry years. However, when conditions are right, populations can significantly increase during the growing season. This agent is best used in tandem with other management strategies including additional biocontrols, chemical, and mechanical methods. However, grazing is not recommended; livestock and wildlife may selectively feed on galls.

Due to parasitoid concerns, it is highly recommended to rear adults out of clipped galls for redistribution. This process is required for biocontrol agents moved across state lines.

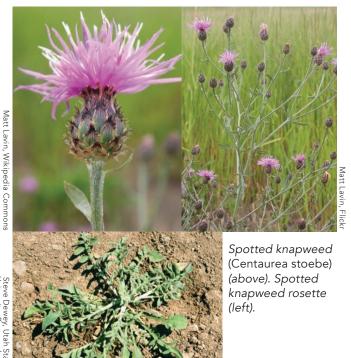
RUSSIAN	RUSSIAN KNAPWEED GALL MIDGE (Jaapiella ivannikova) *	MIDGE (Jaapiella	ivannikova) *
er	Spring	Summer	Tall
	Visible Adults	ults	
	Eggs Laid	Laid	
		Larvae	
		Overwir	Overwinters as Pupae

*There are four or more generations per year, each typically one month long. These generations occur from the beginning of spring to the end of fall.

SPOTTED KNAPWEED

(Centaurea stoebe)

Weed Description: Branched biennial or perennial with a deep taproot. Gray-green, wooly rosettes with deeply divided leaves emerge in early spring, bolt and flower in summer. Stems are ½ to 2 m (1 to 4 ft) in height. Spotted knapweed flowers are usually pink or lavender in color with bristle-topped seeds. Bracts are short, stiff and slightly fringed with dark colored tips.



Biocontrol Agent for Spotted Knapweed

Knapweed Moth

(Agapeta zoegana)



** Effective



Attack Site - Root System



Collection Method - Digging



USDA APHIS PPQ, USDA APHIS PPQ, bugwood.org

Eric Coombs, Oregon Department of Agriculture, bugwood.org



Adult knapweed moth (Agapeta zoegana); ~ 1/2 inch long (top). Knapweed moth (Agapeta zoegana) larva; ~ ¾ inch in length (bottom).

Biocontrol Agent Description: Adult moths are 11 mm (½ in) long with bright yellow forewings and dark gray hind wings. Wingspan ranges from 15-23 mm (¾ in). Females are larger than males. **Larvae** are white with brown mouthparts.

Life Cycle: Adults emerge from summer to early fall while knapweed is in bud and flowering. Eggs are laid on the lower stem and leaves. Larvae hatch and migrate to the **root crown** where feeding occurs. The larvae **overwinter** in the roots, and during the spring **pupation** occurs within the roots or in the soil near the root.

Mode of Attack: Larval feeding within the roots hinders the plant's ability to uptake nutrients and reduces knapweed biomass and density. Feeding can kill small plants if root tissue is completely consumed. Adult moths do not damage the plant.

How to Use: It is not typically necessary to move these moths because they are well established in many locations and find new spotted knapweed infestations on their own. However, they have the greatest impact when combined with other spotted knapweed biocontrol agents.

How to Collect: Collection is difficult and not generally necessary due to their widespread presence throughout Montana and is therefore not recommended.

How to Monitor: Visually inspect or **sweep net** on or near knapweed plants for adults during late spring to late summer. Inspect outdoor lights after dark for the adult moth. Pull roots year-round and check for larval feeding damage. Larvae are visible in the roots around mid-spring.

In Montana: This insect is well-established west of the Continental Divide and populations are increasing east of the Continental Divide.

Note: Spotted knapweed root moth larvae are slender and straight rather than C-shaped like the larvae of the spotted knapweed root weevil (Cyphocleonus achates). Root feeding damage by the moth larvae looks similar to that of damage caused by the root weevil. This biocontrol works well in conjunction with the spotted knapweed root weevil (C. achates). This agent can be used on diffuse knapweed infestations too.

SPOT	SPOTTED KNAPWEED MOTH (Agapeta zoegana)	AOTH (Agapeta	zoegana)	
Winter	Spring	Summer	ιŭ.	Fall
		Visible	Visible as Adults	
			Eggs Laid	
Overwinter as Larvae			Larvae	Φ
	Pupae			

Biocontrol Agent for Spotted Knapweed

Knapweed Root Weevil

(Cyphocleonus achates)



★★★ Very Effective



Attack Site - Root System



Collection Method - Hand Pick or Sweep Net



Adult knapweed root weevil (Cyphocleonus achates); 13-15 mm (~ ½ inch) long (left). Knapweed root weevil (Cyphocleonus achates) larvae with feeding damage in the roots; larvae are 13 mm (~ ½ inch) long (below).



N. Poritz, bio-control.com

Biocontrol Agent Description: Adult **weevils** are 13-15 mm (½ in) long, with short, thick snouts, and long brown/gray spotting. **Larvae** are up to 13 mm (½ in) long, white/pale yellow with large brown head capsules.

Life Cycle: Adults emerge from the roots mid to late summer. Adult females lay eggs in notches on the **root crowns**, just below the soil surface. Once hatched, the larvae will mine into the center of the root to overwinter. **Pupation** occurs within the root around mid-summer. The mature weevils chew their way out of the root to feed and mate.

Mode of Attack: Larval feeding within the roots hinders the plant's ability to uptake nutrients, leading to plant mortality. Small plants can be killed by larval feeding. However, most damage is done when multiple larvae occupy the same root. When high numbers of adult weevils are present, feeding on leaves can affect the rate of photosynthesis.

How to Use: Release 100+ adult weevils in areas with a minimum 1 acre **infestation** (infestations of 5 or more acres are preferable) in late summer to early fall. Ideal release sites should be hot, dry, and flood resistant. Place weevils directly on knapweed plants. In large knapweed infestations release 100+ weevils every ½ mile.

How to Collect: On hot, calm afternoons, from mid to late summer hand-pick or sweep net knapweed plants for adult weevils, sorting the weevils from other insects and plant material. If sweep netting, pick the weevils out periodically to prevent damage. Place weevils into containers with spotted knapweed stems and leaves for transport and storage. Weevils can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: From mid-late spring to late summer large C-shaped larvae, **pupae**, or adults can be found within the roots. Hollow chambers in the roots caused by feeding damage can be seen any time of the year. Visually inspect and sweep net on hot afternoons during mid to late summer for adults.

In Montana: These slow-acting but effective root weevils are well established in many areas throughout the state. However, since they do not fly, they are unlikely to move to new infestations without some help.

Note: This biocontrol agent works well in conjunction with the lesser knapweed flower weevil (*Larinus minutus*), blunt knapweed flower weevil (*L. obtusus*), or the knapweed moth (*Agapeta zoegana*). Spotted knapweed root weevil larvae are large and C-shaped rather than slender and straight like the larvae of the spotted knapweed moth (*A. zoegana*). This recommended agent can be used on diffuse knapweed infestations too.

	Fall				
chates)	ш	Visible as Adults	Eggs Laid		
cleonus ad	mer	Visible a	Eggs		зае
/IL (Cypho	Summer				Pupae
KNAPWEED ROOT WEEVIL (Cyphocleonus achates)	Spring			Overwinter as Larvae	
KNAP	Winter			Overwinter	

Biocontrol Agent for Spotted Knapweed

Lesser Knapweed Flower Weevil (Larinus minutus)

Blunt Knapweed Flower Weevil (Larinus obtusus)





Attack Site - Seed Head(s)



Collection Method - Sweep Net, Hand Pick





Adult blunt knapweed flower weevil (Larinus obtusus); ~ 1/4 inch long (left). Adult lesser knapweed flower weevil (Larinus minutus); ~ 1/4 inch long (right).





Gary Brown, USDA APHIS PPQ, bugwood.org

Larinus spp. larvae exit hole (left). Larinus minutus pupa in spotted knapweed seed head; ~ ¼ inch long (right).

Biocontrol Agent Description: Adult Larinus minutus are 4-5 mm long, a mottled dark brown color, with a large bent snout. **Larvae** are white, C shaped, and have brown head capsules. Eggs are elongated and yellow. *Larinus* species are difficult to differentiate. *Larinus obtusus* adults are slightly larger at 5-7 mm (½ in) long.

Life Cycle: Overwintering adults emerge from **soil litter** from mid-spring to late summer. Eggs are laid within the flower bud, and larvae feed on the seeds. **Pupation** occurs within the **seed head** in small chambers. During late summer to early fall, adult weevils exit the seed head and **overwinter** in the soil.

Mode of Attack: Larval feeding destroys a large portion of the developing seeds, which reduces the rate of knapweed spread. When adult **weevils** are present in large numbers, severe feeding damage to the stems and foliage can occur, which can stunt or even kill some plants.

How to Use: Release 200+ adult weevils in warm,

dry areas with a minimum of 1 acre **infestation** (infestations of 5 or more acres are preferable).

How to Collect: During late spring to early summer, on hot, calm days, sweep net knapweed plants, sorting the weevils from other insects and plant material. Place weevils into containers with spotted knapweed stems and leaves for transport/storage. Weevils can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: Inspect dried-up knapweed plants for adult exit holes in the seed heads, which can be done throughout the year. From late spring to late summer, visually inspect or sweep net for the adult weevils or **dissect** the seed heads to observe larvae or **pupae**.

In Montana: These weevils are wide-spread and therefore monitoring for presence before making releases should occur with the likelihood that releasing additional weevils is unnecessary. In Montana they greatly damage diffuse knapweed and are decreasing seed production in spotted knapweed.

Note: This biocontrol works well in conjunction with the knapweed moth (*Agapeta zoegana*) and the knapweed root weevil (*Cyphocleonus achates*). These recommended agents can also be used on diffuse knapweed infestations. *Larinus obtusus* prefers spotted knapweed, while *L. minutus* prefers diffuse knapweed. They are difficult to differentiate via visual inspection. Many releases likely contain a mixture of both species.

KNAPWEED FLOWER WEEVIL (Larinus minutus & Larinus obtusus)	FLOWER \	NEEVIL ((Larinus mi	nutus & La	rinus obtus	(sns
Winter	Spring	Бu	Sum	Summer	ΐ	Fall
			Visible a	Visible as Adults		
		Eggs	Eggs Laid			
			Larvae			
				Pupae		
Overwinter as Adults	ults					

Biocontrol Agent for Spotted Knapweed

Banded Knapweed Gall Fly (Urophora affinis)

Knapweed Seed Head Fly

(Urophora quadrifasciata)



Moderately Effective



Attack Site - Seed Head(s)





Judy Gallagher, Flick



Colorado State University



Adult banded knapweed gall fly (Urophora affinis); ~ 1/8 inch long (top, left) Adult knapweed seed head fly (Urophora quadrifasciata); 1/8 inch long (top, right). Urophora spp. larva and seed head damage (bottom, left).

Biocontrol Agent Description: Adults are up to 4 mm (1/26 in) long with dark bodies, clear wings, and faint horizontal lines across their body and wings. **Larvae** are white, barrel shaped, with dark brown anal plates by the end of their feeding period.

Life Cycle: Adult flies emerge in the spring as knapweed flower buds form. In late spring to early summer, eggs are laid in immature flower heads, which form **galls**. The larvae **overwinter** in the seed head and **pupate** the following spring.

Mode of Attack: Larval feeding prevents seed formation, reducing the rate of knapweed spread.

How to Use: There is no need to redistribute these flies, as they are well-established in Montana. However, they have the greatest impact when combined with knapweed root **boring** biocontrol agents.

How to Collect: Collection is not needed due to their widespread presence throughout Montana.

How to Monitor: From late summer to the following spring, dissect dried seed heads and look for galls with small, maggot-like larvae. In the spring, repeat this process examining the galls for small dark brown pupae. From late spring to late summer, visually inspect or sweep net for adult flies.

In Montana: These flies are well established across the state where knapweed species occur.

Note: This biocontrol works well in conjunction with the knapweed moth (*Agapeta zoegana*) and the knapweed root weevil (*Cyphocleonus achates*). These recommended biocontrol agents can be used on diffuse knapweed infestations too.

SPOTTED KNAPWEED

KN (U	IAPWEEI rophora q Spr	EED SEED H ra quadrifasci Spring	EAD FLY & ata & Urop	KNAPWEED SEED HEAD FLY & GALL FLY (Urophora quadrifasciata & Urophora affinis) Spring Summer	Fall	
		Visible	Visible as Adults			
			Eggs Laid			
Overwinter as Larvae	/ae					
			Pupae			

SALTCEDAR

SALTCEDAR

(Tamarix ramosissima)

Weed Description: Perennial shrub or small tree ranging from 1 to 8 meters (4 to 26 ft) in height. Saltcedar has an extensive and deep root system. Leaves are scale-like, bluish-green in color and similar in appearance to true cedars. Branches are smooth, slender, and break off easily. Flowers are white to pink and grow in a long spiky, drooping cluster.

Saltcedar (Tamarix ramosissima) plant.



Matt Lavin, Flick

Biocontrol Agent for Saltcedar

Saltcedar Leaf Beetle

(Diorhabda carinulata)



Moderately Effective



Attack Site - Leaves



Collection Method - Sweep Net

*Please read notes on redistribution.







William M. Ciesla, Forest Healtl Management International, Bugwood.org



Adult northern tamarisk beetle (Diorhabda carinulata); ~ ¼ inch long (top left). Larva of Diorhabda spp.; ~ ¾ inch long (top right).

Defoliation of saltcedar (Tamarix ramosissima) by saltcedar leaf beetle (Diorhabda spp.) (above).

SALTCEDAR

Biocontrol Agent Description: Adult beetles are 5-6 mm (¼ in) long with yellowish tan bodies and two large dark stripes alongside the wing cases. **Larvae** are 9 mm (¾ in) long and black with distinct yellow longitudinal stripes.

Life Cycle: In late April – early May, adult beetles emerge from leaf litter accumulated beneath saltcedar where they **overwintered**, to feed and mate. Female beetles deposit small masses of 1-25 eggs on saltcedar leaves. The larvae feed on **foliage** then drop down into the leaf litter to **pupate**. Multiple generations can occur each growing season, depending on environmental conditions. Although four species of this beetle have been released in the US, the species best suited for Montana is *Diorhabda carinulata*.

Mode of Attack: Larval feeding consists of scraping the protective surface from saltcedar bark and foliage. This makes it vulnerable to dehydration, which can result in the death of damaged leaves and branches. Energy reserves stored in the roots of affected plants are depleted by the metabolic demands of repeated regrowth. Extensive and repeated feeding throughout the growing season stresses plants and can lead to a reduction in overall plant growth, health and foliar regrowth, and/or partial or complete mortality. Defoliation also reduces or suppresses flowering and subsequent seed production, which impedes successful spread and colonization of un-infested sites.

How to Use: Because saltcedar biocontrol remains in the early stages of field deployment and establishment in Montana, recommendations are made under the assumption of future high-density

availability of beetles. As an example, releases of 500-20,000 adult beetles, multiple times per season, are made in the southwestern U.S. where beetles are well established and abundant. Because *Diorhabda* spp. adults and **pupae** spend part of the year in the duff under host trees, care should be taken to select release sites away from ant hills and on higher ground in areas subject to seasonal flooding.

How to Collect: Collections of this agent are typically made by sweeping the adult stage of *Diorhabda* spp. from high density populations of the beetle on saltcedar foliage. Beetles can be stored for several days under moderate refrigeration. Be careful not to transfer any seeds between the collection area and release site.

How to Monitor: Look for or sweep net adults and larvae on the foliage in the summer. Check for dead or shriveled foliage as well as **girdling** of bark on the branches. Dense but fine textured and tufty (i.e., "feathery") regrowth following defoliation by *Diorhabda* spp. sometimes occurs late in the growing season.

In Montana: *Diorhabda carinulata* biocontrol efforts have been focused on riparian saltcedar infestations in eastern Montana.

Note: The saltcedar leaf beetle is not permitted to be moved across state lines due to habitat conflicts with an endangered bird, the southwestern willow flycatcher. However, some states including Montana, have made the decision to redistribute insects collected and/or reared in-state to within-state saltcedar infestations. This decision was made because the southwestern willow flycatcher's habitable range lies significantly outside of Montana.

SALTCEDAR

	SALTCEDAR BEET	SALTCEDAR BEETLE (Diorhabda spp.)	
Winter	Spring	Summer	Fall
	Visible a	Visible as Adults	
	Eggs Laid		
		Larvae	
		Pupae	
		0	Overwinter as Adults

(Linaria dalmatica)

Weed Description: Herbaceous, short-lived perennial with a stout taproot and lateral roots. Stems are ½ to 2 m (1 to 4 ft) in height, robust and straight, with the top half frequently branched. Leaves are heart-shaped, thick, blue-green, waxy, tightly clasping where they join the stem, and typically 2 to 5 cm (1 to 2 in) long and nearly as wide. Dalmatian toadflax flowers are bright yellow, tinged with orange, clustered and grow primarily at the top of stems; resembling snapdragon flowers. Upright flowering stems arise in spring from overwintered rosettes that developed during the previous fall.

Dalmatian toadflax plant.



Utah State University, Bugwood.org

Biological Control Agent for Dalmatian Toadflax

Dalmatian Toadflax Stem Mining Weevil

(Mecinus janthiniformis)



** Effective



Attack Site - Stem(s)



Collection Method - Tapping, Aspirator, Hand Pick





Mecinus janthiniformis adult; $\sim \frac{1}{4}$ inch in size (left). Mecinus janthiniformis damage to Dalmatian toadflax plant (right).

Dalmatian toadflax stem mining weevil (Mecinus janthiniformis) larva in Dalmatian toadflax stem; larvae are ~ ½ inch in size (bottom right).



ura Parsons, University daho PSES, bugwood.or

Bob Richard, USDA APHIS PPQ, bugwood.org

Biocontrol Agent Description: Adults are 3-6 mm (~¼ in) long, colored bluish black with long snouts. **Larvae** are also around 5 mm (¼ in) long and white with brown head capsules.

Life Cycle: Adult **weevils** emerge from last season's toadflax stems mid-spring. Females lay eggs within new stems throughout the spring. After eggs have hatched, larvae feed within the stem. **Pupation** also takes place within stems during late summer. New adult weevils remain within the same stem to overwinter

Mode of Attack: Larval stem mining can cause upper portions of the stem to become deformed, hooked at the top, and drooping downward. Larval feeding within the stem reduces water/nutrient transport, with dehydration killing some stems. Defoliation by adults inhibits photosynthesis and reduces flower and seed production.

How to Use: Release 200+ weevils late spring to early summer in warm, dry, and open-canopy areas in a minimum 1 acre infestation (infestations of 5 or more acres are preferable) of Dalmatian toadflax. If the infestation is present on hillsides, it is best to release the weevils at the bottom or lower sections of the hill. They survive winter best in areas where snow is deep enough to cover and insulate at least the bottom half of the stems. Avoid releasing in areas subject to heavy livestock or wildlife feeding or other significant disturbance.

How to Collect: From spring to mid-summer, on hot, calm days, tap insects from plants into a

container, sorting the weevils from other insects and plant material. Place weevils into containers with Dalmatian toadflax stems and leaves for transport/storage. Weevils can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: From spring to mid-summer, visually check or sweep net the plants for adults. Later in the summer to the following early spring, stems can be dissected to look for larval feeding damage, larvae, pupae, new adults or their dry and powdery, sawdust-like excrement. However, keep in mind that stem dissection will reduce the number of adults that will be able to emerge the following spring.

In Montana: Population buildup of these insects has been more rapid west of the Continental Divide, where the winters are mild, and snow cover typically provides adequate insulation for overwintering adults. Success has been more variable east of the Continental Divide.

Note: *Mecinus janthiniformis* (specific to Dalmatian toadflax) and *M. janthinus* (specific to yellow toadflax) look similar, but they will only attack the toadflax that they are specific to. Be sure that you are releasing the correct *Mecinus* species on the toadflax species it was collected from. Dalamatian and yellow toadflax can hybridize (crossbreed). If you suspect you have a hybrid infestation, contact a weed management specialist for treatment recommendations.

DALMATIAN TO	DALMATIAN TOADFLAX STEM MINING WEEVIL (Mecinus janthiniformis)	VING WEE	:VIL (Mecii	nus janthinif	ormis)
Winter	Spring	Summer	mer	Fall	
	Visible as Adults	lts			
	Eggs Laid	75			
	<u>.</u>	Larvae			
			Pupae	96	
Overwinter as Adults					

YELLOW TOADFLAX

(Linaria vulgaris)

Weed Description: Erect, herbaceous perennial with a taproot and lateral spreading roots. Stems are ½ to 1 m (1 to 3 ft) in height. Leaves are pale green, narrow (always longer than wide), hairless, more pointed than rounded at both ends, with a prominent central vein on the underside, and typically 3 to 6 cm (1 to 2 in) long. Yellow toadflax flowers are tightly clustered near the top of stems, light yellow with orange throats, and very similar to snapdragons in shape and size.

Yellow toadflax (Linaria vulgaris) plants.



Roger Kido

Biocontrol Agent for Yellow Toadflax

Yellow Toadflax Stem Mining Weevil

(Mecinus janthinus)



* Fffective



Attack Site - Stem(s)



Collection Method - Tapping, Aspirator, Hand Pick







Bob Richard, USDA APHIS PPC

Adult yellow toadflax stem mining weevil (Mecinus janthinus); approximately 3 mm (1/8 in) in size (left). Yellow toadflax stem mining weevil (M. janthinus) larvae and adult with stem damage (right).

Biocontrol Agent Description: Adults are 2.4 -3.4 mm (~1/8 in) long, bluish black, elongated with long snouts. Larvae are up to 5 mm (1/4 in) long, and white with brown head capsules.

Life Cycle: Adults emerge in early spring after **overwintering** in the previous year's stems. Females deposit eggs within new growth stems throughout spring. The larvae feed exclusively on tissues inside of the same stem. **Pupation** is completed within host stems by late summer. New adult **weevils** remain within the stem to overwinter.

Mode of Attack: Larval stem **mining** causes the upper portions of the stem to be deformed, which results in severed water/nutrient transportation causing death of the stem. When present in high numbers, adult feeding damages the growing tips of the stems, reducing flowering and seed production.

How to Use: Release 200+ weevils during late spring in warm, dry open canopy areas in a minimum of 1 acre **infestation** (infestations of 5 or more acres are preferable). Weevils survive winter best in areas where snow is deep enough to cover and insulate the stems. Weevils have a difficult time establishing if the area is heavily grazed or disturbed.

How to Collect: In the spring, plan collections for warm, sunny, non-windy days. Adult weevils tend to stay on the lower parts of the stem or drop to the ground during windy or rainy conditions, making collections during inclement weather nearly impossible. Tap the stems over a collection pan or bucket to force the weevils to drop into the container. Sort the weevils from other insects and plant material. Place the weevils into containers with yellow toadflax stems and leaves for transport and storage. Weevils can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds

between the collection area and the release site.

How to Monitor: In early spring, check the tips and along the upper portion of the stems for adults. The leaves at the tips of infested stems are often whorled and yellow, with an overall appearance similar to plants with herbicide damage. During the summer, dissect the stems and look for larval feeding damage (tunneling), larvae, pupae, new adults and dry and powdery, sawdust-like excrement. Dissections of stems collected in late summer, fall, winter, and early spring can reveal the number and health of new, pre-emerged but fully developed adults. Note: stem dissections will reduce the number of weevils available to feed and reproduce in the future.

In Montana: Establishment and build-up of Mecinus janthinus to impactful numbers is linked to variability in environmental conditions from site to site and year to year, such as reduced or extended seasonal snow cover and either extreme fluctuations in or extended periods of low ambient temperature. Due to the frequency with which such extreme conditions occur, successful establishment is strongly correlated with repeated releases. This agent spreads very effectively on its own resulting in established populations where no known releases have been made. Surveying prior to releasing is therefore strongly recommended.

Notes: *Mecinus janthiniformis* (specific to Dalmatian toadflax) and *M. janthinus* (specific to yellow toadflax) look similar, but they will only attack the toadflax that they are specific to. Be sure that you are releasing the correct *Mecinus* species on the toadflax species it was collected from.

(snı	Fall					
inus janthir	ιĽ				Pupae	
EVIL (Meci	Summer				Pu	
NING WE	Sun			Larvae		
STEM MII	Spring	Visible as Adults	Eggs Laid	La		
ADFLAX	Sp	Visible				
YELLOW TOADFLAX STEM MINING WEEVIL (Mecinus janthinus)	Winter					Overwinter as Adults

Biocontrol Agent for Yellow Toadflax

Yellow Toadflax Stem Galling Weevil

(Rhinusa pilosa)



Unknown



Attack Site - Stem(s)



Collection Method - Tapping, Hand Pick





Toadflax stem galling weevil (Rhinusa pilosa); 3.2-4.3 mm (1/2 in) in length.

Biocontrol Agent Description: Adults are 3-4 mm (~1/2 in), black, and densely covered in bristled black hairs with a slightly curved snout. Forewings are twice as long as wide with ridges and grooves.

Life Cycle: Adults emerge from the leaf litter in early spring, at approximately the same time that spring growth of yellow toadflax begins (March – May). Adults feed on the new shoots and leaves for 3-5 days, mate, and lay eggs about 10 days thereafter. Female egg laying causes the development of stem galls. After the eggs hatch, the tiny larvae feed inside of the developing galls. During mid-summer pupation occurs within the gall and the pupae

soon turn into adults. New adult **weevils** feed within galls for 10-15 days and then chew their way out through the gall's outer surface. The newly emerged adults feed on yellow toadflax stems and leaves for approximately ten days then estivate (summer hibernation) in the litter. In the fall, adults emerge from the litter to feed for a short time before moving back into the litter to overwinter.

Mode of Attack: The formation of galls in response to egg-laying and larval feeding slows plant growth, flowering, and development.

How to Use: Release 50 to 100+ insects on sunny sites that will not flood and are free of snow early in the spring in a minimum of 1 acre **infestation** (infestations of 5 or more acres are preferable). Do not release them near ant piles.

How to Collect: Collect the adults with pantapping in spring when they are feeding and mating on young yellow toadflax stems. These insects may also be collected in late summer. Collect the galls when the adults start to chew through the "windows" in the galls. This means the adults are mature and are ready to leave the galls. Carefully dissect the galls and collect the adults from each gall. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: Look for stem galls on old and new stems.

In Montana: This insect is in the early stages of release and research as of this writing and may not be widely available for several years.

TOAD	TOADFLAX STEM GALLING WEEVIL (Rhinus pilosa)	NG WEEVIL (Rhinus	oilosa)
Winter	Spring	Summer		Fall
	Visible a	Visible as Adults		
	Eggs	Eggs Laid		
	Larvae	9.6		
		Pupae		
Overwinter as Adult				

LEAFY SPURGE

LEAFY SPURGE

(Euphorbia esula)

Weed Description: Herbaceous perennial with a deep taproot ranging from 3 to 7 m (9 to 21 ft) in depth and an extensive horizontal root system. Stems are densely clustered and are up to 1 meter (3 ft) tall. Leaves are narrow and 3 to 8 cm (1 to 3 in) in length. Leafy spurge flowers are minute, bright green to bright yellow in color and enclosed by showy, yellow-green bracts. When the stem or leaves of this plant are broken, a white, sticky liquid is produced.

Leafy spurge (Euphorbia esula) plants.



Biocontrol Agent for Leafy Spurge

Brown Legged Leafy Spurge Flea Beetle

(Aphthona lacertosa)

Black Dot Leafy Spurge Flea Beetle

(Aphthona nigriscutis)



★★★ Very Effective



Attack Site - Root System



Collection Method - Sweep Net, Accelerator





Mark Schwarzlander, University of Idaho, Bugwood.org

Brown legged leafy spurge flea beetle (Aphthona lacterosa) adult; ~ 1/8 inch in size (left). Black dot leafy spurge flea beetle adult (Aphthona nigriscutis); ~ 1/8 inch in size (right).

LEAFY SPURGE

Biocontrol Agent Description:

Aphthona lacertosa -Adults are 3 mm (1/2 in) long and a shiny black color with reddish brown legs. **Larvae** can be 5 mm (1/4 in) long; they are slender and off white with a brown head capsule.



Neal Spencer, USDA Agricultural Research Service, bugwood.org

Aphthona spp. larva; ~ ¼ inch in size.

Aphthona nigriscutus - Adults are generally just over 3 mm (1/8 in) long, orangish-brown with a black dot near the leaning edge of the wings. Larvae are 1-6 mm (1/5 in) long and are colored white with a brown head capsule.

Life Cycle: Adult beetles emerge from soil in early summer, feed, and mate. Female beetles lay eggs on leafy spurge stems or just below soil surface. Once hatched, larvae burrow into soil to feed on roots. Larvae feed on leafy spurge roots throughout fall and the following spring. **Pupation** occurs in the soil during early spring.

Mode of Attack: Larval feeding on the root hairs and young roots damages the root system of the plant, hindering its uptake of nutrients. Adult beetles feeding on leaves can affect photosynthesis when high numbers are present.

How to Use: Release 500+ adult beetles onto warm, dry **infestations** with a minimum size of 1 acre (infestations of 5 or more acres are preferable) of leafy spurge. Avoid areas where ants are found in

large numbers. In large infestations, release 500+ adult beetles every $\frac{1}{4}$ mile. Do not release in areas that flood regularly.

How to Collect: In early to mid-summer, on hot, calm days, sweep net leafy spurge stands, place the contents of the sweep net into an accelerator. The flea beetles will be separated through the small screen in the accelerator and will fall into the collection container at the bottom. Place beetles into containers or paper bags with leafy spurge stems and leaves for transport/storage. Beetles can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds of any plant between the collection area and the release site.

How to Monitor: During mid to late summer, sweep net leafy spurge infestations for the adult beetles. Visually inspect leafy spurge infestations for an area of dead or dying spurge plants around the initial release site that indicates the presence of well-established flea beetle populations. The area of dead or dying plants will increase in the following years before the beetle population crashes.

In Montana: This insect has shown to be very effective, especially on dry sites. As with all biocontrol agents, effectiveness varies from site to site.

Note: There are six different species of leafy spurge flea beetles that are known to be effective biocontrols. The two species listed are the most commonly found and effective species in Montana. Populations of both the weed and the beetles often follow a periodic high and low population cycle.

LEAFY SPURGE

nthona lacertosa)	Fall				
ona nigriscutis & Apł	Summer	Visible as Adult	Eggs Laid		4)
LEAFY SPURGE FLEA BEETLE (Aphthona nigriscutis & Aphthona lacertosa)	Spring			ае	Pupae
LEAFY SPURGE F	Winter			Overwinter as Larvae	

Biocontrol Agent for Leafy Spurge

Red Headed Leafy Spurge **Borer Beetle**

(Oberea erythrocephala)



Moderately Effective



Attack Site - Root System



Collection Method - Sweep Net, Hand Pick







Agricultural Research Service Retired, bugwood.org

Adult red headed leafy spurge beetle (Oberea erythrocephala); ~ 1/2 inch long (left). Red headed leafy spurge beetle (Oberea erythrocephala) larva; ~ ¾ inch long (right).

Biocontrol Agent Description: Adult beetles are very slender, and 10-12 mm (½ in) long with long dark antennae, red heads, dark grey wings, and light grey bodies. Legs are yellowish brown. Larvae are slender, segmented and white, with a yellow head capsule reaching up to 22 mm (34 in) long.

Life Cycle: Adult beetles emerge from the soil in early to mid-summer, feed, and mate. Females girdle the stem, chew a hole, and deposit a single egg on the lower part of the plant stem. Once the larvae hatch, they mine their way down the stem to the roots. The larvae overwinter in the center of the root or stem and pupate the following spring.

LEAFY SPURGE

Mode of Attack: Larval feeding on the roots and stems causes damage to the plant. This damage hinders the plant's ability to uptake nutrients, which causes plant mortality. Adult beetles feeding on leaves can affect photosynthesis when high numbers are present.

How to Use: Release 50+ adult beetles on warm, open to partially shaded areas with a minimum of 1 acre infestation (infestations of 5 or more acres are preferable). These beetles are strong fliers and will rapidly disperse throughout the infestation.

How to Collect: During mid-spring to midsummer, on hot, calm days, sweep net leafy spurge infestations, sorting the adult beetles from other insects and plant material. When sweep netting, pick the beetles out periodically to prevent causing them damage. Place beetles into containers with leafy spurge stems and leaves for transport/storage. Beetles can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: Sweep net for adult beetles from mid-spring to mid-summer. In early spring, pull up and dissect roots and examine for larvae.

In Montana: These insects are well-established in western and southwestern Montana and are present throughout the majority of the state.

Note: This biocontrol works well in conjunction with leafy spurge flea beetles (*Aphthona* spp.). This insect may attack only specific **biotypes** of leafy spurge, therefore limiting its efficacy in some areas.

LEAFY SPURGE

LEAFY S	PURGE BO	ORER BEE	LEAFY SPURGE BORER BEETLE (Oberea erythrocephala)	ocepha	ıla)
Winter	Spr	Spring	Summer		Fall
			Visible as Adults		
			Eggs Laid		
Overwinter as Larvae	rvae				
		Pupae			

ST. JOHNSWORT

(Hypericum perforatum)

Weed Description: Herbaceous perennial with vertical and horizontal, creeping roots. Stems are erect, branched, and 1/3 to 1 m (1 to 3 ft) in height. Leaves are narrow and 3 cm (1 in) long, have numerous transparent dots or tiny black dots along the center of the leaf. St. Johnswort flowers are bright yellow and have petals with black dots in the center.

Flowering St. Johnswort (Hypericum perforatum) plant.



Biocontrol Agent for St. Johnswort

Klamath Beetles

(Chrysolina hyperici and C. quadrigemina)



Moderately Effective



-Attack Site - Leaves



Collection Method - Sweep Net, Hand Pick



Bugwood.org





Eric Coombs, Oregon
Department of Agriculture,
Bugwood.org



Adult Chrysolina quadrigemina; 6 mm (¼ inch) long (top, left). C. quadrigemina larva: 6 mm (¼ inch) long (top, right). Adult klamath beetle (Chrysolina spp.) damage (left).

Biocontrol Agent Description: Adult beetles are oval shaped, shiny metallic with green, bronze, or blue undertones, and about 6 mm (¼ in) long. Eggs are cylindrical and orange. **Larvae** are initially orange and later gray and about 6 mm (¼ in) long.

Life Cycle: Larvae emerge in early spring and feed on young foliage when the plant is bolting. The larvae pupate in the soil in the late spring and emerge as adults in early summer, as St. Johnswort begins to flower, feeding on the plant's **foliage**. In mid-late

ST. JOHNSWORT

summer the adult beetles rest in the soil until fall rains stimulate them to resume feeding on foliage and lay eggs on leaves. It is most common for these eggs to **overwinter**. However, if rainfall is not sufficient, adults will overwinter and lay eggs in the spring.

Mode of Attack: When high numbers are present, larval and adult feeding can heavily **defoliate** plants, affecting photosynthesis.

How to Use: Release 200+ adult beetles in sunny, open areas in a minimum of 1 acre **infestation** (infestations of 5 or more acres are preferable).

How to Collect: On hot, calm days, during late spring to summer, when St. Johnswort is in flower, sweep net infestations, sorting beetles from other insects and plant material. Beetles can be stored under refrigeration for up to two weeks with fresh St. Johnswort stems and leaves added periodically, prior to release. Be careful not to transfer any seeds to new release sites.

How to Monitor: Visually inspect plants or sweep net for adults during late-spring to mid-summer.

In Montana: This biocontrol agent can be found throughout Montana, generally in low numbers. Unlike populations of this beetle in states with more moderate climate, in Montana the beetle produces only one generation per year, thus making them only moderately effective.

Note: Larvae feed at night and may be difficult to locate. Populations of both the weed and the beetles often follow a periodic high and low population cycle.

ST. JOHNSWORT

KLAMATH BEETLES (Chrysolina hypericia & Chrysolina quadrigemina)	ETLES (Chryso	olina hypericia	& Chrysolina	quadrigemina)
Winter	Spring	S	Summer	Fall
		Visible as Adults		
		Eggs Laid	70	
		Larvae	Φ	
		Pı	Pupae	
Overwinter as Eggs, Adults, or Larvae	gs,			

Depending on conditions, beetles may overwinter as larvae, eggs or adults.

TANSY RAGWORT

(Jacobaea vulgaris)

Weed Description: Herbaceous biennial that can be considered a winter annual or a short-lived perennial under certain conditions. Tansy ragwort begins as a **rosette** within its first year of growth, then produces a stem. Leaves are deeply **lobed** and 8 to 20 cm (3/8 in) long. Stems grow roughly 3/8 to 1 m (1 to 3 ft) in height, typically growing from one to several soft, fleshy roots. Tansy ragwort flowers are yellow and daisy-like. The entire plant is toxic to livestock, causing irreversible liver damage.

Tansy ragwort plant.



Biocontrol Agent for Tansy Ragwort

Cinnabar Moth

(Tyria jacobaeae)





-Attack Site - Leaves



Collection Method - Tapping, Hand Pick

^{*}Please read notes on redistribution.



Tony Wills, Wikipedia Commons



Charles J. Sharp, Sharp Photography, Wikipedia Commons

Cinnabar moth (Tyria jacobaeae) larva; 25 mm (1 in) long (top). Adult cinnabar moth (Tyria jacobaeae); 20 mm (7/8 in) long with 4 cm (1.5 in) wingspan (bottom).

Biocontrol Agent Description: Adult moths have black forewings with two red dots and red lined borders; color brightness fades with age. Wingspans can reach 4 cm (1.5 in). **Larvae** are light brown or orange, eventually turning orange and black and are 25 mm (1 in) long. Eggs are small, bright yellow, and turn black with age.

Life Cycle: Adult moths emerge during late spring to early summer, mate, and lay eggs in clusters on the underside of the **rosette** leaves. Once hatched, the larvae feed in groups attacking the leaves and developing flower buds before overwintering in the soil or plant litter as **pupae**.

Mode of Attack: Feeding larvae may completely **defoliate** the plant, leaving only bare stems. The lack of leaves reduces the plant's ability to photosynthesize, thus causing stress which can lead to a reduction in growth and/or mortality.

How to Use: Release 50-100 larvae in mid-summer, in warm, sunny areas in a large patch.

How to Collect: Shake the plants to force the larvae to drop into a collection pan or bucket. The larvae can also be handpicked from the plants. Place the larvae into containers with tansy ragwort stems and leaves for transport and storage. Larvae can be stored for several days under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: From early to late summer, look for yellow and black larvae feeding on the plant leaves. Larval feeding damage is often obvious as groups of larvae completely strip the plant of leaves, leaving only the plant stem. From late-spring to midsummer, check outdoor lights after dark for the adult moth. You can also walk through the tansy ragwort infestation during the day watching for them to fly.

In Montana: This insect has been highly effective in northwestern Montana, specifically in Lincoln and Flathead counties.

Note: This biocontrol works well in conjunction with the tansy ragwort flea beetle (*Longitarsus jacobaeae*). Due to observed non-target attack, the cinnabar moth is not permitted to be moved across state lines.

	CINNABAR MOT	CINNABAR MOTH (Tyria jacobeae)	
Winter	Spring	Summer	Fall
	Visible a	Visible as Adults	
	Eggs	Eggs Laid	
	Visible a	Visible as Larvae	
Overwinter as Pupae			

Biocontrol Agent for Tansy Ragwort

Tansy Ragwort Flea Beetle

(Longitarsus jacobaeae)



** Effective



Attack Site - Leaves



Collection Method - Insect Vacuum, Sweep Net, Aspirator





Eric Coombs, Oregon Department of Agriculture, Bugwood.org

Adult tansy ragwort flea beetle (Longitarsus jacobaeae); 2-4 mm (1/16 in) in length (left). Tansy ragwort flea beetle (Longitarsus jacobaeae) larva and leaf stalk damage; Larvae are 1-4 mm (1/16 in) in length (right).

TANSY RAGWORT

Biocontrol Agent Description: Adults are golden brown, 2-4 mm (1/16 in) long, with enlarged hindlegs. **Pupae** are white and 2-4 mm long. **Larvae** are white, 1-4 mm (1/16 in) long, with brown head capsules.

Life Cycle: There have been three biotypes of tansy ragwort flea beetles released in Montana, with two establishing and hybridizing. Adult beetles emerge mid-late summer and into the fall. After emergence, the adults feed on the foliage before laying eggs. Some populations overwinter as eggs, while others overwinter as both eggs and larvae. All populations pupate around mid-summer.

Mode of Attack: Adult feeding on the leaves creates numerous holes that create a "shotgun" like effect. These small holes hinder the plant's ability to photosynthesize, thus causing stress to the plant which can result in reduced growth. Larval feeding on the roots causes significant damage. This can result in a depletion of energy storage, reduced plant growth, and/or cause plant mortality.

How to Use: Release 200+ adult beetles mid to late summer in areas where flooding does not occur in a large, unshaded patch. The flea beetle can be released on less dense stands of tansy ragwort and exhibits better establishment than the cinnabar moth. They should be released on **rosettes**, not on **bolted** plants.

TANSY RAGWORT

How to Collect: During mid to late summer, on warm, calm days, rosettes of tansy ragwort infestations can be swept to collect for adult beetles. Sort beetles from other insects and plant material. Place beetles into containers with tansy ragwort stems and leaves for transport and storage. Beetles can be stored for up to two weeks under refrigeration, prior to release. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: From mid-summer through fall, look for the adult "shotgun" feeding damage on rosette leaves. Throughout mid-late summer, visually check or sweep net for adult beetles. In mid-summer, inspect rosettes for larvae or larval **boring** in the **root crown**.

In Montana: This insect has been highly effective in northwestern Montana, specifically in Lincoln and Flathead counties

Note: This biocontrol agent works well individually or in conjunction with the cinnabar moth (*Tyria jacobaeae*). There is also a small, dark-colored flea beetle that feeds on tansy ragwort foliage as an adult.

TANSY RAGWORT

Fall TANSY RAGWORT FLEA BEETLE (Longitarsus jacobaeae) Adults Visible Larvae **Eggs Laid** Pupae Summer Spring Overwinter as Eggs and Larvae Winter

WHITETOP

(Lepidium drabae)

Weed Description: Herbaceous perennial with an extensive lateral root system. Stems are single, erect, and are approximately 17 to 50 cm (7 to 20 in) in height. Leaves are grayish-green in color, arrowhead-shaped, and have uneven toothed margins. Small hairs may be present on the leaf surface. Whitetop flowers are white and are arranged in dense clusters, which create a flat-top appearance.

Whitetop (Cardaria draba) plant.



WHITETOP

Biocontrol Agent for Whitetop

Whitetop Gall Mite

(Aceria drabae)



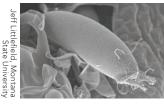
ア Unknown Effectiveness

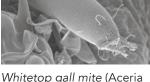


Attack Site - Stem(s) and Seed Head(s)



Collection Method - Clipping







Ann De Meij, Montana State University

drabae): 0.2-0.3 mm in length (left). Broccoli-like

galling in the flowers of whitetop as a result of whitetop gall mite (right).

Biocontrol Agent Description: Adult mites are 0.2-0.3 mm and translucent to opaque white often turning yellow/orange with age. Their abdomen is cylindrical, with equally spaced rings across their body. Eggs are spherical, clear to slightly yellow, and 0.04 mm in length.

Life Cycle: Mites overwinter in dormant buds at the base of the stem. As buds elongate in the spring, mites will feed and lay eggs on the developing plant tissue. Multiple generations occur during the growing season. Feeding by adult and immature mites induces gall formation on the developing stems, or more typical, in the developing flower buds. As the plant senesces, mites move back down onto root buds or sometimes in protective locations in the **root crown**.

Mode of Attack: Mite feeding on developing plant stems or branches and flower buds initiate the development of galls. Galls located in the flowers are broccoli-like in appearance. The formation of galls in response to mite feeding can negatively affect plant growth. This can result in the suppression of flower and seed production and possible plant stunting.

How to Use: These mites are generally moved by passive **dispersal**; including wind and attaching to visiting insects. Galls may also be collected and relocated to new sites. Stems need to be actively growing (pre-bud) for galls to develop.

How to Collect: Galls may be collected in the spring and transferred to new sites. To inoculate plants, bind several actively growing stems together to form a "teepee." Place the galls at the junction of the stems. Galls may be stored for several weeks, refrigerated under humid conditions. Be careful not to transfer any seeds between the collection area and the release site.

How to Monitor: The mites are too small to see with the naked eye. Galls are best observed prior to plant senescence in the summer. Most galls are located in the upper crown.

In Montana: Mites have just recently been released and recovered in the state. They will hopefully become more available for release in the future.

	WHITETOP GALL N	WHITETOP GALL MITE (Aceria drabae)	
Winter	Spring	Summer	Fall
		Emerged as Adults	
	Eggs	Eggs Laid	
		Lan	Larvae
Overwinter as Adults and Larvae			

How to Use Biocontrol

The following "how to" sections are intended to help you understand more about utilizing **ecology** and site selection to best use biocontrol to manage your weed **infestations**. You will also learn how to collect, release, **monitor**, and redistribute biocontrol agents in more detail and will be given more information about the tools you will need in order to handle biocontrol agents.

Biocontrol Agent Ecology

Permitted biocontrol agents have evolved to attack only one species of plant (they are host-specific) and often just one part of a plant, e.g., stem, flower head, roots. It can be helpful to think about biocontrol much like we think about how a workforce supports the local community. Each worker specializes in their role to support the community effort. For biocontrol, each species fills a specific role that targets one part of the plant. Biocontrol agents are categorized as leaf feeders, gallers, seed head feeders, defoliators, stem miners, and root borers. The role a biocontrol agent fills can even differ between growth stages, e.g., a biocontrol agent may attack the roots as a larva and defoliate the plant as an adult. For the best control of target weed infestations, combine biocontrol species that target different parts of the same plant.

How to Pick a Good Release Site for the Biocontrol Agents

The release site should:

- Have a large **infestation** of the target weed (5 acres or more is optimal).
- Be close to additional infestations of the target weed so that the biocontrol agents will have somewhere to spread.
- 3. Fit the ecological needs of the biocontrol agent to increase chances of establishment.
- 4. Fit the goals of the landowner.
- 5. Be easy to access, **monitor**, and collect from in the future.
- 6. Be relatively undisturbed (free of ants or other predators, at low risk of significant flooding, not heavily grazed, plowed, etc.) for at least 5 (preferably 10) years with a landowner agreement.
- Be well marked, photographed, and mapped (GPS coordinates).

How to Acquire Biocontrol Agents

Each county in Montana has a weed district with a county weed coordinator who you can contact to obtain biocontrol agents¹. However, the majority of these biocontrol agents are well established in Montana and therefore, you should inspect your weed infestation to determine if they are already present. Your weed coordinator may be able to show you where and how to collect biocontrol agents from established sites in the area. Be sure you have landowner permission before collecting

biocontrol agents! There are also several private businesses that sell biocontrol agents. Inform your county weed coordinator of all biocontrol releases you make. Be aware that you cannot ship/transport many biocontrol agents across state lines without obtaining or coordinating with someone who has an approved federal permit from USDA APHIS PPQ.

How to Collect Biocontrol Agents

Each biocontrol agent has a different method for collection. Many biocontrol agents are best collected during the hottest part of the day. Three common collection methods are:

- 1. **Sweep netting:** Using a special sturdy "insect net" with a robust canvas bag and "sweeping" it through the target weeds where the biocontrol agents are present. You will catch more than just biocontrol agents, so the mixture of insects in the net must be separated either by hand-picking biocontrol agents out of the net or by various **accelerators**/ separators.
- Hand-picking: Visually locating the biocontrol agent and picking it up by hand, clip galls, or dig roots.
- 3. Pan collecting or tapping: Shaking or tapping the weed over a sweep net, bucket or pan (such as a clean cat litter pan or large sized food container). The biocontrol agents in the pan can then be aspirated or hand-separated into a suitable container. Using plastic vials marked off to indicate a known quantity of a specific agent by volume can make counting agents for redistribution much easier.

As you collect, most biocontrol agents should be immediately put into an appropriate container and into a cooler with an ice pack for protection and transport.

How to Release Biocontrol Agents

Biocontrol agents should be released as soon as possible after collection. Record the



Pan collecting biocontrol agents.

number of biocontrol agents released, release date, and the weather conditions at the time of release. If the biocontrol agents have been cooled, they need to warm up for at least 10 minutes so that they can escape predators once released. Biocontrol agents should not be released near an ant pile, just before or during a rainstorm, on cold days, or just before sunset. To release most biocontrol agent species, carefully open the container and sprinkle them onto their host weeds in one spot. Do not spread the biocontrol agents across the target weed patch. In Montana, the majority of the biocontrol agents used only have one generation per year. Therefore, the biocontrol agents released need to be able to find each other, mate, and lay eggs, ensuring a new generation in your weed infestation the following year. Be sure not to step or drive through the release spot as you leave. Take a photo of the site that shows enough background terrain and landmarks so anyone can find the site using the photo. Take GPS coordinates (longitude and latitude) of the site or make a map to the site that starts from a known landmark such as a city or major highway. Record this at the site on the day you make

the release. Provide a copy of your site information to your county weed coordinator¹.

How to Monitor Biocontrol Release Sites

Four reasons to **monitor** biocontrol agent release sites are to determine:

- 1. If the biocontrol agent becomes established.
- 2. The effect on the target weed population.
- 3. If the biocontrol agent spread from the release site.
- 4. If the biocontrol agent population is large enough to collect for redistribution.

Try to take a photo of the release site from the same location at about the same date each year.

Each biocontrol agent has a different method for monitoring:

- 1. **Seed head** feeders: **Sweep net** for adults, observe the seed head for damage, dissect the seed head and look for feeding damage or **larvae/pupae**.
- 2. **Foliage** feeders: Sweep net for adults, look for larvae and feeding damage to plants.
- 3. **Galling** insects: Sweep net for adults; observe the appropriate weed part for the galls.
- 4. Stem **miners**: Sweep net for adults, dissect the stem and look for feeding damage or larvae/adults.
- 5. Root **borers**: Sweep net for adults, pull up weeds and dissect the roots looking for feeding damage or larvae/pupae.

¹https://www.mtweed.org/weeds/weed-districts/

How to Redistribute Biocontrol Agents

Once the biocontrol agents have become well-established and built up a large population, it is a good idea to start moving them to new target weed **infestations** (on your property and/or sharing them with your neighbors and friends). Although many biocontrol agents can disperse well on their own, some benefit from redistribution to new target weed patches. Simply collect the biocontrol agent that is appropriate for that weed species and quickly take them to the new site and release them.

When NOT to use Biocontrol

- 1. On a small, isolated target weed **infestation**.
- In an area that is being treated or is likely to be treated with herbicide or is scheduled to be controlled with mechanical control; e.g. mowing, plowing, etc.
- On a weed that is new to the area or is a Montana eradication target (Priority 1A or 1B noxious weed).
- 4. On a site which is likely to be significantly disturbed within the next 5 or so years.

Insect Handling Tools

Sweep Net

Many biocontrol agents are best collected with a **sweep net** during the heat of the day. A sweep net is a robust net with a canvas bag used to sweep through weed **infestations** to collect biological control agents. To collect, sweep the net rapidly in

a pendulum motion through the weeds where and when the biocontrol agents are present. Be careful not to pick up ground litter or rocks as these will damage the agents within the net. Also, do not hit sharp objects such as barbed wire fences or tree branches as these will tear the net. As you sweep, collect the biocontrol agents periodically from the net. This can be done by hand, with an aspirator, or the sweepings can be dumped into an **accelerator**/ separator or container. At the end of the day, make sure to remove plant material and seeds from the net to mitigate spreading weeds to a new site. Many county weed districts will have sweep nets that you can check out or rent.





Sweep nets in use (above). Variety of sweep nets available for insect collection (left).

Separator or Accelerator

A separator/accelerator is a field device used primarily for collecting leafy spurge flea beetles. Dump the flea beetle sweepings into the top of the device; the flea beetles will hop through a small mesh screen and fall through a funnel into a container. Periodically, empty the container into suitable insect transport containers. This device will keep the larger insects and many of the smaller insects out of your biocontrol insect collections, leaving mostly flea beetles which can be measured (counted) by volume.

Aspirator and Pump

An aspirator is a small device that uses a vacuum to pull an insect into a container. They are a good way of completely separating the biocontrol agents from all the other insects. Aspirators work well for smaller, hard bodied insects. The vacuum can be created by lung power (inhaling) or a vacuum pump. To aspirate a biocontrol agent, simply inhale on the plastic tube



An accelerator set up in the field (left). Aspirator and pump (right).



while pointing the open metal tube close to the insect. Filter screens on the tube can reduce the inhalation of particles and be purchased from insect supply companies.

Volume Count Container

The container is a plastic vial (measuring 1" x 2 %") with the volume measurements for leafy spurge flea beetles, Dalmatian toadflax stem boring weevils, and knapweed seed head weevils. The vials can be secured from an insect supply store. The measurement label can be found at: http://www.mtbiocontrol.org/wp-content/uploads/2021/09/Insect-measuring-vials.pdf and printed on clear labels.

Insect Containers

Cylindrical cardboard containers are best, because they are strong enough to keep the biocontrol agents from being crushed but allow for good airflow. Plastic, glass, or coated containers should be avoided unless suitable ventilation holes are provided. These can easily be made by inserting a push pin several

Volume count containers (left). Insect containers (right).



times into the lid of the container. Plant material (the weed with no seeds, flowers or root fragments) and/or crumpled paper towels should be placed within the container before the biocontrol agents are added. This gives the insects something to hold onto and moisture/food. For short transport, almost any container will work. Keep the containers out of the direct sun so the insects do not overheat. Tape the lid shut with masking tape so the container does not come open during transport.

Cooler and Refrigerator

Large numbers of biocontrol agents within a container create their own heat and must be immediately cooled. Cooling the insects also slows them down so that they do not injure each other in the container. Insects should be stored and transported at cool but non-freezing



temperatures. For transport, they should be placed in a cooler with ice packs. Use a layer of newspaper, a towel or something similar to separate the containers from the ice to prevent freezing. For storage, place insects in a refrigerator. Do not allow them to freeze. Generally, beetles/weevils can be stored for up to a week whereas delicate insects like moths, small bodied wasps, flies, and midges should not be stored for more than 1-2 days. However, all biocontrol agents should be released as rapidly as possible.

How to Include Biocontrol in Integrated Weed Management (IWM)

An Integrated Weed Management (IWM) plan incorporates a variety of methods to control noxious weed species. Incorporating biocontrol as part of your IWM plan requires understanding how biocontrol agents control their target weed and interact with other management efforts. To visualize how biocontrol can be used in conjunction with other methods, some people find it helpful to think of a weed infestation as if it were a fire complex with smaller satellite weed patches as spot fires out in front of the main weed infestation as the larger fire. Using this visualization, you would release biocontrol agents within the main patch of weeds, finding the site that best fits their ecological needs. You can then apply herbicides to the satellite patches and around the perimeter of the whole infestation to contain it and prevent spreading. Utilizing herbicides in conjunction with biocontrol can be a good strategy as long as the herbicide is not applied directly on areas where biocontrol agents are established. For additional management, hand-pull along waterways and mow or graze the remainder of patches with sheep or goats. Over time, work inwards with herbicide and grazing and let the biocontrol agents work their way out.

The table on the following page informs which weed management tools can be utilized to aid in the management of Montana state listed terrestrial weeds.

Terrestrial Weed Species*	Hand-pulling /Digging	Tillage	Mowing**	Biocontrol Agents	✓ Herbicide***
Blueweed	1	1	1		1
Cheatgrass	1	1	/		1
Cinquefoil, Sulfur	✓	1	1		1
Common Buckthorn	1		1		1
Common Reed					1
Common Tansy			/		✓
Dyers Woad	1	1	1		1
Field Bindweed				1	1
Flowering Rush					1
Hawkweeds	1				1
Hoary Alyssum	1	1			1
Houndstongue	✓	1	1		1
Knapweed, Spotted & Diffuse	✓	1	1	1	1
Knapweed, Russian			1	1	1
Knotweed Complex	✓			1	✓
Leafy Spurge				✓	✓
Medusahead		1	1		1
Oxeye Daisy	✓	✓			1
Purple Loosestrife	1			1	1
Perennial Pepperweed	✓		1		1
Rush Skeletonweed			1	✓	1
Russian Olive		1	/		✓
Scotch Broom					1
St. Johnswort	✓	1	1	✓	1
Tall Buttercup	✓	1	1		1
Tamarisk	✓			1	1
Tansy Ragwort	✓	1	1	1	✓
Thistle, Canada			✓	✓	1
Toadflax, Dalmatian	✓		1	1	1
Toadflax, Yellow	✓		1	1	1
Ventanata			1		✓
Whitetop	✓		1	1	1
Yellowflag Iris	✓		1		
Yellow Starthistle	✓	✓	1	✓	1

LOW IMPACT BIOCONTROL AGENTS

Low Impact Biocontrol Agents

The biocontrol agents included in the table on the following pages are considered low priority for redistribution in Montana due to a low level of impact to their target weed.

This low level of impact may be due to the biocontrol agent's inability to survive in Montana's climate, or it may be a result of an overall inadequate level of impact under field conditions. Therefore, we do not encourage land managers to put significant resources towards obtaining and releasing these insects. However, if no other suitable weed management tools are available and you would like to release the insects that have been approved for redistribution in the US, please think of it more as an experiment. Research regarding the efficacy of these biocontrol agents indicates they do not result in an adequate level of weed control.

^{*}Montana's Aquatic Invasive Species are not included on this list.

^{**}If done correctly with species that reproduce by seed only, mowing can be effective. For optimal timing of mowing, contact your local county weed district.

^{***}Contact your local county weed district or extension agent for herbicide recommendations: Montana Weed Control Association https://www.mtweed.org/ or contact your local state agency.

Target Weed	Biocontrol Agent Latin Name	Biocontrol Agent Common Name	Damage	Approved for Distribution USA	Notes on Redistribution
Tansy Ragwort	Botanophila seneciella	Ragwort seed head fly	Seed feeding	>	Redistribute pupae amid layer of sand/moss during late summer
, c	Hadroplontus litura	Canada thistle stem weevil	Stem mining & feeding	>	Redistribute in spring on ½ acre patch
Thistle	Urophora cardui	Canada thistle stem gall fly	Stem feeding Gall formation	>	Redistribute reared adults (from gall) to new infestations
Russian Knapweed	Subanguina picridis	Russian knapweed nematode	Gall formation	>	Redistribute galls to soil of uninfested patch in fall
Spotted	Bangasternus fausti	Broad-nosed knapweed seed head weevil	Seed feeding	>	Redistribute 200 individuals (adults) to ½ acre patch in summer
Knapweed	Chaetorellia acrolophi	Knapweed peacock fly	Seed feeding	>	Redistribute infested plants into uninfested patches in late fall or early spring

Target Weed	Biocontrol Agent Latin Name	Biocontrol Agent Common Name	Damage	Approved for Distribution USA	Notes on Redistribution
	Sphenoptera jugoslavica	Bronze knapweed root borer	Foliage feeding Root feeding	>	Redistribute 50-200 adults in new site with hot climate and well-drained soil during the summer
Spotted Knapweed (continued)	Metzneria paucipunctella	Spotted knapweed seed head moth	Seed Feeding Seed Binding	>	Redistribute infested plants into uninfested patches in spring
	Terellia virens	Green clearwing knapweed fly	Seed Feeding	>	Redistribute infested plants into uninfested patches in late fall or early spring
3	Aphthona cyparissiae	Brown dot leafy spurge flea beetle	Root feeding Leaf feeding Flower feeding	>	Redistribute 200-300 adults to new sites in mid-summer
המול ל המול ל המול ל	Aphthona czwalinai	Black leafy spurge flea beetle	Root feeding Leaf feeding Flower feeding	>	Redistribute 200-300 adults to new sites in mid-summer

Target Weed	Biocontrol Agent Latin Name	Biocontrol Agent Common Name	Damage	Approved for Distribution USA	Notes on Redistribution
	Aphthona flava	Copper leafy spurge flea beetle	Root feeding Leaf feeding Flower feeding	>	Redistribute 200-300 adults to new sites in late summer
Leafy Spurge (continued)	Hyles euphorbiae	Leafy spurge hawk moth	Foliage feeding	>-	Redistribute 50-100 larvae to new infestations in either spring/early summer or late summer/fall
	Spurgia capitigena	Leafy spurge tip gall midges	Spurge tip feeding Stem feeding	>	Redistribute galls collected prior to spurge flowering (mid-May to mid-June) by cutting stems and transferring to new sites
	Agrilus hyperici	St. Johnswort root borer	Root feeding	>	Redistribute 50-100 adults to new infestations during summer when plants are in flower
St. Johnswort	Aplocera plagiata	St. Johnswort inchworm	Foliage feeding	>	Redistribute 50-100 larvae collected midsummer or early fall and immediately transfer to new infestation

Notes on Redistribution	Redistribute 200 adults to a new infestation during spring when plants are in bud or flowering	n-target attack	-200 adults to in the spring	spring when
Notes on F	Redistribute 200 adults to a ne infestation during spring when plants are in bud or flowering	Concern for non-target attack	Redistribute 100-200 adults to new infestations in the spring	Redistribute late spring when
Approved for Distribution USA	>	Z	>	>
Damage	Flower feeding Seed feeding	Foliage feeding	Gall formation Stem feeding	Gall formation
Biocontrol Agent Common Name	Toadflax flower-feeding beetle	Toadflax moth	Toadflax root- galling weevil	Toadflax seed
Biocontrol Agent Latin Name	Brachypterolus pulicarius	Calophasia Iunula	Rhinusa linariae	Rhinusa Antirrhini
Target Weed		Yellow	Toadflax & Dalmatian Toadflax	

GLOSSARY

Aceospores: The spore stage following spermagonium during which the spores undergo reproduction.

Accelerator: A device that separates smaller insects from larger insects and debris. See also "Accelerator/ Separator" under "Insect Handling Tools."

Annual: A plant that completes its life cycle in one year.

Biennial: A plant that has a two year life cycle. Usually growing a basal rosette the first year and flowering the next.

Biotypes: A group of organisms having the same or nearly the same genetic composition, distinguished from others of the same species by its physiological properties.

Bore/Boring: Feeding into or through a plant part making a hole or tunnel.

Bracts: The leaf-like structures associated with the flowers of a plant; found directly below the flowers.

Bolt: The production of flowering stem(s).

Control: Reducing the number of weeds on a site to the point where they no longer cause economic or environmental harm.

Defoliate: The removal of target weed leaves through biocontrol feeding.

Disperse: To spread widely.

Dissect: To cut or tear apart and observe what is inside.

Dormant: A period of time in which the plant is alive but not actively growing; usually during winter.

Ecology: The branch of biology that deals with the relations of organisms to one another and to their physical surroundings.

Foliage: Non-woody above ground plant components.

Gall (galling): Swelling, a biological agent causing a plant part to swell.

Girdle: To feed or strip a ring around the outside of a stem. This weakens or kills the stem above this point.

Infestation: The presence of an unusually large number of insects, animals, or weeds, typically causing damage or disease.

Inoculate: A substance used to inoculate

Inoculum: A substance used to inoculate.

Integrated Weed Management (IWM): Using multiple weed control methods together to affect a weed in multiple ways and improve overall control.

Larva (Larvae): The immature stage of an insect, with complete metamorphosis, between an egg and a pupa (e.g. caterpillar or maggot).

Lobed: A rounded portion of a leaf margin that is separated by the other part of the leaf by an indentation

Margins: The edges of a leaf.

GLOSSARY

Mine: Insect feeding that typically creates a tunnel through a plant part.

Monitor: Check for establishment of a biological control agent and collecting information on weed and other plants' abundance.

Noxious Weed: A state designated weed species that causes (or has the potential to cause) economic or environmental damage.

Overwinter: Surviving through the winter.

Perennial: A plant that has the potential to live for three or more years.

Pupa/Pupae: The immature stage of an insect, with complete metamorphosis, between a larva and an adult. Inactive, undergoing metamorphosis.

Pupate: In insects with complete metamorphosis the process of changing from a larva to an adult.

Pustules: Raised spots on the leaves and/or stem of a plant infected with rust fungus.

Root crown: The upper portion of a root at ground level, just below the rosette.

Root hairs: Small hair-like extensions near the tip of a root. They function to increase the root's surface area for water and mineral absorption.

Rosettes: A cluster of leaves radiating out from the base of the plant.

Seed head: The fruit of a plant that holds the seeds, produced by the flower.

Senesce: The condition or process of deterioration with age.

Soil litter: Dead plant and animal material lying on top of the soil.

Sweep net: A robust canvas net used to collect insects; often swept through vegetation. See also "Sweep Net" under "Insect Handling Tools."

Spermagonia: A cell produced at an early stage in the formation of a spermatozoa (e.g., a stage in Canada thistle rust fungus which can be identified by golden-orange pustules on leaves that have a fragrant lilac-like smell).

Taproot: A straight tapering root growing vertically downward.

Teliospores: A rust fungus spore stage (e.g., in Canada thistle rust, teliospores can observed in the fall as rust-colored spores on the underside of leaves).

Weevil: One of many forms of beetles, usually with a long snout.

Window (gall): A gall window is caused when an insect chews to the inside edge of a gall but does not quite break the surface. This leaves a clear or opaque layer of tissue that looks like a window into the gall. The insects probably do this to better detect light so they can decide when to emerge from the gall.

USEFUL LINKS

Montana Department of Agriculture https://agr.mt.gov/Weeds

Montana Weed Control Association https://www.mtweed.org/

USDA APHIS PPQ

https://www.aphis.usda.gov/aphis/home/

Montana Biocontrol Coordination Project www.mtbiocontrol.org

North American Invasive Species Management Association (NAISMA)

https://naisma.org/

CABI

https://www.cabi.org/what-we-do/cabi-centres/biological-control-of-invasive-plants/

MSU Extension Publications

https://store.msuextension.org/Departments/Publications.aspx

iBiocontrol

https://www.ibiocontrol.org

Noxious Weed Trust Fund































Richland County Weed District
Powder River County Weed District
Sheridan County Weed District

