WESTERN
MAY 2018

GRDC
GROWNOTES™

GRDC
GRAINS RESEARCH & DEVELOPMENT CORPORATION

TRITICALE

SECTION 7

INSECT CONTROL

INSECT PESTS OF WINTER CEREALS | INTEGRATED PEST MANAGEMENT | APHIDS | CUTWORM | REDLEGGED EARTH MITE | BLUE OAT MITE | BALAUSTIUM MITE | BRYOBIA MITE | LUCERNE FLEA | ARMYWORM | SLUGS AND SNAILS

Insect control

Key messages:

- Triticale varieties are affected by only a few insect pests. [1]
- 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 may be warranted.
- Integrated pest management (IPM) strategies encompass chemical, cultural and biological control mechanisms to help improve pest control and limit damage to the environment.
- For current chemical control options refer to the Pest Genie or Australian Pesticides and Veterinary Medical Authority (APVMA).

Risks from insect damage in triticale are similar to those for wheat. Triticale is vulnerable to grasshoppers, aphids, armyworms and cutworms.

Management practices for these insects are the same as for other cereals. These practices should be applied only when continual scouting indicates that the problem has reached an economic threshold for control. [2]

Earthmites (red-legged and blue oat mites) can be problem in early growth and chemical control may be necessary depending on insect numbers/damage. Aphids may occur in late winter/spring and whilst usually not causing major damage themselves they do transmit BYDV and this may warrant control in severe infestations.

Monitor seedling crops for lucerne flea, red legged earth mite and blue oat mite. Seek local advice to determine if application of insecticide is warranted and ensure grazing withholding periods are met. Aphids can infest early sown crops and then 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.

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

7.1.1 Insect pests of winter cereals

The risk of insect infestation to crops depends on a number of factors (Table 1). Particular insect pests impact crops at different growth stages (Table 2).

1 Mergoum, M., & Macpherson, H. G. (2004). *Triticale improvement and production* (No. 179). Food & Agriculture Org.

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

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

4 Mergoum, M., & Macpherson, H. G. (2004). *Triticale improvement and production* (No. 179). Food & Agriculture Org..

5 Krusteva, H., & Karadjova, O. (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.

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

7.2 Integrated pest management

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

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

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

Key IPM strategies

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

Insecticide choices

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

VIDEOS

WATCH: Integrated Pest Management.

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 NPV is effective where mixed populations of armyworm and helicoverpa occur in maturing winter cereals. [6]

7.2.1 Insect sampling methods

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

Factors that contribute to quality monitoring

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

Keeping good records

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

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

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

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

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) $\frac{3.2}{0.75}$

4.2 Density Estimate per square metre

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

Source: DAFF

Records of spray operations should include:

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

Sampling methods

Beat sheet

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

How to use the beat sheet:

- Place the beat sheet with one edge at the base of plants in the row to be sampled.
- Drape the other end of the beat sheet over the adjacent row. This may be difficult in crops with wide row spacing (one metre or more) and in this case spread the sheet across the inter-row space and up against the base of the next row.
- Using a one metre stick, shake the plants in the sample row vigorously in the direction of the beat sheet 5–10 times. This will dislodge the insects from the sample row onto the beat sheet.
- Reducing the number of beat sheet shakes per site greatly reduces sampling precision. The use of smaller beat sheets, such as small fertiliser bags, reduces sampling efficiency by as much as 50%.

- Use the datasheets to record type, number and size of insects found on the beat sheet.
- One beat does not equal one sample. The standard sample unit is five non-consecutive one-metre long lengths of row, taken within a 20 m radius, i.e. 5 beats = 1 sample unit. This should be repeated at six locations in the field (i.e. 30 beats per field).
- The more samples that are taken, the more accurate is the assessment of pest activity, particularly for pests that are patchily distributed such as pod-sucking bug nymphs.

When to use the beat sheet:

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

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

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

Other sampling methods

- **Visual checking** is not recommended as the sole form of insect checking, however it has an important support role. Leaflets or flowers should be separated when looking for eggs or small larvae, and leaves checked for the presence of aphids and silverleaf whitefly. If required, dig below the soil suface to assess soil insect activity. Visual checking of plants in a crop is also important for estimating how the crop is going in terms of average growth stage, pod retention and other agronomic factors.
- **Sweep net sampling** is less efficient than beat sheet sampling and can underestimate the abundance of pest insects present in the crop. Sweep netting can be used for flighty insects and is the easiest method for sampling mirids in broadacre crops or crops with narrow row spacing (Photo 1). It is also useful if the field is wet. Sweep netting works best for smaller pests found in the tops of smaller crops (e.g. mirids in mungbeans), is less efficient against larger pests such as pod-sucking bugs, and it is not practical in tall crops with a dense canopy such as coastal or irrigated soybeans. At least 20 sweeps must be taken along a single 20 m row.
- **Suction sampling** is a quick and relatively easy way to sample for mirids. Its main drawbacks are unacceptably low sampling efficiency, a propensity to suck up flowers and bees, noisy operation, and high purchase cost of the suction machine.

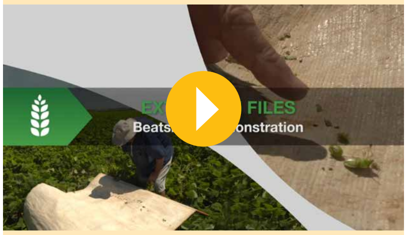
MORE INFORMATION

[IPM Guidelines website.]

[IPM Guidelines for Monitoring tools and techniques.]

VIDEOS

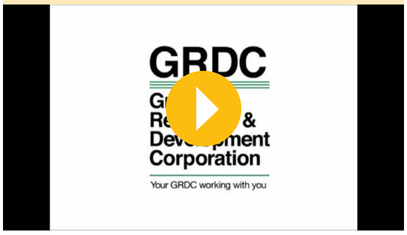
WATCH: [GCTV16: Extension files – IPM Beatsheet Demo.]



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

WATCH: [GRDC's Insect ID App.]

WATCH: [Biopesticides emerge as an alternative cropping tool.]

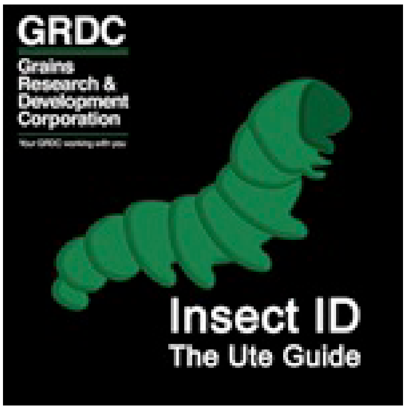


- **Monitoring with traps** (pheromone, volatile, and light traps) can provide general evidence on pest activity and the timing of peak egg lay events for some species. However, it is no substitute for in-field monitoring of actual pest and beneficial numbers. [7]

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

Source: DAFWA and The Beatsheet

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



The Insect ID Ute Guide is a comprehensive reference guide for insect pests commonly affecting broadacre crops and growers 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. [8]

App Features:

- Region selection
- Predictive search by common and scientific names
- Compare photos of insects side by side with insects in the app
- Identify beneficial predators and parasites of insect pests
- Opt to download content updates in-app to ensure you're aware of the latest pests affecting crops for each region
- Ensure awareness of international bio-security pests

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

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

8 GRDC. Apps. https://grdc.com.au/Resources/Apps

VIDEOS

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

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

MORE INFORMATION

Russian Wheat Aphid – PIR SA

Biosecurity Alert - WA

7.3 Aphids

Aphids are occasional pests of cereal crops in Western Australia, however, they can also spread barley yellow dwarf virus that reduces cereal yield. The two main species are corn aphid and oat aphid. [9]

7.3.1 Russian wheat aphid warning

Western Australian grain growers are urged to check cereal crops and grassy weeds for aphids and damage symptoms following the detection of the exotic Russian wheat aphid (*Diuraphis noxia*) in South Australia, Victoria and New South Wales.

Russian wheat aphid (Photo 2) is a major pest of wheat, barley and some grasses (*Poaceae*), which can cause significant yield losses.

Russian wheat aphid is not in WA. [10]

Photo 2: *Russian wheat aphid.*

Source: GRDC

As of 24 August 2016 RWA had not been detected in Western Australia but it is highly likely that RWA will arrive in the state at some time in the future. [11]

As a precaution, it is very important that growers, agronomists and consultants remain vigilant.

7.3.2 Oat or wheat aphid

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

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

Oat aphids vary in colour from olive-green to greenish black and are usually identifiable by a dark rust-red patch on the tip of the abdomen, although under some conditions this is not apparent. Adults are approximately 2 mm long, pear-shaped and have antennae that extend half the body length (Figure 2). Adults may be

9 DAFWA. (2015). Diagnosing cereal aphids. https://www.agric.wa.gov.au/mycrop/diagnosing-cereal-aphids

10 DAFWA. (October, 2016). Biosecurity alert – Russian wheat aphid. https://www.agric.wa.gov.au/barley/biosecurity-alert-russian-wheat-aphid

11 DAFWA. 2017 Barley variety guide for Western Australia. https://grdc.com.au/resources-and-publications/all-publications/publications/2017/01/barleyvarietyguide

MORE INFORMATION

[Oat or Wheat aphid - cesar](http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Oat-aphid)

[Corn aphid - cesar](http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Corn-aphid)

winged or wingless and tend to develop wings when plants become overcrowded or unsuitable. [12]

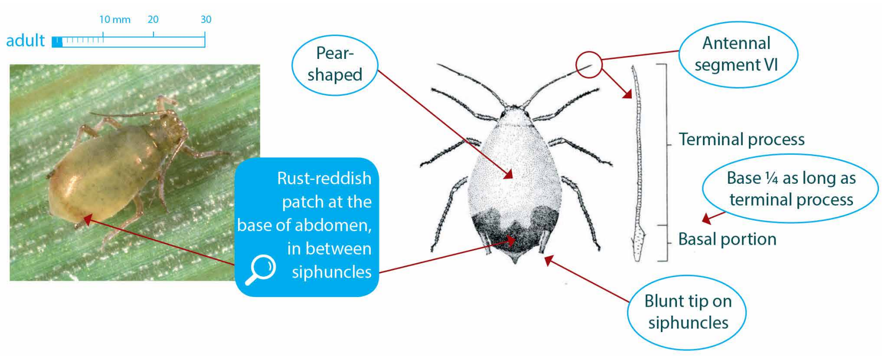


Figure 2: *Distinguishing characteristics of oat or wheat aphids.*

Source: Bellati et al. 2012 in Cesar

7.3.3 Corn aphid

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

Corn aphids are light green to dark green, with two darker patches at the base of each cornicle (siphuncle). Adults grow up to 2 mm long, have an oblong-shaped body and antennae that extend to about a third of the body length (Figure 3). The legs and antennae are typically darker in colour.

Nymphs are similar to adults but smaller in size and always wingless, whereas adults may be winged or wingless. [13]

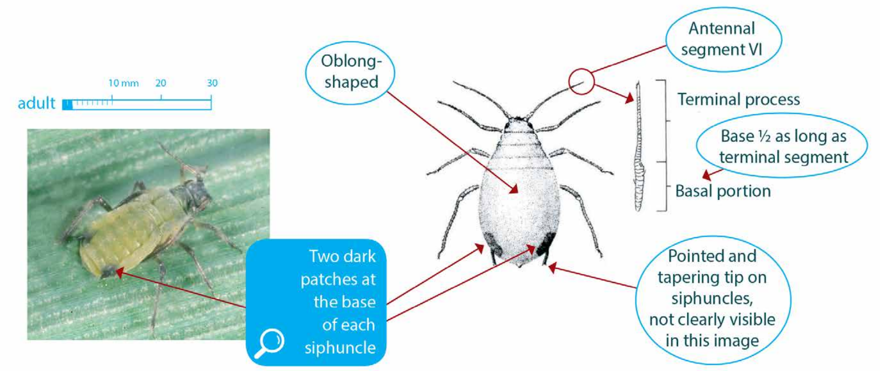


Figure 3: *Distinguishing characteristics of corn aphids.*

Source: Bellati et al. 2012 in Cesar

7.3.4 Symptoms

There may be no obvious symptoms while aphids are feeding and causing direct damage. Heavily infested plants may turn yellow and may be covered in a sugary honeydew produced by the aphids and on which black sooty moulds may develop.

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

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

Much larger yield and quality losses can be sustained when crops are also infected with yellow dwarf virus. Refer to 'See also' section for further information on this virus. [14]

7.3.5 Damage caused by pest

Adult and nymph aphids suck sap with large populations limiting grain yield and size, especially winter and spring infestations.

Aphid feeding can cause direct damage, in the absence of the plant virus; barley yellow dwarf virus (BYDV), by reducing yields by up to 10% and by reducing seed size.

Damaging populations may develop in potentially high-yielding crops (2.5 t/ha or more).

Direct feeding damage occurs when colonies of aphids develop on stems, leaves and heads, from the seedling stage through to head filling.

The degree of damage depends particularly on the percentage of tillers infested, the number of aphids per tiller and the duration of the infestation. [15]

7.3.6 Conditions favouring aphid development

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

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

- Oat aphid – basal leaves, stems and back of ears of cereals
- Corn aphid – inside the leaf whorl of the plant – cast skins indicate their presence
- Grain aphid – colonises the younger leaves and ears of cereals
- Rose grain aphid – underside of lower leaves and moves upwards as these leaves die. [16]

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

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

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

7.3.7 Thresholds for control

Spraying with an approved insecticide is worthwhile if 50% of cereal tillers have 15 or more aphids.

14 Coutts B, Micic S. (2016). Aphid feeding damage to cereal crops. DAFWA. https://www.agric.wa.gov.au/barley/aphid-feeding-damage-cereal-crops

15 Coutts B, Micic S. (2016). Aphid feeding damage to cereal crops. DAFWA. https://www.agric.wa.gov.au/barley/aphid-feeding-damage-cereal-crops

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

Crops sprayed before Zadok's growth stage 30 (start of stem elongation) should be checked again 3–4 weeks after spraying as aphids may re-establish and build up again to threshold levels. [17]

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.

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. [18]

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

7.3.8 Management of insect pest

Chemical control

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

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

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

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, which will assist in deterring aphid landings.

Delayed sowing avoids the autumn peak of cereal aphid activity and reduces the incidence of BYDV. However, delaying sowing generally reduces yields, and this loss must be balanced against the benefit of lower virus incidences. [19]

Biological control

Parasitic wasps, ladybirds, lacewing and hoverfly larvae can provide useful biological control of aphid feeding damage at low aphid densities.

When aphids are in moderate to high densities, these predators and parasites are usually unable to control an increasing population, although given the right conditions certain fungi may kill a large proportion of the population over a short period of time.

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17 Coutts B, Micic S. (2016). Aphid feeding damage to cereal crops. DAFWA. https://www.agric.wa.gov.au/barley/aphid-feeding-damage-cereal-crops

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

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

If predators are present use 'soft' insecticides such as pirimicarb that selectively kill aphids and leave predators intact. [20]

Monitoring

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

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

Check regularly – at least 5 points in the field and sample 20 plants at each point. Populations may be patchy – densities at crop edges may not be representative of the whole field.

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

MORE INFORMATION

Aphids – economic considerations for management

7.4 Cutworm

Cutworms are plump, smooth caterpillars, of several moth species. They feed on all crop and pasture plants, damaging them near the ground. The caterpillars hide under the soil or litter by day. When mature, they pupate in the soil.

Cutworm caterpillars are plump and smooth, growing to about 40 mm long, but they usually cannot be seen as they hide under the soil or litter by day. Often they can be located by scratching the surface near damaged plants where they can be seen curled up in a defensive position (Photo 3).

20 Coutts B, Micic S. (2016). Aphid feeding damage to cereal crops. DAFWA. https://www.agric.wa.gov.au/barley/aphid-feeding-damage-cereal-crops

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

Photo 3: *Cutworm larva in typical curled position when disturbed.*

Source: cesar

Triticale has had mixed response to cutworm damage in Australia. Trials in south-west WA found that triticale that had been attacked by cutworms four weeks after sowing, could regenerate quickly. [22]

In southern New South Wales, cutworms were reported to have caused severe damage to several germinating triticale crops. The damage observed was quite patchy, with some areas suffering 100% plant death. Most problems were observed in paddocks that had weeds and stubble over summer, while 'clean' paddocks that were 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 worse affected paddocks, which were re-sown recovered well. [23]

Caterpillars with a pink tinge belong to the pink cutworm, *Agrotis munda*, which has caused widespread damage in agricultural areas north of Perth. The dark grey caterpillars of the Bogong(b moth, *Agrotis infusa*, have been extremely damaging in most parts of the agricultural areas from time to time. Large numbers of patterned caterpillars belonging to different genera, *Rictonis* and *Omphaletis*, have also been found attacking cereals in agricultural areas.

Adult cutworms are stout-bodied moths with patterned wings. They fly very well and may be seen on window panes at night as they are attracted to lights. [24]

There are several species of pest cutworms that are all similar in appearance. Generally, larvae of all species grow to about 40–50 mm long and are relatively hairless, with a distinctly plump, greasy appearance and dark head (Figure 4).

22 Johnstone C. (2011). Triticale variety demonstration. Online farm trials. http://www.farmtrials.com.au/trial/10587

23 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/

24 Micic S. (2016). Cutworm: pests of crops and pastures. DAFWA. https://www.agric.wa.gov.au/pest-insects/cutworm-pests-crops-and-pastures

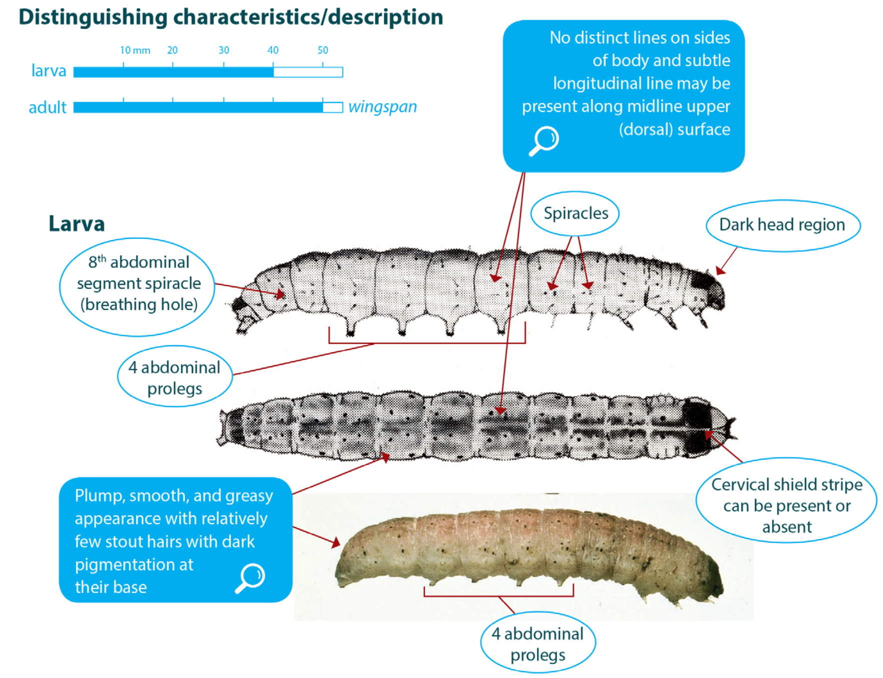

Figure 4: *Distinguishing characteristics of the cutworm.*

Source: Bellati et al, 2012 in cesar

Moths of the common cutworm (sometimes referred to as ‘Bogong moths’) have dark brown or grey-black forewings with dark arrow markings on either wing above a dark streak broken by two lighter coloured dots (Figure 5). Moths of the pink cutworm have grey-brown forewings with darker markings and streaks and a large inner light mark and darker outer mark. Moths of the black cutworm have brown or grey-black forewings with a dark arrow-mark streak broken by two dark ring-shaped dots.

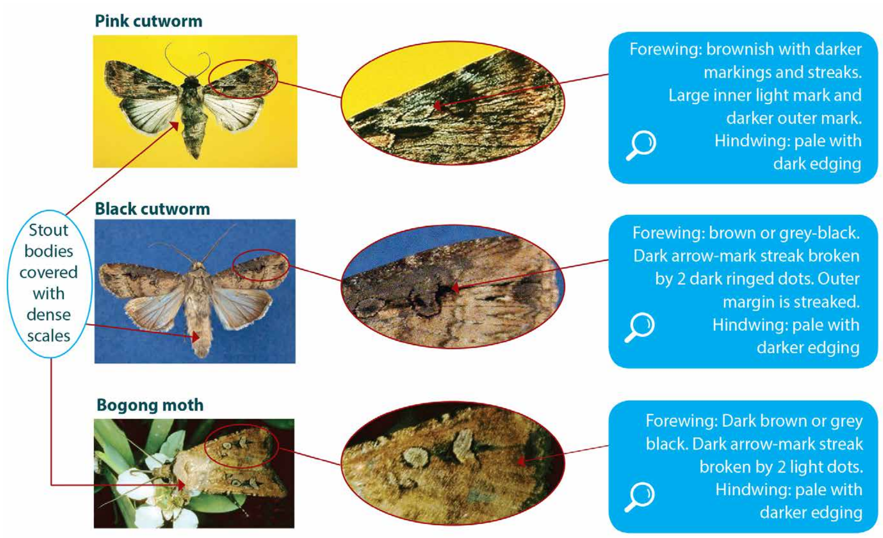

Figure 5: *Distinguishing characteristics of the adult forms of the pink, black and common cutworm.*

Source: Bellati et al, 2012 in cesar

7.4.1 Damage caused by cutworms

All crop and pasture plants are attacked by cutworms. They are most damaging in autumn when large caterpillars (>20 mm) transfer from summer and autumn weeds onto newly emerged crop seedlings. Whole paddocks of cereal seedlings may be destroyed or severely thinned early in the season. Pastures may be attacked at any time during the season but damage usually goes unnoticed. Irrigated crops may be attacked at any time of the year.

When small, the caterpillars feed on the surface tissues of the tender foliage (Figure 6), but as they grow they assume their typical cutworm 'felling' activity. The surface feeding may be confused with damage caused by lucerne flea and the more serious damage may be attributed to webworm. [25]

Figure 6: *Pink cutworm damage to the plant and paddock.*

Source: cesar

7.4.2 Thresholds for control

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

7.4.3 Managing cutworms

Key points:

- Cutworms are easily controlled by insecticides.
- Biological control agents, including fly and wasp parasites, disease organisms and predatory beetles, continually reduce cutworm numbers but cannot be relied on to give adequate control. [26]

Biological

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

25 Micic S. (2016). Cutworm: pests of crops and pastures. DAFWA. https://www.agric.wa.gov.au/pest-insects/cutworm-pests-crops-and-pastures

26 Micic S. (2016). Cutworm: pests of crops and pastures. DAFWA. https://www.agric.wa.gov.au/pest-insects/cutworm-pests-crops-and-pastures

MORE INFORMATION

[Cutworm – economic considerations for management]

[Cutworm - cesar]

Cultural

As autumn cutworm populations may be initiated on 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

If required, cutworms can be easily controlled with insecticides. Several chemicals are registered for controlling cutworms, depending on the state and crop of registration. Spot spraying often provides adequate control in situations where cutworms are confined to specific regions within paddocks. Spraying in the evening is likely to be more effective as larvae are emerging to feed and insecticide degradation is minimised. [27]

7.5 Redlegged earth mite

The redlegged earth mite (*Halotydeus destructor*) (RLEM) is a major pest of pastures, crops and vegetables in regions of Australia with cool wet winters and hot dry summers, costing the Australian grains industry approximately $44.7 million per year. [28] The RLEM was accidentally introduced into Australia from the Cape region of South Africa in the early 1900s. These mites are commonly controlled using pesticides, however, non-chemical options are becoming increasingly important due to evidence of resistance and concern about long-term sustainability.

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

Adult RLEM are 1 mm in length and 0.6 mm wide (the size of a pin head) with 8 red-orange legs and a completely black velvety body (Figure 7). Newly hatched mites are pinkish-orange with 6 legs, are only 0.2 mm long and are not generally visible to the untrained eye. The larval stage is followed by three nymphal stages in which the mites have 8 legs and resemble the adult mite, but are smaller and sexually undeveloped.

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

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

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

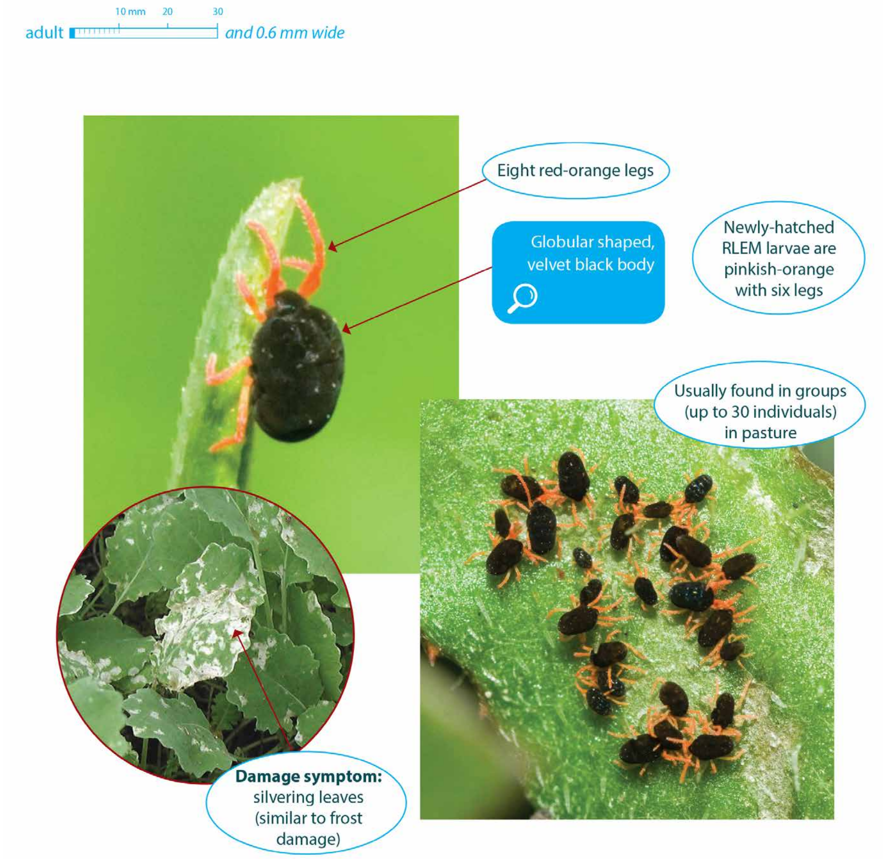

Figure 7: *Distinguishing characteristics of RLEM.*

Source: Bellati *et al.* 2012 in cesar

7.5.1 Damage caused by RLEM

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

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

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

7.5.2 Managing RLEM

Key points:

- Spray only if you need to. RLEM have been detected that have resistance to synthetic pyrethroids. Rotate chemical groups in and between seasons, as this will help to reduce resistance occurring.

- Use insecticide seed treatments for crops and new pastures with moderate pest pressure rather than spraying whole paddocks. This allows for smaller quantities of pesticide to be used that will directly target plant feeding pests.
- Control weeds before seeding, particularly in late autumn or winter sown crops where RLEM are likely to hatch before seeding. At least one week of bare soil can "starve out" most of the mite population before crops are sown.
- Control weeds in the crop and along fencelines that provide habitat for mites. A weed free crop will have few mites and over-summering eggs to carry through to the following season.
- Controlled grazing of pasture paddocks that will be cropped next year will reduce mite numbers to levels that are almost as effective as chemical sprays. Sustained grazing of pastures throughout spring to maintain them at levels below 2 tonnes per hectare. Feed On Offer (FOO) (dry weight) will restrict mite numbers to low levels.
- Apply insecticides to paddocks that are to be cropped during spring to prevent RLEM populations producing over-summering eggs. This will minimise the pest population for the following autumn. TIMERITE® is a free package that provides a date in spring for a spray application to stop female RLEM from producing over-summering eggs.
- Look at your cropping rotations to decrease reliance on pesticides. The risk is generally highest if paddocks have been in long term pasture (with high levels of broad-leafed plants) where mite populations have been uncontrolled. Lower risk paddocks that generally do not require mite control are often those which follow a weed free cereal or chickpea crop. [29]

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

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

Chemical control

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

Autumn sprays:

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

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

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

29 DAFWA. (2015). Diagnosing redlegged earth mite. https://www.agric.wa.gov.au/mycrop/diagnosing-redlegged-earth-mite

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

Spring sprays:

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

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

Biological control

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

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

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

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

Cultural control

Using cultural control methods can decrease the need for chemical control. Rotating crops or pastures with non-host crops can reduce pest colonisation, reproduction and survival. For example, prior to planting a susceptible crop like 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.

MORE INFORMATION

Earth mites (Blue oat and RLEM) – economic considerations

Redlegged Earth Mite – cesar

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

7.6 Blue oat mite

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

Blue oat mites are important crop and pasture pests in southern Australia. They are commonly found in Mediterranean climates of Western Australia, Victoria, New South Wales, South Australia and eastern Tasmania. There are three main species of blue oat mite; *Penthaleus major*, *Penthaleus falcatus* and *Penthaleus tectus*. These species differ in their distributions.

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 8). 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.

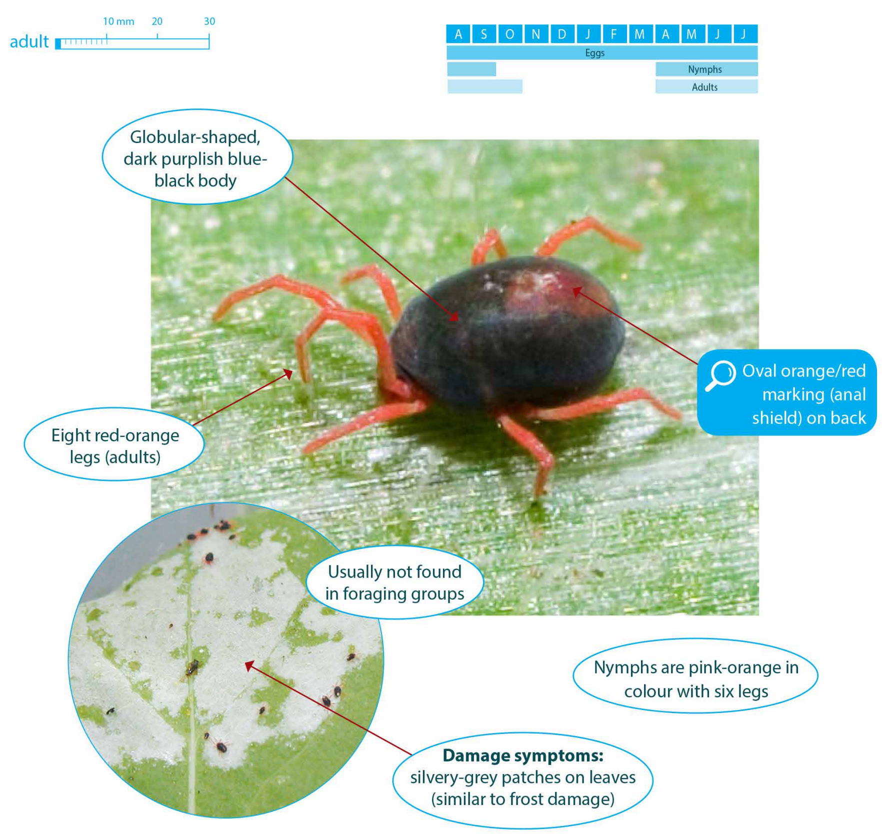

Figure 8: *Distinguishing characteristics of Blue oat mite.*

Source: Bellati et al, 2012 in cesar

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

BOM are often misidentified as redlegged earth mites (RLEM) in the field, which has meant that the damage caused by BOM has been under-represented. Despite having a similar appearance, RLEM and BOM can be readily distinguished from each other. RLEM have a completely black coloured body and tend to feed in larger groups of up to 30 individuals. BOM have the red mark on their back and are usually found singularly or in very small groups. [31]

7.6.1 Damage caused by BOM

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

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

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

The impact of mite damage is increased when plants are under stress from adverse conditions such as prolonged dry weather or waterlogged soils. Ideal growing conditions for seedlings enable plants to tolerate higher numbers of mites. [32]

7.6.2 Managing Blue oat mite

Key points:

- Blue oat mites have higher natural tolerance to a range of pesticides. Ensure pesticide sprays are applied at registered rates.
- To prevent population build up, pesticides should be applied within 3 weeks of the first appearance of mites before adults start laying eggs.

Chemical control

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

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

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

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

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

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

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

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

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

Biological & cultural control

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

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

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

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

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

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

MORE INFORMATION

[Earth mites (Blue oat and RLEM) – economic considerations]

[Blue oat mite - cesar]

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

7.7 Balaustium mite

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

They are sporadically found in areas with a Mediterranean climate in Western Australia, Victoria, South Australia and New South Wales. They have also been found in Tasmania although their exact distribution is unclear. *Balaustium* mites are typically active from March to November, although mites can persist on green feed during summer if available.

Balaustium mites are quite often confused with other pest mites, such as the redlegged earth mite and blue oat mites (*Penthaleus* spp.). They have a rounded dark red/brown coloured body and red legs similar to other pest mites, however they have distinct short stout hairs covering their entire body giving them a velvety appearance (Figure 9). Adults reach about 2 mm in size, which is twice the size of other earth mite species. *Balaustium* mites also have distinct 'pad-like' structures on their front legs and move slower than redlegged earth mites and blue oat mites.

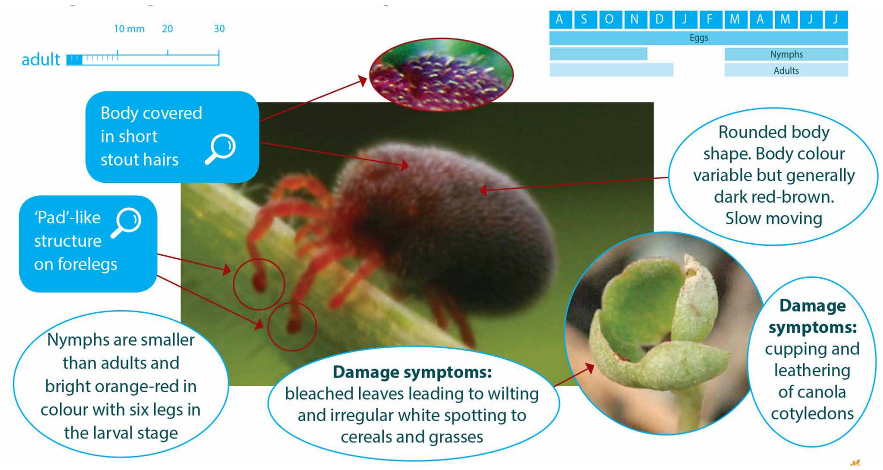

Figure 9: *Adult Balaustium mite.*

Source: Bellati *et al.* 2012 in cesar

Newly laid eggs of *Balaustium* mites are light maroon in colour, becoming darker prior to egg hatch. Larvae are bright orange in colour and have six pairs of legs. The larval stage is followed by a number of nymphal stages in which mites have eight legs and resemble adults, but are much smaller. [34]

7.7.1 Damage caused by Balaustium mite

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

There are no economic thresholds for this pest.

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

7.7.2 Managing Balaustium mite

Key points:

- Early control of summer and autumn weeds, especially capeweed and grasses will help to control populations.
- Applications of synthetic pyrethroids at the highest registered rate provides control. Organophosphates are not effective against this pest. [35]

Monitoring

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

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

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

Control

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

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

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

There have been no biological control agents (predators or parasites) identified in Australia that are effective in controlling *Balaustium* mites. Alternative methods such as cultural control can 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. [36]

MORE INFORMATION

Mites (bryobia mite and balaustium mite) - economic considerations for management

Balaustium mite – cesar

7.8 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.

35 DAFWA. (2015). Balaustium mite. https://www.agric.wa.gov.au/mycrop/diagnosing-balaustium-mite

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

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

There are at least seven species of *Bryobia* mites found in broadacre crops in Australia. These appear very similar. *Bryobia* mites are smaller than other commonly occurring pest mites, although they reach no more than about 0.75 mm in length as adults. They have an oval shaped, dorsally flattened body that is dark grey, pale orange or olive in colour and have eight pale red/orange legs. The front pair of legs is much larger; approximately 1.5 times their body length. If seen under a microscope, they have a sparsely distributed set of broad, spade-like hairs, appearing like white flecks (Figure 10).

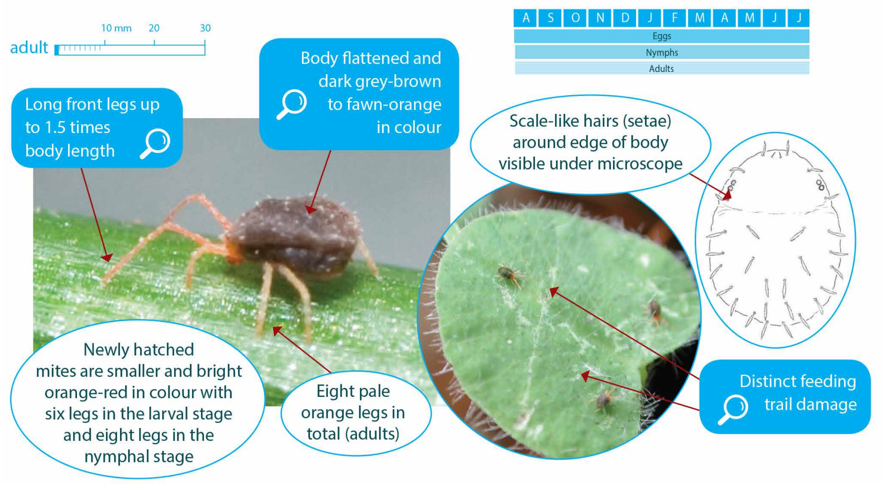

Figure 10: *Distinguishing characteristics of Bryobia mites.*

Source: Bellati et al. 2012 in cesar

7.8.1 Damage cause by mite

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

There are no economic thresholds for control.

7.8.2 Managing Bryobia mites

Key points:

- Bryobia mite is difficult to control if sprays are targeted to stop damage to crops at emergence.
- It is best controlled by killing all weeds well before seeding and/or applying a miticide to the weeds with the knockdown herbicide. [37]

Biological

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

37 DAFWA.(2015). Diagnosing bryobia mite. https://www.agric.wa.gov.au/mycrop/diagnosing-bryobia-mite

MORE INFORMATION

Mites (bryobia mite and balaustium mite) - economic considerations for management

Bryobia mite - cesar

Cultural

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

Chemical

Some insecticides are registered for *Bryobia* mites, however, be aware that recommended rates used against other mites might be ineffective against *Bryobia* mites. *Bryobia* mites have a natural tolerance to several chemicals. Insecticides do not kill mite eggs. Generally organophosphate insecticides provide better control against *Bryobia* mites than synthetic pyrethroids. [38]

7.9 Lucerne flea

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

High numbers are often found in the winter rainfall areas 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.

Lucerne fleas are mainly a pest of young legume pastures and broadleaf crops but can also affect cereals. They are commonly observed on loam-clay soils.

Lucerne flea is a European insect that is a pest on heavy soils in WA. It requires cool, moist conditions and will produce up to five generations in most years with the final generation of females each season laying eggs that over-summer in the soil. The first soaking autumn rains cause over-summering eggs to hatch. Broadleaf weeds, particularly capeweed, favour lucerne flea.

In the paddock look for small jumping bugs that appear early in the season and chew young leaves on heavier textured soils.

On plants look for chewed leaves with transparent 'windows'. [39]

The adult lucerne flea is approximately 3 mm long, light green-yellow in colour and often with mottled darker patches over the body. They are wingless and have enlarged, globular shaped abdomens (Figure 11). They are not related to true fleas. Newly hatched nymphs are pale yellow and 0.5–0.75 mm long, and as they grow they resemble adults, but are smaller.

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

39 DAFWA. (2015). Diagnosing Lucerne flea. https://www.agric.wa.gov.au/mycrop/diagnosing-lucerne-flea

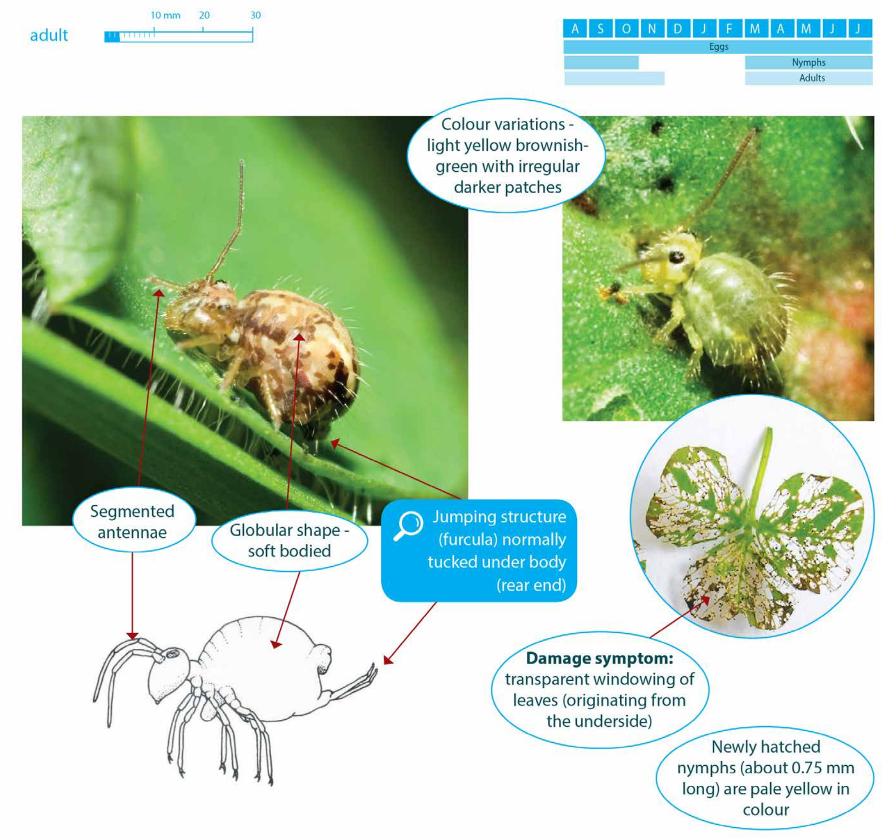

Figure 11: *Distinguishing characteristics of the Lucerne flea.*

Source: Bellati et al, 2012 in cesar

7.9.1 Damage caused by Lucerne flea

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

Lucerne fleas move up plants from ground level, eating tissue from the underside of foliage. They consume the succulent green cells of leaves through a rasping process, avoiding the more fibrous veins and leaving behind a layer of leaf membrane. This makes the characteristic small, clean holes in leaves which can appear as numerous small 'windows'. In severe infestations this damage can stunt or kill plant seedlings. [40]

7.9.2 Managing Lucerne flea

Key points:

- Apply systemic or contact insecticides.
- Do not use synthetic pyrethroid sprays as these are ineffective against lucerne flea. [41]

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

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

41 DAFWA. (2015). Diagnosing Lucerne flea. https://www.agric.wa.gov.au/mycrop/diagnosing-lucerne-flea

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

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

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

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

Chemical control

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

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

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

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

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

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

Biological and cultural control

Several predatory mites, various ground beetles and spiders prey upon lucerne fleas. Snout mites (which have orange bodies and legs) are particularly effective predators of this pest (Photo 4). The pasture snout mite (*Bdellodes lapidaria*) and the spiny snout mite (*Neomulgus capillatus*), have been the focus of biological control efforts against lucerne flea.

The pasture snout mite was originally found in Western Australia but has since been distributed to eastern Australia and 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 4: *Predatory adult snout mite.*

Photo: A. Weeks (CESAR)

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

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

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

In pastures, avoid clover varieties that are more susceptible to lucerne flea damage and avoid planting susceptible crops such as canola and lucerne into paddocks with a history of lucerne flea damage. [42]

MORE INFORMATION

Lucerne flea – economic considerations

Lucerne flea - cesar

7.10 Armyworm

Armyworms are pests of cereal crops and historically have been frequently found along the south coast of Western Australia and occassionally in other wheatbelt localities.

In WA damage to wheat and oat crops from armyworms occurs less frequently and is usually minor compared to damage in barley. Armyworms are seldom a serious problem in pastures.

Armyworm caterpillars vary in colour depending on their species and numbers within crops. They can be distinguished from other caterpillars by their large head and three prominent white stripes on the 'collar' behind the head. They have smooth bodies with a sparse covering of fine hairs. Moths have stout bodies pale to cream in colour with a wing span of 40 millimetres (mm), they fly at night and some armyworm species are strongly attracted to lights.

Occasionally armyworm moths move in large flights in search of food, but usually damaging populations breed within localised areas. On the south coast of Western Australia armyworms have 3–4 generations per year and can survive the summer on self-sown cereals and grasses that germinate with summer rains. During spring it can take as little as three weeks for larvae to reach a damaging size after eggs are laid.

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

The first visible sign of armyworm caterpillars is often their green to straw-coloured droppings, about the size of a match head, found on the ground between the cereal rows. Damage to weeds, especially their preference for ryegrass, is also a sign of their presence.

In cereal crops isolated patches of the crop can be found with chewed leaves, awns and grains on the seed heads damaged. Caterpillars of various sizes up to 4 cm long may be seen in the crop (Figure 12). They may be on the plant or under leaf litter on the ground. Armyworm can be found during the day on plants but are usually unseen as they prefer to shelter during the day and feed mostly at night. Armyworm caterpillars can often be found hiding under the inter-row leaf litter within patches of crop where damage is seen. Caterpillar droppings resemble small 'green' bales of hay and can often be seen on the ground below the crop canopy. [43]

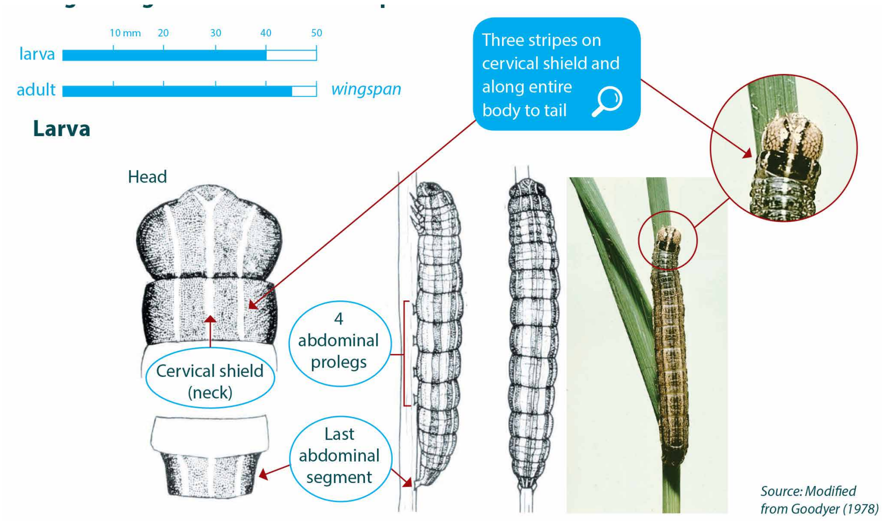

Figure 12: *Distinguishing characteristics of Armyworm larvae.*

Source: cesar

7.10.1 Thresholds for control

The threshold for control in cereals other than barley is much higher than for barley as only grains are consumed and heads are very rarely dropped. Laboratory trials have shown that the yield loss in wheat per hectare per grub per square metre equals 5.4 kilograms per hectare. Given a wheat price of $180 per tonne and the cost of insecticide and its application of $10 per hectare, the threshold number of grubs, above which spraying is warranted on economic grounds, is approximately 10 per square metre. [44]

7.10.2 Managing armyworms

Key points:

- Destroy weedy paddocks several weeks before sowing pasture or crop. This will reduce the feed source for insects.
- Heatwaves may reduce armyworm caterpillar numbers.
- Native parasites can control armyworm biologically so spraying every year is not normally required.
- Spray application to damaging levels of armyworm maybe needed close to crop ripening. Spray withholding periods need to be observed. Increased spray volumes or chemical rates may be required in high-yielding bulky crops.

43 Micic S. (2016). Management of armyworm in cereal crops. DAFWA. https://www.agric.wa.gov.au/grains/management-armyworm-cereal-crops?page=0%2C0

44 Micic S. (2016). Management of armyworm in cereal crops. DAFWA. https://www.agric.wa.gov.au/grains/management-armyworm-cereal-crops?page=0%2C0

Armyworm are easily controlled by insecticides, especially if detected early and sprays are applied when economic damage is imminent.

On the south coast spraying is unnecessary in most years, as natural events can control the pest or allow the crop to mature without damage. The presence of large larvae in spring should not prompt treatment automatically.

The most serious situation is the presence of many large caterpillars coinciding with the maturing of the crop. Usually, little damage occurs in the leafy stages, but it is advisable to check crops regularly after the flag leaf appears.

Weather is the most important factor determining the size and stage of the pest population. Outbreaks appear in spring, following successful preceding generations. The weather is also important when the crop is maturing, as an extended ripening allows the pest more time to develop and damage the crop.

Biological control agents can be important in some years. These include parasitic flies and wasps, predatory beetles and diseases.

Chemical control may finally be necessary as the crop begins to ripen. A number of effective synthetic pyrethroid insecticides are registered for the control of armyworm. However, their effectiveness is often dependent on good penetration into the crop. This can sometimes be difficult to achieve in high-yielding thick canopy crops, especially when caterpillars are resting under leaf litter at the base of plants.

Monitor after spraying

Crops should be check after spraying to ensure that the application is effective. Consideration of insecticide withholding periods is important in late sprayed crops.

Monitoring

Assessing the numbers of armyworm in a cereal crop can be difficult, as their movements will vary with weather conditions and feeding preference. Sometimes they are found sheltering on the ground and under leaf litter, whilst on other days they will be high up on the plants or on the heads and easily picked up using sweepnets.

If ryegrass is present in the crop, they often prefer to feed on that, until it runs out.

Armyworm caterpillars may be confined to only small portions of a crop. Several different locations within the crop should be checked for caterpillar numbers before deciding on control measures.

A suggested monitoring procedure is:

- Look for signs of caterpillar droppings and damaged ryegrass heads (if present).
- Look for damage to the foliage of the crop.
- Look for caterpillars on the plants and on the ground after shaking the plants and searching the leaf litter between rows.

If you can't find caterpillars in spring, it can be two or three weeks before a population of damaging-sized caterpillars could develop, so check again in at least two weeks' time. [45]

7.11 Slugs and snails

Numbers of slugs and snails (Table 3) have increased in broadacre cropping in Western Australia with the use of minimum tillage and stubble-retention practices. These systems increase the organic content of paddocks and the soil moisture content leading to higher survival levels of slugs and snails.

Slugs are pests of crops, especially in the higher rainfall regions of Western Australia. Slugs tend to be restricted to soils with a clay content.

MORE INFORMATION

Snail Identification and control: The Back Pocket Guide

Slugs in Crops: The Back Pocket Guide

45 Micic S. (2016). Management of armyworm in cereal crops. DAFWA. https://www.agric.wa.gov.au/grains/management-armyworm-cereal-crops?page=0%2C0

Snails are found on all soil types. White Italian and vineyard snails prefer alkaline sandy soils; the small pointed snail is able to survive on all soil types even acidic soils. Liming areas where there are snails will aid snail survival.

The small pointed snails however, are only known to cause economic crop damage in high rainfall areas. Whereas the vineyard and white Italian snails are known to cause crop damage in the Greenough flats (which is the region between Dongara and Geraldton) and the Geraldton region. [46]

Table 3: *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

46 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

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 a species-specific character.

Source: IPM Guidelines

7.11.1 Damage caused by slugs and snails

Slug and snail pests damage plant seeds (mainly legumes), recently germinated seeds, seedlings and leaves and can be a contaminant of grain at harvest.

Snails are not known to damage seeds, but may damage germinated seeds close to the soil surface. However, slugs, especially black keeled slugs, will feed in the furrows on seeds of legumes. These slugs are not known to feed on ungerminated canola or cereal seeds.

Irregular pieces chewed from leaves and shredded leaf edges are typical of snail and slug presence. Damage to canola and legume crops can be difficult to detect if seedlings are chewed down to the ground during emergence.

Cereal crops are likely to survive damage by slugs and snails, while canola and lupins cannot compensate for the damage or loss of cotyledons. If cereals are deep sown into a fine, firm seedbed, the slugs and snails are not able to feed on the growing point and emerging crops may recover from damage after treatment.

Different species of slugs cause differing amounts of damage. Cereals are less likely to sustain damage from reticulated slugs, than from black keeled slugs. Canola crops need careful monitoring to assess plant losses. [47]

47 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

7.11.2 Thresholds for control

Table 4: *Suggested thresholds for control of slugs and snails in broadacre crops.*

Species	Oilseeds	Cereals	Pulses	Pastures
Black keeled slug	1–2/m^2	1–2/m^2	1–2/m^2	5/m^2
Reticulated slug	1–2/m^2	5/m^2	1–2/m^2	5/m^2
Small pointed snail	20/m^2	40/m^2	5 per seedling	100/m^2
Vineyard snail	5/m^2	20/m^2	5/m^2	80/m^2
White Italian snail	5/m^2	20/m^2	5/m^2	80/m^2

Please note: the above thresholds are from limited data. It is essential to carefully monitor crops as distributions of snails and slugs are patchy.

Source: DAFWA

7.11.3 Management of slugs and snails

From a management point of view, slugs and snails have similar lifecycles. This means similar management techniques can be employed to control them in broadacre crops. Effective management requires applying controls that coincide with different phases of the pest's lifecycle (Figure 13).

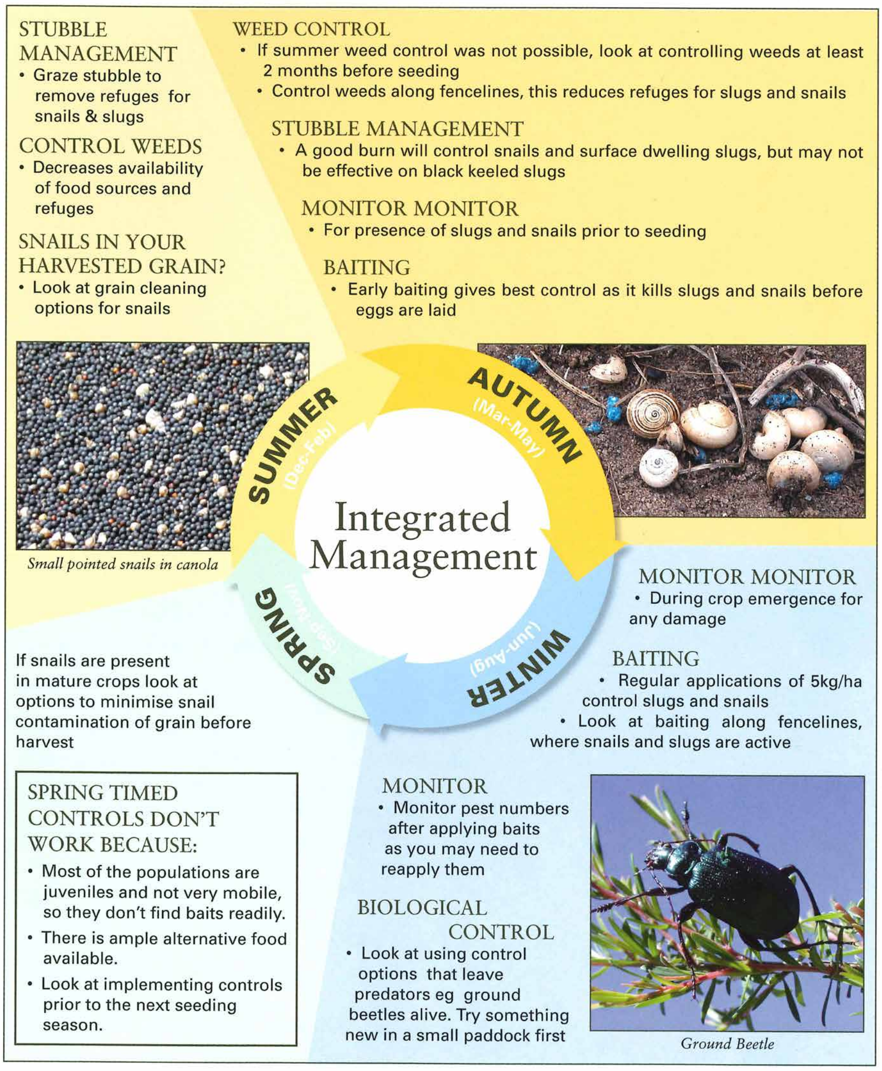

Figure 13: *Integrated control options that align with slug and snail lifecycles, breaking the cycle of reinfestation.*

Source: DAFWA

Chemical control

There are no sprays registered for snail and slug control in broadacre cropping. Be aware that insecticides commonly used to control insect pests of broadacre crops are not effective against slugs and snails.

Baits

Slugs and snails can only be controlled by baits if they are mobile and looking for food. Note that young snails ie those less than 7 mm in diameter for round snails and 7 mm in height for conical snails are not likely to be controlled by baits. Young snails feed on decaying plant matter and are not likely to be attracted to baits.

Snail and slug numbers should be monitored to determine if there is a need to bait especially during crop emergence. Baiting will generally only kill 50% of a slug population at any one time and then mainly the larger ones. Younger slugs may emerge in successive waves. Monitoring numbers (refer to Table 1) will determine if there is a need for multiple bait applications. Based on this, baiting can be confined to areas of high snail/slug density.

All baiting must be stopped at least two months prior to harvest to ensure baits are broken down and do not become a contaminant of grain.

MORE INFORMATION

Snails: Bash'em Burn'em Bait'em

Biological control

There are a range of native ground beetles (family Carabidae: carabids) that are generalist predators, which attack slugs. These beetles would normally eat other prey, but some have been found to have a significant impact on slug populations. They can be important factor in controlling slugs, in combination with baiting.

The only biological control developed for snails (by the South Australian Research and Development Institute) is a parasitic fly, *Sarcophaga penicillata.* Its effectiveness has been limited.

Cultural control

Burning

Burning prior to seeding, is one of the most effective methods for pre-breeding snail control and provides some slug control. The burning itself kills snails but does not kill slugs. The lack of food and shelter following a burn makes it more likely that slugs will move elsewhere.

Before deciding to burn, soil type and weather conditions need to be taken into consideration. Also, summer weeds should be desiccated and browned off. Rocks also provide hiding places and these, if possible, should be turned by cabling or fire harrowing just prior to burning.

It is important to ensure that an even burn is applied across the paddock, as unburnt patches will provide habitats (refuges) especially for snails. An even burn causes 80–100% kill, patchy burn 50–80% kill. Burning on a warm day with little wind in a paddock that has a reasonable fuel load should achieve good control, can be less effective on small pointed snails if rocks are not turned.

When snail populations are large, a strategic burn every three or four years will assist in controlling snail numbers.

Grazing

Grazing animals will knock snails from stubble and may also trample them. Grazing will also decrease the stubble load into a paddock about to be seeded. Decreasing stubble ground cover will decrease refuges for slugs and snails.

Tillage

The most effective form of tillage to reduce numbers of snails and slugs is wide points or full-cut discs that are used in conventional tillage methods. Ploughing the soil to a depth of 5 cm or more will bury surface snails and slugs. Burying snails, especially small pointed snails, can reduce surface numbers of snails by around 40–60%.

Conventional tillage may have limited impact on black keeled slugs. Tillage will disrupt burrows made by these slugs and may cause some mortality. However, it is unlikely that tillage alone will decrease the number of black keeled slugs sufficiently to protect crops.

If tillage coincides with egg laying by slugs and snails, it may expose buried eggs to the environment. This may cause eggs to dry out and die, thereby decreasing slug and snail populations.

Cultivation of the soil does bury surface trash, disturbing potential shelters for slugs and snails. Ploughing trash residues after harvest has been found to remove over-summering habitat for slugs and snails. [48]

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48 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0

7.11.4 Monitoring

Monitoring regularly, means pests can be detected early, ideally before seeding as there are more control options available at this time. Once the crop has been seeded and germination is commencing, control options are limited to baiting. At this time crops should be examined at night for slug and snail activity.

It is best to look for slugs and snails on moist, warm and still nights. Fresh trails of white and clear slime (mucus) visible in the morning also indicate the presence of slugs or snails. However, prior to and after applying control measures, it is necessary to estimate how many slugs and snails are present.

It is a good idea to monitor in:

- January/February to assess stubble management options for slug and snail management
- March/April to assess options for burning and/or baiting
- May to August to assess options for baiting especially along fencelines
- For snails 3–4 weeks before harvest to assess risk of snail contamination of grain and if required, implement options to minimise the risk.

How to find slugs

A useful method to detect areas infested with slugs, prior to seeding or crop emergence, is to lay lines of slug pellets with a rabbit baiter. In infested areas, slugs are attracted to the freshly turned soil and pellets placed in the furrow. Very large numbers can be found dead or dying in the furrows or nearby. On sloping ground, furrows should be run along contours to reduce the risk of soil erosion in the event of heavy rain.

An alternative method to gain an indication of the numbers of slugs present in a paddock is to place wet carpet squares, hessian sacks or tiles on the soil surface. They should at least be 32x32 cm (10% of a square metre). Place pellets under them. After a few days, count the number of slugs under and around each square. Multiplying by 10 will give an estimate of slugs per square metre (/m^2), at least 1–2 slugs/m^2 will cause damage to canola. The table below gives an indication of thresholds.

How to find snails

Snails are usually found on stumps, fencelines and under stubbles. A good way to determine snail numbers on open ground is to use a 32x32 cm square quadrant and count all of the live snails in it. This is an area of 10% of a square metre so multiplying by 10 will give an estimate of snails/m^2. [49]

MORE INFORMATION

Snails – economic considerations for management

Slugs – economic considerations

49 Micic S. (2016). Identification and control of pest slugs and snails for broadacre crops in Western Australia. DAFWA. https://www.agric.wa.gov.au/grains/identification-and-control-pest-slugs-and-snails-broadacre-crops-western-australia?page=0%2C0