



Manaaki Whenua  
Landcare Research

# BIOLOGICAL CONTROL AGENTS FOR WEEDS IN NEW ZEALAND: A Field Guide

Compiled by Lynley Hayes

© Landcare Research New Zealand Ltd 2005.

This information may be copied and distributed to others without limitation, provided Landcare Research Ltd and the source of the information is acknowledged. Under no circumstances may a charge be made for this information without the express permission of Landcare Research Ltd.

Biological control agents for weeds in New Zealand : a field guide. -- Lincoln, N.Z. : Landcare Research, 2005.

ISBN 0-478-09372-1

1. Weeds -- Biological control -- New Zealand.
2. Biological pest control agents -- New Zealand.
3. Weeds -- Control -- New Zealand.

UDC 632.51(931):632.937

### **Acknowledgements**

We are grateful to the Forest Health Research Collaborative for funding the preparation of this field guide and to regional councils and the Department of Conservation for funding its production. Thank you to the many people at Landcare Research who provided information or pictures, checked or edited the text, helped with proof-reading, or prepared the layout, especially Christine Bezar and Jen McBride.

## Contents

Foreword

Tips for Finding Biocontrol Agents

Tips for Safely Moving Biocontrol Agents Around

Alligator Weed Beetle

Alligator Weed Moth

Blackberry Rust

Broom Psyllid

Broom Seed Beetle

Broom Twig Miner

Californian Thistle Gall Fly

Californian Thistle Leaf Beetle

Californian Thistle Pathogens

Gorse Colonial Hard Shoot Moth

Gorse Pod Moth

Gorse Seed Weevil

Gorse Soft Shoot Moth

Gorse Spider Mite

Gorse Thrips

Native Insects on Gorse

Heather Beetle

Hemlock Moth

Hieracium Gall Midge

Hieracium Gall Wasp

Hieracium Rust

Mexican Devil Weed Gall Fly

Mist Flower Fungus

Mist Flower Gall Fly

Nodding Thistle Crown Weevil

Nodding Thistle Gall Fly

Nodding Thistle Receptacle Weevil

Old Man's Beard Leaf Fungus

Old Man's Beard Leaf Miner

Ragwort Cinnabar Moth

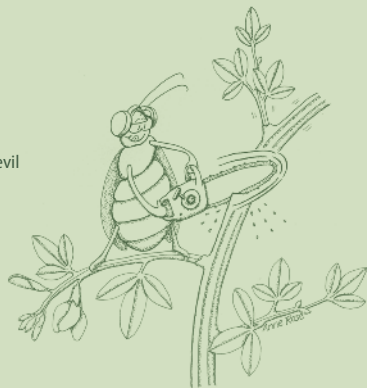
Ragwort Flea Beetle

Ragwort Seedfly

Scotch Thistle Gall Fly

St John's Wort Beetles

Glossary



## Foreword

Alien weeds, including exotic grasses, shrubs, vines and trees, pose a serious and increasing threat to all of New Zealand's ecosystems. Unless current control is improved more than 575 000 ha of high priority conservation land will soon be threatened by weeds. In the longer term, the ecosystem-altering effects of invasive plants will have serious impacts on New Zealand's indigenous biodiversity and productive sectors, by altering hydrological regimes, disturbing the flow of energy and nutrients, and changing the structure and composition of native communities.

The financial cost of weeds is also huge. For example, in 1982 the cost of pastoral weeds alone (in terms of production losses plus weed control expenditure) was estimated to be \$393 million per annum, which equates to about \$1.1 billion today.

Biological control is increasingly being recognised as an important tool for managing New Zealand's serious weed problems. Successful biological control for mist flower (*Ageratina riparia*), St John's wort (*Hypericum perforatum*), and ragwort (*Senecio jacobaea*) means it is now uncommon for other control methods to be required. The need for control measures against alligator weed (*Alternanthera philoxeroides*), Mexican devil weed (*Ageratina adenophora*), and nodding thistle (*Carduus nutans*) has also been substantially reduced.



This field guide explains how to find and recognise biocontrol agents that have been deliberately and successfully introduced to attack weeds in New Zealand. The most significant of the self-introduced and native species that commonly attack weeds in New Zealand are also covered. Species currently under development are not included but we hope to produce additional pages for them in the future.

## Foreword

We also alert you to some of the species that are most commonly confused with biocontrol agents, because they look a lot like them, or damage other plant species in a similar way. False reports that biocontrol agents are damaging non-target plants are not uncommon. Not everyone is aware that New Zealand's native plants have natural enemies of their own, and people become alarmed if they notice any damage. Before biocontrol agents are introduced into New Zealand, great care is taken to ensure that they will only damage the target weed. Permission to introduce new biocontrol agents must be granted by the Environmental Risk Management Authority. Biological control of weeds in New Zealand has a good safety record and any reports of non-target attack are carefully followed up.

Although the number of biocontrol agents available for weeds has grown in recent times (e.g. there are 30 species of insects and 7 species of fungi covered in this field guide) insect biocontrol agents for weeds comprise only a little more than 0.1% of all the insects in New Zealand, and only a little over 1% of all introduced species.

When looking for biocontrol agents in the field it can be extremely important to look at exactly the right time. Newly released or established control agents may be quite rare and difficult to find until numbers build up – this can take many years.

Populations of biocontrol agents will also fluctuate from year to year and place to place as conditions will not always be ideal for them. Once biocontrol agents begin to bring a weed under control their populations will decline accordingly and the agents may become quite rare. If conditions subsequently promote the growth of the weed (which may have a large seed bank) then control may appear to be failing. However, with time the control agents should build up damaging populations and exert control again.

Establishing biocontrol agents can be a long and slow process and many are greatly enhanced by efforts to assist agent dispersal. We have provided some tips on how best to go about this.

Other weed management techniques (such as chemical and mechanical control) may interfere with biocontrol agents. As a rule these activities should be avoided, particularly when attempting to establish new control agents and where agents are performing well.

For more information about biocontrol of weeds in New Zealand see: [www.landcareresearch.co.nz/research/biosecurity/weeds/biocontrol/](http://www.landcareresearch.co.nz/research/biosecurity/weeds/biocontrol/). To source biocontrol agents either contact biosecurity staff at your local regional council or Landcare Research (see back page).

We hope that you enjoy learning about the secret life of weed biocontrol agents as much as we have!

## Tips for Finding Biocontrol Agents



Garden leaf-vacuum

- Look at the right time of the year. Some insect agents hide away in late summer or winter and some life stages such as eggs may be quite well hidden or camouflaged.
- Look when the weather is favourable. Biocontrol agents are more active in warm weather and will often be more visible then. It will be more difficult to find most control agents during wet, cold and windy weather. Fungi are often most visible after warm, wet weather.
- Look during the warmer part of the day as many insect agents will be more active then.

### Search Aids

A number of techniques can be used to improve the chances of finding biocontrol agents:

- It may be possible to see agents, and/or their damage by simply examining the host plant, but for smaller organisms a hand lens or magnifying glass will come in useful.
- When agents are small and hard to see (e.g. gorse thrips) it may be easier to see them if you beat the plant with a stout stick over a white beating tray (you can improvise with a sheet of material or cardboard). If the agents are present they will be dislodged onto the tray, and will be much easier to see. Ideally plants need to be dry, otherwise a beating tray will quickly become sodden.
- When the weed is low growing (and preferably not too spiny) you can sweep the foliage with a butterfly net and examine the contents. A net can also be used to catch flying insects for closer inspection.
- Suction devices, like a garden leaf-vacuum, can be useful for finding and collecting hard-bodied insects (e.g. nodding thistle crown weevil, ragwort flea beetle) in low-growing foliage. They are not suitable for collecting delicate winged insects like broom psyllids or gorse pod moths, as these are too easily

## Tips for Finding Biocontrol Agents



Pooter

- damaged. A pooter (aspirator) can be used to collect control agents or transfer them from one container to another. To make or use a pooter see below.
- Sometimes control agents can be lured out of hiding with attractants such as light traps (e.g. hemlock moth) and pheromones (e.g. gorse pod moth and gorse soft shoot moth). Pitfall traps and window traps can also be put out to catch insects. For advice on traps contact Landcare Research (see back page).

### **Making and Using a Pooter**

Get some plastic tubing about 1 cm in diameter and 30 cm long, and a plastic container the size of a small jam jar. Punch two holes in the lid of the container so the tubing can just fit through. Cut the tubing into equal lengths. Push the plastic tubing through the holes so that the bulk of it is above the top of the lid, leaving 1–2 cm below. Tie a piece of gauze securely around the short end (below the lid) of one tube.

Attach the tube with the gauze end to a portable compressor. The gauze prevents the agents from being sucked into the compressor. Put some plant material or tissue paper inside the jar to cushion the agent's fall. Turn the compressor on and check that the suction is not too strong. Position the end of the free tube over the agent to be collected and it will be sucked into the jar. When you turn the compressor off plug up the end of the collecting tube to prevent the contents of the jar from escaping. Suction can also be provided by mouth but is not recommended because of the potential health hazards of inhaling spores, scales etc.

## Tips for Safely Moving Control Agents Around



An ideal container

- Plastic containers can be used to house agents in transit but they need to be modified to provide ventilation. The easiest way to do this is by creating a lid using a piece of finely woven fabric secured with an elastic band.
- Paper bags are also good except that you cannot see inside, and the contents can be crushed. A good way to seal paper bags securely is by folding the top over several times and stapling it.
- Do not use plastic bags as they puncture easily and have no ventilation, so their contents can rapidly overheat.
- Always put some plant material in your containers for food and protection. Add tissues or paper towels to your containers to absorb excess moisture and provide places for the control agents to hide (the padding also gives them a smoother ride).
- Do not leave control agents in the sun or a closed vehicle as high temperatures will kill them quickly. To keep control agents cool put them in a chillybin with freezer pads. Wrap the freezer pads in paper so they are not in direct contact with containers, which can cause excess condensation.
- Always release the control agents as soon as possible.



**Host:**

Alligator Weed (*Alternanthera philoxeroides*)

**Agent:**

Alligator Weed Beetle (*Agasicles hygrophila*)



Adult beetle

**Background and life cycle**

- Native to South America, this beetle was first imported in 1981 and released widely in the early 1980s. It is now well established throughout Auckland and Northland, and at at least one site in the Waikato.
- A multivoltine species, this beetle can complete up to four generations each year during the warmer months (a generation can be completed in as little as 3–4 weeks). Adult females begin egg-laying in spring. Larvae feed and develop quite quickly and then pupate. New adults emerge about a week later.

**Distinguishing features**

- Adults are about 5.5–7.0 mm long (females tend to be larger than males), with striking yellow and black colouration.
- Eggs are oval-shaped and laid in batches on the undersides of leaves. They start off whitish but quickly become pale yellowish-orange in colour.
- Larvae are black and caterpillar-like. Initially they are gregarious but eventually disperse.
- Pupae are initially cream but later turn brown, and can be found inside the stems.

**Best time to look**

- Look for adults or larvae feeding on the leaves during the warmer months of the year.

**Damage**

- Both adults and larvae feed on the non-submerged parts of the plant, especially around the edges of the weed mats.
- Young larvae tend to feed on the undersides of leaves and leave the upper

**Host:**

Alligator Weed (*Alternanthera philoxeroides*)

**Agent:**

Alligator Weed Beetle (*Agasicles hygrophila*)



Damaged weed

epidermis intact. Early feeding damage looks like pin pricks in the leaves but later these holes become larger and more irregular in shape.

- Older larvae and adults feed on both sides of leaves and on the stems, and may destroy the plant down to water level.
- Large populations can cause considerable damage to alligator weed and each year they successfully control the weed in many lakes and ponds.
- The beetles are not able to control the weed in flowing water that is regularly flooded (they get washed away), on terrestrial infestations (the eggs need high humidity to develop successfully and the stems can become too solid for the beetles to pupate in), or in areas that get frosts (cold conditions either kill the beetles or reduce their ability to lay viable eggs).
- Specificity testing and follow-up field surveys indicate this insect only causes serious damage to alligator weed but may occasionally cause minor damage to *Alternanthera sessilis* and *A. denticulata*.

**Management**

- The beetles should only need to be harvested and moved around if new infestations of the weed appear on static water bodies. To do this collect at least 100 beetles in early summer using a pooter or a net.

**Host:**

Alligator Weed (*Alternanthera philoxeroides*)

**Agent:**

Alligator Weed Moth (*Arcola malloi*)



Caterpillar inside stem

**Background and life cycle**

- Native to South America, this moth was first imported in 1982 and released widely during the 1980s. It is now patchily established in Northland and Auckland, but is not as common yet as the alligator weed beetle.
- A multivoltine species, this moth can complete several generations during the warmer months (a generation can be completed in as little as 6–7 weeks). Adult females begin egg-laying in spring. Larvae feed for about a month before pupating and new adults emerge about a week later.

**Distinguishing features**

- Adults are about 13–14 mm long, and are pale brown with large black eyes. They are nocturnal and hide away during the day.
- Eggs are white, oval-shaped and laid singly on the underside of the leaves and in the leaf axils near the top of stems.
- Caterpillars are whitish or light amber and develop brownish stripes along their bodies. They live inside the stems.
- Pupae are initially amber but later turn dark brown. They can be found in sealed off chambers within the stem, with a small round membranous window that the new adults later emerge through.

**Best time to look**

- Look for wilted stems during the warmer months of the year and split these apart to see the caterpillars or pupae inside.

**Host:**

Alligator Weed (*Alternanthera philoxeroides*)

**Agent:**

Alligator Weed Moth (*Arcola malloi*)



Damaged weed

**Damage**

- The adults do not feed on alligator weed. They feed on the nectar of various flower species but this is not harmful to these plants.
- The caterpillars feed inside the stems causing them to collapse. Each caterpillar can destroy as many as nine stems.
- Large populations can cause considerable damage to alligator weed and each year they successfully control the weed in some lakes and ponds.
- The moths are not able to control the weed in flowing water that is regularly flooded (they get washed away) and cool temperatures do not appear to suit them either. Although the moth is able to move further onto land than the alligator weed beetle, it is unable to control terrestrial infestations.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack alligator weed.

**Management**

- Although the moths appear to be strong fliers, it will take them some time to find all alligator weed infestations, so it may still be useful to harvest and move them around. To do this collect at least 2–3 plastic rubbish bags full of damaged stems in late summer.

**Host:**

Blackberry (*Rubus fruticosus* agg.)

**Agent:**

Blackberry Rust (*Phragmidium violaceum*)



Purple-brown spots

**Background and life cycle**

- Native to Europe, this rust was first noticed here in 1990 and is now widely established throughout the country. It is believed to have blown over from Australia where an illegal release was made in 1984. Another strain officially released there in the early 1990s is thought not to have established here.
- Winter spores germinate in spring to begin a new cycle of infection. A sexual cycle involving three different types of spores is then completed on new leaves. Yellow summer spores are produced continuously from late spring until autumn, and are spread by wind to start new infections. Sticky black winter spores are produced from late summer onwards.

**Distinguishing features**

- Purple-brown spots, 2–3 mm in diameter, on the upper surface of the leaves have corresponding yellow or black powdery pustules, up to 1 mm across, on the undersides.
- The only way to tell different strains apart is by comparing their DNA.
- Two less common fungal species may be confused with blackberry rust. Blackberry cane and leaf rust (*Kuehneola uredinis*) forms lemony-yellow pustules on the lower surfaces of the leaves without any corresponding spots above. *Septoria* leaf spot (*Septoria rubi*) forms similar purple-brown spots on the upper surfaces of leaves but never powdery pustules below.

**Best time to look**

- It may be possible to see symptoms at any time of the year, but they are likely to be most obvious in autumn.

**Host:**

Blackberry (*Rubus fruticosus* agg.)

**Agent:**

Blackberry Rust (*Phragmidium violaceum*)



Black winter and yellow summer spores

**Damage**

- The yellow summer spores are the damaging stage and heavily infected leaves are usually killed and fall prematurely. Young leaves at the cane tips are particularly susceptible.
- Continuous leaf loss eventually weakens the plant. Rust epidemics result in shorter canes, fewer fruit and seed, and fewer daughter plants produced at the cane tips. Heavily infected plants can look as if they have been sprayed with herbicide.
- The rust's impact has been patchy and limited because the 18 species that we collectively refer to as blackberry range from highly susceptible to resistant. More effective control may be achieved if additional strains of the rust are established here. Eight additional strains are being released in Australia.
- Specificity testing suggests that this rust is only likely to attack blackberry and possibly native bush lawyer species (*Rubus schmidelioides*, *R. cissoides*, and *R. australis*), and some cultivated thornless blackberry species. However, follow-up field surveys have only found minor damage on *R. cissoides* to date.

**Management**

- There is little to gain by spreading the rust around further – plants that are not infected are probably resistant. Slashing plants can increase susceptibility.

**Host:**  
Broom (*Cytisus scoparius*)

**Agent:**  
Broom Psyllid (*Arytainilla spartiophila*)



Adults

#### **Background and life cycle**

- Native to Europe, this insect was first imported in 1992 and released widely during the 1990s. It is now well established at sites throughout most of the country.
- A univoltine species, adult females lay eggs from late spring until early summer. Then there is no further sign of the psyllids until the following spring when nymphs emerge, feed and develop through five stages, becoming adults by late spring.

#### **Distinguishing features**

- Adults are small (about 2–3 mm long), pale brown, winged, and look similar to aphids.
- Eggs are embedded in the stems. They may have a waxy cap over the top and are not easy to see.
- Nymphs are pink to orangey-brown, <2 mm long, and often found on new growth. They are less mobile than adults.
- Both adults and nymphs produce a sticky honeydew, and sooty mould may grow on this.
- Small insects called mirids are often found associated with the psyllids and may prey on them.

#### **Best time to look**

- Look in late spring for nymphs and/or new adults feeding on new growth and for honeydew or sooty mould.

#### **Damage**

- Both adults and nymphs suck sap out of the tender new growth in spring. When

**Host:**  
Broom (*Cytisus scoparius*)

**Agent:**  
Broom Psyllid (*Arytainilla spartiophila*)



Blackened stems and damage to new growth buds

populations are high the damage to new growth can be severe. Populations are beginning to reach these levels in parts of New Zealand.

- Specificity testing and follow-up field surveys suggest this insect is only likely to attack Scotch broom (*Cytisus scoparius*). Even other species of broom such as Montpellier broom (*Genista monspessulana*) or white broom (*Cytisus multiflorus*) are not attacked.

#### **Management**

- Adults can fly but appear to disperse slowly, so harvesting and moving this agent around is likely to be useful. To do this, collect nymphs in October–November by cutting infested material and carefully putting it into paper rubbish bags. Later wedge the cut material firmly into uninfested broom bushes. Although they can establish from extremely low numbers, aim to release at least several hundred. It is not ideal to shift adults as they are quite fragile and may be too old to lay many eggs.
- Extra care needs to be taken to keep psyllids safe since they spend much of the year as immobile life forms and appear to be particularly sensitive to herbicides.



**Host:**  
Broom (*Cytisus scoparius*)

**Agent:**  
Broom Seed Beetle (*Bruchidius villosus*)



Adult beetle

#### **Background and life cycle**

- Native to Europe, this beetle was first imported in 1985 and released widely during the 1990s. It is now well established at sites throughout most of the country.
- A univoltine species, adult females begin egg-laying in spring once pods are beginning to form. Larvae develop inside the seeds during spring and early summer. New adults are released when mature pods burst open.

#### **Distinguishing features**

- Adults are small (2–4 mm long), black, and roundish.
- Eggs are just visible to the naked eye as shiny oval spots, smaller than a pinhead, and are often laid close to the edge of the pod. Empty egg cases take on a white appearance.
- Larvae are cream and they burrow through the pod wall into the soft green seeds. Infested seeds develop a distinctive bulge and/or show discolouration. Sometimes dark trails where the larvae have been burrowing can be seen on the walls of green pods.
- Pupae are cream and are hidden away inside the seeds.

#### **Best time to look**

- Look for adults in spring when they congregate on broom flowers to feed on the pollen.
- Also look inside intact ripe pods just before they burst open to see new adults and hollowed-out seeds inside. The beetles are unable to chew their way out of pods. You may notice holes in pod walls that are made by other insects (e.g. a parasitic *Pteromalus* sp., or gorse pod moth).

**Host:**

Broom (*Cytisus scoparius*)

**Agent:**

Broom Seed Beetle (*Bruchidius villosus*)



Damaged pod

**Damage**

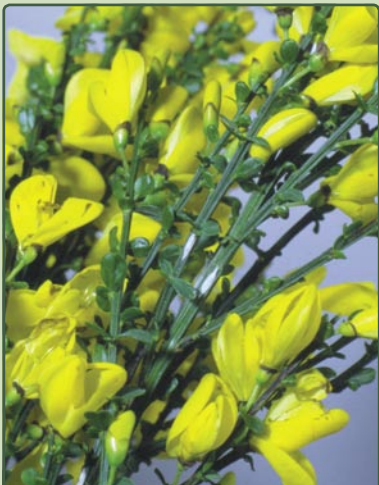
- Adults feed on the pollen of many flower species, but this is not harmful to these plants.
- Larvae are the damaging stage and each larva destroys one seed.
- Studies have shown that this insect is capable of destroying as much as 80–90% of seed.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack broom and tree lucerne (*Chamaecytisus palmensis*) seeds. Even other species of broom such as Montpellier broom (*Genista monspessulana*) or white broom (*Cytisus multiflorus*) are not attacked.

**Management**

- The beetles are able fliers and are dispersing steadily, but it may still be useful to harvest and move them around in some areas. To do this either beat broom flowers with a stick over a sheet in spring and suck the beetles up with a pooter, or put a large bag over flowers and give it a good shake. Shift at least several hundred. Alternatively, harvest infested pods when they are mature and blackish-brown in colour and beginning to burst open.

**Host:**  
Broom (*Cytisus scoparius*)

**Agent:**  
Broom Twig Miner (*Leucoptera spartifoliella*)



Pupae

#### **Background and life cycle**

- Native to Europe, this moth was first recorded here in 1950 and was probably accidentally introduced on ornamental broom plants. It is now common throughout the country.
- A univoltine species, adults emerge in early summer and females lay eggs over the summer months. Larvae feed from early autumn to spring and emerge to pupate in mid-late spring.

#### **Distinguishing features**

- Adults are tiny (3–4 mm) silvery-white moths and may be seen flying about or sitting on broom in summer.
- Eggs are oval and white. They are laid on young stems and are just visible to the naked eye.
- Larvae are translucent. They feed just under the surface of the stems, which results in characteristic brown mines and dieback of stems. To see the larvae, peel back the bark covering mines.
- Pupae are white and are usually found on the undersides of branches. Old empty pupal cases persist for some time and can usually be found all year round.

#### **Best time to look**

- Look for mined twigs and dieback in late winter/early spring, and new pupae in late spring.
- Also look for adults during summer, or pupal cases on the undersides of stems and old mines at any time of the year.

**Host:**

Broom (*Cytisus scoparius*)

**Agent:**

Broom Twig Miner (*Leucoptera spartifoliella*)



Heavily mined broom

**Damage**

- Larvae damage broom by feeding on the stem tissues. When a large proportion of green material has been affected then bushes grow and flower less, and whole branches and even entire bushes may die. Large outbreaks causing severe damage have become common in the South Island in recent times. This damage is most noticeable before new growth begins to form. Bushes may look as if they have been sprayed.
- Specificity testing and follow-up field surveys indicate this insect only attacks Scotch broom (*Cytisus scoparius*). Even other species of broom such as Montpellier broom (*Genista monspessulana*) or white broom (*Cytisus multiflorus*) are not attacked.

**Management**

- The moth is already widespread so there should be no need to harvest and move it around. However, if uninfested pockets are found, branches of broom with fresh pupae on them (usually around November) could be wedged there. Aim to shift at least several hundred pupae.

**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
Californian Thistle Gall Fly (*Urophora cardui*)



Adult fly

#### **Background and life cycle**

- Native to Europe, this fly was first imported in 1975 but did not establish from a small number of releases. This agent was imported again and released during the 1990s, and is now believed to have established at a limited number of sites, but is not common or widespread.
- A univoltine species, adults emerge in spring and females lay eggs in new shoots. Larvae burrow into the plant causing plant deformities (galls) to develop by early summer, and they feed through until autumn. When thistles die back over winter the galls fall to the ground and rot. Once air gets inside, the larvae are triggered to pupate.

#### **Distinguishing features**

- Adults are about 5–8 mm long with black bodies. They have clear wings with a striking black W-shaped marking on each one.
- Eggs cannot be seen as they are inserted in the terminal and lateral shoots in spring.
- Larvae are whitish and, as they feed, green swellings develop around them. These galls are made of hard tissue and become bigger over summer as the larvae inside grow, and can reach several centimetres across. The galls turn brown during autumn as they mature.
- Pupae are reddish-brown.

#### **Best time to look**

- Look for galls on plants in the autumn.
- You may also see the distinctive-looking adult flies resting on thistles during spring and summer but they can be quite hard to spot.

**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
Californian Thistle Gall Fly (*Urophora cardui*)



Galls

#### Damage

- Larval feeding tricks the plant into diverting valuable nutrients (which would normally be used for plant growth and increasing root reserves) into forming galls to feed the developing larvae. Terminal galls are more damaging to the plant than lateral galls, as they stop bud production and significantly reduce stem height.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack Californian thistle. Even other thistles are unlikely to be attacked.

#### Management

- Although its distribution is limited at present, it is probably not worth attempting to establish the flies in any areas that are grazed, since grazing animals are likely to seek out and eat the galls. In ungrazed areas it may be worth collecting at least 50–100 mature galls in late autumn and hanging them on a fence in a peg basket or a container made out of wire mesh – the holes need to be big enough for the adult flies to get through when they emerge the following spring.

**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
Californian Thistle Leaf Beetle (*Lema cyanella*)



Adult beetle

#### Background and life cycle

- Native to Europe and Asia, this beetle was first imported in 1981 with one, unsuccessful, release made. The beetle was imported again in 1990, and released widely in subsequent years, but establishment has been disappointing, and it is thought they have only persisted in low numbers at one site in Auckland.
- A similar beetle, the Californian thistle flea beetle (*Altica carduorum*), was also released widely during the early 1990s but, after doing well initially, is thought to have died out.
- A univoltine species, adult females lay eggs on new shoots in the spring. Larvae feed on plants in late spring/early summer before pupating. New adults emerge and feed briefly in late summer/early autumn.

#### Distinguishing features

- Adults are about 5 mm long and metallic bluish-black. Adults are hard to see, as they tend to drop to the ground whenever they detect movement or noise close by. They tend to be most obvious for a couple of weeks when they are mating in early spring.
- Eggs are creamy-white, oval, pinhead sized, and are laid singly on the leaves and stems.
- Larvae are grey and slug-like, and tend to feed on the undersides of the leaves during summer.
- Pupae are enclosed in white cases in the soil.

#### Best time to look

- Look in summer for leaves with holes in them, or patches where there is only a

**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
Californian Thistle Leaf Beetle (*Lema cyanella*)



Damaged foliage

thin membrane left, giving a windowed appearance. Feeding damage around the margins of the leaves is usually caused by other invertebrates like slugs. Turn damaged leaves over to look for the larvae feeding underneath.

#### **Damage**

- Both adults and larvae feed on the leaves and stems. Although they can cause heavy damage when kept on caged plants, under field conditions the level of damage appears to be inconsequential to the plant.
- Specificity testing suggested that this insect is only likely to attack Californian thistle, and possibly Scotch thistle (*Cirsium vulgare*), nodding thistle (*Carduus nutans*), and variegated thistle (*Silybum marianum*) to a lesser extent.

#### **Management**

- Because this agent appears to have limited potential, no further effort should be put into increasing its distribution or numbers.



**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
White Soft Rot (*Sclerotinia sclerotiorum*), Phoma Leaf Blight (*Phoma exigua* var. *exigua*), Californian Thistle Rust (*Puccinia punctiformis*)

Grateme Bourdôt



Californian thistle rust

### Background and life cycle

Three accidentally introduced fungal pathogens attack Californian thistle here.

- White soft rot is common and widespread. Hardened structures known as sclerotia germinate in spring to produce mushroom-like fruiting bodies which release sexual spores that disperse and create new cycles of infection. Sclerotia are produced in dead plant tissue and rest in the soil over winter.
- Californian thistle rust is common and widespread. Winter spores germinate in spring to begin a new cycle of infection. A sexual cycle involving three different types of spores is then completed on the leaves and roots. Then yellow, brown and orange spores are produced continuously from late spring until autumn, and are spread by wind to start new infections. Sticky brown winter spores are produced from late summer onwards.
- Phoma leaf blight is becoming common and widespread. Spores germinate in spring and cause infection on the thistle leaves. Fruiting bodies are formed which release spores that disperse and create new cycles of infection. The fungus overwinters as spores and mycelium in pasture litter.

### Distinguishing features

- White soft rot causes water-soaked brown or black lesions, usually near the base of the thistle stems which turn yellow and wilt, and flower stems can be readily dislodged.
- Phoma leaf blight causes plants to look yellowish (chlorotic) and later turn brown as they die.
- Californian thistle rust causes plants to look chlorotic or stunted, and they will also be covered in brightly coloured spores (yellow, orange or brown).

**Host:**  
Californian Thistle (*Cirsium arvense*)

**Agent:**  
White Soft Rot (*Sclerotinia sclerotiorum*), Phoma Leaf Blight (*Phoma exigua* var. *exigua*), Californian Thistle Rust (*Puccinia punctiformis*)



Phoma leaf blight

#### **Best time to look**

- Look anytime during the growing season for symptoms of all three.

#### **Damage**

- White soft rot attacks a wide range of plants. Large natural outbreaks on thistles are uncommon.
- Phoma leaf blight attacks a variety of thistle species. The impact is highly variable with damaging systemic infection only occurring rarely.
- Californian thistle rust attacks only Californian thistle. Infected stems do not usually flower and root buds may also be affected. It is common to see a few diseased shoots in a patch of thistles and outbreaks occur occasionally, but it appears to be limited in its ability to infect plants.

#### **Management**

There are no quick and simple ways of enhancing the impact of any of these pathogens.

- AgResearch are developing white soft rot into a mycoherbicide for a range of pasture weeds.
- Research suggests the strains of phoma leaf blight here are not worth pursuing further.
- Californian thistle rust is also not a suitable candidate to develop into a mycoherbicide. It may be more useful in the future if an insect biocontrol agent that can vector it is released here.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Colonial Hard Shoot Moth (*Pempelia genistella*)



Caterpillars inside web

### Background and life cycle

- Native to western Europe, this moth was first imported in 1995. Although releases have been limited to date, the moth is already known to have established in Canterbury.
- A univoltine species, adults emerge and females lay eggs during summer. Larvae feed from autumn till spring, developing slowly through the cooler months and putting on a growth spurt in spring. Pupation occurs in late spring/early summer.
- Another hard shoot moth (*Scythris grandipennis*) was imported in 1992 but is not believed to have established from one small release.

### Distinguishing features

- Adults are 10–15 mm long, light brown with darker black, brown and white markings on the wings, and males have a small tuft at the base of the antennae.
- Eggs are tiny, initially yellow but quickly turn pinky-red, and are laid inside old webs or on maturing green foliage.
- Caterpillars have green and brown stripes and grow up to 2.5 cm long. They aggregate to spin a coarse creamy-grey web with tunnels inside, often at the base of current growth. This communal web is used as a base from which to forage on surrounding foliage in autumn and spring and as a hideaway during winter. Caterpillars wriggle rapidly when disturbed.
- Pupae are dark reddish-brown and are tucked away in the web.

### Best time to look

- Look in late spring (just before new growth starts to appear) when webs are largest (up to 20 cm across with often 2–9 caterpillars inside, but sometimes as many as 30)

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Colonial Hard Shoot Moth (*Pempelia genistella*)



Damaged foliage

and feeding damage is most obvious.

- Adults are nocturnal and inactive during the day, but you might see them sitting on or close to old webs during summer.

#### Damage

- Caterpillars feed on the spines, leaves, buds, shoots and flowers causing foliage around the web to brown off and die. When the caterpillars are small, the area damaged is usually only a few centimetres in diameter; but as the caterpillars become larger in the spring, the damaged area can extend to 20–40 cm around the web.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack gorse. Overseas it also attacks *Ulex minor*, which we do not have in New Zealand.

#### Management

- Once the moths are present in harvestable numbers it would be worth helping to establish them in all areas where they are needed as soon as possible. To do this harvest branches with webs in late spring when large caterpillars or pupae are present. Shift at least 50 webs to each new site and wedge them firmly in new bushes.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Pod Moth (*Cydia ulicetana*)



Adult moth

#### Background and life cycle

- Native to Europe, this moth was first imported in 1989 and released widely during the 1990s. It is now widely established throughout the country.
- A bivoltine species, adult females lay eggs in spring and larvae feed inside pods until fully grown and then pupate. Some new adults emerge to produce a second generation to coincide with the second peak of flowering in autumn. Others do not emerge until the following spring.

#### Distinguishing features

- Adults are 5–8 mm long (females tend to be larger than males), pale brown, and fly in an erratic circling manner, landing from time to time.
- Eggs are flat, shiny and white, and about 1 mm in diameter. They are laid on the petals and parts of fertilised flowers that cover the developing pod.
- Caterpillars are small and creamy-white with black heads. They chew their way into the pods.
- Pupae are light brown and can be found inside pods or tucked away in plant material or litter on the ground.

#### Best time to look

- Look in autumn when the gorse seed weevil will not be present to confuse you. Check inside pods for the caterpillars – they may have already eaten the seeds and moved on, in which case there will just be some frass and an exit hole. There is only ever one caterpillar per pod. Pods can also be checked in spring, but if you see several white grubs then you have found the seed weevil.
- Also look for adults flying about on a warm sunny day whenever gorse is flowering.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Pod Moth (*Cydia ulicetana*)



Damaged pod with frass

#### Damage

- Caterpillars destroy seeds, with each one consuming the contents of 2–3 pods.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack gorse and Scotch broom (*Cytisus scoparius*), Spanish broom (*Spartium junceum*), Montpellier broom (*Genista monspessulana*), tree lupin (*Lupinus arboreus*), Russell lupin (*Lupinus polyphyllus*), lotus (*Lotus pedunculatus*), and possibly other exotic members of the Fabaceae family to a lesser extent.

#### Management

- The moths are able fliers and are dispersing quickly, but it may still be useful to harvest and move them around. To do this harvest infested pods in the spring or autumn. Cut branches when the pods are leathery and green to light brown in colour. If cut too early the caterpillars may die, and if too late the pods will be empty. Shift several hundred pods in the spring or at least 1000 pods in the autumn.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Seed Weevil (*Apion ulicis*)



Adult weevil

#### Background and life cycle

- Native to Europe, this weevil was first imported in 1926 and released widely in the 1930s and early 1940s. It has become common and abundant in most areas except the West Coast of the South Island.
- A univoltine species, adult females lay eggs in green pods in spring. Larvae feed and once fully grown pupate inside the pods. New adults emerge when mature pods burst open.

#### Distinguishing features

- Adults are small (1.8–2.5 mm long), grey, and pear-shaped with a long curved snout (rostrum), characteristic of the weevil family. Females tend to have larger rostrums than the males, and are bigger overall.
- Eggs are tiny and yellow, and are usually laid in clusters of up to 20 inside green pods.
- Larvae are white, squat, legless grubs, with small brown heads. They grow to about 2.5 mm long.
- Pupae are grey and enclosed in white pupal cells inside the pods.

#### Best time to look

- Look in spring for the larvae feeding on the seeds inside pods. If the pod has a single creamy-white caterpillar inside it is the gorse pod moth. If the pod is empty except for some frass then a pod moth caterpillar has fed on the seeds and moved on. You may also see a wasp (*Pteromalus* sp.) which parasitises the weevil.
- Adults may also be found all year round (they hibernate on gorse in winter) but are easiest to find in spring and early summer. New adults may also be seen inside mature pods – they can't escape until the pods burst open.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Seed Weevil (*Apion ulicis*)



Larvae

#### **Damage**

- Adults feed on the foliage and flowers, but this is thought to be insignificant.
- The main damage is caused by the larvae destroying seeds. Each larva feeds on one seed. Together they can destroy as much as 99% of spring seed in some areas, but are not able to attack seed produced in autumn and winter.
- Specificity testing and follow-up field surveys indicate this insect only attacks gorse seeds.

#### **Management**

- The weevil is already widespread so there should be no need to harvest and move it around. In areas where it is not common this is likely to be because conditions are not suited to them.



**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Soft Shoot Moth (*Agonopterix ulicetella*)



Damaged tips

### Background and life cycle

- Native to western Europe, this moth was first imported in 1983 but was not widely released until the early 1990s. It has established at a few sites in both islands and is slowly becoming more common around these areas.
- A univoltine species, adult females lay eggs in spring. Larvae feed on new growth during late spring and early summer and then pupate. New adults emerge during summer.

### Distinguishing features

- Adults are about 12 mm long, and are light brown with darker brown markings on the wings. Adults are unlikely to be seen as they are nocturnal and hide away inside gorse bushes – they can be flushed out with a bee-smoker.
- Eggs are pale yellow and barrel-shaped, and are laid singly at the base of spines next to developing buds in early spring.
- Caterpillars are initially dark brown (with black heads) but later turn greyish-green. They migrate to the new-growth buds, where they spin webs and feed on new shoots. Leafroller caterpillars found on gorse are generally brighter green and smaller than soft shoot moth caterpillars, which grow up to 2 cm long.
- Pupae are dark reddish-brown and may be seen inside the webbed tips but often fall to the ground. Leafroller pupae are paler.

### Best time to look

- Look for webbed or deformed tips in late November/early December. You may be able to see the caterpillars inside – they wriggle rapidly when disturbed. The timing can be quite critical as the caterpillars are difficult to see when they are small and

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Soft Shoot Moth (*Agonopterix ulicetella*)



Caterpillar

may only be obvious for a few weeks. Unless populations are large it is not always possible to be sure that damage was caused by soft shoot moth caterpillars, once pupation has occurred.

#### **Damage**

- Caterpillars feed on the new growth buds and soft tips in the spring. Each can destroy up to five shoots.
- The first damaging outbreak was seen in Marlborough in 2004 where nearly every new growing tip was attacked on bushes close to the release site.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack gorse.

#### **Management**

- The moths are strong fliers but appear to disperse fairly slowly so harvesting and moving them around is likely to be useful. To do this harvest branches with webs or whole bushes in late spring when large caterpillars or pupae are present. Shift at least several hundred webs to each new site and wedge them firmly in new bushes.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Spider Mite (*Tetranychus lintearius*)



Mite colony

### Background and life cycle

- Native to Europe, this mite was first imported in 1988 and released widely during 1989–1990. It established well except in warm, wet areas so additional strains were imported and released widely in 1993. This agent is now established in all regions of New Zealand.
- A multivoltine species, this mite produces around five generations during the warmer months (a generation can be completed in as little as 3 weeks). Adult females begin egg-laying in spring, and juveniles grow and moult through six stages before becoming adults.

### Distinguishing features

- Adults are brick red. Females are smaller than a pinhead, and males are even tinier and more triangular in shape. The sex ratio is skewed with about five females for every male.
- Eggs are round, brownish, and laid in clusters close to gorse stems. Small black specks seen in the web are frass.
- Juveniles are smaller and more orange than adults. Their cast-off white skins may be visible.
- Both adults and juveniles live in colonies and spin fine white webs that may be as small as a fist or cover entire bushes.
- It is not possible to tell the various strains apart by eye.
- A small black ladybird (*Stethorus bifidus*) and a slightly larger, paler, mite (*Phytoseiulus persimilis*) may also be seen in webbing – both feed on the mites.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Spider Mite (*Tetranychus lintearius*)



Heavily attacked bush with webbing and bleached foliage

#### **Best time to look**

- Look during the warmer months when the colonies are largest, although they may be visible all year round. Webbing is destroyed by rain and is most obvious after warm, dry weather. Mites are more visible and active during warm weather – in cold weather they cluster at the centre of the web. Populations tend to grow for 2–3 years and then suddenly decline during summer due to predation and/or migration. Migration is imminent when large numbers congregate on the tips of branches and may even hang from them like icicles.

#### **Damage**

- Adults and juveniles have sucking mouthparts that extract the cell contents. Foliage takes on a bleached and later a brown appearance. When present in large numbers the mites can cause considerable damage. Growth and flowering is reduced but they rarely stay on gorse bushes long enough to kill them.
- Specificity testing and follow-up field surveys revealed this insect only attacks gorse. A closely related species, an almost identical-looking mite, can be found on native *Coprosma*, and possibly other species as well.

#### **Management**

- The mites are already widespread so there should be no need to harvest and move them around.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Thrips (*Sericothrips staphylinus*)



Adult thrips

#### Background and life cycle

- Native to Europe, this insect was first imported in 1989 and released widely during the 1990s. It has established at sites throughout New Zealand but has been slow to disperse, often moving only metres per year. A second, Portuguese, strain, that is thought to disperse more quickly, was imported in 2001 and widely released in subsequent years. It has also established.
- A multivoltine species, this thrips can complete several generations during the warmer months of the year (a generation can be completed in as little as 5–6 weeks). Adult females begin egg-laying in the spring. Juveniles grow and moult through several stages before becoming prepupae and then pupae. New adults emerge soon after.

#### Distinguishing features

- Adults are tiny (1–2 mm long) and black. Most only have wing buds, but some have proper wings. Wingless forms get about by jumping or crawling.
- Eggs are laid in the gorse stems and are not visible.
- Juveniles are creamy-yellow and similar in shape and size to the adults.
- Pupae and prepupae are creamy and less mobile than adults or juveniles.
- It is not possible to tell the two strains apart by eye.

#### Best time to look

- Look for adults on new growth soon after flowering has ended (for most areas this would be December–February). Avoid looking when flowers and hence flower thrips (*Thrips obscuratus*) are present. It is just possible to see thrips by eye but a magnifying glass will help, as will beating foliage over a white sheet.
- You may be able to see the thrips at other times of the year too.

**Host:**

Gorse (*Ulex europaeus*)

**Agent:**

Gorse Thrips (*Sericothrips staphylinus*)



Healthy gorse (left) and damaged gorse (right)

**Damage**

- Adults and juveniles have sucking mouthparts that extract the cell contents. This feeding results in small white spots that give the gorse a mottled blotchy appearance, which is less obvious than the bleaching caused by gorse spider mites. Thrips prefer new growth, but will feed on older, harder growth during winter. When present in good numbers, growth and flowering is reduced and seedlings may be killed.
- Specificity testing and follow-up field surveys suggest this insect is only likely to attack gorse.

**Management**

- Thrips are not yet widespread so it would be useful to harvest and move them around. If possible, harvest thrips from areas where the Portuguese strain has been released, from October to March. Cut infested material and carefully put it inside paper rubbish bags. Later wedge it firmly into uninfested gorse bushes that have new growth on them. Although they can establish from low numbers aim to shift at least several hundred.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Stem Miner (*Anisoplaça pyoptera*), Lemon Tree Borer (*Oemona hirta*)



Gorse stem miner caterpillar

### Background and life cycle

Two native species will readily attack gorse and at times produce highly visible damage.

- Gorse stem miner was first noticed on gorse in Canterbury in the early 1970s and has since spread to other areas, but is still most common in the South Island. Its original hosts are indigenous (and rare) broom species. Most adults emerge and females lay eggs during summer. Larval development can take nearly a year with pupation occurring in later spring/early summer.
- Lemon tree borer attacks a wide range of woody plants and is particularly damaging to citrus and grapes. It can be commonly found throughout the North Island and the top of the South Island. Adult females begin egg-laying in the spring. Larvae take nearly 2 years to complete development and do not pupate until their second winter. New adults emerge the following spring.

### Distinguishing features

- Gorse stem miner adults are brown moths that hide away during the day. Larvae are creamy, about 1–2 cm long, and tunnel under the bark of stems resulting in initially yellow and then brown branches on what may be otherwise healthy bushes. Mined branches break off easily to reveal the tunnelling and usually sawdust-like frass.
- Lemon tree borer adults are typical longhorn beetles with long antennae, an elongate body (15–25 mm long), and are brownish in colour. Larvae are pale cream with distinct body ridges and can grow up to 4 cm – they look like huhu grubs. Larvae tunnel beneath the bark and bore through the centre of stems. The tunnels may be very long with exits off to the sides for removing the sawdust-like frass. Damaged material also breaks off easily.

**Host:**  
Gorse (*Ulex europaeus*)

**Agent:**  
Gorse Stem Miner (*Anisoplaça pyoptera*), Lemon Tree Borer (*Oemona hirta*)



Typical damage

#### **Best time to look**

- Gorse stem miner damage can usually be seen at any time but will be most obvious in midsummer and particularly under drought conditions.
- Lemon tree borer damage also becomes most obvious during summer. Dieback of young twigs in early summer is often the first sign.

#### **Damage**

- For both species the larvae are the damaging stage. Their tunnelling sometimes results in ringbarking of stems with the foliage above this point dying from water stress, especially when conditions are dry. Damage may be restricted to one or two shoots, but if the larvae have fed near ground level the whole plant may die. Both also attack Scotch broom to a lesser extent.

#### **Management**

- No effort should be made to increase the numbers or distribution of either species because of the possible damage to beneficial plant species.



**Host:**  
Heather (*Calluna vulgaris*)

**Agent:**  
Heather Beetle (*Lochmaea suturalis*)



Larvae

#### **Background and life cycle**

- Native to north-west Europe, this beetle was first imported in 1992 but widespread releases were delayed until the late 1990s due to problems with a protozoan parasite infection. The beetle is now established, but not yet widespread, in Tongariro National Park and Rotorua.
- A univoltine species, adult females lay eggs in the spring. Larvae feed for about a month during summer and develop through three stages. Pupation also lasts for about a month before new adults emerge. New adults feed during autumn and then hibernate for the winter.

#### **Distinguishing features**

- Adults are about 6 mm long and are brownish. They are hard to see as they tend to drop to the ground when they see movement or detect vibration close by.
- Eggs are pinhead sized, and initially pale yellow later turning dark orange and then brown just before hatching.
- Larvae are greyish-white with black heads and grow to about 12 mm long.
- Pupae are enclosed in earthen cells just below the soil surface or in the litter layer.

#### **Best time to look**

- Look during summer for damaged heather plants and larvae feeding on them. A sweep net can be useful for detecting the beetles when present at low levels.

#### **Damage**

- Both larvae and adults feed on the foliage. When present in large numbers they can severely defoliate whole plants causing them to turn reddish-brown and die.

**Host:**  
Heather (*Calluna vulgaris*)

**Agent:**  
Heather Beetle (*Lochmaea suturalis*)



Damaged heather

- The beetle outbreaks regularly in its native range and devastates heather. Such outbreaks may eventually occur here too, at least in some areas. At this stage the beetles are doing best in Rotorua where conditions appear to be more favourable for them.
- Specificity testing and follow-up field surveys revealed this insect only attacks Scottish heather. Even Spanish heath (*Erica lusitanica*) is not considered to be a suitable host.

#### **Management**

- Although the adults are capable of flying at least several kilometres after spring emergence, they probably only do this when surrounding heather is in poor condition. Distribution is still quite limited so harvesting and moving the beetles to new areas is likely to be useful. Cut foliage with larvae on it during summer and carefully place it inside a chillybin. Aim to shift at least several hundred larvae although several thousand would be better. Wedge the infested foliage into new plants so the larvae can move across.

**Host:**

Hemlock (*Conium maculatum*)

**Agent:**

Hemlock Moth (*Agonopterix alstromeriana*)



Damaged foliage

**Background and life cycle**

- Native to Europe, this moth was first noticed here in 1990 in Central Otago. It is not known how this insect got here, but it spread quickly and can now be found throughout the country.
- A univoltine species, adult females lay eggs in early spring. Larvae feed and grow for about a month until early summer. Pupation takes about a fortnight and new adults begin to emerge in midsummer.

**Distinguishing features**

- Moths are small (about 10 mm long) and pale greyish-brown with a distinctive large dark brown spot on each wing. The moths are nocturnal and hide away during the day. They are attracted to light and may be seen inside houses if windows are left open during the warmer months.
- Eggs are tiny, pale-coloured, and laid singly on the undersides of leaves. They are just visible to the naked eye.
- Caterpillars are initially predominantly yellow with black head capsules. As they feed and grow they become light green in colour with three dark green longitudinal stripes. The caterpillars roll up the leaves with fine webbing to form tubes. Older caterpillars also make tubes from the flowers and developing seed heads. If disturbed, the caterpillars wriggle violently and will often abandon their leafy tubes and fall to the ground, so it is not unusual to find lots of empty tubes. Fully grown caterpillars measure about 1 cm long.
- Pupae are reddish brown and are hidden away in the soil.

**Host:**

Hemlock (*Conium maculatum*)

**Agent:**

Hemlock Moth (*Agonopterix alstromeriana*)

Eric Coombs



Caterpillars

**Best time to look**

- Look in late spring and early summer for the caterpillars and their feeding damage.

**Damage**

- The caterpillars are the damaging stage. They can reduce large hemlock plants to bare stalks. Severe damage to hemlock has been seen at many sites, with up to 40 caterpillars per stem. Because the flowers are eaten too, the amount of seed produced is reduced.
- Specificity testing suggests this insect is only likely to attack hemlock.

**Management**

- The moth has spread fast naturally so there should be no need to harvest and move it around. However, if any areas are found where they are absent, caterpillars could be shifted in late spring. Wear rubber gloves as hemlock is poisonous. Cut infested foliage and put it in a chillybin (that will not be used for food in future) or a paper rubbish bag. Aim to move at least several hundred caterpillars. Wedge or tie the cut material into uninfested plants so the caterpillars can easily move across.

**Host:**  
Hawkweeds (*Hieracium* spp.)

**Agent:**  
Hieracium Gall Midge (*Macrolabis pilosellae*)



Galled plants

### Background and life cycle

- Native to northern Europe, this midge was first imported in the late 1990s and released widely in the early 2000s. It is known to have already established at some sites in both Islands.
- A multivoltine species, with two or three generations produced each year during the warmer months (a generation can be completed in as little as 2 months). Adult females begin egg-laying in spring. Larvae burrow into the plant causing plant deformities (galls) to develop. Once fully grown they emerge and pupate in the soil and new adults emerge a couple of weeks later.

### Distinguishing features

- Adults are tiny (<2 mm long), fragile, short-lived orange flies with poorly developed heads. They will be difficult to differentiate in the field from other small, winged insects.
- Eggs are laid in the centre of rosettes, in stolon tips, and leaf axils, and sometimes in the flower heads.
- Larvae are tiny (up to 1 mm long) and orange. Their feeding causes galls to form which makes the leaves in these areas curl. The hieracium gall wasp also galls the stolon tips, but these galls are quite different, being firm to the touch and most often occurring as clusters of distinct peppercorn-sized chambers. Gall midge galls are much softer and are associated with curled leaves.
- Pupae are tiny (2 mm), orangey-red and are hidden away in the soil.

### Best time to look

- Look in late summer/early autumn for swollen plant deformities and curled leaves.

**Host:**  
Hawkweeds (*Hieracium* spp.)

**Agent:**  
Hieracium Gall Midge (*Macrolabis pilosellae*)



Galled flowerhead

#### Damage

- Gall formation and development reduces the amount of nutrients available for normal plant growth, so affected plants are stunted and are likely to produce fewer flowers and stolons.
- Specificity testing suggests this insect is only likely to attack mouse-ear hawkweed (*Hieracium pilosella*), king devil hawkweed (*H. praealtum*) and field hawkweed (*H. caespitosum*). Even other closely related hawkweeds are unlikely to be attacked.

#### Management

- Once the midges are present in harvestable numbers it would be worth helping to establish them in all areas where they are needed, as soon as possible. To do this dig up at least 20 plants with fresh new galls on them in late spring. Leave as much soil on the roots and around the plant as possible, to minimise harming the plants and allow pupae to be shifted as well. Transplant these plants in uninfested areas and water as often as required for the plants to become re-established. The midges will be able to complete development and emerge to attack plants at the new site.

**Host:**

Mouse-Ear Hawkweed (*Hieracium pilosella*)

**Agent:**

Hieracium Gall Wasp (*Aulacidea subterminalis*)



Galled stolon

**Background and life cycle**

- Native to northern Europe, this wasp was first imported in 1997 and widespread releases began in 1999. It is known to have established already at sites in the South Island.
- A univoltine species, adults begin egg-laying in spring. Larvae burrow into the stolon tips causing plant deformities (galls) to develop. Pupation also occurs inside the galls and new adults do not emerge until the following spring.

**Distinguishing features**

- Adults are small (2–3 mm long) and dark brownish-black. They are parthenogenic so there are no males, only females. Adults would be difficult to differentiate in the field from other small, winged insects. Although technically wasps, they are harmless to humans and do not sting.
- Eggs are tiny, milky white, and laid inside the stolon tips, often with several laid in the same stolon tip.
- Larvae are creamy-white and they feed on the stolon tips over the summer. The plant responds by laying down extra tissue around the larvae, and galls about the size of peas are formed. Over time the galls become quite hard and woody.
- Pupae are small (2 mm long), white, and housed inside the galls.

**Best time to look**

- Look for galls in late summer or autumn by examining the ends of stolons and if necessary squeezing them between thumb and forefinger.

**Host:**

Mouse-Ear Hawkweed (*Hieracium pilosella*)

**Agent:**

Hieracium Gall Wasp (*Aulacidea subterminalis*)



Larvae inside multi-chambered gall

**Damage**

- The galls reduce vegetative reproduction by interfering with the production of daughter plants at the tips of each stolon.
- Specificity testing suggests this insect is only likely to attack mouse-ear hawkweed. Even other closely related hawkweeds are unlikely to be attacked.

**Management**

- Once the wasps are present in harvestable numbers it would be worth helping to establish them in all areas where they are needed, as soon as possible. To do this harvest woody galls in the autumn and leave these on the ground in a safe and sheltered place (like the base of tussocks) so that the wasps can emerge the following spring. Aim to shift at least 100 galls if possible.



**Host:**

Mouse-Ear Hawkweed (*Hieracium pilosella*)

**Agent:**

Hieracium Rust (*Puccinia hieracii* var. *piloselloidarum*)



Rusty-coloured spores

**Background and life cycle**

- Native to Europe, this rust was first noticed here in 1995 on plants collected from Molesworth Station. It is not known how it got here. At the time of discovery, researchers were studying the rust in Europe to see if it would be suitable to import. Mouse-ear hawkweed populations vary in their susceptibility to the rust, and many were resistant to this particular strain. Another two strains have since been imported. As a result of natural and human-assisted dispersal the rust now occurs throughout the country.
- Winter spores germinate in spring to begin a new cycle of infection. A sexual cycle involving three different types of spores is then completed on the leaves. Light cinnamon to dark brown spores are produced continuously from late spring through until autumn, and are spread by wind to start new infections. Sticky brown winter spores are produced from summer onwards.

**Distinguishing features**

- The first sign of infection can be a yellowing of the leaves. Later rusty-coloured spores appear on the upper surface of the leaves – pustules containing spores develop inside the leaves and eventually burst out through the top. During summer small black pockmarks appear, which are scars made by the pustules.
- A powdery mildew (*Erysiphe cichoracearum*) that attacks many members of the Asteraceae (daisy) family is common on mouse-ear hawkweed. Infected leaves have a powdery whitish appearance and there is no black scarring. After a heavy attack the leaves may become pale red in colour, but this can also happen anytime the plant is stressed.

**Host:**

Mouse-Ear Hawkweed (*Hieracium pilosella*)

**Agent:**

Hieracium Rust (*Puccinia hieracii* var. *piloselloidarum*)



Powdery mildew

**Best time to look**

- Look in spring and autumn when the symptoms are likely to be most obvious although it may be possible to see them at any time of the year.

**Damage**

- The rust feeds and grows inside the leaves. It can only develop on living tissue.
- A field study has suggested that the growth of infested plants may be suppressed by around 10–20%. The fungus performs best under moist conditions but its impact can be most severe when infection is followed by drought.
- Specificity testing and follow-up field surveys suggest this rust is only likely to attack mouse-ear hawkweed. Even other closely related hawkweeds are unlikely to be attacked. Two other varieties of this rust (*P. hieracii* var. *hieracii* and *P. hieracii* var. *hypochoeridis*) are also present here. They are found on a wide range of hosts including dandelion, catsear, and chicory.

**Management**

- The rust is already widespread so no further effort to spread it around should be required.

**Host:**

Mexican Devil Weed (*Ageratina adenophora*)

**Agent:**

Mexican Devil Weed Gall Fly (*Procecidochares utilis*)



Adult fly

**Background and life cycle**

- Native to Mexico, this fly was first imported in 1958 and released at a limited number of sites soon after. It established readily and can now be commonly found wherever Mexican devil weed occurs.
- A multivoltine species, this fly should be able to complete several generations during the warmer months (a generation can be completed in as little as 6–7 weeks). Adult females begin egg-laying in spring. Larvae burrow into the plant causing plant deformities (galls) to develop by early summer. Pupation also occurs inside the plant with new adults emerging several weeks later.

**Distinguishing features**

- Adults are similar in size (8 mm wingspan) and appearance to several other biocontrol agents such as the closely related mist flower gall fly (*Procecidochares alani*) and the thistle gall flies (*Urophora* spp.). They have boldly patterned wings and females have a long black ovipositor.
- Eggs are laid into the apical or lateral growing points.
- Larvae are creamy-white and they burrow into the tender buds. As the larvae feed and grow, the plant forms gall tissue around them. These small pea-sized swellings increase in size with mature galls reaching up to 2–3 cm in diameter, especially if several coalesce.
- Pupae are brown and pupation takes place inside the gall. New adults emerge through a thin window that is made by the larvae before pupation.

**Best time to look**

- Look for the galls in late summer or autumn.

**Host:**

Mexican Devil Weed (*Ageratina adenophora*)

**Agent:**

Mexican Devil Weed Gall Fly (*Procecidochares utilis*)



Galled stem

- You may also be able to see the adult flies resting on plants at any time during the warmer months.

**Damage**

- The plant is tricked into diverting valuable nutrients, which would normally be used for plant growth, into the galls to feed the developing fly larvae. Stem elongation may be retarded, resulting in shorter plants with reduced vigour that can be more easily out-competed by desirable vegetation.
- Although there were initially reports of major damage, today only minor galling is commonly seen because of moderate–high levels of parasitism by an Australian wasp (*Megastigmus* sp.).
- Specificity testing and follow-up field surveys revealed this insect only attacks Mexican devil weed. Even the closely related mist flower (*A. riparia*) is not attacked.

**Management**

- Because this fly is already widespread and limited by parasitism there should be no need to harvest and move it around.

**Host:**

Mist Flower (*Ageratina riparia*)

**Agent:**

Mist Flower Fungus (*Entyloma ageratinae*)



White spores

**Background and life cycle**

- Native to Jamaica and Mexico, this fungus was first imported and released in 1998. It established readily and spread quickly, and can now be found almost everywhere mist flower grows in the North Island, including small, extremely isolated clumps. The fungus has not yet been seen on mist flower plants in Nelson.
- White spores germinate in spring and begin a cycle of infection that continues as long as conditions are favourable.

**Distinguishing features**

- The plants develop angular reddish-brown lesions with yellow margins on the upper surfaces of leaves. The undersides of each lesion may have a powdery white appearance because large numbers of white spores have been produced there, giving rise to the common name white smut. As the disease progresses, the lesions on the upper surfaces of the leaves coalesce and become dark brown.
- Another fungus (*Phoma* sp.) causes similar symptoms but does not produce white spores. Unless white spores are present only an experienced plant pathologist will be able to tell the two species apart.

**Best time to look**

- Look in spring as the optimum conditions for infection are warm temperatures and high humidity.

**Damage**

- The fungus causes the leaves to die and fall from the plant prematurely. Under favourable conditions the fungus also invades stem tissue and causes dieback of

**Host:**

Mist Flower (*Ageratina riparia*)

**Agent:**

Mist Flower Fungus (*Entyloma ageratinae*)



Damaged foliage

shoots. Plants can be heavily defoliated over wide areas.

- Studies have shown that the percentage cover of mist flower at some sites has declined on average from 90% to 35% and that the plant is no longer spreading.
- Specificity testing and follow-up field surveys suggest this smut is only likely to attack mist flower. Even the closely related Mexican devil weed (*Ageratina adenophora*) is not affected. Mexican devil weed is commonly attacked by a leaf blight (*Phaeoramularia eupatorii-odorati*).

**Management**

- The fungus is already widespread so no further effort should be required to spread it around. However, if need be, infected leaves can be soaked in a small amount of water, which can then be sprayed onto uninfected plants (it will keep for up to 30 hours if refrigerated). It may also be possible to infect mist flower by simply dragging a bundle of infected stems through wet plants, or by wiping infected leaves with a damp sponge and then wiping it on uninfected leaves. Keep the sponge cool and wet during transit.

**Host:**  
Mist Flower (*Ageratina riparia*)

**Agent:**  
Mist Flower Gall Fly (*Procecidochares alani*)



Adult fly

#### **Background and life cycle**

- Native to Mexico, this fly was first imported in 2000 and released widely soon after. It is already well established and appears to be dispersing steadily.
- A multivoltine species, this fly should be able to complete several generations during the warmer months (a generation can be completed in as little as 6–7 weeks). Adult females begin egg-laying in spring. Larvae burrow into the plant causing plant deformities (galls) to develop by early summer. Pupation also occurs inside the plant with new adults emerging several weeks later.

#### **Distinguishing features**

- Adults are similar in size (8 mm wingspan) and appearance to several other biocontrol agents such as the closely related Mexican devil gall fly (*Procecidochares utilis*) and the thistle gall flies (*Urophora* spp.). They have boldly patterned wings and females have a long black ovipositor.
- Eggs are laid into the apical or lateral growing points.
- Larvae are creamy-white and they burrow into the tender buds. As the larvae feed and grow, the plant forms gall tissue around them. These small pea-sized swellings increase in size with mature galls reaching up to 2–3 cm in diameter.
- Pupae are brown and pupation takes place inside the gall. New adults emerge through a thin window that is made by the larvae before pupation.

#### **Best time to look**

- Look for the galls in late summer or autumn.
- You may also be able to see the adult flies resting on plants at any time during the warmer months.

**Host:**

Mist Flower (*Ageratina riparia*)

**Agent:**

Mist Flower Gall Fly (*Procecidochares alani*)



Galls near growing tips

**Damage**

- The plant is tricked into diverting valuable nutrients, which would normally be used for plant growth, into the galls to feed the developing fly larvae. Stem elongation is retarded, resulting in shorter plants with reduced vigour that can be more easily out-competed by desirable vegetation.
- Specificity testing and follow-up field surveys revealed this insect only attacks mist flower. Even the closely related Mexican devil weed (*A. adenophora*) is not attacked.

**Management**

- Although the flies appear to be dispersing steadily it will still be useful to harvest and move them around. To do this look for plants with large mature galls, without emergence holes, during summer and autumn. Cut this material and leave it on the ground at new sites. You would need to aim to shift preferably at least 100 galls for each new site.



**Host:**

Thistles (*Carduus* spp., *Cirsium* spp., *Onopordum acanthium*)

**Agent:**

Nodding Thistle Crown Weevil (*Trichosiromalus* spp.)



Adult weevil

**Background and life cycle**

- Native to Europe, this weevil was first imported in 1982 and mass reared and released widely during the late 1980s and early 1990s. It is now well established throughout much of the country.
- A univoltine species, adult females generally lay their eggs from March to November, but some lay all year round. Larvae burrow into the crown and feed and grow through three stages before pupating. New adults emerge a couple of weeks later.

**Distinguishing features**

- Adults are small (3–4 mm long) and greyish-brown. They can look like small crumbs of soil and tend to play dead when disturbed.
- Eggs are yellowish-white and usually laid in cavities along the leaf ribs, but occasionally on the leaf surface.
- Larvae are white grubs. As they feed in the crown they produce black frass, and the ribs of the surrounding leaves take on a reddish-brown colour at the base. Severely damaged rosettes lose their prickliness.
- Pupae are formed in silken cells in the soil.

**Best time to look**

- Look for damaged rosettes during winter and spring before plants begin to bolt.
- Damaged rosettes and adults may be seen all year round. Adults often hide away during late summer but at other times may be seen sitting on plants or under the leaves.

**Host:**

Thistles (*Carduus* spp., *Cirsium* spp., *Onopordum acanthium*)

**Agent:**

Nodding Thistle Crown Weevil (*Trichosirocalus* spp.)



Damaged rosette

**Damage**

- Adults feed on the foliage but this is insignificant. Larval feeding in the crown usually kills the plants. Plants that are not killed are stunted with fewer flowering stems, and any lateral regrowth may be attacked. Plants of all sizes are attacked. A reduction in thistles has been seen at many infested sites.
- As many as three species may have been imported with differing host preferences – some DNA work is needed to clarify this. Nodding (*Carduus nutans*), plumeless (*C. acanthoides*), winged (*C. tenuiflorus*), slender-winged (*C. pycnocephalus*), Scotch (*Cirsium vulgare*), marsh (*Cirsium palustre*), and cotton (*Onopordum acanthium*) thistles may all be attacked to varying degrees. It is extremely unlikely from specificity testing and follow-up field surveys that any other plants will be attacked.

**Management**

- The weevils can be slow to disperse so it may still be useful to harvest and move them around in some areas. To do this use a garden-leaf vacuum machine (fitted with a sleeve to form a bag in the mouth of the tube) to collect adults whenever they can be found in good numbers. Aim to shift at least 200 to each new site. Be sure to sort collected material to prevent the spread of any unwanted pests.
- Mowing flowering thistles will not harm the weevils but will harm seed-feeding agents.

**Host:**  
Thistles (*Carduus* spp.)

**Agent:**  
Nodding Thistle Gall Fly (*Urophora solstitialis*)



Adult fly

#### **Background and life cycle**

- Native to Europe, this fly was first imported in 1989 and mass reared and released widely during the early 1990s. It is now well established throughout much of the country.
- A bivoltine species, flies emerge in spring and the females lay eggs on green flower buds. Larvae feed during summer and then pupate. New adults emerge and begin a second generation in autumn, which remains as prepupae until the following spring.

#### **Distinguishing features**

- Adults are about 5–8 mm long and have black bodies and distinctive markings on the wings. Females have a long black ovipositor. They look similar to the Scotch thistle gall fly but the wing markings are subtly different.
- Eggs are laid inside the green flower buds.
- Larvae are creamy-white. They burrow into the receptacle where their feeding stimulates the plant to produce gall tissue, which becomes hard as it matures.
- Pupae are brownish and pupation occurs inside the gall.

#### **Best time to look**

- Look for infested flower heads in autumn once they are mature. They will have shiny white pappus hairs still attached, feel hard and lumpy, and be difficult to break open – a knife will be needed to reveal the yellowish chipboard-like interior. If easy to break open and black inside, they are infested with the receptacle weevil. Flower heads may also be infested with both agents, and show some of the characteristics of each.
- Adults may be seen during the warmer months flying about or sitting on thistles.

**Host:**  
Thistles (*Carduus* spp.)

**Agent:**  
Nodding Thistle Gall Fly (*Urophora solstitialis*)



Infested flowerheads

#### Damage

- Larval feeding affects seed production. Each larva destroys about six seeds. It is not yet known what proportion of seeds the flies destroy here, but they appear to complement damage caused by the receptacle weevil.
- Specificity testing and follow-up field surveys suggest this insect strongly prefers nodding (*Carduus nutans*) and plumeless thistle (*C. acanthoides*). They may attack other *Carduus* thistles but other plants are not thought to be at risk.

#### Management

- The flies are dispersing steadily but it may still be useful to harvest and move them around in some areas. To do this collect mature infested flower heads in autumn, using secateurs or thick gloves. Aim to shift between 50 and 100 flower heads to each new site. Tie them up off the ground in onion bags (or similar) in the shade.
- Avoid mowing thistles before the flower heads have dried off in the autumn, as you are likely to kill both the gall fly and receptacle weevil.
- Avoid overstocking, as hungry animals may eat all the flowers.

**Host:**  
Thistles (*Carduus* spp.)

**Agent:**  
Nodding Thistle Receptacle Weevil (*Rhinocyllus conicus*)



Adult weevil

#### **Background and life cycle**

- Native to Europe and western Asia, this weevil was first imported in 1972 and released soon after. As a result of redistribution efforts in the late 1970s and early 1980s this weevil is now common throughout the country.
- A bivoltine species, adult females lay eggs on green flower buds in spring. Larvae feed during late spring and summer and then pupate. New adults that emerge in early summer may produce another generation straight away, but most do not until the following spring.

#### **Distinguishing features**

- Adults are about 6 mm long, and are dark brown with lighter speckles. They have the long snout (or rostrum), characteristic of the weevil family.
- Eggs are generally laid on the undersides of the buds. They are spherical in shape, about 1.5 mm long, and are covered in a protective capsule of brown frass.
- Larvae are white. They burrow into flower buds until they reach the receptacle and remain there until fully grown.
- Pupae are housed within hard black cells inside the flower heads.

#### **Best time to look**

- Look for adults congregating on rosette plants in spring.
- Look for infested flower heads in summer. Mature flower heads will feel hard and lumpy, should be easy to break open, and look black inside. If they are difficult to break open and look yellow inside then they are infested with nodding thistle gall fly. Flower heads may also be infested with both agents, and show some of the characteristics of each.

**Host:**  
Thistles (*Carduus* spp.)

**Agent:**  
Nodding Thistle Receptacle Weevil (*Rhinocyllus conicus*)



Infested flowerhead cut open to expose pupa

#### Damage

- Adults make small round holes in the leaves but this damage is inconsequential. The main damage is caused by larvae feeding in the receptacle, preventing the production of healthy seeds.
- Studies have shown that larvae can destroy most of the seed produced by primary flowers, but are less effective on secondary and tertiary flowers.
- Specificity testing and follow-up field surveys suggest this insect prefers nodding thistle but will also attack plumeless (*Carduus acanthoides*), winged (*C. tenuiflorus*), slender-winged (*C. pynocephalus*), Californian (*Cirsium arvense*), and Scotch (*Cirsium vulgare*) thistles to varying degrees. Other plants are not thought to be at risk.

#### Management

- The weevils are widely established so there should be no need to harvest and move them around.
- Avoid mowing thistles before the flower heads have dried off in the autumn, as you are likely to kill both this weevil and the gall fly.
- Avoid overstocking, as hungry animals may eat all the flowers.

**Host:**

Old Man's Beard (*Clematis vitalba*)

**Agent:**

Old Man's Beard Leaf Fungus (*Phoma clematidina*)



Infected leaves

**Background and life cycle**

- Native to Europe, this fungus was imported from California in 1990 and released widely during the late 1990s. It established readily and quickly became widespread throughout the country.
- Overwintering spores, produced in fruiting bodies, germinate in spring to attack new leaves. New fruiting bodies produced on infected leaves release spores that disperse and create new cycles of infection. Occasionally sexual spores are produced in sacs and these also cause new cycles of infection.

**Distinguishing features**

- Black spotting and slight yellowing of the leaves, which can then cause premature leaf death, leaf fall, and reduced vigour. Younger leaves are more vulnerable than older leaves, and the stems, flowers, seed pods, and seedlings can also be affected. If the stems are also infected then they may initially appear to be wilted. Later it may look as though plants have been given a bad haircut.
- Other, less virulent strains of the fungus are also present in New Zealand and tend to mostly cause some cosmetic damage in autumn. Only experienced plant pathologists will be able to identify which strain is causing disease symptoms.

**Best time to look**

- Look in spring or autumn for discoloured or black, slimy, decaying plant material. The severity of the fungal infection depends on the amount of moisture available, so it is best to look after periods of warm, wet weather.

**Host:**

Old Man's Beard (*Clematis vitalba*)

**Agent:**

Old Man's Beard Leaf Fungus (*Phoma clematidina*)



Damaged foliage

**Damage**

- Severe defoliation has been seen at some sites, especially when the fungus was first released, but on the whole damage has tended to be minor and cosmetic or it has occurred too late in the season to have much impact.
- A recent study has found that the fungus can exist as a symptomless endophyte in the tissues of both old and young leaves. This suggests that either host plant resistance and/or external environmental factors are probably limiting infection and systemic disease progression.
- Specificity testing and follow-up field surveys suggest this fungus will only attack old man's beard and possibly cause slight damage to some of the ornamental *Clematis* species that are closely related to old man's beard.

**Management**

- Given that the fungus is already widespread, and possibly limited in its ability to damage its host, no further effort to increase its distribution or abundance is probably warranted.



**Host:**  
Old Man's Beard (*Clematis vitalba*)

**Agent:**  
Old Man's Beard Leaf Miner (*Phytomyza vitalbae*)



Mines and feeding punctures

#### **Background and life cycle**

- Native to Europe, this fly was first imported in 1995 and released widely soon after. It established and dispersed readily, and quickly became common throughout the country.
- A multivoltine species, which probably completes at least five generations during the warmer months. Adult females begin egg-laying in spring. Larvae feed inside the leaves and once fully grown emerge to pupate. New adults emerge about a week later.

#### **Distinguishing features**

- Adults are tiny (1–2 mm long) flies that will be difficult to distinguish from other small fly species in the field.
- Eggs are laid inside the leaves and are too small to see.
- Larvae are small white maggots that mine between the top and bottom layer of the leaves leaving a squiggly trail behind them. This mine often quickly turns black.
- Pupae are initially brown and turn black as they mature. Pupation can occur on the leaves, stems or soil.

#### **Best time to look**

- Autumn is the best time to look but it should be possible to find leaf miners anytime from late spring until leaf fall occurs (or even all year round in areas where the plant is not deciduous). Look for mined leaves. Hold them up to the light to look for larvae feeding at the head of the mines, and also for tiny pinpricks in the leaves which are the feeding punctures made by adults.

**Host:**  
Old Man's Beard (*Clematis vitalba*)

**Agent:**  
Old Man's Beard Leaf Miner (*Phytomyza vitalbae*)



Pupae

#### Damage

- Larval feeding disrupts the flow of nutrients around the leaves by mining through the leaf veins. Heavily scarred leaves turn brown, shrivel up, and fall off the plant. Both the larval mines and the adults' feeding punctures can also allow fungal pathogens to invade the plant, although it seems to be unlikely that the adults act as vectors for the fungus.
- Laboratory studies on small plants suggest that 2–3 mines per leaf alone can reduce growth by 50%. Some damaging outbreaks have been seen but overall the leaf miner is not performing as well as hoped, which could be due to parasitism.
- Specificity testing and follow-up field surveys suggest this insect may cause slight damage to some of the ornamental *Clematis* species that are closely related to old man's beard if they are growing nearby. A handful of old man's beard leaf miners have been reared from one native *Clematis* species (*C. foetida*) growing in close proximity to old man's beard. However, because female leaf miners need to feed on old man's beard before they can lay eggs, this damage is very rare and insignificant, compared to mining by a native leaf miner (*Phytomyza clematidi*).

#### Management

- Since the leaf miner is already widespread there should be no need to harvest and move it around.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Cinnabar Moth (*Tyria jacobaeae*)



Adult moth and eggs

#### **Background and life cycle**

- Native to Europe, this moth was first imported in 1926 and released widely from 1929 to 1932 but it only established in the southern North Island. Moths were collected from there in the 1980s, bred in large numbers, and re-released throughout the country. As a result they now occur patchily throughout most of New Zealand, seem to be steadily increasing in distribution, and are more common some years than others.
- A univoltine species, the moths emerge and females lay eggs in the spring. Caterpillars feed and grow throughout late spring/early summer. Once fully grown they pupate and remain in this state until the next spring.

#### **Distinguishing features**

- Moths are about 2 cm long and brownish-black with striking red markings.
- Eggs are yellow and spherical and are laid in clusters on the undersides of leaves.
- Caterpillars are initially inconspicuous but develop smooth, bold, yellow-and-black stripes as they grow. Take care not to confuse them with the native magpie moth (*Nyctemera annulata*) that is also found on ragwort – its “woolly bear” caterpillars have long black bristles and predominantly black colouration.
- Pupae are brown and are usually well hidden, close to the ground, in sheltered crevices.

#### **Best time to look**

- Look from December to February for caterpillars stripping plants.
- You may also see the moths flying around ragwort infestations in spring and early summer.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Cinnabar Moth (*Tyria jacobaea*)



Caterpillars

#### Damage

- Caterpillars feed on the leaves and flowers. The severity of the attack depends on the number of caterpillars, and can vary from a few damaged leaves to bare stalks. If the damaged plants have to cope with additional stresses, e.g. drought, they may die; otherwise they will usually regrow.
- Specificity testing and follow-up field surveys suggest this insect will only attack ragwort and, occasionally, closely related *Senecio* species if they are nearby when caterpillars have completely defoliated ragwort and are desperate for food.

#### Management

- The moths can be slow to disperse so it may still be useful to harvest and move them around in some areas. To do this cut ragwort leaves with medium-large caterpillars on them, and put these in a chillybin. Aim to shift at least 2000. Wedge the material into new plants but do not overload them.
- Establishment seems to be poor in some areas. Survival may be enhanced by providing good sites for pupation, e.g. old dry logs. If a release fails under favourable conditions it may be better to try a different site next time.
- Ensure that the ragwort at the release point is not heavily grazed.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Ragwort Flea Beetle (*Longitarsus jacobaeae*)



Adult beetle

#### **Background and life cycle**

- Native to Europe, this beetle was first imported in 1981 and released widely during the late 1980s and early 1990s. It is now well established throughout most of the country.
- A univoltine species in its native range, where adult females lay eggs in autumn, larvae develop over winter and pupate in spring, with new adults emerging in early summer. However, new adult females have been found laying eggs here in spring which suggests that they are completing two generations (bivoltine) in at least some parts of the country.

#### **Distinguishing features**

- Adults are small (2.5–3.8 mm long) and golden-brown with large hind legs – when disturbed they can easily leap 1 m.
- Eggs are tiny (<1 mm long) and are laid singly around the crown of plants or in the surrounding soil.
- Larvae are white and feed on the roots, inside the crown, and within the leaf petioles. To see them, pull leaves off rosette plants and examine the end of the petioles or dig up and cut open rosettes.
- Pupae are housed in earthen cells in the soil.

#### **Best time to look**

- Look in autumn for adults and their small square-shaped feeding holes on leaves. You may see them at other times of the year too, except during late summer when they aestivate.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Ragwort Flea Beetle (*Longitarsus jacobaeae*)



Adult feeding damage

#### Damage

- Adult feeding on leaves is inconsequential. Larvae damage plants by feeding on the roots and crown of rosette plants. Heavily infested plants die. Plants that are not killed produce fewer flowering stems.
- Trials here and overseas have shown that the beetle can often reduce ragwort populations to low levels. They are good at finding isolated plants. However, not all conditions suit them equally.
- Specificity testing and follow-up field surveys confirmed this insect only attacks ragwort.

#### Management

- Although the beetles are widespread it may still be useful to harvest and move them around in some areas. To do this use a garden-leaf vacuum machine (fitted with a sleeve to form a bag in the mouth of the tube) to collect adults from heavily damaged rosettes in autumn (or whenever they can be found in good numbers). Aim to shift at least 300 and sort collected material to prevent the spread of any unwanted pests.
- Ensure that the ragwort at the release point is not heavily grazed.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Ragwort Seedfly (*Botanophila jacobaeae*)



Infested flowerheads

#### **Background and life cycle**

- Native to Europe, this fly was first imported in 1928 but not released until the late 1930s. It only established in the central North Island and efforts to transfer it to other areas have been unsuccessful. A similar fly (*Botanophila seneciella*) is thought to have been released at the same time but did not establish.
- A univoltine species, flies emerge in late spring and females lay eggs once plants begin to flower. Larvae feed and develop over summer and pupate in late summer/early autumn, remaining in this state until the following spring.

#### **Distinguishing features**

- Adults are small (about 4–5 mm long), delicate, greyish flies, with males tending to be darker and smaller than females. They will not be easy to distinguish from other fly species in the field.
- Eggs are white, and are usually laid singly among the florets or alongside the green bracts of flower heads.
- Larvae are white maggots that feed inside the flower heads. The presence of larvae is revealed by a browning of the flowers (caused by the larvae feeding). Also the flower pappus (the feathery structures that allow seed to become airborne) is pushed out of the flower head by the growing larvae and matted together with a larval secretion. Fully grown larvae are about 5 mm long.
- Pupae are reddish-brown, barrel-shaped, and 4–5 mm long. Pupation occurs in the soil.

#### **Best time to look**

- Look in summer for signs that the larvae are feeding inside the flower heads.

**Host:**  
Ragwort (*Senecio jacobaea*)

**Agent:**  
Ragwort Seedfly (*Botanophila jacobaeae*)



Larva in flowerhead

#### **Damage**

- Each larva consumes 80% of the seeds in a single flower head. Viability of the remaining uneaten seeds is reduced and matting of the pappus may restrict dispersal. A high proportion of the first seedheads are infested by the seedfly, but this declines throughout the summer, when the majority of ragwort plants flower. Studies have shown that 80–90% of seeds escape attack.
- Specificity testing and follow-up field surveys indicated this insect only damages ragwort.

#### **Management**

- Because the seedfly does not have enough impact on seed production to reduce ragwort populations, no further effort to increase its distribution or abundance is warranted.



**Host:**  
Scotch Thistle (*Cirsium vulgare*)

**Agent:**  
Scotch Thistle Gall Fly (*Urophora stylata*)



Infested flowerhead cut open to expose larvae

#### **Background and life cycle**

- Native to Europe, this fly was first imported in 1997 and released at a limited number of sites in the late 1990s / early 2000s. It has established.
- A bivoltine species, flies emerge in late spring and females lay eggs on green flower buds. Larvae feed during summer and autumn and then pupate. Some new adults emerge to attack late flower heads in autumn but most remain as prepupae until the following spring.

#### **Distinguishing features**

- Adults are about 4–8 mm long, and have dark bodies and distinctive markings on the wings. Females have a long black ovipositor. They look similar to the nodding thistle gall fly but the wing markings are subtly different.
- Eggs are laid in batches on the green flower buds.
- Larvae are creamy-white. They burrow their way into the receptacle where their feeding stimulates the plant to produce gall tissue, which becomes hard as it matures.
- Pupae are brownish and pupation occurs inside the gall.

#### **Best time to look**

- Look for infested flower heads in autumn once they are mature. They will feel hard and lumpy, and be difficult to break open – a knife will be needed to reveal the yellowish chipboard-like interior. If easy to break open and black inside, they are infested with the receptacle weevil. Flower heads may also be infested by both agents, and show some of the characteristics of each.
- Adults may be seen during the warmer months flying about or sitting on thistles,

**Host:**  
Scotch Thistle (*Cirsium vulgare*)

**Agent:**  
Scotch Thistle Gall Fly (*Urophora stylata*)



Infested flowerheads

especially males as they set up territories on bolting thistles and attract females by displaying their wings.

#### **Damage**

- Larval feeding affects seed production. In Canada the flies attack as many as 90% of flower heads and have reduced seed production by 60%. We do not yet know what percentage of seeds are destroyed here.
- Specificity testing and follow-up field surveys suggest this insect prefers Scotch thistle but may attack Californian thistle (*Cirsium arvense*) to a lesser extent.

#### **Management**

- The flies are dispersing steadily but it will still be useful to harvest and move them around in some areas. To do this collect mature infested flower heads in autumn, using secateurs or thick gloves. Aim to shift between 50 and 100 flower heads to each new site. Tie them up off the ground in onion bags (or similar) in the shade.
- Avoid mowing thistles before the flower heads have dried off in the autumn, as you are likely to kill both the gall fly and receptacle weevil.
- Avoid overstocking, as hungry animals may eat all the flowers.

**Host:**  
St John's Wort (*Hypericum perforatum*)

**Agent:**  
Lesser St John's Wort Beetle (*Chrysolina hyperici*), Greater St John's Wort Beetle (*Chrysolina quadrigemina*)



Adult beetle

### Background and life cycle

- The lesser St John's wort beetle is native to Europe and western Asia. It was first imported in 1943 and rapidly became established widely. This species tends to be the more common of the two beetles.
- The greater St John's wort beetle is native to parts of Europe and Africa. It was first imported in 1965 and was rare for many years but can now be found throughout the country.
- Both are univoltine species. Adults aestivate in late summer and begin to lay eggs in the autumn (greater St John's wort beetles come out about 6 weeks earlier than lesser St John's wort beetles). Greater St John's wort beetle eggs hatch straight away but lesser St John's wort beetle eggs do not hatch until the following spring. Once larvae are mature they pupate for 2–3 weeks. New adults appear in late spring/early summer.

### Distinguishing features

The two species can be difficult to tell apart:

- Adults – lesser St John's wort beetles are about 0.5 cm long and metallic green or bronze. Greater St John's wort beetles are slightly larger (0.5–0.7 cm long) and may be blue, green or bronze.
- Eggs – lesser St John's wort beetle's eggs are orange and elongated while the greater St John's wort beetle's eggs are orangey-red and oval, but eggs are difficult to tell apart with the naked eye. Eggs are laid on the undersides of the leaves and in the growing tips.
- Larvae – both species are orange and humpbacked. As they grow they become plump and greyish-pink in colour.
- Pupae – both pupate in cells in the soil.

**Host:**

St John's Wort (*Hypericum perforatum*)

**Agent:**

Lesser St John's Wort Beetle (*Chrysolina hyperici*), Greater St John's Wort Beetle (*Chrysolina quadrigemina*)



Feeding front advancing to right

**Best time to look**

- Look in early summer when adults often form dense feeding clusters. Avoid late summer when adults will be aestivating.

**Damage**

- Both adults and larvae defoliate the plants so heavily that flowering and seed production is suppressed. The larvae can destroy new spring growth almost as soon as it is produced. These beetles have successfully controlled the plant in many areas.
- Specificity testing and follow-up field surveys suggest that these beetles will only attack St John's wort and possibly some other *Hypericum* species.

**Management**

- The beetles are already widespread so there should be no need to harvest and move them around. However, if any areas are found where they are absent, beetles could be shifted there in the autumn. To do this use a garden leaf-vacuum with a sleeve fitted, and aim to shift at least several hundred adults.

## Glossary

**abdomen** - hindmost part of an insect's body

**aestivation** - summer hibernation (dormancy)

**antennae** - paired sensory organs on an insect's head (feelers)

**beating tray** - large (about 1x1 m) white sheet placed beneath foliage to collect any insects beaten from the foliage during surveys

**beetle** - hard-bodied insect (as an adult) with chewing mouthparts and hard wing covers, belonging to the order Coleoptera

**biocontrol** - abbreviated form of biological control

**biocontrol agent** - term for a living organism that is deliberately being used to control another living organism

**biological control** - when one living organism is used to control another

**bivoltine** - two life cycles per year

**bolting (plant)** - when a plant begins to grow taller and put up flowering stems

**caterpillar** - juvenile stage of a butterfly or moth that hatches out of an egg

**chlorotic** - lacking the green plant pigment chlorophyll so has a yellowish appearance

**colonial** - where many insects live together often building and sharing a retreat, e.g. a web

**crown** - centre of a rosette plant

**defoliate** - remove foliage (leaves)

**disperse** - move into new areas

**established** - the status given to a biocontrol agent when it is found in increasing numbers for two or more years following its release

(univoltine species), or after several generations (multivoltine species), i.e. it is now a permanent resident

**fly** - insect with only one pair of wings, belonging to the order Diptera

**frass** - droppings from insects with chewing mouth parts

**fungus** - an organism that is neither a plant nor an animal. Many feed and grow on plant tissues and some of these cause disease (plant pathogens)

**gall** - hard, sometimes unusual-shaped swelling on a plant formed in response to attack from certain insects, mites or fungi

**garden leaf-vacuum** - suction device designed to collect leaves, which can also be modified for collecting insects

**generalist feeder** - insect that feeds on a wide range of different plants

**grub** - another name for a beetle larva

**hibernate** - become dormant during cold weather

**insect** - small invertebrate animal with six legs, 2-4 wings, and a body divided into three parts (head, thorax, and abdomen)

**instar** - growth stage of an insect (in between moults), e.g. newly hatched = first instar

**larva** - the life stage in between an egg and a pupa

**leaf axil** - junction of a leaf and a stem

**leafroller** - moth whose caterpillars web leaves or growing tips together

**lesion** - blemish that shows a plant is infected with a pathogen

**maggot** - larval stage of a fly

**mine** - damage cause by an insect feeding between the top and bottom surfaces of a leaf; often looks like a squiggly line or a blotch

## Glossary

**mite** - tiny invertebrate with eight legs and sucking mouth parts

**moth** - adult with wings covered in fine scales, belonging to the order Lepidoptera, usually more drab than butterflies (also Lepidoptera) and often nocturnal

**multivoltine** - several life cycles per year

**mycoherbicide** - herbicide where the active ingredient is a fungus

**native** - occurring naturally in a country but perhaps in other places too

**natural enemy** - organism that naturally attacks another organism

**nocturnal** - active at night

**nymph** - juvenile stages, typical of sap-sucking insects that become more like adults as they grow instead of undergoing metamorphosis

**overwinter** - spend the winter

**ovipositor** - structure used to lay eggs

**parthenogenetic** - able to reproduce without fertilisation

**pathogen** - disease-causing organism

**petiole** - small stalk that attaches a leaf to a stem

**pooper (aspirator)** - suction device used to collect insects

**prepupa** - life stage that some insects enter before pupation

**pupa (cocoon, chrysalis)** - resting life stage during which metamorphosis occurs

**pustule** - blister-like structure encasing fungal spores

**receptacle** - part of the flower that supports and nourishes developing seeds

**ringbark** - damage encircling a stem or trunk; eventually kills the

plant above this point

**rosette** - juvenile, low-growing plant growth form, occurs between germination and bolting

**rust** - type of fungus that can only survive on living plant tissue, with readily wind-dispersed spores (often orange or rust coloured)

**sawfly** - type of wasp with no sting, belonging to the order Hymenoptera, has plant-feeding larvae similar to moths or butterflies

**smut** - type of fungus similar to a rust in that it needs a living host but its spores are not orange. Some smuts infect flowers and replace plant seeds with spores

**spore** - tiny structures that fungi use to disperse and create new infections, equivalent to a plant seed

**stolon** - narrow stem (runner) that some plants send out across the ground to spread vegetatively (without reproduction) by producing daughter plants at the tips

**sweep net** - butterfly net used to catch insects by sweeping low-growing foliage

**thrips** - tiny sap-sucking insect belonging to the order Thysanoptera; referred to as thrips even in the singular

**univoltine** - one life cycle per year

**vector** - organism that carries disease

**vigour** - measure of how strong and healthy plant growth is

**weevil** - hard-bodied insect also belonging to the order Coleoptera, easily distinguished from other beetles by their elongated snouts (rostrums) and elbowed antennae

For further information see:

[www.landcareresearch.co.nz/research/biosecurity/weeds/biocontrol/](http://www.landcareresearch.co.nz/research/biosecurity/weeds/biocontrol/)

or contact:

Lynley Hayes

Landcare Research

PO Box 69

Lincoln 8152

New Zealand

email: [hayesl@landcareresearch.co.nz](mailto:hayesl@landcareresearch.co.nz)

Ph (03) 325 6700

Fax (03) 3252 418



Manaaki Whenua  
Landcare Research