SOUTHERN

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GRDC GROWNOTES™

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 7

INSECT CONTROL

POTENTIAL INSECT PESTS | INTEGRATED PEST MANAGEMENT | RUSSIAN WHEAT APHID | APHIDS | CUTWORM | MITES | LUCERNE FLEA | ARMYWORM | SLUGS AND SNAILS | WIREWORMS AND FALSE WIREWORMS | PLAGUE LOCUSTS

Insect control

Key messages

- To date, triticale varieties are affected by only a few insect pests.
- Triticale has the same insect predators during growth as other cereals, but in general fewer insect control measures are required, with the exception of grain-storage insects.
- Triticale is vulnerable to grasshoppers, aphids, armyworms and cutworms.
- Insects are not usually a major problem in cereals, but sometimes they build up to an extent that control is warranted.
- Integrated pest management (IPM) encompasses chemical, cultural and biological control mechanisms to help improve pest control and limit damage to the environment.
- For current chemical control options refer to Pest Genie or the Australian Pesticides and Veterinary Medical Authority (APVMA).

The risks from insect damage in triticale are similar to those for wheat. Triticale is affected by only a few insect pests [1]: it is vulnerable to grasshoppers, aphids, armyworms and cutworms. Management practices for these insects are the same as for other cereals: they should be applied only when continual scouting indicates that the problem has reached an economic threshold for control. [2]

Earth mites (redlegged and blue oat mites) can be a problem in early growth, and chemical control may be necessary depending on insect numbers and damage. Aphids may occur in late winter and spring and while usually not a cause of major damage themselves they do transmit Barley yellow dwarf virus (BYDV) and this may warrant control in severe infestations. Monitor seedling crops for lucerne flea, redlegged earth mite and blue oat mite. Seek local advice to determine if the application of insecticide is warranted and ensure grazing withholding periods are met. Aphids can infest early-sown crops and attack the crop again in spring. Early in the season they can spread viral disease while in spring they can cause yield damage. Seek local advice on thresholds and management options. [3]

In the US, it has been recommended to replace early-sown wheat with triticale because of its greater resistance to insect pests. [4] Research in Europe suggests that later sowing may help to limit insect damage to triticale [5]; however, the efficacy of this practice would need to be tested in Australian cropping systems.

1 M Mergoum, H Gómez-Macpherson (eds) (2004) Triticale improvement and production. FAO Plant Production and Protection Paper No. 179. Food and Agriculture Organisation, http://www.fao.org/3/a-y5553e/y5553e00.pdf

2 Alberta Agriculture and Forestry (2016) Triticale crop protection. Alberta Agriculture and Forestry, http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/fcd10572

3 Waratah Seed Company (2010) Triticale: planting guide. Waratah Seed Company, http://www.porkcrc.com.au/1A-102_Triticale_Guide_Final_Fact_Sheets.pdf

4 M Mergoum, H Gómez-Macpherson (eds) (2004) Triticale improvement and production. FAO Plant Production and Protection Paper No. 179. Food and Agriculture Organisation, http://www.fao.org/3/a-y5553e/y5553e00.pdf

5 H Krusteva, O Karadjova (2011) Impacts of triticale crop sowing date on the insect pest species composition and damage caused. Bulgarian Journal of Agricultural Science, 17 (4), 411–416.

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

Stay informed about invertebrate pest threats throughout the winter growing season by subscribing to SARDI's PestFacts South Australia and cesar's PestFacts south-eastern.

Subscribers to cesar's PestFacts also benefit from special access to cesar's extensive insect gallery, which can be used to improve skills in identifying pest and beneficial insects. Information from these sources can be combined with information about pest risk on the Queensland Government and GRDC's website of integrated pest management guidelines (Table 1). [6] Table 2 gives a graphic representation of the degree of damage to expect at different cropping stages.

Table 1: *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 expose 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 Snails are common on sandy soils in SA and western Vic	Slugs 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

6 Queensland Government, GRDC (2016) Winter cereals: inset pest risk. In IPM Guidelines, http://ipmguidelinesforgrains.com.au/crops/winter-cereals/

High risk	Moderate risk	Low risk
Aphids		
Higher risk of Barley yellow dwarf virus (BYDV) 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)
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.*

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

Present in crop but generally not damaging

Crop susceptible to damage and loss

* Snails are also a grain contaminant at harvest

Source: IPM Guidelines

Use Table 3 [7] to assess risk and determine control measures for establishment pests.

Table 3: *Establishment pests affecting cereal crops in the southern cropping region.*

	Pre-season	Pre-sowing	Emergence	Crop establishment
Earth mites and lucerne flea	Assess risk High risk when: – history of high mite pressure – pasture rotating into crop – susceptible crop being planted (e.g. canola, pasture, lucerne) – seasonal forecast is for dry or cool, wet conditions that slow crop growth If risk is high: – ensure accurate identification – use Timerite® (redlegged earth mites only) – heavily graze pastures in early-mid spring	If high risk: – use an insecticide seed dressing on susceptible crops – plan to monitor more frequently until crop establishment – use higher sowing rate to compensate for seedling loss – consider scheduling a post-emergent insecticide treatment If low risk: – avoid insecticide seed dressings (esp. cereal and pulse crops) and plan to monitor until crop establishment	Monitor susceptible crops through to establishment using direct visual searches. Be aware of edge effects; mites move in from weeds around paddock edges. If spraying: – ensure accurate identification of species before deciding on chemical – consider border sprays (mites) and 'spot' sprays (lucerne flea) – spray prior to winter egg production to suppress populations and reduce risk in the following season	As the crop grows, it becomes less susceptible unless growth is slowed by dry or cool, wet conditions
Slugs	Assess risk High risk when: – high stubble load – annual average rainfall - 450 mm – history of slug infestations – canola being planted – summer rainfall – heavy clay soils	If high risk: – burn stubble – cultivate worst areas – remove weeds in paddocks/ along fence-lines, at least 8 weeks before sowing – deploy shelter traps prior to sowing – sow early to get crop established prior to cold conditions – use soil compaction at sowing (e.g. press wheels) – bait at/after sowing prior to emergence	Assess risk High risk under cold conditions and slow plant growth Use shelter traps or directly search at night when slugs are active to confirm slugs as the cause of seedling loss. If slug pressure is high, successive baiting may be required. Monitoring will guide bait use.	As the crop grows, it becomes less susceptible unless growth is slowed by cool conditions. Re-sowing may be required if plant stands are unsatisfactory.

7 Queensland Government, GRDC (2016) Best bet IPM strategy: establishment pests, southern region. On IPM Guidelines, http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_EstablishmentSouth2014.pdf

	Pre-season	Pre-sowing	Emergence	Crop establishment
False wireworm and true wireworm	Assess risk High risk when: – history of wireworm pressure – soils high in organic matter – high stubble and summer/ autumn litter cover	Conduct direct visual search for adult beetles over summer and autumn. Directly search (in soil) for beetle larvae 2 weeks prior to sowing. If high risk: – re-assess crop choice of timing of sowing – consider an insecticide seed dressing (particularly fipronil) or in-furrow treatment – use soil compaction at sowing (e.g. press wheels) – consider higher sowing rate to compensate for seedling loss	Limited options for control once crop is sown. Consider re-sowing severely affected areas of crop.	Damage to established crops is rare
Scarabs	Assess risk High risk when: – sowing crops into pasture, especially those with a high clover content – previous history of scarab damage to crop in that field – wetter than average seasons – minimum/no tillage Under high pressure: – spray African black beetle adults in spring – void overgrazing pastures	Dig soil within paddock to determine incidence of scarab larvae If high risk: – cultivate land – avoid sowing grass pastures – use soil compaction at sowing (e.g. press wheels) – consider higher sowing rate to compensate for seedling loss	Assess risk High risk when dry conditions slow plant growth Limited options for control once crop is sown. Larvae of most species do not emerge from the soil. For black-headed pasture cockchafer, spray around heavy dews or light rainfall which will trigger larvae activity	Re-sowing may be an option, but as some species have a 2-year life cycle, larvae can persist through winter into spring. ID will guide this decision.
Others (e.g. earwigs, slaters, millipedes, weevils)	Assess risk. – high risk when: – history of high pest pressure – minimum/no tillage – high stubble load – heavier soils Monitor in spring using shelter traps, direct searches and/or pitfall traps	If high risk: – burn stubble – cultivate worst areas – use cracked wheat baits – avoid sowing canola	Monitor susceptible crops through to establishment. Directly search at night to confirm pest species as the cause of seedling loss (Note: large numbers of these pests can be found in paddocks without causing crop damage)	Damage to established crops is rare

Source: IPM guidelines

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 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 pesticide exposure on the farm.

7.2.1 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.

7.2.2 Insecticide choices

- The redlegged earth mite (RLEM), blue oat mite (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, synthetic pyrethroids (SPs) and organophosphates (OPs) in particular. Be aware that the use of some pesticides may select for pests that are more tolerant.

VIDEOS

WATCH: Integrated pest management

7.2.3 Insecticide resistance

- RLEM has been found to have high levels of resistance to synthetic pyrethroids such as bifenthrin and alpha-cypermethrin.
- Helicoverpa armigera has historically had high resistance to pyrethroids and the inclusion of biological control agents of IPM are effective where mixed populations of armyworm and *Helicoverpa* spp. occur in maturing winter cereals. [8]

7.2.4 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 and beneficials and their life cycles** is essential when planning your monitoring program. As well as visual identification, you need to know where on the plant to look and what is the best time of day to get a representative sample.
- **Monitoring frequency and pest focus** should be directed at the crop at stages when you are likely to incur economic damage. Critical stages may include seedling emergence and flowering and grain formation.
- **Sampling technique** is important to ensure that 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. The actual sampling

8 Queensland Government, GRDC (2016) Winter cereals: inset pest risk. On IPM Guidelines, http://ipmguidelinesforgrains.com.au/crops/winter-cereals/

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 to be 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 paddock, but any obvious hotspots 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). [9] 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
- crop stage and any other relevant information (e.g. row spacing, 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: DAF Qld

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)

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

- amount of product and volume applied per hectare
- method of application including nozzle types and spray pressure
- 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). It is particularly effective for sampling caterpillars, bugs, aphids and mites. A standard beat sheet is made from yellow or white tarpaulin material with a heavy dowel on each end. Beat sheets are generally 1.3–1.5 m wide by 1.5–2.0 m deep, with the larger dimensions being 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.

To use the beat sheet:

- Place the sheet with one edge at the base of plants in the row to be sampled.
- Drape the other end 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 to dislodge insects from the sample row onto the 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 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 paddock (i.e. 30 beats per paddock).
- 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.
- Caterpillar pests are not mobile within the canopy, and checking at any time of the day should result in reporting 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.
- 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 row spacing, divide the average pest counts by 0.75.

Other sampling methods

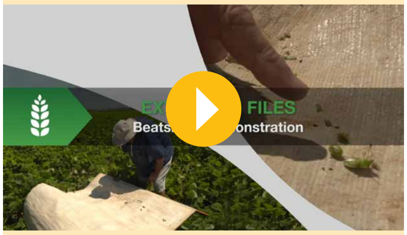
- **Visual checking** is not recommended as the sole form of insect checking, although it has an important support role. Leaflets or flowers should be separated when looking for eggs or small larvae, and leaves checked for the presence of aphids and silverleaf whitefly. If required, dig below the soil surface to assess soil-insect activity. Visual checking 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 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 it is not at all useful 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 the high purchase cost of the suction machine.
- **Monitoring with traps** (pheromone, volatile, and light traps) can provide general evidence of pest activity and the timing of peak egg laying for some species. However, it is no substitute for in-field monitoring of actual numbers of pests and beneficials. [10]

Photo 1: *Using a beat sheet (left) and a sweep net (right) to search for insects.*

Sources: The Beatsheet and DAFWA

VIDEOS

WATCH: GCTV16: Extension files—IPM beatsheet demo



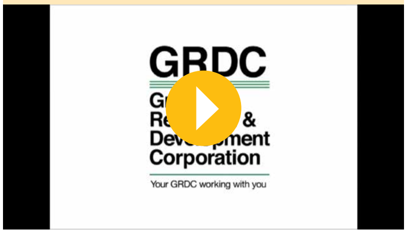
WATCH: How to use a sweep net to sample for insect pests

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

VIDEOS

WATCH: GCTV11: GRDC's Insect ID app

WATCH: Biopesticides emerge as an alternative cropping tool



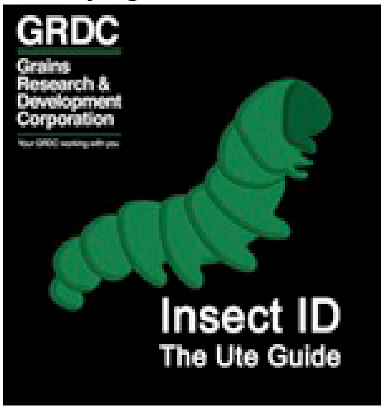
MORE INFORMATION

Insect ID: The Ute Guide is available for Android devices and the iPhone.

IPM Guidelines website

IPM Guidelines, Monitoring tools and techniques

Identifying insects



GRDC's insect ID ute guide is a comprehensive reference for insect pests that commonly affect 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. [11]

The app features:

- Region selection.
- Predictive search by common and scientific names.
- Ability to compare photos of insects side by side with insects in the app.
- Identification of beneficial predators and parasites of insect pests
- An option to download content updates inside the app to ensure you're aware of the latest pests affecting crops for each region.
- Ensure awareness of international biosecurity pests.

For pest identification consult the GRDC's Crop insects: Ute Guide Online

7.3 Russian wheat aphid

Key points:

- Triticale and rye are thought to be moderately resistant to resistant to Russian wheat aphid.
- Russian wheat aphid is a major pest of cereal crops, found in all major cereal production regions around the world, but not in Australia before 2016.
- During feeding, it injects toxins into the plant that retard growth; heavy infestations will kill the plant.
- Affected plants show whitish, yellow and pink-purple leaf stripes/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).

11 GRDC. Apps, https://grdc.com.au/Resources/Apps

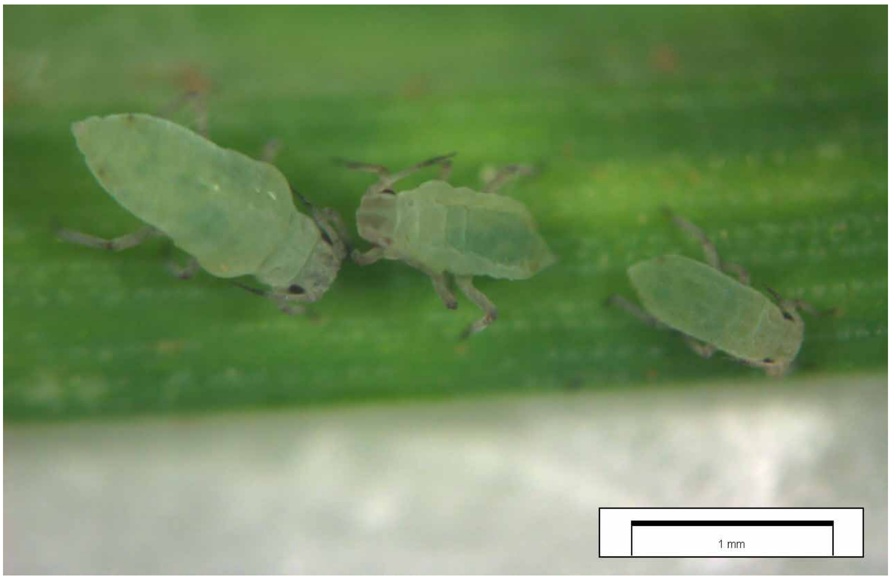


Photo 2: *The Russian wheat aphid (Diuraphis noxia).*

Photo: Michael Nash

The Russian wheat aphid (*Diuraphis noxia*) is a major pest of cereal crops, found in all major cereal production regions around the world. It has only recently been found in Australia. Based on overseas data, RWA tends to favour as hosts, in descending order: barley, durum wheat, bread wheat, triticale, cereal rye, and oats. [12]

Early research on triticale, rye and wheat resistance to RWA suggests that triticale and rye are moderately resistant–resistant to RWA. In this study the highest level of resistance was found in three triticale cultivars that originated, like the RWA, in Russia. [13]

Grain growers and advisers across the southern region are urged to monitor cereal paddocks closely for signs of damage caused by this aphid. If needed, growers should implement a considered management strategy to control the pest.

RWA was recently declared not technically feasible to eradicate 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 13 May 2016. [14] Since then, the aphid has been identified in cropping regions across South Australia [15] and in the Wimmera and Mallee regions of Victoria. In Victoria, 48 crop samples have been confirmed to have RWA infestations:

- 44 confirmed samples in an area bounded by Edenhope, Stawell, Bendigo, Echuca, Swan Hill, Manangatang, Patchewollock and the South Australian border;
- One sample each at properties to the west of Ararat, to the west of Daylesford, to the west of Werribee, and to the south of Inverleigh (west of Geelong). [16]

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 reproduces asexually, meaning it does not need males and

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

13 KK Nkongolo, JS Quick, WL Meyer, FB Peairs (1989) Russian wheat aphid resistance of wheat, rye, and triticale in greenhouse tests. Cereal Research Communications, 227–232.

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

15 PIRSA (2016) Russian wheat aphid: area affected within South Australia. PIRSA, http://www.pir.sa.gov.au/__data/assets/pdf_file/0006/276432/Russian_wheat_aphid_area_affected_20160811.pdf

16 Agriculture Victoria (2016) Russian wheat aphid. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/plant-diseases/grains-pulses-and-cereals/russian-wheat-aphid

females to breed. The aphid takes about three weeks in winter and 10 to 14 days in mid-spring to reach maturity. It then produces about two live nymphs a day for 2–4 weeks, for a total of 30–60 nymphs per female. This means it has a great capacity to increase numbers rapidly.

Further research is required to determine the impact of local environment factors on RWA population dynamics. [17]

7.3.1 Damage caused by RWA

RWA differs from other common cereal aphid species by injecting salivary toxins into the leaf of the host plant during feeding. The toxins kill the photosynthetic chloroplasts, and cause 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 the new leaf growth is unaffected. [18]

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 one tonne per hectare occurred in plants 95% infested with RWA at growth stage (GS) 59. In another overseas study, losses increased from 18% with 15–20 aphids per shoot to 79% with 185–205 aphids per shoot. [19]

7.3.2 Where to look and what to look for

According to South Australian Research and Development Institute (SARDI) entomologists, RWA is being found regularly in early-sown crops and 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, fescue, ryegrass, wild oats, phalaris and couch grass. RWA particularly favours brome grass, according to overseas information.

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 is approximately 2 mm 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 2). [20]

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

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

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

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

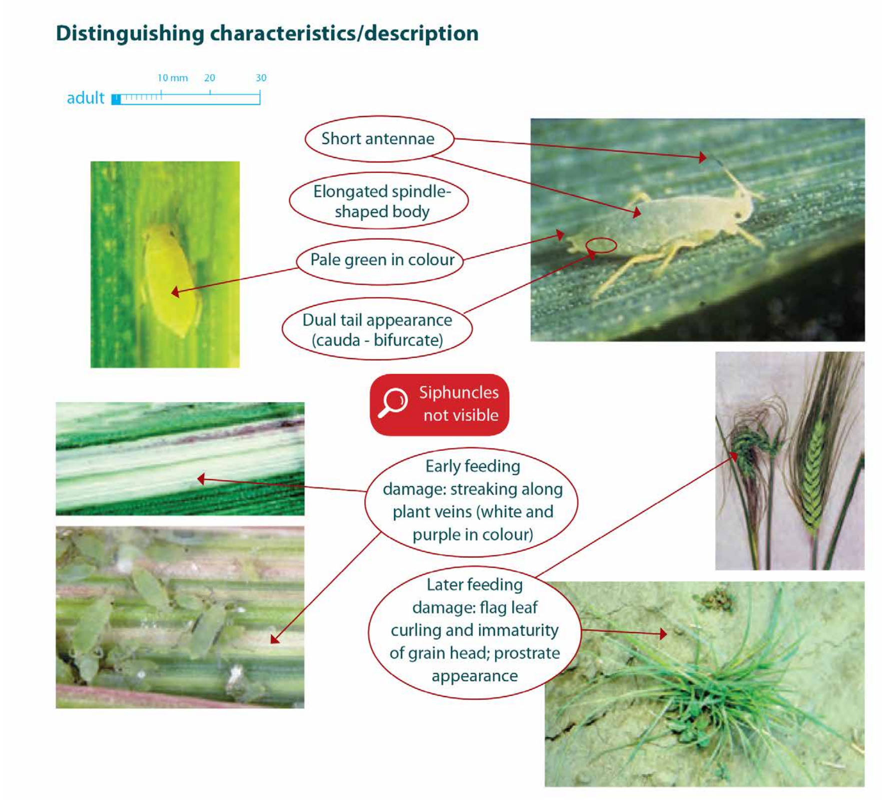


Figure 2: *Distinguishing characteristics of Russian wheat aphid.*

Photo: Frank Peairs

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

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

Measures to increase the likelihood of detecting RWA

The measures that will increase the likelihood of detecting RWA are:

- Target early-sown cereal crops and volunteer cereals (and brome grass, if present), particularly along crop edges.
- Follow a repeatable sampling pattern that 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 (GS20 and above) (Photo 3) [21]
- Deformed 'goose-neck' or 'fish-hook' head as result of awn trapped by unrolled flag leaves (GS50 and above) (Photo 4). [22]

21 Agriculture and Consumer Protection (n.d.) Plate 61. FAO Corporate Document Repository. FAO, http://www.fao.org/docrep/006/y4011e/y4011e0x.htm

22 Agriculture and Consumer Protection (n.d.) Plate 62. FAO Corporate Document Repository. FAO, http://www.fao.org/docrep/006/y4011e/y4011e0x.htm

Photo 3: *Plants damaged by toxins from feeding RWA, showing stunting and longitudinal striping on tightly rolled leaves.*

Source: FAO

Photo 4: *'Fish hook' deformation of a cereal head (right), caused by feeding RWA, compared to a normal cereal head (left).*

Source: FAO

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.
- At low densities plant beating has proven successful for detection. [23]

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

MORE INFORMATION

Russian wheat aphid: Taking and submitting samples for identification

VIDEOS

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

WATCH: Integrated pest management to combat the Russian wheat aphid

Photo 5: *Colony of Russian wheat aphids.*

Photo: Frank Peairs

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 (see below) as a guide for when to spray for the pest.

While the economic thresholds for control still need to be determined for Australian conditions, aphid numbers should be a key consideration before making the decision to spray. The key message is not to implement prophylactic insecticide applications, and to reconsider the need to spray where RWA is 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 according to the individual situation. The decision to spray should be based on a number of factors including:

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

In most of the 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 can be implemented as required. Overseas data indicate that RWA is susceptible to heavy winter rainfall, and the combination of cold, 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 (GS30–60). Vigilant monitoring for RWA is encouraged during these crop stages, and should continue through flowering to dough development. [24]

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

MORE INFORMATION

Russian wheat aphid: a new pest for Australian cereal crops

Ramp up monitoring for Russian wheat aphid

Paddock practices, southern, June 2016: Monitor RWA numbers closely over winter

Plant Health Australia, Russian wheat aphid

Russian wheat aphid surveillance reporting sheet (PDF, 279.7 KB)

NSW DPI, Exotic pest alert: Identification of Russian wheat aphid and associated damage

PIRSA, Russian wheat aphid: Paddock decontamination protocol (DOC, 197 KB)

Biosecurity Portal, RWA distribution map

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.

The authority has also issued permit PER82304 for the use of products containing 600 g/L IMIDACLOPRID as their only active constituent. Application rate is 120 mL product per 100 kg seed. This is for seed treatment only, and only for the control of Russian wheat aphid in winter cereals.

Note that these chemical control strategies are likely to change as new data allows for new permits and labels to be produced.

The permits must be read and understood by all persons, and operated on in accordance with the rules:

- Permit 82792 [PDF file, 33.3 KB]
- Permit 82792 [MS Word document, 46.8 KB]
- Permit 82304 [PDF file, 48.2 KB]
- Permit 82304 [MS Word document, 48.0 KB]

Chemical users must read and understand all sections of chemical labels and permits prior to use. There are numerous prohibitory statements on the product labels that it is critical to heed so as to correctly manage the risks associated with the use of the 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.

Other instructions that apply are:

- As well as following all prohibitory statements, observe all relevant withholding periods, export slaughter intervals (ESIs) and export grazing intervals (EGIs).
- 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. [25]
- 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 they can take appropriate steps to minimise the risks to their hives. Contact details can generally be found on the hives, or you can contact the owner of the land where the hives are located.

7.4 Aphids

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

The major species of aphids that can infest winter cereals are:

25 Agriculture Victoria (2016) Russian wheat aphid: Treatment Advice 23/06/2016. Factsheet. Agriculture Victoria, http://agriculture.vic.gov.au/__data/assets/word_doc/0017/321164/Final-RWA-Treatment-Factsheet.docx-.docx

- Oat or wheat aphid
- Corn aphid
- Rose-grain 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 (*Rhopalosiphum padi*) is a relatively common aphid that is most prevalent in wheat and oats. It 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 causing 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. It is widespread, being found in all states of Australia. It typically colonises 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 3). Adults may be winged or wingless; they tend to develop wings when plants become overcrowded or unsuitable. [26]

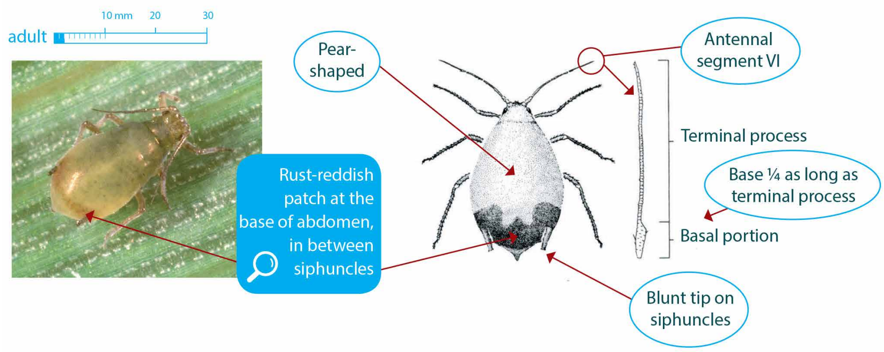


Figure 3: *Distinguishing characteristics of oat or wheat aphids.*

Source: cesar

7.4.2 Corn aphid

The corn aphid (*Rhopalosiphum maidis*) is introduced, and a relatively minor pest of cereal crops. It attacks crops at all stages, but most damage occurs when high populations infest cereal heads. The corn aphid is most prevalent in years when there is an early break to the season, followed by mild weather in autumn. This aphid transmits 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 4). The legs and antennae are typically darker in colour.

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

Nymphs are similar to adults but smaller in size and always wingless, whereas adults may be winged or wingless. [27]

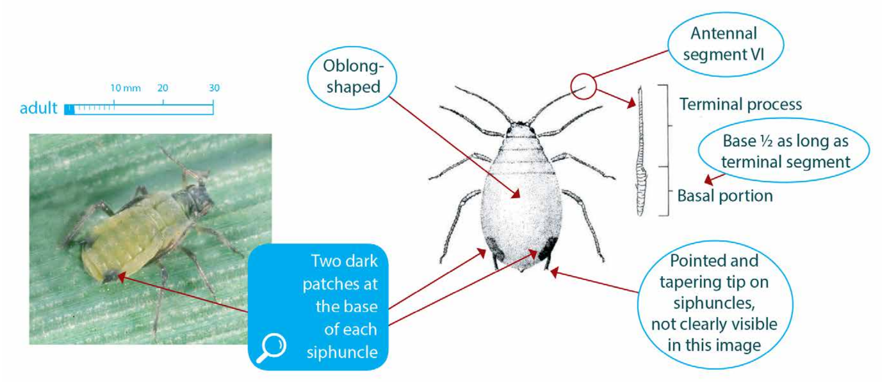


Figure 4: *Distinguishing characteristics of corn aphids.*

Source: cesar

7.4.3 Rose-grain aphid

The rose-grain aphid (*Metopolophium dirhodum*) is an introduced species that has been recorded in South Australia, Victoria, Tasmania, New South Wales and Queensland.

Adults and nymphs are sap-suckers. Under heavy infestations, plants may turn yellow and appear not to be thriving. They 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). [28] There is a dark green stripe down the middle of the back. Antennae reach beyond the base of the siphunculi. Nymphs are similar, but smaller in size. Because of its distinctive colour, it is unlikely to be confused with other aphids.

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

Source: DAF Qld

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

28 DAF Qld (2011) Rose-grain aphid. DAP Qld, https://www.daf.qld.gov.au/plants/field-crops-and-pastures/broadacre-field-crops/integrated-pest-management/a-z-insect-pest-list/aphid-overview/rose-grain-aphid

7.4.4 Conditions favouring aphid development

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.

However, they can be found all year round, often persisting on 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.

The aphids favour different environments:

- Oat aphid—basal leaves, stems and back of ears of wheat, barley and oats.
- Corn aphid—inside the leaf whorl of the plant, where cast skins indicate their presence; it is seldom on wheat or oats.
- Grain aphid—colonises the younger leaves and ears of wheat, oats and barley. [29]

Aphids can reproduce both asexually and sexually, although 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 breed 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 the honeydew excreted by aphids. When plants become unsuitable or overcrowding occurs, the population produces winged aphids (alates), which migrate to other plants or crops.

7.4.5 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.

The recommended control rate is 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. [30]

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

7.4.6 Managing aphids

Though aphid numbers are rarely high enough to warrant control, it is important to know the critical periods for aphid management (Figure 5). [31]

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

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

31 PIRSA (2015) Pest notes, southern: corn aphid. Fact sheet. PIRSA, SARDI, and cesar, http://www.pir.sa.gov.au/__data/assets/pdf_file/0006/275496/Corn_Aphid.pdf

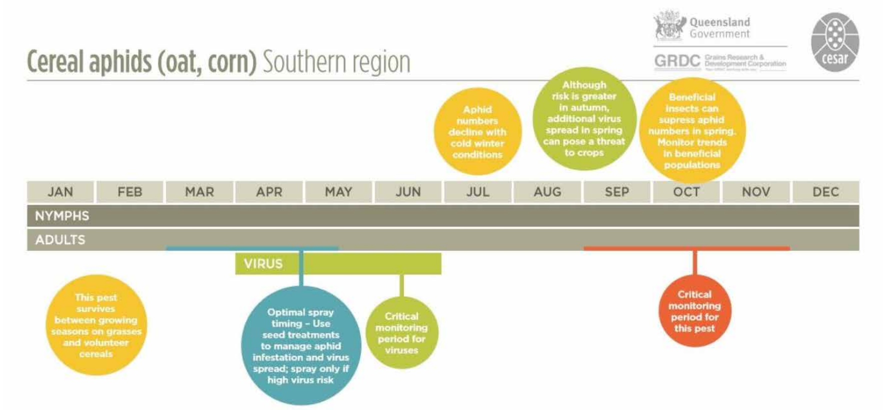


Figure 5: *Lifecycles, critical monitoring and management periods for cereal aphids in the southern region of Australia.*

Source: cesar and DAF Qld

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 parasitised than indicated by the proportion of mummies. The naturally occurring aphid fungal diseases *Pandora neoaphidis* and *Conidiobolyus obscurus* can also suppress aphid populations.

Cultural control

Sowing resistant cereal varieties is the most effective method of reducing losses. 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, to 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 or 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 sprays as 'insurance', 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, if left untouched, these natural enemies can play an important role in suppressing aphid populations. [32]

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

MORE INFORMATION

IPM Guidelines, Monitoring for insect pests and beneficials

IPM Guidelines, Keeping records

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 at least 5 points in the paddock, and sample 20 plants at each point. Populations may be patchy: densities at crop edges may not be representative of the whole paddock.

The average number of aphids found on samples of stems or tillers 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). [33]

7.5 Cutworm

Cutworms (*Agrotis* spp.) 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). [34] 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.

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

Source: cesar

33 IPM Guidelines (2016). Aphids in winter cereals. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/aphids/aphids-in-winter-cereals/

34 P Umina, S Hangartner 2015) Cutworm. cesar, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm

There has been a mixed response to cutworm damage in triticale in Australia. In trials in WA, it was found that after being attacked by cutworm four weeks after sowing, triticale could regenerate quickly. [35] In the south-west slopes of New South Wales, near Tarcutta, cutworms were reported to have caused severe damage to a several germinating triticale crops. The damage observed was patchy, although in some areas 100% of the plants died. Most problems were observed in paddocks that had contained weeds and stubble over summer, while clean paddocks that had been cropped in previous years typically had few problems. Prolonged autumn green feed is likely to have allowed caterpillars to develop to a large size by the time crops started to emerge. Chemical control was required in the worst-affected paddocks, and re-sown crops appeared to be emerging well. (The report was published before the crop matured, so the outcome was not recorded.) [36]

Cutworms are sporadic pests that are widely distributed in South Australia, Tasmania, Victoria, Western Australia, New South Wales 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, and they are similar in appearance. Generally, the 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 6). [37]

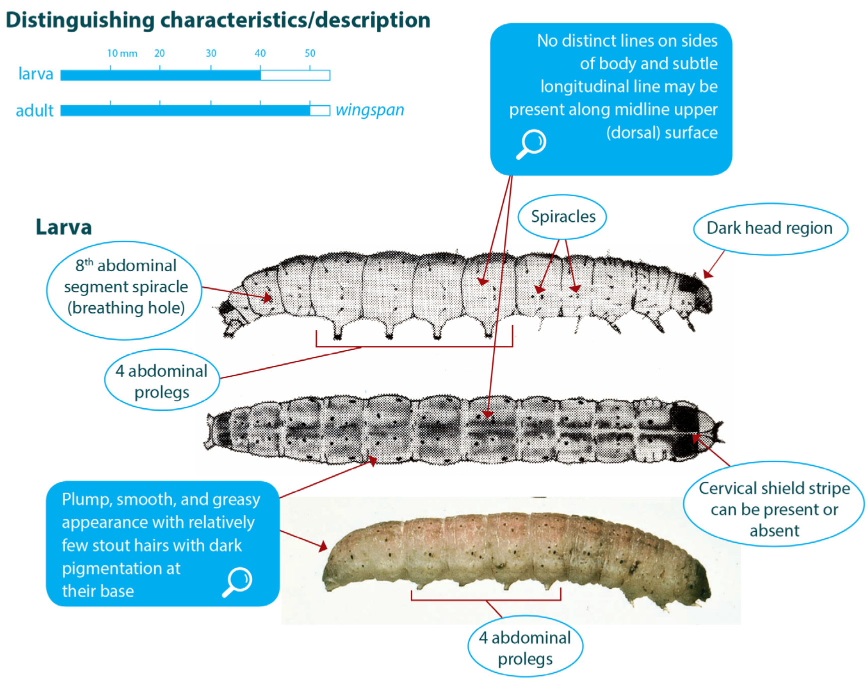


Figure 6: *Distinguishing characteristics of the cutworm.*

Source: cesar

Moths of the common cutworm (sometimes referred to as bogong moths) have dark brown or grey-black forewings with dark arrow markings on each wing, above a dark streak broken by two lighter coloured dots (Figure 7). 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 broken by two dark rings.

35 C Johnstone (2011) Triticale variety demonstration 2011. Online Farm Trials, http://www.farmtrials.com.au/trial/10587

36 McDonald G, Govender A & Umina P. PestFacts south-eastern Issue No. 3 – 21st May 2010. Cutworms. **cesar** pty ltd. http://www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2010/pestfacts-issue-no-3-21st-may-2010/cutworms/

37 P Umina, S Hangartner 2015) Cutworm. cesar, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Cutworm

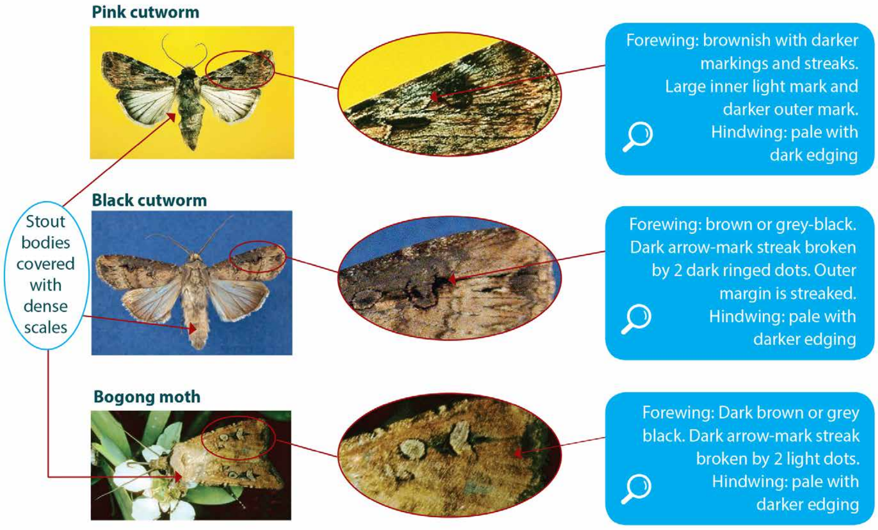


Figure 7: *Distinguishing characteristics of the adult forms of the pink, black and common cutworm.*

Source: cesar

7.5.1 Damage caused by cutworms

Larvae feed at ground level, chewing through leaves and stems. Stems are often cut off at the base. 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 (Photo 8). Smaller larvae can cause similar damage to lucerne fleas when they feed on the surface tissue of leaves. Young plants are favoured and are more adversely affected than older plants.

Occasionally another, undescribed genus of caterpillars, which are marked by a herringbone pattern on the abdomen, inflict cutworm-like damage on emerging crops.

Photo 8: *Pink cutworm damage to the plant (left) and paddock (right).*

Source: cesar

7.5.2 Thresholds for control

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

7.5.3 Managing cutworm

The critical periods for controlling cutworm are illustrated in Figure 8.

Figure 8: *Critical periods for controlling cutworms.*

Source: cesar

Biological control

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 that will also prey upon cutworms.

Cultural control

As autumn cutworm populations may be initiated from populations harboured by crop weeds or volunteers in and around the crop, removal of this green bridge 3–4 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 control

If required, cutworms can be easily controlled with insecticides. Several chemicals are registered for controlling them, the choice 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. [38]

7.6 Mites

7.6.1 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. This pest costs the Australian grains industry approximately $44.7 million per year. [39] The RLEM, was accidentally introduced into Australia from the Cape region of South Africa in the early 1900s. The mite is commonly controlled using pesticides, although non-chemical options are becoming increasingly important

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

39 GRDC (2013) Ground cover supplement: emerging issues with diseases, weeds and pests. GRDC, https://grdc.com.au/Media-Centre/Ground-Cover-Supplements/GCS102

due to evidence of resistance and concern about the long-term sustainability of pesticide use.

The RLEM is widespread throughout most agricultural regions of southern Australia. It is found in southern NSW, on the east coast of Tasmania, the south-east of SA, the south-west of WA and throughout Victoria (Figure 9). [40] Genetic studies have found high levels of gene flow and migration within Australia. Although individual adults only move short distances between plants in winter, recent surveys have shown an expansion of the range of the mite in Australia over the last 30 years. Long-range dispersal is thought to occur via the movement of eggs in soil that adheres 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.

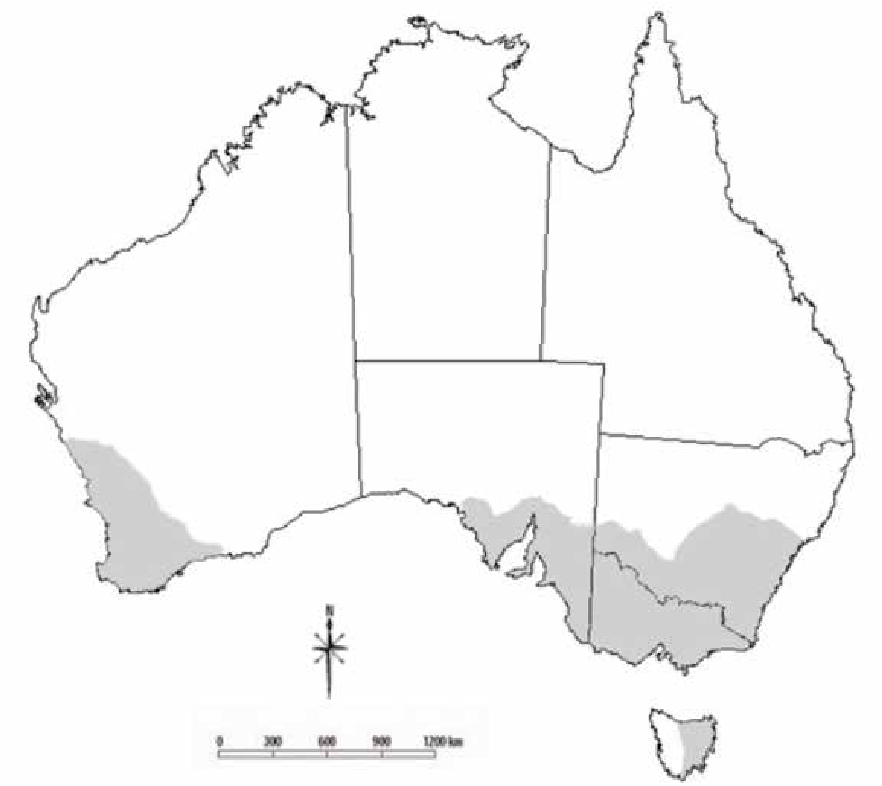


Figure 9: *The known distribution of redlegged earth mites in Australia.*

Source: cesar

Adult RLEM are 1 mm in length and 0.6 mm wide (i.e. about the size of a pin head) with eight red-orange legs and a completely black velvety body (Figure 10). Newly hatched mites are 0.2 mm long, are pinkish-orange and have six legs. They are not generally visible to the untrained eye. The larval stage is followed by three nymphal stages in which the mites have eight legs and resemble the adult, 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 groups of up to 30 individuals.

40 P Umina, S Hangartner (2015) Redlegged earth mite. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Redlegged-earth-mite

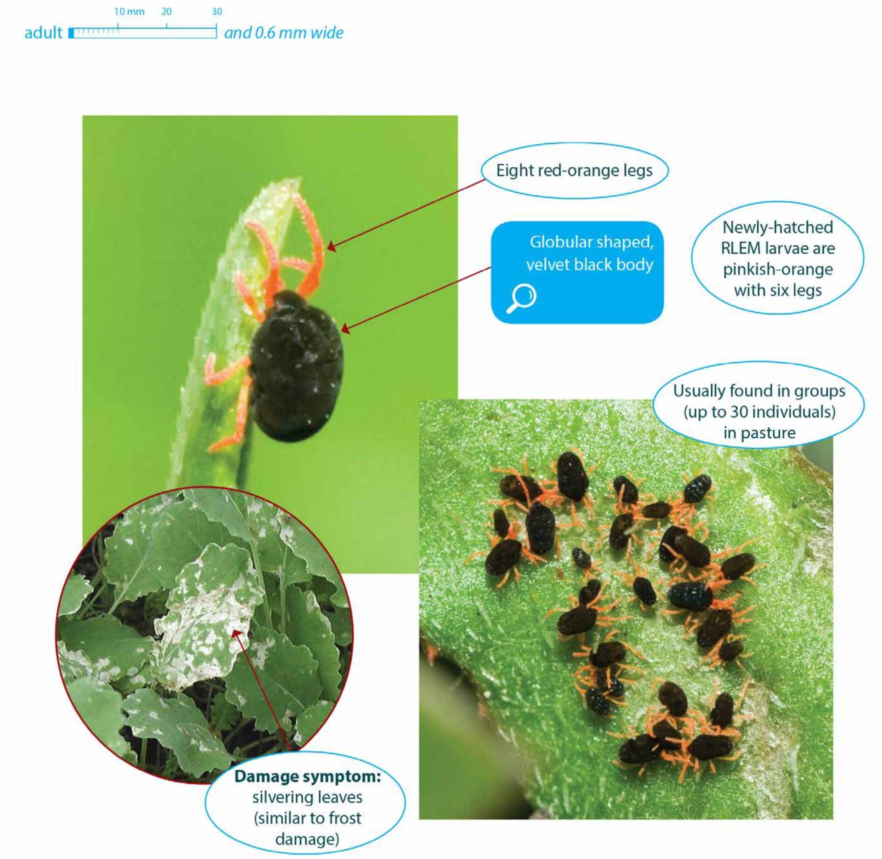


Figure 10: *Distinguishing characteristics of RLEM.*

Source: cesar

Damage caused by RLEM

RLEM hosts include pasture legumes, subterranean and other clovers, medics and lucerne. The mites is particularly damaging to seedlings of all legumes, oilseeds and lupins when it occurs in high numbers. It feeds on ryegrass and young cereal crops, especially oats. It also feeds on several weed species, including Paterson's curse, skeleton weed, variegated thistle, ox-tongue, smooth cats' ear and capeweed.

Typical mite damage appears as silvering or whitening of attacked foliage. Mites use their mouthparts to lacerate the leaf tissue and suck up the sap that is discharged. 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 an RLEM attack.

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

Managing RLEM

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.

It is important to understand the critical phases of the mite's life cycle so as to implement effective control (Figure 11).

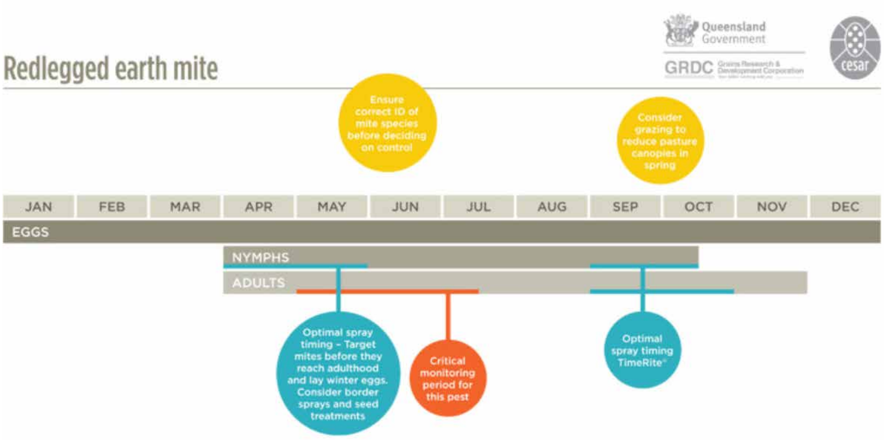


Figure 11: *Critical periods for managing RLEM.*

Source: cesar

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, although locally successful, it disperses and establishes only slowly, so the benefits of utilising this mite have 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 that inhabit windbreaks and roadside vegetation have been demonstrated to suppress RLEM in adjacent pasture paddocks. However, the application of border sprays to prevent mites moving into a crop or pasture also kills beneficial insects, thereby inadvertently 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 such as canola, 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. [41]

Chemical control

Chemicals are the most commonly used control 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. The timing of chemical application is critical.

Pesticides with persistent residual activity can be used as bare-earth treatments, either before 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 effective.

Systemic pesticides are often applied as seed dressings. Seed dressings act by maintaining the pesticide at toxic levels within the growing plant, and affect the 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 be badly damaged before the pesticide has much effect.

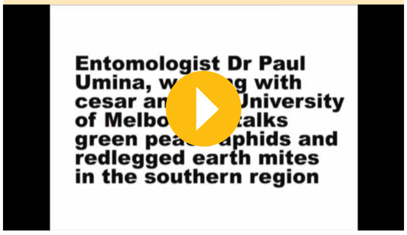
Spring sprays

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 spraying technique is not recommended as it could lead to populations evolving resistance to the pesticide. To prevent the development of resistance, the selective rotation of products with different modes of action is advised.

VIDEOS

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



41 P Umina (2007) Redlegged earth mite. Note AG0414. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/?a=223443

7.6.2 Balaustium mite

The Balaustium mite (*Balaustium medicagoense*), has recently been identified in 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. *It* attacks a variety of agriculturally important plants.

The mite is found sporadically in areas with a Mediterranean climate in Victoria, New South Wales, South Australia and Western Australia (Figure 12). [42] It has also been found in Tasmania, although its exact distribution is unclear. *Balaustium* mites are typically active from March to November, although they can persist on green feed during summer if it is available.

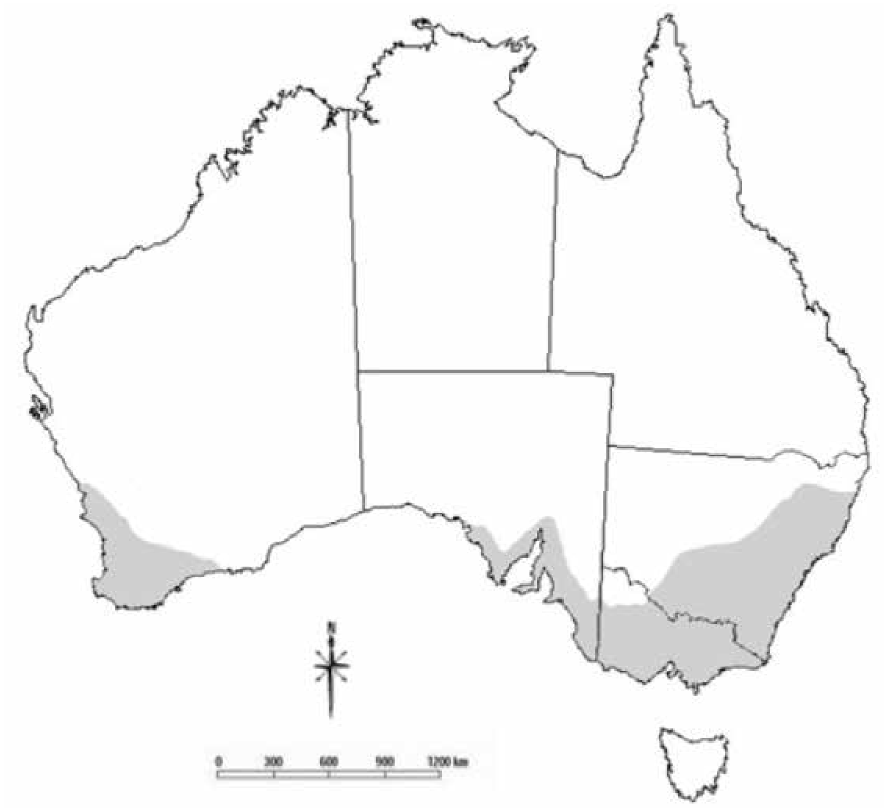


Figure 12: *The known distribution of Balaustium mites in Australia.*

Source: cesar

Balaustium mites are quite often confused with other pest mites, such as the redlegged earth mite, and the blue oat mite (*Penthaleus* spp.). They have a rounded dark red–brown body and red legs similar to other pest mites, and the distinctly short, stout hairs covering their entire body give them a velvety appearance (Figure 13). 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.

42 P Umina, S Hangartner (2015) Balaustium mite. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Balaustium-mite

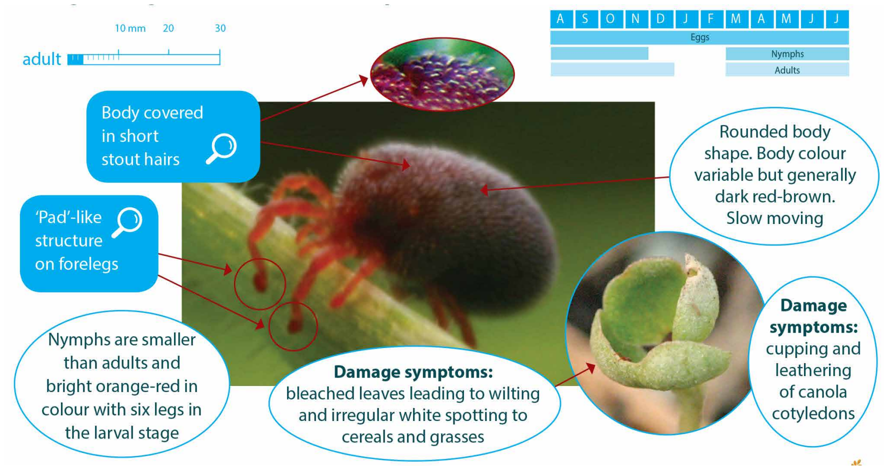


Figure 13: *Characteristics of adult Balaustium mite.*

Source: cesar

Newly laid eggs of Balaustium mites are light maroon in colour, becoming darker prior to the egg hatching. The bright orange larvae have six 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. [43]

Damage caused by Balaustium mite

Balaustium mites feed on plants using their adapted mouthparts to probe the leaf tissue of plants and suck up sap. In most situations, *they* 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.

There are no economic thresholds for this pest.

Management

It is important to understand the critical phases of the mite's life cycle so as to implement the most effective control (Figure 14).

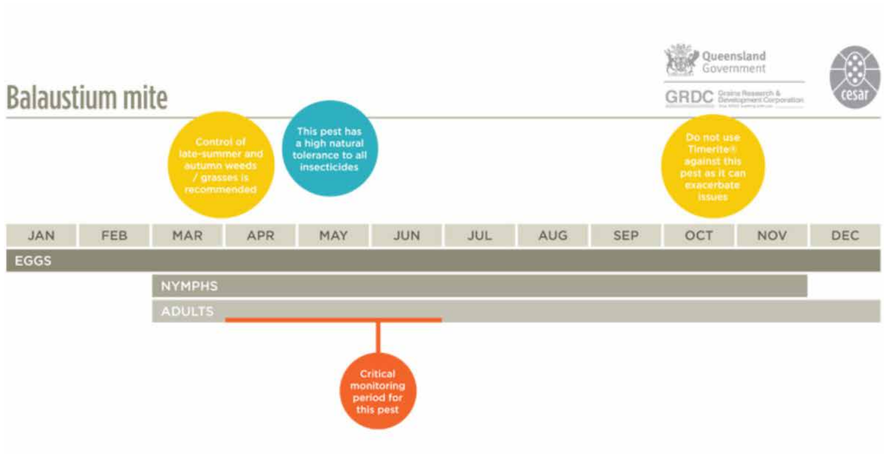


Figure 14: *Critical periods for Balaustium mite management.*

Source: cesar

43 D Grey (2010) Balaustium mite. Note AG1413. 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 grew 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 when feeding on the leaves, especially on or near the tips, during the warmest part of the day. They 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. Typically, a standard petrol-powered garden blower–vacuum machine, e.g. those manufactured by Stihl or Ryobi, is used. A sieve is placed over the end of the suction pipe to trap mites vacuumed from plants and the soil surface.

Biological control

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 prove to 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 or canola, a paddock could be sown to a broadleaf plant that *Balaustium* mites have not been reported to attack, such as vetch. [44]

MORE INFORMATION

APVMA

Chemical control

Currently no chemical has been registered to control Balaustium mite in any state or territory of Australia. The APVMA maintains a database of all chemicals registered for the control of agricultural pests in Australia. When a chemical is approved, it will appear on the database, so check the website for changes, or consult chemical resellers or a local chemical standards officer.

7.6.3 Blue oat mite

Blue oat mites (*Penthaleus* spp.) are species of earth mites that are major agricultural pests in southern Australia and other parts of the world, attacking various pasture, vegetable and crop plants. Blue earth mites (BOM) were introduced from Europe, and were first recorded in New South Wales in 1921. Management of these mites in Australia has been complicated by the recent discovery of three distinct species of BOM, which had previously been believed to be a single species.

The three species are *Penthaleus major*, *P. falcatus* and *P. tectus*. Although they are commonly found in Mediterranean climates in Victoria, New South Wales, South Australia, Western Australia and eastern Tasmania (Figure 15) [45], the distribution of each species differs.

44 D Grey (2010) Balaustium mite. Note AG1413. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/balaustium-mite

45 P Umina, S Hangartner (2015) Blue oat mite. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Blue-oat-mite

Figure 15: *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 8 red–orange legs. They have a blue-black coloured body with a characteristic red mark on their back (Figure 16). 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.

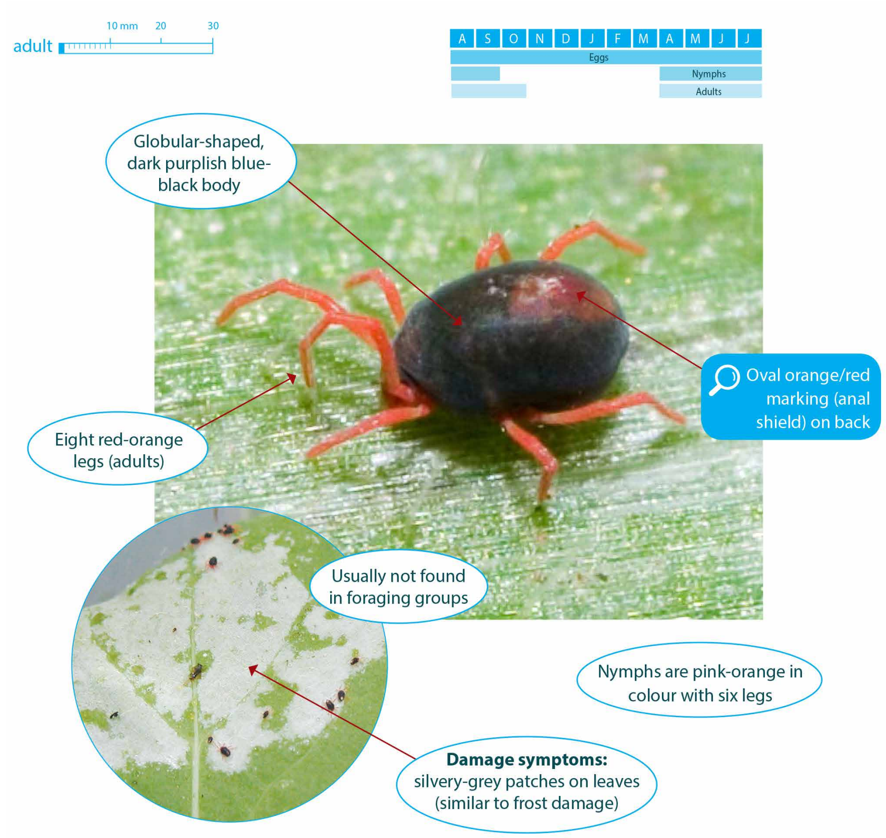


Figure 16: *Distinguishing characteristics of blue oat mite.*

Source: cesar

BOM are often misidentified as redlegged earth mites 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 body and tend to feed in larger groups of up to 30 individuals, whereas 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. When there are large mite populations, Affected seedlings can die at emergence. 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 sap discharged. Resulting cell and cuticle destruction promotes desiccation, retards photosynthesis and produces the characteristic silvering that is often mistaken as frost damage (Photo 9). [46] 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: Agriculture Victoria

Young mites prefer to feed on the sheath leaves or tender shoots near the soil surface, while adults feed on more mature plant tissues. 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

It is important to understand the critical phases of the mite's life cycle so as to implement the most effective control (Figure 17).

46 Agriculture Victoria (2007) Blue oat mite. Note AG 1300. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/blue-oat-mite

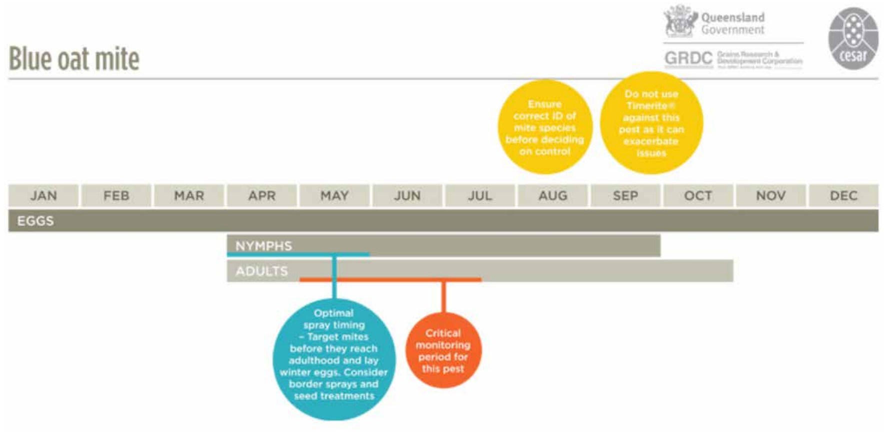


Figure 17: *Critical time periods for managing BOM.*

Source: cesar

Biological 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 the 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 control

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 bristly ox-tongue and cats ear, can help reduce BOM numbers.

Appropriate grazing 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. [47]

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 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 having to spray a second time. 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 build-up 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, occupational health and safety (OH&S), residues and off-target effects should be obtained before making decisions on which pesticide to use. This information is available from the chemical standards branch of your state agriculture department, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and material safety data sheet (MSDS) before using any pesticide.

7.6.4 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. They are unlikely to be a problem over winter, although 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, South Australia, New South Wales and Western Australia (Figure 18). [48] They have also been recorded in Tasmania and Queensland.

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

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

Figure 18: *Known distribution of Bryobia mites in Australia.*

Source: cesar

Bryobia mites 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 eight pale red–orange legs. The front pair of legs is much larger than the others, and approximately 1.5 times their body length. If seen under a microscope, they have a sparsely distributed set of broad, spade-like hairs, that appear like white flecks (Figure 19).

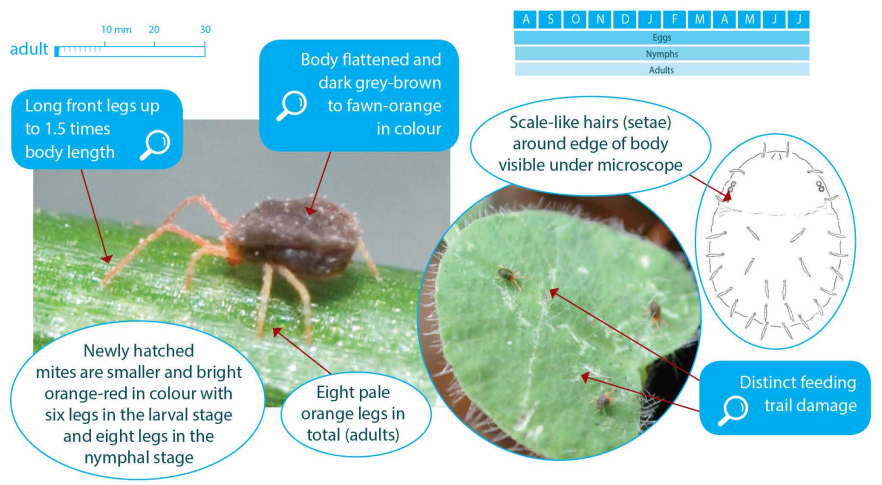


Figure 19: *Distinguishing characteristics of Bryobia mites.*

Source: cesar

Damage cause by Bryobia mites

Bryobia mites tend to cause the most damage in autumn where they attack 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 up leaf material. This feeding causes distinctive trails of whitish-grey spots on leaves. Extensive feeding damage can lead to cotyledons shrivelling. On grasses, Bryobia mite feeding can resemble that of redlegged earth mites.

There are no economic thresholds for control.

Managing Bryobia mites

To know the best times and methods for controlling Bryobia mites, it is important to understand their life cycle (Figure 20). [49]

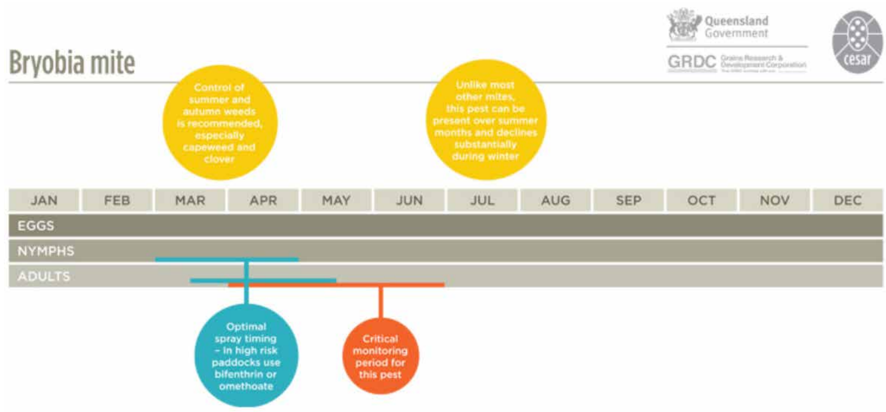


Figure 20: *Critical control periods for the Bryobia mite.*

Source: cesar

Biological control

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

Cultural control

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 control

Some insecticides are registered for use against Bryobia mites; however, be aware that recommended rates used against other mites might be ineffective against *Bryobia* spp., which 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. [50]

7.7 Lucerne flea

The lucerne flea (*Sminthurus viridis*) is a springtail that is found in both the northern and southern hemispheres but is restricted to areas that have a Mediterranean 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.

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

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

Lucerne fleas are common pests found in Victoria, Tasmania, South Australia, New South Wales and Western Australia (Figure 21). Higher numbers are often found in the winter rainfall areas of southern Australia, including Tasmania, or in irrigation areas where moisture is plentiful. They are generally more problematic on loam/clay soils. Lucerne fleas are often patchily distributed within paddocks and across a region.

Figure 21: *The known distribution of the Lucerne flea in Australia.*

Source: cesar.

The lucerne flea (*Sminthurus viridis*) 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. It is not related to the true fleas. 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, among them 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. It is wingless and has an enlarged, globular abdomen (Figure 22). [51] Newly hatched nymphs are pale yellow and 0.5–0.75 mm long, and as they grow they resemble adults, but are smaller.

51 P Umina, S Hangartner, G McDonald (2015) Lucerne flea. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Lucerne-flea

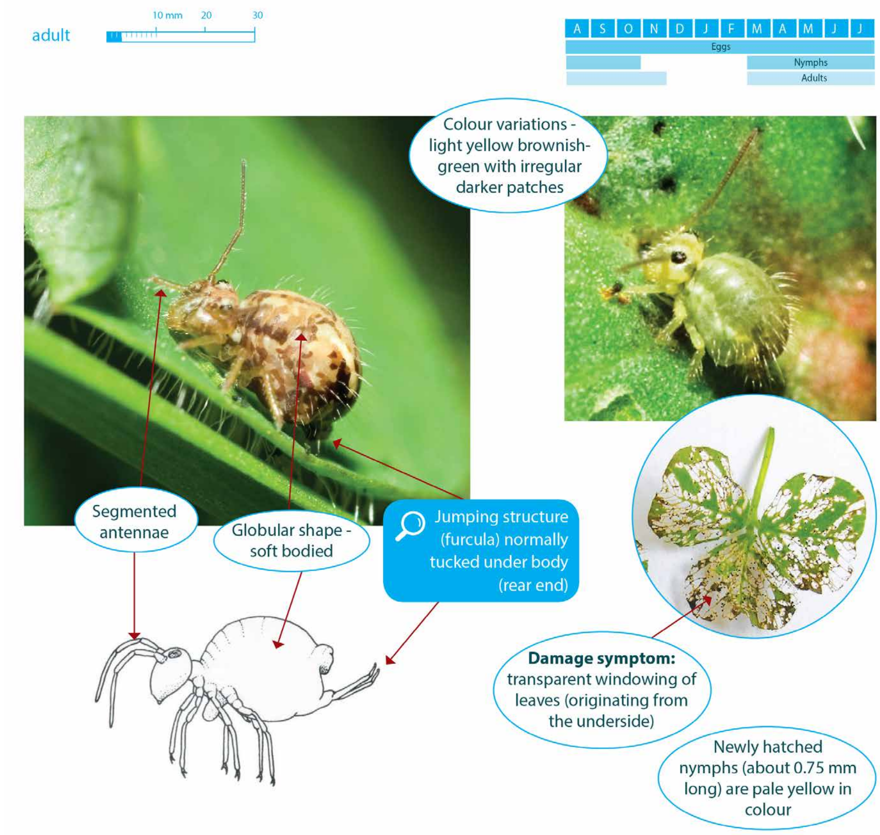


Figure 22: *Distinguishing characteristics of the lucerne flea.*

Source: cesar

7.7.1 Damage caused by the lucerne flea

Although grasses and cereals are not preferred hosts, lucerne fleas can 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 use a rasping process to consume the succulent green cells of leaves, avoiding the more fibrous veins and leaving behind a layer of leaf membrane. This makes the characteristic small, clean holes in leaves which can appear as numerous tiny 'windows'. In severe infestations this damage can stunt or kill plant seedlings.

7.7.2 Managing the lucerne flea

Monitoring is the key to reducing the impact of the lucerne flea. Crops and pastures grown in areas where the lucerne flea has previously been a problem should be monitored fortnightly for damage from autumn through to spring. Weekly monitoring is better where there have been problems in previous years. Susceptible crops and pastures should also be carefully inspected for the presence of the flea and evidence of the damage it causes.

It is important to frequently inspect winter crops, particularly canola and pulses, in the first three to five weeks after sowing, as crops are most susceptible to damage immediately following the emergence of seedlings.

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

Some sprays must be applied 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.

Biological control

Several predatory mites, various ground beetles, and spiders prey on 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 fleas.

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

Photo 10: *Predatory adult snout mite.*

Photo: A. Weeks

Cultural control

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

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

Other cultural techniques such as cultivation, trap crops 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. [52]

52 G McDonald (2008) Lucerne flea. Note AG0415. Updated. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/lucerne-flea

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 occur 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 hatchings, 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 be damaged where they follow a weedy crop or a pasture in which lucerne fleas have not been controlled. Therefore, controlling the fleas 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 fleas. When both lucerne fleas and redlegged earth mites are present, it is recommended that control strategies account for both pests: use a product registered for both, at the higher rate of 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 chemical standards branch of your state agriculture department, chemical resellers, APVMA and the pesticide manufacturer. Always consult the label and MSDS before using any insecticide.

7.8 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 budworms will also 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, armyworms will 'march' out of crops and pastures in search of food, hence their common name.

Barley, oats and rice are most susceptible to economic damage, but armyworms are also commonly found in wheat, triticale and grass pastures where extreme defoliation or head loss occasionally occurs.

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

- common armyworm (*Leucania convecta*)
- southern armyworm (*Persectania ewingii*)
- inland armyworm (*Persectania dyscrita*)

These are native pests. The common armyworm (*Leucania convecta*) is found in all states of Australia and, potentially, will invade all major broadacre-cropping regions year round, but particularly spring and summer. The Persectania species are more typically found in southern regions of Australian autumn and winter, but they may also be active into spring.

Caterpillars of the three species are similar in appearance. They grow from about 2 mm to 40 mm in length. They have three prominent white or cream stripes running down the back and sides of their bodies. They are most obvious where they start on the thoracic segment ('collar') immediately behind the head, and become 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 23). [53]

Mature caterpillars are 30–40 mm long. For 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 their stripes, which stay constant no matter what variation there is in the colour of the body. Other species of caterpillar which may be confused with armyworms include:

loopers (tobacco looper or brown pasture looper) which walk with a distinct looping action and have one or two pairs of abdominal prolegs—whereas armyworms have four pairs, and do not walk with a looping action once they are >10 mm.

budworm larvae, which have prominent but sparse hairs and bumps on their skin, or anthelid larvae which are covered in hairs—whereas armyworms are smooth-bodied with no obvious hairs.

cabbage moth larvae, which wriggle vigorously when disturbed—whereas armyworms curl up into a tight C.

- cutworm (brown or common cutworm) larvae, which have no obvious stripes or markings and are uniformly brown, pink or black.

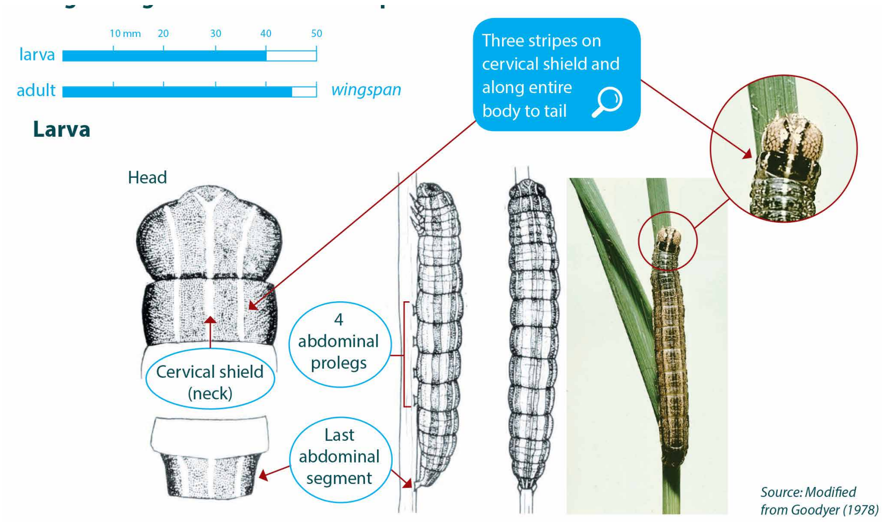


Figure 23: *Distinguishing characteristics of armyworm larvae.*

Source: cesar

The 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 (Figure 24):

- 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, and dark grey hind wings.
- Inland armyworm—similar to the southern armyworm except the white 'dagger' is divided into two discrete light ellipses which almost touch, and pale grey hind wings.
- Common armyworm—the forewings are dull yellow to reddish-brown, speckled with tiny black dots, and a small white dot near the centre.

53 G McDonald (2015) Armyworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Armyworm

Pupae of all three species are about 20 mm long and shiny brown. They are found under clods or in cracks in the soil. [54]

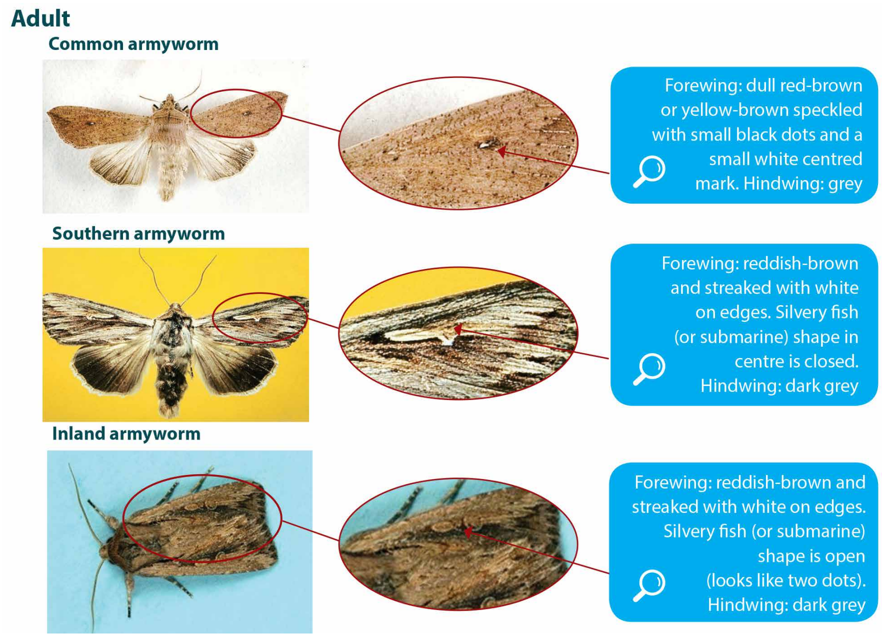


Figure 24: *Distinguishing characteristics of the moths of the three armyworm species.*

Source: cesar

7.8.1 Damage caused by armyworms

Armyworms prefer lush growth that provides good cover and protection. Bare patches adjacent to barley fields or damage to weeds may indicate armyworm presence before it is evident in crops. [55] The crops affected include all Gramineae crops: cereals, grassy pastures, and maize.

The caterpillars produce green–straw-coloured droppings the size of a match head. These are visible between the rows.

The young larvae feed initially on 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, leaving leaf margins that look tattered, chewed or scalloped. This becomes increasingly evident by mid to late winter. In extreme cases whole leaves may be severed at the stem. By the end of winter or early spring, the larvae are reaching full size and maximum food consumption. It is this stage that farmers most frequently notice them, as complete leaves and tillers may be consumed or severed from the plant.

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 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.

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:

54 G McDonald (1995) Armyworms. Note AG0412. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

55 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

MORE INFORMATION

Agriculture Victoria, Armyworms

- the standing stubble from the previous year's cereal crop, in which the eggs are laid;
- neighbouring pastures which dry out, forcing the resident armyworms to march into the crop.
- In spring and 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.

7.8.2 Thresholds for control

Economic threshold estimated at 10 grubs/m^2. (The threshold for triticale is higher than barley because heads are rarely lopped.) [56]

For winter outbreaks (during tillering), economic thresholds of 8 to 10 larvae per m^2 provide a guide for spray decisions. For spring outbreaks (during crop ripening) spraying is recommended when the density of larvae exceeds 1 to 3 larvae per 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). [57]

7.8.3 Managing armyworms

Sampling and detection

Signs of the presence of armyworms include:

- Chewing or leaf scalloping along the leaf margins.
- Caterpillar excreta (frass) which collects on leaves or at the base of the plant.
- 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 or bucket, or visually searching the ground or crop for caterpillars or signs of damage.

The sweep-net or bucket method provides a rapid and approximate estimate of infestation size. The utensil should be swept across the crop in 180o arcs numerous times, preferably 100 times, at different sites in 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, at each site counting the number of caterpillars within a square metre.

Most farmers fail to detect armyworms until the larvae are almost fully grown, by which stage 10–20% of the crop may be damaged. 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 three to four weeks

56 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

57 G McDonald (1995) Armyworms. Note AG0412. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/armyworms

before harvest. [58] In order to control them, it is important to understand their life cycle and know when to monitor for them (Figure 25). [59]

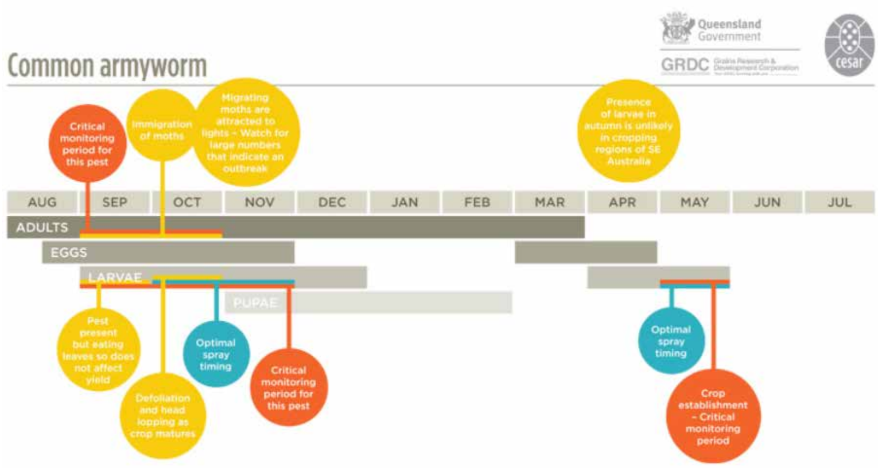


Figure 25: *Critical monitoring and management stages in the armyworm life cycle.*

Source: cesar

Biological control

Around 20 species of predators and parasitoids have been recorded attacking armyworms. 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* and *Campoletis spp*.). Viral and fungal diseases are recorded as killing armyworms. Predator outbreaks are more common when there are high densities of armyworms.

Cultural control

Control weeds to remove alternative hosts, and keep an eye on other crops, too: armyworms 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 may move into cereals if adjacent pastures are chemically fallowed, spray topped or cultivated in spring. Monitor for at least a week after doing any of these things. Damage is generally confined to crop margins.

Chemical control

There are several insecticides registered against armyworms in broadacre crops. See the APVMA website for current chemical options. The biological insecticide *Bacillus thuringiensis* (Bt) is effective on armyworms and is also 'soft' on natural enemies. Spray *Bt* late in the day/evening to minimise UV breakdown of the product, and ensure the insecticide is sprayed out within 2 hours of mixing. Make sure the appropriate strain is used for the target pest, add a wetting agent and use high water volumes to ensure good coverage on leaf surfaces. When insecticides are required, it is recommended that applications be carried out in the late afternoon or early evening. [60]

To be effective, chemical control requires good coverage to ensure contact with the caterpillars. Control is more difficult in high-yielding crops with thick canopies where larvae rest under the leaf litter at the base of plants.

MORE INFORMATION

IPM Guidelines, Common predators

IPM Guidelines, Common parasitoids

IPM Guidelines, Viral and fungal diseases of crop pests

MORE INFORMATION

IPM Guidelines, Farm hygiene

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

59 G McDonald (2015) Armyworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Armyworm

60 G McDonald. (2016). Armyworm – cesar PestNotes southern. http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Armyworm

Be aware of withholding periods when chemical control is used close to harvest. [61]

7.9 Slugs and snails

Slugs and snails are predominantly pests in the southern and western regions (Table 4). [62]

Increased slug and snail activity may be due to the increase in zero-till and minimum-till farming and greater stubble retention, because the organic content of paddocks increases under such systems, providing more food, 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.

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 is greater than 25%	Resident pest Surface active, but seeks moist refuge in soil macropores
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 or maize crops fail to emerge Prefers sandy soil in high-rainfall areas (>550 mm), and heavier soils in low-rainfall areas (<500 mm) Surface active (feeding), but seeks moist refuge in soil macropores

61 IPM Guidelines (2016) Armyworm. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/armyworm/

62 IPM Guidelines (2016) Slugs and snails. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
Brown field slug *Deroceras invadens* or *D. laeve*  Photo: Michael Nash, SARDI	Usually brown all over with no distinct markings 25–35 mm long 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
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 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 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 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.

Species	Distinguishing features	Characteristic damage	Seasonal occurrence	Other characteristics
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
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 Like 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 species-specific.

Source: IPM Guidelines

7.9.1 Economic thresholds for control

Thresholds (Table 5) can be unreliable due to the interaction between weather, crop growth and snail activity. For example, high populations in the spring do not always relate to the number of slugs and snails harvested. Their movement into the crop canopy is dictated by weather conditions prior to harvest. [63]

Table 5: *Thresholds for controlling snails and slugs in a paddock. If there are more than the number specified per metre for a given pest then actions for controlled the pest should be taken.*

Pest	Number of pest per square metre
Round snails	20
Small pointed snails	40
Grey field slug	5-15
Black-keeled slug	1-2

Source: IPM Guidelines.

7.9.2 Managing slugs and snails

Biological control

Free-living nematodes when carrying bacteria that kill snails and slugs are thought to help reduce populations under certain paddock conditions.

63 IPM Guidelines (2016) Slugs in seedling crops. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/slugs-in-seedling-crops/

Note that baits containing methiocarb are toxic to a number of other invertebrates and beneficials.

Natural enemies of slugs

Some species of carabid beetles can reduce slug populations, but generally not below established economic thresholds. Many other soil fauna, such as are protozoa, may cause high levels of slug egg mortality under moist, warm conditions. Biological controls alone cannot be solely relied on for slug control.

Cultural control

- Hard grazing of stubbles
- Cabling and/or rolling of stubbles when soil temperature is above 35°C
- Burning if numbers are very high and you can ensure hot, even burns
- Cultivation that leaves a fine, consolidated tilth
- Removal of summer weeds and volunteers

Chemical control

Snails

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 over 7 mm in length or diameter will feed on bait while bait is less effective on juveniles. Baiting before egg lay is vital. Try to bait when snails are moving from resting sites after summer rains. Stop baiting eight 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. As the actual number is yet to be determined, label rates may be revised ion the future. In cool, moist conditions, snails can move 30 m/week, so treated fields can be re-invaded from fence lines, vegetation and roadsides. Rain at harvest can cause snails to crawl down from crops.

Slugs

Baiting is the only chemical option available to manage slugs. Molluscidial baits containing 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. Make sure to bait after/at sowing prior to crop emergence when soil is moist (>20% soil moisture). Re-apply baits to problem areas 3–4 weeks after first application if monitoring indicates slugs are still active.

Note that the number of baits/ha is more important than total weight of bait per hectare. The minimum baits needed for effective control is 250,000 bait points per hectare.

Monitoring snails

Monitor regularly to establish numbers, types and activity (Table 6), and measure 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 or cabling

Monitoring technique:

- sample 30 x 30 cm quadrat at 50 locations across the paddock.
- if two groups (round and conical) are present, record the number of each group separately
- to determine the age class of round snails, place into a 7 mm sieve box, shake gently to separate into two sizes >7 mm (adults) and <7 mm (juveniles).
- make sieve boxes from two stackable containers, e.g. sandwich boxes, remove the bottom from one and replace by a punch-hole screen with screen size of 7 mm round or hexagonal
- use 5 sampling transects in each paddock, one each at 90 degrees to each fence line and the fifth running across the centre of the paddock, and take five samples (counts), 10 metres apart along each transect

Record the size and number of the snails in each sample. Average the counts for each transect and multiply this figure by 10 to calculate the number of snails per square metre in that area of the paddock.

Table 6: *Monitoring snails at different stages of crop development.*

Pre-sowing	Seedling–vegetative stages	Grain fill and podding stage	Harvest
High risk: weedy fields alkaline calcareous soils retained stubble wet spring, summer, autumn history of snails All species congregate at the base of summer weeds or in topsoil. Pointed snails can also be found at the base of or up in stubble as well as inside stubble stems. Appear to build up most rapidly in canola, field peas and beans, but can feed and multiply in all crops and pastures. Most active after rain and when conditions are cool and moist Dormant in late spring and summer	Damage: consume cotyledons, which may resemble crop failure shredded leaves where populations are high chewed leaf margins irregular holes Wide range of sizes indicates snails are 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	Can be found up in the crop prior to harvest. Check for snails under weeds or shake mature crops unto tarps.	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 L of wheat more than half a dead or one live snail is found in 200 g pulse sample

Source IPM Guidelines

Monitoring slugs

Monitor with surface refuges to provide an estimate of active density (Table 7). Refuges include:

- terracotta paving tiles
- carpet squares or similar

Use a 300 mm by 300 mm refuge when soil moisture is favourable (more than 20%) as slugs require moisture to travel across the soil surface. Slugs are attracted to the refuges from approximately 1 m, so numbers found can be used as numbers per square metre.

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. Alternatively, put out metaldehyde bait strips and check the following morning for dead slugs. Monitor for plant damage.

Slug populations are not evenly distributed in the paddock and are often clumped. Where crop damage is evident inspect the area at night. [64]

Table 7: *Monitoring slugs at different stages of crop development.*

Pre-sowing	Germination–vegetative stages
High risk: • high rainfall areas >450 mm a year • 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

Source IPM Guidelines

MORE INFORMATION

GRDC factsheet, Slug identification and management

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 which are commonly called click beetles. They are from the family Elateridae. False wireworms are also the larval form of adult beetles, some of which are known as pie-dish beetles. They belong to another family, Tenebrionidae, and have distinctively different forms and behaviour.

Both groups inhabit native grassland and improved pastures where they generally cause little damage. However, cultivation and fallowing decimates their food supply, so any new seedlings that grow may be attacked and sometimes destroyed. They attack the pre-emergent and post-emergent seedlings of all oilseeds, grain legumes and cereals, particularly in light, well-draining soils with a high organic content. Crops with fine seedlings, such as 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

False wireworms are the larvae of native beetles which normally live in grasslands or pastures, and cause little or no damage there. In crops, they are mostly found in paddocks with large amounts of stubble or crop litter, and they may affect all winter-sown crops.

There are a large and varied number of species of false wireworms, but all species exhibit some common characteristics. Larvae are cylindrical, hard bodied, fast moving, golden brown to black-brown or grey with pointed, upturned tails or a pair

64 IPM Guidelines (2016) Slugs in seedling crops. Queensland Government and GRDC, http://ipmguidelinesforgrains.com.au/pests/slugs-and-snails/slugs-in-seedling-crops/

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 large or eastern false wireworm (*Pterohelaeus spp*.)
- the southern false wireworm (*Gonocephalum spp*.)

In the grey or small false wireworm, the larvae grow to about 9 mm in length. They are grey-green, have two distinct protrusions from the last abdominal (tail) segment, and tend to have a glossy or shiny exterior (Figure 26). 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 one most associated with damage (Figure 26). [65]

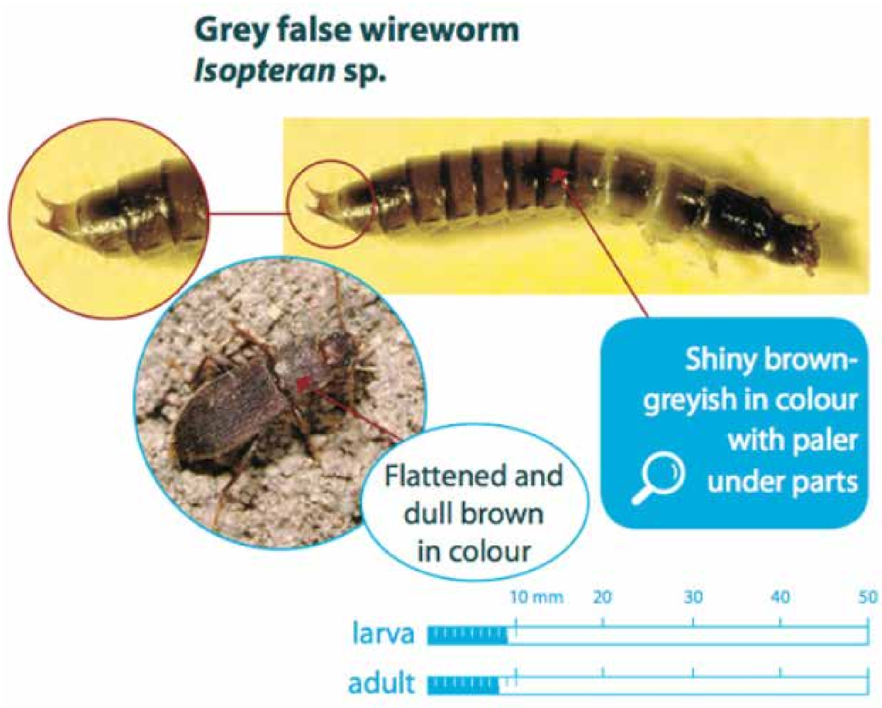


Figure 26: *Distinguishing characteristics of the grey false wireworm.*

Source: cesar

The large or eastern false wireworms 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. The last abdominal segment has no obvious protrusions, although, under a microscope, a number of distinct hairs can be seen. Adults are large, conspicuous and often almost ovoid beetles with black shiny bodies (Photo 11). [66]

65 G McDonald (2016) Grey false wireworm. Updated. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Grey-false-wireworm

66 G McDonald (2016) Eastern false wireworm. Updated. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Eastern-false-wireworm

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

Source: cesar

Southern false wireworms (*Gonocephalum spp*.) grow to about 20 mm in length, and have similar body colours and markings to the large false wireworm. Adults are generally dark brown–grey, oval beetles, which sometimes have a coating of soil on the body (Figure 27). [67] The edges of adults' bodies are flanged, hence the common name pie-dish beetle.

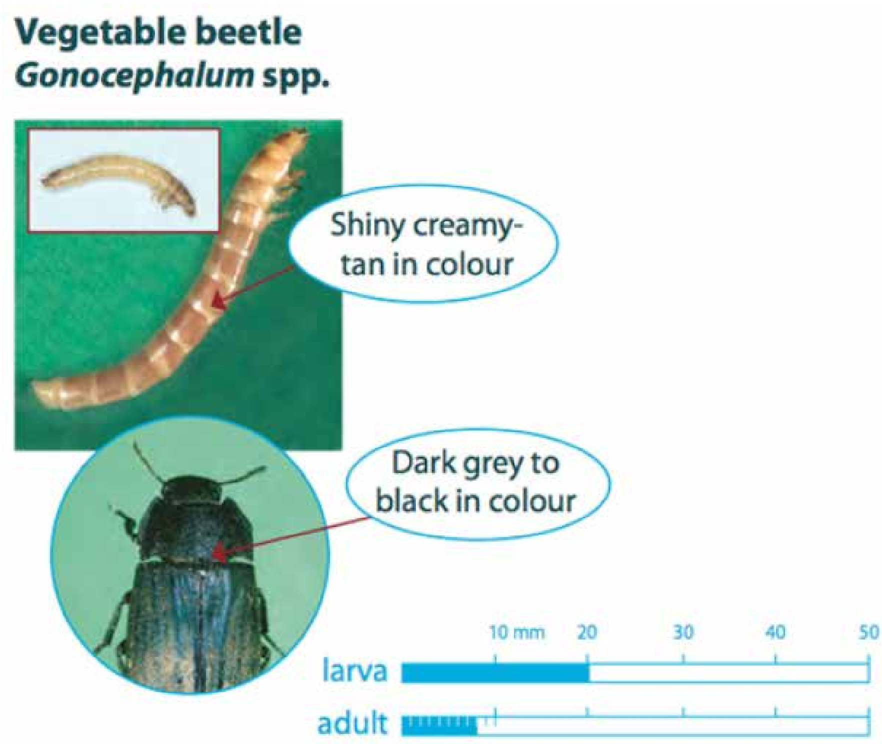


Figure 27: *Distinguishing characteristics of the southern false wireworm.*

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 paddocks where stubble has been retained.

67 P Umina, G McDonald (2015) Southern false wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Southern-False-wireworm

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 is dampened by dew.

Nothing is known about what triggers the false wireworm to change from feeding on organic matter and litter to feeding on plants. However, it is recognised that significant damage of plants is likely to occur when soils remain dry for extensive periods. Larvae are likely to stop feeding on organic matter when it dries out, and when 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). [68] Damage is usually greatest when crop growth is slow due to cold, wet conditions.

Photo 12: *False wireworm damage to pasture.*

Source: SARDI

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 per square meter 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 in warm conditions. Larger seedlings (e.g. those of grain legumes) may also be attacked, but the larvae appear to be too small to cause significant 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.

68 P Umina, G McDonald (2015) Southern false wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Southern-False-wireworm

7.10.2 True wireworm

The true wireworms are many species in the family Elateridae. The slow-moving larvae in this family tend to be less common in broadacre cropping regions, although they are always present. They are generally associated with wetter soils than the larvae of false wireworms.

Larvae grow to 15–40 mm, are soft-bodied, and flattened, and these characteristics help distinguish them from false wireworms. Their colour ranges from creamy yellow in the most common species to red-brown; their head is dark brown and wedge-shaped. The tail piece 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. The beetles are dark brown, elongated and 9–13 mm long (Figure 28). [69]

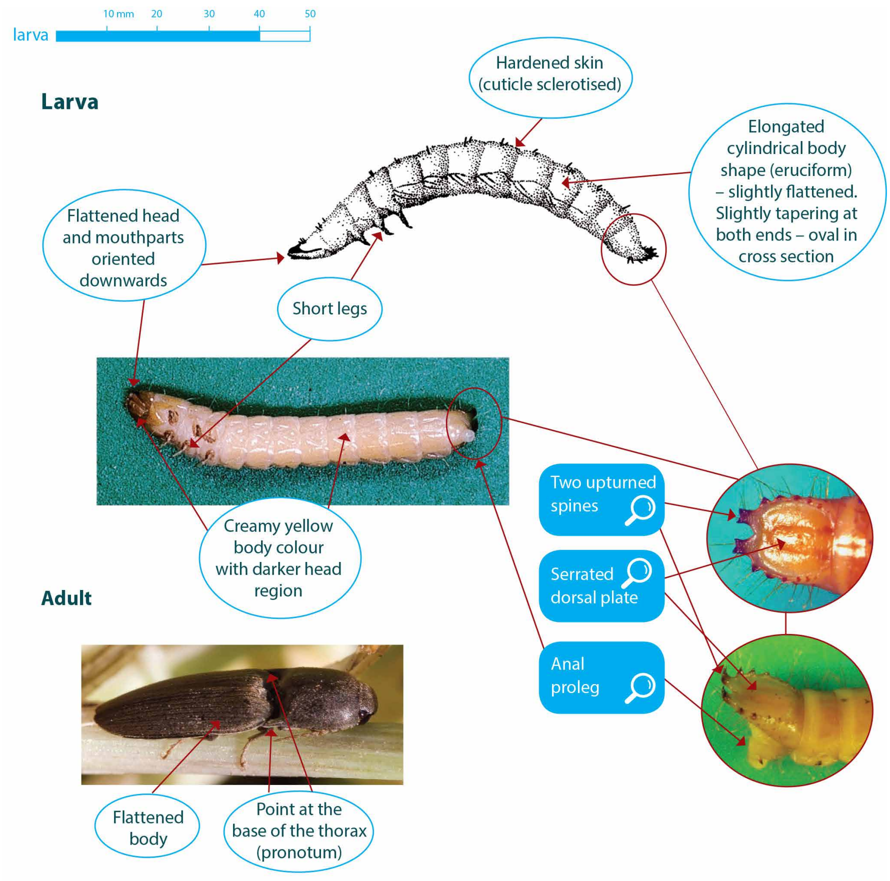


Figure 28: *Distinguishing characteristics of true wireworms.*

Source: cesar

Biology

There may be one or several generations per year, depending on the species. 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. Most damage occurs from April to August. Adults emerge in spring, and 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, although one species (*Hapatesus hirtus*) is better understood. It is known as the potato wireworm although it is found in many other crops and pastures as well as in potatoes. It is very long-lived and

69 B Kimber (2015) True wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/True-wireworm

probably takes five years or more to pass through all the wireworm stages before pupating and finally emerging as an adult beetle.

After emerging, adult click beetles 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 along 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 of it is restricted to below the soil surface. Larvae eat the contents of germinating seeds, and the underground stems of establishing plants, causing wilting and death.

7.10.3 Sampling and detection of wireworms

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

Paddocks should be sampled immediately before sowing. There are two methods, although neither is 100% reliable. This is because larvae change their behaviour according to soil conditions, particularly soil moisture and temperature. The two methods are:

- Soil sampling—take a minimum of five random samples from the soil. Each sample should consist of the top 20 mm of a 0.50 m x 0.50 m area. Carefully inspect the soil for larvae. Calculate the average density per square metre 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 larger false wireworms.
- Seed baits—these have been used to successfully 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 to give an approximation of density. Take about 200–300 g of a large seed, such as that of any grain legume, and soak for 24 hours. Select 5–10 sites in the paddock and place a handful of the soaked seed into a shallow hole (50 mm) and cover with about 10 mm of soil. Mark each hole with a stake, and excavate each hole after about seven days. Inspect the seed and surrounding soil for false wireworm larvae. This technique is most likely to be successful when there is some moisture in 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 sun. 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 beetles. Clean cultivation over summer will starve adults and larvae and expose them to hot, dry conditions, thus preventing population increases. Suitable crop rotations may also limit increases in population numbers.

Seedbeds must be sampled before sowing if control is to be successful. Insecticides may be applied to soil or seed at sowing. Most chemicals registered to control false wireworms 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. [70] The critical periods for control of false wireworm and shown in Figure 29. [71]

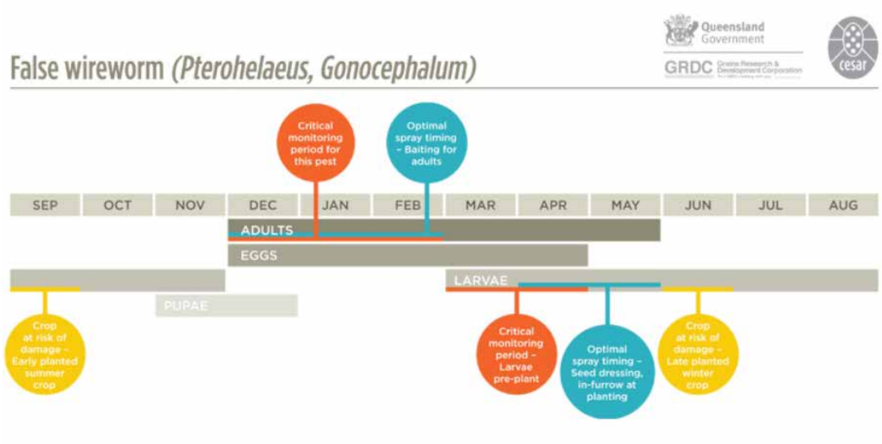


Figure 29: *Critical periods for controlling the false wireworm.*

Source: cesar

7.11 Plague locusts

The Australian plague locust (*Chortoicetes terminifera*) is a native insect (Photo 13). [72] It is a pest of pastures, field crops, and vegetables, infrequently in South Australia and Victoria, and more commonly in New South Wales and southern Queensland. [73]

Following the major Australian plague locust outbreak in southern Australia in 2010 and early 2011, locust numbers have returned to near-normal levels in most areas.

Landholders should be aware that locusts can have an impact on Victorian and southern Australian agriculture in any season, but effects are usually on a local scale.

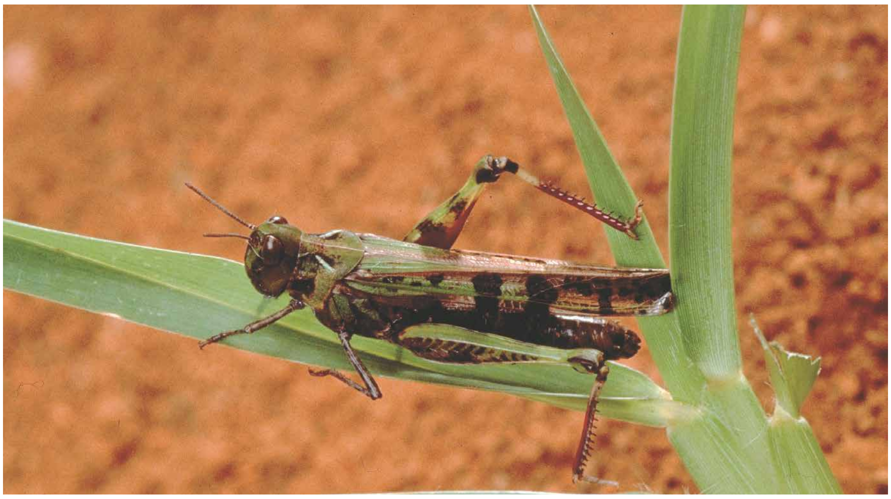


Photo 13: *Australian plague locust on grass leaf.*

Source: DAFWA

MORE INFORMATION

Australian plague locust: identification and biology

Australian Plague Locust Commission

Australian plague locust response: assessment of effects in Victoria

VIDEOS

WATCH: Locust videos

70 G McDonald (1995).Wireworms and false wireworms. Note AG0411. Agriculture Victoria. http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/wireworms-and-false-wireworms

71 G McDonald (2016) Eastern false wireworm. cesar, http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Eastern-false-wireworm

72 DAFWA (2016) Biosecurity alert: Australian plague locust. DAFWA, https://www.agric.wa.gov.au/invasive-species/biosecurity-alert-australian-plague-locust

73 Agriculture Victoria. Australia plague locust: Identification and biology. Factsheet. Agriculture Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/plague-locusts/fact-sheet-identification-and-biology