AN OVERVIEW OF

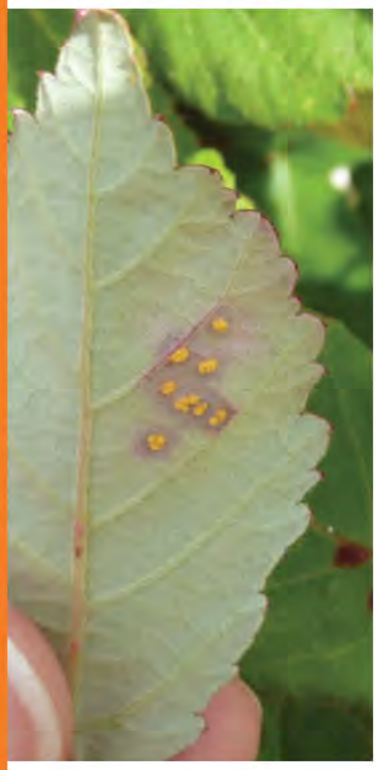
Weed Biocontrol Agents

IN SOUTH AUSTRALIA

BLACKBERRY biocontrol

Target weed:
Blackberry species *Rubus fruticosus* aggregate

Biocontrol agent:
Blackberry leaf rust fungus (blackberry rust)
Phragmidium violaceum



BLACKBERRY LEAF RUST FUNGUS
PHRAGMIDIUM VIOLACEUM

First official releases occurred in Australia in 1991 and 1992, with an additional release program of selected strains in 2006.

Lifecycle: The blackberry rust has five spore types, three sexual spore stages in spring, golden spores in summer and sticky, black spores in winter. In the field, golden summer spores and black winter spores will overlap in summer and autumn.

Impact: Summer spores will germinate in the presence of moisture. The rust spore germ tube enters the leaf through the stomata (pores) in the lower surface on the leaf. Over time purple-brown blotches will appear on the leaf upper surface. Summer defoliation will result when the infection is heavy. Long term monitoring has shown a reduction in daughter plant production and a reduction in total biomass, resulting in reduced canopy density that allows native species to germinate and grow through the thicket.

When and how to release: SPORE WATER. Make a spore suspension as per the spore water method (details on page 11). Spray the suspension immediately onto the underside of blackberry canes until run-off occurs. The rust appears to do best in open sunny locations.

When and how to monitor: Check leaves in summer for golden summer spore pustules, and sticky black winter spore pustules, on underside of leaves. Look for characteristic purple-brown blotches on upper leaf surface. Blotches should be associated with pustules on the leaf underside.

Above: Yellow summer spores and black overwintering spores
Below: Yellow summer spores associated with purple/brown blotches on the leaf surface, observed in Belair NP

Target weed:
Boneseed *Chrysanthemoides monilifera monilifera*

Biocontrol agent:
Boneseed leaf buckle mite *Aceria* sp.

BONESEED LEAF BUCKLE MITE
ACERIA SP.

First released in Australia in 2008.

Lifecycle: Female mites collect a spermatophore that has been deposited by a male. Fertilised eggs are then laid by the female within the shelter of an erineum, or the female is carried by wind to colonise new buds. An erineum is a buckle or gall associated with white/brown hairs that distorts leaf formation.

Impact: Feeding on the plant meristem induces gall formation. Heavy infestations may result in reduced flower and seed production, though this is yet to be confirmed under Australian conditions.

How and when to release: CUTTINGS. Boneseed leaf buckle mite can be released by transferring affected leaves onto new host plants. Mites will move across to the new host as the transferred leaf fragments dehydrate and become unsuitable. The best time for releasing mites is in autumn and spring when conditions are mild and the plant is actively growing.

How and when to monitor: Monitor plants in spring and autumn looking for erinea. Buckles must be associated with dense, white or light brown, hairy patches - from where colonies will develop and expand.

Above: Erineum formation showing dense hair coverage over the buckles. Observed on a boneseed plant in the south-east of South Australia

BRIDAL CREEPER biocontrol

Target weed:
Bridal creeper *Asparagus asparagoides*

Biocontrol agents:
Bridal creeper leafhopper undescribed Erythroneurini
Bridal creeper rust fungus *Puccinia myrsiphylli*
Bridal creeper leaf beetle *Crioceris* sp.

BRIDAL CREEPER LEAFHOPPER
UNDESCRIBED ERYTHRONEURINI

First released in Australia in 1999.

Lifecycle: The leafhopper has multiple generations in one season. Nymphs hatch from eggs and develop through five instars before becoming winged adults.

Impact: Adults and nymphs feed on mesophyll cells of cladodes (leaf-like structures) producing small chlorotic spots that develop into zigzag patterns, reducing the plant's ability to photosynthesise.

How and when to release: CUTTINGS. Transfer plant material infested with leafhoppers in autumn/winter. Insects will move across to the new host as the transferred material dries out.

How and when to monitor: Look for distinctive feeding damage and leafhopper adults in autumn/winter.

BRIDAL CREEPER RUST FUNGUS
PUCCINIA MYRSIPHYLLI

First released in Australia in 2000.

Lifecycle: The bridal creeper rust fungus has five spore states. The rust first appears around May, one or two months after opening autumn rains. The two spore stages most commonly observed are the orange uredinia fruiting structures that produce urediniospores, and the brown-black over-summering telia fruiting structures that produce teliospores.

Impact: The rust parasitises living plant cells and absorbs plant nutrients, resulting in the allocation of resources to the rust fungus and away from the host plant. Heavy repeated infestations result in a severe reduction in bridal creeper above-ground biomass. Experiments have shown a reduction in below-ground biomass as well.

Top: Bleached appearance of bridal creeper leafhopper damaged leaves.
Bottom: Bridal creeper leafhopper adult (photo: CSIRO)

How and when to release: CUTTINGS or SPORE WATER. Releases can be made by transferring infected leaf material or through the distribution of spore water in autumn and winter. Spore water production is outlined on page 11. Spore water should be sprayed on humid days and not during hot dry weather.

How and when to monitor: Monitor the rust in winter looking for chlorotic plants and distinctive rust spores on the back of cladodes.

Top: Orange uredina fruit bodies
Bottom: Visual damage (yellowing/chlorosis) caused by bridal creeper rust fungus

BRIDAL CREEPER LEAF BEETLE
CRIOCERIS SP.

First released in Australia in 2002.

Lifecycle: The leaf beetle has up to two generations per year. Adults over-summer in cocoons and then emerge to lay eggs from autumn through to early winter. A second generation may complete its cycle to produce over-summering adults for the next season.

Impact: Adults and larvae feed on new growing tips with the larvae doing the most damage, limiting the plant's ability to climb in the early part of the season.

How and when to release: Releases of this agent are currently unavailable because of lack of sufficient nursery sites. Distribution is via collection and relocation of larvae.

How and when to monitor: Look for adults, larvae and feeding damage on plant tips in autumn.

Left: Bridal creeper leaf beetle larva
Above: Adult observed on the Eyre Peninsula, South Australia

CACTUS biocontrol

Target weeds:
Various *Opuntia* and *Cylindropuntia* species

Biocontrol agents:
Cochineal scale *Dactylopius* species (see table below)
Cactoblastis moth *Cactoblastis cactorum*

Common name	Scientific name	Biocontrol agent	Release year
Engelmann's prickly pear	*Opuntia engelmannii*	Cochineal scale *Dactylopius* sp.	unknown
Hudson pear	*Cylindropuntia rosea*	Cochineal scale *Dactylopius tomentosus*	1925
Prickly pear	*Opuntia stricta*	Cochineal scale *Dactylopius opuntiae*	1921
		Cactoblastis moth *Cactoblastis cactorum*	1926
Wheel cactus	*Opuntia robusta*	Cochineal scale *Dactylopius* sp.	unknown
Rope pear	*Cylindropuntia imbricata*	Cochineal scale *Dactylopius tomentosus*	1925

Top: Cottony white cochineal colonies on a cactus pad
Right: Cochineal juveniles positioning themselves for wind dispersion

Left: Cactus pads heavily impacted by cochineal
Top: Cactoblastis feeding damage (photo: Shauna Potter)
Bottom: Cactoblastis larvae (photo: Frank Bernhardt)

COCHINEAL SCALE
VARIOUS SPECIES OF THE GENUS *DACTYLOPIUS*

First released in Australia in the 1920's (see table).

Lifecycle: Five to six generations per year. Wingless adult females cluster and feed on cactus pads, females are unable to move once they begin feeding. Females are visited by small winged males. After mating, the female produces nymphs that disperse on the pad to feed, later moving to the edge of the pad and onto spines to be dispersed by the wind to new hosts. Males cannot feed as adults and only live long enough to mate.

Impact: Juveniles and adult females suck fluid from plant tissues, and if numbers are high enough they may cover a large area of photosynthetic surfaces, potentially impacting on energy production. Secondary bacterial or fungal infection may result where feeding damage occurs.

How and when to release: CUTTINGS. Wedge the cochineal infested pad low on the new host plant in a spot that will protect it from rain, with the most heavily infested surface as close as possible to the surface of the new host plant. This will allow for ready movement of wingless cochineals. Avoid piercing the new host plant to secure the infested pad as this will cause scaring which may compromise the success of the release.

Beware of spines and small, fine glochids. Both can be painful and the glochids are especially difficult to remove. Protective clothing, in particular stout gloves, should be worn. Pads can be handled with kitchen tongs.

How and when to monitor: Throughout the year look for white cottony spots (clusters of adult females) on the outer surface of plant pads/segments.

CACTOBLASTIS MOTH
CACTOBLASTIS CACTORUM

Released in Australia in 1926.

Lifecycle: Two to three generations per year, depending on climatic conditions. After mating, adult female moths lay 'egg sticks' containing up to 50 eggs on the outer surface of the cactus. The larvae emerge after approximately one month, tunnel into the pad and live and feed gregariously inside the plant for as little as two months in summer, and up to four months in winter. Larvae exit the plant to pupate under debris on the ground and emerge as moths.

Impact: Larvae feed inside pads, hollowing out segments and causing plant collapse.

How and when to release: Collect egg sticks and relocate to new host plants.

How and when to monitor: During warmer months look for orange/red caterpillars on, or inside, plant pads. These are associated with yellowing and withering of the pads.

CAPE BROOM biocontrol

Target weed:
Cape broom (Montpellier broom)
Genista monspessulana

Biocontrol agents:
Cape broom psyllid *Arytinnis hakani*

Above: Cape broom psyllid adult (photo: Peter Crisp, SARDI)
Below: "Sugar" deposits from adults and nymphs

CAPE BROOM PSYLLID
ARYTINNIS HAKANI

First released unknown.

Lifecycle: Multiple generations per year. Overwintering eggs hatch in early spring and emergent nymphs complete development by late spring. Each generation can take 30 to 60 days to complete development. Adults and late instar nymphs may not survive periods of hot weather, however the population will quickly expand from surviving early instar nymphs and unhatched eggs.

Impact: Nymphs sucking sap from leaves and buds can reduce plant growth, flowering and seed set. Feeding damage may also expose the plant to diseases that could hamper growth.

How and when to release: SWEEP NET or TAPPING. Adults are collected by sweep netting infested plants during late spring or early summer. Plant material infested with nymphs can be harvested and secured to plants at new release sites.

How and when to monitor: Observe plant foliage in spring and autumn for nymphs and white sugary deposits left by nymphs and adults. Also, sweep net or beat foliage over a tray to find adults.

DOCK biocontrol

Target weed:
Dock *Rumex* sp.

Biocontrol agents:
Dock moth *Pyropteron doryliformis*

DOCK MOTH
PYROPTERON DORYLIFORMIS

First released in Australia between 1994 and 1999.

Lifecycle: One generation per year. Adult female moths lay eggs on dock stems in spring/summer. On hatching, larvae tunnel into the tap root where they spend summer feeding on the root, they then undergo diapause though autumn and winter. Adults emerge in spring.

Impact: Larvae tunnel in and feed on the roots, preventing plant regeneration with autumn rains. The density of dock at release sites is severely reduced initially when every plant is inoculated with an egg stick. Several years on, that level of control diminishes but the agent continues to have an impact on plant density.

How and when to release: This agent is well established in southern Australia. Distribution involves laboratory rearing and breeding techniques. Releases of eggs from the lab rearing process can occur during late spring/ early summer.

How and when to monitor: Dock roots can be dug up, dissected and examined for larvae during autumn and winter.

Top: Dock moth adult (photo: Tasmanian Institute of Agriculture)
Bottom: Dock moth larva (photo: John Heap)

ENGLISH BROOM
biocontrol

Target weed:
English Broom (Scotch broom) *Cytisus scoparius*

Biocontrol agents:
English broom gall mite *Aceria genistae*
Broom psyllid *Arytainilla spartiophila*
Broom twig mining moth *Leucoptera spartifoliella*

ENGLISH BROOM GALL MITE
ACERIA GENISTAE

First released in Australia in 2008.

Lifecycle: Multiple generations per year. Adult females lay eggs within the existing gall, or can be wind dispersed to colonise new buds on nearby plants. Young mites develop and feed inside the gall.

Impact: Mites feeding on developing bud tissues create abnormal growth and the formation of galls that provide shelter for the colony. This can impact on the available photosynthetic tissues, and impede flower and seed pod production.

How and when to release: CUTTINGS. Collect plant material with galls from nursery sites during spring and autumn. Immediately release into a new area by tying small clumps of gall-covered stems to broom bushes, surrounding the galls with fresh bud-covered growth to increase the likelihood of colonisation.

How and when to monitor: Look for small, fuzzy, rosette-like growths appearing from buds up to 18 months after release.

Above: English broom mite gall causing flower distortion
Below: English broom mite gall at each bud point

BROOM PSYLLID
ARYTAINILLA SPARTIOPHILA

First released in Australia in 1999.

Lifecycle: Single generation per year. Eggs are laid into the stem of the plant over summer and undergo diapause for five to six months over autumn/winter. Hatching coincides with bud burst in spring. Nymphs will develop rapidly, becoming adults four to eight weeks later. Adults are active and very mobile, and live for three to four weeks.

Impact: Adults and nymphs suck sap from new growth on the plant, damaging cells and stunting growth.

How and when to release: SWEEP NET or TAPPING. Adult psyllids can be released in large numbers during fine, still weather in spring, when broom is actively growing. As of 2013 there are no sites in South Australia where this agent can be collected.

How and when to monitor: Sweep net for adults in summer, or observe stems for nymphs sheltering beneath bud scales in spring.

BROOM TWIG MINING MOTH
LEUCOPTERA SPARTIFOLIELLA

First released in South Australia in 1999 and 2009.

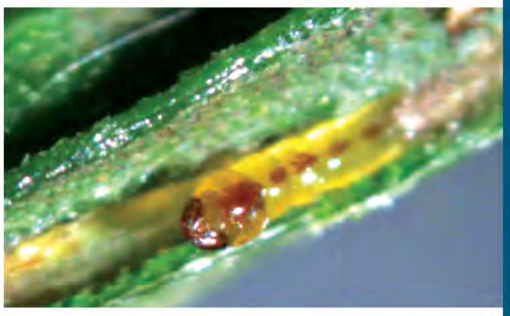
Lifecycle: Single generation per year. Eggs are laid into the stem furrows of the plant in late summer and hatch two to three weeks later. The larvae bore straight into the stems and actively feed in tunnels during the remaining warm months, then become inactive over winter. Feeding resumes in spring when most damage is done by the older larvae. During mid-spring the larvae vacate the stem to spin a white silk cocoon and pupate on plant stems. One month later adults emerge, mate and lay eggs.

Impact: Tunnelling larvae cause damage to the plant stems, reducing plant growth and seed production. Heavily infested branches can die.

How and when to release: SWEEP NET or CUTTINGS. Adult moths are released in large numbers during summer, or cut stems containing cocoons can be attached to new plants during late spring. As of 2013 there are no sites in South Australia where this agent can be collected.

How and when to monitor: Observe plants in spring looking for signs of brown stem 'mines' running up and down the new growth. White, silky cocoons of the pupating larvae can be seen stuck to the outside of stems around October, and adults can be sampled by sweep netting over summer.

Above: English broom psyllid adult resting on flower (photo: © D. Ouvrard/ Psyl'list/NHM-London)



Top: Exposed broom twig miner larva with tunnel evident as brown scarring on twig surface.
Bottom: Twig miner adult (photo: Tasmanian Institute of Agriculture)

GORSE biocontrol

Target weed:
Gorse *Ulex europaeus*

Biocontrol agents:
Gorse seed weevil *Exapion ulicis*
Gorse spider mite *Tetranychus lintearius*
Gorse thrips *Sericothrips staphylinus*
Gorse soft shoot moth *Agonopterix umbellana*

GORSE SEED WEEVIL
EXAPION ULICIS

First released in Australia in 1939.

Lifecycle: Single generation per year. Adults will overwinter on the plant then mate and lay eggs in spring. Females bore holes in young seed pods to deposit eggs which hatch in around four weeks. Larvae will feed on the seed, pupate and emerge in summer when pods ripen and open.

Impact: Larvae feed on developing seeds in pods over spring and summer, reducing viable seed production.

How and when to release: The seed weevil is already well distributed in South Australia and no further distribution is required.

How and when to monitor: Beat stem tips over a shallow tray during summer and autumn to observe adult weevils. Open seed pods during late spring and summer to observe weevil larval damage to seeds.

Above: Gorse seed weevil adult (photo: Tasmanian Institute of Agriculture)

GORSE SPIDER MITE
TETRANYCHUS LINTEARIUS

First released in Australia in 2001.

Lifecycle: Multiple generations per year, with the lifecycle being as short as three weeks when temperatures are warm. Females live for up to one month, and produce up to 40 eggs which hatch in around two weeks. Juveniles pass through three active growth stages before reproducing. The colony lives within fine silk webbing constructed around the gorse stems, and congregates at the stem tip to migrate by wind to nearby plants.

Impact: Mite feeding damage causes gorse foliage to appear bleached. Extensive feeding can kill shoots, reduce plant growth and cause flower abortion.

How and when to release: CUTTINGS. Collect migrating mite colonies in spring or summer by severing the very tip of the stem which may have an icicle-like congregation of red mites. The colony is then placed onto a new gorse plant. Avoid taking a larger section (>5 cm) of stem that may transfer predatory mites feeding deep within the colony.

How and when to monitor: Look for the white webbing and tiny, red adult mites of active colonies, and bleached stems and foliage on plants where mites have been feeding.

Above: Gorse spider mite webbing and part of a gorse spider mite colony

GORSE THRIPS
SERICOTHRIPS STAPHYLINUS

First released in South Australia in 2006.

Lifecycle: Two generations per year. Eggs laid at the end of winter hatch in early spring. Juveniles feed on new growth and mature in time for another round of egg-laying and juvenile development over summer. Some adults overwinter and commence egg-laying towards the end of winter. Adults can be found on plants all year round.

Impact: Adults and juveniles suck out the contents of leaf cells. This causes foliage to appear mottled and blotchy, and can result in stunted growth.

How and when to release: TAPPING. Collect large numbers of adults in spring by beating stems over shallow trays and sucking up thrips with an aspirator. Immediately transfer to a new site of dense gorse infestation.

How and when to monitor: Tap plants and observe 1mm long adults during late spring and summer.

Above: Gorse thrips adult with visible white wing buds (photo: Tasmanian Institute of Agriculture)

GORSE SOFT SHOOT MOTH
AGONOPTERIX UMBELLANA

First released in South Australia in 2011.

Lifecycle: Single generation per year. In early spring adults emerge from diapause, mate and lay eggs near buds. Newly hatched larvae spin a protective silken tube over themselves and the new bud growth they are feeding on. Pupation occurs within the tube by mid-summer and adults emerge in late summer, moving into the centre of the bush for winter diapause.

Impact: Larvae feed on new buds and shoots, restricting growth, with the potential to limit flower production.

How and when to release: This agent is new to South Australia and establishment has not yet been confirmed. Collection and release is not yet possible.

How and when to monitor: Look for silk tubes spun by larvae on new growth in spring/summer; the new plant growth will become distorted and characteristically bent at the tip. Look for the presence of adults in late summer.

Above left: Gorse soft shoot moth released at Norton Summit in 2011
Above right: Gorse soft shoot moth damage seen in Tasmania

HOREHOUND biocontrol

Target weed:
Horehound *Marrubium vulgare*

Biocontrol agents:
Horehound plume moth *Wheeleria spilodactylus*
Horehound clearwing moth *Chamaesphecia mysiniformis*

HOREHOUND PLUME MOTH
WHEELERIA SPILODACTYLUS

First released in Australia in 1995.

Lifecycle: Two to three generations per year. Adult female moths lay eggs on the underside of horehound leaves and larvae feed on the foliage and shoot tips. Pupation occurs inside a silky cocoon on the upper leaf surface.

Impact: The voracious feeding by larvae reduces the plant biomass and lifespan, and can cause abortion of flower buds as they consume young shoots.

How and when to release: The plume moth is already widely distributed in South Australia and no further distribution is required.

How and when to monitor: Look for small, hairy, green larvae on the leaves and stems of plants, particularly during the warmer months. (Note: The larvae are very well camouflaged as they are identical in colour to horehound leaves). Adult moths are very distinctive, holding their wings out to the side rather than folded over their backs.

HOREHOUND CLEARWING MOTH
CHAMAESPHECIA MYSINIFORMIS

First released in South Australia in 1997.

Lifecycle: One generation per year. Adult female moths lay eggs on plant stems and flowers in late spring/early summer. On hatching larvae tunnel down the stem into the crown and root system where they spend summer feeding, then undergo diapause over autumn and winter. Adults emerge in spring.

Impact: Larvae tunnel and feed inside the stem and roots, disrupting water transport from roots to stem. This activity can kill significant portions of the plant and severely impact the amount of seed produced.

How and when to release: Distribution involves laboratory rearing and breeding techniques. Releases of eggs from the lab rearing process can occur during late spring/early summer.

How and when to monitor: Horehound crowns and roots can be dug up, dissected and examined for evidence of larvae, tunnelling, and pupae in spring and early summer.

Above: Horehound clearwing moth larvae within a root

Below left: Horehound plume moth larva found on plants in the south-east of South Australia
Below right: Horehound clearwing moths mating

SALVATION JANE
biocontrol

Target weed:
Salvation Jane (Paterson's Curse) *Echium plantagineum*

Biocontrol agents:
Salvation Jane leaf mining moth *Dialectica scalariella*
Salvation Jane flea beetle *Longitarsus echii*
Salvation Jane crown weevil *Mogulones larvatus*
Salvation Jane root weevil *Mogulones geographicus*
Salvation Jane pollen beetle *Meligethes planiusculus*

SALVATION JANE LEAF MINING MOTH
DIALECTICA SCALARIELLA

First released in Australia in 1988. Earlier releases in 1980 failed.

Lifecycle: Five to seven generations per year, with reduced activity in winter. Eggs are laid on leaves, and larvae tunnel and mine the leaf, forming blisters. Larvae pupate within the leaf mine and emerge as adults.

Impact: Larval leaf mines appear as blisters on the leaf surface that can reduce photosynthetic material, decreasing plant vigour.

How and when to release: The leaf mining moth is already well distributed in South Australia and no further distribution is required.

How and when to monitor: Look for larvae in winter and spring, visible on the underside of leaves through a brownish membrane 'pocket' or 'blister'

Above left: Adult leaf miner moth
Above central: Leaf miner larval feeding damage visible as blistering on the underside of the leaf

SALVATION JANE ROOT WEEVIL
MOGULONES GEOGRAPHICUS

First released in South Australia in 1997.

Lifecycle: One generation per year. Eggs are laid into leaf petioles in autumn. Larvae hatch and tunnel into the tap root, where they feed through winter. Pupation occurs in the soil and new adults emerge in spring. Adults feed on maturing plants and flowers then aestivate over summer in pasture litter.

Impact: Larvae can cause extensive damage to the root system through their tunnelling and feeding, restricting the movement of water and nutrients, and providing an entry point for plant pathogens.

How and when to release: SWEEP NET. Adults can be collected once they have pupated by sweep netting across flowering plants in summer.

How and when to monitor: Dig up plant roots and inspect for larvae in mid to late winter. Adults can be found under plant leaves in autumn, or sweep netted from flowering plants in summer.

Above: Root weevil adult

SALVATION JANE FLEA BEETLE
LONGITARSUS ECHII

First released in South Australia in 1999.

Lifecycle: One generation per year. Eggs are laid on the tap root surface in late winter - from where larvae tunnel and feed on the root. Larvae move out of the root to pupate deep in the soil over summer. Adults emerge with winter rainfall.

Impact: Adult beetle feeding produces shot holes or 'windows' where part of the leaf membrane remains intact. High adult densities can severely impact on the number of juvenile plants. Larvae can cause extensive damage to the root system which reduces nutrient intake and exposes the plant to possible plant pathogen infection.

How and when to release: SWEEP NET. Adults can be collected by sweep netting over plants in August during fine, sunny weather.

How and when to monitor: Dig up plant roots and inspect for larvae in spring. Sweep net for adults and observe characteristic feeding pattern of small, 'window-like' shot holes on leaves in late winter.

Above: Flea beetle feeding damage visible as "windows"
Middle: Flea beetles feeding on a Salvation Jane leaf
Below: Adult flea beetle

SALVATION JANE CROWN WEEVIL
MOGULONES LARVATUS

First released in South Australia in 1995.

Lifecycle: One generation per year. Eggs are laid into leaf petioles in autumn. Larvae hatch and tunnel into the crown of the plant where they feed on crown material through winter. Pupation occurs in the soil and new adults emerge in spring. Adults feed on maturing plants and flowers then aestivate over summer in leaf litter and other debris on the ground.

Impact: Larvae feeding in the crown cause the plant to produce a purple/black slimy by-product, and can readily kill a small rosette.

How and when to release: SWEEP NET. Adults can be collected once they have pupated by sweep netting across flowering plants in summer.

How and when to monitor: Observe slimy blackened rosette crowns in autumn and winter - these can be dissected to find fat, white weevil larvae. Adults can be found under plant leaves in autumn, or sweep netted from flowering plants in summer.

Above left: Crown weevil adult
Above right: Crown weevil larval feeding damage seen as purple/black slime around the top of the crown

SALVATION JANE POLLEN BEETLE
MELIGETHES PLANIUSCULUS

First released in South Australia in 1999.

Lifecycle: Usually one generation per year. In spring, eggs are laid on unopened flower buds and larvae hatch and burrow into the bud, eating the pollen and immature seeds. Larvae drop to the ground to pupate in the soil. Adults appear in less than two weeks and return to open flowers to feed on pollen. They oversummer and overwinter in the soil, though some adults may break diapause to feed briefly on new autumn rosettes. Adults commence egg-laying in spring.

Impact: Adults and larvae feed on pollen and developing seed, reducing the plant's ability to reproduce.

How and when to release: SWEEP NET. Adults can be collected once they have pupated by sweep netting flowering plants in spring and summer.

How and when to monitor: Sweep net or tap flowers over a tray and look for adults once the majority of flowers have opened in spring and summer.

Above: Pollen beetles on Salvation Jane flowers

SLENDER THISTLE biocontrol

Target weed:
Slender thistle *Carduus pycnocephalus* and winged slender thistle *Carduus tenuiflorus*

Biocontrol agents:
Slender thistle rust fungus *Puccinia cardui-pycnocephali*

SPEAR THISTLE biocontrol

Target weed:
Spear thistle or black thistle *Cirsium vulgare*

Biocontrol agents:
Spear thistle gall fly *Urophora stylata*

SLENDER THISTLE RUST FUNGUS
PUCCINIA CARDUI-PYCNOCEPHALI

First released in Australia in 1993.

Lifecycle: The rust fungus can have several generations per year under optimal conditions. Spores are transported to new plants by wind or water, and infect the leaf through pores in the lower surface. After infection, new pustules are produced that erupt two to three weeks later to produce tens of thousands of spores that are carried to new plants.

Impact: Heavily infected leaves and stems may dry up and wither prematurely, causing significant reduction of plant growth and seed production.

How and when to release: SPORE WATER. Releases can be made by transferring infected leaf material or through the distribution of spore water. Spore water production is outlined on page 11. Collect pustule infected leaves in late winter/ early spring to make the spore suspension and spray it onto new hosts immediately.

How and when to monitor: Look for rust pustules from autumn through to spring, and withering leaves and stems.

SPEAR THISTLE GALL FLY
UROPHORA STYLATA

First released in Australia in 1993.

Lifecycle: One generation per year, though a partial second generation may be possible. Adult females lay eggs at the base of new flowers during spring. Larvae feed inside developing flowers causing a hard gall to form in the heart of the flower. Larvae overwinter and pupate inside the gall, emerging as adults in spring.

Impact: Larval feeding action and development of a gall lessens the viable seed in each flower head. Some seed may be bound to the forming gall, reducing the plants' reproductive output.

How and when to release: CUTTINGS. Collect previous season's flower heads with galls (hard lump in the centre of flower) from nursery sites during winter and early spring. Release into a new area by enclosing the flower heads in a medium gauge mesh cage suspended off the ground (e.g. attached to a star picket or stake) in close proximity to actively growing spear thistle plants.

How and when to monitor: Wearing thick gloves, press dry flower heads with fingers to feel for hard lumps (from pea to marble size) at the heart of the flower. This is best done during winter when the previous season's flower spikes are still standing. Confirm presence of larvae by slicing galls open with secateurs.

Top left: Slender thistle rust fungus (photo: © J Kruse, Fungiworld.com)
Above: Developing spear thistle gall fly gall with larva visible
Above right: Spear thistle gall flies mating on flower head

ST JOHN'S WORT
biocontrol

Target weed:
St John's wort *Hypericum perforatum*

Biocontrol agents:
St John's wort leaf beetles
Chrysolina hyperici and *Chrysolina quadrigemina*

ST JOHN'S WORT LEAF BEETLES
CHRYSOLINA HYPERICI AND
CHRYSOLINA QUADRIGEMINA

First released in Australia in 1930, with additional releases in 1980-81.

Lifecycle: One generation per year. Eggs of both species are laid under leaves in autumn, *C. quadrigemina* larvae hatch and feed on rosette leaves over winter, *C. hyperici* larvae do not emerge until early spring. Larvae pupate in the soil and adults emerge in late spring. They feed on the leaves and erect flower stems.

Impact: Defoliation of rosette growth and stem growth reduces photosynthetic material.

How and when to release: Already thought to be widespread throughout southern Australia.

How and when to monitor: Look for larvae of *C. quadrigemina* feeding on leaves during winter at night, and adults of both species on erect stems in late spring/early summer.

Above: St John's wort leaf beetle, *Chrysolina hyperici* (photo: NSW DPI)

STEMLESS THISTLE
biocontrol

Target weed:
Stemless thistle *Onopordum acaulon*

Biocontrol agents:
Seed weevil *Larinus latus*
Crown or rosette weevil *Trichosirocalus briesei*
Petiole moth *Eublemma amoena*

SEED WEEVIL *LARINUS LATUS*

First released in Australia in 1992.

Lifecycle: One generation per year. Females chew a hole into the flower heads and lay eggs into the hole in late spring to early summer. The hole is then covered over with faecal deposits to protect the eggs. Larvae bore into the flower head to feed on the receptacle tissue and developing seed. Pupation occurs in the flower head, and adults emerge in late summer before moving to overwintering sites.

Impact: A high density of larvae has the potential to destroy all seed. This agent is yet to be detected in South Australia.

How and when to release: CUTTINGS or SWEEP NET. Currently agents are collected from the eastern states in Australia. Collection can involve two methods. Collect flower heads in January that contain pupating weevils, as evidenced by holes covered in faecal plugs, and redistribute heads to new locations where the new adults will emerge. Alternatively, adults can be collected in spring when they congregate on flower heads to mate and egg lay. Adults are released directly onto early flowering plants.

How and when to monitor: Look for adults congregating on flower heads in spring.

Above: Seed weevil on stemless thistle

CROWN WEEVIL
TRICHOSIROCALUS BRIESEI

First released in Australia in 1997.

Lifecycle: One generation per year. Adults become active in autumn and begin egg-laying from autumn through to spring. Eggs are laid in the midrib on the underside of leaves. Larvae burrow down through the midrib into the crown to feed. The larvae will exit the crown to pupate in earthen cells in the soil. Adults emerge in late spring to feed before entering a dormant period over summer.

Impact: Work in Spain has shown that high numbers of larvae can kill small plants and reduce the growth of larger plants. The establishment of this agent in South Australia has not been confirmed.

How and when to release: SWEEP NET. This insect is not available for collection in South Australia. Collect freshly emerged adults from flowering plants in spring and release at the new site in a release cage or tent if possible (see page 13). Over 100 adults will be needed to overcome predation during their dormant summer period.

How and when to monitor: Observe adult feeding damage, visible as shot holes, in autumn. Look for adults on flower heads in spring and early summer.

Above: Crown weevil adult
(photo: CSIRO)

PETIOLE MOTH
EUBLEMMA AMOENA

First released in Australia in 1998.

Lifecycle: Three generations per year. The first generation emerges from pupal cells within the rosette in spring. After mating, eggs are laid on thistle leaves from where larvae hatch to feed within the petiole. Larvae can continue to feed down to the crown and roots before pupating within the rosette. The second generation of adults will emerge in midsummer, and the progeny of this generation will develop quickly in the warm weather. The third generation will emerge in late summer. The progeny from this generation will slowly develop through the autumn and winter before the rate of development increases in warmer spring conditions. The adults of this generation will be the first generation of the next growing season.

Impact: Feeding can cause the leaf to shrivel and die. Feeding by larvae in the crown and roots can kill smaller plants. Feeding by the progeny of second generation adults can cause potential plant death by inflicting damage at a rate that plant growth can't compensate for, reducing competition for other pasture species.

How and when to release: These moths are not available for collection in South Australia. Release adult moths into a cage over dense plants (see page 13), or free-release adults when plants are not at high density. Release the moths from early spring to late summer.

How and when to monitor: Look for dying and dead leaves, or dissect plants to look for larvae, in late spring and throughout summer.

Above: Petiole moth
(photo: CSIRO)

SKELETON WEED
biocontrol

Target weed:
Skeleton weed *Chondrilla juncea*

Biocontrol agents:
Skeleton weed gall midge *Cystiphora schmidti*
Skeleton weed rust fungus *Puccinia chondrillina*
Skeleton weed gall mite *Aceria chondrillae*

SKELETON WEED GALL MIDGE
CYSTIPHORA SCHMIDTI

First released in Australia in 1971.

Lifecycle: This agent produces four to six generations per year. Adult female midges lay eggs just below the surface of the rosette leaves, stems and stem leaves. Upon hatching larvae feed inside the leaf and stem tissue, forming galls in which they proceed to pupate. After a life cycle of 25-45 days new adults emerge to begin the next generation.

Impact: Larvae feeding on plant tissue induce the formation of small galls, sometimes in large numbers, stunting and weakening the plant. A high rate of attack can turn stems purple.

How and when to release: CUTTINGS. Distribute infested plant material displaying galls (3-4 mm long lumps) amongst new host plants in spring and early summer.

How and when to monitor: Look for galls on the leaves and stems of older plant material throughout the year.

SKELETON WEED RUST FUNGUS
PUCCINIA CHONDRILLINA

First released in Australia in 1971.

Lifecycle: The rust fungus can have several generations per year under optimal conditions. Spores are transported to new plants by wind or water and infect the leaf through its pores. After infection, new pustules are produced that erupt to produce thousands of spores which are carried to new plants.

Impact: Infection results in dieback and premature death of the rosette and stems. Seed set is reduced and root energy reserves gradually diminish.

How and when to release: SPORE WATER. Make a spore suspension as per the spore water method (details on page 11). Spray the spore suspension immediately onto new hosts. The spore water is best applied on dewy nights where surface water will remain on the leaves for a number of hours to allow for maximum infection.

How and when to monitor: Look for reddish-brown rust spores covering any above-ground growth.

SKELETON WEED GALL MITE
ACERIA CHONDRILLAE

First released in Australia in 1971.

Lifecycle: Feeding damage of mites creates a gall in which they live and reproduce over spring and summer. When the stems senesce in autumn the mites disperse to new rosettes, either by wind or crawling, and overwinter without causing damage until plant growth resumes in spring.

Impact: Mite feeding induces the formation of large galls up to 4 cm in diameter, causing the abortion of stems, reduced seed production, and general weakening of the plant and its roots.

How and when to release: CUTTINGS. Distribute infected plant material displaying galls amongst new host plants in early autumn, prior to host plant senescence.

How and when to monitor: Look for galls on stems of older plant material in summer and autumn.

Above: Skeleton weed gall midge and developing galls (photo: Charles Turner, USDA Agricultural Research Service, Bugwood.org)

Above: Skeleton weed rust fungus (photo: CSIRO)

Above: Skeleton weed gall mite galls (photo: Eric Coombs, Oregon Department of Agriculture, Bugwood.org)

Weed biocontrol release form

Site Details

Site ID

Site Name

Location (nearest town)

Land use

UTM Zone

GPS Easting | GPS Lat

GPS Northing | GPS Long

Landholder/Manager

Postal address or email

Phone/Mobile

Release Details

Target weed

Infestation size

Agent released

Date released

Number released

Life stage released

No. of plants infested

Caged/fenced release

Release site manager

Email

Phone/mobile

Present at release

Organisation

Photopoint (Sketch a map of release site on back of form)

GPS Easting

GPS Northing

Distance

Bearing

Notes/Comments

See additional data suggestions on page 14.

Glossary

Aestivate: Summer dormancy, where an organism is metabolically inactive due to high temperatures and dry conditions.

Agent or biocontrol agent: An insect, pathogen or other organism, that is used to control another organism through feeding damage at one or more lifecycle stages, or through infection.

Aspirator: A device used to suction insects; for example, from a collection tray into a holding container. Traditional aspirators were made of two tubes going through a stopper into a collection jar. One tube was placed over the insect while the other is placed in the collector's mouth. Air drawn in will suction insect into the first tube to be deposited into the collecting jar. A modified battery operated computer keyboard vacuum cleaner can be used to provide the suction with the collecting jar attached directly into the vacuum cleaner with a filter to stop insects moving into the suction mechanism.

Biocontrol: A short word to mean biological control.

Biological control: The use of one organism, often a natural enemy, to control another organism.

Crown: A plant structure at the root/stem interface from where leaves, stems and roots emerge. In some cases crowns can be storage structures allowing plants to resprout after the above-ground structures have been damaged or removed.

Diapause: A state of restrained development or reduced metabolic activity triggered by, and ended by, specific conditions.

Erineum (plural: erinea): A leaf distortion, with dense matted hairs, formed as a response to the feeding of a boneseed leaf buckle mite colony.

Gall: A plant structure that forms often in response to feeding by galling insects e.g. the dense leaf deformity caused by English broom gall mites or the woody gall formed in spear thistle flower heads by the spear thistle gall fly.

Instar: A juvenile insect growth stage separated by moulting.

Integrated weed management: Weed control methods used in combination to exert control over weeds. For example: biocontrol used in combination with grazing and quarantining of transported grazing animals.

Larva (plural: larvae): The juvenile stage of insects that have metamorphosis, occurring between the egg and the pupal stages. Larvae may have several recognised growth stages, called instars. Larvae may be commonly called caterpillars, grubs or maggots.

Native range surveys: Surveys for insect and pathogen predators of target weed species in the countries of origin.

Nymph or nymphs: A juvenile stage of insects that do not have a metamorphosis. There can be a number of instars within the nymphal stage of development, each of which takes the general form of the adult but lacks wings.

Nursery sites: Release sites where agents have multiplied sufficiently to allow harvesting without damage to the population.

Pathogen: A disease producing organism. In weed biocontrol it is often, but not exclusively, a fungal disease.

Pupa (plural: pupae): A phase between larval and adult stages when larval anatomical features are destroyed and adult features are constructed (metamorphosis). Often the pupal stage is contained within a pupal case, cocoon or earthen cell.

Rosette: A growth stage for some plants where plant leaves grow from the one central point, usually at ground level, often the plant will then develop one or many stems from where flowers and other reproductive structures form.

Spores: A fungal reproductive cell.

Weed biocontrol: The use of a natural enemy such as an insect, pathogen or other organism that is used to control a weed. Often the natural enemy or agent has co-evolved with the target weed in their country of origin.







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