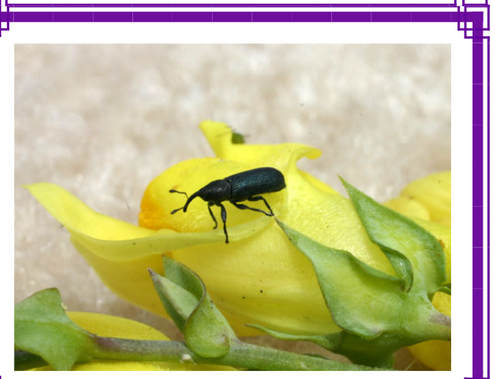
BIOLOGICAL CONTROL OF NOXIOUS WEEDS IN LINCOLN COUNTY



LEARN HOW TO USE INSECTS AND PLANT DISEASES TO BATTLE NOXIOUS WEEDS

The members of the Lincoln County Noxious Weed Control Board, the Coordinator and Administrative Assistant determined that an identification book specific to Lincoln County and showing how to identify and utilize biological control agents to control noxious weeds found in and around Lincoln County was needed.

The use of biological agents to control noxious weeds is situation specific and is not recommended for every noxious weed infestation site. The Lincoln County Noxious Weed Control Board strongly recommends not considering implementing biological control unless the landowner has a solid stand of noxious weed(s) that infests at least 20 acres.

We ask that you consult this manual and contact the Lincoln County Noxious Weed Control Board before implementing Biological agents on your property.

We recommend that if you are interested in using biological control that you obtain a copy of the Noxious Weed Management Booklet from the Noxious Weed Control Office.

We hope that you enjoy this publication. Be sure to alert the staff of any changes or additions that you would like to see for future updates.

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NOTES

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- Services We Provide
- Herbicide Recommendations
- Full Circle Noxious Weed Control
- Noxious Weeds of Lincoln County
- Biocontrol of Noxious Weeds in Lincoln County
- Lincoln County Noxious Weed List
- Herbicide Facts
- Noxious Weeds For Home Buyers
- No Tolerance Noxious Weeds
- Options for Control of:
  - Phragmites (Common Reed)
  - Kochia
  - Myrtle Spurge
  - Rush Skeletonweed
  - Puncturevine
  - Japanese Knotweed
  - Yellow Flag Iris
  - Western water hemlock
  - Whitetop/Hoary Cress
- Biological Control of:
  - Canada Thistle
  - Common mullein
  - Dalmatian Toadflax
  - Houndstongue
  - Knapweed
  - Poison Hemlock
  - Rush Skeletonweed
  - Russian Thistle

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INTRODUCTION

Biological weed control is an evolving science. Researchers are working to understand how plant-insect and plant-disease interactions and interrelationships influence weeds, biological control agents, and the environment. It is important to know how these processes can be manipulated to benefit one organism (the biological control agent) over another (the target weed).

Many introduced weeds in the United States are not problems in their native lands, but are merely members of their respective plant communities. Biological control seeks to use some of the native land's biotic factors that suppress the populations of plants such as leafy spurge, spotted and diffuse knapweed, tansy ragwort, and purple loosestrife. Continued research in the field of biological control is needed to learn how a plant's natural enemies survive, the plant's response to natural enemies, how each is influenced by conditions and forces in the environment, and interrelationships between natural enemies and hosts. Integration of effective biological control agents into weed management programs is the ultimate goal of a weed biological control program.

BIOLOGICAL CONTROL OF WEEDS

Biological control, or *biocontrol*, is the intentional use of living organisms to reduce the population of a pest. It may include the use of insects, nematodes, mites, plant pathogens, and vertebrates. Often more than one biocontrol agent is introduced on a weed. Each enemy detrimentally affects the weed to some degree. This effect may be obvious, such as when the plant is defoliated, or it may be subtle, such as when slight damage caused by the biocontrol agent allows secondary organisms (such as pathogens) to inflict greater damage.

Because the majority of the noxious weeds in the United States are introduced without their natural enemies, and many of these weeds are minor members of the plant communities in their native lands, insights about weed management may be found by studying these plants in their native homelands. Studies reveal which organisms are associated with the target plant, which of these damage the weed, and which damage other plants. From these results, potential biocontrol agents are selected and tested to determine their host range. Those that have a very limited host range under starvation feeding trials are approved for release into the United States.

The eventual impacts of a biological control agent on its target plant will be the result of: 1) the density of weeds compared to the density of the agent; 2) the effect of the local conditions on the agent and on the weed; 3) the plant's reproductive ability (seeds only or seeds and vegetative reproduction); 4) the agent's ability to stress the plant each year and the plant's ability to maintain and replace root reserves; 5) the plant's ability to recover from the effects of the biocontrol agent; and 6) the interactions of multiple biocontrol agents attacking a single weed species.

Both advantages and disadvantages are associated with the use of biocontrol agents. One advantage is that once a biological control agent becomes established it usually will reproduce, increase its numbers, and continue to attack the target organism, generally without additional costs to the land manager. Second, biocontrol agents move to host plants anywhere within their climatic range, readily crossing ownership boundaries and some geographical barriers. Third, approved biocontrol agents are selective. Host weeds are attacked without damage to the surrounding vegetation. Finally, properly tested biological control agents are not a source of environmental contamination.

A disadvantage of biocontrol is that it often takes many years for the populations of the introduced agents to increase to levels that permanently decrease the pest plant population. A limited number of eggs are laid by insects and the initial population build-up appears slow. However, insect numbers increase exponentially. As biocontrol agent populations gradually increase, the weed population will gradually decrease and may be unnoticed by the landowner. Photo points can help document the seriousness of the original weed problem and the change in the weed population over time. A second disadvantage is that some biocontrol agents may be subject to predators.

insect: An **arthropod** with an external skeleton, three body sections, usually three pairs of jointed legs, antennae, and sometimes wings.
instar: A larval stage of insect development between successive molts.
involucre: A whorl of bracts below a flower cluster.
meristem: A group of plant cells capable of dividing indefinitely and whose main function is the production of new growth; the growing tips of plants.
mesophyll: Internal plant leaf tissue that supports photosynthesis and the storage of starch.
mite: A tiny arthropod that may feed on plants, other mites, or small insects.
multivoltine: Able to complete many (generally, at least three) generations within a year.
nematode: A minute worm that may be parasitic on insects or plants.
oviposit: To lay eggs.
ovipositor: A specialized structure in adult female insects for depositing eggs.
pappus: A tuft of hairs or bristles often found at the ends of fruits or seeds (such as dandelions).
parasitism: The interaction of species populations in which one, typically small, organism (the parasite) lives in or on another (the host), from which it obtains food, shelter, or other requirements.
parasitoid: An insect (especially a wasp or fly) whose larval stage is parasitic and often kills its host; its adult stage is free-living.
parenchyma: Plant tissue composed of thin-walled, general purpose cells that form a large part of the bulk of many plants.
peduncle: The flower stalk of a plant.
petiole (adj.: **petiolate, nonpetiolate**)**:** The stalk by which a leaf is attached to a stem.
phytophage: Plant-eater (adj. **phytophagous**).
pilose: Covered with fine hairs or down.
pith: The spongy core of a stem.
prothorax: The front of an insect's middle body region (**thorax**).
pruinosity (adj. **pruinose**)**:** A whitish, powdery covering.
receptacle: The seed-producing tissue at the base of a flower.
reticulate: Marked with a mesh or network pattern of crossing veins or fibers.
rhizome (adj. **rhizomatous**)**:** A horizontally creeping underground stem with nodes that can bear roots or leaves.
root crown: The area where main roots join the plant stem, usually at or near ground level; root collar.
rosette: A ground-level cluster of leaves.
sacculate: Formed by or divided into small sacs.
sclerotized: Hardened.
stolon (adj. **stoloniferous**)**:** A stem or "runner" that grows horizontally along the ground.
thorax: An insect's middle body region.
tubercles: Small, round, raised nodes.
umbelliferous: Having flowers that grow in flat-topped clusters, such as carrots, parsley, and leafy spurge.
weevil: A type of beetle; adults have long, curved snouts and larvae (grubs) are curled, legless, and often bore into fruit, seeds, plant roots and shoots.

REFERENCES

Biological Control of Weeds in the West. 1995. Norman E. Rees, Paul C. Quimby, Jr., Gary L. Piper, Eric M. Coombs, Charles E. Turner, Neal R. Spencer, and Lloyd V. Knutson, Noah Poritz.

Pictures that are not credited were taken by Lincoln County Noxious Weed Control Staff.

Glossary

abdomen: The last of an insect's three body regions.
abiotic: Non-living.
achene: A small, dry fruit, usually single-seeded.
annulate: Ringed.
apex: The tip.
apomictic: The ability to reproduce without fertilization.
arthropod: An organism that has jointed appendages and an external skeleton (**exoskeleton**); this classification includes insects, mites, and spiders.
axil: The upper angle where a leaf stalk or small stem joins a larger stem.
biotic: Pertaining to the living organisms of an ecosystem.
biotype: A group of individuals that are genetically identical but that show physiological, biochemical, or pathogenic differences.
bract: A petal-like leaf with a flower growing from its base (in the **axil**).
capitulum: A flower head.
cortex: In plant stems, the tissue immediately below the outer layer of cells (**epidermis**); also referred to as **cortical tissue**.
cotyledon: A seed leaf (or leaves) growing from the plant embryo.
cyathium: Small, cup-like inflorescence.
diapause: A dormant state exhibited by some insects to survive unfavorable environmental conditions.
EBCL: European Biological Control Laboratory, located in Montpellier, France, and operated by USDA-ARS.
efficacy: Effectiveness.
epidermis: The outermost layer of cells in a plant or animal.
exoskeleton: The hard, supporting structure on the outside of the body of an insect or other arthropod.
exuviae: Anything an animal sloughs off, such as the "skin" left behind by an insect after molting.
frass: Insect (especially larval) excrement that contains feces and undigested plant material.
glabrous: Smooth, hairless.
haploid: A cell with only one chromosome set; an organism with only haploid cells.
hyaline: Translucent or transparent; glassy.
IIBC: International Institute of Biological Control [formerly named the Commonwealth Institute of Biological Control (CIBC)] based in England. IIBC is an institute of the Centre for Agriculture and Biosciences International.
incubation: The maintenance of an organism in conditions favorable to development; the time between infection and the appearance of disease symptoms.
inflorescence: A flower cluster.

Third, environmental conditions (shade versus sun, low versus high rainfall, sandy versus clay soils) often exclude some biocontrol agents from certain locations. Finally, biological control agents usually do not eradicate weed populations. Use of multiple control methods is important when implementing any management system.

Using biological control agents to help manage weed problems is more effective when the landowner understands the target weed biology, the biological control agents available and how they impact the weed, and the environmental and management restrictions in the area.

Basic plant biology

An understanding of basic plant biology will allow the land manager to better choose appropriate control tools in a long-term management program. Understanding the life cycle of the weed will help landowners determine when the plant is most vulnerable to a particular control method.

Annual weeds germinate from seeds, flower, produce seeds and die in one year or less. Most annual plants are easiest to control as seedlings. Prevention of seed production is the most effective control. Annual plants are not well adapted to a biological control program.

Annual weeds are classified as summer annuals or winter annuals. *Summer annuals* germinate early in the growing season, grow and produce seed during the summer, mature and die in the fall. Kochia is an example of a summer annual weed. *Winter annuals* complete their life cycle from fall to spring or early summer. They germinate in the fall and overwinter as seedlings or rosettes. They usually produce seeds in spring and die by midsummer. Jointed goatgrass is an example of a troublesome winter annual weed.

Biennial weeds

Biennial weeds complete their life cycle in two years. During their first season of growth they develop a deep root system and a low-growing rosette of leaves. They are dormant over the winter in the rosette stage and send up flowering stalks, or *bolt,* early in the second spring of the life cycle. During the second year they flower, produce seeds, mature and die. Control is most effective during the first season of growth when the plant is in the rosette stage and prior to the development of viable seed. Houndstongue is an example of a biennial weed.

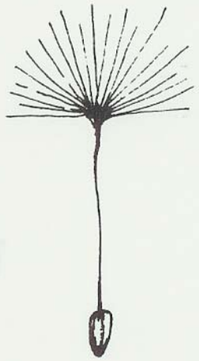
Perennial weeds

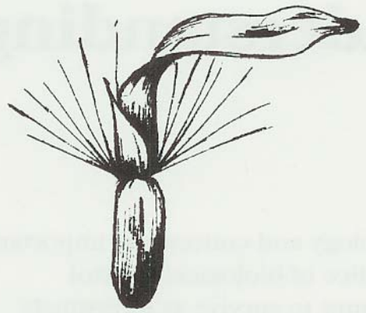
Perennial weeds live for more than two years. Most reproduce by seeds and many are able to spread vegetatively by underground stems, or *rhizome*s, by tubers, or by an extensive root system. They are classified according to their method of reproduction as simple or creeping.

Simple perennials spread by seed. They cannot naturally spread vegetatively, but can produce new plants if injured or cut. The roots are generally fleshy and may grow very large. The plant re-grows for many years from the crown area of the plant. Common St. Johnswort in an example of a simple perennial.

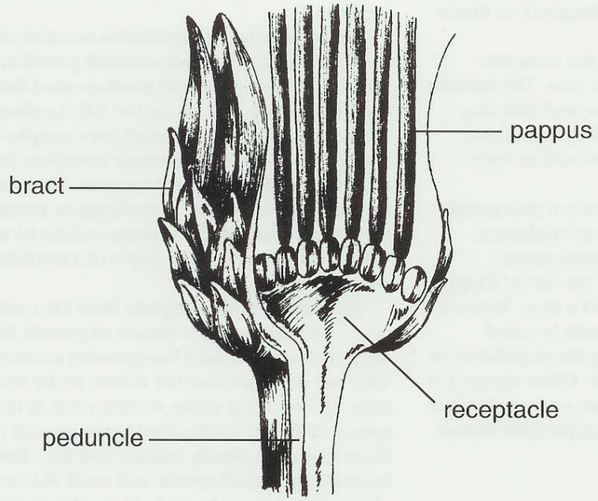
Creeping perennials reproduce by creeping roots, by creeping aboveground stems, or *stolons*, or by rhizomes. Canada thistle is an example of a creeping perennial.

Once an area is infested, creeping perennials are probably the most difficult group to control. Plowing and tilling may spread these weeds. Continuous and repeated cultivations, mowing and persistent herbicide applications are often necessary for control. Perennial weeds are the most logical target for a biocontrol program.





The pappus is a feathery tuft attached to the seed. It can take many forms.



Capitulum, or seed head

Illustrations: Susan Kedzie-Webb

Eustenopus villosus— Yellow starthistle hairy weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (outside the host plant).

Egg stage: Single eggs are laid inside mature, closed head buds in early-to-mid-summer. The eggs hatch in three days.

Larval stage: The larvae feed on the receptacle and developing seeds. Larval development is completed in 16 days.

Pupal stage: Pupation occurs within the seed head in a chamber fashioned from chewed seeds and pappus hairs. The pupal stage lasts from 8 to 13 days.

Adult stage: The adults appear during late June and July. The beetles are brown with whitish stripes and have long hairs on the back. They have long, slender snouts and are 0.16 to 0.24 inch long, not including the snout.

EFFECT

Destructive stages: Adult and larval.

Plant species attacked: Yellow starthistle

Site of attack: Seed heads

Impact on the host: Adults feed on small head buds, usually destroying a high percentage of them. The larvae feed inside the heads and reduce seed production by as much as 100%.

RELEASES

Habitat: Cool climates (coastal, higher elevations and latitudes) are unfavorable for weevil survival. High humidity may also be unfavorable.

Stages to transfer: Adult

Redistribution: Adults can be swept or hand-picked from the host plants.

Actual adult size

USDA-ARS

USDA-ARS EBCL

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Bangasternus orientalis— Yellow starthistle bud weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (outside the host plant).

Egg stage: Single eggs covered with a dark mucilage are laid on or near scale leaves beneath the immature head buds at the tips of flowering shoots in late spring to early summer. A female may produce up to 470 eggs.

Larval stage: Hatched larvae tunnel through the scale leaf, the flowering stalk, and the flower head bracts into the head where they feed on receptacle tissue and developing seeds.

Pupal stage: Pupation occurs within the heads in chambers formed from damaged and undamaged seeds.

Adult stage: Adults exit from the pupal chambers in the heads in late summer to overwinter outside the host plant. The adults are 0.16 to 0.24 inch long (not including the snout), and brown with yellow to whitish hairs that give a somewhat mottled appearance.

EFFECT

Destructive stages: Larval

Plant species attacked: Yellow starthistle

Site of attack: Seed head interior

Impact on the host: Larval feeding reduces seed production. Preliminary data indicate that a single larva destroys 50 to 60% of the seeds in a head.

RELEASES

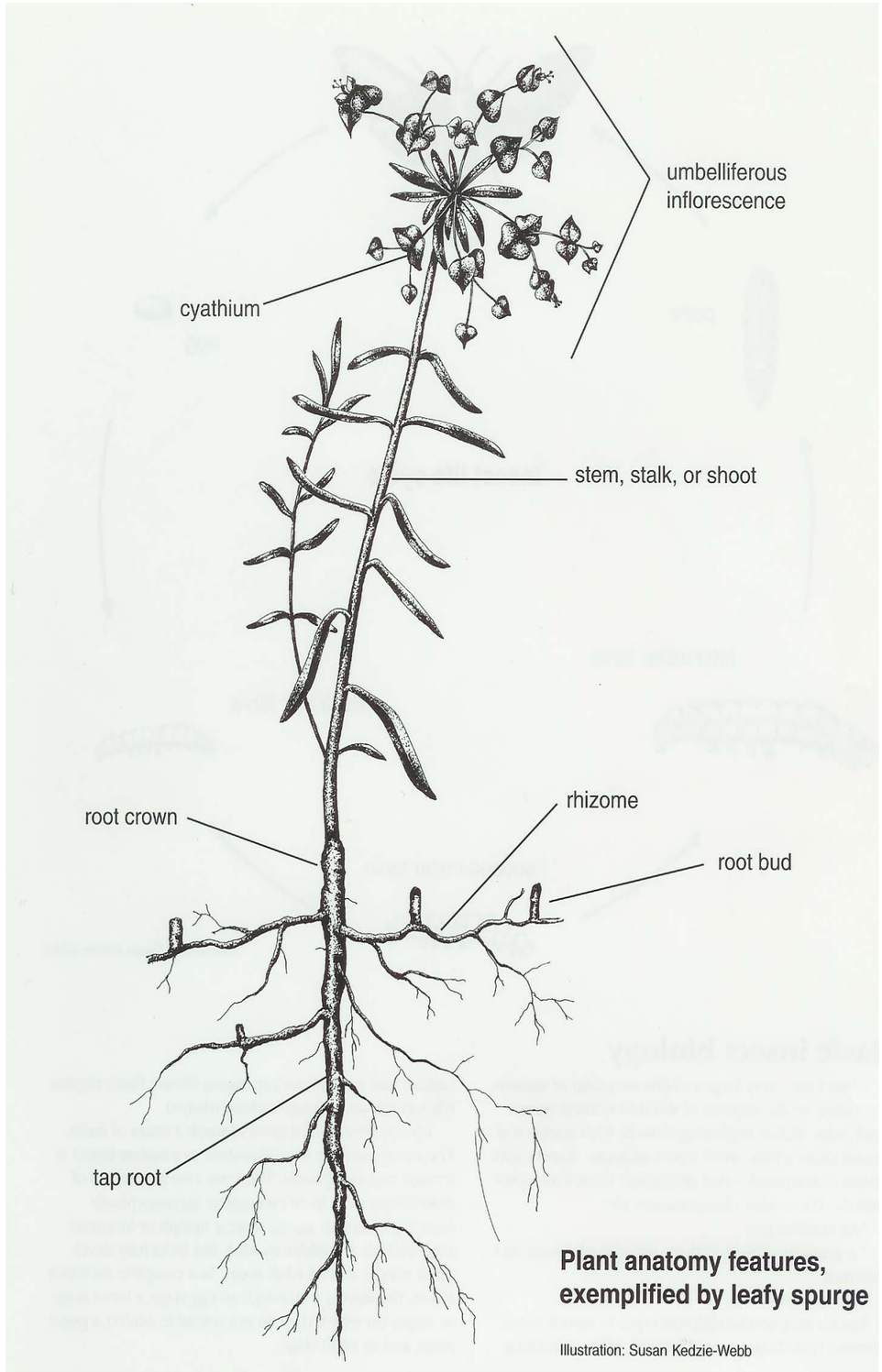
Habitat: Cool climates (coastal, higher elevations and latitudes) are unfavorable for weevil survival.

Stages to transfer: Adult

Redistribution: Adults can be swept or hand-picked from the host plants.

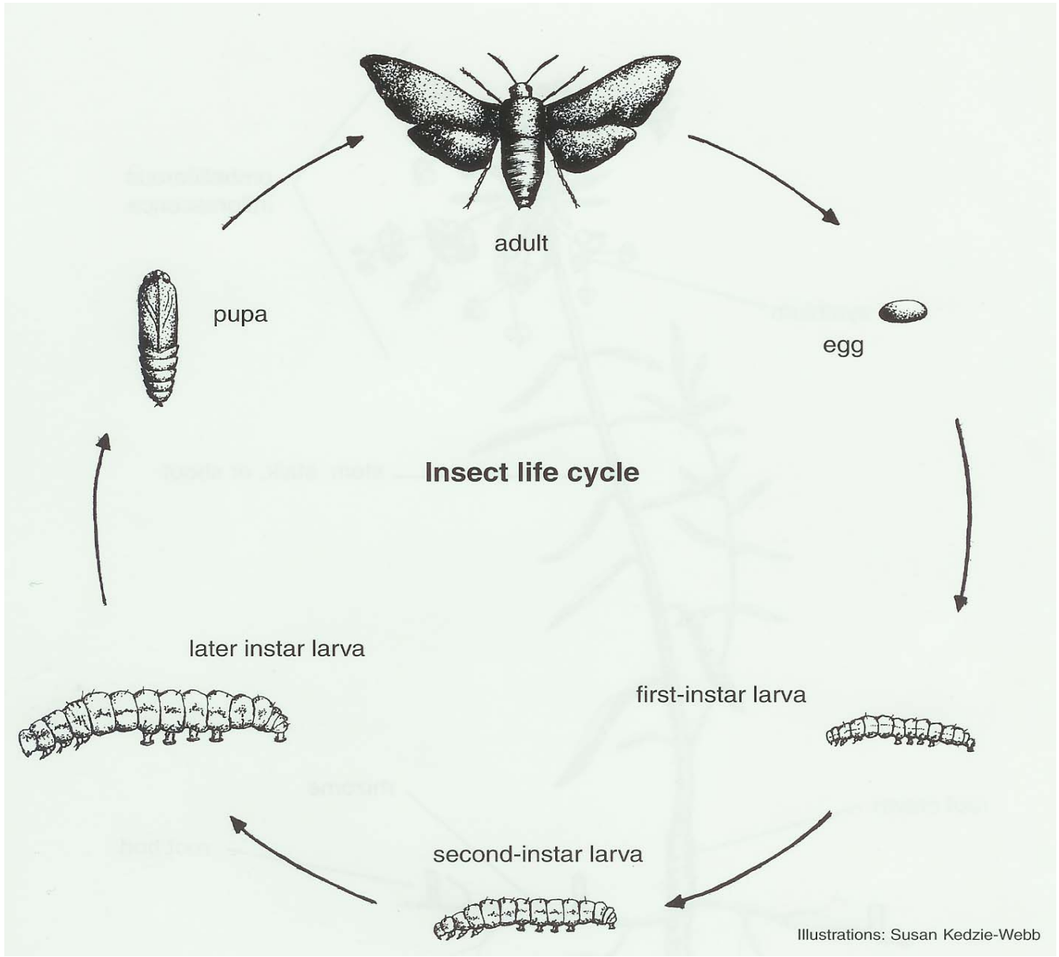
Actual adult size

USDA-ARS



Plant anatomy features, exemplified by leafy spurge

Illustration: Susan Kedzie-Webb



Illustrations: Susan Kedzie-Webb

Basic insect biology

Insects are a very large and diverse group of animals and comprise the majority of weed biocontrol agents used today. Before beginning to work with insects you should know a little about insect anatomy. Insects have several characteristics that distinguish them from other animals. These adult characteristics are:

* An exoskeleton;
* A segmented body of three parts: head, thorax and abdomen;
* Three pairs of legs.

Insects have several different types of mouth parts: chewing (grasshoppers and beetles); piercing-sucking (aphids and mosquitoes); sponging (house flies); rasping (fly larvae); and rasping/sucking (thrips).

Insects develop and grow through a series of molts. The transformation of an immature to a mature insect is termed *metamorphosis*. There are two types of metamorphoses. In an incomplete metamorphosis insects go through an egg stage, a nymph or immature stage (which resembles an adult, but lacks fully developed wings), and an adult stage.

Apion fuscirostre— Scotch broom seed weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (in duff near host)

Egg stage: Females must feed on flowers in the spring to stimulate egg production. Between five and ten small, white to yellowish, round eggs are inserted into the pods where they hatch in 5 to 15 days.

Larval stage: Larvae feed on developing seeds inside pods where they complete development in 20 to 40 days. Comma-shaped larvae are creamy white with brownish head capsules.

Pupal stage: The pupal period lasts from 10 to 20 days, depending on the temperature. Larvae pupate within the seed pod without forming a pupal case. They are creamy white, becoming darker as they mature. They resemble the adult weevil with the legs held close to the body. Several pupae often occur together in the same pod.

Adult stage: Adults can be found throughout the year, including on warm winter days, feeding on terminal twigs. Overwintering adults may still be active when the first-generation adults begin to emerge. The adult weevils are freed from the pods when the pods dry and split open. In some areas, high temperatures may kill adults that cannot escape from mature pods. Adults feed on terminal stem growth, giving the shoots a grayish, mottled appearance. Adults fly to the yellow flowers of scotch broom in late winter and spring. They are active walkers, searching rapidly up and down the stems. Adults are 0.08 to 0.12 inch long and are laterally compressed. Each has a long curved beak, a dark gray body, a wide dark gray band that extends down the back, and light brown legs.

EFFECT

Destructive stages: Larvae feed on seeds in pods and adults feed on flowers; in large numbers, adults damage tips of twigs.

Plant species attacked: Scotch broom

Site of attack: Seed pods, flowers, and leaves.

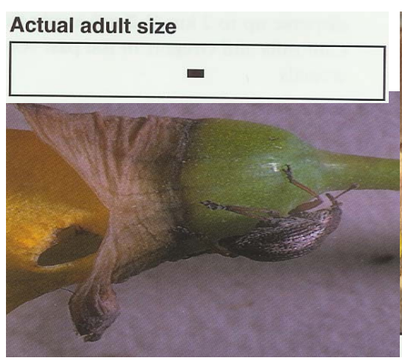
Impact on the host: This insect effectively reduces scotch broom seed production and, thus, decreases rate of spread. Extensive feeding by adults on small twigs has caused terminal die-back. The insect's overall effectiveness in reducing scotch broom stand densities is questionable.

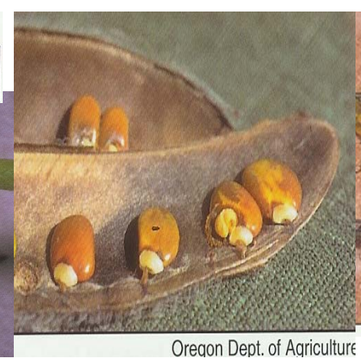
RELEASES

Habitat: Prefers meadows and hillsides with southern exposures, while cold, damp, and heavily shaded areas, north-facing hillsides are undesirable.

Stages to transfer: Collect and redistribute adults after they have mated. Moving adults in seed pods by using bouquets of Scotch broom has proven to be only marginally successful.

Redistribution: Heavy sweep nets or a beating sheet with a beat stick can be used to dislodge adults from plants. Most collections are made in April and May. Collecting adults late in the flowering season is difficult because the presence of numerous aphids, psocids, and other insects makes it impossible to collect only the weevils. Also the honeydew excreted by these insects makes nets very sticky. Releases of 100 to 250 adults are normally sufficient to colonize a site. Populations usually become collectible by the third or fourth year following release. Adults can be easily stored for a week or two if kept cool and dry. Adults do well in containers provided with shredded tissue paper for the insects to crawl on and a small amount of plant material for food.




Oregon Dept. of Agriculture

Oregon Dept. of Agriculture

Puccinia chondrillina— Rush skeletonweed rust

BIOLOGY

Generations per year: Multiple

Overwintering stage: Urediniospores and/or teliospores

Life cycle of the fungus: From spring to fall, cinnamon brown, circular, eruptive pustules (uredia) develop on all aboveground plant parts and release ineffective spores. Lesions (telia) form at the bases of flowering shoots in the fall. The lesions produce spores that remain dormant until spring. Spores germinate on the rosette leaves and form clusters of yellowish pycnia which soon yield pycniospores. These produce aecia and aeciospores on the leaves. Aeciospores germinate to produce brown pustules, thus completing the life cycle.

EFFECT

Destructive stages: Uredia and telia

Plant species attacked: Rush skeletonweed

Site of attack: Leaves, stems, buds, and flowers.

Impact on the host: Fall and spring rosette infection often results in premature death of plants, especially seedlings. Open lesions cause desiccation, reduce photosynthetic area, and decrease plant vigor. Fungus-infected stems are stunted, deformed, and produce few branches and floral buds. Seed yield, weight, and viability are reduced in rusted plants. Rush skeletonweed's ability to regenerate from root buds is also diminished as a consequence of *P. chondrillina* infection.

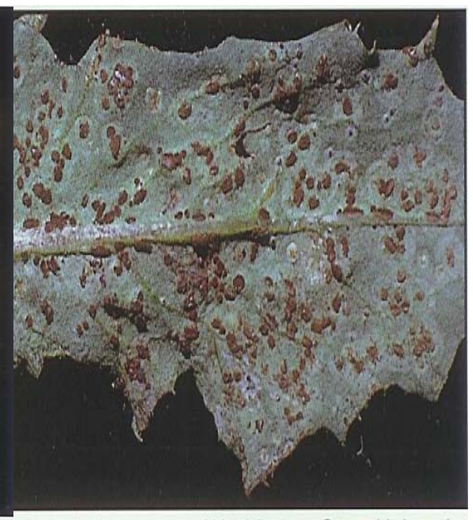
RELEASES

Habitat: The rust survives under a variety of moisture regimes but its development is best in mesic habitats. It is less damaging in hot and dry sites.

Stages to transfer: Urediniospores

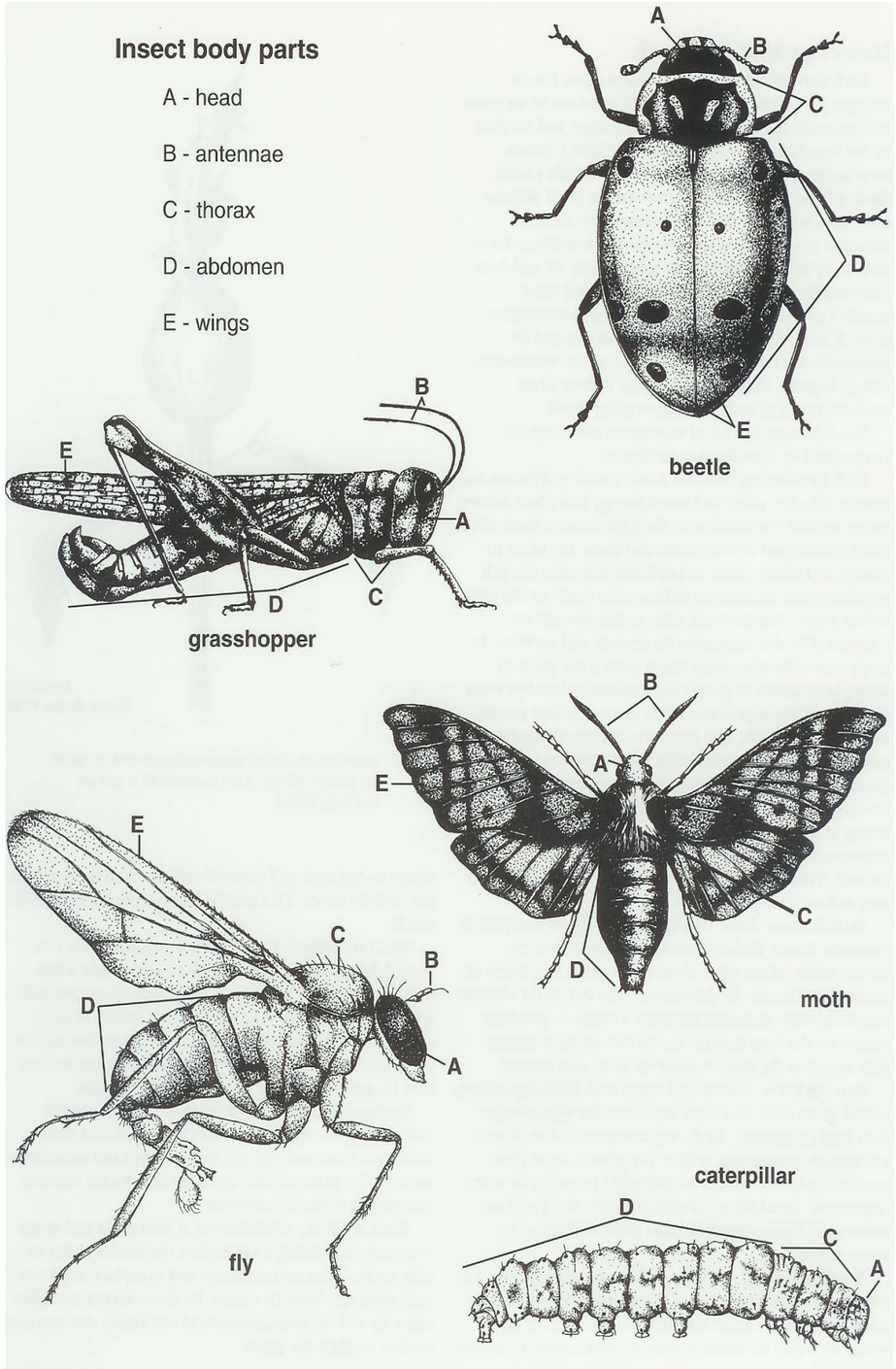
Redistribution: Rosettes infected with uredia can be dug and transplanted among uninfested plants during the spring and fall. During the summer, rusted floral stems can be harvested and placed among non-rusted rush skeletonweed to initiate infection. To ensure spore germination and subsequent infection, urediniospore-laden material should be released in the evening when temperatures are cooler and when and extended dew period is anticipated. It is also worthwhile to spray the uninfested plants with water prior to pathogen dissemination to enhance the infectivity rate. Rust-infected stems can be stored at 41 to 50°F for several weeks without hurting spore viability.

Oregon Dept. of Agriculture



Washington State University

In a complete metamorphosis the insects go through an egg stage, a larval stage or stages (in which they do not resemble adults), a pupal stage and an adult stage.



Insect points of attack

Each specialized biological control agent has co-evolved with its plant host. Limited numbers of an agent will generally have little effect on the vigor and survival of the host, but as the number of available biocontrol agents increase in relation to the number of available plants, there will be an increased impact on the plant population. This may result in visible symptoms, such as damaged leaves, flowers, stems or roots; wilting, discoloration of foliage; dropping of leaves; reduced numbers and viability of seeds; smaller plant size and vigor; retarded growth or flowering periods; and sometimes plant death. Injured plants may also attract and be vulnerable to attack by other insects, mites, nematodes, and pathogens. Multiple attacks may reduce plant reproduction and may even cause plant death. The following is a list of biocontrol insect agents categorized by their feeding strategies:

Gall-producing insects

Adult female gall-producing insects sting the plant and insert an egg into plant tissues; larvae secrete chemicals into the plant tissues. Both affect plant growth and development and cause the plant to change its cell structure and cell function near the gall producer, thus creating an enlargement (gall) of the plant at that point. Nutrient-rich cells within the gall are consumed by the organisms for growth and survival. In many cases, the biocontrol agent causes the plant to produce or assists in producing hardened chamber walls that protect the biocontrol agent from potential predators and parasitoids. The presence of limited numbers of gall organisms is often not lethal to the plants, since fresh plant cells must be maintained during the gall producer's development. However, the galls influence the plant by acting as a nutrient sink, causing the plant to direct nutrients to the tissues rather than into seeds or plant growth. This demand reduces the vigor of the plant and may reduce seed production.

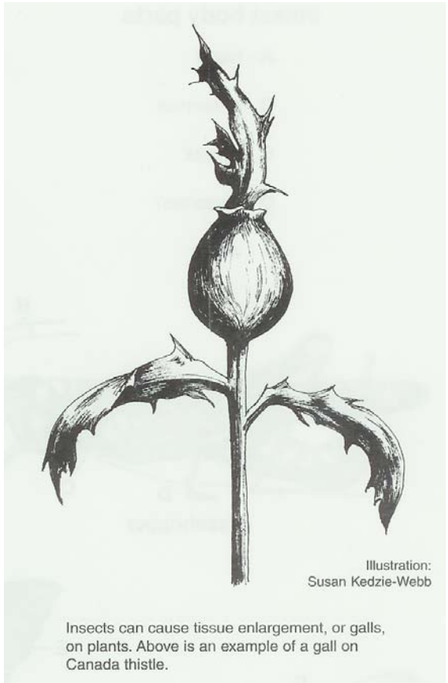


Illustration: Susan Kedzie-Webb

Insects can cause tissue enlargement, or galls, on plants. Above is an example of a gall on Canada thistle.

Defoliators

Some defoliators partially or completely consume leaves, flowers, bracts and sometimes the stems, while others mine these areas, removing layers of outer plant tissues. In this manner, the defoliator obtains nutrition while reducing the plant's ability to produce sugars for the root system. Reduction of these sugars may suppress the plant's ability to grow and survive.

Sap suckers

Insects and mites with piercing-sucking mouth parts feed on a plant similar to the way mosquitoes feed on animals. Reducing nutrients in the plant's circulatory system may reduce the plant's vigor, thus weakening it and making it vulnerable to attack by other organisms. In addition, viruses, bacteria and fungi are sometimes transmitted from one plant to another by these arthropods.

Seed-attackers

Damage from biocontrol agents that attack the seeds or seed-producing tissues may be direct such as when the agent consumes some or all of the seeds, or it may be indirect, such as when seed-producing tissue is damaged and nutrients are diverted from producing healthy seeds. This greatly reduces the viability of the seeds.

Eriophyes chondrillae— Skeletonweed gall mite

BIOLOGY

Generations per year: Multiple

Overwintering stage: Adult (females on the rosette bud).

Egg stage: Each female can deposit between 60 and 100 eggs within the gall it occupies. Eggs are spherical, about 0.002 inch in diameter, and translucent upon deposition but turn pale orange as embryonic development progresses.

Nymphal stage: Several hundred nymphs feed within a gall. Nymphal development can be completed in 10 days during the summer. The pale yellow-orange first– and second-stage nymphs look somewhat humpbacked, have four legs, and lack a genital opening. Body length of the first-stage nymph is 0.003 to 0.004 inch; Second-stage nymph length is 0.004 to 0.007 inch.

Adult stage: Overwintered adults invade shoot buds when the weed bolts in the spring. Feeding by E. chondrillae transforms the buds into contorted, leaf-like galls that may reach a diameter of 2 inches. Mites increase and galls form until floral shoots cease growing in the fall. Adults may live three to four weeks. Adults are worm-like, soft-bodied, pale yellow-orange, and possess two pairs of legs. Males range in length from 0.006 to 0.007 inch and females from 0.008 to 0.01 inch.

EFFECT

Destructive stages: Nymphal and adult

Plant species attacked: Rush skeletonweed

Site of attack: Axillary and terminal buds.

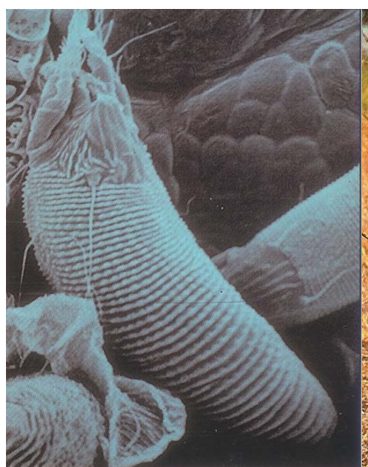
Impact on the host: Infestation of the buds by the mite decreases plant vigor by reducing root carbohydrate reserves, hinders rosette formation from established roots, stunts the plant and reduces the number of vegetative shoots produced, decreases or completely prevents seed production, and commonly results in death of seedlings or first-year satellite plants.

RELEASES

Habitat: It rapidly colonizes plants growing in undisturbed, well-drained soils on south-or-west-facing slopes. Mite populations do not persist in sites subjected to repetitive soil disturbance, such as cropland.

Stages to transfer: Adult and Nymphal (with stem galls).

Redistribution: Galled stems can be gathered from July to mid-October. Galled shoots should be placed in direct contact with uninfested stems. Once the galls begin to dry up, the mites will exist and infest the buds of healthy plants. Mite-galled stems retained within plastic garbage bags can be stored at 41 to 50°F for several weeks without any adverse effect.



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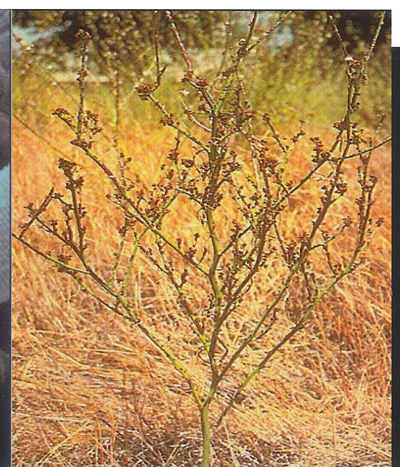

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Cystiphora schmidti— Skeletonweed gall midge

BIOLOGY

Generations per year: Four to five

Overwintering stage: Mature larval, prepupal or pupal (in stem or rosette leaf galls or in the soil).

Egg stage: Females insert eggs within rosette and stem leaves and stems. A female can produce about 100 eggs. The incubation period averages nine days. The eggs are elongate oval, 0.0004 inch wide by 0.0008 inch long, and pale white with a green or yellow tinge.

Larval stage: The larvae feed on the leaf or stem tissues at the egg deposition site. Feeding activity initiates gall formation which is characterized by a swelling and yellowish to maroon discoloration of affected tissue. Leaf galls are circular, about 0.12 inch in diameter, and slightly raised whereas stem galls are elongated and usually more elevated. The larvae complete development in four to seven days. The larvae are flattened, 0.04 to 0.10 inch long, and are pink or orange.

Pupal stage: The mature larvae sometimes leave the galls and drop to the soil or surface litter where they pupate. More often, however, they pupate inside a silken cocoon within the gall. The pupae rupture the gall tissue with their horns to facilitate adult emergence. The pupal exuviae can often be seen partially protruding from the exit hole after the insects have departed. The pupal period lasts four to six days.

Adult stage: Adults are found in the field from April to October; males live one to two days and females three to four days. First-generation females lay eggs in the rosette leaves. Succeeding generations attack the flowering stems. The adults are small, light to medium brown, and lightly sclerotized. Females are 0.03 to 0.07 inch long; males are 0.04 to 0.06 inch long. The female's abdomen is swollen and terminates in a bulbous enlargement. The male's abdomen is slender with the genitalia readily visible.

EFFECT

Destructive stages: Larval

Plant species attacked: Rush skeletonweed

Site of attack: Leaves and stem

Impact on the host: The midge damages both the rosette and flowering stems, reducing the quantity of photosynthate available for plant growth and maintenance. Leaf and stem tissues are injured or destroyed, causing premature yellowing, desiccation, and death. Rosettes may die. Infested plants have fewer branches and flower heads than do uninfested plants. Seeds exhibit decreased weight and reduced viability. Heavily infested stands may take on a purple-reddish cast.

RELEASES

Habitat: The insect is most abundant in areas where the yearly average temperature exceeds 63°F and precipitation is less than 16 inches. Plants subject to the heaviest attack grow in open locations in well-drained soil. Can be found in almost every rush skeletonweed infestation in Lincoln County.

Stages to transfer: Larval and pupal within stem and leaf galls.

Redistribution: The midge is best collected by harvesting galled stems from early July to late September. Any seed heads and flowers on the stems of infected plants should be removed and the stems then tied into bundles to form "teepees". Teepees should be placed among the uninfested plants at the release site. Many of the immature midges will complete their development within the galls, emerge, and attack the new plants.

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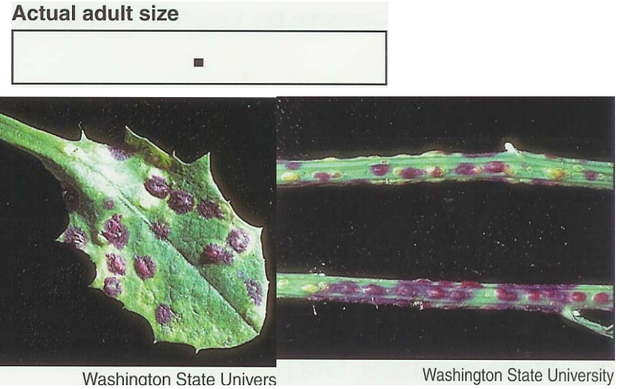

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Stem-dwellers

Stem-dwelling organisms are protected from potential parasitoids and predators while they mine within the tissues. These tissues are generally alive during larval development of the insect. In some cases, secondary damage from pathogens or destructive arthropods caused after the stem-dweller leaves its host may be greater than the direct damage it causes.

Crown-and root-burrowers

Many species of insects burrow into the plant's crown and root. Their feeding activity reduces the root reserves and sometimes reduces the plant's ability to either translocate nutrient reserves or replenish nutrients.

Root feeders

Organisms that feed upon and in the root hairs and young roots reduce the plant's ability to take up moisture and nutrients and to replace depleted root reserves. Wounds caused by these agents may allow entry by soil microorganisms and secondary diseases may further weaken the plant.

Basic disease biology

There are an estimated 100,000 parasitic plant diseases. Most occur rarely or on a very limited scale. Plant diseases have been studied as biological control organisms and show much promise for the future.

Plant disease is the result of the right combination of a susceptible host plant (in this case, the target weed), a virulent pathogen (the disease-causing agent), and suitable climatic and environmental conditions. Variations from normal climatic conditions are often responsible for sudden outbreaks of diseases that would not normally occur. This may be the case when some weeds are seriously injured in a limited location or a particular year.

Plant diseases are either non-parasitic or parasitic. *Non-parasitic* (physiological) diseases include: 1) nutrient deficiencies or excesses; 2) environmental extremes; 3) air pollution and pesticide injury; 4) drought; 5) genetic abnormalities; and 6) other physiological disorders. Non-parasitic diseases are not predictable, repeatable, nor can they spread from plant to plant and so are not useful as biological control tools.

Parasitic diseases are caused by living organisms that can multiply and spread from infected to healthy plants. Organisms commonly causing parasitic diseases are fungi, bacteria, viruses and mycoplasmas. To date the most common plant pathogens used for biological control of weeds are fungi. Some research is being conducted on the use of bacteria for biocontrol of weeds.

Fungi are simple microorganisms lacking chlorophyll. They obtain nutrients from living plants and animals or decaying organic matter, and enter plants through wounds, natural openings, or by penetrating directly through the plant tissue. Fungi cause local or general disintegration of plant cells or tissue, stunting, or abnormal vegetative growth. They may affect plant growth by removing or blocking nutrients to the plant or by producing toxins that can affect the structural and metabolic activity of the plant. Fungi life cycles range from simple to very complex.

Bacteria are commonly found one-celled organisms that can be seen only with high-powered microscopes. Bacteria reproduce rapidly through simple cell division, and enter plant tissue through wounds or natural openings in the plants. Once inside they multiply rapidly, causing cell death, abnormal plant growth, or tissue breakdown. Some produce toxins. Bacteria are spread effectively by cultivation, rain, flowing water, wind, dust and transport of diseased plant material.

Viruses are complex macromolecules composed of ribonucleic acid with a protective protein coat. They resemble chromosomes found in all living cells and can only function and reproduce in a living cell. Viruses divert normal growth and development processes in plants, causing stunting, streaking, yellowing, mosaics, ringspot or streaking. They may be spread by direct contact between healthy and diseased tissue or by vectors, such as insects or nematodes.

Mycoplasmas are bacteria-like organisms without cell walls. Most cause "yellows" or "witches'-broom" symptoms in plants. Leafhoppers are common insect vectors.

Some insect biological control agents may cause wounding of the target weed that allows secondary infection by disease organisms. Additional research is needed to understand and to develop additional plant disease agents for biological control of weeds.

Other biocontrol agents

Mites are similar to insects but have two body parts. Mature mites have four pairs of legs, although immature mites have three pairs of legs. Eriophyid mite adults and immatures, however, have only two pairs of legs. Plant-feeding mites may attack the plant bud, form galls, cause cupping or curling of the leaf, discolor the fruit, or retard the plant's growth. High temperatures and humidity provide favorable conditions for mite populations.

Nematodes are microscopic, unsegmented roundworms that live in water or soil. They can injure plants by sucking plant juices through hollow, spear-like mouth parts. Nematode feeding lowers natural plant resistance, results in gall formation, reduces plant vigor and yield, and allows easy entrance for fungi and bacteria. Nematode-damaged plants are often more susceptible to winter injury, drought, disease and insect attack.

Some nematodes enter plant tissues to complete their life cycle, while others remain outside the plant with only their feeding parts attached to the roots. All plant parasitic nematodes reproduce by laying eggs. Nematodes generally require several years to build up damaging populations in the soil. They are easily spread by moving infested soil, plant parts or contaminated objects. Identification of nematodes is difficult and must be done in a laboratory equipped with extraction equipment and microscopes.

Integrating biocontrol with other control methods

A weed infestation may increase in density and area faster than the newly released biocontrol agent populations, therefore other control methods must be used in conjunction with the release of biocontrol agents. The perimeter of the infestation my be sprayed to keep the weed from spreading while the main infestation is grazed by sheep or goats, if appropriate, to suppress the weed population and reduce seed production. As biocontrol agents increase in density and begin to occupy more area, herbicide use or grazing animals may be reduced to provide more resources for the biocontrol agents. Eventually, a spray program might be reduced to occasional spot treatments. When the target weed species has been eliminated from the area, the control program may be discontinued. However, the landowner must continue monitoring the area for the weeds for five or more years.

Hylobius transversovittatus— Loosestrife root weevil

BIOLOGY

Generations per year: One, or one generation over two years.

Overwintering stage: Egg, larval, pupal or adult

Egg stage: Eggs are laid from June through August. Only one or two eggs are laid daily with a peak of about three eggs per day in June and early July. Most eggs are deposited in the soil while some are inserted into the stems just above the soil surface. Females lay about 300 eggs each over a two-year period. Eggs hatch in 11 days. The pale yellow eggs are oval and about 0.08 inch long.

Larval stage: The larvae are normally present from August through June of the next year, although the larval stage may last for two years. The larvae mine the roots and pack the feeding tunnels with light-brown frass. Larvae are cream-colored with dark brown head capsules, somewhat crescent-shaped, and 0.32 to 0.40 inch long.

Pupal stage: Pupation occurs within the damaged root crown during late spring to early summer. Pupae are crescent-shaped and cream-colored.

Adult stage: The adults emerge in mid-to late summer and may live for up to three years. The adults are robust 0.32 to 0.48 inch long, reddish weevils with two rows of white tufted hairs across the back.

EFFECT

Destructive stages: Adult and larval

Plant species attacked: Purple loosestrife

Site of attack: Larvae live in the roots while the adults feed on the foliage.

Impact on the host: Effects of larval feeding are dependent upon root size, attack intensity, and duration. Small roots can be destroyed within two years if infested by several larvae. Larger roots may die after several consecutive years of infestation.

RELEASES

Habitat: Sites without prolonged flooding are favored for weevil development

Stages to transfer: Adult, egg and first-instar larvae

Redistribution: Adults can be hand-collected at night or reared from infested roots. Weevils can be easily kept in captivity for two months as long as they are cool and supplied with new plants for feeding and egg laying. Eggs and/or larvae can be inserted in holes in the base of stems or placed in the soil near the roots. Egg and larval inoculation of plants is a laborious undertaking.

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Agriculture and Agri-Food Canada

Galerucella pusilla— Golden loosestrife beetle

BIOLOGY

Generations per year: One with a partial second in warmer climates.

Overwintering stage: Adult

Egg stage: Eggs are laid from May to June and from August to September. Females lay up to 10 eggs per day in groups of two to four. The eggs are 0.02 inch in diameter, barrel-shaped, tan to cream-colored, and are often decorated with a line of frass on top.

Larval stage: Feeding and development of larvae are similar to *G. calmariensis*. The larval period lasts five to six weeks. The 0.02 inch long larvae are light tan with darker, sclerotized heads.

Pupal stage: Larvae pupate in soil litter or in the upper 1.2 inches of soil. Pupae are orange to pale brown and about 0.16 inch long.

Adult stage: Overwintered adults emerge from hibernation, mate, and lay eggs from May through June. New adults emerge between July and August and may lay eggs before hibernation. Females emerging before mid-July will lay eggs prior to hibernation. Adults are a light golden color and average 0.16 inch long.

EFFECT

Destructive stages: Adult and larval

Plant species attacked: Purple loosestrife

Site of attack: Leaves and buds.

Impact on the host: Like its sister species, this beetle defoliates purple loosestrife so completely that plants are often killed.

RELEASES

Habitat: The beetle readily establishes in infested areas that do not remain flooded.

Stages to transfer: Adult and larval

Redistribution: Sweep or hand-pick the adults and transfer them and/or shoots infested with larvae to new weed stands. The insect can be kept for two weeks in captivity if provided with fresh food. Eggs can be placed in the leaf axils.

Agriculture and Agri-Food Canada


NY Cooperative Fish & Wildlife Research Unit

Timing of herbicide applications may be an extremely important factor in the interaction of biocontrol agents and host plants. Herbicides should be applied when their effects on the host plants will not interfere with the life cycle of the biological control agents. Indirect effects of herbicide applications might become apparent if the sprayed weed dies or the foliage becomes unpalatable before the biocontrol agent has completed its development. Research continues on the interactions between biological control agents and other weed management techniques.

Making biological control work in the field

Biological weed control programs are a desirable part of a land management program. To prevent problems that can waste time, money and scarce biological control agents, the landowner needs to have the proper knowledge and experience to develop and implement a program. Valuable knowledge includes: 1) which species attack your target weed; 2) which species will do best in the environment of your target site; 3) knowing whether the agents you want to release have already been established nearby; 4) knowing whether agents are free from pathogens or parasites; 5) knowing of potential predators in the area; and 6) proper identification of both the biocontrol agent and the host plant.

The following precautions can help prevent problems when developing a biological control program:

1) Learn as much as possible about biological weed control and how it works prior to initiating a program on your land. Know which biocontrol agents feed on your target weeds and determine which of these agents will work best under your land management and environmental conditions. Understand how to integrate biocontrol into your land management practices. Know how to monitor the biological agent population and its effect on the weed. Much of this information can be learned from the Lincoln County Noxious Weed Control Board.

2) Select a site that is at least 20 acres solid of infested weeds. Sites that are infested with less weeds should be controlled with another method other than biocontrol.

3) Select the best biocontrol agents for your habitat and release those agents on the areas of your property that best meet their requirements. Protect the release area from grazing, chemical sprays, and general disturbance until the insects are well established (possibly up to five years).

   Within the core area, the agents can increase in number and area occupied and migrate to other weed-infested areas. When numbers warrant (generally after three to four years), you can collect from this core area and redistribute to more distant locations. Removal of these “starter colonies” at this time should not noticeably diminish the effect of the established colony.

4) Continue your current weed management program outside the biocontrol agent release areas while you are waiting for biocontrol agents to establish and multiply. For biocontrol agents that don’t disperse rapidly, determine annually how far the colony has spread and calculate a buffer zone. Beyond this zone, continue other weed control programs. Although the biocontrol agent population may increase each year, the weed also will increase each year. Using faster-acting management techniques around the infestation’s perimeter allows the agent to catch up and suppress the weed over time.

5) Photograph the colony site at the same time each year from the same location and with the same horizon in the viewfinder. These photographs will document the extent of the weed infestation and the yearly impact of the biocontrol agents.

Biological control agents released in Washington

1948-2001

WEED	ORGANISM	FIRST RELEASE
St. Johnsonwort	Chrysolina hyperici (E)	1948
	C. quadrigemina (E)	1948
	Agrilus hyperici (E)	1954;1988
	Zeuxidplosis giardi (F)	1955;1981
	Aplocera plagiata (E)	1991
Puncturevine	Microlarinus lareynii (F)	1961;1982;1993
	Microlarinus lypriformis (F)	1961;1982;1993
Scotch broom	Leucoptera spartifoliella (E)	1948
	Apion ulicis (E)	1964
	Bruchidius villosus (E)	1998
Canada thistle	Altica carduorum (F)	1966
	Ceutorhynchus litura (E)	1974;1984;1988
	Larinus planus (E)	1993
	Rhinocyllus conicus (E)	1985?
	Urophora cardui (E)	1982
Dalmatian toadflax	Brachypterolus pulicarius (E)	1920's
	Calophasia lunula (E)	1968;1982
	Mecinus janthinus (E)	1997?;2000
Diffuse knapweed	Urophora affinis (E)	1974
Spotted knapweed	U. quadrifasciata (E)	1979?
	Sphenoptera jugoslavica (E)	1980
	Metzneria paucipunctella (E)	1981
	Agapeta Zoegana (E)	1987;1991
	Pterolonche inspersa (F)	1987
	Larinus minutus (E)	1991
	L. obtusus (E)	1993
	Bangasternus fausti (?)	1993;2000
	Cyphocleonus achates (E)	1993
	Terellia virens (?)	1994

Galerucella calmariensis— Black-margined loosestrife beetle

BIOLOGY

Generations per year: One, with a partial second generation in warmer climates.

Overwintering stage: Adults

Egg stage: Egg laying occurs from May to June and from August to September. Females lay up to 10 eggs per day in groups of three to six or more on the stems, leaves, and leaf axils. Each female can produce 300 to 400 eggs during her lifetime. The incubation period is 12 days. The eggs are 0.02 inch in diameter, barrel-shaped, tan-to-cream-colored and are often decorated with a line of frass on top.

Larval stage: There are three larval instars. The larvae initially feed upon young buds and leaves located at the shoot tips. The larvae later feed upon the developing leaves. Feeding occurs for about 14 days. The developing larvae are light tan to orange with dark brown, sclerotized heads.

Pupal stage: Pupation occurs in the soil beneath the plant. The pupal period lasts about seven days. The pupae are light brown and about 0.16 inch long.

Adult stage: The peak dispersal of overwintered adults occurs during the first several weeks of plant development. Overwintered adults emerge from hibernation, mate and lay eggs from May through June. First-generation adults emerge and disperse to new locations during July and August; a few beetles may lay eggs before hibernation. The 0.16 to 0.20 inch long adults are light tan with dark bands along the wing margins and have a dark, triangular marking behind the head.

EFFECT

Destructive stages: Adult and larval

Plant species attacked: Purple loosestrife

Site of attack: Buds and foliage

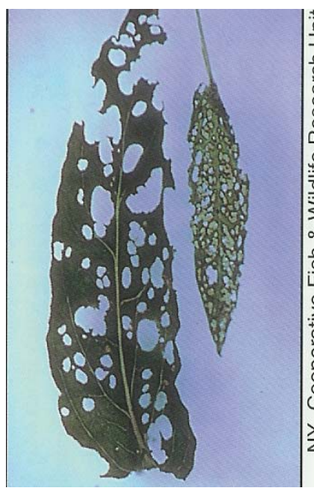
Impact on the host: Adult and larvae feeding upon the buds results in stunted plants and reduced seed production. After emerging from soil litter from off site in the early spring, adults feed on exposed shoots that are about 4 inches long. With heavy defoliation, the host plant becomes skeletonized and turns brown and is obvious among the other green plants. Heavily defoliated plants may die or produce fewer shoots the following year.

RELEASES

Habitat: Continuously flooded habitats are not suitable for beetle survival.

Stages to transfer: Adult and larval

Redistribution: Use a sweep net or hand-pick the adults and transfer them and /or shoots infested with larvae to the new weed stands. Insects can be kept two weeks if provided with fresh food. Eggs can be placed in the leaf axils.



Agonopterix alstroemeriana*— Hemlock moth

BIOLOGY

Generations per year: One

Overwintering stage: Adult

Egg stage: Females affix oval, slightly flattened, pale yellow eggs to the undersurfaces of leaves during late April and May. Approximately 200 eggs are laid by a female over a three-week period. Eggs hatch in six days.

Larval stage: First-instar larvae chew irregularly shaped holes through leaf tissues. Second to fifth instars are leaf rollers and consume leaves as well as flowers, developing inflorescences, immature seeds, and stem tissues. When disturbed, larvae wriggle wildly and often drop from the plant. Larval development is completed in 24 days. Larvae are light green with a blackish-brown head and are 0.4 inches long at maturity.

Pupal stage: The reddish-brown pupae are 0.28 to 0.36 inch long. Pupation typically occurs within a cell formed in the soil. The pupal period lasts 15 days.

Adult stage: The 0.32 to 0.36 inch adult is grayish-brown; each forewing is marked by a large black spot and an adjacent smaller, brick-red spot near the middle of the wing. Overwintered adults resume activity during early to mid-April. The moths hide in soil litter and vegetation during the day and, when disturbed, make short (6 to 10 foot) flights before alighting on foliage or the soil surface. First-generation adults appear during June and July and disperse during late summer and early fall before seeking overwintering sites.

EFFECT

Destructive stages: Larval

Plant species attacked: Poison-hemlock

Site of attack: Leaves, inflorescences, and stems.

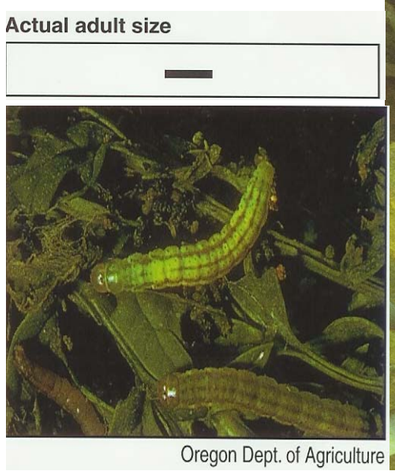
Impact on the host: Injury is severe; plants are often completely defoliated by several hundred larvae per plant. Larval destruction of the inflorescences may prevent seed production. *Agonopterix*-damaged plants resemble those treated with phenoxy herbicides

RELEASES

Habitat: Unknown

Stages to transfer: Adult and larval

Redistribution: Because of its excellent reproductive and dispersal abilities, this moth already occurs in most poison-hemlock infested locations, so redistribution is often unnecessary. Adults can be collected with a sweep net, although this is not recommended because it is too labor intensive. It is much easier to collect and transfer older larvae. Clip heavily infested leaves, stems, and inflorescences and distribute the material among unattacked poison-hemlock. The caterpillars will quickly colonize the healthy plants.



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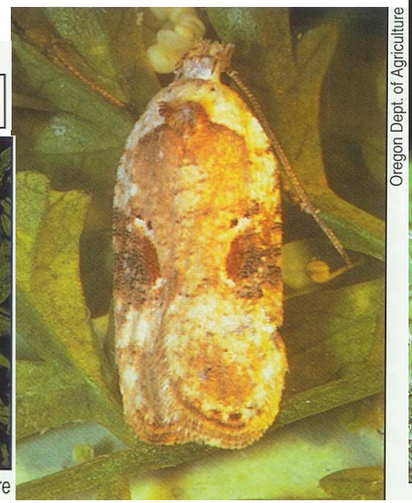

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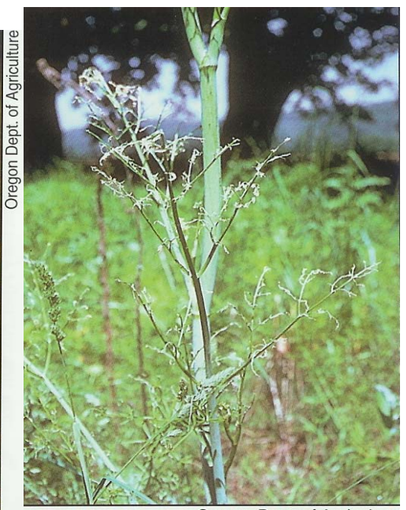

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WEED	ORGANISM	FIRST RELEASE
Field bindweed	Aceria malherbae (F)	1995
Rush skeletonweed	Cystiphora schmidti (E)	1976
	Puccinia chondrillina (E)	1978
	Eriophyes chondrillae (E)	1979
Russian knapweed	Subanguina picridis (F)	1984;1990
Yellow Starthistle	Bangasternus orientalis (E)	1985
	Urophora sirunaseva (E)	1985;1990
	Chaetorellia australis (E)	1989
	Chaetorellia succinea (E)	1992?
	Eustenopus villosus (E)	1990
	Larinus curtus (E)	1992
Purple loosestrife	Galerucella calmariensis (E)	1992;1993
	G. pusilla (E)	1992;1993
	Hylobius transversovittatus (E)	1992;1993
	Nanophyes marmoratus (E)	1992
Poison hemlock	Agonopterix alstroemeriana (E)	1985?
Leafy spurge	Hyles euphorbiae (F)	1974;1985
	Apthona flava (E)	1989;1990;1992
	A. nigriscutis (E)	1989;1990;1991-3
	A. cyparissiae (E)	1989;1991;1992
	A. lacertosa (E)	1993
	A. czwalinae (E)	1993
	Oberea erythrocephala (?)	1994
	Spurgia esulae (?)	1994

Established (E); Failed to establish (F); Status undetermined (?)

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BIOLOGICAL CONTROL AGENTS

The following pages describe the biological control agents.

These agents have been cleared for release in the United States, with the exception of those that were accidentally introduced (noted with an asterisk *).

Aphthona lacertosa— Brown-legged leafy spurge flea beetle

BIOLOGY

Generations per year: One

Overwintering stage: Larval (within the spurge roots).

Egg stage: The eggs are deposited in small batches underground near the root of either host over a period of several months during the summer.

Larval stage: Upon hatching, the larvae migrate to the root hairs and feed until the onset of cool fall temperatures and dormancy.

Pupal stage: Pupation occurs within a soil cell from late spring to early summer.

Adult stage: The adults emerge throughout the summer and feed on the leaves of leafy spurge. Each female produces 200 to 300 eggs. Adults are about 0.12 inch long and black.

EFFECT

Destructive stages: Larval and adult

Plant species attacked: Leafy spurge

Site of attack: Adult (leaves and flowers) and larval (within the root hairs and young roots).

Impact on the host: As with the other flea beetle species, the beetles reduce the plant's root reserves and diminish its ability to replace them. Since the beetles are concentrated in the feeding areas, the effects are obvious. In low populations the affected plants are shorter and have delayed flowering periods. High concentrations of the beetles reduce plant density, or cause what often is referred to as "a hole in the spurge."

RELEASES

Habitat: Found in the steppe biome of western Europe, mesic-dry to wet soils, with loamy soils and well developed herbaceous vegetation. Dry sites or flooded areas are considered unfavorable. Over 300,000 insects have been released in Lincoln County.

Stages to transfer: Adult

Redistribution: Collect the beetles from leafy spurge plants with a sweep net during the summer. The storage and shipping times are similar to those of other *Aphthona* spp. Sprinkle beetles in moderately dense leafy spurge infestations. Areas of high ant activity should be avoided.

Actual adult size

USDA-ARS

Aphthona nigriscutis— Black dot leafy spurge beetle

BIOLOGY

Generations per year: One

Overwintering stage: Larval (within the spurge roots).

Egg stage: The eggs are laid on the stem of the plant near or below the soil surface.

Larval stage: Larvae can be found from July to early spring of the following year. After hatching, they burrow into the soil and begin feeding on small roots. Feeding continues throughout the summer until the onset of cold temperatures and dormancy.

Pupal stage: Pupation occurs within a soil cell from late spring to early summer.

Adult stage: Adults are in the field in late June, July and August. They are 0.12 to 0.14 inch long, and brown or brownish with a black dot on the back behind the thorax at the leading edge of the wings.

EFFECT

Destructive stages: Adult and larval

Plant species attacked: Leafy spurge

Site of attack: Adult beetles feed on the leaves and flowers while larvae feed on the root hairs and young roots.

Impact on the host: Adult feeding on the foliage causes some injury, but larval feeding in and on the root hairs and young roots causes the greatest damage. The former reduces the plant's ability to make sugars for the root reserves, and the latter impairs the roots from taking up moisture and nutrients, thus reducing the potential plant height and retarding the flowering period. Higher concentrations of the beetles often reduce plant density, causing what often is referred to as " a hole in the spurge."

RELEASES

Habitat: It is believed that this insect prefers dry habitats such as sandy knolls and hilltops. Over 300,000 insects have been released in Lincoln County.

Stages to transfer: Adult

Redistribution: Collect the beetles with a sweep net from July through early August. The adult beetles can be shipped or stored for several days at cool temperatures if fed fresh leafy spurge leaves and confined in cardboard containers. They can also be kept at room temperature for several weeks in large cages with fresh food, or for several weeks in smaller cardboard containers if kept cool and exercised and fed periodically under warmer conditions. To release, sprinkle beetles on moderately dense leafy spurge plants.

Actual adult size

USDA-APHIS

USDA-ARS

Urophora cardui—Thistle stem gall fly

BIOLOGY

Generations per year: One

Overwintering stage: Mature, third-instar larval.

Egg stage: From one to 30 eggs are laid in the vegetative shoots at any time during the plant's warm, active growing season.

Larval stage: Newly hatched larvae spend the first instar within the egg. Second-instar larvae tunnel into the stems and form galls. Larvae grow slowly in the second instar while the gall is growing. As the gall matures, the larvae molt to the third instar and quickly assume 98% of their total body weight. Larvae are white and barrel-shaped with dark anal plates. Multiple larvae are usually found within a single gall.

Pupal stage: Pupation occurs in early spring. The length of the pupal period is 24 to 35 days at 64 to 68°F. Puparia are dark reddish-brown and are located within the gall.

Adult stage: The adult flies emerge from deteriorating galls in late spring to early summer. Adult flies are 0.2 to 0.32 inch long and have very distinct, black W-shaped markings on the wings.

EFFECT

Destructive stage: Larval

Plant species attacked: Canada thistle (Cirsium arvense).

Site of attack: Adults deposit eggs in the stems of the plant. Developing larvae within the stem cause the plant to form a gall which looks like a small green crab apple in the middle of the stem or on one of the side branches. Gall size varies considerably; they are generally marble-to-walnut sized depending on the number of larvae within the gall. After the plant dies or freezes in late fall or early winter, the gall becomes a brown to gray, woody structure that is very hard except when wet.

Impact on the host: Most of the effect of Urophora cardui is in the formation of a metabolic sink where the plant's nutrients are concentrated. This reduces the plant's vigor making it less able to compete, to resist pathogens, and to resist attacks by other insects. Stems above the galls are often retarded and may not produce flowers. However, by itself, this insect does not kill the plant.

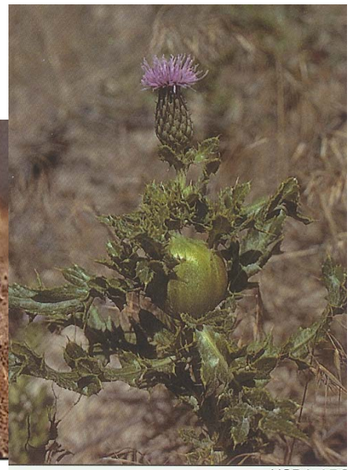
RELEASES

Habitat: This fly does best in disturbed areas where Canada thistle is dense and where adult flies can locate moisture, either from surface water or high relative humidity. Semi-shaded areas seem to be slightly preferred over those in full sun. Occasionally found in some Canada thistle infestations in Lincoln County.

Stages to transfer: Pupal (in the galls) or adult.

Redistribution: Galls are collected in the fall, winter, or early spring by snipping them from last year's plants. These are stored in paper sacks or cardboard boxes in the refrigerator at 39°F to 46°F. If the refrigerator has ventilation and/or a drying effect, it may become necessary to mist the contents of the containers with water every two to four weeks.

Actual adult size



USDA-ARS

Larinus planus*— Canada thistle bud weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult

Egg stage: The female lays a single egg into each hole she has drilled in the side of an unopened bud. If more than one egg is deposited, only one larva will survive.

Larval stage: Larvae feed on the developing tissues of the receptacle, seeds, and the basal part of the pappus.

Pupal stage: Pupation occurs in the bud inside a loose cocoon of chewed bud tissue.

Adult stage: Adults emerge through the loose pappus hairs at the apex of the bud and feed on the young foliage. Mating can occur one to two weeks after the adults emerge from their overwintering sites, with egg laying occurring within 14 to 26 days.

EFFECT

Destructive stage: Larval. However, adults in large numbers may damage upper leaves and developing buds.

Plant species attacked: Canada thistle (Cirsium arvense).

Site of attack: Seed-producing tissue.

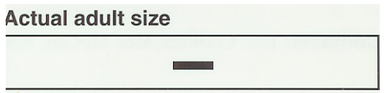
Impact on the host: Larvae feed on the developing tissues of the receptacle, on seeds, and on the basal part of the pappus. Therefore, infested buds often become distorted and fail to open fully. Canada thistle reproduces most often by vegetative regrowth; this agent will affect only its spread by wind blown seeds.

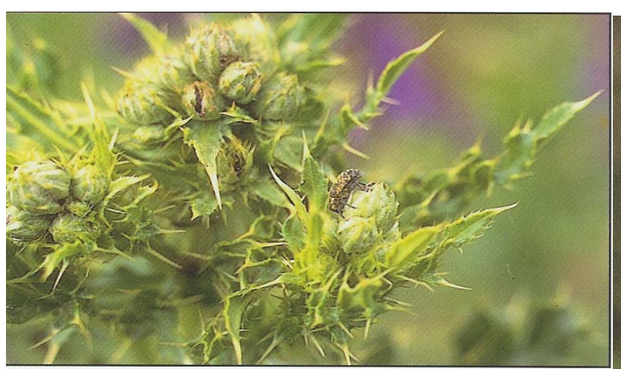
RELEASES

Habitat: The weevil apparently does well under a wide range of climatic conditions. Found in most Canada thistle infestations in Lincoln County.

Stages to transfer: Pupal (in the galls) or adult.

Redistribution: Galls are collected in the fall, winter, or early spring by snipping them from last year's plants. These are stored in paper sacks or cardboard boxes in the refrigerator at 39°F to 46°F. If the refrigerator has ventilation and/or a drying effect, it may become necessary to mist the contents of the containers with water every two to four weeks.




Oregon Dept. of Agriculture


Oregon Dept. of Agriculture

Aphthona flava— Copper leafy spurge flea beetle

BIOLOGY

Generations per year: One

Overwintering stage: Larval (within young leafy spurge roots).

Egg stage: The eggs are deposited in June through early fall, generally on the plant stem at or below the soil surface, and sometimes on or in soil but near the plant stem.

Larval stage: The larvae are active from July through early spring of the following year. The young larvae begin feeding in/on the root hairs; as they become older and larger, they migrate to the larger roots. They are difficult to observe except under a microscope. The more mature larvae are whitish and worm-like and can be observed with the naked eye in freshly extracted roots.

Pupal stage: Pupation occurs in a soil cell from late spring to early summer.

Adult stage: Adults will emerge in June through early fall, depending on degree-days. This species is larger and more yellow than *Aphthona nigriscutis*. It has the characteristic flea beetle appearance and jumps when disturbed. Adult males are about 0.13 inch long; females are about 0.14 inches long.

EFFECT

Destructive stage: Adults (on the leaves) and larval (root hairs and young roots).

Plant species attacked: Leafy spurge

Site of attack: Adult beetles feed on the leaves and flowers; larvae feed in/on the root hairs and young shoots.

Impact on the host: Feeding on the foliage reduces photosynthesis, and flower consumption slightly reduces flowering ability. Feeding within the roots reduces the plant's ability to absorb moisture and nutrients. Light populations reduce plant height and retard flowering, while high populations reduce plant density and cause what is often referred to as " a hole in the spurge". At one research site this species reduced the aerial portion of leafy spurge in a 700 by 550 foot area in six years from 57% to less than 2%.

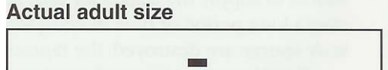
RELEASES

Habitat: The best areas for this beetle are on south-facing slopes in cooler climates that receive 18 to 20 inches of moisture per year. Sunny locations are also desirable. The beetles are hard to establish in clay or acidic soils and in heavily shaded areas. Over 300,000 insects released in Lincoln County.

Stages to transfer: Adult

Redistribution: Collect the beetles with a sweep net from late June through mid-August. Beetles can be kept several days at room temperature if given fresh leafy spurge leaves and confined in containers. The beetles can also be maintained for several days at room temperature if given fresh leafy spurge leaves and confined in containers. The beetles can also be maintained for several weeks at room temperature if kept in large cages and given fresh food, or for several weeks if kept cool and fed and exercised periodically at room temperature. However, the longer they are kept in captivity, the fewer eggs will remain for the field. To release, sprinkle beetles on moderately dense leafy spurge plants. Areas of high ant activity should be avoided for initial releases


USDA-ARS

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Sphenoptera jugoslavica— Bronze knapweed root-borer

BIOLOGY

Generations per year: One

Overwintering stage: Larval (in the root).

Egg stage: Eggs are placed between the appressed petioles of rosette leaves during July and August. The flat eggs are white when deposited, but turn bluish-gray after four or five days.

Larval stage: Second-instar larvae enter the petiole and mine down to the taproot where they overwinter. Feeding resumes in the spring. The larvae are long, whitish, with the front part of the body wider than the head.

Pupal stage: Pupation occurs within the upper part of the root and lasts from late May or early June until mid-June to mid-September. The duration of the pupal period is 15 to 21 days. Pupae are white during the first half of their development, then turn black as they mature. Some larvae may not pupate until their second year.

Adult stage: The peak adult emergence occurs in July which coincides with the beginning of the flowering period of their host. Adults are 0.3 to 0.4 inch long, somewhat flattened, and metallic, dark reddish-brown.

EFFECT

Destructive stage: Although the adults feed externally on the leaves, most of the damage is caused by the larvae mining within the roots.

Plant species attacked: Spotted knapweed and diffuse knapweed

Site of attack: The adults feed on the leaves of seedlings, rosettes, and flowering plants while the larvae mine within the roots and form spindle-shaped galls within the central vascular tissues.

Impact on the host: Feeding by the larvae depletes root carbohydrate reserves and stops rosette growth.

RELEASES

Habitat: Warm, dry areas

Stages to transfer: Adult

Redistribution: Adults can be collected with a sweep net during mid-July in the early evening.

Actual adult size

USDA-ARS

USDA-ARS

Rhinocyllus conicus— Thistle head weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult in sheltered locations such as caves, the hollow of trees, or occasionally the attics of homes.

Egg stage: Each female will produce from 100 to 150 eggs, and generally deposits them on bud bracts (the modified leaves below the flower). Eggs are covered with chewed plant material which becomes tan with age and appears as "warts" on the buds and stems, thus protecting the eggs from predators. Eggs hatch six to eight days after being laid.

Larval stage: The larvae infest the seed head or stem from early June to fall. They develop for 25 to 40 days, feeding on the receptacle and maturing seed tissue. Each larva feeds within the chamber or cell it forms. The feeding stimulates the plant to concentrate nutrients and tissue in the affected area. The mature larvae eventually coat the inner cell walls with feces and chewed plant material to produce hard, protective chambers for the pupal stage. Larvae are C-shaped, creamy-white, and have amber-brown sclerotized heads.

Pupal stage: Pupation occurs within the plant tissue in which the larvae developed. The pupal stage lasts from 8 to 14 days. Pupae are whitish to creamy-white.

Adult stage: Adults remain within the cells for several weeks, turning from a cream or reddish-tan to almost black. When weevils emerge from the plant, their body hair is a patchy mixture of black and yellow, which gives the impression that the weevils are covered with pollen. Weevils chew their way out of the seed heads through the face of the receptacle, whereas those in the stems exit through several small openings chewed near the attachment of the seed head. Adults are present for only a short period after emerging from the plants. They can occasionally be seen flying about on warm fall days. This weevil has a short snout, and although the size is variable, most larger weevils are no more than about 0.24 inch long.

EFFECT

Destructive stage: Larval

Plant species attacked: Thistles belonging to the genera *Carduus*, *Cirsium*, *Onopordum*, and *Silybum*.

Site of attack: Seed head and sometimes the stem. Adults may slightly defoliate plants.

Impact on the host: Because the insect attacks the seed-producing tissue. It is extremely effective by itself in those areas where the plant reproduces solely by seed. In those plant species that reproduce by other means, it only affects the seed production potential.

RELEASES

Habitat: Meadows and areas where there is adequate moisture and moderate temperature are best for the weevil, while very hot, dry areas greatly limit this insect's population. Areas where summer arrives quickly do not allow it to use secondary and lateral seed heads. Found in most Canada thistle infestations in Lincoln County.

Stages to transfer: Adult.

Redistribution: Collections should be made as the weevils gather on the plants in the early spring and begin to mate (May through June). Adults are dislodged onto a tarp, table top, or into a plastic bag for sorting. Beetles can then be stored for up to a week, especially if kept at 46° to 54°F.

Actual adult size

Oregon Dept. of Agriculture

Oregon Dept. of Agriculture

Chrysolina quadrigemina— Klamath weed beetle

BIOLOGY

Generations per year: One

Overwintering stage: Egg, larval and (sometimes) adult

Egg stage: Eggs are usually deposited on leaves in the fall, but sometimes in the spring. They are laid singly or in clusters of two to four on the underside of the leaves. Eggs that are deposited on foliage during the late fall or early winter can survive and hatch the following spring. Each female may lay several hundred eggs during her lifetime. Eggs are oval and orange to reddish.

Larval stage: Eggs hatch about 3 weeks after they are laid. The larvae migrate to the leaf buds and immature leaves. Larvae can completely defoliate a plant before they reach maturity which forces them to move to other plants. When the larvae mature, they burrow into the soil and create cells and pupate. Larvae are somewhat humpbacked or C-shaped and plump. They are orange at first and become a dirty, grayish-pink with age. Larvae of this species resemble those of *Chrysolina hyperici*.

Pupal stage: Mature larvae burrow into the soil in February and March and pupate in oval cells. They emerge from late April until June. The orange pupae are oval; the wing pads, legs, head, and antennae are readily apparent.

Adult stage: Adult emergence and behavior is very similar to that of *Chrysolina hyperici*. Adult beetles emerge in the spring, feed for several weeks, and then enter the soil to rest. Fall rains activate the adults to mate and lay eggs. The oval beetles are shiny, metallic black, blue, green or bronze, and 0.2 to 0.28 inch long.

EFFECT

Destructive stage: Larval and adult

Plant species attacked: Common St. Johnswort

Site of attack: Both the adults and larvae attack the leaves

Impact on the host: Larval feedings in the fall and spring reduces the foliage and lowers root reserves making it very difficult for the plants to survive the harsh winter or summer environmental conditions.

RELEASES

Habitat: It is found in mountainous, open sunny and warm areas. In its native homeland it thrives in a Mediterranean climate with dry summers and mild, moist winters. It apparently does not do well in shaded, barren and rocky locations. Found in most St. Johnswort infestations in Lincoln County.

Stages to transfer: Adult.

Redistribution: Collect the adults with a sweep net or hand-collect from infested stems. The adults may be readily kept for several weeks in storage.

Actual adult size

USDA-ARS

USDA-ARS

Cyphocleonus achates— Knapweed root weevil

BIOLOGY

Generations per year: One

Overwintering stage: Larval

Egg stage: Eggs are laid singly in a notch excavated by the female on the root crown, just below the soil surface. Females may deposit more than 100 eggs. Eggs are oval and white to pale yellow when laid, becoming yellower with age. They hatch in 10 to 12 days.

Larval stage: Immediately upon hatching, the larvae mine toward the cortex of the root. There are four larval instars, with the second instar overwintering. Third-and fourth-instar cause a gall-like enlargement in the root.

Pupal stage: Pupation occurs within the galled root. The pupal period lasts about two weeks.

Adult stage: Adults emerge from early August to mid-September. The adult weevils feed on knapweed leaves, preferring those of young plants. Adults are 0.56 to 0.6 inch long and generally live eight to 15 weeks, but do not overwinter. A single female will mate several times during her lifetime.

EFFECT

Destructive stage: Larval

Plant species attacked: Spotted knapweed and diffuse knapweed

Site of attack: Larvae mine and gall the central vascular tissue of the roots.

Impact on the host: Newly hatched larvae mine into the root cortex. Feeding by older larvae causes considerable damage to the root, especially to small plants or plants containing multiple larvae.

RELEASES

Habitat: Prefers well drained soils that lack dense vegetation other than knapweed. About 200 have been released in Lincoln County.

Stages to transfer: Adult.

Redistribution: Adults can be collected either from the field or from infested roots that have been placed in a sleeve box for adult emergence.

Actual adult size

USDA-ARS

Montana State University

Larinus obtusus— Blunt knapweed flower weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (in the soil litter or in soil cracks near the host plant).

Egg stage: Eggs are laid among the inner florets of newly opened flower heads. Hatching occurs in three days at 77°F. The eggs are yellowish, oval to round, and measure 0.05 inches long by 0.03 inches wide.

Larval stage: Larvae feed within the seed head on the pappus hairs and developing seeds. There are three instars and development is completed in 17 days.

Pupal stage: Pupation occurs within the chambers constructed from seeds and pappus hairs which were cemented together by the mature larvae. The pupal period lasts nine days.

Adult stage: Adults emerge through holes chewed in the tops of the pupal chambers. Overwintering adults appear at the end of May and reach peak populations during early July. First-generation adults exit the attacked seed heads during late July and early August. Adults are black with a somewhat mottled appearance caused by patches of white hairs on the back. Body length is 0.20 to 0.28 inch.

EFFECT

Destructive stage: One or two larvae destroy most of the developing seeds in the head.

Plant species attacked: Spotted knapweed

Site of attack: Seed heads.

Impact on the host: Seed production is reduced.

RELEASES

Habitat: The beetle prefers areas more moist than does *L. minutus*.

Stages to transfer: Larval and pupal (in the seed heads), and adult.

Redistribution: Sweep the adults from the plants or move insects within the seed heads during late July and early August.

Actual adult size

USDA-APHIS

Montana State University

Chrysolina hyperici— Klamath weed beetle

BIOLOGY

Generations per year: One

Overwintering stage: Egg, larval and (sometimes) adult

Egg stage: In the native country and in California and Oregon the eggs are laid on the leaves of St. Johnswort in the fall, while in the northwestern United States the eggs are laid in the spring. Each female produces several hundred eggs which are deposited singly or in clusters and hatch in six to seven days. Eggs are elongated and orange.

Larval stage: Upon hatching, the larvae migrate to the leaf buds and immature leaves. Larvae can completely defoliate a plant before they reach maturity which forces them to move to other plants. When mature, larvae burrow into the soil where they create cells and pupate. Larvae are somewhat humpbacked or C-shaped and plump. They are orange at first, becoming a dirty grayish-pink with age. Larvae of this species resemble those of *C. quadrigemina*.

Pupal stage: Pupation occurs during late spring; the pupal period lasts about 12 days.

Adult stage: Adult beetles emerge in the spring; feed for several weeks, and then enter the soil to rest during the summer. Fall rains activate the adults to mate and lay eggs in their native country and some areas of California. If fall rains do not occur, as is often the case in Pacific Northwest, spring rains will induce mating and egg laying. Adults are generally shiny metallic green, black, bronze, or blue, about 0.2 in long and robust. This species is slightly smaller than C. quadrigemina and it is difficult to differentiate the two species.

EFFECT

Destructive stage: Larval and adult

Plant species attacked: Common St. Johnswort

Site of attack: Leaves and flowers.

Impact on the host: Heavy larval feeding in the fall reduces the foliage and lowers the root reserves which makes it very difficult for the plant to survive the winter. However, if feeding occurs in the spring, the plant can sometimes outgrow the feeding injury inflicted by the insect, especially when summer rains occur.

RELEASES

Habitat: The beetle prefers conditions more moist than *C. quadrigemina*, and avoids shaded or barren, rocky locations. Found in most St. Johnswort infestations in Lincoln County.

Stages to transfer: Adult

Redistribution: Hand-pick or collect with a sweep net. The beetles can be kept for several weeks in cool storage and several days in transit without ill effects.

Actual adult size

Oregon Dept. of Agriculture

Brachypterolus pulicarius*— flower-feeding beetle

BIOLOGY

Generations per year: This beetle typically has one generation per year; although two generations per year have been reported in Germany.

Overwintering stage: Pupal

Egg stage: Eggs are deposited in the toadflax flowers.

Larval stage: Larvae reportedly feed on pollen, anthers, ovaries, and maturing seeds of toadflax which reduces pollination success and seed production.

Pupal stage: Pupation occurs in the soil beneath the host plant.

Adult stage: The adults emerge in late May. They are small, black, oval beetles about 0.08 inch long.

EFFECT

Destructive stage: Adult and larval.

Plant species attacked: Yellow toadflax and Dalmatian toadflax

Site of attack: Adults attack the young succulent shoot tips, and perhaps some of the reproductive parts of toadflax plants. Larvae feed on pollen, anthers, ovaries and maturing seeds of toadflax.

Impact on the host: Adult feeding on the young toadflax shoots causes increased branching of the plants. Larval feeding on the reproductive parts of the plants and the inhibition of early-season flowering by the adults and larvae reduce seed production.

RELEASES

Habitat: This beetle appears to be well-established at most major yellow toadflax infestations in North America. It is found less frequently associated with Dalmatian toadflax. A couple of releases have been made in Lincoln County, results are undetermined.

Stage to transfer: Adult.

Redistribution: Collect with a sweep net or aspirator, sort and transport.

Montana State University

Larinus minutus— Lesser knapweed flower weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (in plant litter at the base of the plants).

Egg stage: Eggs are deposited between June and September, depending on climate, in the capitulum between the pappus hairs. Up to five eggs are clustered; the number of eggs laid per female ranges between 28 and 130. The elongate, yellow eggs are 0.06 inches long and hatch about three days after being laid.

Larval stage: There are three larval instars. The newly eclosed first-instar larvae feed on the pappus hairs and then move downward to the achenes where they consume the contents of individual seeds as well as some nearby seeds and the receptacle. Feeding lasts about four weeks.

Pupal stage: This weevil constructs a cocoon (partly from seed coats) which is attached to the receptacle. Pupae are white but turn brown shortly before emergence.

Adult stage: Adults are active in the field from May or June until August. In the laboratory they will live up to 14 weeks. Mating occurs continuously in the field over a period of 11 weeks from early June until August. Adults normally feed on the leaves and flowers prior to laying eggs. Adults emerge from mid-July to mid-August. Larinus minutus adults are 0.16 to 0.2 inch long, black and have a large snout.

EFFECT

Destructive stage: Larval and adult

Plant species attacked: Spotted knapweed and diffuse knapweed.

Site of attack: Larvae begin feeding on the pappus hairs and then mine downward through the capitulum to the seeds which are then consumed. Adults feed on rosette leaves in the spring and in flowers.

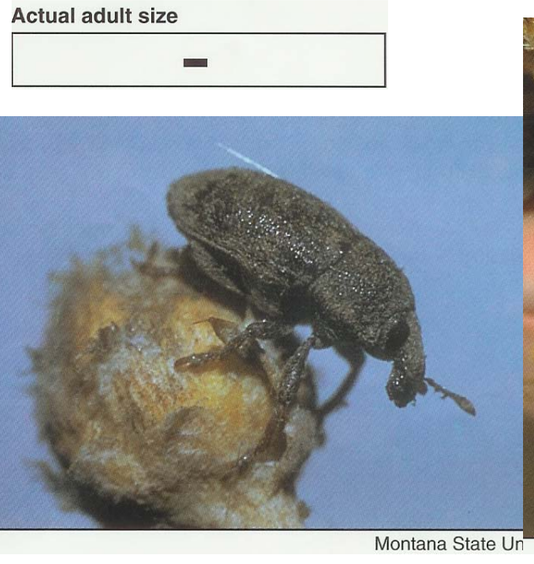
Impact on the host: The moth attacks the seeds and complements the damage inflicted by *Urophora affinis* and *U. quadrifasciata*.

RELEASES

Habitat: The beetle prefers hot and dry areas. Numerous releases have occurred around Lincoln County.

Stages to transfer: Adult, and larval and pupal (in the seed heads).

Redistribution: Collect and transfer the seed heads, or use a sweep net during flowering to collect the adults. When they congregate around the root crown, adults can be collected with an aspirator.



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USDA-ARS

Urophora quadrifasciata— UV knapweed seed head fly

BIOLOGY

Generations per year: One or two

Overwintering stage: Larval or pupal (in the seed head).

Egg stage: Eggs are laid during the summer between the bracts of the developing flower buds. Incubation last three to four days.

Larval stage: Larvae can be found in the seed head from early summer until the following early spring if there is only one generation. If there are two generations, larvae can be found from early summer until late summer or early fall, then early fall until early spring. The small, whitish larvae are found in the ovaries of the seed head. Multiple larvae generally live in the seed head.

Pupal stage: Pupation occurs within the papery galls.

Adult stage: First-generation adults can be found from spring to early summer, while adults of the second generation live from late summer to late fall. Adults are black, measure about 0.16 inch long and have distinctive dark bands forming a "UV" pattern on each wing.

EFFECT

Destructive stage: Larval (in the seed head)

Plant species attacked: Spotted knapweed and diffuse knapweed.

Site of attack: Larvae feed and develop in the maturing seed heads.

Impact on the host: The activities of both *Urophora* fly species reduce knapweed seed production by 95%.

RELEASES

Habitat: This species is found almost in every knapweed infestation throughout Lincoln County.

Stage to transfer: Adult, larval and pupal

Redistribution: Seed heads infested with larvae and pupae can be transferred to new sites. Adult flies also can be reared in a sleeve box for removal of parasitoids.

Actual adult size

Oregon Dept. of Agriculture

USDA-ARS

*Mecinus janthinus**— Stem-boring weevil

BIOLOGY

Generations per year: One

Overwintering stage: Adult (inside pupal cell).

Egg stage: Eggs are deposited inside cavities chewed in the shoots by the females and covered with what is assumed to be chewed plant material. Eggs are laid from June to mid-July. They are oval and 0.02 inch wide by 0.03 inch long. The incubation period is six to seven days.

Larval stage: Larvae develop successfully only in shoots with a diameter of more than 0.04 inch, although the weevils may lay eggs into smaller shoots. Larval development takes between 23 and 34 days. The larvae are C-shaped and white with pale brown head capsules.

Pupal stage: Pupation occurs within the larval mine. The pupae are 0.12 to 0.18 inch long, and white at first but gradually turning black.

Adult stage: In the former Yugoslavia, adults emerge in May, feed, copulate, and lay eggs from the end of May to mid-July. The adults are small, jet-black weevils that appear somewhat elongated. They are 0.14 to 0.16 inch long.

EFFECT

Destructive stage: Adult and larval

Plant species attacked: Dalmatian toadflax and yellow toadflax

Site of attack: Adults feed on the leaves and stem; larvae mine the stems.

Impact on the host: Adult feeding on the leaves and stems of toadflax apparently has a limited effect under field conditions in Europe. However, mining of the stems by the larvae causes premature wilting of shoots and suppresses flower formation, particularly under conditions of high weevil density and cases of multiple attack. Effects of the weevil on the plant reportedly are enhanced under drought stress.

RELEASES

Habitat: Undetermined. Several successful releases have been made in Lincoln County. Areas are open to full sun.

Stage to transfer: Adult

Redistribution: Similar to other weevil species.

Actual adult size

Metzneria paucipunctella— Seed head moth

BIOLOGY

Generations per year: One

Overwintering stage: Mature larval (at the base of the seed head)

Egg stage: Each female lays from 60 to 100 eggs in a three-week period beginning in June. Eggs are placed on bracts at the base of the young flower heads, or on the stems just below the heads. Eggs are reddish-brown when newly deposited, but turn yellowish as they mature. They are elongate, oval, and measure about 0.03 inch long. The incubation period is about 10 days.

Larval stage: Upon emergence, the larvae enter the open flower heads. The first-instar larvae feed on the florets while second-instar larvae feed on the seeds. The third-instar larvae mine in the receptacle which reduces the viability of uneaten seeds. Although several larvae may occupy the seed head while they are developing, generally only one reaches maturity. The larvae can be identified by their dark brown head capsules, white color, and wrinkled thoracic and abdominal segments.

Pupal stage: Pupation occurs within the seed head during May.

Adult stage: Adults are present in early June, but they only fly at dusk and, therefore, are rarely seen. Adults are small moths about 0.32 inch long that rest with their wings folded over the back. The front wings are light gray with peppery spotting and are dark at the tip.

EFFECT

Destructive stage: Larval

Plant species attacked: Spotted knapweed and diffuse knapweed.

Site of attack: Larvae feed on the seeds with each larva destroying an average of eight seeds. Older larvae web the seeds together, preventing their dispersal.

Impact on the host: The moth attacks the seeds and complements the damage inflicted by *Urophora affinis* and *U. quadrifasciata*.

RELEASES

Habitat: Sites with good winter snow cover contribute to larval survival. Released in the Keller Ferry area with no determination of impact.

Stage to transfer: Larval and pupal

Redistribution: Moth-infested seed heads should be collected in early spring and transported to release sites prior to adult emergence. Seed heads can be caged to yield adults. Emergence can be delayed by storing seed heads at cool temperatures.

Actual adult size

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Urophora affinis— Banded gall fly

BIOLOGY

Generations per year: One, although a partial second generation may occur.

Overwintering stage: Larval (in the seed head gall).

Egg stage: Eggs are deposited in the summer in immature knapweed seed heads and hatch in three to four days.

Larval stage: The developing larvae form hard, teardrop-shaped galls from receptacle tissues and feed on the nutritive cell lining of the gall chamber. Larvae are short and white with a distinct brown spiracular plate.

Pupal stage: Pupation occurs within the gall during late May. Pupation lasts about 14 days.

Adult stage: Adults are active during June and July when flower buds are forming. They mate and the females insert their eggs into the immature flower buds. The adults are about 0.16 inch long, black, and have faint horizontal bands on the wings.

EFFECT

Destructive stage: Larval

Plant species attacked: Spotted knapweed and diffuse knapweed.

Site of attack: Larvae feed in the developing seed heads.

Impact on the host: Both *Urophora affinis* and *U. quadrifasciata* (especially *U. affinis*) can reduce knapweed seed production by up to 95%. The galls act as metabolic sinks by draining nutrients from other plant parts. Multiple galls may develop in the seed head. Each U. affinis gall has been shown to reduce seed production in diffuse knapweed by 2.4 seeds per head and in spotted knapweed by 2 seeds per head.

RELEASES

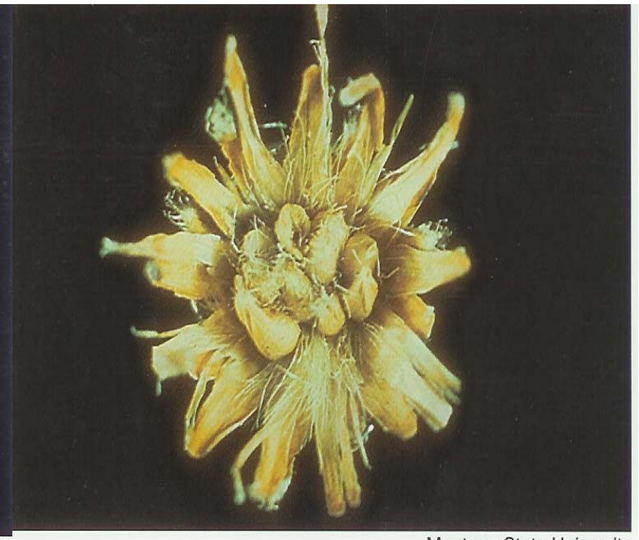
Habitat: This species is widely distributed throughout much of the knapweed-infested areas of Lincoln County. Seems to prefer full sun locations.

Stage to transfer: Adult, larval and pupal

Redistribution: Transfer infested seed heads by collecting and holding them for emergence the following spring. Adult flies can be reared from seed heads in cages and then released.

Actual adult size

USDA-ARS



Montana State University