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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

DURUM

SECTION 7

INSECT CONTROL

POTENTIAL INSECT PESTS | INTEGRATED PEST MANAGEMENT | RUSSIAN WHEAT APHID | OTHER APHIDS | ARMYWORM | CUTWORM (AGROTIS SPP.) | MITES | LUCERNE FLEA | SLUGS AND SNAILS | WIREWORMS AND FALSE WIREWORMS | HELICOVERPA SPP

Insect control

Key messages:

- Know the enemy: accurate identification of beneficial and pest species is fundamental.
- Know the control thresholds for pests in your crops.
- Monitor pest populations prior to seeding, during the growing season and after control treatments.
- Use appropriate and consistent sampling methods.
- Select appropriate control methods.
- Insects are not usually a major problem in cereals but sometimes they build up to an extent that control may be warranted.
- Integrated Pest Management (IPM) strategies encompass chemical, cultural and biological control mechanisms to help improve pest control and limit damage to the environment.

Insect pests cause grain crop losses totaling hundreds of millions of dollars across Australia every year, so reducing the potential for pest damage is a high priority for growers. Insects are not usually a major problem in wheat but sometimes they build up to an extent that control may be warranted. For current chemical control options, refer to the Pest Genie or Australian Pesticides and Veterinary Medical Authority (APVMA) websites.

Where chemical control is warranted, farmers are increasingly being strategic in their management and avoiding broad-spectrum insecticides where possible. Thresholds and potential economic damage are carefully considered.

Agronomist's view

7.1 Potential insect pests

Insect and other arthropod pests that can pose a problem in wheat include blue oat mite (*Penthaleus* spp.), redlegged earth mite (*Halotydeus destructor*), Bryobia mites (*Bryobia* spp.), *Balaustium* mite, cutworms, aphids, slugs, snails, earwigs, millipedes, slaters, armyworms, pasture webworm, pasture cockchafers, grass anthelids, lucerne flea (*Sminthurus viridis*), leaf hoppers and locusts. Mice may also cause damage.

Stay informed about invertebrate pest threats throughout the winter growing season by subscribing to the South Australian Research and Development Institute's (SARDI) PestFacts South Australia newsletter and cesar's PestFacts south eastern newsletter. Subscribers to cesar's newsletter also benefit from special access to the company's extensive insect gallery, which can be used to improve skills in identifying pest and beneficial insects.

Table 1: *Situations and insect pest risk for winter cereals.*

High risk	Moderate risk	Low risk
Soil insects, slugs and snails		
Some crop rotations increase the likelihood of soil insects. Cereal sown into a long-term pasture phase. High stubble loads. Above average rainfall over summer-autumn. History of soil insects, slugs and snails. Summer volunteers and brassica weeds will increase slug and snail numbers. Cold, wet establishment conditions exposes crops to slugs and snails.	Information on pest numbers prior to sowing from soil sampling, trapping and/or baiting will inform management. Implementation of integrated slug management strategy (burning stubble, cultivation, baiting) where history of slugs. Increased sowing rate to compensate for seedling loss caused by establishment pests.	Slugs and snails are rare on sandy soils
Earth mites		
Cereals adjacent to long term pastures may get mite movement into crop edges. Dry or cool, wet conditions that slows crop growth increases crop susceptibility to damage. History of high mite pressure.	Leaf curl mite populations (they transmit wheat streak mosaic virus) can be increased by grazing and mild wet summers.	Seed dressings provide some protection, except under extreme pest pressure.
Aphids		
Higher risk of barley yellow dwarf virus disease transmission by aphids in higher rainfall areas where grass weeds are present prior to sowing. Wet summer and autumn promotes survival of aphids on weed and volunteer hosts.	Wet autumn and spring promotes the growth of weed hosts (aphids move into crops as weed hosts dry off). Planting into standing stubble can deter aphids landing. Use of seed dressings can reduce levels of virus transmission and delay aphid colonisation. Use of SPs and OPs to control establishment pests can kill beneficial insects and increase the likelihood of aphid survival.	Low rainfall areas have a lower risk of BYDV infection. High beneficial activity (not effective for management of virus transmission).

High risk	Moderate risk	Low risk
Armyworm		
Large larvae present when the crop is at late ripening stage.	High beneficial insect activity (particularly parasitoids). Rapid crop dry down.	No armyworm present at vegetative and grain filling stages.

Source: IPM Guidelines

Table 2: *Impact of insect according to crop stage.*

	Crop stage			
Pest	Emergence	Vegetative	Flowering	Grainfill
Wireworms	Damaging	Present		
Cutworm	Damaging			
Black headed cockchafer	Damaging	Present		
Earth mites	Damaging	Present		
Slugs, snails*	Damaging			
Brown wheat mite		Damaging		
Aphids	Present	Damaging	Present	Present
Armyworm		Present	Present	Damaging
Helicoverpa armigera				Damaging

* Snails are also a grain contaminant at harvest
Source: IPM Guidelines

The SARDI Entomology Unit provides an insect identification and advisory service. The Unit identifies insects to the highest taxonomic level for species where this is possible and can also give farmers biological information and guidelines for control. [1]

Table 3 provides an identification key for common crop pests.

Table 3: *Crop damage pest identification key for the southern region. Pests labelled with an asterix (*) are relevant in south-eastern Australia only.*

Damage to crop	Pest
Leaves or plants cut off and lying on the ground or protruding from small holes next to plants; brown caterpillars (up to 15 mm long) with black heads, present in web-lined tunnels; wheat or barley seeded into grassy pasture paddocks.	Webworm
Leaves or plants cut off and lying on the ground or protruding from small holes next to plants. Slender larvae, up to 35 mm long, construct silk-lined tunnels that protrude above ground to form chimneys.	Pasture tunnel moth*
Leaves or plants cut off and lying on the ground or protruding from small holes next to plants. Larvae are brown with black and yellow marking, covered in tufts of stout hairs and can grow up to 50 mm in length.	Grass anthelid*
Leaves of young seedlings fed upon or damaged; in severe cases seedlings are ring-barked at ground level causing them to drop. Adults are 3–5 mm long, round and dull brown resembling small clods of dirt.	Mandalotus weevil*

1 PIRSA (2015) Insect diagnostic service. Primary Industries and Regions South Australia, June 2015, http://pir.sa.gov.au/research/research_specialties/sustainable_systems/entomology/insect_diagnostic_service

Damage to crop	Pest
Plants eaten close to or below ground level causing plant death and bare patches within the crop.	Polyphrades weevil*
Larvae emerge from tunnels with rain events to feed on foliage. Can cause bare patches in crops during late autumn and early winter. 'C' shaped larvae with six legs and a black to brown head capsule.	Blackheaded pasture cockchafers*
Large portions of plants eaten and some leaves or plants cut off. Smooth, fat caterpillars up to 40 mm long usually found just under the soil surface and may curl up when disturbed.	Cutworms
Green material removed in irregular patches from one surface of the leaf leaving white window-like areas; paddocks may appear white; presence of dumpy, wingless, greenish yellow insects, which spring off plants when disturbed.	Lucerne flea
Leaves shredded or chewed, slimy trails.	Slugs and snails
Smooth, shiny brown animals with curved pincers at the end of the body. Damage irregular, often similar to slug damage, mostly in patches, when sown in heavy stubble.	Earwigs
Grasshoppers and locusts.	Grasshoppers and locusts
Minor leaf chewing; presence of dark brown to black caterpillars up to 60 mm long with two yellow spots near posterior end.	Pasture day moth
Presence of tiny eight-legged (nymphs have six legs) velvety black or brown crawling creatures with orange-red legs, found on plants or on soil surface at the base of plants.	Redlegged earth mite, blue oat mite, Balaustium mite
Plants stunted and dying at emergence and up to tillering; chewing of seed and stem below ground; white legless larvae up to 7 mm long present near point of attack.	Spotted vegetable weevil or Desiantha weevil
Plants stunted or dying; roots eaten; slow-moving, soft bodied insects usually in a 'C' shape, cream-coloured apart from head and visible gut contents; found near roots.	Cockchafers, African black beetle
Plants yellowing and withering; on light soils mostly on coastal plain; stems underground shredded; presence of elongated, cylindrical insects up to 75 mm long, first pair of legs adapted for digging.	Sandgropers*
Green and straw-coloured insect droppings like miniature square hay bales on ground; cereal heads on ground; some chewing of leaves and seed heads of weeds such as ryegrass. Smooth, fat caterpillars up to 40 mm long, with three stripes on collar behind head; found at base of plants or climbing plants.	Armyworm
Seeds chewed but heads not severed; caterpillars up to 40 mm long, sparsely covered with small bumps and bristles, may be various shades of green, yellow, orange or brown; found on seed heads.	Native budworm and related species
Presence of many grey-green insects approx. 2 mm long, with or without wings, on upper portions of stem. If heavy infestations, plants stunted; sticky with secretions, possibly black mould growing on secretions.	Aphids
Damage in fine pale dots in wriggly or zigzag lines. Yellow to green, 3 mm long wedge-shaped sucking insects that jump sideways when disturbed.	Leafhoppers

Source: I Spy.

7.2 Integrated pest management

Pests are best managed by using an integrated pest management (IPM) approach. Careful planning prior to sowing, followed by regular monitoring of crops after sowing, will ensure that potential problems are identified and, if necessary, treated early.

The IPM approach uses a range of management tactics to keep pest numbers below the level where they cause economic damage. It focuses on natural regulation of pests, particularly by encouraging natural enemies, and on using broad-spectrum chemicals only as a last resort. IPM relies on monitoring the crop regularly, having pests and beneficial insects correctly identified, and making strategic control decisions according to established damage thresholds.

IPM uses a combination of biological, cultural and chemical control methods to reduce insect pest populations. A key aim of IPM is to reduce reliance on insecticides as the sole and primary means of pest control. IPM can improve growers' profitability while reducing environmental damage and limiting the risk of on-farm pesticide exposure.

Key IPM strategies

- Where the risk of establishment pest incidence is low (e.g. earth mites), regular monitoring can be substituted for the prophylactic use of seed dressings.
- Where establishment pests and aphid infestations are clearly a result of invasion from weed hosts around the field edges or neighbouring pasture, a border spray of the affected crop may be sufficient to control the infestation.

Insecticide choices

- RLEM, BOM, and other mite species can occur in mixed populations. Determine species composition before making decisions as they have different susceptibilities to chemicals.
- Establishment pests have differing susceptibilities to insecticides (SPs, OPs in particular). Be aware that the use of some pesticides may select for pests that are more tolerant.

Insecticide resistance

- RLEM has been found to have high levels of resistance to synthetic pyrethroidssuch as bifenthrin and alpha-cypermethrin.
- *Helicoverpa armigera* has historically had high resistance to pyrethroids and the inclusion of NPV is effective where mixed populations of armyworm and helicoverpa occur in maturing winter cereals. [2]

VIDEOS

WATCH: Integrated Pest Management.

7.2.1 Insect sampling methods

Monitoring for insects is an essential part of successful integrated pest management programs. Correct identification of immature and adult stages of both pests and beneficials, and accurate assessment of their presence in the field at various crop stages, will ensure appropriate and timely management decisions. Good monitoring procedure involves not just a knowledge of and the ability to identify the insects present, but also good sampling and recording techniques and a healthy dose of common sense.

Factors that contribute to quality monitoring

- **Knowledge of likely pests/beneficials and their life cycles** is essential when planning your monitorng program. As well as visual identification, you need to know where on the plant to look and the best time of day to get a representative sample.

2 IPM Guidelines. Winter cereals. GRDC and DAFF, http://ipmguidelinesforgrains.com.au/crops/winter-cereals/

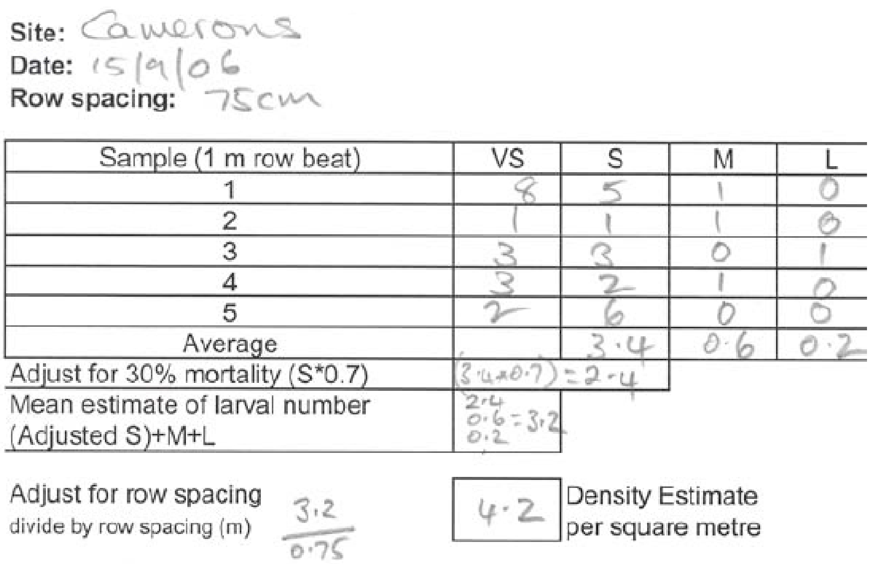
- **Monitoring frequency and pest focus** should be directed at crop stages likely to incur economic damage. Critical stages may include seedling emergence and flowering/grain formation.
- **Sampling technique** is important to ensure a representative portion of the crop has been monitored since pest activity is often patchy. Having defined sampling parameters (e.g. number of samples per paddock and number of leaves per sample) helps sampling consistency. Actual sampling technique, including sample size and number, will depend on crop type, age and paddock size, and is often a compromise between the ideal number and location of samples and what is practical regarding time constraints and distance covered.
- **Balancing random sampling with areas of obvious damage** is a matter of common sense. Random sampling aims to give a good overall picture of what is happening in the field, but any obvious hot-spots should also be investigated. The relative proportion of hotspots in a field must be kept in perspective with less heavily infested areas.

Keeping good records

Accurately recording the results of sampling is critical for good decision making and being able to review the success of control measures (Figure 1). Monitoring record sheets should show the following:

- numbers and types of insects found (including details of adults and immature stages);
- size of insects—this is particularly important for larvae;
- date and time; and
- crop stage and any other relevant information (e.g. row spacings, weather conditions, and general crop observations).

Consider putting the data collected into a visual form that enables you to see trends in pest numbers and plant condition over time. Being able to see whether an insect population is increasing, static or decreasing can be useful in deciding whether an insecticide treatment may be required, and if a treatment has been effective. If you have trouble identifying damage or insects present, keep samples or take photographs for later reference.


Site: Camerons
Date: 15/9/06
Row spacing: 75cm

Sample (1 m row beat)	VS	S	M	L
1	8	5	1	0
2	1	1	1	0
3	3	3	0	1
4	3	2	1	0
5	2	6	0	0
Average		3.4	0.6	0.2
Adjust for 30% mortality (S*0.7)	(3.4*0.7) = 2.4			
Mean estimate of larval number (Adjusted S)+M+L	2.4 0.6 0.2 = 3.2			

Adjust for row spacing divide by row spacing (m) 3.2 / 0.75

4.2 Density Estimate per square metre

Figure 1: *An example of a field check sheet for chickpeas, showing adjustments for field mortality and row spacings.*

Source: DAFF

Records of spray operations should include:

- date and time of day;
- conditions (wind speed, wind direction, temperature, presence of dew and humidity);
- product(s) used (including any additives);
- amount of product(s) and volume applied per hectare;
- method of application including nozzle types and spray pressure; and
- any other relevant details.

Sampling methods

Beat sheet

A beat sheet is the main tool used to sample row crops for pests and beneficial insects (Photo 1). Beat sheets are particularly effective for sampling caterpillars, bugs, aphids and mites. A standard beat sheet is made from yellow or white tarpaulin material with heavy dowel on each end. Beat sheets are generally between 1.3–1.5 m wide by 1.5–2.0 m deep (the larger dimensions are preferred for taller crops). The extra width on each side catches insects thrown out sideways when sampling and the sheet´s depth allows it to be draped over the adjacent plant row. This prevents insects being flung through or escaping through this row.

How to use the beat sheet:

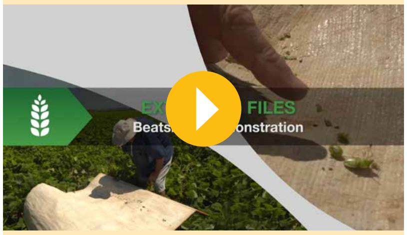
- Place the beat sheet with one edge at the base of plants in the row to be sampled.
- Drape the other end of the beat sheet over the adjacent row. This may be difficult in crops with wide row spacing (one metre or more) and in this case spread the sheet across the inter-row space and up against the base of the next row.
- Using a one-metre stick, shake the plants in the sample row vigorously in the direction of the beat sheet 5—10 times. This will dislodge the insects from the sample row onto the beat sheet.
- Reducing the number of beat sheet shakes per site greatly reduces sampling precision. The use of smaller beat sheets, such as small fertiliser bags, reduces sampling efficiency by as much as 50%.
- Use the datasheets to record type, number and size of insects found on the beat sheet.
- One beat does not equal one sample. The standard sample unit is five non-consecutive one-metre long lengths of row, taken within a 20 m radius, i.e. 5 beats = 1 sample unit. This should be repeated at six locations in the field (i.e. 30 beats per field).
- The more samples that are taken, the more accurate is the assessment of pest activity, particularly for pests that are patchily distributed such as pod sucking bug nymphs.

When to use the beat sheet:

- Crops should be checked weekly during the vegetative stage and twice weekly from the start of budding onwards.
- Caterpillar pests are not mobile within the canopy, and checking at any time of the day should report similar numbers.
- Pod-sucking bugs, particularly green vegetable bugs, often bask on the top of the canopy during the early morning and are more easily seen at this time.
- Some pod-sucking bugs, such as brown bean bugs, are more flighty in the middle of the day and therefore more difficult to detect when beat sheet sampling. Other insects (e.g. mirid adults) are flighty no matter what time of day they are sampled so it is important to count them first.
- In very windy weather, bean bugs, mirids and other small insects are likely to be blown off the beat sheet.

VIDEOS

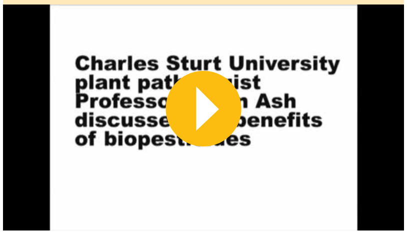
WATCH: GCTV16: Extension files—IPM Beatsheet Demo.



WATCH: How to use a sweep net to sample for insect pests.

WATCH: GRDC's Insect ID App.

WATCH: Biopesticides emerge as an alternative cropping tool.



- Using the beat sheet to determine insect numbers is difficult when the field and plants are wet.

While the recommended method for sampling most insects is the beat sheet, visual checking in buds and terminal structures may also be needed to supplement beat sheet counts of larvae and other more minor pests. Visual sampling will also assist in finding eggs of pests and beneficial insects.

Most thresholds are expressed as pests per square metre (pests/m^2). Hence, insect counts in crops with row spacing less than one metre must be converted to pests/m^2. To do this, divide the "average insect count per row metre" across all sites by the row spacing in metres. For example, in a crop with 0.75 m (75 cm) row spacing, divide the average pest counts by 0.75.

Other sampling methods

- **Visual checking** is not recommended as the sole form of insect checking, however it has an important support role. Leaflets or flowers should be separated when looking for eggs or small larvae, and leaves checked for the presence of aphids and silverleaf whitefly. If required, dig below the soil surface to assess soil insect activity. Visual checking of plants in a crop is also important for estimating how the crop is going in terms of average growth stage, pod retention and other agronomic factors.
- **Sweep net sampling** is less efficient than beat sheet sampling and can underestimate the abundance of pest insects present in the crop. Sweep netting can be used for flighty insects and is the easiest method for sampling mirids in broadacre crops or crops with narrow row spacing (Photo 1). It is also useful if the field is wet. Sweep netting works best for smaller pests found in the tops of smaller crops (e.g. mirids in mungbeans), is less efficient against larger pests such as pod-sucking bugs, and is not practical in tall crops with a dense canopy such as coastal or irrigated soybeans. At least 20 sweeps must be taken along a single 20 m row.
- **Suction sampling** is a quick and relatively easy way to sample for mirids. Its main drawbacks are unacceptably low sampling efficiency, a propensity to suck up flowers and bees, noisy operation, and high purchase cost of the suction machine.
- **Monitoring with traps** (pheromone, volatile, and light traps) can provide general evidence on pest activity and the timing of peak egg lay events for some species. However, it is no substitute for in-field monitoring of actual pest and beneficial numbers. [3]

Photo 1: *Sweep-netting for insects (left) and use of a beatsheet (right).*

Source: DAFWA and The Beatsheet

It has been found that, while narrow row spacing has been increasingly recommended as a means to increase crop yields, opting for the "wider" of the

3 DAFF (2012) Insect monitoring techniques for field crops, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/help-pages/insect-monitoring

narrow row spacing options had the most positive outcomes in terms of insect detection and management. [4]

For pest identification see the A-Z pest list or consult the GRDC Insect ID: The Ute Guide.

The Insect ID Ute Guide (Figure 2) is a comprehensive reference guide for insect pests commonly affecting broadacre crops across Australia, and includes the beneficial insects that may help to control them. Photos have been provided for multiple life-cycle stages, and each insect is described in detail, with information on the crops they attack, how they can be monitored and other pests that they may be confused with. Use of this app should result in better management of pests, increased farm profitability and improved chemical usage. [5]

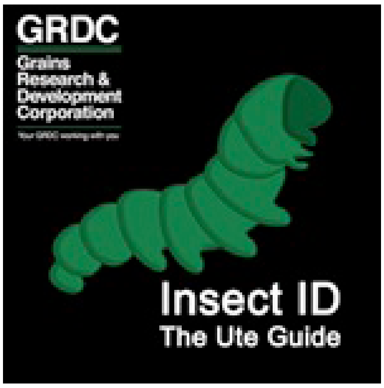


Figure 2: *GRDC's Ute Guide for insect identification is available as an app.*

Source: Grains Research and Development Corporation

MORE INFORMATION

IPM Guidelines website.

IPM Guidelines for Monitoring tools and techniques.

App features:

- region selection
- predictive search by common and scientific names
- compare photos of insects side by side with insects in the app
- identify beneficial predators and parasites of insect pests
- opt to download content updates in-app to ensure you're aware of the latest pests affecting crops for each region
- ensure awareness of international bio-security pests.

Insect ID, The Ute Guide is available on Android and iPhone.

Beneficials

Beneficial insects and other invertebrates ("beneficials") offer a variety of ecosystem services that are essential within agricultural environments and it is important to conserve and promote them as far as is practical within the constraints of controlling for major crop pests. For example, many beneficial species are important in soil health and nutrient cycling. Some beneficial invertebrates can also take the form of "natural enemies" of pest species and play a major role in the suppression of pest populations within our cropping systems. [6]

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4 GRDC (2016) What row spacing increases yield but decreases pest and disease pressure? Grains Research and Development Corporation, July 2016, https://grdc.com.au/Media-Centre/Hot-Topics/What-row-spacing-increases-yield-but-decreases-pest-and-disease-pressure

5 GRDC Apps. Grains Research and Development Corporation, https://grdc.com.au/Resources/Apps

6 GRDC (2011) Dont forget the good guys—recognising and identifying beneficial insects in your paddock. GRDC Update Papers. Grains Research and Development Corporation, September 2011, http://elibrary.grdc.com.au/ark%21%2133517/vhnf54t/nax0b3j

7.3 Russian wheat aphid

Key points:

- Russian wheat aphid (RWA) is found in all major cereal production regions around the world, however it has never been found in Australia before now.
- It is a major pest of cereal crops that injects toxins into the plant during feeding which retards growth and with heavy infestations, kills the plant.
- Affected plants will show whitish, yellow and red/purple leaf markings and rolling leaves.
- Russian wheat aphid is approximately 2 mm long, pale yellowish green with a fine waxy coating. The body is elongated compared with other cereal aphid species (Photo 2).

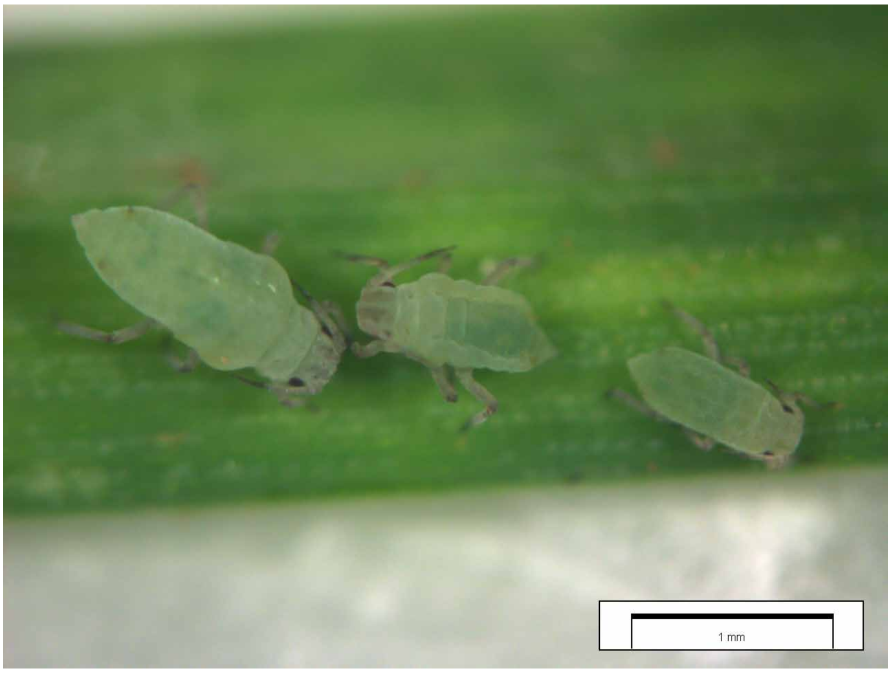


Photo 2: *The Russian wheat aphid (Diuraphis noxia).*

Photo: Michael Nash. Source: GRDC

According to South Australian Research and Development Institute (SARDI) entomologists, RWA is being regularly found in early-sown crops or those sown into paddocks containing volunteer cereals. In order of host preference based on overseas data, RWA tends to favour: barley, durum wheat, bread wheat, triticale, cereal rye and oats. [7]

Grain growers and advisers across the southern region are urged to monitor cereal paddocks closely for signs of damage caused by RWA.

If needed, growers should also implement a considered management strategy to control the pest.

It was recently declared not technically feasible to eradicate RWA from south-east Australia by the National Management Group (NMG) after it was first identified in a wheat crop at Tarlee in South Australia's mid north on May 13, 2016.

Since then, the aphid has been identified in many cropping regions across South Australia (Figure 4) and in the Wimmera and Mallee regions of Victoria.

In Victoria, 48 crop samples have been confirmed for RWA infestation (Figure 3):

7 Farming ahead (2016) Monitor RWA numbers closely over winter, http://www.farmingahead.com.au/articles/1/12169/2016-06-29/cropping/monitor-rwa-numbers-closely-over-winter

- 44 confirmed samples in an area bounded by Edenhope, Stawell, Bendigo, Echuca, Swan Hill, Manangatang, Patchewollock and the South Australian border.
- One sample to the west of Ararat; one sample to the west of Daylesford; one sample to the west of Werribee; and one sample to the south of Inverleigh (west of Geelong).

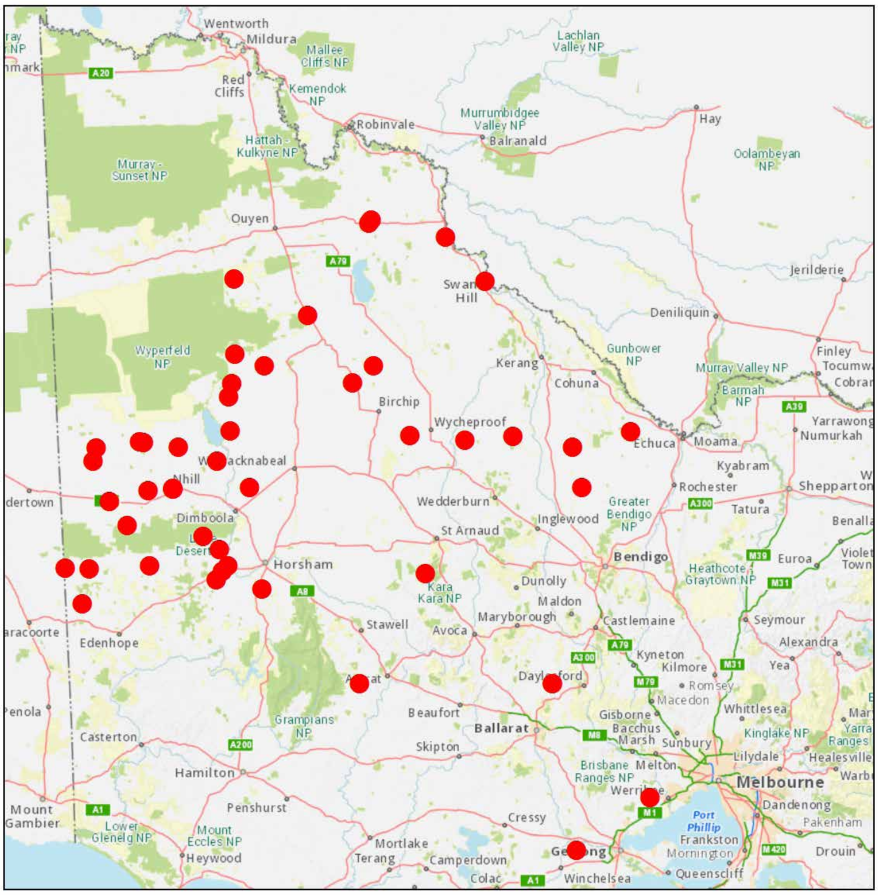


Figure 3: *Confirmed instances of Russian Wheat Aphid in Victoria.*

Source: AgVic

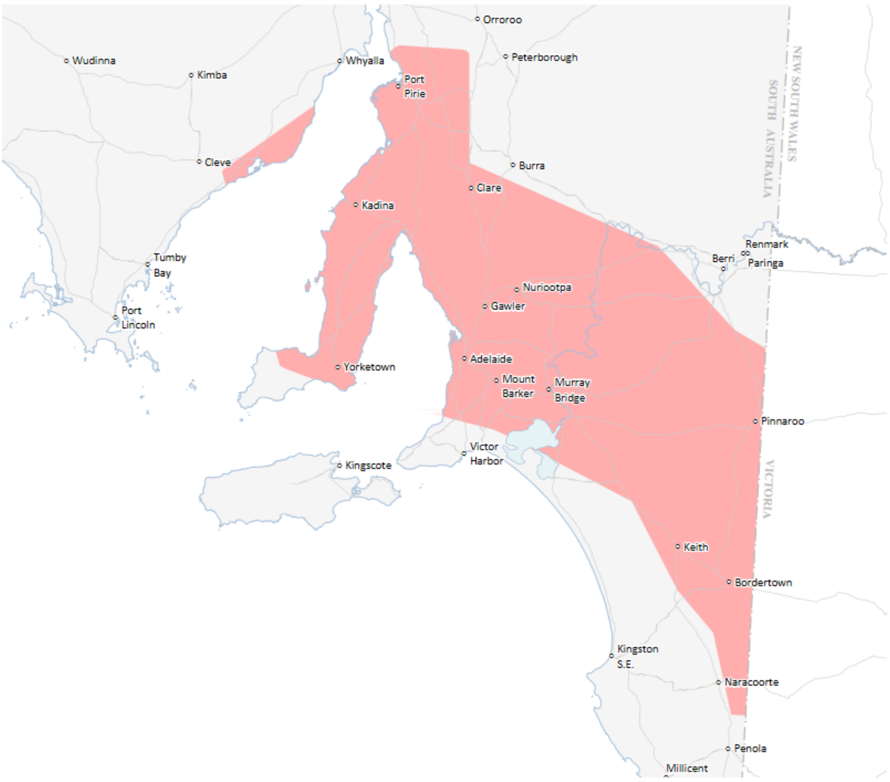


Figure 4: *Area affected by Russian Wheat Aphid in South Australia.*

Source: PIRSA

Following this declaration, experts are calling on growers and advisers to find, identify, consider aphid numbers and economic thresholds and enact a management strategy (FITE) if needed.

RWA is a major pest of cereal crops worldwide. It is easily spread by the wind and on live plant material.

It is asexual, meaning it does not need males and females to breed. The aphid takes about three weeks in winter and 10 to 14 days in mid-spring to reach maturity. It then continues to produce about two nymphs on a daily basis for two to four weeks, totalling 30—60 nymphs produced per female. This means it has a great capacity to increase numbers rapidly.

Further research is required to determine the impact of local environmental factors on RWA population dynamics. [8]

7.3.1 Damage caused by RWA

RWA differs from other common cereal aphid species in that it injects salivary toxins into the leaf of the host plant during feeding, which kills the photosynthetic chloroplasts and causes chlorosis and necrosis of the infested leaves. This retards growth and, in cases of heavy infestation, kills the plant. The effect of these toxins is localised and hence only infested leaves will show symptoms. Once the RWA infestation is controlled, new leaf growth is unaffected. [9]

Yield losses are proportionate to RWA abundance, measured as either percentage of plants infested or aphid numbers per shoot. According to overseas data, losses of 1 t/h occurred in plants 95% infested with RWA at GS59. In another overseas study,

8 Farming ahead (29 June 2016) Monitor RWA numbers closely over winter, http://www.farmingahead.com.au/articles/1/12169/2016-06-29/cropping/monitor-rwa-numbers-closely-over-winter

9 Farming ahead (29 June 2016) Monitor RWA numbers closely over winter, http://www.farmingahead.com.au/articles/1/12169/2016-06-29/cropping/monitor-rwa-numbers-closely-over-winter

losses increased from 18% with 15-20 aphids per shoot to 79% with 185–205 aphids per shoot. [10]

7.3.2 Where to look and what to look for

According to South Australian Research and Development Institute (SARDI) entomologists, RWA is being regularly found in early-sown crops or those sown into paddocks containing volunteer cereals. There are also a number of grass weed and pasture hosts of RWA, including: barley grass, brome grass (particularly favourable, based on overseas information), fescue, ryegrass, wild oats, phalaris and couch grass.

Symptoms of RWA damage include longitudinal rolling of leaves where the aphids shelter and whitish, yellowish to pink-purple chlorotic streaks along the length of the leaves. These symptoms can often be confused with nutrient deficiency or herbicide damage from bleaching herbicides such as diflufenican.

RWA are approximately two millimetres long and a pale yellowish green colour with a fine, waxy coating. The lack of visible cornicles and elongated body distinguishes RWA from common cereal aphid species.

RWA can be confused with the rose grain aphid; however, it differs due to its dark or black eyes, double short “tails” (caudal processes), short antennae and apparent lack of cornicles (Figure 5).

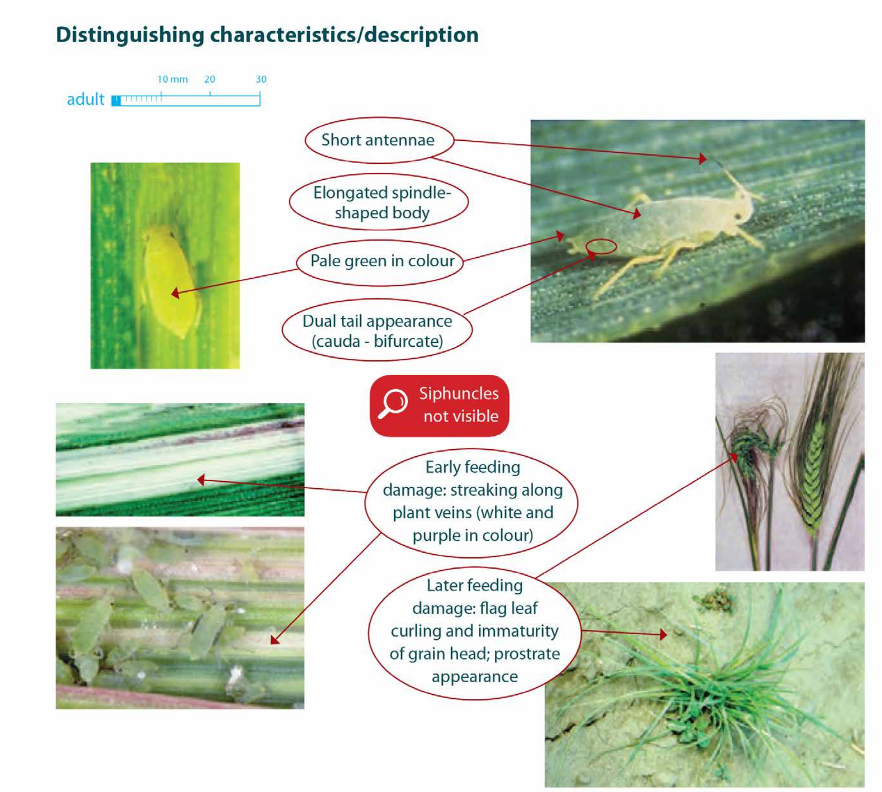


Figure 5: *Russian wheat aphid, distinguishing characteristics.*

Photo: Frank Peairs. Source: GRDC

Growers are encouraged to work with their agronomist or seek expert advice from an entomologist to help positively identify RWA if they are unsure.

State agriculture departments are keen to take samples of RWA in order to build up scientific information about the pest and sample different populations.

10 A Lawson (2016) Monitor RWA numbers closely over winter, https://grdc.com.au/Media-Centre/GRDC-E-Newsletters/Paddock-Practices/Monitor-RWA-numbers-closely-over-winter

Measures to increase the likelihood of RWA detection

- Target early sown cereal crops and volunteer cereals (and brome grass if present), particularly along crop edges.
- Follow a repeatable sampling pattern, which targets early sown and volunteer plants. A perimeter search and a 'W' shaped search pattern through each paddock will give a consistent sampling effort
- Look for RWA symptomatic plants:
- Rolling of terminal and sub-terminal leaves (Growth stage 20 and above).
- Longitudinal whitish to pink-purplish streaking of leaves (Growth stage 20 and above, Photo 3).
- Deformed "goose-neck" head as result of awn trapped by unrolled flag leaves (Growth stage 50 and above, Photo 4).

Photo 3: *Plants damaged by toxins from feeding Russian wheat aphid (Diuraphis noxia), showing stunting and longitudinal striping on tightly rolled leaves.*

Source: FAO

Photo 4: *Fish hook" deformation of a cereal head (right), caused by feeding Russian wheat aphid compared to a normal cereal head (left).*

Source: FAO

Where to find the RWA

Search within:

- Rolled leaves, particularly in the leaf base (Photo 5).
- Leaf sheaths.
- In high numbers RWA are being found active on exposed parts at base of plants.

MORE INFORMATION

Taking and submitting samples for identification.

- At low densities, plant beating has proven successful for detection. [11]

Photo 5: *Colony of Russian wheat aphids.*

Photo: Frank Peairs. Source: PIRSA

7.3.3 Thresholds for control

While registered chemical control tactics will be important in managing infestations of RWA, growers are encouraged to consider international economic thresholds (below) as a guide for when to spray for the pest.

Whilst the economic thresholds for control still need to be determined under Australian conditions, aphid numbers should be a key consideration before making the decision to spray. The key message is to not implement prophylactic insecticide applications and to reconsider the need to spray where RWA is only present in very low numbers.

Current international advice suggests an economic threshold of 20% of plants infested up to the start of tillering and 10% of plants infested thereafter. These thresholds serve as a guide and need to be considered based upon the individual situation. The decision to spray should be based upon a wide range of factors including:

- Aphid numbers.
- Crop growth stage and time of season.
- Crop yield potential.
- Cost of the control option to be employed.
- Beneficial insect populations.
- Yield loss under Australian conditions.
- Forecast weather conditions.
- Other insect pest species present.

In the majority of cases identified in SA and Victoria to date, RWA has been present in very low numbers and infestations have been well below international economic thresholds. Regular monitoring of aphid numbers through winter and spring will be required to ensure appropriate control measures may be implemented as required. Overseas data indicates that RWA is susceptible to heavy winter rainfall, and the combination of cold and wet weather will help check its build-up during mid-winter.

To ensure protection of the major yield contributing leaves it is most important to control RWA below threshold levels from the start of stem elongation, through flag leaf development and ear emergence. As a result, vigilant monitoring for RWA is encouraged during these crop stages (growth stage 30–60), and should continue through flowering to dough development. [12]

11 PIRSA (2016) Russian wheat aphid—paddock surveillance, http://www.pir.sa.gov.au/biosecurity/plant_health/exotic_plant_pest_emergency_response/russian_wheat_aphid

12 A Lawson (2016) Monitor RWA numbers closely over winter, https://grdc.com.au/Media-Centre/GRDC-E-Newsletters/Paddock-Practices/Monitor-RWA-numbers-closely-over-winter

7.3.4 Management of RWA

Control options

An emergency Australian Pesticides and Veterinary Medicines Authority (APVMA) permit (PER82792) has been issued for the use of products containing 500 g/L chlorpyrifos (rate: 1.2 L/ha), with a LI700 surfactant (rate: 240 ml/ha), and products containing 500 g/kg pirimicarb (rate: 200-250 g/ha) to control RWA in winter cereals.

An Australian Pesticides and Veterinary Medicines Authority (APVMA) permit (PER82304) has been issued for the use of products containing 600 g/L IMIDACLOPRID as their only active constituent. Application rate 120 mL product / 100 kg seed. This is for seed treatment only for the control of RWA in winter cereals.

The permit must be read and understood by all persons operating in accordance with it.

The Australian Pesticides and Veterinary Medicines Authority (APVMA) have issued an emergency permit (82792) for growers to control Russian wheat aphid.

- Permit 82792
- Permit 82792

A new permit has been issued by the Australian Pesticides and Veterinary Medicines Authority (APVMA) for growers to control Russian wheat aphid during seed treatment over winter.

- Permit 82304
- Permit 82304

Chemical users must read and understand all sections of chemical labels and permits prior to use. There are numerous statements (e.g. DO NOT statements) on product labels that are critical in the managing risks associated with the use of chemicals. Examples of such statements include:

- DO NOT spray any plants in flower while bees are foraging.
- DO NOT re-apply to the same crop within seven days (unless specifically recommended in the directions for Use).
- DO NOT apply if heavy rains or storms that are likely to cause surface runoff are forecast in the immediate area within two days of application.
- DO NOT allow animals or poultry access to treated area within three days of application.

Bees

As for all field chemical use, it is recommended that users consider the risks of chemical use to bees that may be present in the local area. Chemical users are encouraged to contact hive owners as soon as possible so that they can take appropriate steps to minimise the risks to their hives.

Contact details can generally be found on the hive(s) or you can contact the land owner on which the hives are located.

General instructions

- Read and follow the APVMA permit and labels of associated chemical products.
- Ensure all DO NOT statements and relevant Withholding Periods, Export Slaughter Intervals (ESIs) and Export Grazing Interval (EGIs) are observed.
- Adopt best-practice farm hygiene procedures to retard the spread of the pest between fields and adjacent properties.
- Keep traffic out of affected areas and minimise movement in adjacent areas. [13]

MORE INFORMATION

Russian wheat aphid—a new pest for Australian cereal crops

Ramp up monitoring for Russian wheat aphid

Monitor RWA numbers closely over winter

Russian wheat aphid—Plant health Australia

VIDEOS

WATCH: GCTV20: Russian wheat aphid—recommendations for ongoing treatment.

WATCH: Integrated pest management to combat the Russian wheat aphid.

13 Agriculture Victoria (2016) RWA treatment factsheet. http://agriculture.vic.gov.au/__data/assets/word_doc/0017/321164/Final-RWA-Treatment-Factsheet.docx-.docx

7.4 Other Aphids

Aphids are usually regarded as a minor pest of winter cereals, but in some seasons, they can build up to very high densities.

Four different species of aphid can infest winter cereals:

1. Oat or wheat aphid
2. Corn aphid
3. Rose-grain aphid
4. Rice root aphid

Aphids are a group of soft-bodied bugs commonly found in a wide range of crops and pastures. Identification of crop aphids is very important when making control decisions. Distinguishing between aphids can be easy in the non-winged form but challenging with winged aphids. See a pictorial guide to distinguishing winged aphids.

7.4.1 Oat or wheat aphid

The oat aphid is a relatively common aphid that is most prevalent in wheat and oats. This aphid has an olive green body with a characteristic rust-red patch on the end of the abdomen. Oat aphids are an important vector of barley yellow dwarf virus (BYDV). They can affect cereals by spreading BYDV as well as by direct feeding damage to plants when in sufficient numbers. When populations exceed thresholds, the use of targeted spraying with selective insecticides is recommended.

The oat aphid is an introduced species that is a common pest of cereals and pasture grasses. They are widespread and found in all states of Australia. Oat aphids typically colonise the lower portion of plants, with infestations extending from around the plant's base, up on to the leaves and stems.

Oat aphids vary in colour from olive-green to greenish black and are usually identifiable by a dark rust-red patch on the tip of the abdomen, although under some conditions this is not apparent. Adults are approximately 2 mm long, pear-shaped and have antennae that extend half the body length (Figure 6). Adults may be winged or wingless and tend to develop wings when plants become overcrowded or unsuitable. [14]

14 P Umina, S Hangartner (2015) Oat aphid. Cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

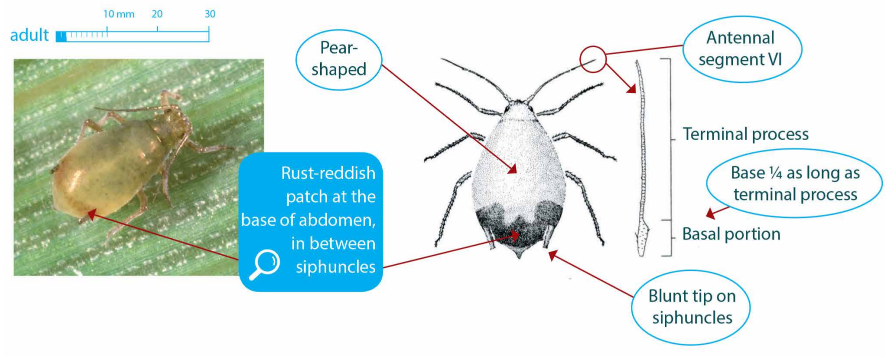


Figure 6: *Distinguishing characteristics of oat or wheat aphids.*

Source: Bellati et al. (2012), in Cesar

7.4.2 Corn aphid

Corn aphids are introduced, and are a relatively minor pest of cereal crops. They attack all crop stages but most damage occurs when high populations infest cereal heads. Corn aphids are most prevalent in years when there is an early break to the season followed by mild weather conditions in autumn. Corn aphids transmit a number of plant viruses, which can cause significant yield losses.

Corn aphids are light green to dark green, with two darker patches at the base of each cornicle (siphuncle). Adults grow up to 2 mm long, have an oblong-shaped body and antennae that extend to about a third of the body length (Figure 7). The legs and antennae are typically darker in colour.

Nymphs are similar to adults but smaller in size and always wingless, whereas adults may be winged or wingless. [15]

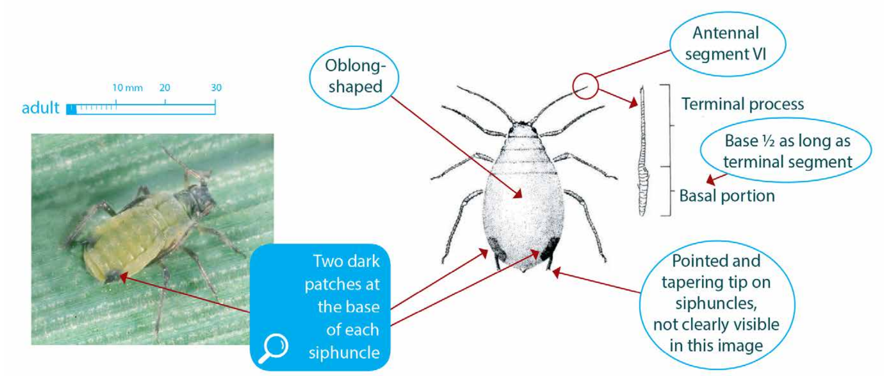


Figure 7: *Distinguishing characteristics of corn aphids.*

Source: Bellati et al. (2012) in Cesar

7.4.3 Rose-grain aphid

Rose-grain aphids are an introduced species that has been recorded in SA, Victoria, Tasmania, NSW and Queensland.

Adults and nymphs are sapsuckers. Under heavy infestations, plants may turn yellow and appear unthrifty. Rose-grain aphids can spread barley yellow dwarf virus in wheat and barley.

Adults are 3 mm long, green to yellow-green with long and pale siphunculi (tube-like projections on either side at the rear of the body) and may have wings (Photo 6). There is a dark green stripe down the middle of the back. Antennae reach beyond

15 P Umina, S Hangartner (2015) Oat aphid. Cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Corn-aphid

the base of the siphunculi. Nymphs are similar but smaller. Because of its distinctive colour, it is unlikely to be confused with other aphids.

Photo 6: *Adult Rose-grain aphid with nymphs.*

Source: QDAFF

7.4.4 Conditions favouring aphid development

Aphids can be found all year round, often persisting on a range of volunteer grasses and self-sown cereals during summer and early autumn. Winged aphids fly into crops from grass weeds, pasture grasses or other cereal crops, and colonies of aphids start to build up within the crop.

Aphids are most prevalent on cereals in late winter and early spring. High numbers often occur in years when there is an early break in the season and mild weather in autumn and early winter provide favourable conditions for colonisation and multiplication.

- Oat aphid—basal leaves, stems and back of ears of wheat, barley, oats.
- Corn aphid—inside the leaf whorl of the plant; cast skins indicate their presence; seldom on wheat or oats.
- Grain aphid—colonises the younger leaves and ears of wheat, oats and barley;
- Rose-grain aphid—underside of lower leaves and moves upwards as these leaves die. [16]

Aphids can reproduce both asexually and sexually, however, in Australia, the sexual phase is often lost. Aphids reproduce asexually whereby females give birth to live young.

Temperatures during autumn and spring are optimal for aphid survival and reproduction. During these times, the aphid populations may undergo several generations. Populations peak in late winter and early spring; development rates are particularly favoured when daily maximum temperatures reach 20–25°C.

Young wingless aphid nymphs develop through several growth stages, moulting at each stage into a larger individual. Plants can become sticky with honeydew excreted by the aphids. When plants become unsuitable or overcrowding occurs, the population produces winged aphids (alates), which can migrate to other plants or crops.

16 IPM Guidelines (2016) Aphids in winter cereals, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

7.4.5 Damage caused by aphids

Aphids can impair growth in the early stages of crop and prolonged infestations can reduce tillering and result in earlier leaf senescence. Some research indicates that aphid infestations can reduce yield by ~10% on average. Infestations during booting to milky dough stage, particularly where aphids are colonising the flag leaf, stem and ear, result in yield loss, and aphid infestations during grainfill may result in low protein grain. As aphids may compete with the crop for nitrogen, crops grown with marginal levels of nitrogen can be more susceptible to the impact of an aphid infestation.

Aphids feed directly on stems, leaves and heads, and in high densities cause yield losses and plants may appear generally unthrifty. This type of damage is rare throughout the grainbelt. Aphids can spread Barley yellow dwarf virus in wheat and barley. [17]

Aphids can damage crops by spreading viruses or causing direct damage when feeding on plants. Feeding damage generally requires large populations, but virus transmission can occur before aphids are seen to be present. Pre-emptive management is required to minimise the risk of aphids and their transmission of viruses. Viruses are widespread in cereal, pulse and oilseed crops throughout southern and western Australia and can cause significant economic losses, especially when extensive infection occurs in early crop growth. Aphids are the principal, but not sole, vectors of viruses in crops; some are also transmitted in seed. A few aphids can cause substantial damage if they are spreading viruses, especially early in the season. it takes large numbers of aphids to damage crops by direct feeding. different aphid species transmit different viruses to particular crop types; species identification is important because management strategies can vary. integrated management practices that aim to control aphid populations early in the season are important to minimising virus spread. [18]

7.4.6 Thresholds for control

When determining economic thresholds for aphids, it is critical to consider several other factors before making a decision. Most importantly, the current growing conditions and moisture availability should be assessed. Crops that are not moisture stressed have a greater ability to compensate for aphid damage and will generally be able to tolerate far higher infestations than moisture stressed plants before a yield loss occurs.

Recommended control thresholds are more than 15 aphids per tiller on 50% of tillers if the expected yield will exceed 3 t/ha.

Thresholds for managing aphids to prevent the incursion of aphid-vectored virus have not been established and will be much lower than any threshold to prevent yield loss via direct feeding. [19]

Aphid populations can decline rapidly, which may make control unnecessary. In many years, aphid populations will not reach threshold levels.

7.4.7 Management of aphids

Though aphid numbers are rarely high enough to warrant control, it is important to know the critical periods for aphid management (Figure 8).

17 DAFQ (2012) Insect pest management in winter cereals. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

18 GRDC. (2010). Aphids and viruses in pulse crops Fact sheet – western and southern regions. https://grdc.com.au/uploads/documents/GRDC_FS_AphidsAndViruses.pdf

19 P Umina, S Hangartner (2015) Oat aphid. Cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

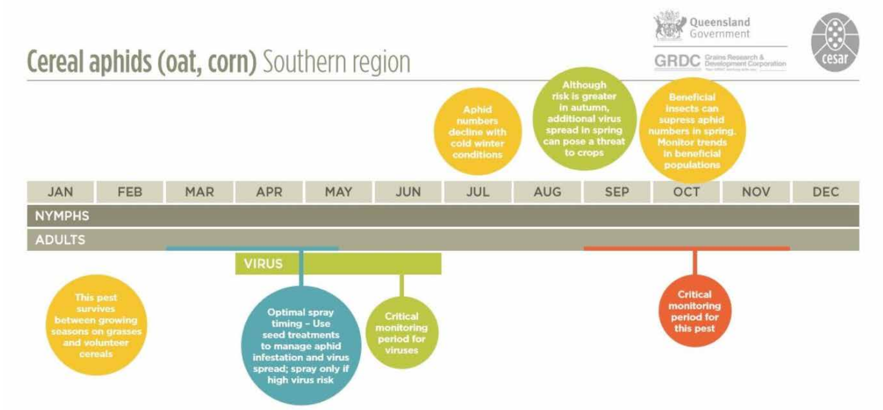


Figure 8: *Lifecycles, critical monitoring and management periods for cereal aphids in the southern region of Australia.*

Source: cesar and QDAFF

Biological control

There are many effective natural enemies of aphids. Hoverfly larvae, lacewings, ladybird beetles and damsel bugs are known predators that can suppress populations. Aphid parasitic wasps lay eggs inside bodies of aphids and evidence of parasitism is seen as bronze-coloured enlarged aphid "mummies". As mummies develop at the latter stages of wasp development inside the aphid host, it is likely that many more aphids have been parasitized than indicated by the proportion of mummies. Naturally occurring aphid fungal diseases (*Pandora neoaphidis* and *Conidiobolyus obscurus*) can also suppress aphid populations.

Cultural control to manage MYDV threat from aphids

Sowing resistant cereal varieties is the most effective method of reducing losses to BYDV. See crop variety guides for susceptibility ratings.

Control summer and autumn weeds in and around crops, particularly volunteer cereals and grasses, to reduce the availability of alternate hosts between growing seasons.

Where feasible, sow into standing stubble and use a high sowing rate to achieve a dense crop canopy, which will assist in deterring aphid landings.

Delayed sowing avoids the autumn peak of cereal aphid activity and reduces the incidence of BYDV. However, delaying sowing generally reduces yields, and this loss must be balanced against the benefit of lower virus incidences.

Chemical control

The use of insecticide seed treatments can delay aphid colonisation and reduce early infestation, aphid feeding and the spread of cereal viruses.

There are several insecticides registered against corn aphids in various crops including cereals. A border spray in autumn/early winter, when aphids begin to move into crops, may provide sufficient control without the need to spray the entire paddock.

Avoid the use of broad-spectrum "insurance" sprays, and apply insecticides only after monitoring and distinguishing between aphid species. Consider the populations of beneficial insects before making a decision to spray, particularly in spring when these natural enemies can play a very important role in suppressing aphid populations if left untouched. [20]

20 P Umina, S Hangartner (2015) Oat aphid. Cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid

Monitoring

Monitor all crop stages from seedling stage onwards. Look on leaf sheaths, stems, within whorls and heads, and record the number of large and small aphids (adults and juveniles), beneficials (including parasitised mummies), and the impact of the infestation on the crop.

Stem elongation to late flowering is the most vulnerable stage. Frequent monitoring is required to detect rapid increases of aphid populations.

Check regularly—at least five points in the field and sample 20 plants at each point. Populations may be patchy—densities at crop edges may not be representative of the whole field.

Average number of aphids per stem/tiller samples gives a useful measurement of their density. Repeated sampling will provide information on whether the population is increasing (lots of juveniles relative to adults), stable, or declining (lots of adults and winged adults). [21]

7.5 Armyworm

Armyworms are caterpillar pests of grass pastures and cereal crops. They are the only caterpillars that growers are likely to encounter in cereal crops, although occasionally native budworm will attack grain when underlying weed hosts dry out. Armyworms mostly feed on leaves, but under certain circumstances will feed on the seed stem, resulting in head loss. The change in feeding habit is caused by depletion of green leaf material or crowding. In the unusual event of extreme food depletion and crowding, they will "march" out of crops and pastures in search of food, which gives them the name "armyworm".

There are three common species of armyworm found in southern Australia:

- Common armyworm (*Mythimna convecta*)
- Southern armyworm (*Persectania ewingii*)
- Inland armyworm (*Persectania dyscrita*)

These are native pests. Common armyworm (*Leucania convecta*) is found in all states of Australia and potentially will invade all major broadacre-cropping regions year round, but particularly in spring and summer. The *Persectania* species are more typically found in southern regions of Australian autumn and winter, but their activity can sometimes extend into spring.

Caterpillars of the three species are similar in appearance. They grow from about 2–40 mm in length. They have three prominent white or cream stripes running down the back and sides of their bodies. These are most obvious where they start on the thoracic segment ("collar") immediately behind the head, and become particularly apparent in larvae that are >10 mm. They have no obvious hairs, are smooth to touch and curl up when disturbed. Armyworms have four abdominal prolegs (Figure 9).

Mature caterpillars are 30–40 mm long. For an accurate identification, they must be reared through to the adult (moth) stage.

Armyworms can be distinguished from other caterpillar pests that may be found in the same place by three pale stripes running the length of the body; these stay constant no matter the variation in the colour of the body.

Other species of caterpillar that may be confused with armyworms include:

- Loopers (tobacco looper or brown pasture looper) walk with a distinct looping action and have one or two pairs of abdominal prolegs. Armyworms have four pairs, and when >10 mm do not walk with a looping action.
- Budworm larvae have prominent but sparse hairs and bumps on their skin; anthelid larvae are covered in hairs. Armyworms are smooth bodied with no obvious hairs.

21 IPM Guidelines (2016) Aphids in winter cereals, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

- Cabbage moth larvae wriggle vigorously when disturbed. Armyworms curl up into a tight "C".
- Cutworm (brown or common cutworm) larvae have no obvious stripes or markings and are uniformly brown, pink or black.

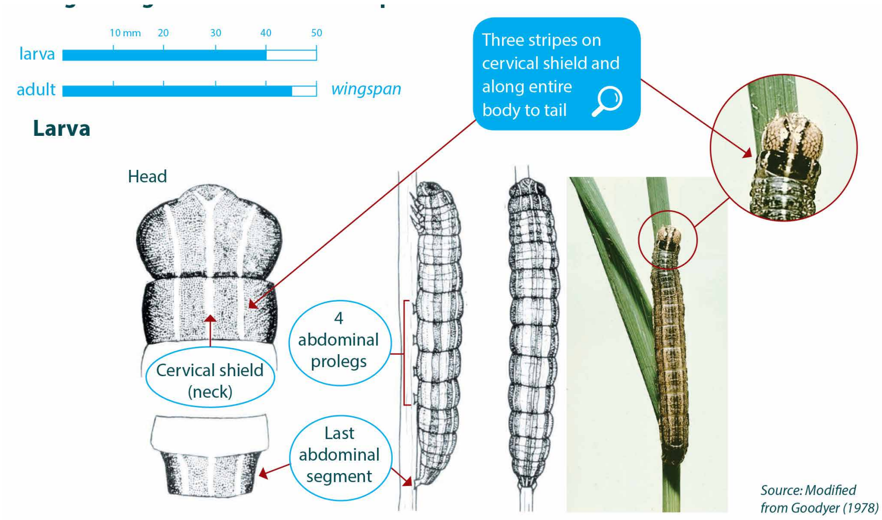


Figure 9: *Distinguishing characteristics of Armyworm larvae.*

Source: cesar

Adults

Moths are often seen flying on warm, humid nights. They are medium-sized, with a wingspan of 30–40 mm. Each species has a characteristic colour and wing markings.

Southern armyworm: grey-brown to red-brown forewings with white zigzag markings on the outer tips and a pointed white "dagger" in the middle of the forewing. The hind wings are dark grey (Figure 10).

Inland armyworm: similar to the southern armyworm except that the white "dagger" in the centre of the forewing is divided into two discrete light ellipses which almost touch. The hind wings are pale grey.

Common armyworm: the forewings are dull yellow to red-brown, speckled with tiny black dots and a small white dot near the centre.

Pupae of all three species are about 20 mm long, shiny brown and are found under clods or within cracks in the soil. [22]

22 G McDonald (1995) Armyworms, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

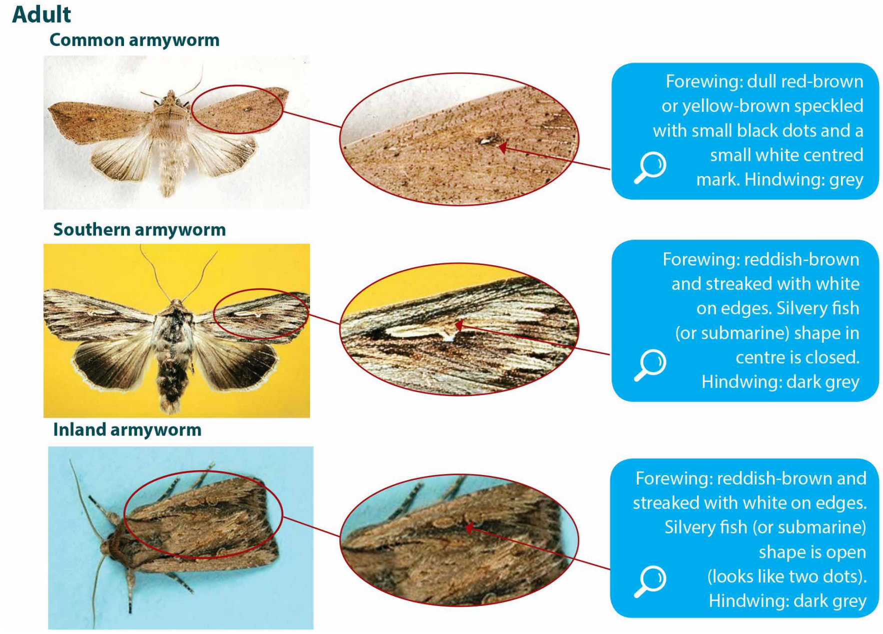


Figure 10: *Distinguishing characteristics of the three Armyworm adult moth species.*

Source: cesar

7.5.1 Damage caused by armyworms

- Prefer lush growth that provides good cover and protection.
- Feed on leaf tissue—leaf margins have tattered/chewed/scalloped appearance; in extreme cases whole leaves may be severed at the stem.
- Caterpillars produce green/straw coloured droppings (size of match head). These are visible between the rows.
- Bare patches adjacent to barley fields or damage to weeds may indicate armyworm presence before it is evident in crops. [23]

The young larvae feed initially from the leaf surface of pasture grasses and cereals. As the winter and spring progress and the larvae grow, they chew “scallop” marks from the leaf edges. This becomes increasingly evident by mid to late winter. By the end of winter or early spring, the larvae are reaching full growth and maximum food consumption. It is this stage that farmers most frequently notice as complete leaves and tillers may be consumed or removed from the plant.

Damaging infestations or outbreaks occur in three situations:

In winter when young tillering cereals are attacked and can be completely defoliated. The caterpillars may come from:

- the standing stubble from the previous year's cereal crop, in which the eggs are laid; or
- neighbouring pastures that dry out, resulting in the resident armyworms being forced to march into the crop.

In spring / early summer when crops commence ripening and seed heads may be lopped.

In early summer when grass pastures are cut for hay, particularly in Gippsland.

Leaves of cereal plants or grasses appear chewed ("leaf scalloping") along the edges. The most damage, however, is caused in ripening crops when the foliage dries off. The armyworms then begin to eat any green areas remaining. In cereals, the last section of the stem to dry out is usually just below the seed head. Armyworms, particularly the older ones, that chew at this vulnerable spot cause lopping of the

23 IPM Guidelines (2016) Armyworm, http://ipmguidelinesforgrains.com.au/pests/armyworm/

MORE INFORMATION

Armyworms—Agriculture Victoria.

heads and can devastate a crop nearing maturity in one or two nights. Generally, the larger the armyworm, the greater the damage. In wheat and barley, whole heads are severed, while in oats individual grains are bitten off below the glumes.

The crops affected include all Gramineae crops including cereals, grassy pastures, corn and maize.

7.5.2 Thresholds for control

Economic threshold estimated at a minimum of 10 grubs/m^2 (higher than barley as heads are rarely lopped). [24]

For winter outbreaks (during tillering), economic thresholds of 8–10 larvae/m^2 provide a guide for spray decisions. For spring outbreaks (during crop ripening) spraying is recommended when the density of larvae exceeds 1–3 larvae/m^2 although this figure must be interpreted in the light of:

- timing of harvest;
- green matter available in the crop;
- expected return on the crop; and
- larval development stage (if most are greater than 35–40 mm or pupating, it may not be worth spraying). [25]

7.5.3 Managing armyworms

Sampling and detection

Signs of the presence of armyworms include:

- Chewing/leaf scalloping along the leaf margins.
- Caterpillar excreta or "frass" which collects on leaves or at the base of the plant. These appear as green or yellow cylindrical pellets 1–2 mm long.
- Cereal heads or oat grains on the ground. Oat grains may be attached to a small piece of stalk (1–2 mm), whereas wind removed grains are not. Barley heads may be severed completely, or hang from the plant by a small piece of stalk.

Early detection is essential, particularly when cereals and pasture seed or hay crops are at the late ripening stage. Although accurate estimates of caterpillar densities require considerable effort, the cost saving is worthwhile.

Sampling can be achieved by using a sweep-net/bucket, or visually ground or crop searching for either caterpillars or damage symptoms.

The sweep-net/bucket method provides a rapid and approximate estimate of infestation size. The net or bucket should be swept across the crop in 180° arcs several times—preferably 100 times—at different sites within the crop to give an indication of density and spread. Armyworms are most active at night, so sweeping will be most effective at dusk. Average catches of more than 5—10 per 100 sweeps suggest that further searches on the ground are warranted to determine approximate densities.

When ground sampling, it is necessary to do at least ten "spot checks" in the crop, counting the number of caterpillars within a square metre.

Most farmers fail to detect armyworms until the larvae are almost fully grown, and 10–20% damage may result. The earlier the detection, the less the damage. The young larvae (up to 8 mm) cause very little damage, and are more difficult to find. The critical time to look for armyworms is the last 3–4 weeks before harvest. [26]

It is important to know the critical periods for control in armyworms (Figure 11).

24 IPM Guidelines (2016) Armyworm, http://ipmguidelinesforgrains.com.au/pests/armyworm/

25 G McDonald (1995) Armyworms, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

26 G McDonald (1995) Armyworms, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

Figure 11: *Critical periods for control in armyworms.*

Source: cesar

Biological control

Around 20 species of predator and parasitoids have been recorded attacking armyworm. The most frequently observed predators are predatory shield bugs, ladybeetles, carabid beetles, lacewings and common brown earwigs. Parasitoids include tachnid flies and a number of wasp species (e.g. *Netelia*, *Lissopimpla*, *Campoletis*). Viral and fungal diseases are recorded as causing mortality of armyworm. Such outbreaks are more common at high armyworm densities.

Cultural control

Control weeds to remove alternative hosts. Armyworm often feed on ryegrass before moving into cereal crops.

Standing stubble from previous crops, dead leaves on crops and grassy weeds are suitable sites for female armyworm to lay eggs.

Larvae can move into cereals if adjacent pastures are chemically fallowed, spray topped or cultivated in spring. Monitor for at least a week post treatment. Damage is generally confined to crop margins.

Chemical control

Effectiveness requires good coverage to get contact with the caterpillars. Control is more difficult in high-yielding crops with thick canopies where larvae are resting under leaf litter at the base of plants.

Armyworms are active at night—spray late afternoon or early evening to maximum likelihood of contact.

Be aware of withholding periods when chemical control is used close to harvest. [27]

7.6 Cutworm (*Agrotis* spp.)

Cutworms are caterpillars of several species of night-flying moths, one of which is the well-known bogong moth. The mature grubs are plump, smooth caterpillars (Photo 7). The caterpillars are called cutworms because they cut down young plants as they feed on stems at or below the soil surface. They are most damaging when caterpillars transfer from summer and autumn weeds onto newly emerged seedlings. Natural predators and early control of summer and autumn weeds will help reduce larval survival prior to crop emergence. If required, cutworms can be controlled with insecticides; spot spraying may provide adequate control.

27 IPM Guidelines (2016) Armyworm, http://ipmguidelinesforgrains.com.au/pests/armyworm/

Photo 7: *Cutworm larva in typical curled position when disturbed.*

Source: cesar

Cutworms are sporadic pests that are widely distributed in SA, Tasmania, Victoria, WA, NSW and Queensland. Winter generation moths emerge in late spring and summer. Eggs are laid onto summer and autumn weeds, where larvae can then emerge onto newly sown crops.

There are several species of pest cutworms that are all similar in appearance. Generally larvae of all species grow to about 40–50 mm long and are relatively hairless, with a distinctly plump, greasy appearance and dark head (Figure 12).

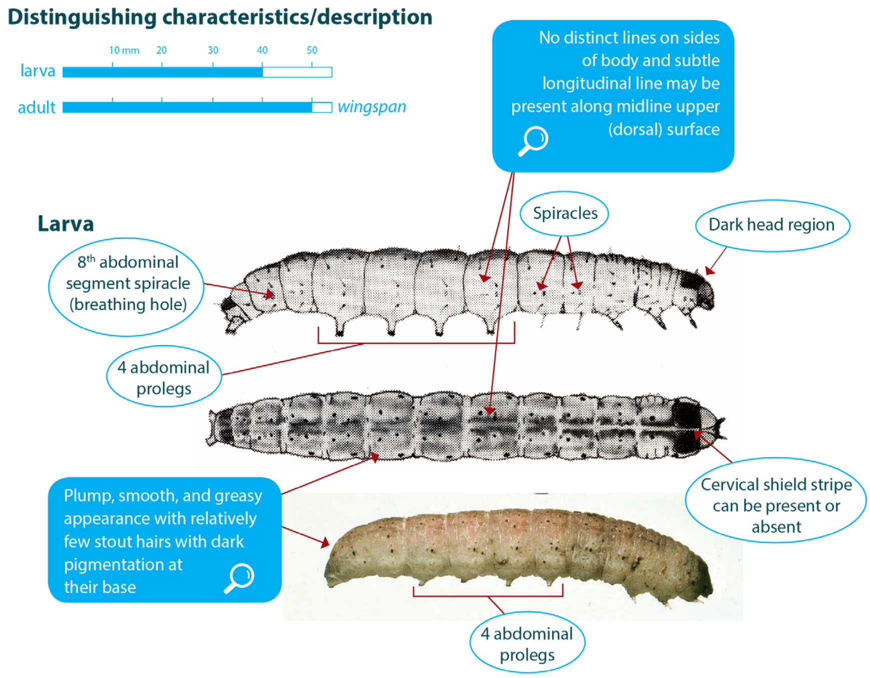


Figure 12: *Distinguishing characteristics of the cutworm.*

Source: Bellati et al. (2012) in cesar

Moths of the common cutworm (sometimes referred to as Bogong moths) have dark brown or grey-black forewings with dark arrow markings on either wing above a dark streak broken by two lighter coloured dots (Figure 13). Moths of the pink cutworm have grey-brown forewings with darker markings and streaks and a large inner light mark and darker outer mark. Moths of the black cutworm have brown or grey-black forewings with a dark arrow-mark streak broken by two dark ring-shaped dots.

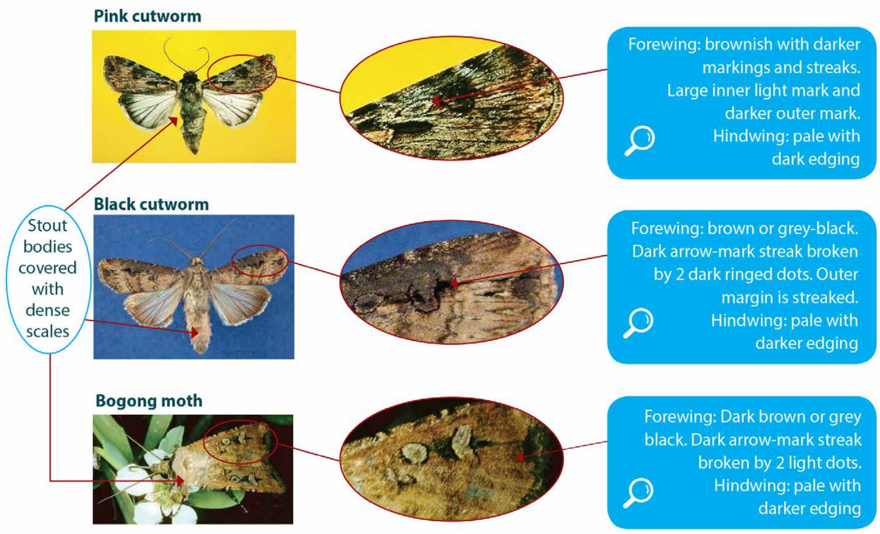


Figure 13: *Distinguishing characteristics of the adult forms of the pink, black and common cutworm.*

Source: Bellati et al. (2012) in cesar

7.6.1 Damage caused by cutworms

Larvae feed at ground level, chewing through leaves and stems. Stems are often cut off at the base, hence the name “cutworm”. Winter crops are most susceptible in autumn and winter, although damage can occur throughout the year, especially in irrigated crops. Damage mostly occurs at night when larvae are active. When numbers of larvae are high, crops can be severely thinned (Figure 8). Smaller larvae can cause similar damage to lucerne flea when they feed on leaf surface tissue. Young plants are favoured and are more adversely affected than older plants.

Occasionally, another undescribed genus of caterpillars marked with a herringbone pattern on their abdomen inflict cutworm-like damage on emerging crops.

Photo 8: *Pink cutworm damage to the plant and paddock.*

Source: cesar

7.6.2 Thresholds for control

Treatment of cereals and canola is warranted if there are two or more larvae per 0.5 m of row.

7.6.3 Managing cutworm

Figure 14: *Critical periods for controlling cutworm.*

Source: cesar

Biological

Naturally occurring insect fungal diseases that affect cutworms can reduce populations. Wasp and fly parasitoids, including the orange caterpillar parasite (*Netelia producta*), the two-toned caterpillar parasite (*Heteropelma scaposum*) and the orchid dupe (*Lissopimpla excelsa*) can suppress cutworm populations. Spiders are generalist predators so will also prey upon cutworms.

Cultural

As autumn cutworm populations may be initiated on crop weeds or volunteers in and around the crop, removal of this green bridge three to four weeks before crop emergence will remove food for the young cutworms.

If required, cutworms can be easily controlled with insecticides, and spot spraying may provide adequate control. Spraying in the evening is likely to be most effective.

Chemical

If required, cutworms can be easily controlled with insecticides. Several chemicals are registered for controlling cutworms, depending on the state and crop of registration. Spot spraying often provides adequate control in situations where cutworms are confined to specific regions within paddocks. Spraying in the evening is likely to be more effective as larvae are emerging to feed and insecticide degradation is minimised. [28]

7.7 Mites

7.7.1 Redlegged earth mite

The redlegged earth mite (*Halotydeus destructor*) (RLEM) is a major pest of pastures, crops and vegetables in regions of Australia with cool wet winters and hot dry summers, costing the Australian grains industry approximately $44.7 million per year. [29] The RLEM was accidentally introduced into Australia from the Cape region of South Africa in the early 1900s. These mites are commonly controlled using pesticides, however, non-chemical options are becoming increasingly important due to evidence of resistance and concern about long-term sustainability.

The RLEM is widespread throughout most agricultural regions of southern Australia. They are found in southern NSW, on the east coast of Tasmania, the south-east of SA, the south-west of WA and throughout Victoria (Figure 15). Genetic studies have found high levels of gene flow and migration within Australia. Although individual adult RLEM only move short distances between plants in winter, recent surveys have shown an expansion of the range of RLEM in Australia over the last 30 years. Long range dispersal is thought to occur via the movement of eggs in soil adhering to livestock and farm machinery or through the transportation of plant material. Movement also occurs during summer when over-summering eggs are transported by wind.

28 S Hangartner, G McDonald, P Umina (2015) Cutworm, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm

29 GRDC (2013) Ground cover supplement—emerging issues with diseases, weeds and pests.

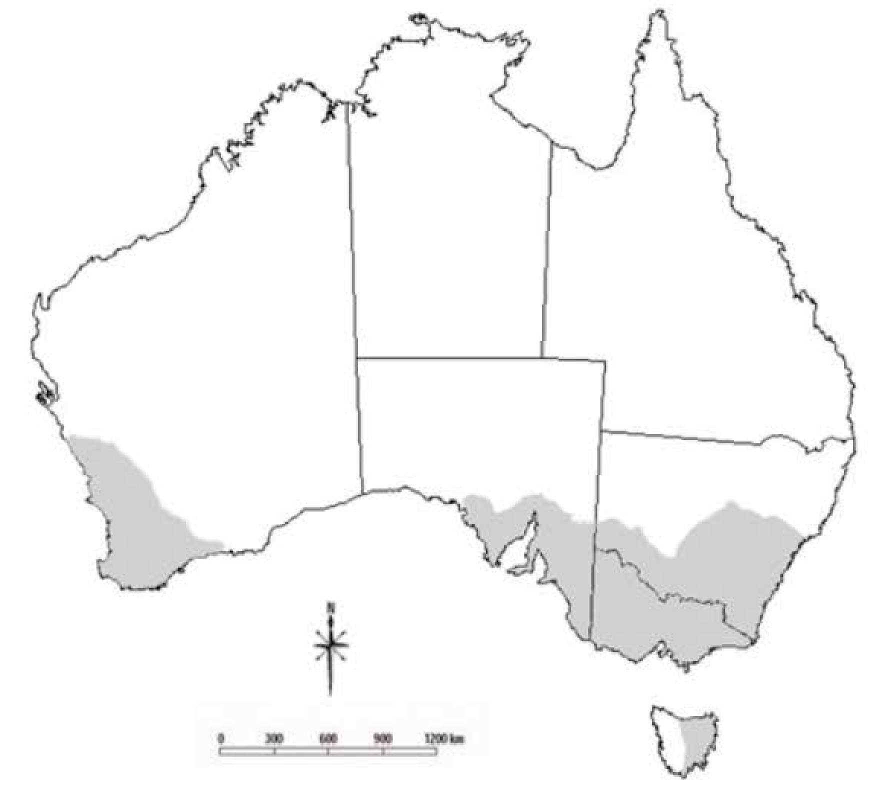


Figure 15: *The known distribution of redlegged earth mites in Australia.*

Source: cesar

Adult RLEM are 1 mm in length and 0.6 mm wide (the size of a pin head) with 8 red-orange legs and a completely black velvety body (Figure 16). Newly hatched mites are pinkish-orange with 6 legs, are only 0.2 mm long and are not generally visible to the untrained eye. The larval stage is followed by three nymphal stages in which the mites have 8 legs and resemble the adult mite, but are smaller and sexually undeveloped.

Other mite pests, in particular blue oat mites and the balaustium mite, are sometimes confused with RLEM in the field. Blue oat mites can be distinguished from RLEM by an oval orange/reddish mark on their back, while the balaustium mite has short hairs covering its body and can grow to twice the adult size of RLEM. Unlike other species that tend to feed singularly, RLEM generally feed in large groups of up to 30 individuals.

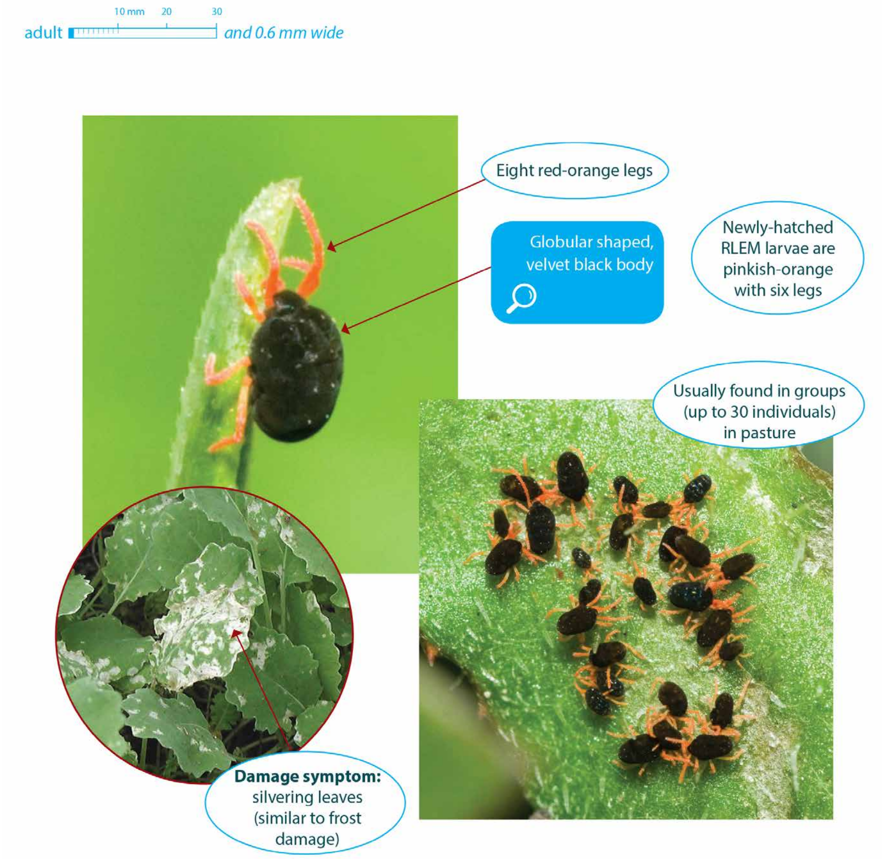


Figure 16: *Distinguishing characteristics of RLEM.*

Source: Bellati *et al.* (2012) in cesar

Damage caused by RLEM

Typical mite damage appears as "silvering" or "whitening" of the attacked foliage. Mites use adapted mouthparts to lacerate the leaf tissue of plants and suck up the discharged sap. The resulting cell and cuticle damage promotes desiccation, retards photosynthesis and produces the characteristic silvering that is often mistaken as frost damage. RLEM are most damaging to newly establishing pastures and emerging crops, greatly reducing seedling survival and development. In severe cases, entire crops may need re-sowing following RLEM attack.

RLEM hosts include pasture legumes, subterranean and other clovers, medics and lucerne. They are particularly damaging to seedlings of all legumes, oilseeds and lupins when in high numbers. They feed on ryegrass and young cereal crops, especially oats. RLEM also feed on a range of weed species including Patersons' curse, skeleton weed, variegated thistle, ox-tongue, smooth cats' ear and capeweed.

RLEM feeding reduces the productivity of established plants and has been found to be directly responsible for reduction in pasture palatability to livestock.

Managing RLEM

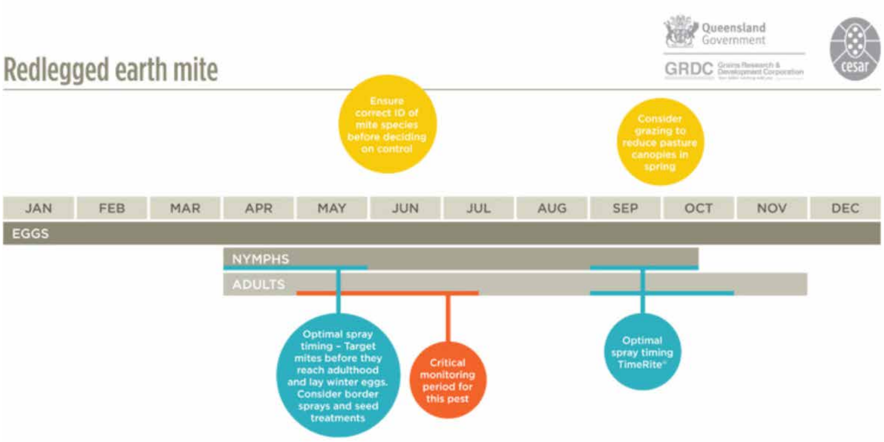


Figure 17: *Critical periods for managing RLEM.*

Source: cesar

Carefully inspect susceptible pastures and crops from autumn to spring for the presence of mites and evidence of damage. It is especially important to inspect crops regularly in the first three to five weeks after sowing. Mites are best detected feeding on the leaves in the morning or on overcast days. In the warmer part of the day RLEM tend to gather at the base of plants, sheltering in leaf sheaths and under debris. They will crawl into cracks in the ground to avoid heat and cold. When disturbed during feeding they will drop to the ground and seek shelter.

RLEM compete with other pasture pests, such as blue oat mites, for food and resources. Competition within and between mite species has been demonstrated in pastures and on a variety of crop types. This means control strategies that only target RLEM may not entirely remove pest pressure because other pests can fill the gap. This can be particularly evident after chemical applications, which are generally more effective against RLEM than other mite pests.

Chemical control

Chemicals are the most commonly used control option against earth mites. While a number of chemicals are registered for control of active RLEM in pastures and crops, there are no currently registered pesticides that are effective against RLEM eggs.

Autumn sprays:

Controlling first generation mites before they have a chance to lay eggs is the only effective way to avoid the need for a second spray. Hence, pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults begin to lay eggs. Timing of chemical application is critical.

Pesticides with persistent residual activity can be used as bare earth treatments, either pre-sowing or at sowing to kill emerging mites. This will protect seedlings, which are most vulnerable to damage.

Foliage sprays are applied once the crop has emerged and are generally an effective method of control.

Systemic pesticides are often applied as seed dressings. Seed dressings act by maintaining the pesticide at toxic levels within the growing plant, which then affects mites as they feed. This strategy aims to minimise damage to plants during the sensitive establishment phase. However, if mite numbers are high, plants may suffer significant damage before the pesticide has much effect.

Spring sprays:

Research has shown that one accurately timed spring spray of an appropriate chemical can significantly reduce populations of RLEM the following autumn. This approach works by killing mites before they start producing diapause eggs in mid-late spring. The optimum date can be predicted using climatic variables and tools such as TIMERITE® can help farmers identify the optimum date for spraying. Spring RLEM sprays will generally not be effective against other pest mites.

Repeated successive use of the "spring spray" technique is not recommended as this could lead to populations evolving resistance to the strategy. To prevent the development of resistance, the selective rotation of products with different Modes of Action is advised.

Biological control

There is evidence of natural RLEM populations showing resistance to some chemicals; therefore, alternative management strategies are needed to complement current control methods.

At least 19 predators and one pathogen are known to attack earth mites in eastern Australia. The most important predators of RLEM appear to be other mites, although small beetles, spiders and ants also play a role in reducing populations. A predatory mite (*Anystis wallacei*) has been introduced as a means of biological control; however, it has slow dispersal and establishment rates. Although locally successful, the benefits of this mite are yet to be demonstrated.

Preserving natural enemies may prevent RLEM population explosions in established pastures, but this is often difficult to achieve. This is mainly because the pesticides generally used to control RLEM are broad-spectrum and kill beneficial species as well as the pests. The chemical impact on predator species can be minimised by choosing a spray that has least impact and by reducing the number of chemical applications. Although there are few registered alternatives for RLEM, there are groups that have low-moderate impacts on many natural enemies such as cyclodienes.

Natural enemies residing in windbreaks and roadside vegetation have been demonstrated to suppress RLEM in adjacent pasture paddocks. When pesticides with residual activity are applied as border sprays to prevent mites moving into a crop or pasture, beneficial insect numbers may be inadvertently reduced, thereby protecting RLEM populations.

Cultural control

Using cultural control methods can decrease the need for chemical control. Rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival. For example, prior to planting a susceptible crop like, a paddock may be sown to cereals or lentils to help reduce the risk of RLEM population build up. Cultivation can also help reduce RLEM populations by significantly decreasing the number of over-summering eggs. Hot stubble burns can provide a similar effect.

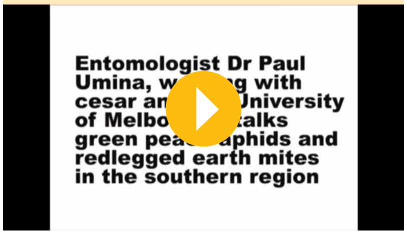
Clean fallowing and controlling weeds around crop and pasture perimeters can also act to reduce mite numbers. Control of weeds, especially thistles and capeweed, is important, as they provide important breeding sites for RLEM. Where paddocks have a history of damaging, high-density RLEM populations, it is recommended that sowing pastures with a high clover content be avoided.

Appropriate grazing management can reduce RLEM populations to below damaging thresholds, possibly because shorter pasture results in lower relative humidity, which increases mite mortality and limits food resources.

Other cultural techniques including modification of tillage practices, trap or border crops, and mixed cropping can reduce overall infestation levels to below the economic control threshold, particularly when employed in conjunction with other measures. [30]

VIDEOS

WATCH: Green peach aphid and redlegged earth mite resistance in Australia's southern cropping region.



30 P Umina (2007) Redlegged earth mite, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/?a=223443

7.7.2 Balaustium mite

The *Balaustium* mite, *Balaustium medicagoense* (Acari: Erythreidae), has recently been identified within the Australian grains industry as an emerging pest of winter crops and pasture. This mite is the only species of the genus *Balaustium* recorded in Australia and was probably introduced from South Africa, along with the redlegged earth mite (*Halotydeus destructor*), in the early 1900s. *Balaustium* mites are found throughout areas of southern Australia that have a Mediterranean-type climate, attacking a variety of agriculturally important plants.

They are sporadically found in areas with a Mediterranean climate in Victoria, NSW, SA and WA (Figure 18). They have also been found in Tasmania although their exact distribution is unclear. *Balaustium* mites are typically active from March to November, although mites can persist on green feed during summer if available.

Figure 18: *The known distribution of Balaustium mites in Australia.*

Source: cesar

Balaustium mites are quite often confused with other pest mites, such as the redlegged earth mite and blue oat mites (*Penthaleus* spp.). They have a rounded dark red/brown coloured body and red legs similar to other pest mites, however they have distinct short stout hairs covering their entire body giving them a velvety appearance (Figure 19). Adults reach about 2 mm in size, which is twice the size of other earth mite species. *Balaustium* mites also have distinct pad-like structures on their front legs and move slower than redlegged earth mites and blue oat mites.

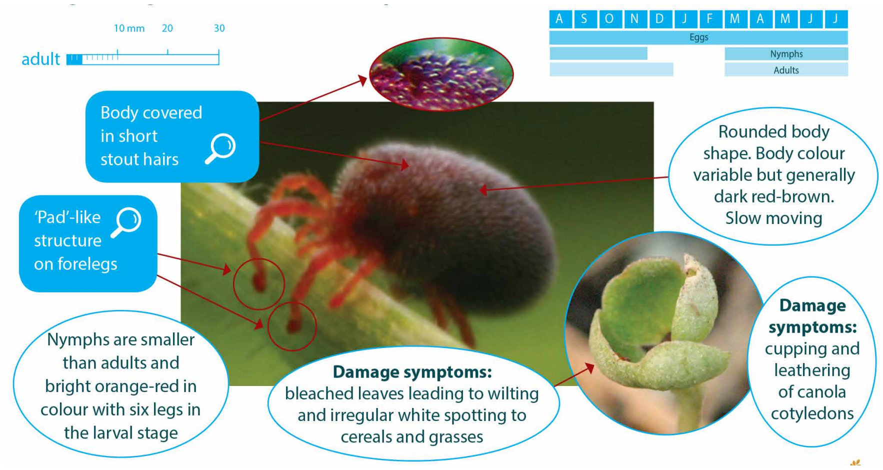


Figure 19: *Adult Balaustium mite.*

Source: Bellati et al. (2012) in cesar

Newly laid eggs of *Balaustium* mites are light maroon in colour, becoming darker prior to egg hatch. Larvae are bright orange in colour and have six pairs of legs. The larval stage is followed by a number of nymphal stages in which mites have eight legs and resemble adults, but are much smaller. [31]

Damage caused by Balaustium mite

Balaustium mites feed on plants using their adapted mouthparts to probe leaf tissue of plants and suck up sap. In most situations *Balaustium* mites cause little damage, however when numbers are high and plants are already stressed due to other environmental conditions, significant damage to crops can occur. Under high infestations, seedlings or plants can wilt and die. *Balaustium* mites typically attack leaf edges and leaf tips of plants.

There are no economic thresholds for this pest.

Management

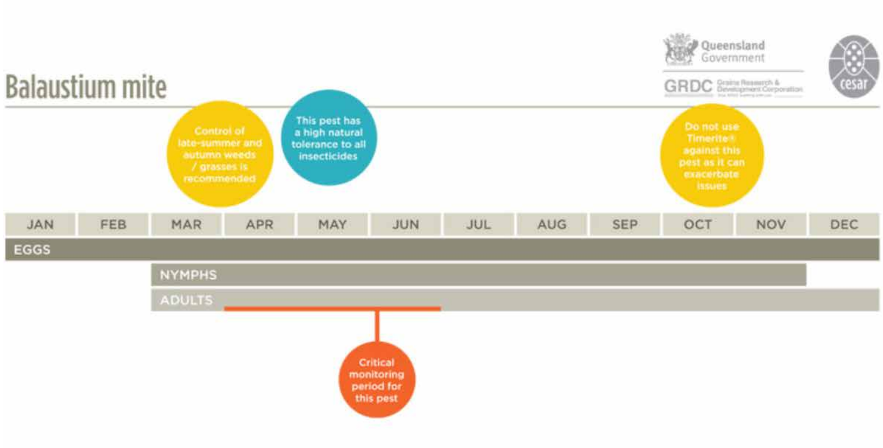


Figure 20: *Critical periods for Balaustium management.*

Source: cesar

31 D Grey (2010) Balaustium mite. Agriculture Victoria , http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/balaustium-mite

Monitoring

The impact of mite damage is increased when plants are under stress from adverse conditions such as prolonged dry weather or waterlogged soils. Ideal conditions for seedling growth enable plants to tolerate higher numbers of *Balaustium* mites. Carefully inspect susceptible pastures and crops from autumn to spring for the presence of mites and evidence of damage. It is especially important to inspect crops regularly in the first three to five weeks after sowing.

Crops sown into paddocks that were pasture the previous year should be regularly inspected for *Balaustium* mites. Weeds present in paddocks prior to cropping should also be checked for the presence and abundance of *Balaustium* mites. Mites are best detected feeding on the leaves, especially on or near the tips, during the warmest part of the day. *Balaustium* mites are difficult to find when conditions are cold and/or wet.

One of the most effective methods to sample mites is using a D-vac, which is based on the vacuum principle—much like a vacuum cleaner used in the home. Typically, a standard petrol powered garden blower/vacuum machine is used, such as those manufactured by Stihl® or Ryobi®. A sieve is placed over the end of the suction pipe to trap mites vacuumed from plants and the soil surface.

Control

Currently no product has been registered to control *Balaustium* mite in any state or territory of Australia. The Australian Pesticides and Veterinary Medicine Authority (APVMA) maintain a database of all chemicals registered for the control of agricultural pests in Australia. Reference to the APVMA website will confirm the registration status of products for *Balaustium* mite, or consult chemical resellers or a local chemical standards officer.

Ensure the relevant Maximum Residue Limits (MRLs) for the chemical in the end market is met, be it domestic or export.

Chemical users must read and understand all sections of chemical labels prior to use.

There have been no biological control agents (predators or parasites) identified in Australia that are effective in controlling *Balaustium* mites. Alternative methods such as cultural control can be effective at controlling this mite. Early control of summer weeds, within and around paddocks, especially capeweed and grasses, can help prevent mite outbreaks. Rotating crops or pastures with non-host crops can also reduce pest colonisation, reproduction and survival. For example, prior to planting a susceptible crop like cereals, a paddock could be sown to a broadleaf plant that *Balaustium* mites have not been reported to attack, such as vetch. [32]

7.7.3 Blue oat mite

Blue oat mites (BOM) (*Penthaleus* spp.) are species of earth mites, which are major agricultural pests of southern Australia and other parts of the world, attacking various pasture, vegetable and crop plants. BOM were introduced from Europe and first recorded in NSW in 1921. Management of these mites in Australia has been complicated by the recent discovery of three distinct species of BOM, whereas prior research had assumed just a single species.

Blue oat mites are important crop and pasture pests in southern Australia. They are commonly found in Mediterranean climates of Victoria, NSW, SA, WA and eastern Tasmania (Figure 21). There are three main species of BOM: *Penthaleus major*, *Penthaleus falcatus* and *Penthaleus tectus*. These species differ in their distributions.

32 D Grey (2010) Balaustium mite. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/balaustium-mite

Figure 21: *The known distribution of blue oat mites in Australia.*

Source: cesar

Adult BOM are 1 mm in length and approximately 0.7–0.8 mm wide, with eight red-orange legs. They have a blue-black coloured body with a characteristic red mark on their back (Figure 22). Larvae are approximately 0.3 mm long, are oval in shape and have three pairs of legs. On hatching, BOM are pink-orange in colour, soon becoming brownish and then green.

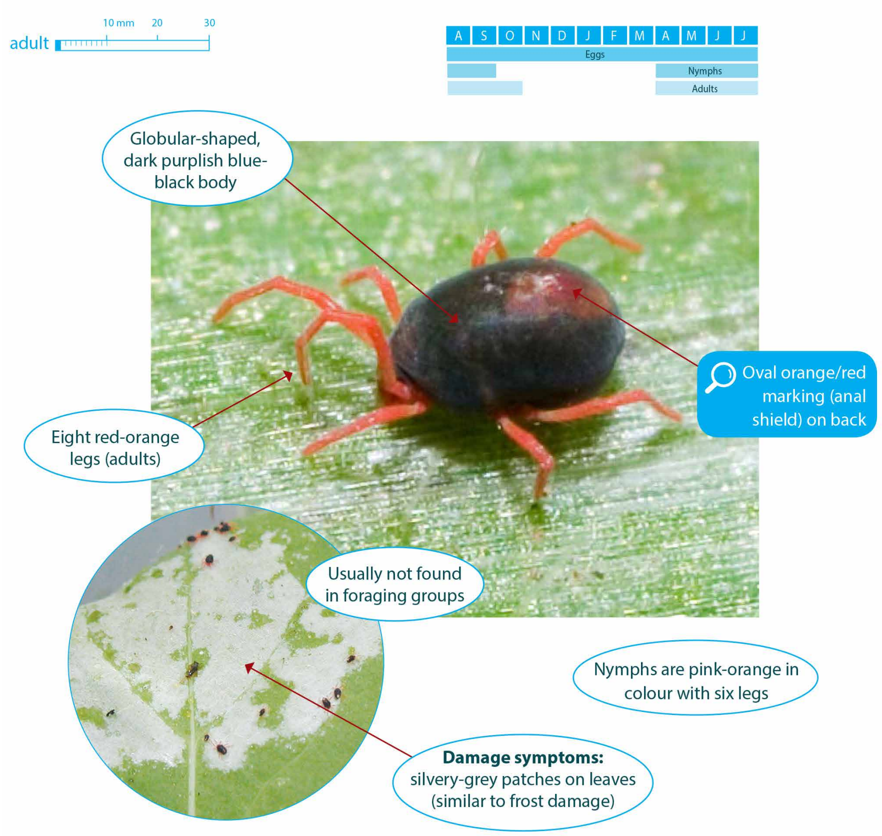


Figure 22: *Distinguishing characteristics of Blue oat mite.*

Source: Bellati et al. (2012) in cesar

BOM are often misidentified as redlegged earth mites (RLEM) in the field, which has meant that the damage caused by BOM has been under-represented. Despite having a similar appearance, RLEM and BOM can be readily distinguished from each other. RLEM have a completely black coloured body and tend to feed in larger groups of up to 30 individuals. BOM have the red mark on their back and are usually found singularly or in very small groups.

Damage caused by BOM

Feeding causes silvering or white discoloration of leaves and distortion, or shrivelling in severe infestations. Affected seedlings can die at emergence with high mite populations. Unlike redlegged earth mites, blue oat mites typically feed singularly or in very small groups.

Mites use adapted mouthparts to lacerate the leaf tissue of plants and suck up the discharged sap. Resulting cell and cuticle destruction promotes desiccation, retards photosynthesis and produces the characteristic silvering that is often mistaken as frost damage (Photo 9). BOM are most damaging to newly establishing pastures and emerging crops, greatly reducing seedling survival and retarding development.

Photo 9: *Typical Blue oat mite damage to leaf.*

Source: AgVic

Young mites prefer to feed on the sheath leaves or tender shoots near the soil surface, while adults feed on more mature plant tissues. BOM feeding reduces the productivity of established plants and is directly responsible for reductions in pasture palatability to livestock. Even in established pastures, damage from large infestations may significantly affect productivity.

The impact of mite damage is increased when plants are under stress from adverse conditions such as prolonged dry weather or waterlogged soils. Ideal growing conditions for seedlings enable plants to tolerate higher numbers of mites.

Managing BOM

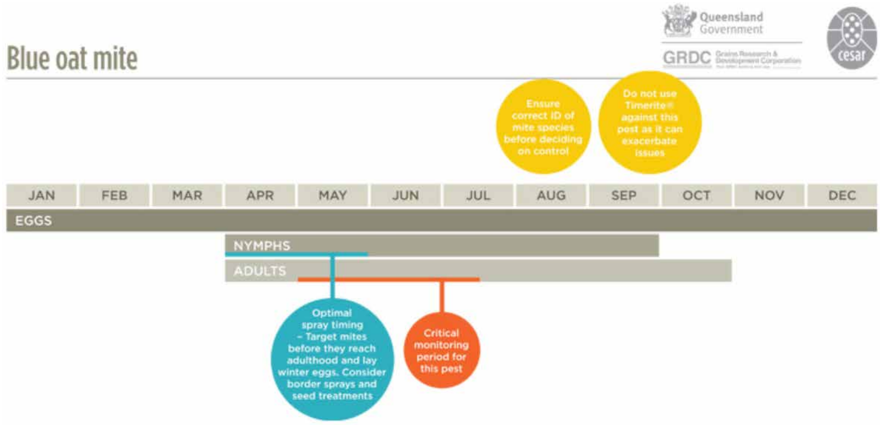


Figure 23: *Critical time periods for managing BOM.*

Source: cesar

Chemical control

Chemicals are the most common method of control against earth mites. Unfortunately, all currently registered pesticides are only effective against the active stages of mites; they do not kill mite eggs.

While a number of chemicals are registered in pastures and crops, differences in tolerance levels between species complicates management of BOM. *P. falcatus* has a high natural tolerance to a range of pesticides registered against earth mites in Australia and is responsible for many control failures involving earth mites. The other BOM species have a lower level of tolerance to pesticides and are generally easier to control with chemicals in the field.

Chemical sprays are commonly applied at the time of infestation, when mites are at high levels and crops already show signs of damage. Control of first generation mites before they can lay eggs is an effective way to avoid a second spray. Hence, pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, as adults will then begin laying eggs. While spraying pesticides in spring can greatly reduce the size of RLEM populations the following autumn, this strategy will generally not be as effective for the control of BOM.

Pesticides with persistent residual effects can be used as bare-earth treatments. These treatments can be applied prior to, or at sowing to kill emerging mites and protect the plants throughout their seedling stage.

Systemic pesticides are often applied as seed dressings to maintain the pesticide at toxic levels within the plants as they grow. This can help minimise damage to plants during the sensitive establishment phase, however, if mite numbers are high, significant damage may still occur before the pesticide has much effect.

To prevent the buildup of resistant populations, spray pesticides only when necessary and rotate pesticides from chemical classes with different modes of action. To avoid developing multiple pesticide resistance, rotate chemical classes across generations rather than within a generation.

Information on the registration status, rates of application and warnings related to withholding periods, OH&S, residues and off-target effects should be obtained before making decisions on which pesticide to use. This information is available from the DEPI Chemical Standards Branch, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and MSDS before using any pesticide.

Biological and cultural control

Integrated pest management programs can complement current chemical control methods by introducing non-chemical options, such as cultural and biological control.

Although no systematic survey has been conducted, a number of predator species are known to attack earth mites in Australia. The most important predators of BOM appear to be other mites, although small beetles, spiders and ants may also play a role. The French anystis mite is an effective predator but is limited in distribution. Snout mites will also prey upon BOM, particularly in pastures. The fungal pathogen, *Neozygites acaracida*, is prevalent in BOM populations during wet winters and could be responsible for observed "population crashes".

Preserving natural enemies when using chemicals is often difficult because the pesticides generally used are broad-spectrum and kill beneficial species as well as the pests. Impact on natural enemies can be reduced by using a pesticide that has the least impact and by minimising the number of applications. Although there are few registered alternatives for BOM control, there are groups such as the chloronicotinyls, which are used in some seed treatments that have low–moderate impacts on many natural enemies.

Cultural controls such as rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival, decreasing the need for chemical control. When *P. major* is the predominant species, canola and lentils are potentially useful rotation crops, while pastures containing predominantly thick-bladed grasses should be carefully monitored and rotated with other crops. In situations where *P. falcatus* is the most abundant mite species, farmers can consider rotating crops with lentils, while rotations that involve canola may be the most effective means of reducing the impact of *P. tectus*.

Many cultural control methods for BOM can also suppress other mite pests, such as RLEM. Cultivation will significantly decrease the number of over-summering eggs, while hot stubble burns can provide a similar effect. Many broad-leaved weeds provide an alternative food source, particularly for juvenile stages. As such, clean fallowing and the control of weeds within crops and around pasture perimeters, especially of bristly ox tongue and cats ear, can help reduce BOM numbers.

Appropriate grazing management can also reduce mite populations to below damaging thresholds. This may be because shorter pasture results in lower relative humidity, which increases mite mortality and limits food resources. Grazing pastures in spring to less than 2 t/ha Feed On Offer (dry weight), can reduce mite numbers to low levels and provide some level of control the following year. [33]

7.7.4 *Bryobia* mite

There are over 100 species of *Bryobia* mite worldwide, with at least seven found in Australian cropping environments. Unlike other broadacre mite species, which are typically active from autumn to spring, *Bryobia* mites prefer the warmer months of the year. *Bryobia* mites are smaller than other commonly occurring pest mites. They attack pastures and numerous winter crops earlier in the season.

Bryobia mites (sometimes referred to as clover mites) are sporadic pests typically found in warmer months of the year, from spring through to autumn. They are unlikely to be a problem over winter, however they can persist throughout all months of the year. They are broadly distributed throughout most agricultural regions in southern Australia with a Mediterranean-type climate, including Victoria, SA, NSW and WA (Figure 24). They have also been recorded in Tasmania and Queensland.

33 Agriculture Victoria (2007) Blue oat mite, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/blue-oat-mite

Figure 24: *Known distribution of* Bryobia *mites in Australia.*

Source: cesar

There are at least seven species of *Bryobia* mites found in broadacre crops in Australia. These appear very similar. *Bryobia* mites are smaller than other commonly occurring pest mites, although they reach no more than about 0.75 mm in length as adults. They have an oval shaped, dorsally flattened body that is dark grey, pale orange or olive in colour and have eight pale red/orange legs. The front pair of legs is much larger, approximately 1.5 times their body length. If seen under a microscope, they have a sparsely distributed set of broad, spade-like hairs, appearing like white flecks (Figure 25).

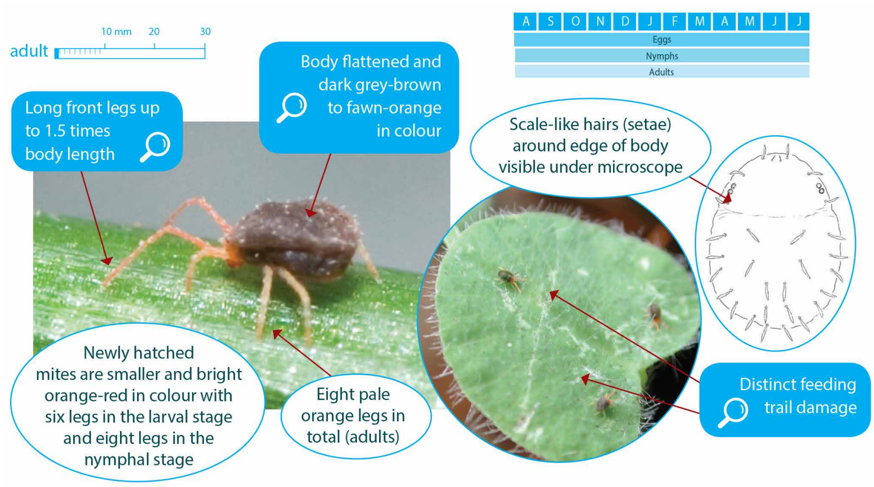


Figure 25: *Distinguishing characteristics of Bryobia mites.*

Source: Bellati et al. (2012) in cesar

Damage cause by mite

Bryobia mites tend to cause most damage in autumn when they attack newly establishing pastures and emerging crops, greatly reducing seedling survival and retarding development. They feed on the upper surfaces of leaves and cotyledons by piercing and sucking leaf material. This feeding causes distinctive trails of whitish-grey spots on leaves. Extensive feeding damage can lead to cotyledons shriveling. On grasses, Bryobia mite feeding can resemble that of redlegged earth mites.

There are no economic thresholds for control.

Managing Bryobia mites

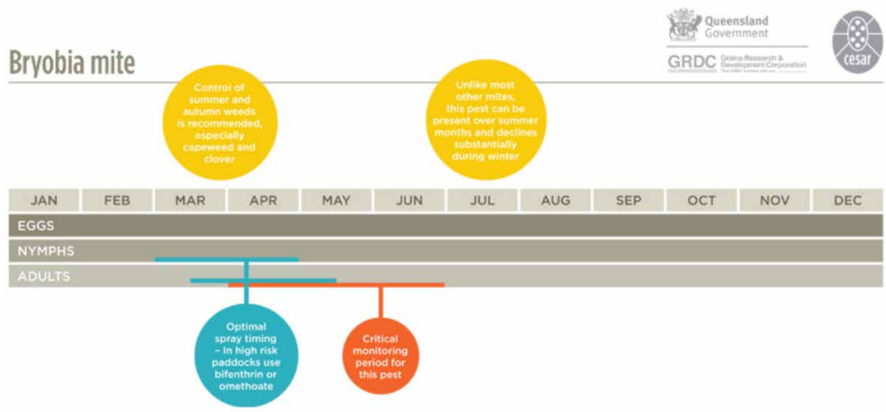


Figure 26: *Critical time periods for managing Bryobia mite.*

Source: cesar

Biological

There are currently no known biological control agents for *Bryobia* mites in Australia.

Cultural

Crops that follow pastures with a high clover content are most at risk. Avoid planting susceptible crops such as canola, lupins, vetch and lucerne into these paddocks. Early control of summer and autumn weeds within and around paddocks, especially broadleaf weeds such as capeweed and clovers, can help prevent mite outbreaks.

Chemical

Some insecticides are registered for *Bryobia* mites, however, be aware that recommended rates used against other mites might be ineffective against *Bryobia* mites. *Bryobia* mites have a natural tolerance to several chemicals. Insecticides do not kill mite eggs. Generally, organophosphate insecticides provide better control against *Bryobia* mites than synthetic pyrethroids. [34]

7.8 Lucerne flea

The lucerne flea, *Sminthurus viridis* (Collembola: Sminthuridae), is a springtail that is found in both the northern and southern hemispheres but is restricted to areas that have a Mediterranean-type climate. It is thought to have been introduced to Australia from Europe and has since become a significant agricultural pest of crops and pastures across the southern states. It is not related to the fleas, which attack animals and humans.

Lucerne fleas are common pests found in Victoria, Tasmania, SA, NSW and WA (Figure 27). Higher numbers are often found in the winter rainfall areas of southern Australia, including Tasmania, or in irrigation areas where moisture is plentiful. They

34 P Umina, S Hangartner, G McDonald (2015) Bryobia mite, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Bryobia-mite

are generally more problematic on loam/clay soils. Lucerne fleas are often patchily distributed within paddocks and across a region.

Figure 27: *The known distribution of the Lucerne flea in Australia.*

Source: cesar

The lucerne flea is a springtail—this is a group of arthropods that have six or fewer abdominal segments and a forked tubular appendage or furcula under the abdomen. Springtails are one of the most abundant of all macroscopic insects and are frequently found in leaf litter and other decaying material, where they are primarily detritivores. Very few species, including the lucerne flea, are regarded as crop pests around the world.

The adult lucerne flea is approximately 3 mm long, light green-yellow in colour and often with mottled darker patches over the body. They are wingless and have enlarged, globular shaped abdomens (Figure 28). They are not related to true fleas. Newly hatched nymphs are pale yellow and 0.5–0.75 mm long, and as they grow they resemble adults, but are smaller.

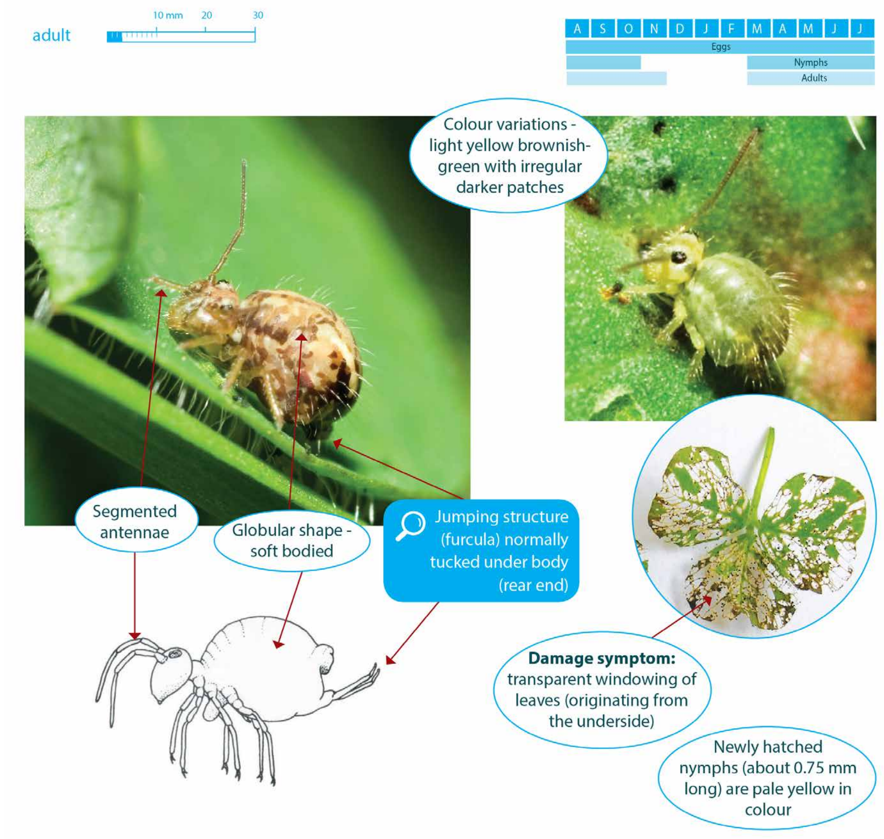


Figure 28: *Distinguishing characteristics of the Lucerne flea.*

Source: Bellati et al. (2012) in cesar

Damage caused by Lucerne flea

Although grasses and cereals are non-preferred hosts, lucerne flea can also cause damage to ryegrass, wheat and barley crops. In pastures, lucerne fleas have a preference for subterranean clover and lucerne.

Lucerne fleas move up plants from ground level, eating tissue from the underside of foliage. They consume the succulent green cells of leaves through a rasping process, avoiding the more fibrous veins and leaving behind a layer of leaf membrane. This makes the characteristic small, clean holes in leaves that can appear as numerous small “windows”. In severe infestations this damage can stunt or kill plant seedlings.

Managing Lucerne flea

Monitoring is the key to reducing the impact of lucerne flea. Crops and pastures grown in areas where lucerne flea has previously been a problem should be regularly monitored for damage from autumn through to spring. Susceptible crops and pastures should also be carefully inspected for the presence of lucerne fleas and evidence of damage.

It is important to frequently inspect winter crops, in the first three to five weeks after sowing. Crops are most susceptible to damage immediately following seedling emergence. Pastures should be monitored at least fortnightly from autumn to spring, with weekly monitoring preferred where there have been problems in previous years.

Lucerne fleas are often concentrated in localised patches or “hot spots” so it is important to have a good spread of monitoring sites within each paddock. Examine foliage for characteristic lucerne flea damage and check the soil surface where insects may be sheltering.

Some sprays require application at a particular growth stage, so it is also important to note the growth stage of the population. Spraying immature lucerne fleas before they have a chance to reproduce can effectively reduce the size of subsequent generations.

Lucerne fleas compete for food and resources with other agricultural pests such as redlegged earth mites and blue oat mites. This means control strategies that only target one species may not reduce the overall pest pressure because other pests can fill the gap. It is therefore important to assess the complex of pests before deciding on the most appropriate control strategy.

Chemical control

Lucerne fleas are commonly controlled post-emergence, usually after damage is first detected. Control is generally achieved with an organophosphate insecticide (e.g. omethoate). In areas where damage is likely, a border spray may be sufficient to stop invasion from neighbouring pastures or crops. In many cases spot spraying, rather than blanket spraying, may be all that is required.

If the damage warrants control, treat the infested area with a registered chemical approximately three weeks after lucerne fleas have been observed on a newly emerged crop. This will allow for the further hatch of over-summering eggs but will be before the lucerne fleas reach maturity and begin to lay winter eggs.

In pastures, a follow-up spray may be needed roughly four weeks after the first spray to control subsequent hatches, and to kill new insects before they lay more eggs. Grazing the pasture before spraying will help open up the canopy to ensure adequate spray coverage. The second spray is unlikely to be needed if few lucerne fleas are observed at that time.

Crops are most likely to suffer damage where they follow a weedy crop or a pasture in which lucerne flea has not been controlled. As such, lucerne flea control in the season prior to the sowing of susceptible crops is recommended.

Caution is advised when selecting an insecticide. Several chemicals registered for redlegged earth mites (i.e. synthetic pyrethroids such as cypermethrin) are known to be ineffective against lucerne flea. When both lucerne fleas and redlegged earth mites are present, it is recommended that control strategies consider both pests, and a product registered for both is used at the highest directed rate between the two to ensure effective control.

Information on the registration status, rates of application and warnings related to withholding periods, OH&S, residues and off-target effects should be obtained before making decisions on which insecticide to use. This information is available from the DPI Chemical Standards Branch, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and MSDS before using any insecticide.

Biological and cultural control

Several predatory mites, various ground beetles and spiders prey upon lucerne fleas. Snout mites (which have orange bodies and legs) are particularly effective predators of this pest (Photo 10). The pasture snout mite (*Bdellodes lapidaria*) and the spiny snout mite (*Neomulgus capillatus*), have been the focus of biological control efforts against lucerne flea.

The pasture snout mite was originally found in WA but has since been distributed to eastern Australia and there are some examples of this mite successfully reducing lucerne flea numbers. Although more rare, the spiny snout mite can also drastically reduce lucerne flea populations, particularly in autumn.

Photo 10: *Predatory adult snout mite.*

Photo: A Weeks. Source: cesar

Appropriate grazing management can reduce lucerne flea populations to below damaging thresholds. This may be because shorter pasture lowers the relative humidity, which increases insect mortality and limits food resources.

Broad-leaved weeds can provide alternative food sources, particularly for juvenile stages. Clean fallowing and the control of weeds within crops and around pasture perimeters, especially of capeweed, can therefore help reduce lucerne flea numbers.

Other cultural techniques such as cultivation, trap and border crops, and mixed cropping can help reduce overall infestation levels to below economically damaging levels, particularly when employed in conjunction with other measures. Grasses are less favourable to the lucerne flea and as such can be useful for crop borders and pastures.

In pastures, avoid clover varieties that are more susceptible to lucerne flea damage, and avoid planting susceptible crops such as canola and lucerne into paddocks with a history of lucerne flea damage. [35]

7.9 Slugs and snails

Slugs and snails are predominantly pests in the southern and western regions (Table 4). Snails are not a problem in the northern region, however damaging slug populations have been reported in seedling crops in northern NSW and southern Queensland in recent years.

Increased slug and snail activity may be due to the increase in zero/minimum till and stubble retention practices because the organic content of paddocks increases under such systems, providing an increased food source especially to young slugs and snails.

Other risk factors include prolonged wet weather, trash blankets, weedy fallows and a previous history of slugs and snails. Slugs and snails are best controlled before the crop is planted.

35 G McDonald (2008) Lucerne flea, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/lucerne-flea

Table 4: *Description of common slugs and snails.*

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Slugs				
Grey field or reticulated slug *Deroceras reticulatum*  Photo: Michael Nash, SARDI	Light grey to fawn with dark brown mottling. 35–50 mm long. Produces a white mucus.	Rasping of leaves (complete areas of crop may be missing).	Autumn to spring when conditions are moist especially when soil moisture greater than 25%.	Resident pest. Surface active, but seeks moist refuge in soil macro-pores.
Black keeled slug *Milax gagates*  Photo: Michael Nash, SARDI	Black or brown with a ridge continuing from its saddle all the way down its back to the tip of the tail. 40–60 mm long.	Rasping of leaves (complete areas of crop may be missing), and hollowed out grains.	All year round, if conditions are moist, but generally later in the season in colder regions.	Burrows so cereal/ maize crops fail to emerge/ Prefers sandy soil in high rainfall areas (>550 mm), heavier soils in low rainfall areas (<500 mm). Surface active (feeding), but seeks moist refuge in soil macro-pores.
Brown field slug *Deroceras invadens* or *D. laeve*  Photo: Michael Nash, SARDI	25–35 mm long, and usually brown all over with no distinct markings. Produces a clear mucus.	Rasping of leaves. Leaves a shredded appearance.	All year round, if conditions are moist.	Prefers warmer conditions and pastures. Less damaging than grey field and black keeled slugs.

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Snails				
Vineyard or common white snail *Cernuella virgata*  Photo: Michael Nash, SARDI	Coiled white shell with or without a brown band around the spiral. Mature shell diameter between 12–20 mm. Open, circular umbilicus*. Under magnification, regular straight scratches or etchings can be seen across the shell.	Shredded leaves where populations are high. Found up in the crop prior to harvest.	Active after autumn rainfall. Breeding occurs once conditions are moist (usually late autumn to spring).	Mainly a contaminant of grain. Congregates on summer weeds and up off the ground on stubble.
White Italian snail *Theba pisana*  Photo: Michael Nash, SARDI	Mature snails have coiled white shells with broken brown bands running around the spiral. Some individuals lack the banding and are white. Mature shell diameter between 12–20 mm. Semi-circular or partly closed umbilicus*. Under magnification, cross hatched scratches can be seen on the shell.	Shredded leaves where populations are high. Found up in the crop prior to harvest.	Active after autumn rainfall. Breeding occurs once conditions are moist (usually late autumn to spring).	Mainly a contaminant of grain. Congregates on summer weeds and up off the ground on stubble.
Conical or pointed snail *Cochlicella acuta*  Photo: Michael Nash, SARDI	Fawn, grey or brown. Mature snails have a shell length of up to 18 mm. The ratio of the shell length to its diameter at the base is always greater than two.	Shredded leaves where populations are high. Found up in the crop prior to harvest.	Active after autumn rainfall. Breeding occurs once conditions are moist (usually winter to spring).	Mainly a contaminant of grain. Can be found over summer on and in stubble and at the base of summer weeds.

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Small pointed snail *Prietocella barbara*  Photo: Michael Nash, SARDI	Fawn, grey or brown. Mature shell size of 8-10 mm. The ratio of its shell length to its diameter at the base is always two or less.	Shredded leaves where populations are high. Found up in the crop prior to harvest.	Active after autumn rainfall. Breeding occurs once conditions are moist (usually winter to spring).	A contaminant of grain, especially hard to screen from canola grain as the same size. Mainly found over summer at the base of summer weeds and stubble. Similar to slugs will go into soil macropores. Especially difficult to control with bait at current label rates.

*Umbilicus – a depression on the bottom (dorsal) side of the shell, where the whorls have moved apart as the snail has grown. The shape and the diameter of the umbilicus is usually a species-specific character.

Source: IPM Guidelines

7.9.1 Managing slugs and snails

Table 5 provides recommendations for the control of slugs in seedling crops.

Table 5: *Controlling slugs.*

Objectives	Pre-sowing	Germination – Vegetative
Find insects and damage Species of slugs	**High risk:** High rainfall areas >450 mm/annum. Above average spring–autumn rainfall. Cold wet establishment conditions. No till stubble retained. Summer volunteers. Previous paddock history of slugs. Soils high in clay and organic matter. Slugs are nocturnal and shelter during dry conditions and generally not visible.	**Damage:** Rasping of leaves. Leaves have a shredded appearance. Complete areas of crop may be missing. Slugs will eat all plant parts but the seedling stage is most vulnerable and this is when major economic losses can occur. Grey and brown field slugs are mainly surface active but the black keeled slug burrows and can feed directly on germinating seed.

Objectives	Pre-sowing	Germination – Vegetative
Monitor and record	Monitor with surface refuges to provide an estimate of active density. Refuges can include: terracotta paving tiles carpet squares or similar Use a 300 mm by 300 mm refuge when soil moisture is favourable (> 20%) as slugs require moisture to travel across the soil surface. Research has shown that slugs are attracted to the refuges from approximately 1 m hence numbers found can be used as numbers per m^2. Place refuges in areas of previous damage, after rainfall, on damp soil before sowing. Use 10 refuges per 10 hectares. Check the refuges early in the morning, as slugs seek shelter in the soil as it gets warmer. An alternative option to monitoring with refuges is to put out metaldehyde bait strips and check the following morning for dead slugs.	Monitor for plant damage. Slug populations are not even distributed in the field and are often clumped. Where crop damage is evident—inspect the area at night.
Natural enemies	Some species of carabid beetles can reduce slug populations but generally not below established economic thresholds. Free living nematodes that carry associated bacteria that cause slug death are thought to help reduce populations under certain field conditions. Many other soil fauna, such as are protozoa, may cause high levels of slug egg mortality under moist warm conditions however biological controls alone can not be solely relied on for slug control.	
Cultural control	Hard grazing of stubbles. Burning. Cultivation leaving a fine consolidated tilth. Removal of summer volunteers. Rolling at sowing. Early sowing for quick establishment.	
Thresholds	Thresholds have been established but should be used as a guide only. Also, take into account the field, the season, crop health and weather conditions.	Suggested thresholds per square metre: Grey field slug Canola 0.5–1.5 Cereals 5–15 Pulses 1–2 Black keeled slug Canola <1 Cereals 1–2 Pulses 1–2

Objectives	Pre-sowing	Germination – Vegetative
Chemical control	Baiting slugs is the only chemical option available to manage slugs. Molluscidial baits containing either metaldehyde or chelated iron are IPM compatible. Baits containing methiocarb are also toxic to carabid beetles—one of the few predators of slugs. Different responses to bait can be due to species behaviour. The value of applying bait after a significant rainfall event prior to sowing is still to be tested. For black keeled slugs—broadcast baits when dry or place with seed at sowing. For grey field slugs—broadcast baits Do not underestimate slug populations—always use rate that gives 25–30 per metre. Calibrate bait spreaders to ensure width of spread, evenness of distribution and correct rate.	Bait after/at sowing prior to crop emergence when soil is moist (i.e. >20% soil moisture). Re-apply baits to problem areas 3–4 weeks after first application if monitoring indicates slugs are still active. The number of baits/ha is more important than the total weight of bait/ha. Current research indicates that 250,000 bait points/ha is the minimum required for effective control.
Multi-pest interactions	Different species respond differently to environmental and field conditions leading to staggered emergence and need for repeated application under some conditions.	
Communicate and discuss management	Know paddock history and slug presence before sowing. Where retained stubble—graze or burn to control slugs before sowing. Control summer volunteers that may harbour slugs. Discuss optimum times for baiting and observations regarding population activity. Consult industry publications for up-to-date information of pest problems. No single method will provide complete control of slugs. Consider cultural and chemical control and work on pest control year-round to achieve a reasonable level of control.	

Source: IPM Guidelines

Table 6 provides recommendations for the control of snails in seedling crops.

MORE INFORMATION

Slug management Factsheet.

Table 6: *Controlling snails.*

Objectives	Pre-sowing	Seedling – Vegetative	Grain fill / Podding	Harvest
Find insects and damage Species of snails	**High risk:** Weedy fields Alkaline calcareous soils Retained stubble Wet spring, summer, autumn History of snails All species of snails congregate at the base of summer weeds or in topsoil. Pointed snail species can also be found at the base or up in stubble as well as inside stubble stems. Snails appear to build up most rapidly in canola, field peas and beans but can feed and multiply in all crops and pastures. Snails are most active after rain and when conditions are cool and moist. Snails are dormant in late spring and summer.	**Damage:** Snails consume cotyledons and this may resemble crop failure Shredded leaves where populations are high. Chewed leaf margins Irregular holes A wide range of snail sizes are an indication of snails breeding in the area. If most snails are the same size, snails are moving in from other areas. Round snails favour resting places off the ground on stubble, vegetation and fence posts. Pointed snails are found on the ground in shady places.	Snails can be found up in the crop prior to harvest. Check for snails under weeds or shake mature crops unto tarps	**Snails are predominantly a grain contaminant.** At harvest, snails move up in the crop and may shelter between grains or under leaves. They can also be found in windrows. The small pointed snail is especially hard to screen from canola grain due to similar size. Buyers will reject grain if: More than half a dead or one live snail is found in 0.5 litre of wheat. More than half a dead or one live snail is found in 200 gram pulse sample.
Monitor and record	Monitor snails regularly to establish their numbers, types and activity and success of controls Look for snails early morning or in the evening when conditions are cooler and snails are more active. Key times to monitor: 3–4 weeks before harvest to assess need for harvester modifications and cleaning After summer rains—check if snails are moving from resting sites Summer to pre-seeding—check numbers in stubble before and after rolling/slashing/cabling Monitoring technique: Sample 30 x 30 cm quadrat at 50 locations across the paddock. If two snail groups are present (round and conical), record the number of each group separately. To determine the age class of round snails, place into a 7 mm sieve box, shake gently and they will separate into two sizes: >7 mm (adults) and <7 mm (juveniles). Sieve boxes can be constructed from two stackable containers, e.g. sandwich boxes. Remove the bottom from one and replace by a punch hole screen. Suggested screen size is 7 mm round or hexagonal. Five sampling transects should be taken in each paddock. One transect is taken at 90° to each fence line whilst the fifth transect runs across the centre of the paddock. Take five samples (counts) 10 m apart along each transect. Record the size and number of the snails in each sample. Average the counts for each transect and multiple this figure by 10 to calculate the number of snails per m^2 in that area of the paddock.			
Natural enemies	Free living nematodes when carrying associated bacteria that causes snail death are thought to help reduce populations under certain field conditions.			

Objectives	Pre-sowing	Seedling – Vegetative	Grain fill / Podding	Harvest
Cultural control	Hard grazing of stubbles Cabling and/or rolling of stubbles—when soil temperature is above 35°. Burning—if numbers are very high and ensure hot, even burns. Cultivation leaving a fine consolidated tilth. Removal of summer weeds and volunteers.			Reduce contamination. Stripper fronts in medium to heavy crops. Raising cutting heights. Harvester modifications (see Snail fact sheet). Seed cleaning (see Snail fact sheet). Windrowing. Trials with windrowed barley resulted in reduced round snail contamination. Early windrowing when cool produces better results.
Thresholds	To control snails, apply a combination of treatments throughout the year.	Thresholds can be unreliable due to the interaction between weather, crop growth and snail activity. For example: high snail populations in the spring do not always relate to the number of snails harvested. Their movement into the crop canopy is dictated by weather conditions prior to harvest. Suggested thresholds for round snails: Cereals—20/m² Pulses and oilseeds—5/m² Suggested thresholds for small pointed snails: Cereals—40/m² Oilseeds—20/m² Baiting before egg lay is vital.		Thresholds to warrant harvester modifications are difficult to define. Contamination depends on snail types and size in relation to grain as well the position of snails in relation to cutting height.
Chemical control	Molluscidial baits containing either Metaldehyde or Chelated iron are IPM compatible. Apply to the bare soil surface when snails are active after autumn rain as early as March. Aim to control snails pre-season.	Mature snails larger than 7 mm in length or diameter will feed on bait but this can be less effective on juveniles. Baiting before egg lay is vital. Bait when snails are moving from resting sites after summer rains. Stop baiting 8 weeks before harvest to avoid bait contamination in grain. Bait rates need to be at the highest label rate to achieve a greater number of bait points. The actual number is yet to be determined; hence, label rates may be revised ion the future. Note that in cool, moist conditions, snails can move 30 m/week and treated fields can be re-invaded from fence lines, vegetation and roadsides.		Rain at harvest can cause snails to crawl down from crops.
Multi-pest interactions	Baits containing Methiocarb are toxic to a range of other invertebrates and beneficials.			

Objectives	Pre-sowing	Seedling – Vegetative	Grain fill / Podding	Harvest
Communicate and discuss management	Know paddock history and snail presence before sowing. Where retained stubble—graze, burn or bash to remove snails before sowing. Control summer volunteers and brassica weeds that may harbour snails. Consider harvester modifications id snails present at harvest. Discuss optimum times for baiting. Consult industry publications for up-to-date information of pest problems.			

Source IPM Guidelines

7.10 Wireworms and False wireworms

Wireworms and false wireworms are common, soil-inhabiting pests of newly sown winter and summer crops. Wireworms are the larvae of several species of Australian native beetles that are commonly called "click" beetles, coming from the family *Elateridae*.

False wireworms are also the larval form of adult beetles, some of which are known as pie-dish beetles, which belong to another family (*Tenebrionidae*), but have distinctively different forms and behaviour. Both groups inhabit native grassland and improved pastures where they cause little damage. However, cultivation and fallow decimates their food supply, and hence any new seedlings that grow may be attacked and sometimes destroyed. They attack the pre- and post-emerging seedlings of all oilseeds, grain legumes and cereals, particularly in light, draining soils with a high organic content. Fine seedling crops like canola and linola are most susceptible.

The incidence of damage caused by wireworms and false wireworms is increasing with increasing use of minimum tillage and short fallow periods.

7.10.1 False wireworms

(Family *Tenebrionidae*; numerous species)

These insects are the larvae of native beetles that normally live in grasslands or pastures and cause little or no damage in this situation. In crops, they are mostly found in paddocks with high stubble and crop litter contents. They may affect all winter-sown crops.

There are a large and varied number of species, but the general characteristics of false wireworm are as follows.

Larvae are cylindrical, hard bodied, fast moving, golden brown to black-brown or grey with pointed upturned tails or a pair of prominent spines on the last body segment. There are several common groups (genera) of false wireworms found in south-eastern Australia:

- The grey or small false wireworm (*Isopteron* (*Cestrinus*) *punctatissimus*). The larvae grow to about 9 mm (3/8") in length. They are grey-green in colour, have two distinct protrusions from the last abdominal (tail) segment and tend to have a glossy or shiny exterior (Figure 29). Hence, they are most easily recognised in the soil on sunny days when their bodies are reflective. The adults are slender, dark brown and grow to about 8 mm in length. The eggs are less than 1 mm in diameter. There are several species of this pest genus, although I. punctatissimus appears to be the species most associated with damage.

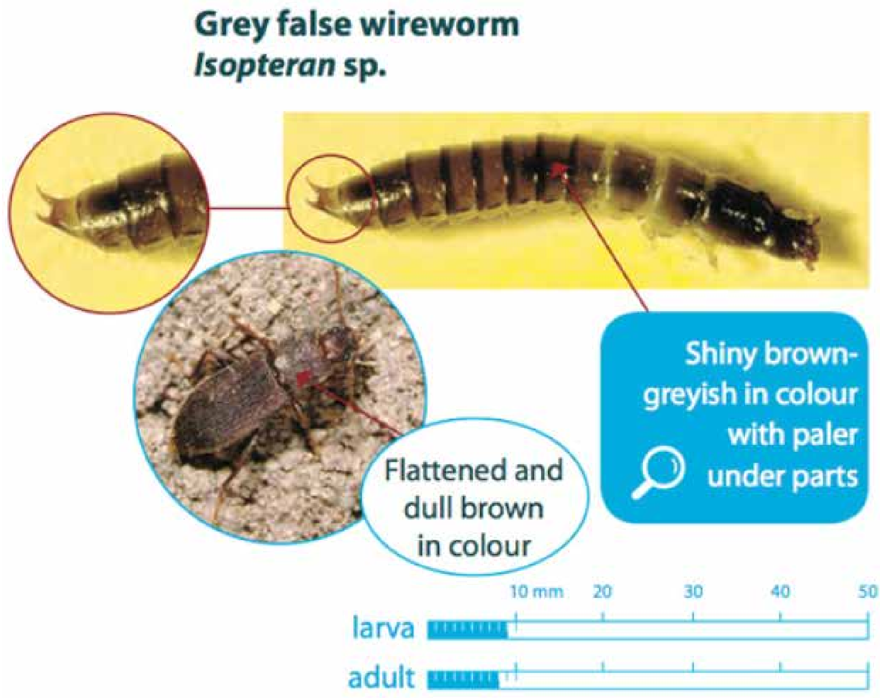


Figure 29: *Distinguishing characteristics of the grey false wireworm.*

Source: cesar

- The large or eastern false wireworm (*Pterohelaeus* spp.). These are the largest group of false wireworms. They are the most conspicuous in the soil and grow up to 50 mm in length. They are light cream to tan in colour, with tan or brown rings around each body segment, giving the appearance of bands around each segment. The last abdominal segment has no obvious protrusions, although, under a microscope, there are a number of distinct hairs. Adults are large, conspicuous and often almost ovoid beetles with a black shiny bodies (Photo 11).

Photo 11: *Eastern false wireworm adult beetle (left) and larva (right).*

Source: cesar

- The southern false wireworm (*Gonocephalum* spp.) grows to about 20 mm in length, and has similar body colours and marking to the large false wireworm. Adults are generally dark brown-grey, oval beetles, which sometimes have a coating of soil on the body (Figure 30). Adults have the edges of the body flanged, hence the common name "pie-dish" beetles.

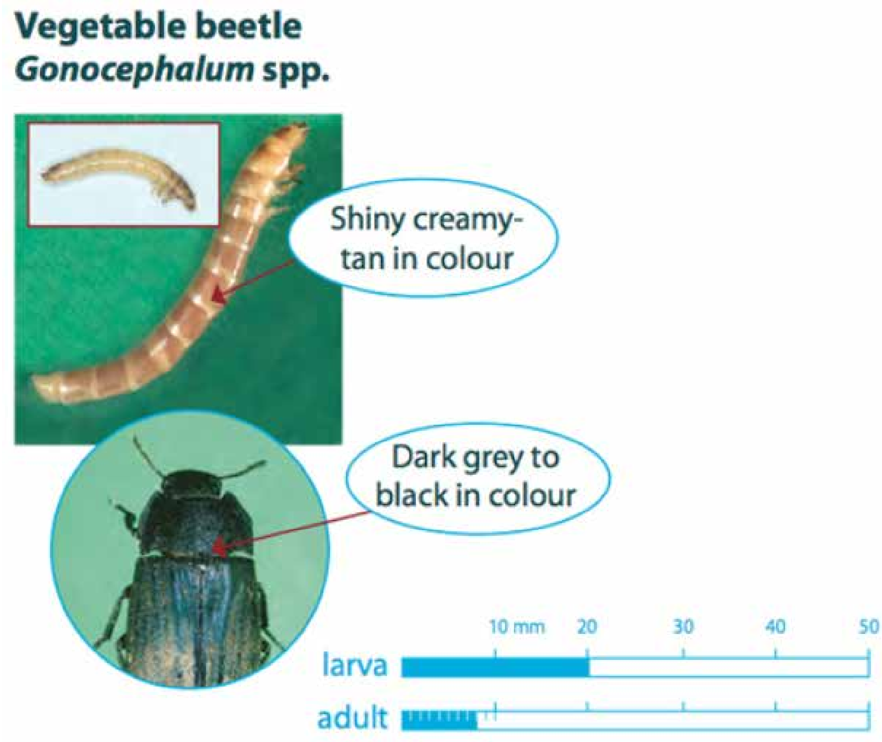


Figure 30: *Distinguishing characteristics of the southern false wireworm.*

Source: cesar

Biology

Usually only one generation occurs each year. However, some species may take up to 10 years to complete the life cycle. Adults emerge from the soil in December and January and lay eggs in or just below the soil surface, mostly in stubbles and crop litter. Hence, larvae are most commonly found in stubble-retained paddocks.

Larvae of most false wireworm species prefer to feed on decaying stubble and soil organic matter. When the soil is reasonably moist, the larvae are likely to aggregate in the top 10–20 mm where the plant litter is amassed. However, when the soil dries, the larvae move down through the soil profile, remaining in or close to the subsoil moisture, and occasionally venturing back to the soil surface to feed. Feeding is often at night when the soil surface becomes dampened by dew.

Nothing is known of the conditions that trigger the switch in the false wireworm feeding from organic matter/litter to plants. Significant damage is, however, likely to be associated with soils that remain dry for extensive periods of time. Larvae are likely to stop feeding on organic matter when it dries out, and when the crop plants provide the most accessible source of moisture.

Damage caused by false wireworms

Affected crops may develop bare patches, which could be large enough to require re-sowing (Photo 12). Damage is usually greatest when crop growth is slow due to cold, wet conditions.

Photo 12: *False wireworm damage to pasture.*

Source: SARDI in cesar

Infestations of the small false wireworm can be as high as hundreds of larvae per square meter, although densities as low as five larger false wireworm larvae/m^2 can cause damage under dry conditions.

The larvae of the small false wireworm are mostly found damaging fine seedling crops shortly after germination. They feed on the hypocotyl (seedling stem) at or just below the soil surface. This causes the stem to be "ring-barked", and eventually the seedling may be lopped off or it wilts under warm conditions. Larger seedlings (e.g. grain legumes) may also be attacked, but the larvae appear to be too small to cause significant seedling damage.

The larger false wireworms can cause damage to most field crops. The larvae can hollow out germinating seed, sever the underground parts of young plants, or attack the above surface hypocotyl or cotyledons. In summer, adult beetles may also chew off young sunflower seedlings at ground level. Damage is most severe in crops sown into dry seedbeds and when germination is slowed by continued dry weather.

7.10.2 True wireworm

(Family *Elateridae*; numerous species)

These slow moving larvae tend to be less common, although always present, in broadacre cropping regions and are generally associated with wetter soils than that of false wireworms.

Larvae grow to 15–40 mm, are soft-bodied, flattened and slow moving; they can be distinguished from false wireworms, which are hard bodied, cylindrical and fast moving. Their colour ranges from creamy yellow in the most common species to red brown; their head is dark brown and wedge-shaped. The tailpiece is characteristically flattened and has serrated edges. Adults are known as "click" beetles, due to their habit of springing into the air with a loud click when placed on their backs. They are dark brown, elongated and 9–13 mm long (Figure 31).

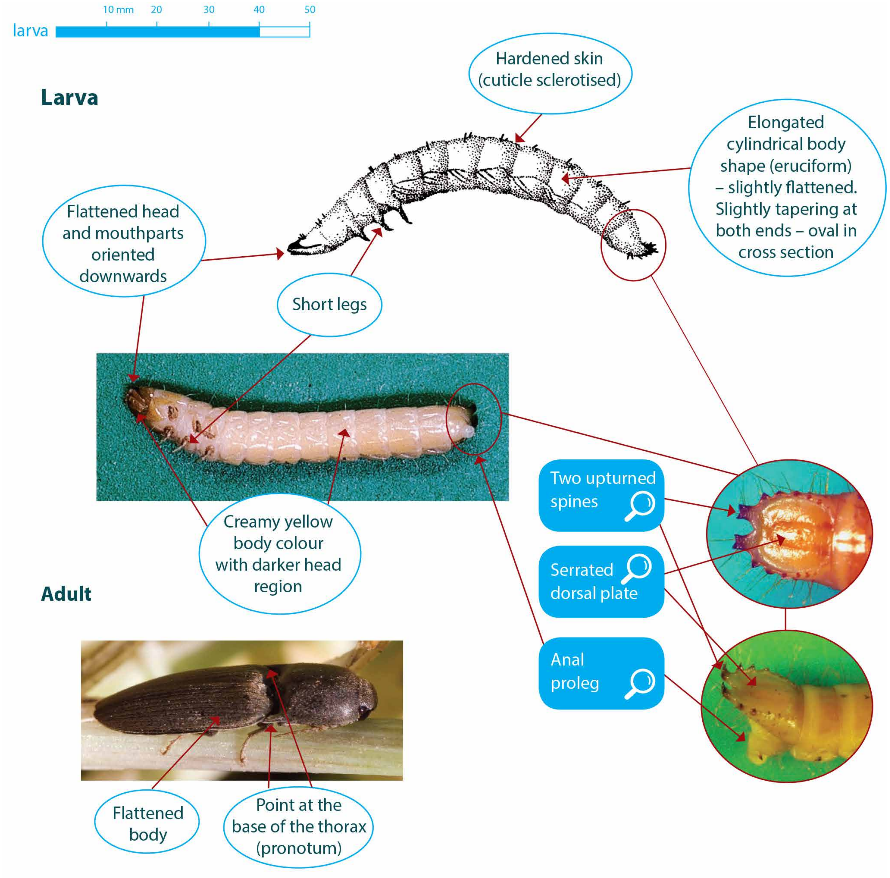


Figure 31: *Distinguishing characteristics of true wireworms.*

Source: cesar

Biology

There may be one or several generations per year, depending on species. Most damage occurs from April to August and adults emerge in spring. Wireworms prefer low-lying, poorly drained paddocks and are less common in dry soils. Larvae are reasonably mobile through the soil and will attack successive seedlings as they emerge. Adults are typically found in summer and autumn in bark, under wood stacks or flying around lights.

There is little known of the biology of most species, but one species (*Hapatesus hirtus*) is better understood. This species is known as the potato wireworm, although it is found in many other crop and pasture situations. It is very long-lived and probably takes five years or more to pass through all the wireworm stages before pupating and finally emerging as an adult beetle.

Adult click beetles emerge in spring and summer, mate and lay eggs, and then may spend a winter sheltering under the bark of trees. The connection between trees and adult beetles is probably why damage is often, but not always, most pronounced on tree-lines. The wireworms have a long life in the soil and are active all year, even in winter.

Damage

The damage caused by wireworms is similar to that of false wireworms, except that most damage is restricted to below the soil surface. Larvae eat the contents of germinating seed, and underground stems of establishing plants, causing wilting and death.

7.10.3 Sampling and detection

The principles for detection and control of false and true wireworms are generally similar, although different species may respond slightly differently according to soil conditions.

Sampling

Crops should be sampled immediately before sowing. There are two methods available, although neither provides a 100% reliable method of detection. This is because larvae change their behaviours according to soil conditions, particularly soil moisture and temperature.

- Soil sampling. Take a minimum of five random samples from the paddock. Each sample should consist of the top 20 mm of a 0.50 m area of soil. Carefully inspect the soil for larvae. Calculate the average density per meter squared by multiplying the average number of larvae found in the samples by 4. Control should be considered if the average exceeds 10 small false wireworms, or 10 of the larger false wireworms.
- Seed baits. Seed baits have been used successfully to sample true and false wireworms in Queensland and overseas. In Victoria, they have not been rigorously tested. Preliminary work has shown that they can be used to show the species of larvae present, and give an approximate indication of density. Take about 200–300 gm of a large seed bait, such as that of any grain legume, and pre-soak over 24 hours. Select five to 10 sites in the paddock and place a handful of the soaked seed into a shallow hole (50 mm), then cover with about 10 mm of soil. Mark each hole with a stake, and re-excavate each hole after about 7 days. Inspect the seed and surrounding soil for false wireworm larvae. This technique is most likely to be successful when there is some moisture within the top 100 mm of soil.

Detection

Larvae of the small false wireworms are relatively difficult, although not impossible, to see in grey and black soils because of their small size and dark colour. However, they can be found in the top 20 mm of dry soil by carefully examining the soil in full sunlight. Larvae of the other false wireworm species are more prominent because of their relatively pale colour and large size.

7.10.4 Control

Crop residues and weedy summer fallows favour survival of larvae and over-summering adult beetles. Clean cultivation over summer will starve adults and larvae by exposing them to hot dry conditions, thus preventing population increases. Suitable crop rotations may also limit increases in population numbers. Seedbeds must be sampled prior to sowing if control is to be successful. Insecticides may be applied to soil or seed at sowing. Most chemicals registered for false wireworm control are seed treatments, although these may not be consistently reliable. They probably work best when the seedling grows rapidly in relatively moist soils. Adults may also be controlled with insecticide incorporated into baits. If damage occurs after sowing, no treatment is available, other than re-sowing bare patches with an insecticide treatment. The critical periods for control of false wireworm are shown in Figure 32 below. [36]

36 G McDonald (1995) Wireworms and false wireworms. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/wireworms-and-false-wireworms

MORE INFORMATION

[False wireworms in seedling crops]

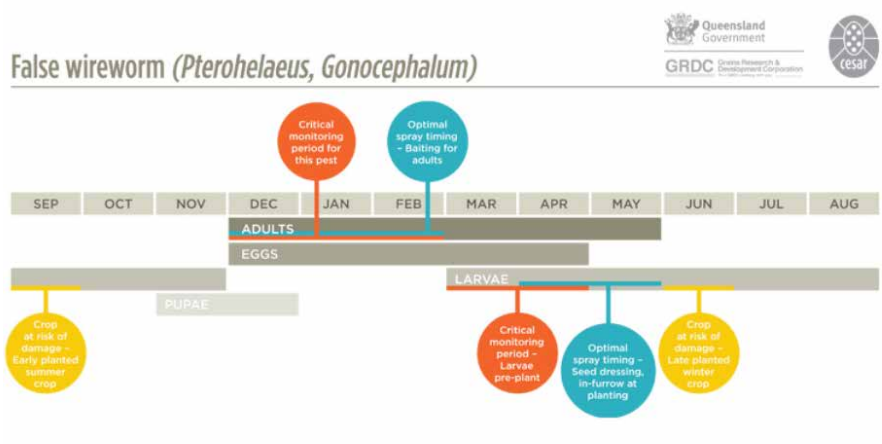


Figure 32:

Source: cesar

7.11 *Helicoverpa* spp.

Helicoverpa spp. are frequently found in winter cereals, usually at levels too low to warrant control, but occasionally numbers may be sufficiently high to cause economic damage. Virtually all *Helicoverpa* present are *H. armigera* (Photo 13), which has developed resistance to many of the older insecticide groups. It is not unusual to find both *Helicoverpa* and armyworm in cereal crops, so correct identification of the species present is important.

Photo 13: *Helicoverpa armigera.*

Source: Department of Agriculture and Fisheries Queensland

There are two species that are pests of field crops, particularly grain legumes, summer grains and cotton—*H. armigera* and *H. punctigera*. The latter is more common in southern cropping regions.

Eggs are 0.5 mm in diameter and change from white to brown to a black head stage before hatching. Newly hatched larvae are light in colour with tiny dark spots and dark heads. As larvae develop, they become darker and the darker spots become more obvious. Both species of helicoverpa look the same at the egg and small larvae stages. Medium larvae develop lines and bands running the length of the body and are variable in colour. *H. armigera* have a saddle of darker pigment on the fourth segment and at the back of the head and dark-coloured legs. *H. punctigera* have no saddle and light-coloured legs. Large larvae of *H. armigera* have white hairs around the head; *H. punctigera* have black hairs around the head. Pupae are found in soil underneath the crop. Healthy pupae wriggle violently when touched. *H. armigera* pupal tail spines are more widely spaced than those of *H. punctigera*. Moths are a dull light brown with dark markings and are 35 mm long. *H. armigera* has a small light or pale patch in the dark section of the hindwing, while the dark section is uniform in *H. punctigera*. Forewings are brown in the female and cream in the male. [37]

7.11.1 Damage caused by pest

Helicoverpa do not cause the typical head-cutting damage of armyworms. Larvae tend to graze on the exposed tips of a large number of developing grains, rather than totally consuming a low number of whole grains, thus increasing the potential losses. Most (80–90%) of the feeding and crop damage is done by larger larva (the final two instars). Larvae feed on leaves but are most damaging when feeding on growing terminals, buds or squares, flowers, pods, seed and/or fruit. This includes direct losses through shedding and reduced quality. [38]

7.11.2 Management of insect pest

Check for larvae on the plant throughout the growing season. Monitoring can be done in conjunction with sampling for armyworm.

Chemical control

H. armigera has developed resistance to a wide range of insecticides; however, several products are now registered for both species that have reduced impacts on natural enemies in the crop. Larvae are best targeted when smaller than 7 mm. Small larvae (<7 mm) can be controlled with biopesticides (e.g. nucleopolyhedrovirus [NPV]). Larger larvae are more difficult to control than small larvae, and NPV is most effective when larvae <13 mm long are targeted. *H. armigera* has historically had high resistance to pyrethroids, and control of medium-large larvae using pyrethroids is not recommended. [39]

Natural enemies

All stages of the Helicoverpa lifecycle are attacked by a wide range of predators, parasitoids and pathogens, and conserving these in the crop through the avoidance of broad-spectrum insecticides can help prevent/minimise the need for insecticide treatments. Predators of Helicoverpa eggs and larvae include spined predatory bug, glossy shield bug, damsel bug and big-eyed bug. [40]

37 DAFQ (2012) Insect pest management in winter cereals. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

38 DAFQ (2012) Insect pest management in winter cereals. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

39 DAFQ (2012) Insect pest management in winter cereals. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals

40 DAFQ (2012) Insect pest management in winter cereals. Department of Agriculture and Fisheries Queensland, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/ipm-information-by-crop/insect-pest-management-in-winter-cereals