I SPY

This document is part of a larger publication "I Spy – Insects of Southern Australian Broadacre Farming Systems Identification Manual and Educational Resource" (ISBN 978-0-6482692-1-2) produced under the National Invertebrate Pest Initiative (NIPI) and is subject to the disclaimers and copyright of the full version from which it was extracted. The remaining sections and the full version of this publication, as well as updates and other legal information, can be found at https://grdc.com.au/ by searching for "I SPY".

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NIPI National Invertebrate Pest Initiative
GRDC Grains Research & Development Corporation
Plant Health Australia
cesar
Government of South Australia Primary Industries and Regions SA
SARDI South Australian Research and Development Institute
Government of Western Australia Department of Primary Industries and Regional Development

INDEX OF CHANGES

Index of major changes (ex. additional species, resistance updates)

Pg 4.11 - 4.12 (budworms): chemical resistance information added; lifecycles added; cotton earworm pest status updated, monitoring information added; chemical management options added, additional reference links added
Pg 4.14 (DBM): chemical resistance information added, additional reference links added
Pg 4.19 - 4.23 (cockchafers): African black beetle added, additional reference links added
Pg 4.39 -4.41 (cereal aphids): russian wheat aphid integrated with other cereal aphids (and biosecurity status updated); economic thresholds added; chemical and cultural management options added, additional reference links added
Pg 4.43 - 4.44 (canola aphids): chemical resistance information added; discussion of viruses added; economic thresholds added; biological, chemical and cultural management options added, additional reference links added
Pg 4.46 (pulse aphids): chemical resistance information added; discussion of viruses added; economic thresholds added; biological and chemical management options added, additional reference links added
Pg 4.68 - 4.69 (round snails): monitoring information updated, cultural management options added, additional reference links added, cultural management information added
Pg 4.71 (conical snails): monitoring information updated, cultural management information added, additional reference links added
Pg 4.76 (RLEM): chemical resistance information added; lifecycles added; link to economic thresholds added; chemical management options added, additional reference links added
Pg 4.95 (reference page): several reference addresses added and updated
Pg 5.14-15: Table 5.2 updated
Pg 5.23 (Case study 3): Case study 3 (case study 4 in previous version) replaced with updated study "IPM in Australian Grains: the costs and benefits of insecticides"

Index of minor changes

Introduction: Contributor information and affiliations updated
Chapter 3: page numbers in keys updated

Addition of text *

Pg 4.6 (armyworms): chemical management options added, additional reference links added
Pg 4.8 (cutworms): chemical management options added, additional reference links added
Pg 4.16 (Etiella): monitoring information added; chemical management options added, additional reference links added
Pg 4.17 (Beetles): biosecurity discussion of Bruchid beetles added with link to additional information
Pg 4.25 (true wireworms): monitoring information added; chemical management options added, additional reference links added
Pg 4.27 (false wireworms): monitoring information added; chemical and biological management options added, dditional reference links added
Pg 4.37 (crop aphids): mention of BWYV virus added
Pg 4.56 - 4.57 (exotic leafminers): discussion of *Liriomyza sativae* added
Pg 4.63 -4.64 (earwigs): damage information updated; chemical management options updated, additional reference links added
Pg 4.66 (springtails): lifecycles added; economic thresholds added, additional reference links added
Pg 4.73 (slugs): monitoring information added; chemical management options added, additional resources added to 'confused with/similar to' section, additional reference links added
Pg 4.79 (blue oat mite): lifecycles added; discussion of three species' host preferences added; chemical management options added, additional reference links added
Pg 4.80 (balaustium mite): lifecycles added; chemical management options updated, additional reference links added
Pg 4.81 (bryobia mite): lifecycles added; chemical management options added, additional reference links added
Pg 5.3: Link to the "Best Bet" IPM strategies added (http://ipmguidelinesforgrains.com.au/workshops/resources/#bestbet)
Table 6.4: Russian wheat aphid added to barley, wheat and oats (risk period: emergence through flowering)
Pg 6.10: Link to the "Economic threshold ready reckoners" resource added (http://ipmguidelinesforgrains.com.au/workshops/resources/#bestbet)

Pg 8.2: Added to glossary: "Entomopathogenic: a term used to describe microorganisms and viruses capable of causing disease in an insect host" and "Endophyte: Fungi that live within healthy plant tissue, forming a symbiotic relationship where the endophyte obtains nutrition and from the plant and the plant obtains a number of benefits from chemicals produced by the endophyte, such as increased resistance to pests or drought."

Species-specific information included in minor additions can be found by going to the PestNotes webpage and searching by pest name:* ***http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/*

Replacement/removal of text:

Pg 4.12 (budworms):
"Rarely found in dryland broadacre crops but often associated with irrigated and/or horticultural crops" is replaced with "Can attack all field crops, particularly cotton, sorghum, maize, sunflowers, chickpeas, lupins and lucerne. The species is also occasionally found grazing on wheat and barley heads. They can cause damage to foliage, flowers and pods on canola"
"For corn earworm, please refer to DEEDI website" is removed and a reference to "http://cesaraustralia.com/sustainable-agriculture/pestnotes/" is added

Pg 4.16 (Etiella):
In the references below management table, "and the SARDI website (Etiella management in lentils)" is replaced with "http://cesaraustralia.com/sustainable-agriculture/pestnotes/ -and- http://pir.sa.gov.au/research/"

Pg 4.21 (cockchafers):
For YH cockchafer, "One generation per year" is replaced with "The biology of the species is not well understood; some species are thought to have two-year lifecycles."

Pg 4.44 (canola aphids):
"(e.g. pirimicarb)" is removed as a suggestion for "Selective foliar spray"

Pg 4.57 (exotic leafminers):
"linear and shallow on the upper leaf surface (e.g. L. trifolii)" is replaced with "tight and convoluted and often appearing blotch like (e.g. L. trifolii)"

Pg 4.64 (earwigs):
"Native earwigs rarely cause damage to southern Australian grain crops" is replaced with "Native earwigs are not believed to be damaging to southern Australian grain crops"
"Carbaryl is registered for control of earwigs in some situations" is replaced with "There are no foliar insecticides currently registered for European earwigs in broadacre crops"

Pg 4.68 - 4.69 (round snails):
"Thresholds for control options: Cereals at seedling growth stage - 20 snails/m2 ; Pulses and canola at seedling - 5 snails/m2" is replaced with"Thresholds can be misleading because populations cannot be accurately estimated. **Good snail management requires population reduction at every opportunity.** This includes tactics for minimising snail contamination of grain at harvest."

The "chemical options" in the management table have been replaced with "Molluscicidal baits can be used effectively in autumn to control mature snails across the whole paddock. Start baiting when moisture triggers snail activity in autumn and before significant egg-laying. Repeat applications may be needed after monitoring. Around 60-90% kill can be achieved depending on timing, snail activity and bait application rate. Fence line and border baiting can be effective after autumn rains when snails are moving from aestivation sites." is replaced with "Molluscicide baiting of fence lines and borders can be effective after autumn rains when snails are moving from aestivation sites.
To achieve optimal baiting results across the whole paddock get your spreader professionally calibrated with your preferred bait product. Bait when autumn moisture triggers snail activity and before egglaying commences. Ensure at least 30 bait points per square metre for good results.Repeat applications may be needed after monitoring.

Commonly used bran baits need to be re-applied within 2 weeks. More expensive products will last 3-4 weeks.Baiting in winter is less effective.Many bait products are degraded by rain. Avoid applying baits before significant rain events.
For further bait guidelines and bait product comparison chart, refer to the snail and slug baiting guidelines (pdf) on the **pirsa.sa.gov.au** website."

Pg 4.71 (conical snails):
"No thresholds established for conical snails. See round snail thresholds as a guideline" is replaced with "Thresholds can be misleading because populations cannot be accurately estimated. **Good snail management requires population reduction at every opportunity.** This includes tactics for minimising snail contamination of grain at harvest."

"Flies were released in 2000 on the Yorke Peninsula, SA, but the impact on control is unclear." is replaced with "Flies were released on the Yorke Peninsula, SA, however parasitism rates on SA conical snails have been extremely low, and attempts to explain the lack of parasitism have been as yet inconclusive."

The "chemical options" in the management table have been replaced with ""Molluscicidal baits can be used effectively in autumn to control mature snails across the whole paddock. Start baiting when moisture triggers snail activity in autumn and before significant egg-laying. Repeat applications may be needed after monitoring. Around 60-90% kill can be achieved depending on timing, snail activity and bait application rate. Fence line and border baiting can be effective after autumn rains when snails are moving from aestivation sites." is replaced with "Molluscicide baiting of fence lines and borders can be effective after autumn rains when snails are moving from aestivation sites.To achieve optimal baiting results across the whole paddock get your spreader professionally calibrated with your preferred bait product.Bait when autumn moisture triggers snail activity and before egglaying commences. Ensure at least 30 bait points per square metre for good results.Repeat applications may be needed after monitoring. Commonly used bran baits need to be re-applied within 2 weeks. More expensive products will last 3-4 weeks.Baiting in winter is less effective.Many bait products are degraded by rain. Avoid applying baits before significant rain events.
For further bait guidelines and bait product comparison chart, refer to the snail and slug baiting guidelines (pdf) on the **pirsa.sa.gov.au** website."

Pg 4.80 (balaustium mite):
"No chemicals currently registered." is replaced with "See APVMA website for registered chemicals. Pyrinex® Super is registered to control Balaustium mites in Australian canola crops."

Pg 4.81 (bryobia mite):
"Some chemicals are registered for the control of Bryobia mites" is removed

Figure 5.1:
Point two is removed.
Point one is replaced with "1. Identify the pests that are present. Previous monitoring and paddock history will help inform this decision (consider both the primary pest and other pests, and consider presence of beneficial species that could control the pest in the short-term or long-term.)"
Point 3 (now point 2) is replaced with "2. Are there sufficient pests to cause an economic loss or crop damage? Refer to economic thresholds if they exist (see Section 4 species pages)."

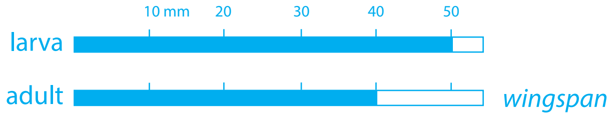
Table 6.4: Corn earworms (SE Australia only) is replaced with "Corn earworm"

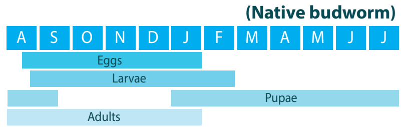
Pages containing major changes are included in the following pages:

BUDWORMS Lepidoptera: Noctuidae

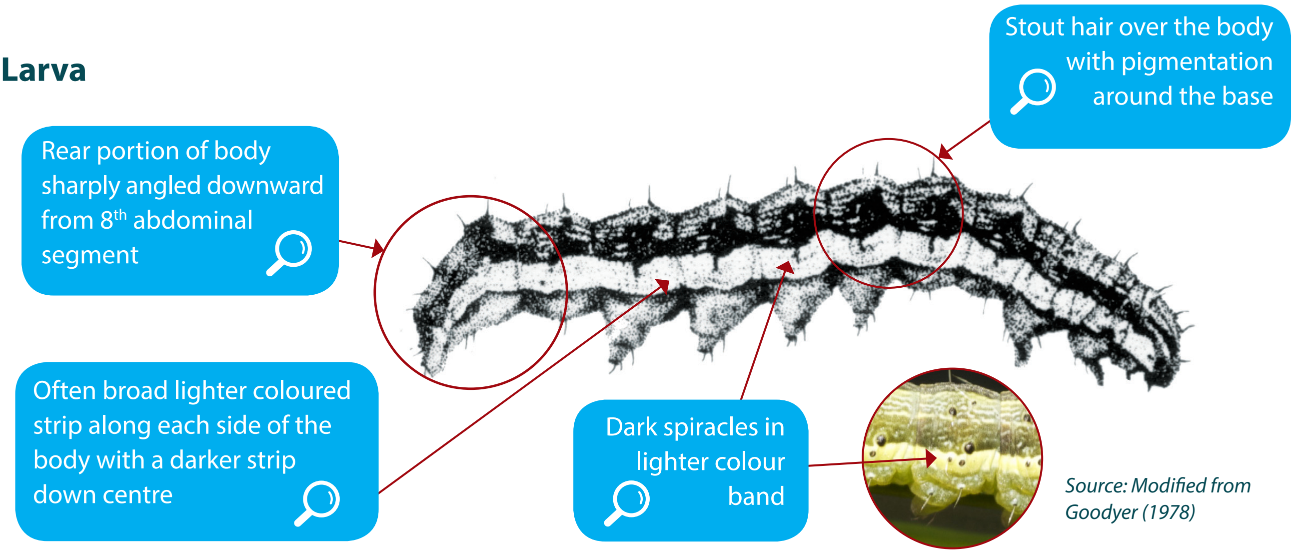
Native budworm (*Helicoverpa punctigera*), Lesser budworm (*Heliothis punctifera*) and Corn earworm/cotton bollworm (*Helicoverpa armigera*)

Distinguishing characteristics/description

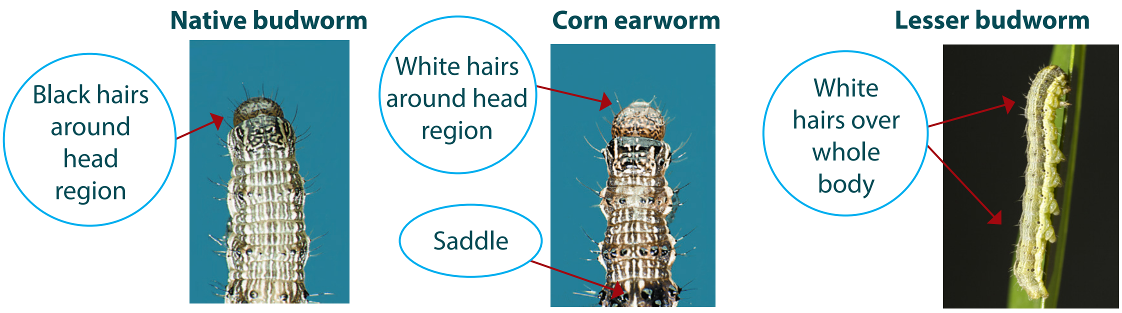




Larva

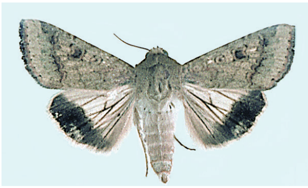


Source: Modified from Goodyer (1978)



Adult

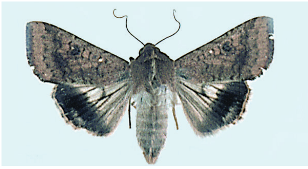
Male



Male

Male

Female



Female

Female

Confused with/similar to

Armyworm and cutworm in general appearance and size.

Distribution, pest status and risk period

Native budworm: Occurs in most years and often migrates into agricultural areas from nearby pastoral areas. It is a native species and is usually easily controlled with insecticides.

Lesser budworm: Infrequent pest.

Corn earworm/cotton bollworm: Less inclined than native budworm moths to undertake long-distance migratory flights, problems in spring and summer generally arise from local populations that survive over winter as diapausing pupae in winter crops. This pest is known to develop strong resistance to insecticides and can be difficult to control.

Crops attacked/host range

Native budworm: Broad leaf and legume crops such as field pea, faba bean, lentil, chickpea, lupin and canola. Pastures such as pasture serradalla, lucerne, annual medic and clovers. Only occasionally feeds on cereals and some grasses.

Lesser budworm: Wide host range, will feed on both broad leaf grasses and cereals.

Corn earworm/cotton bollworm: Wide host range. Can attack all field crops, particularly cotton, sorghum, maize, sunflowers, chickpeas, lupins and lucerne. The species is also occasionally found grazing on wheat and barley heads. They can cause damage to foliage, flowers and pods on canola.

Damage symptoms

Holes or chewing damage may be seen on pods and/or seed heads. Grubs may be seen occasionally.

All budworms are at their most damaging when they feed on the fruiting parts and seeds of plants.

Losses attributed to budworms come from direct weight loss through seeds being wholly or partly eaten. Grain quality may also be downgraded through unacceptable levels of chewed grain.

Monitoring/sampling

The quickest and easiest method to sample most crops is sweep netting. Multiples of 10 sweeps should be taken in several parts of the crop and larval numbers averaged. The use of pheromone traps (which attract male moths) can provide an early warning of moth arrival to an area or their emergence from local winter diapause. These traps should be set up in early spring.

Caterpillars eat increasing quantities of seed and plant material as they grow. The last two growth stages (5th & 6th instar) account for over 90% of their total grain consumption.

Field pea, chickpea, lentil and faba bean crops are very susceptible to all sizes of native budworm caterpillars during the formation and development of pods. Small caterpillars can enter emerging pods and damage developing seed while larger caterpillars may devour the entire pod contents. Narrow-leafed lupin and canola crops will not be damaged by native budworm until they are close to maturity and leaf fall commences. For lesser budworm, the same principles as native budworm can be applied.

For detailed economic threshold guidelines, go to the PestNotes webpage and search 'native budworm' and 'corn earworm.'

Management options

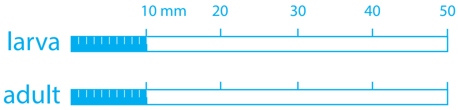
Biological	Cultural	Chemical
Naturally-occurring insect fungal diseases and viruses can be very successful in some seasons. Predatory shield bugs, damsel bugs and fly parasites may also be active in preventing serious outbreaks. Parasites include the orange and two-toned caterpillar parasite (*Heteropelma scaposum*), the orchid dupe (*Lissopimpla excelsa*) and *Trichogramma ivalae*. Refer to Southern (pp. 120 & 122) and Western (pp. 96-97) Ute Guides for more detail.	Swathing canola or desiccating pulse crops such as field peas may be an option to advance the drying of crops when small/medium size larvae are present.	Native budworm and lesser budworm are easily controlled by synthetic pyrethroids. Corn earworm populations are resistant to endosulfan, synthetic pyrethroids and carbamates, as well as lower levels of resistance to organophosphates, spinosad and indoxacarb. In cotton, a comprehensive resistance management framework exists (see link below). Use of Bt and NPV biological insecticides are important IPM options. Timing of chemical applications and coverage are critical. Target small larvae up to 7 mm in length and apply insecticides before larvae move into flowering pods.

Ute Guides, Southern (pp. 18-20)/Western (pp. 17-19).
http://ipmguidelinesforgrains.com.au/workshops/resources/#bestbet : Canola , Sorgum North, Summer Pulses, Winter Cereals North, Winter Pulses South
http://www.cesaraustralia.com/sustainable-agriculture/pestnotes/
http://www.cottoninfo.com.au/publications/cotton-pest-management-guide

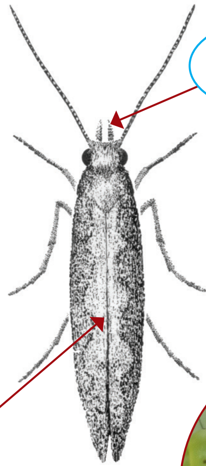
Lepidoptera: Plutellidae

Diamondback moth - DBM (*Plutella xylostella*)

Distinguishing characteristics/description



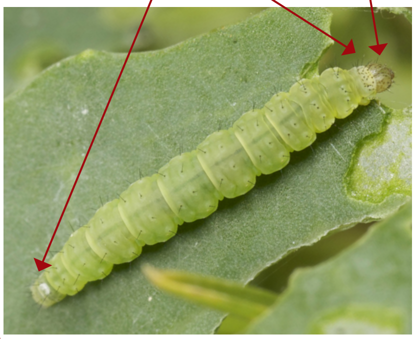
Adult

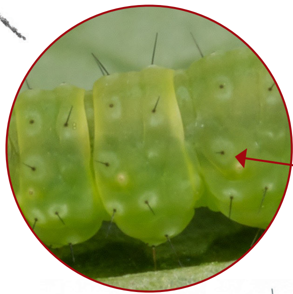



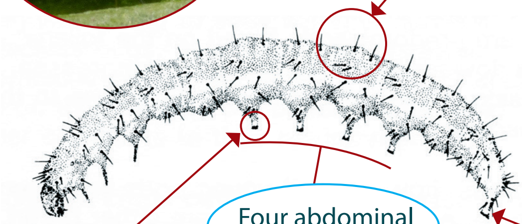
Mesh-like pupal casing

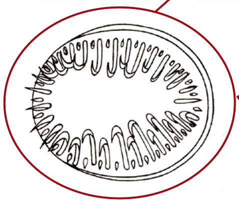
Leaf mine of 1st larval instar

Larva









Eggs are pale yellow, oval and about 0.5 mm in length. Eggs are laid singularly or in clusters along the leaf margins.

Larvae develop through four instars. The first two instars have a dark head, but the first instar is not visible as it lives and feeds inside leaf tissue (its presence is indicated by a leaf mine). Larvae wriggle vigourously when disturbed and often drop from the plant on a silken thread.

The **pupal** casing is mesh-like in appearance and the pupa inside is cream-green initially, but darkens before the adult emerges.

Confused with/similar to

Diamondback moth (DBM) larvae can be confused with young cabbage white butterfly (*Pieris rapae*) and cabbage centre grub (*Hellula* sp.) larvae.

Distribution, pest status and risk period

DBM is a worldwide pest with a high propensity to evolve insecticide resistance. DBM is widely distributed in southern Australia.

DBM has no diapause phase in Australia and has overlapping generations. All life stages can be present at any one time. Adults are active flyers but usually do not move far within a crop.

They are capable of long distance migration on prevailing winds, particularly when host material has died off. Weather conditions can impact dramatically on DBM populations. Development is faster in warm weather and slower in cool weather. For example, at 15 °C the life cycle takes approximately 36 days to complete, but at 28°C it takes approximately 11 days to complete.

Crops attacked/host range

DBM feeds on canola and all *Brassica* plants, including weeds.

The availability of *Brassica* host plants can influence outbreaks. Summer rainfall can also provide a green bridge of summer weeds.

DBM adults migrate from summer weed sources into canola crops in autumn and winter. Significant rainfall events (greater than 8 mm) can reduce larval abundance by drowning or dislodging larvae or facilitating death by disease.

Damage symptoms

Larvae can cause damage to all growth stages of the canola plant. They feed on the foliage before flowering and, as flowering progresses, an increasing proportion of the larvae move to the floral buds, flowers and pods. Maturing pods are surface grazed or scarred by the larvae. They are not as damaging as native budworm as they do not chew into the pods. Premature shattering of pods rarely occurs.

Larger larvae feeding on the underside of leaves can create holes, often with the upper surface intact, producing a window effect.

Canola can tolerate considerable foliar feeding damage before crop yield is affected. Severe feeding damage can cause complete defoliation resulting in yield reduction.

Monitoring/sampling

Crops should be monitored using a sweep net at the first sign of damage and throughout the growing season from late winter to late spring.

Take a minimum of five sets of 10 sweeps and calculate the average number of larvae per 10 sweeps.

If spraying, it is important to monitor 5-7 days after spray application to assess the effectiveness of treatment.

Management options

Threshold guidelines indicate spraying is recommended when:

- 50 larvae are collected per 10 sweeps for pre-flowering unstressed crops.
- 30 larvae are collected per 10 sweeps for pre-flowering stressed crops.
- 100-200 larvae are collected per 10 sweeps for unstressed crops with the majority of plants in flower.

If monitoring detects a rapid increase in DBM larvae and numbers exceed spray thresholds, a two-spray policy is thought to be more effective than a single spray. The second spray should be applied approximately seven days after the first if more than 20% of the initial population remains. **Good spray coverage is critical for effective DBM control** as more than 20% of the larvae reside in the bottom third of the plant. You should consider the size of the majority of the larvae before making a management decision. Target treatment at larvae <5 mm in length (2nd & 3rd instar) to achieve more effective control. Chemical resistance to synthetic pyrethroids and organophosphates is widespread in DBM populations on *Brassica* vegetable crops throughout Australia, and to a lesser and varying extent, in many canola cropping regions.

Biological	Cultural	Chemical
The most important natural enemies are small wasp parasitoids (*Diadegma semiclausum, Apanteles ippeus* and *Diadromus collaris*). Predators such as brown lacewings, spiders, damsel bugs and other predatory bugs can contribute to DBM mortality. Naturally-occurring insect fungal diseases may also be very successful in some seasons under ideal conditions (i.e. a combination of rainfall, high humidity and warm temperatures).	Summer weed control close to crop areas will help break the 'green bridge'. Area wide management.	This species is difficult to control with insecticides and evolves resistance readily. A resistance management strategy for DBM has been developed and is available on the GRDC webpage. *Bacillus thuringiensis* (Bt) is the softest insecticide on natural enemies and very effective on DBM. Correct application is critical to achieve effective control. Refer to Bt checklist, section 5 page 13.

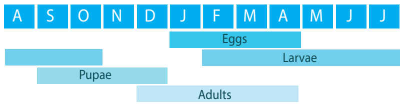
Ute Guides, Southern (pp. 25-26)/ Western (pp. 26-27).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_Canola2014.pdf
https://grdc.com.au/fs-resistancestrategydiamondbackmoth

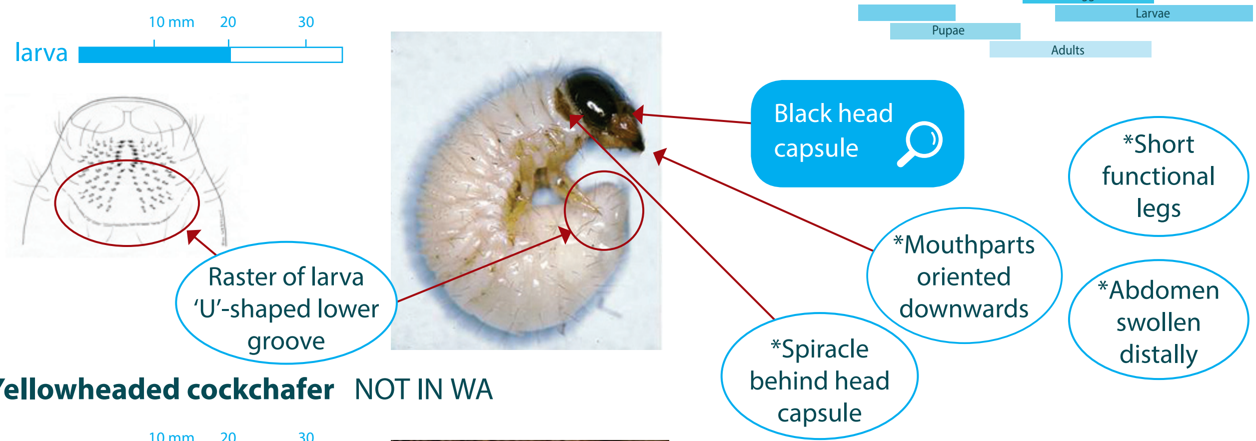
COCKCHAFERS Coleoptera: Scarabaeidae

Blackheaded pasture cockchafer (*Acrossidius tasmaniae*), Yellowheaded cockchafer (*Sericesthis* sp.), Redheaded pasture cockchafer (*Adoryphous coulonii*) and African black beetle (*Heteronychus arator*)

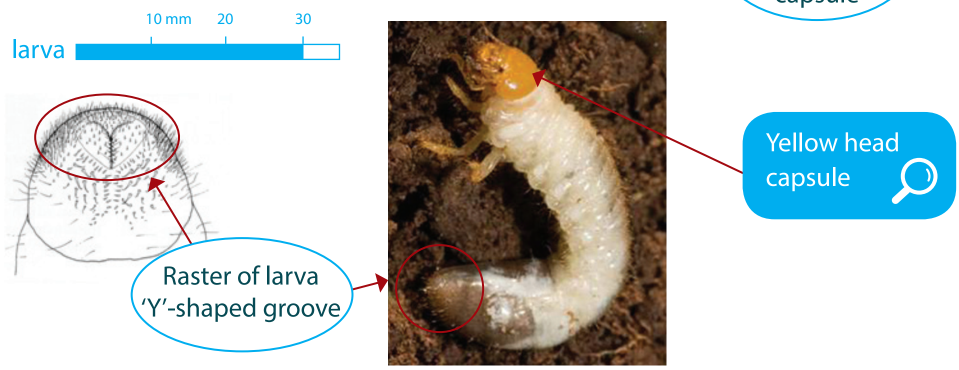
Distinguishing characteristics/description: larvae

Blackheaded pasture cockchafer NOT IN WA

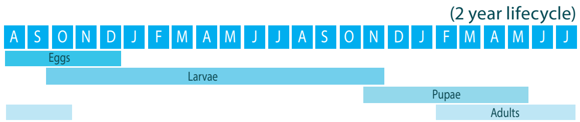


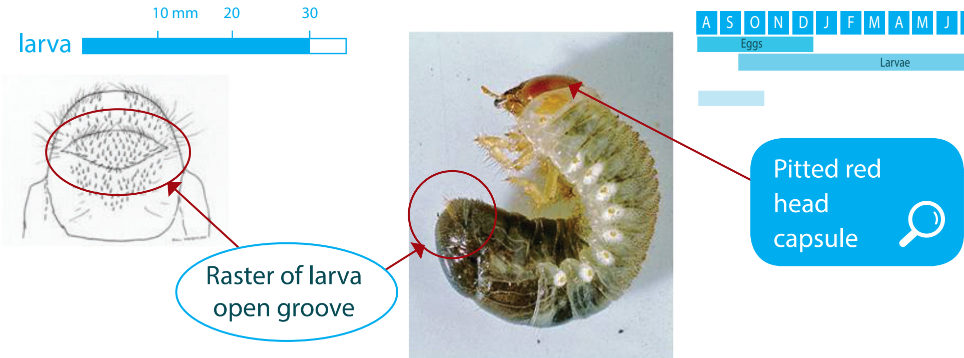


Yellowheaded cockchafer NOT IN WA

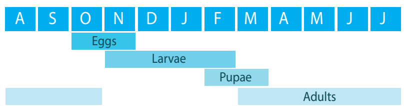


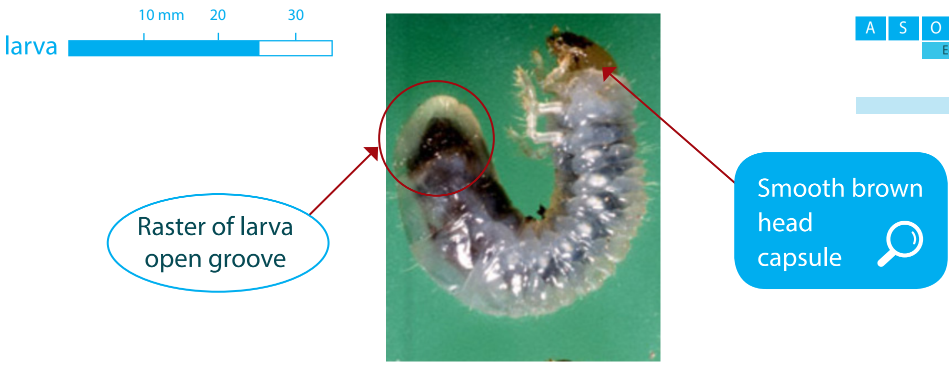
Redheaded pasture cockchafer NOT IN WA





African black beetle NOT IN TAS



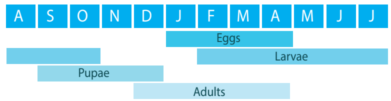


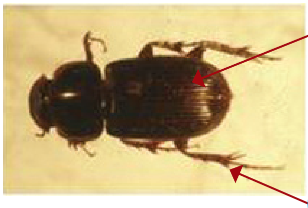
** indicates character for all species*

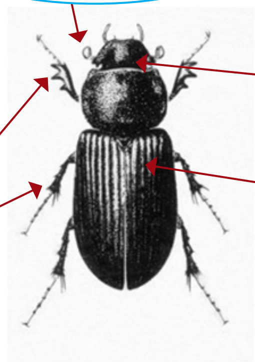
Distinguishing characteristics/description: adults

Blackheaded pasture cockchafer NOT IN WA

10 mm 20 30
adult

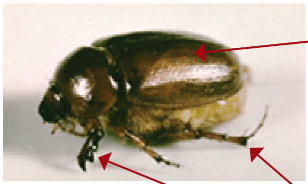


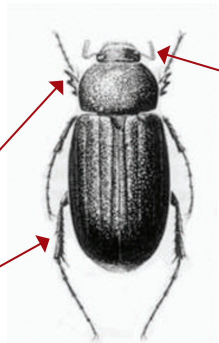




Yellowheaded cockchafer NOT IN WA

10 mm 20 30
adult

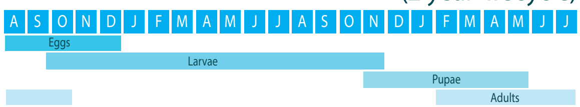


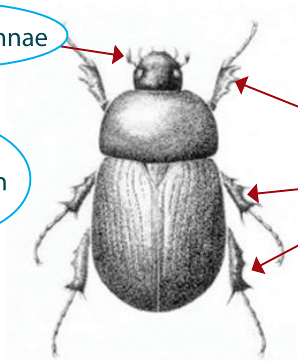


Redheaded pasture cockchafer NOT IN WA

(2 year lifecycle)

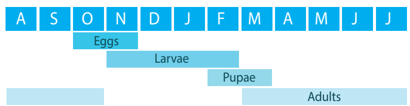
10 mm 20 30
adult





African black beetle NOT IN TAS

10 mm 20 30
adult



** indicates character for all species*

The larval stages of all cockchafers and dung beetles are 'C'-shaped grubs that curl up when disturbed or handled. They have relatively short functional legs, the abdomen is swollen distally and their mouthparts are oriented downwards.

Cockchafer species usually live in vertical tunnels in soil and are free-living. The presence of tunnels can sometimes make the soil appear spongy.

WA Cockchafers
Species of cockchafers found in Western Australia and eastern Australia differ. Although many WA species appear similar to those found in eastern Australia, most are not damaging. A few species (e.g. *Heteronyx obesus*) can cause extensive below-ground damage in some seasons. Larvae are soil-dwelling root feeders that do not come to the surface. Refer to Western Ute Guide (p. 46) for more detail.

Blackheaded (BH) pasture cockchafers are foliage feeders and the presence of green material in tunnels is also a good indicator of this species.

Yellowheaded (YH) cockchafer and **Redheaded (RH) pasture cockchafer** larvae are soil-dwelling (root feeders). Newly-hatched larvae are about 5 mm long.

African black beetle (ABB) are pests as both larvae and adults. Larvae are soil-dwelling (root feeders). Adults chew plants at or just beneath ground level.

Confused with/similar to

Similar to all other Scarabaeidae 'C'-shaped larvae (e.g. dung beetles). Distinguishing between most species at the larval stage is difficult and generally only possible using a microscope to compare hair (setae) structure.

The Scarabaeidae family includes other beneficial species such as beneficial dung beetles. In general, beneficial dung beetles are found with brood balls. Brood balls are balls of dung on which dung beetles lay eggs. Eggs hatch into larvae which feed on the dung of the brood ball. Refer to Ute Guides, Southern (p. 150) / Western (p. 125) for more detail.

Distribution, pest status and risk period

WA Cockchafers are found throughout the state. Their presence in the soil does not always mean that damage will occur. The larval stages feed underground and are most damaging to seedling crops during autumn/winter. Damage may occur every second year as some species have a two year lifecycle.

BH pasture cockchafers are found in higher rainfall areas in southeastern Australia (not WA). Larval growth rates depend on the number of rainy days during autumn and winter, which is when pastures and crops are most at risk. Pupation occurs towards the end of October with adults emerging during January to March. Their emergence and activity is dependent on the frequency of rainfall events. Adults live for several weeks and will lay egg batches on bare earth. One generation per year.

YH cockchafers are found across southeastern Australia (not WA), including New South Wales, Victoria and South Australia. Larvae live in the soil until mid-late summer when they emerge as adult beetles. Cereal and pasture plants are most likely to be damaged from emergence to late autumn or early winter. The biology of these species is not well understood; some species are thought to have two-year lifecycles.

RH pasture cockchafers are found throughout south-eastern Australia (not WA), but are most common in south-west and central Victoria, the southern tablelands of New South Wales, south-eastern South Australia and northern Tasmania. Although they are typically found in higher rainfall zones, RH pasture cockchafers tend to be more numerous and problematic in drier years. Pastures are most likely to be damaged from emergence to late autumn or early winter. Although RH pasture cockchafers have a two year life cycle, they can be problematic every year if generations overlap. Larvae are present from autumn to spring and pupation occurs over summer. Adults remain in the soil until the following spring when they emerge, fly off, and then lay their eggs in the soil.

ABB are found throughout Australia, but have not been recorded in Tasmania. Outbreaks are associated with warm springs, as the developing larvae do not tolerate temperatures below 15°C. High soil moisture is also detrimental to larval development. Larvae reach their most damaging lifestage between January and March. Adults may continue to feed on crops throughout autumn, winter and spring.

Crops attacked/host range

Cockchafers are important pests of pastures and cereals. Crops sown into long term pasture paddocks are most at risk of attack. Adults do not feed on crops.

BH pasture cockchafer larvae feed on the foliage of annual pasture species (e.g. subterranean clover), and occasionally perennial pasture species and cereal crops.

YH cockchafer larvae mainly attack the roots of cereal crops but can also attack pastures.

RH pasture cockchafer larvae attack the roots of clovers and a range of annual and perennial grasses, typically in the top 10 cm of soil. They also occasionally attack wheat.

WA cockchafer larvae attack a range of crops and pastures. They can cause extensive damage to wheat crops.

ABB attack long-term pastures and grasses, turf and some horticulture crops. Preffered pasture species include ryegrass, tall fescue, kikuyu, and paspalum. ABB also attack several cereal crops including barley, triticale and wheat. Legume species are considered unfavourable.

Damage symptoms

BH pasture cockchafer larvae usually only come to the surface to feed after rain and they take enough food into their tunnels for 7-10 days. Most damage occurs to pastures during late winter and at the seedling stage in cereals when larvae eat all the leaves. The amount of damage varies from year to year.

YH cockchafers are primarily cereal root feeders and they will damage roots of young plants while foraging for soil organic matter. Damaged plants initially grow normally but wither and die at tillering, resulting in bare patches in the crop. Damage is worse under drought conditions as the plant's capacity to replace severed roots is reduced.

RH pasture cockchafers are primarily root feeders. Moisture stimulates the larvae to move closer to the soil surface in autumn where they feed on roots of newly emerging seedlings. High numbers of grubs sever the roots of pasture plants below the soil surface, which allows the pasture to be rolled back like a carpet. Damage can also result in completely bare regions within a paddock, ranging in size from small isolated patches to very large areas.

ABB larvae are primarily root feeders and can prune or completely sever roots of perennial grasses. In severe cases, pasture becomes patchy and can be rolled back like a carpet. ABB adults feed on the stems of young plants either underground or just above the soil surface, often killing growing points so that the central shoots wither and the plants die. They may sever the stem or cause 'ring barking' on larger plants. Older plants usually survive, but remain weak.

Monitoring/sampling

Inspect susceptible paddocks prior to sowing. Check established and newly sown pastures or weed growth in autumn to early winter, particularly in areas where bare batches were present over summer. For ABB, also monitor crops and pastures in late spring to mid-summer for larval damage. Dig to a depth of 10-20 cm with a spade and count the number of larvae present. This should be repeated 10 times across the paddock to get an estimate of larval numbers. Summing the number of larvae found across the ten samples and multiplying the sum by 2.5 will give approximate number of pests per m^2 .

For **BH cockchafers**, control is warranted If densities exceed 30 per m^2. An average infestation of 30-40 larvae per m^2 can cause a 50-70% reduction in winter pasture production and a 40-50% loss of desirable pasture species production in spring.

For **ABB**, densities in excess of 10 per m^2 during September may result in significant summertime crop damage. In early February, densities in excess of 15-20 per m^2 are considered damaging.

No economic thresholds have been established for **YH cockchafers** nor for **RH pasture cockchafers**.

For more information, go to the PestNotes webpage and search by pest name.

Management options

Biological	Cultural	Chemical
For all cockchafers • Birds prey upon grubs and are most effective after cultivation or tillage. • Several predatory and parasitic flies and wasps. • Other general predatory invertebrates. • Existing on-farm native vegetation should be preserved, and breeding habitats for birds and parasitic insects should be maintained. • Fungal pathogens *Metarhizium* spp. and *Cordyceps gunnii* attack pasture cockchafers and can have a devastating influence on local populations. For RH • There is an entomopathogenic nematode, *Heterorhabitis zealandica*, which is used for control in turf and nurseries, but these are unlikely to be cost effective in broad acre crops.	For WA cockchafers • If damage is anticipated, increase sowing rate for higher plant density. For BH • Avoid overgrazing of pastures as bare batches are more attractive to adults laying eggs during summer and early autumn. If possible, maintain pasture cover at 400-600kg DM/ha or 5 cm in height. For RH and YH • Cultivation • Grazing of pasture during late spring, summer and autumn (for YH) and heavy grazing in spring (for RH). • Re-sow affected areas using a higher seeding rate. • Re-sowing is best done using a method which disturbs the soil surface, leaving grubs vulnerable to predation. • Sowing less palatable crops (e.g. oats). • Spring-prepared fallows will help reduce damage in the following year. • Intensive crop rotations and short pasture rotations can also be used to prevent future damage. For ABB • Delay autumn sowing until May. • Sow less favourable pastures and crops such as legumes, oats and lucerne. ABB-resistant endophytes are now available in perennial ryegrass, such as AR37 (follow recommendations to avoid stock performance issues). • Increase seeding rates in paddocks where the pest is anticipated to cause damage. • Keep the paddock as bare fallow for as long as is feasible prior to planting.	For WA cockchafers • Surface applications of insecticides are not effective. • Chemical seed treatments or insecticides incorporated during seeding can assist in control. For BH • Foliar application of an insecticide is effective, particularly on young larvae before they begin to feed on green plant material. For best results insecticide sprays should be applied before June. For RH • Surface-applied insecticides are generally not effective given the subterranean feeding habits of larvae. • There are currently no synthetic insecticides registered. For YH • Surface-applied insecticides are generally not effective given the subterranean feeding habits of larvae. • A mixed formulation product has been registered as a seed protectant in pastures. Control is expected for 3-4 weeks after sowing, but will not control heavy populations. For ABB • Surface-applied insecticides are generally not effective given the subterranean feeding habits of larvae. • A mixed formulation product has been registered as a seed protectant in pastures. Control is expected for 3-4 weeks after sowing, but will not control heavy populations. • Chlorpyrifos is registered in maize however no other foliar insecticide is registered for broadacre crops.

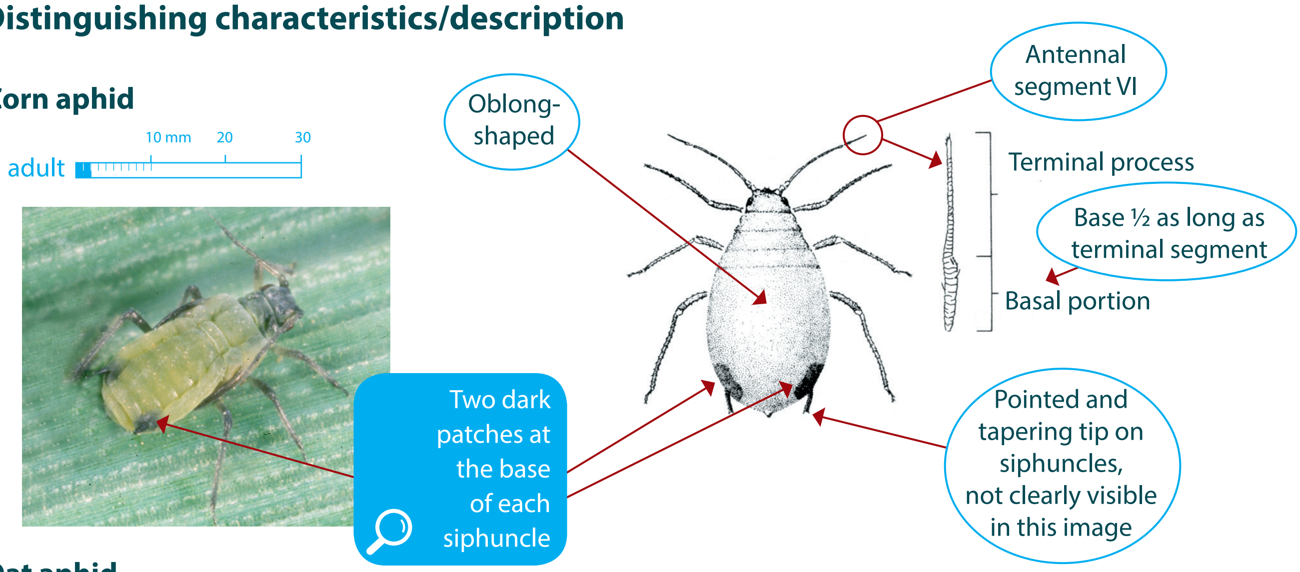
Ute Guides, Southern (pp. 61-63)/ Western (p. 46).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_EstablishmentSouth2014.pdf

CEREAL APHIDS

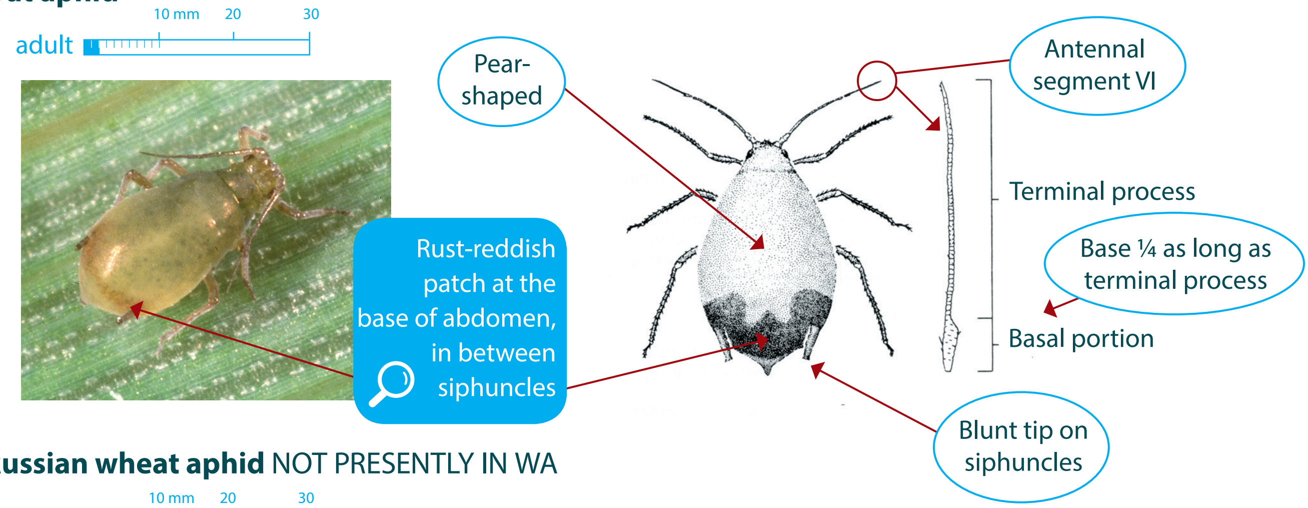
Corn aphid (*Rhopalosiphum maidis*), Oat aphid (*Rhopalosiphum padi*), and Russian wheat aphid (*Diuraphis noxia*)

Distinguishing characteristics/description

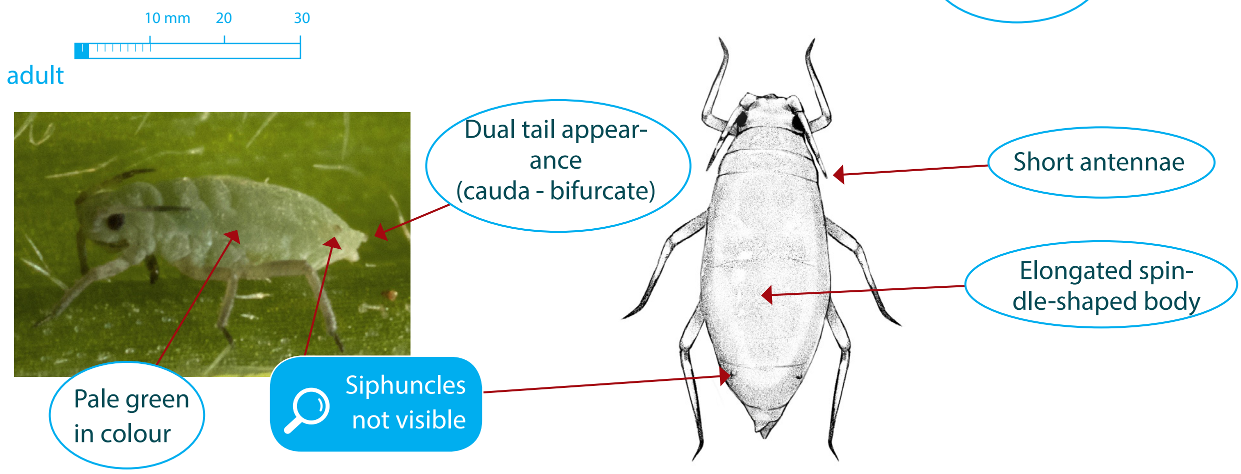
Corn aphid



Oat aphid



Russian wheat aphid NOT PRESENTLY IN WA



Confused with/similar to

These aphids can be confused with each other and other minor cereal aphids (e.g. rose-grain aphid, grain aphid and rice root aphid).

Corn aphids tend to be light green to dark olive in colour and oat aphids olive-green to black in colour. A definitive diagnostic character to distinguish between oat and corn aphids (both adults and nymphs) is the length of the terminal part of the antennae relative to the base of the antennae (see diagram above). Russian wheat aphid (RWA) are pale green in colour, often with a fine dusting of whitish wax. A lack of visible siphuncles distinguishes Russian wheat aphid from other cereal aphids.

Distribution, pest status and risk period

Cereal aphids can be found all year round and on all cereal crop growth stages. They sometimes cause feeding damage to cereals when there is a rapid increase in their reproduction and populations rise above economically damaging levels, usually in spring.

Oat and corn aphids can vector plant diseases such as barley yellow dwarf virus (BYDV). This is more common in high rainfall cropping zones where virus-infected self-sown cereals and grasses are present, along with large numbers of aphids during the early growth stages of new season crops.

Russian wheat aphid (RWA) is present in parts of South Australia, Victoria, New South Wales and Tasmania, but is not presently found in Western Australia or Queensland. Growers in Western Australia and Queensland are encouraged to report suspected new infestations to either the Exotic Plant Pest Hotline (1800 084 881) or using the state-specific contacts provided at: **http://www.planthealthaustralia.com.au/russian-wheat-aphid-management/**

Crops can become infested by RWA under warmer conditions in autumn, during the early stages of establishment, from wingless aphids walking off nearby senescing hosts. Populations frequently start to increase as temperatures warm in spring or typically from tillering onwards.

Crops attacked/host range

Oat aphids mainly attack oats and wheat, but can occur on all cereals and grasses.

Corn aphids mainly attack barley, but can also attack other cereals and grasses.

RWA can attack most cereal crops. Wheat and barley are most susceptible, while most other hosts, such as triticale, oats and rye, seem to be inferior in comparison.

All three aphids may be found during summer/early autumn on a range of volunteer grasses (alternate host plants) and self-sown cereals.

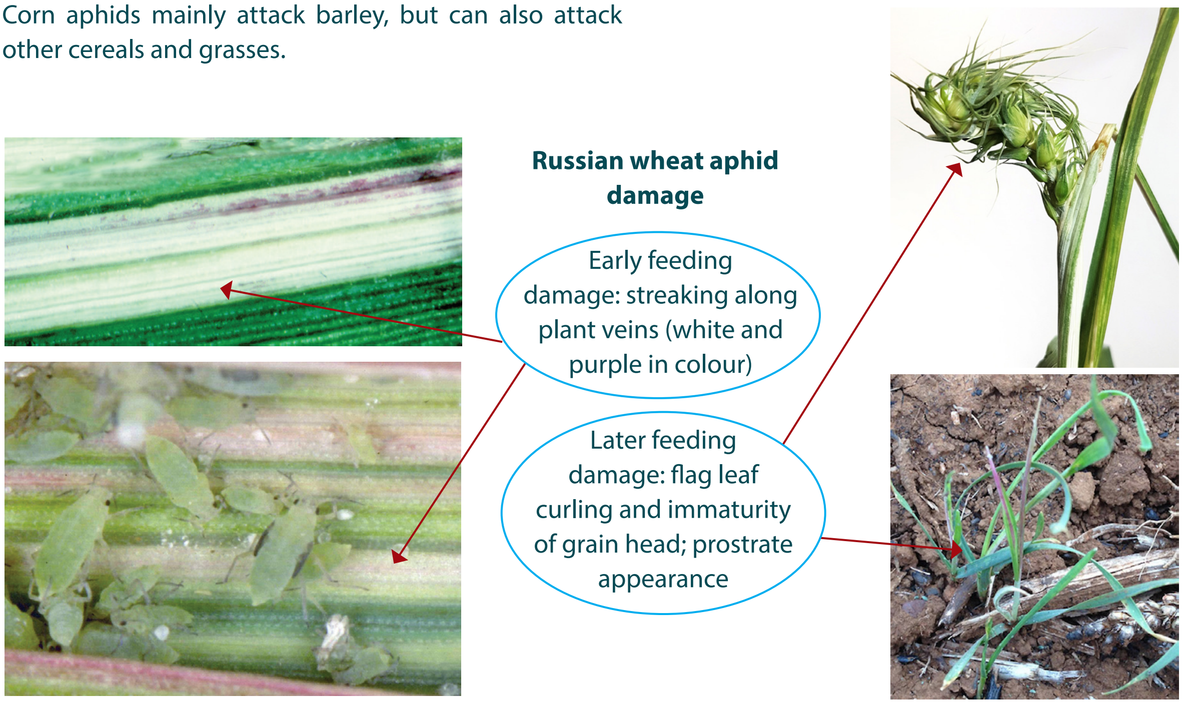
Damage symptoms

Oat and corn aphids cause direct feeding damage by large numbers of aphids on plants can result in sap removal that can cause nutrient loss and plant-wilting. Visual symptoms are usually not very obvious until close inspection of leaf whorls and sheaths, where dark-coloured masses of aphids may be seen. In some cases, aphid colonies infest the seed heads and congregate in large numbers.

Large amounts of honeydew (aphid exudates) and black sooty mould may be seen in prolonged, severe cases.

Oat and corn aphids cause indirect damage by spreading plant viruses.

RWA cause plant damage symptoms including leaf curl and discolouration, as well as white and purple streaks along the veins. RWA prefers to live in leaf whorls and tightly rolled leaves, thus damage begins at the base and progresses towards the tip of the leaves. Often the leaves will lay prostrate on the ground. Later infestations can cause damage to the flag leaf which curls, trapping the awn and preventing the head from completely emerging. This produces a 'gooseneck' head and as a result, the grain does not properly mature. Heads can also appear bleached. There is little evidence of significant transmission of plant viruses where RWA occurs overseas.



These symptoms can also be caused by other diseases and disorders such as herbicide and virus damage, nutrient deficiencies and frost. It is important to identify these symptoms in conjunction with the presence of aphids to be more confident in the diagnosis.

Monitoring/sampling

Direct visual searches and/or sweep netting.

Regular monitoring for cereal aphids should start in late winter and continue through to early spring with more frequent monitoring at the most vulnerable crop stage (stem elongation to late flowering). Check at least five points over the entire paddock including representative parts. Visually search for aphids on a minimum of 20 plants at each point and count the number of tillers infested with aphids.

For aphid-prone areas (high rainfall), regular monitoring is recommended from crop emergence in autumn, to detect aphids moving into crops, particularly along paddock edges. Very few aphids are required to transmit BYDV from infected to healthy seedlings. If aphids are seen, it may be too late for control unless plants are at the early seedling stage.

When widespread early infection occurs, BYDV can reduce grain yields by up to 50%. More commonly, the disease is confined to patches close to crop edges, where early aphid disease transmission occurred.

Western Australian and NSW recommendations for aphid feeding damage action thresholds on cereals at tillering is to consider control if aphid populations exceed 15 aphids/tiller on 50% of tillers for crops expected to yield 3 t/ha or more.

Western Australian research on aphid feeding damage in the absence of BYDV demonstrated variable yield losses up to 10% and reduction in seed size with aphid infestations at these levels.

RWA can be effectively controlled chemically, however decisions on the need for foliar treatments are based on the proportion of seedlings or tillers infested. Chemical control is warranted if infestations exceed thresholds of 20% of seedlings infested up to the start of tillering and 10% of tillers infested thereafter. Damage may be minimised through protection of the top three (major yield contributing) leaves.

Management options

Biological	Cultural	Chemical
Hover fly, lacewing larvae and ladybirds are known predators that help suppress populations. Aphid parasitoid wasps, evident by the presence of 'mummies'. Naturally occuring aphid fungal diseases can dramatically affect populations.	Summer/autumn pre-season weed control by heavy grazing or herbicides to control alternate host plants (e.g. volunteer grasses and cereals). 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 (as studies have shown aphids land in greater numbers when more bare ground is exposed).	BYDV control: • Use of appropriate insecticide seed dressings and/or synthetic pyrethroid sprays in the first eight weeks of crop development. Aphid feeding damage: • Seed treatments delay colonisation. • Border spraying (e.g. autumn/early winter) when aphids begin to colonise crop edges may provide sufficient control. Selective chemicals (i.e. pirimicarb) should be considered because they are effective against aphids but relatively harmless to beneficial species and other non-targets. Avoid prophylactic insecticides **RWA** have cryptic feeding habits, and therefore complete coverage and use of an insecticide with fumigant or systemic activity is required. See the APVMA website for current chemical options.

Ute Guides, Southern (pp. 70-71, 171)/ Western (pp. 52-53, 138)
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_Canola2014.pdf
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_WinterCereals-North2014.pdf

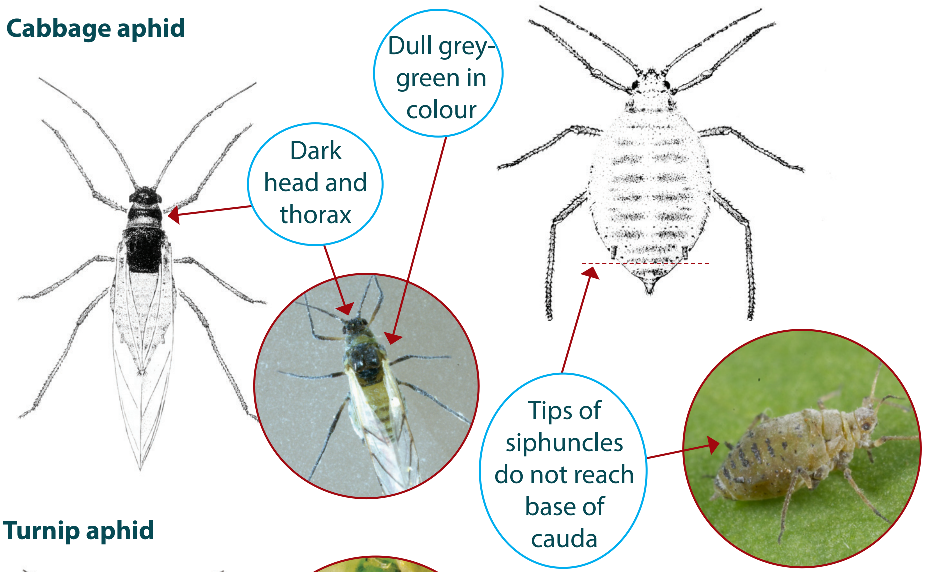
CANOLA APHIDS

Cabbage aphid (*Brevicoryne brassicae*), Turnip aphid (*Lipaphis erysimi*) and Green peach aphid (*Myzus persicae*)

Distinguishing characteristics/description

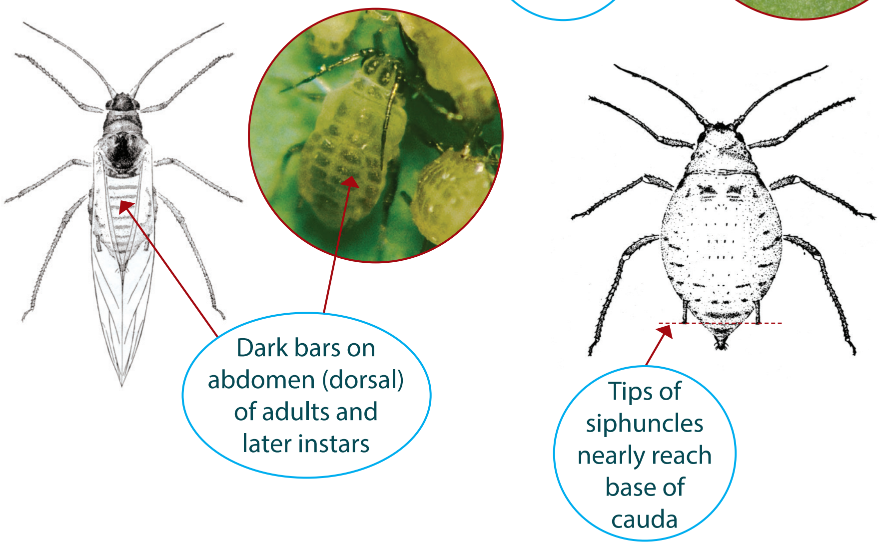
adult 10 mm 20 30 *for all species*

Cabbage aphid



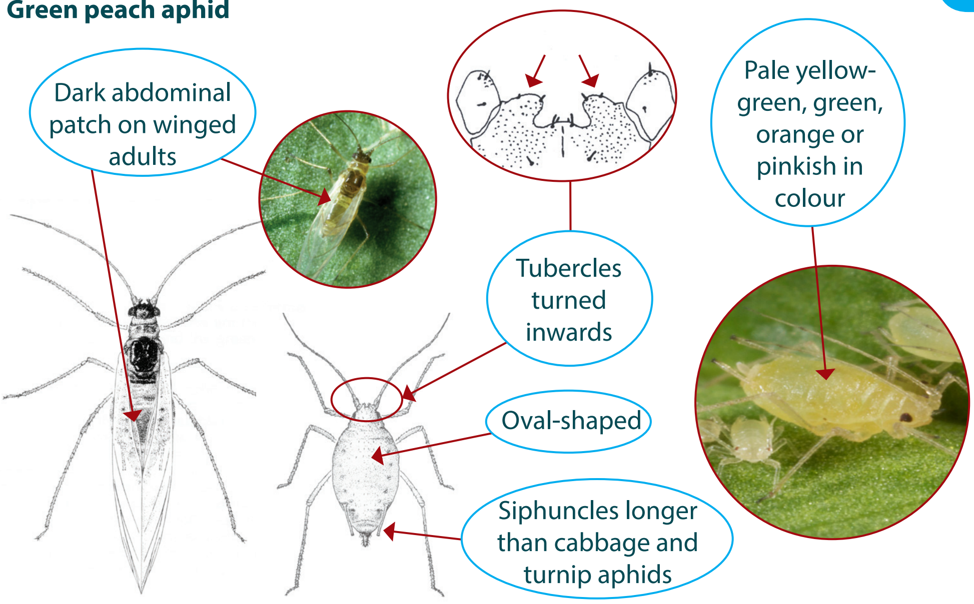
Form dense colonies (appear bluish grey) with a fine, whitish powder covering. Often found on flowering spikes and early pods

Turnip aphid



Form dense colonies with a WAXY covering (less pronounced than powdery cover of cabbage aphids). Often found on flowering spikes and early pods

Green peach aphid



Mainly found sparsely distributed on undersides of leaves

Confused with/similar to

Cabbage, turnip and green peach aphids can be confused with each other and some pulse aphids.

Distribution, pest status and risk period

Cabbage and turnip aphid infestations occur most frequently from early flowering to late pod development. They are most prolific in autumn and spring when the warm weather enables them to rapidly multiply. Rates of development reduce over winter. Canola is most vulnerable to aphid damage during bud formation through to late flowering. The cabbage aphid is more tolerant of cold weather than the turnip aphid and will continue to develop slowly at temperatures around 5-9° C.

Green peach aphids are most common in autumn and seldom cause economic loss to canola crops.

Crops attacked/host range

Cabbage and turnip aphid host plants are generally restricted to the crops and weeds belonging to the cruciferous plant family.

Green peach aphids will attack many plant families (including broad leaf pastures, pulse crops and oilseeds).

Damage symptoms

Aphids can cause direct feeding damage to plants, when in large numbers, as they remove sap. This reduces nutrient flow and can cause plant wilting.

Heavy infestations, particularly at flowering, can lead to large amounts of honeydew and black sooty mould.

Cabbage and turnip aphids usually form dense colonies on the floral parts, especially at the maturing, terminal flowering spike. Colonies on leaves often become evident by the distortion and discoloration (yellowing) of infested parts. Younger developing plant parts are preferred to older senescing parts.

Green peach aphids are usually found on the lower surface of basal, senescing leaves. They do not generally form dense colonies or cause leaf distortion. Large numbers occasionally occur on young, vegetative canola.

Cabbage aphids, turnip aphids and green peach aphids are all important vectors of plant diseases including turnip yellows virus (also known as beet western yellows virus), cauliflower mosaic virus and turnip mosaic virus all of which cause damage in canola. Turnip aphids also transmit cucumber mosaic virus. Green peach aphids transmit also transmit cucumber mosaic virus and bean yellow mosaic virus (see p. 38).

Monitoring/sampling

Direct visual searches, sweep netting, yellow sticky traps or yellow pan traps.

Monitoring for aphids should start in late winter and continue through early spring with regular checks at the most vulnerable crop stage (bud formation to late flowering).

For disease-prone areas (high rainfall), regular aphid monitoring from autumn onwards is recommended to detect aphids moving into crops, particularly along paddock edges.

Check at least five points over the entire paddock, including representative parts. Visually search for aphids on a minimum of 20 plants at each point and count the number of plants infested with aphids.

Generally, if more than 20% of plants are infested, control measures should be considered to avoid yield losses. Specific economic thresholds for cabbage and turnip aphids can be found by going to the PestNotes webpage and searching by pest name.

Economic thresholds for direct feeding damage have not been established for green peach aphids.

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, as virus can be transmitted by relatively few individuals, even prior to their detection within a crop.

Management options

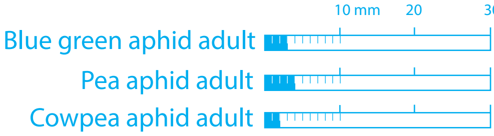
Biological	Cultural	Chemical
Hover fly, lacewing larvae and ladybirds are effective predators and can help suppress populations. Aphid parasitoid wasps (evident by the presence of 'mummies'). If the parasitism trend increases over time, there are good prospects that aphid populations will be controlled naturally. Naturally occurring aphid fungal diseases (e.g. *Pandora neoaphidis* and *Conidiobolyus obscurus*) can also suppress aphid populations.	Implementing early summer weed control in areas where aphids build up on alternate host plants (e.g. cruciferous weeds). Sow crops early where possible to enable plants to begin flowering before aphid numbers peak. 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. Select cultivars that are less susceptible to aphid-feeding damage where possible.	Seed treatments and border spraying (autumn/early winter) when aphids begin to colonise crop edges may provide sufficient control. Selective foliar spray. **Cabbage and turnip aphids** have not been found to have evolved resistance to any insecticides in Australia. Imidacloprid is registered as an insecticide seed treatment against turnip aphids, however there are no foliar sprays registered specifically for this species. **Green peach aphid** (GPA) populations in Australia have evolved resistance to synthetic pyrethroids, carbamates (e.g. pirimicarb), organophosphates and neonicotinoids (e.g. imidacloprid). A sulfoxaflor foliar insecticide remains an effective means to control GPA in canola crops, and should be used judiciously. To reduce the risk of resistance to any insecticide group, it is important to rotate insecticides with different modes of action, avoid the use of broad-spectrum insecticides, and apply appropriate insecticides only after careful monitoring and correct identification of species.

Ute Guides, Southern (pp. 73-75)/Western (pp. 54-56).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_Canola2014.pdf
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_WinterPulsesSouth2014.pdf

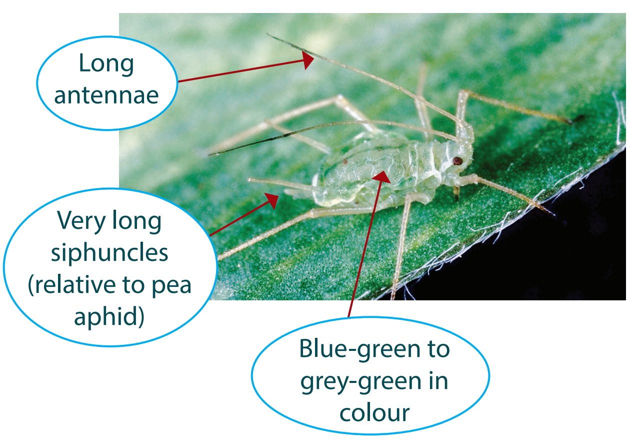
PULSE APHIDS

Blue green aphid (*Acyrthosiphon kondoi*), Pea aphid (*Acyrthosiphon pisum*), Cowpea aphid (*Aphis craccivora*) and Green peach aphid (*Myzus persicae*)

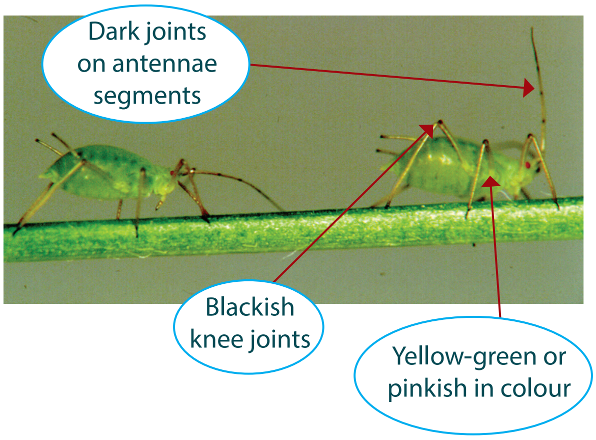
Distinguishing characteristics/description



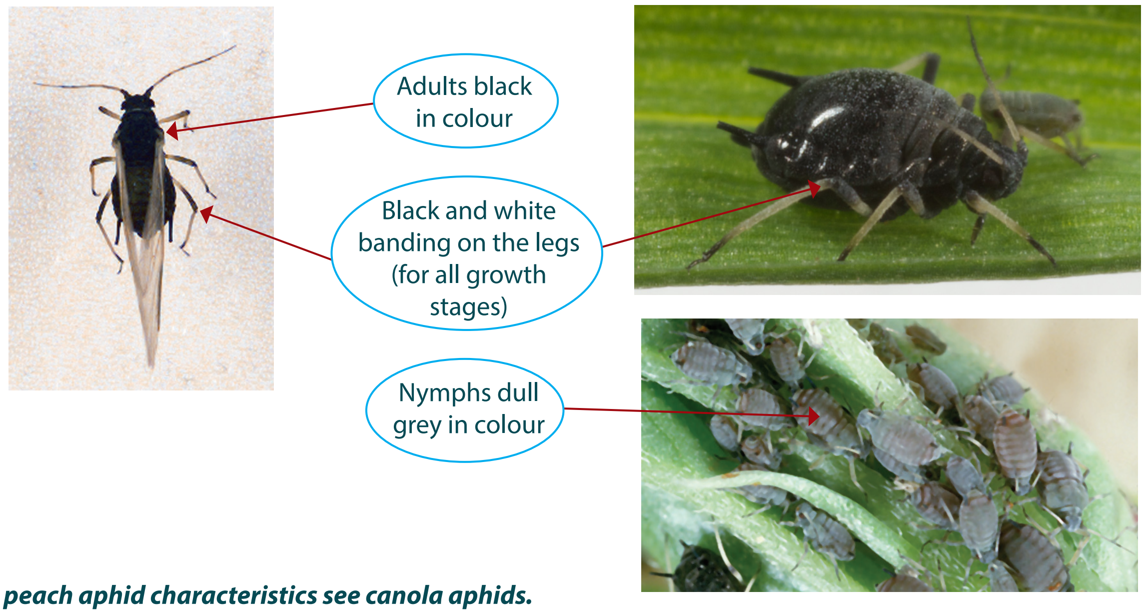
Blue green aphid



Pea aphid



Cowpea aphid



For green peach aphid characteristics see canola aphids.

Confused with/similar to

Can be confused with other pulse and canola aphids. Currently there are no aphid biosecurity threats for pulses.

Distribution, pest status and risk period

Pulse aphids are common in winter and spring and are usually found on the upper part of the plants, particularly growing points.

Virus management is critical for disease-prone areas (see monitoring/sampling overleaf) as these pulse aphids can transmit plant viruses and diseases.

Crops attacked/host range

These aphids are commonly found on all pulses including field peas, lupins, lentils, faba beans and other legumes.

Blue green aphids are also found on annual medic, subterranean clover pastures and vetch.

Damage symptoms

Aphids can cause direct feeding damage to plants when in large numbers as they remove sap, which can cause wilting of plants. Aphids also cause indirect damage by spreading plant viruses that they take up and pass on when sucking sap from infected plants and then feeding on uninfected plants.

Bluegreen aphids, cowpea aphids, and pea aphids all transmit important plant viruses including cucumber mosaic virus and bean yellow mosaic virus. Cowpea and pea aphids also transmit alfalfa mosaic virus and pea seed-borne mosaic virus.

Heavy infestations deform leaves, growing points and stunt plants. At flowering, heavy infestations can lead to large amounts of honeydew and black sooty mould.

Monitoring/sampling

Direct visual searches and counts, sweeping netting, yellow sticky traps or yellow pan traps (can assist in early aphid detection).

For disease-prone areas (high rainfall), regular monitoring for virus management is critical in pulses. Minimising the virus source, sowing seed that is virus-free, managing crop agronomy (to reduce aphid landing sites) and monitoring for early detection are some key management strategies.

Regular monitoring for aphids should start in autumn and continue through to early spring with several checks a week at the most vulnerable crop stage (bud formation to late flowering).

Check at least five points over the entire paddock including representative parts. Visually search for aphids on a minimum of 20 plants at each point and count the number of plants infested with aphids.

Generally, if more than 20% of plants are infested, control measures should be considered to avoid yield losses. Specific economic thresholds for bluegreen aphids, cowpea aphids and pea aphids can be found by going to the PestNotes webpage and searching by pest name.

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, as virus can be transmitted by relatively few individuals, even prior to their detection within a crop.

Management options

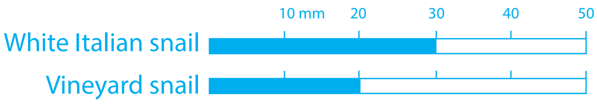
Biological	Cultural	Chemical
Hover fly, lacewing larvae and ladybirds are effective predators and can help suppress populations. Aphid parasitoid wasps (evident by the presence of 'mummies'). If the parasitism trend increases over time, there are good prospects that aphid populations will be controlled naturally.	Implementing early summer weed control on your property where aphids build up on alternate host plants (e.g. broad leaf weeds). Sow crops early where possible to enable plants to begin flowering before aphid numbers peak. Select cultivars that are less susceptible to aphid feeding damage. Ensuring rapid development of dense crop canopy so that bare ground is covered will assist in deterring aphid landings. Narrow rows with high seeding rates can assist.	Selective foliar spray (e.g. pirimicarb). Seed treatments. Border spraying (autumn/early winter) when aphids begin to colonise crop edges may provide sufficient control. **Green peach aphid** populations in Australia have evolved resistance to several insecticides (see canola aphids management options). Chemical rotation of insecticide groups will minimise the risk of further resistance issues.

Ute Guides, Southern (pp. 75-78)/Western (pp. 54, 57, 58, 60).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_SummerPulses2014.pdf
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_WinterPulsesSouth2014.pdf

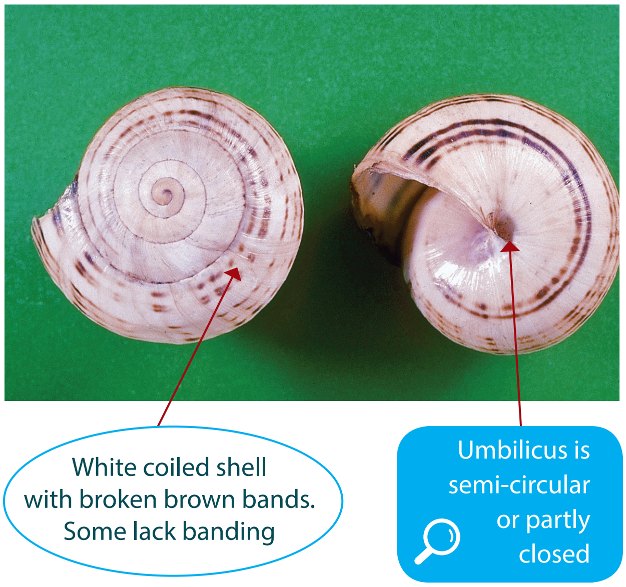
ROUND SNAILS Helicidae

White Italian snail (*Theba pisana*) and Vineyard or common snail (*Cernuella virgata*)

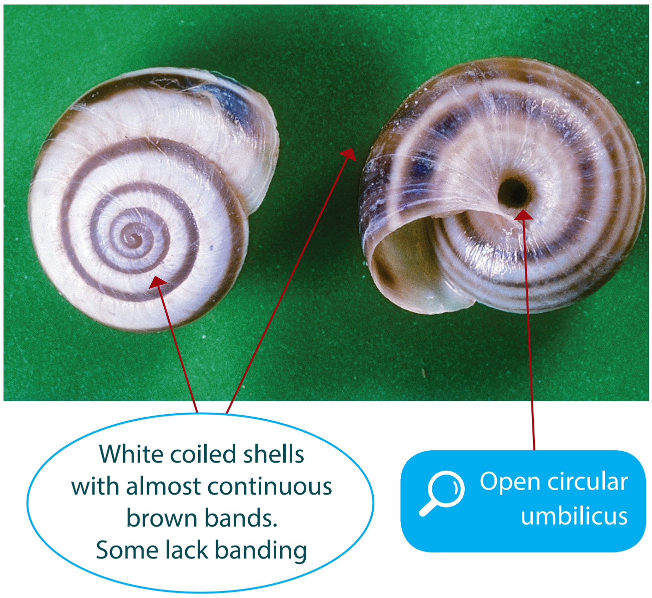
Distinguishing characteristics/description



White Italian snail



Vineyard or common snail



Confused with/similar to

These snails are similar to and can be easily confused with other round snail species.

Distribution, pest status and risk period

Round snails are an important pest of crops and pastures across southern Australia, particularly where conservation farming involves stubble retention, reduced burning and reduced tillage. Crops and pastures grown on calcareous and highly alkaline soils are highly susceptible. Crops are most vulnerable at emergence and early development.

Snails can be active all year round with a small amount of moisture and cool conditions. Snails are least likely to be active in hot, dry conditions, particularly in late spring and early summer.

Round snails are a grain contaminant.

Crops attacked/host range

All crops and pastures can be attacked. Emerging and young plants of crops and pastures. Barley, canola, and pulse crops are most susceptible.

Damage symptoms

Round snails can shred leaves and defoliate young plants, due to their rasping action when feeding. During extended periods of inactivity (aestivation) snails can be found resting above ground on stems, stubble and fence posts.

Monitoring/sampling

Monitor all year round to allow for full use of all available control options. Monitor using a 0.1 m^2 quadrat, counting all the live snails found within the quadrat on the ground. Separate round from conical snails and split snails into two size groups, 7 mm and larger and < 7 mm, using a sieve. Snails < 7 mm in diameter are unlikely to be controlled successfully by baits.

Suggested key monitoring times are:

- Jan-Feb, assess stubble management options
- Mar-April, assess for burning and/or baiting
- 3-4 weeks prior to harvest, assess for header alterations

Management options

Several cultural control options, and associated economic thresholds, appear in detail in *Bash'Em Burn'Em Bait'Em – Integrated snail management in crops and pastures*. Thresholds can be misleading because populations cannot be accurately estimated.

Good snail management requires population reduction at every opportunity. This includes tactics for minimising snail contamination of grain at harvest.

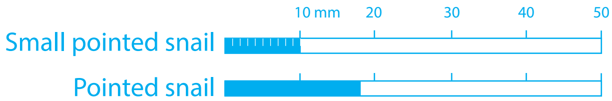
Biological	Cultural	Chemical
Carabid beetles are known predators and can help suppress populations.	Stubble management includes rolling, cabling and slashing. Use these techniques post harvest, after mid-morning on hot days over 35ºC. Ideally this should be done when several hot days will follow. Around 50-90% kill can be achieved when temperatures are over 35º C. This is less effective in dense cereal stubbles. Burning is best undertaken early in the burn season. Aim for an even paddock burn. Around 80-100% kill can be achieved with an even burn and about 50-80% kill with a patchy burn. Note the potential risk for soil erosion with these methods. Summer weed control especially along fence lines and borders, and prior to stubble management. Snails have been found along all major transport routes between South and Western Australia, suggesting snails are moving between regions on transport. Maintaining good farm biosecurity practices around hygiene and movement can reduce the risk of moving snails from infested to clean areas. Farm machinery and produce such as hay should be inspected and if necessary cleaned of snails.	Molluscicide baiting of fence lines and borders can be effective after autumn rains when snails are moving from aestivation sites. To achieve optimal baiting results across the whole paddock get your spreader professionally calibrated with your preferred bait product. Bait when autumn moisture triggers snail activity and before egglaying commences. Ensure at least 30 bait points per square metre for good results. Repeat applications may be needed after monitoring. Commonly used bran baits need to be re-applied within 2 weeks. More expensive products will last 3-4 weeks. Baiting in winter is less effective. Many bait products are degraded by rain. Avoid applying baits before significant rain events. For further bait guidelines and bait product comparison chart, refer to the snail and slug baiting guidelines (pdf) on the pirsa.sa.gov.au website**.**

Ute Guides, Southern (pp. 92-93)/ Western (pp. 72-73).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
www.grdc.com.au/GRDC-Snails-BashBurnBait

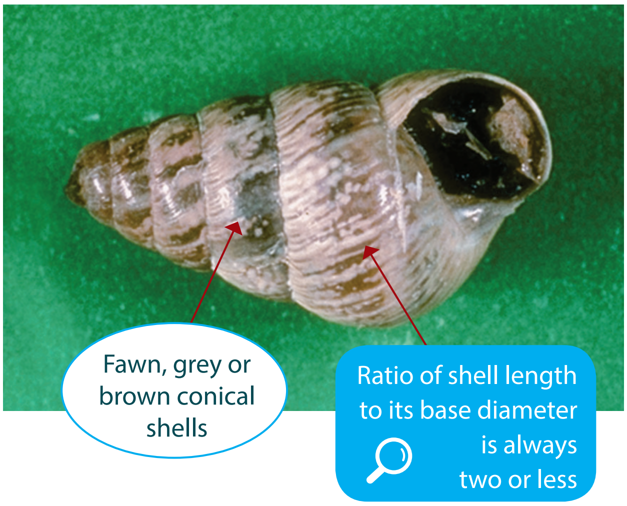
CONICAL SNAILS Helicidae

Small pointed snail (*Prietocella barbara*) and Pointed or conical snail (*Cochlicella acuta*)

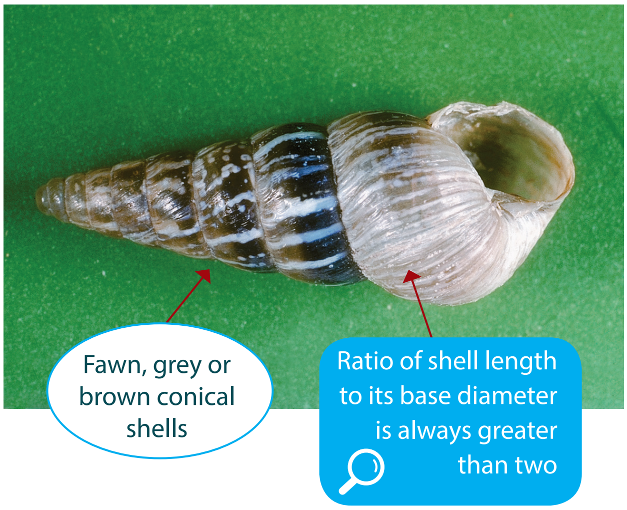
Distinguishing characteristics/description



Small pointed snail



Pointed or conical snail



Confused with/similar to

These snails can be confused with each other as well as native conical snail species.

Distribution, pest status and risk period

Small pointed snails favour areas of rainfall higher than 500 mm. Crops and pastures grown on calcareous and highly alkaline soils can be highly susceptible. Numbers can build up in the pasture phase of cropping rotations. They are most active under cool conditions and may move over crops at night or during cool days. Conical snails are more likely than other snail species to be found intact in harvested grain, as their size and shape makes them difficult to dislodge from grain heads. Conical snails over-summer under stones and stumps, and on posts and vegetation.

Conical snails are found in the highest concentration on the Yorke Peninsula, SA but scattered populations can be found in other parts of SA, Victoria, NSW and WA.

The pest status of this species comes from being a contaminant of grain, particularly barley. Smaller snails can be a contaminant of canola and cereal grains. Their presence could cause rejection of grain at receival points, posing a serious risk to grain exports.

Crops attacked/host range

Conical snails are mainly a pest of crops at harvest when they can contaminate grain and seed.

Small pointed snails are a pest of pastures, lucerne, canola, and some pulses across southern Australia, particularly where conservation farming involves stubble retention, reduced burning and reduced tillage.

Conical snails are rarely recorded directly feeding on crops and pasture as these snails prefer dead organic material.

Damage symptoms

Small pointed snails may eat seedlings off at ground level when snail numbers are very high.

Conical snails prefer dead organic material and therefore have limited impact on the crop directly.

Monitoring/sampling

Monitor all year round to allow for full use of all available control options. Monitor using a 0.1 m^2 quadrat, counting all the live snails found when the quadrat is placed on the ground. Separate round from conical snails and split snails into two size groups, 7 mm and larger and < 7 mm, using a sieve. Snails < 7 mm in diameter are unlikely to be controlled successfully by baits.

Management options

Several cultural control options, and assoicated economic thresholds, appear in detail in *Bash'Em Burn'Em Bait'Em – Integrated snail management in crops and pastures*. Thresholds can be misleading because populations cannot be accurately estimated.

When temperatures are high, conical snails are more likely to seek shelter in cool locations, such as under stubble. Harvesting at hottest time of the day can thereby reduce conical snail contamination. Post harvest grain cleaning can be a last opportunity to remove snails.

Good snail management requires population reduction at every opportunity. This includes tactics for minimising snail contamination of grain at harvest.

Biological	Cultural	Chemical
Carabid beetles are known predators and can help suppress populations. A parasitic fly, *Sarcophaga villeneuveana* (previously known as *S. penicillata)*, is the only currently available biological control for the conical snail. Flies were released on the Yorke Peninsula, SA, however parasitism rates on SA conical snails have been extremely low, and attempts to explain the lack of parasitism have been as yet inconclusive.	Stubble management includes rolling, cabling and slashing. Use these techniques post harvest, after mid-morning on hot days over 35°C. Ideally this should be done when several hot days will follow. Around 50-90% kill can be achieved when temperatures are over 35° C. This is less effective in dense cereal stubbles. Burning is best undertaken early in the burn season. Aim for an even paddock burn. Around 80-100% kill can be achieved with an even burn and about 50-80% kill with a patchy burn. Note the potential risk for soil erosion with these methods. Summer weed control especially along fence lines and borders, and prior to stubble management. Snails have been found along all major transport routes between South and Western Australia, suggesting snails are moving between regions on transport. Maintaining good farm biosecurity practices around hygiene and movement can reduce the risk of moving snails from infested to clean areas. Farm machinery and produce such as hay should be inspected and if necessary cleaned of snails.	Molluscicide baiting of fence lines and borders can be effective after autumn rains when snails are moving from aestivation sites. To achieve optimal baiting results across the whole paddock get your spreader professionally calibrated with your preferred bait product. Bait when autumn moisture triggers snail activity and before egglaying commences. Ensure at least 30 bait points per square metre for good results. Repeat applications may be needed after monitoring. Commonly used bran baits need to be re-applied within 2 weeks. More expensive products will last 3-4 weeks. Baiting in winter is less effective. Many bait products are degraded by rain. Avoid applying baits before significant rain events. For further bait guidelines and bait product comparison chart, refer to the snail and slug baiting guidelines (pdf) on the pirsa.sa.gov.au website.

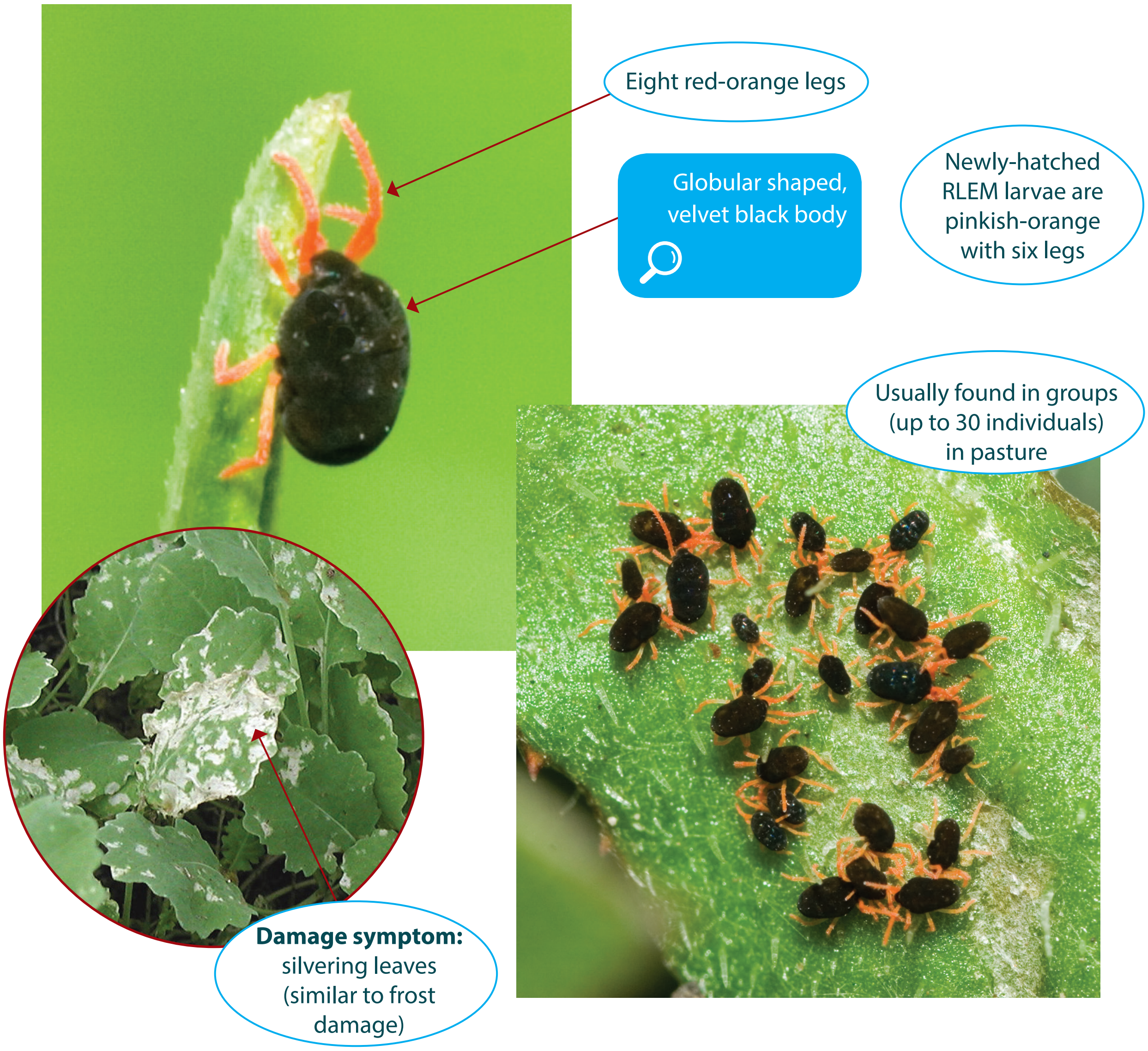
Ute Guides, Southern (pp. 94-95)/ Western (p. 74).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
www.grdc.com.au/GRDC-Snails-BashBurnBait

Acarina: Penthaleidae

Redlegged earth mite - RLEM (*Halotydeus destructor*)

Distinguishing characteristics/description

10 mm 20 30
adult *and 0.6 mm wide*



Newly-hatched redlegged earth mite (RLEM) larvae are only 0.2 mm long and are generally not visible to the untrained eye. In the following three nymphal stages, mites have eight legs and resemble adults, but are smaller and sexually undeveloped.

Confused with/similar to

Other mite pests, in particular blue oat mites and the *Balaustium* mite, are sometimes confused with RLEM in the field. Unlike other species that tend to feed singularly, RLEM generally feed in large groups of up to 30 individuals.

Distribution, pest status and risk period

The RLEM is widespread throughout most agricultural regions of southern Australia. They are found in southern NSW, on the east coast of Tasmania, the south-east of SA, the south-west of WA and throughout Victoria.

RLEM are active from autumn to late spring. They are most damaging to newly-establishing pastures and emerging crops, greatly reducing seedling survival and development. RLEM can also cause significant feeding damage and a reduction in legume seed-set of pastures in spring.

Crops attacked/host range

All crops and pastures, although canola, lupins, cereals and legume seedlings are most at risk. RLEM also feed on a range of weed species including Paterson's curse, ox-tongue and capeweed. RLEM feeding reduces the productivity of established plants and has been found to be directly responsible for a reduction in pasture palatability to livestock.

Damage symptoms

Typical mite damage appears as silvering or whitening on the attacked foliage. Mites use scissor-like chelicerae 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. Affected seedlings can die at emergence with high mite populations.

Monitoring/sampling

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 weeks after crop emergence. Mites are best detected feeding on leaves in the morning or on overcast days. In the warmer part of the day, redlegged earth mites tend to gather at the base of plants, sheltering in leaf sheaths and under debris. When disturbed during feeding they will drop to the ground and seek shelter.

For crop specific economic thresholds, go to the PestNotes webpage and search by pest name.

Management options

Biological	Cultural	Chemical
French *Anystis* mites can suppress populations in some pastures.	Crop rotations with non-preferred crops, such as lentils and chickpeas. Weed control pre-sowing. Grazing management of spring pastures in the year prior to cropping.	Resistance to synthetic pyrethroids (including bifenthrin and alpha-cypermethrin) and organophosphates (including omethoate and chlorpyrifos) has been detected for RLEM in Western Australia and recently, South Australia. **Resistance is a risk for all southern grains.** Rotate chemical classes. For low-moderate populations, seed dressings are effective. Avoid prophylactic sprays. Pesticides used at or after sowing should be applied within three weeks of the first appearance of mites, before adults commence laying eggs. Insecticides do not kill mite eggs. Border spraying. Carefully timed spring spraying (e.g. TIMERITE®).

Ute Guides, Southern (p. 97)/ Western (p. 75).
http://cesaraustralia.com/sustainable-agriculture/pestnotes/
http://ipmguidelinesforgrains.com.au/wp-content/uploads/BestBet_EstablishmentSouth2014.pdf

More Information

Website links

DPIRD	Department of Primary Industries and Regional Development, Western Australia https://www.agric.wa.gov.au/
CESAR	CESAR www.cesaraustralia.com
	PestNotes http://www.cesaraustralia.com/sustainable-agriculture/pestnotes
SARDI	South Australian Research and Development Institute www.pir.sa.gov.au/research
PIRSA	Department of Primary Industries and Regions, South Australia www.pir.sa.gov.au
DEDJTR	Department of Economic Development, Jobs, Transport and Resources, Victoria http://economicdevelopment.vic.gov.au/
QDAF	Department of Agriculture and Fisheries, Queensland https://www.daf.qld.gov.au/
NSW DPI	Department of Primary Industries, New South Wales www.dpi.nsw.gov.au
CSIRO	Commonwealth Scientific and Industrial Research Organisation www.csiro.au
GRDC	Grains Research and Development Corporation www.grdc.com.au
	"Best Bets" http://ipmguidelinesforgrains.com.au/workshops/resources/
PHA	Plant Health Australia: Grains Biosecurity http://www.planthealthaustralia.com.au/biosecurity/
PaDIL	Pest and Disease Image Library www.padil.gov.au
APVMA	Australian Pesticides and Veterinary Medicine Authority https://apvma.gov.au/

PestFax/PestFacts services

The PestFax/PestFacts services are free interactive tools designed to keep growers and advisers informed about pest-related issues - and solutions - as they emerge during the growing season.

The services are distributed as electronic newsletters and aim to help growers achieve maximum yield and quality for the lowest cost by providing timely information about pest outbreaks, effective controls and current information about relevant and new research findings.

To provide this service PestFax/PestFacts draws on the field observations of consultants, growers and researchers across southern Australia as they report on the location and extent of invertebrate outbreaks. Growers can access maps through PestFax/PestFacts that show the location of invertebrate crop pests reports.

The PestFax/PestFacts services, part of GRDC's National Invertebrate Pest Initiative (NIPI), also issue warnings (or reminders) for a range of invertebrate pests of broadacre crops, including pulses, oilseeds, cereals and fodder crops.

The PestFax/PestFacts Reporter app can be used to report or identify any broadacre crop pest, unknown invertebrate or beneficial, and is available on iTunes (apple) and Google Play (android).

For further information or to subscribe to these services visit:

PestFax (DPIRD)
https://www.agric.wa.gov.au/newsletters/pestfax

PestFacts SA (SARDI)
http://www.pir.sa.gov.au/research/services/reports_and_newsletters/pestfacts_newsletter

PESTFACTS SOUTH AUSTRALIA NEWSLETTER
Government of South Australia Primary Industries and Regions SA
SARDI SOUTH AUSTRALIAN RESEARCH AND DEVELOPMENT INSTITUTE

PestFacts South-Eastern (CESAR)
http://cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/

Table 5.2 Impact of insecticides on natural enemies in crops

INSECTICIDES		TOXIC EFFECT ON SPECIFIC NATURAL ENEMIES									
Active Ingredient	Persistence	Hymenoptera [1]			Predatory beetles [2]	Predatory bugs [3]	Lacewings	Spiders	Thrips [4]	Toxicity to bees [5]	Predatory mites
		Egg parasitoids	Larval & pupal parasitoids	Ants							
Bacillus thuringiensis (VRP)	very short	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
NP virus	very short	VL	VL	VL	VL	VL	VL	VL	VL	VL	VL
pirimicarb	short	H	L-H	VL	L	L	L	VL	L	VL	L
indoxacarb	medium	VL	H	VH	H[7]	L	VL	VL	VL	H[6]	VL
Metarhizium anisopliae	short	L	L	L	L	L	L	L	L	L	-
spinosad	medium	H	M-H	H	VL	M	VL	VL	H	H[6]	M
fipronil	medium	M	VH	VH	L	M	L	M	VH	VH	VH
methiocarb	medium	VH	VH	-	VH	VH	VH	-	-	VH	VH
methomyl	very short	VH	H-VH	H	H	H	H	M	H	H[6]	H
organophosphates	short-medium	VH	H-VH	VH	H	H	M	M	H	H	H
carbaryl	short	H	H	-	H	H	H	-	H	H	VH
synthetic pyrethroids	long	VH	H-VH	VH	VH	VH	VH	VH	VH	H	VH
paraffinic oil	short	VL	-	H	VL	VL	VL	L	VL	VL	-
spinetoram	unknown	-	-	-	-	-	-	-	-	H	-
sulfoxaflor (full rate)	medium	H	-	VH	H	L	H	L	H	-	-
chlorantraniliprole	long	L	-	L	L	VL	VH	VL	VL	-	-
clothianidin (low)	medium	M	H	VH	M	L	H	M	VL	-	-
clothianidin (high)	medium	H	VH	VH	H	M	H	M	VL	-	-
thiamethoxam	medium	H	-	VH	H	M	M	VL	H	H	-
abamectin	medium	M	H	H	L	M	VL	M	M	H	-
amorphous silica	short	-	-	M	L	M	L	L	VL	-	-
dimethoate (low)	short	M	-	H	M	M	M	L	M	H	-
emamectin	medium	M	-	VL	L	H	L	M	M	H	-
thiodicarb	long	M	-	M	VH	M	VL	M	H	M[6]	-

VRP = Various Registered products

Overall impact rating (% reduction in natural enemies following application):

VL (Very Low) less than 10%	L (Low) 10-20%	M (Moderate) 20-40%
H (High) 40-60%	VH (Very High) > 60%	A dash (-) indicates no data available

Persistence of pest control: short = < 3 days; medium = 3-7 days; long = > 10 days
Pyrethroids may include alpha-cypermethrin, beta-cyfluthrin, cyfluthrin, bifenthrin, esfenvalerate, deltamethrin, lamba-cyhalothrin and gamma-cyhalothrin.
Organophosphates may include dimethoate, omethoate, profenofos, chlorpyrifos, methidathion, parathion-methyl, diazinon, fenitrothion, maldison, phosmet and methamidophos.

[1] Toxicity ratings for hymenoptera are for adults only.
[2] Predatory beetles include ladybeetles, red and blue beetles, and other predatory beetles. Toxicity ratings for predatory beetles are for adults only.
[3] Predatory bugs include big-eyed bugs, minute pirate bugs, brown smudge bugs, glossy shield bug, predatory shield bug, damsel bug, assassin bug, and apple dimpling bug.
[4] Effects on thrips are for populations found on leaves. This is relevant to seedling crops, where thrips damage leaves, and to mid-late season when thrips adults and larvae help control mites by feeding on them as well as on leaf tissue. Note that flowers are a protected site, so live adult thrips may be found in flowers even after crops have been treated with products that would control them on leaves
[5] Data Source: British Crop Protection Council. 2003. The Pesticide Manual: A World Compendium (Thirteenth Edition),. Where LD50 data is not available impacts are based on comments and descriptions. Where LD50 data is available impacts are based on the following scale: very low = LD50 (48h) > 100 ug/bee, low = LD50 (48h) < 100 ug/bee, moderate = LD50 (48h) < 10 ug/bee, high = LD50 (48h) < 1 ug/bee, very high = LD50 (48h) < 0.1 ug/bee.
[6] Wet residue of these products is toxic to bees, however, applying the products in the early evening when bees are not foraging will allow spray to dry, reducing risk to bees the following day.
[7] Very high impact on minute two-spotted ladybeetle and other ladybeetles for wet spray, moderate impact for dried spray.
[8] May be detrimental to eggs and early stages of many insects, generally low toxicity to adults and later stages.

IMPORTANT NOTICE: Although the authors have taken reasonable care in the advice, neither the agencies involved nor their officers accept any liability resulting from the interpretation or use of the information set in this document. Information provided is based on the current best information available from research data. Users of insecticides should check the label for registration in their particular crop & state, and for rates, pest spectrum, safe handling and application details.
Further information on products can be obtained from the manufacturer.

Data sources (Table 5.2):

Cotton Pest Management Guide 2015-2016. Cotton Info Team (2015)
Toxicity of Tomato & Bell Pepper Insecticides/Miticides to Beneficial Insects. Mark A. Mossler, University of Florida AFAS Extension (2008).
Koppert Biological Systems (http://side-effects.koppert.nl/).
HAL project VG04004 "National diamondback moth project: integrating biological chemical and area-wide management of brassica pests".
BioBest Beneficials Data (http://www.biobestgroup.com/en/side-effect-manual)
Llewellyn R (Ed.). 2002. The Good Bug Book, 2nd edition. Integrated Pest Management Pty Ltd.

Case study 3

IPM in Australian Grains: the costs and benefits of insecticides

Location: Charlton Victoria, Cootamundra NSW, Churramulka SA, Beverly and Wickepin in WA
Date: two cropping seasons (canola in 2010, wheat in 2011)
Lead Researcher: Dr Darryl Hardie

Summary: In theory an application of an insecticide should lead to fewer pests, therefore less feeding damage to crop plants, and ultimately higher yields at the end of the season. However, the use of some insecticides can lead to other problems such as pest resurgence, secondary pest outbreaks and the development of pesticide resistance. This project developed on-farm demonstration trials, established with regional grower groups across southern Australia, to understand the costs and benefits of different levels of insecticide-use.

Each trial consisted of three pest management strategies; a conventional approach, based on the spray pattern used to manage pests in each local area; an alternative approach using monitoring of pest and beneficials, and plant damage to decide when (and if) to intervene with sprays, and a control with little to no insecticide applications. We found that greater insecticide use reduced insect pests and associated feeding damage. However this was not coupled with higher yields. For canola, insecticide seed treatments were most likely to deliver a yield benefit. Other insecticide inputs were unnecessary and economically costly in low-pest pressure years. For wheat, none of the insecticide inputs provided an economically justifiable yield gain.

These results indicate that there are opportunities for growers to reduce insecticide inputs without risking yield loss in low-pest pressure years. Identifying low pest pressure years in advance may allow growers to use strategic monitoring to assess risk of pest outbreaks. Repeating this study at times of high pest pressure will give us a better indication of the benefits of certain insecticide groups.

(Adapted from final report for GRDC project #UWA00134)

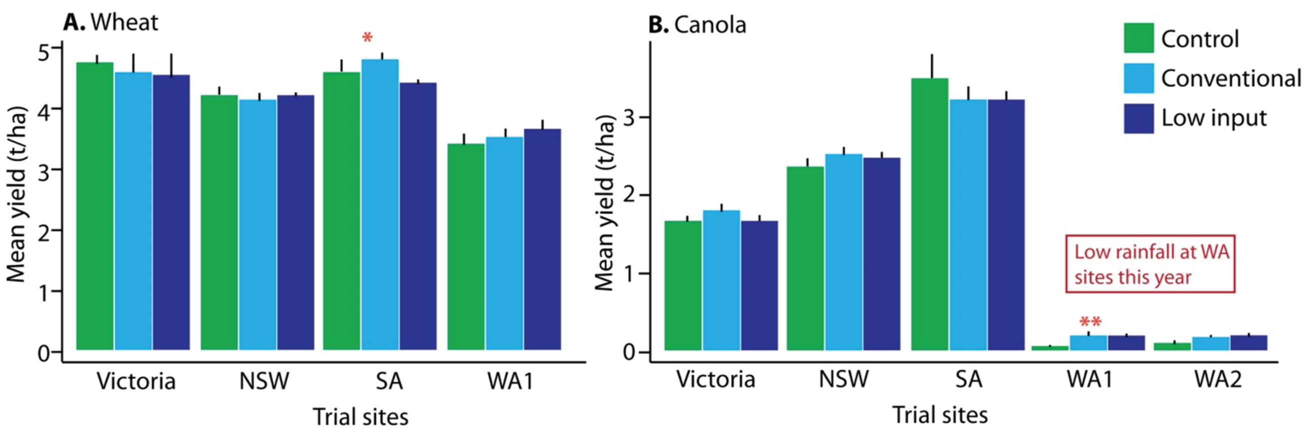


*Figure 1: Impact of pest management approach on crop yield in field trials of wheat (A) and canola (B) at five sites across southern Australia. Overall we found no significant effect of pest management approach on crop yield (** exception WA1 canola). In SA wheat * we found a significant effect but this was sensitive to the presence or absence of one sample point.*