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CANOLA

SECTION 7

INSECT CONTROL

INTEGRATED PEST MANAGEMENT | INCIDENCE OF INSECT PESTS IN CANOLA | EARTH MITES | LUCERNE FLEA | SLUGS | DIAMONDBACK MOTH | APHIDS | RUTHERGLEN BUGS | HELICOVERPA PUNCTIGERA (NATIVE BUDWORM) | SNAILS | SOIL PESTS

SECTION 7

Insect control

Stay informed

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

Subscribers to PestFacts also benefit from special access to **cesar**'s extensive Insect Gallery, which can be used to improve identification skills of pest and beneficial insects.

More information

SARDI: PestFacts South Australia

cesar: PestNotes

cesar: PestFacts south eastern

GRDC Update Papers: Viral diseases in canola and winter pulses

GRDC Update Papers: Emerging insect pests

GRDC: 'Serial pests' wrap up—lessons from 2014 and 2015 and some research updates

CropPro: Canola

Insects that can pose a problem in canola include blue oat mites (*Penthaleus* spp.), redlegged earth mites (*Halotydeus destructor*), *Bryobia* mites (*Bryobia* spp.), *Balaustium* mites (*Balaustium medicagoense*), cutworms, diamondback moth (DBM, *Plutella xylostella*), aphids, slugs, snails, earwigs, millipedes, slaters, lucerne flea (*Sminthurus viridis*) and Rutherglen bugs (RGB, *Nysius vinitor*).

Viruses can also occur in canola, carried by aphids that suck sap from leaves, transferring the virus and causing yield loss and sometimes plant death. Protection against early aphid infestation in seedling canola may reduce the incidence of viruses in the crop.

Gaucho® (imidacloprid) is the only seed dressing registered for control of aphids in canola. Sowing canola into standing cereal stubble may help to reduce aphid numbers and hence virus infection (Figure 1). [1]

Figure 1: Sowing canola into standing cereal stubble may help to reduce aphid numbers and hence virus infection. (Photo: Penny Heuston)

[1] L Serafin, J Holland, R Bambach, D McCaffery (2005) Canola: northern NSW planting guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0016/148300/canola-northern-NSW-planting-guide.pdf

More information

IPM Workshops: Decision making for insect management in grain crops

IPM Workshops: 'Best Bet' IPM strategy

NIPI: I SPY, Insects of southern Australian broadacre farming systems identification manual

DEDJTR: Pest insects and mites

Research paper: Insect pests

cesar: PestFacts south-eastern

7.1 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. [2]

7.1.1 Key IPM considerations for canola

Integrated pest management is a year-round approach to pest management and includes 'off-season' operations and planning as well as crop management:

- Monitor regularly and record numbers of pests and beneficials. Review checking data for population trends.
- Tolerate early damage. Canola can compensate for early damage by setting new buds and pods to replace those damaged by pests. Excessive early damage may reduce yield.
- Use aphid-selective products (e.g. pirimicarb) to preserve the beneficial insects, potentially reducing the need for follow-up applications.
- Biopesticides used in vegetative canola prior to flowering will preserve beneficials.
- Nuclear polyhedrosis virus (NPV) is effective against *Helicoverpa* larvae <7 mm long.
- *Bacillus thuringiensis* (Bt) is effective against DBM and *Helicoverpa* (<7 mm long).
- Consider the use of spray oils where aphid populations are low to moderate (repeat applications required).
- Where pests invade from adjacent fields, consider spraying only borders and not the whole field.
- Control some pests (e.g. lucerne flea or mites) in preceding pasture or broadleaf crops.
- Seed dressings may be the most effective control for some soil insects, as well as the least disruptive to natural enemies.
- Consider cultural control or biological control methods (Table 1). [3]

[2] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

[3] IPM guidelines—Canola. National Invertebrate Pest Initiative, http://ipmguidelinesforgrains.com.au/crops/canola/

Table 1: Summary of 'Best Bet' IPM strategies [4]

Summer–autumn	Winter	Spring
Aphids, particularly green peach aphid (GPA)		
Assess virus risk. High risk where: • summer rainfall creates a *Brassica* green bridge • warm conditions favour early aphid buildup and timing of flights If high risk: • use an insecticide seed treatment to manage virus spread (e.g. *Beet western yellows virus*) by GPA • manage *Brassica* weeds and volunteers (ideally area wide) 3–4 weeks before sowing • sow early to promote early flowering in spring before aphids peak	Monitor crops for aphid colonisation from late winter when daily temperatures start to rise. High risk where: • mild winter • GPA present on vegetative plants • forecast is for warm and dry conditions that favour aphid development • no beneficial activity (predation or parasitism)	Monitor trends in aphid and beneficial populations over time. High risk where: • aphid populations rapidly increasing during early flowering–bud formation • forecast is for warm and dry conditions to continue • low or no beneficial activity • broad-spectrum insecticides (e.g. synthetic pyrethroids (SPs)/organophosphates (OPs) have been used to control DBM or native budworm) Use thresholds to guide spray decisions, considering crop stage (% flowering) and moisture stress. NSW, SA, WA thresholds: 10–50% of plants infested. If spraying: • use soft products (pirimicarb) to retain beneficials • consider border sprays to prevent/delay buildup • rotate insecticide groups to reduce selection for resistance in GPA
Rutherglen bug (RGB)		
Remove summer–autumn weeds (especially fleabane, wireweed, and cape weed) in and around fields 3–4 weeks before sowing. Monitor crops for RGB and other pests during establishment. High risk if: • warm conditions in late summer–autumn • nearby weeds (in or near crop) drying off If spraying: • border-spray infested areas of crop and nearby host weeds • monitor for reinvasion and the need for repeat application	Increased risk where: • abundant weed hosts overwinter allowing build-up of local populations	Monitor crops from flowering to windrowing–harvest. High risk where: • hot, dry conditions in spring and early summer force RGB to move from weed hosts • moisture stressed plants (limited compensation potential) • long-distance migration into cropping areas Use economic thresholds to guide spray decisions, considering moisture stress. If spraying, monitor for reinvasion and the need for repeat sprays. Large numbers of RGB at harvest may pose a live-insect contamination risk. NSW threshold: 10 adults or 20 nymphs per plant (podfill–harvest)
Diamondback moth (DBM)		
Manage *Brassica* weeds and volunteers (ideally area wide) 3–4 weeks before sowing. High risk where: • high summer rainfall creates a green bridge of *Brassica* hosts (e.g. wild radish, volunteer canola) • warm summer–autumn conditions favour early DBM buildup	Monitor crops for moths and larvae from midwinter. High risk where: • DBM population present in mid–late winter • warm temperatures in mid–late winter • seasonal forecast is for a warm/dry spring If high risk: • consider a *Bt* spray to delay population buildup. Best results where most larvae are small and beneficial activity and/or DBM parasitism (e.g. *Diadegma* sp.) is detected.	Monitor crop with a sweep-net for larvae until maturity. High risk where: • warm and dry conditions favour rapid population development • low beneficial activity and/or DBM parasitism (note: this can also happen if SPs/OPs are used) • moisture-stressed plants Use thresholds to guide spray decisions, considering crop stage and moisture stress. If spraying: • avoid SPs/OPs, which destroy beneficial insects (may flare pests) and increase resistance selection in DBM • consider *Bt* to control small larvae • consider emamectin or spinetoram to control larger larvae • rotate insecticide groups across seasons • ensure good spray penetration into the canopy • monitor after spraying to determine need for repeat application SA threshold: Mid–late flowering: 20 larvae per 10 sweeps Pod maturation: 50 larvae per 10 sweeps

[4] 'Best Bet' IPM strategy. IPM Workshops, http://ipmworkshops.com.au/wp-content/uploads/BestBet_Canola2014.pdf

Summer–autumn	Winter	Spring
Helicoverpa punctigera (native budworm)		
	Monitor for moth flight activity from mid–late winter, using pheromone traps or monitoring outside lights at night. High risk when: • wet winter in inland breeding areas • moth flights detected If high risk: • monitor crops for eggs and larvae consider biological insecticides (Bt or NPV) to control small larvae	Monitor crops with a sweep net 1 or 2 times per fortnight from flowering–podding until maturity. If spraying is warranted: • consider biological insecticides (Bt or NPV) to control small larvae <7–8 mm • avoid SPs where aphids and/or DBM are present (flare pests and increase resistance selection in DBM) Thresholds: • NSW: ≥5 larvae (>10 mm)/m^2 + evidence of pod damage • WA: 4 larvae per 10 sweeps at pod maturity

7.2 Incidence of insect pests in canola

Various factors contribute to whether a canola crop is at risk from insect pests (Table 2). Economic damage from insect pests is most likely to occur during establishment and from flowering until maturity (Table 3).

Rutherglen bug is best known as a seed-feeding pest, attacking grain as it develops and fills. However, in some seasons, large numbers of nymphs and adults can cause damage to establishing winter or summer crops. RGB populations can build up in summer weeds and move from these into establishing winter crop, feeding on and killing small seedlings. Large numbers of RGB moving out of canola stubble pose a threat to nearby establishing summer crop.

Table 2: Insect pest risk in canola

High risk	Reduced risk	Low risk
Earth mites		
• Canola sown into paddocks coming out of pastures	• Intensive grazing reduces survival of mites in pasture	• Rotation with non-host crop (e.g. lentils, chickpeas, wheat, barley, lupins and linseed) will reduce the size of mite populations in a paddock (non-host crop must be weed-free)
Lucerne flea		
• History of lucerne flea. • Loamy, clay soils • Weedy fallow or pasture with no lucerne flea control	• Intensive grazing reduces carry-over • Cultivation can reduce oversummering eggs	
Cutworm		
• Weedy fallow hosting cutworm • Weeds in proximity to seedling crops • Spraying-out weeds with large cutworm larvae that then move onto establishing crop	• Controlling weed hosts at least 2 weeks prior to crop emergence	

High risk	Reduced risk	Low risk
Diamondback moth (DBM)		
• High summer rainfall creating *Brassica* green bridge • Warm and dry conditions July through spring • No significant rainfall events (>10 mm)	• Significant heavy rainfall (>10 mm) (will dislodge and drown larvae) • High beneficial activity and/or DBM parasitism	• Cool moist conditions late winter through spring • Epizootics of fungal disease (e.g. *Zoopthera radicans*)
Aphids		
• Weedy crop edges and neighbouring fields with *Brassica* weeds (wild radish, wild turnip, cape weed) • Above-average rainfall in autumn promotes weed growth • Use of broad-spectrum insecticides will kill natural enemies that may suppress populations	• Drought stress increases impact of aphids by increasing the rate of aphid population growth and reducing the crop's ability to compensate for flower and pod abortion	• Early sowing so crop flowers in early spring, before aphid populations peak • Cold, wet conditions in winter suppress populations • High in-season rainfall can suppress populations and promote the outbreak of diseases • Soft chemicals (pirimicarb, petroleum spray oils) that preserve beneficials that may control survivors
Native budworm		
• Wet winters in breeding areas of Central Australia + suitable weather conditions facilitate spring migrations • Repeated influxes of moths over long periods mean reinfestation can occur post-treatment	• Hot spring weather can cause small larvae to burrow into pods • Broadleaf weeds can host large numbers which can move into crops as medium–large larvae and rapidly damage pods • Treating aphids and DBM with broad-spectrum insecticides can disrupt beneficials that may suppress outbreaks	• Dry winters in breeding areas contribute to a low population source and the absence of migration opportunities
Slugs and snails		
• Annual rainfall >500 mm • Above average spring–autumn rainfall • No-till stubble retained • Previous paddock history of slugs and snails • Summer volunteers and weeds • No sheep in enterprise	• 450–500 mm annual rainfall • Tillage or burnt only • Sheep on stubble	• <450 mm annual rainfall • Drought • Tillage and burnt stubbles • No volunteers and weeds
Other pests		
Late sowing into cold soil reduces plant growth and increases vulnerability to insects and slugs		Cultivation in autumn destroys the potential habitat and food source of many pests Early-sown crops

Use Table 3 and I SPY to identify insect pests by key behavioural and morphological characteristics, and by the damage caused.

Table 3: I SPY ready reckoner for key insects in canola [5]

Crop damage or symptom in canola	Possible pest
Transparent windows and holes chewed in leaves. Dumpy, wingless, greenish-yellow insect-like creatures that spring off plants when disturbed	Lucerne flea
Plants stunted or dying, roots eaten. Slow-moving, soft-bodied insects usually in a 'C' shape, cream-coloured apart from yellow or brown head; found near roots	
Surface tissue of leaves rasped or mottled by small mites with black or brown bodies and 8 orange-red legs (tiny nymphs have 6 legs), giving leaves a silvered appearance	Redlegged earth mite, blue oat mite, *Bryobia* mite, *Balaustium* mite
Pear-shaped insects sucking leaves, usually come from summer weeds	Rutherglen bug
2-mm-long cigar-shaped with and without wings; rarely cause damage	Thrips
Presence of smooth, fat caterpillars without distinctive markings, up to 40 mm long; just under soil clods during the day	Cutworms (could be confused with armyworms)
Large sections of leaves chewed; in severe cases plants eaten down to ground level; roots not damaged. Presence of dull grey-brown weevils (adults) 10 mm long or yellow-green larvae up to 15 mm long with flattened, slug-like bodies; larvae usually found in winter	Vegetable weevil, adult and larvae
Large sections of leaves chewed; in severe cases plants eaten down to ground level. Adult weevils chew cotyledons, leaves and stems and may eat plants down to ground level	Spotted vegetable (*Desiantha*) weevil, Fullers rose weevil
Feed on leaves of young seedlings; in severe cases seedlings are ring-barked at ground level causing them to drop. Adults are 3–5 mm long, round and dull brown, resembling small clods of dirt	*Mandalotus* weevil (south-eastern Aust. only)
Areas of leaves chewed; presence of black and yellow striped caterpillars up to 30 mm long that walk with looping motion	Brown pasture looper
Plants eaten at ground level. Shiny, dark brown larvae (up 20 mm) with spines or pincers at the tail end; mainly present when canola is sown in heavy stubble. (This could also describe grey or small false wireworm.) Earwigs attack all parts of emerging seedlings, and are known to shred leaves. Their damage can be very different to bronzed field beetle	Bronzed field beetle, European earwigs
Seedlings can be defoliated and die. Caterpillars feed on leaves under a fine web, skeletonising leaves; mostly present in seasons with early autumn rainfall and warm weather	Weed web moth
Minor leaf chewing; presence of dark brown to black caterpillars up to 60 mm long with two yellow spots near posterior end. Minor pest, usually after pasture	Pasture day moth
Leaves shredded or chewed, slimy trails	Slugs and snails
Germinating seed or emerging seedlings are ring-barked and hypocotyl severed just below the surface; large bare patches can be seen a few weeks after sowing. Larvae up to 9 mm long, shiny brown-grey on top with paler undersides and two distinct upturned spines on last body segment	Grey false wireworm (south-eastern Aust. only)
Seedlings chewed at or above ground level, ring-barking or completely cutting stems. Adults of common species are 6–8 mm long, dark grey–black and often have a covering of soil	False wireworms or vegetable beetle adult
Flower stems covered with masses of small, soft-bodied insects and black sticky mould; small soft-bodied insects on undersurface of leaves	Aphids
Holes chewed in leaves, surface of pods attacked by small, thin, green caterpillars, up to 10 mm long that wriggle rapidly when touched and hang down on a thread	Diamondback moth

[5] J Bellati, P Mangano, P Umina, K Henry (2012) I SPY. Insects of southern Australian broadacre farming systems identification manual and education resource. PIRSA/DAFWA, http://www.grdc.com.au/Resources/Bookshop/2012/11/I-SPY

Crop damage or symptom in canola	Possible pest
Round holes in pods; seeds eaten by large (up to 40 mm long), sparsely haired and often brightly coloured caterpillars	Native budworm
Leaves and flowers attacked, especially the basal leaves; leaves can be combined together with webbing. Small, creamish caterpillars with dark heads; may tunnel into growing points	Cabbage centre grub
Large, irregular holes chewed in leaves. Velvety green caterpillars (up to 30 mm)	Cabbage white butterfly
Pieces of leaves and stems chewed; complete defoliation can occur in severe cases. Grasshoppers and locusts present	Grasshoppers and locusts
Plant growth stunted, and in severe cases, heads can be distorted. Large numbers of narrow-bodied, greyish-brown flying insects, 3–4 mm long, contaminating harvested grain	Rutherglen bug

More information

NIPI: I SPY, Insects of southern Australian broadacre farming systems identification manual

7.3 Earth mites

Earth mites are the major pests of seedling canola. Redlegged earth mite and blue oat mite (*Penthaleus major*) are two soil-dwelling mites that damage crops in autumn, winter and spring. They are primarily pests of seedlings but can also seriously injure older plants. Winter crops at establishment may be severely damaged, particularly if growth during and following emergence is slow. Damaged plants die or remain stunted and weak. Sometimes seedlings are killed before they emerge. Both mites prefer light, sandy or loamy, well-drained soils and often occur together in crops. [6]

Bryobia and/or *Balaustium* mites are an increasing problem in some areas. A good mite-control program starts with a population-reduction treatment the previous spring. Learn to identify these four species of mites to ensure that the correct insecticide and rate is applied to the correct species.

See www.apvma.gov.au for up-to-date on-label information.

More information

GRDC Ground Cover: Nutrient management may double as pest control

Table 4: Recommended control strategies for earth mites [7]

Pre-season (previous spring–summer)
Assess risk High-risk situations: History of high mite pressure Pasture going into crop Susceptible crop being planted (e.g. canola, pasture, lucerne) Seasonal forecast is for dry or cool, wet conditions that slow crop growth Actions if risk is high: Ensure accurate identification of species Use Timerite® (redlegged earth mites only) Heavily graze pastures in early-mid spring
Pre-sowing
Actions if risk is high: Use an insecticide seed dressing on susceptible crops Plan to monitor more frequently until crop established Use higher sowing rate to compensate for seedling loss Consider scheduling a post-emergent insecticide treatment Actions if risk is low: Avoid insecticide seed dressings (esp. cereal and pulse crops) Plan to monitor until crop establishment

[6] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

[7] P Umina (2014) Persistent pests; aphids, mites, millipedes and earwigs. GRDC Update Papers, 5 February 2014, http://grdc.com.au/Research-and-Development/GRDC-Update-Papers/2014/02/Persistent-pests-aphids-mites-millipedes-and-earwigs

Emergence
Monitor susceptible crops through to establishment using direct visual searches Be aware of edge effects; mites move in from weeds around paddock edges Actions if spraying: Ensure accurate identification of species before deciding on chemical Consider border sprays Spray prior to the production of winter eggs to suppress populations and reduce risk in the following season Follow threshold guidelines
Crop establishment
As the crop grows, it becomes less susceptible unless growth is slowed by dry or cool, wet conditions

7.3.1 Redlegged earth mite

The redlegged earth mite is native to southern Africa, and cape weed (*Arctotheca calendula*) is its preferred host plant. Other hosts include prickly paddy melon, wild turnip, common sowthistle, Paterson's curse and chickweed (weeds); and pastures, canola, lupins, field peas and linseed (field crops). Sometimes, mites may move into young winter cereals from a fenceline or adjoining pasture and cause damage along one or more of the crop edges.

Description

Adult mites are eight-legged and ~1 mm long with oval, flattened, black bodies and pinkish-orange legs and mouthparts (Figure 2).

Figure 2: Redlegged earth mites (Halotydeus destructor). (Source: **cesar***)*

Seasonal development

Three overlapping generations usually occur between mid-autumn and spring, and adult populations are normally highest in May–June and September–October. Redlegged earth mites oversummer as unlaid, aestivating eggs in the dead bodies of spring-generation adult mites lying on or near the soil surface. The aestivating eggs are highly resistant to desiccation and usually do not begin to develop until late summer–early autumn. They hatch when favourable conditions of soil temperature and moisture occur in the following mid-autumn to early winter.

More information

GRDC Update Papers: Persistent pests; aphids, mites, millipedes and earwigs

TIMERITE® for management of redlegged earth mite

TIMERITE® is an information package that provides individual farmers with the optimum spray date on their farm to control redlegged earth mites during spring. Developed by CSIRO and Australian Wool Innovation, TIMERITE® predicts the optimum date in spring to control redlegged earth mites, just after they have ceased laying normal winter eggs on pasture and just before diapause. (Diapause is when adult redlegged earth mites produce eggs that are retained in the body of the adult female and are therefore protected from the effects of insecticide applications.) The single, strategic spray has a two-fold effect, controlling redlegged earth mites in spring and decreasing the summer

population that emerges in the following autumn. The package may form part of an integrated management strategy to control redlegged earth mites.

Close attention should be paid to individual pesticide labels when controlling earth mites. Application rates vary with situations, such as bare earth or post-emergence of crops or pasture. Correct identification of earth mite species is essential. Registrations sometimes include redlegged earth mites only, not blue oat mites or *Bryobia* mites. Application rates may vary with earth mite species. See www.apvma.gov.au.

More information

CSIRO: TIMERITE information package

This strategic approach has little effect on non-target invertebrates, both pest and beneficial, during the following autumn. Farmers need to identify geographically the location to be sprayed. This can be done by a local feature, such as town or mountain, or the longitude and latitude of the area. This information is used to find the optimum date from the package. The spray date for each farm is the same date each year. For information, phone Australian Wool Innovation toll free on 1800 070 099 or visit the website www.timerite.com.au. [8]

7.3.2 Blue oat mite

Blue oat mites are often confused with redlegged earth mites. There are three recognised pest species of blue oat mites in Australia: *Penthaleus major*, *P. falcatus*, and *P. tectus*. Accurate identification of the species requires examination by an entomologist. The species vary with respect to their geographical distribution in Australia.

Description

Adult mites have eight legs and are ~1 mm long with oval, rounded, dark brown to black bodies, bright red or pinkish red legs and mouthparts, and a red spot or streak towards the hind end of the back (Figure 3). [9]

Figure 3: Blue oat mite (Penthaleus sp.). (Photo: A Weeks, **cesar***)*

Seasonal development

Overlapping generations of the blue oat mites usually occur between mid-autumn and late spring. Blue oat mites oversummer as aestivating eggs laid in mid–late spring by the second-generation adults. These aestivating eggs are highly resistant to desiccation. They do not begin to develop until late summer–early autumn, and they do not hatch until favourable temperature and moisture conditions occur in the following mid-autumn to early winter. [10]

[8] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

[9] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

[10] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

Impact

Damage to crops and pastures is incurred in the establishment phase. [11] Feeding causes a silver or white discoloration of leaves (Figure 4) and distortion or shrivelling if severe. Mites are most damaging to newly establishing pastures and emerging crops, greatly reducing seedling survival and development. [12]

Host-plant preferences vary with the species, as do their life cycles and tolerances to various pesticides. Host plants include pastures and various weeds, such as black thistle, chickweed, curled dock, dandelion, deadnettle, prickly lettuce, shepherds purse, variegated thistle and wild oat. Cultivated field-crop hosts include canola, wheat, barley, oats, rye, field peas, lupins and linseed. [13]

Figure 4: Feeding damage from blue oat mite.

7.3.3 *Balaustium* mites

Description

Balaustium mites grow to 2 mm in length and have a rounded red-brown body with eight red-orange legs (Figure 5). Adults are covered with short, stout hairs. They are slow moving and have distinctive, pad-like structures on their forelegs. The *Balaustium* mite is commonly confused with *Bryobia* mite, and sometimes with blue oat mite and redlegged earth mite. However, *Balaustium* mites are generally twice as large as other mites when adults. Newly hatched mites are bright orange with six legs and are only 0.2 mm in length.

Figure 5: Balaustium mites (Balaustium medicagoense). (Photos: A Weeks, **cesar***)*

Seasonal development

Little is known about the biology of *Balaustim* mites. *Balaustium* mites usually have two generations per season and are unlikely to require cold temperatures to stimulate egg hatching like other species.

[11] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

[12] GRDC. Blue oat mite (south). Ute Guide Crop Insects. GRDC, https://www.grdc.com.au/Resources/Ute-Guides/Insects/Mites/South/Blue-Oat-Mite

[13] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

Impact

Balaustium mites are unusual in that they not only feed on plants but also prey upon other small invertebrates. They have been reported to feed on several different groups, including various Collembola species and other mites. *Balaustium* mites were originally thought to be a beneficial predator with some reports suggesting that they provided localised control of redlegged earth mites. Only recently have *Balaustium* mites been confirmed to feed on plant material.

Canola, lupins and cereals are the most susceptible crops, particularly at the seedling stage. Some broadleaf weeds are alternative hosts. Typical damage to cereals, grasses and pulses is 'silvering' or 'whitening' of the attacked foliage, similar in appearance to damage caused by redlegged earth mites and blue oat mites. However, *Balaustium* mite damage differs in that they tend to attack the leaf edges and tips of plants. Adult mites are likely to be responsible for the majority of feeding damage to plants.

In canola, feeding damage is characterised by distorted and cupped cotyledons, which may have a leathery appearance (Figure 6).

Balaustium mites feed on plants by using their adapted mouthparts to probe leaf tissue and suck up sap. In most situations, they cause little damage; however, when numbers are high and plants are already stressed from other environmental conditions, significant damage to crops can occur.

Figure 6: Typical Balaustium mite damage on canola. (Photo: A Weeks, **cesar***)*

More information

GRDC Back Pocket Guides: Crop mites

Management

There are very few effective biological control options. Early control of summer and autumn weeds within and around paddocks, especially cape weed and grasses, will help to control populations. *Balaustium* mites have a high natural tolerance to chemicals and they will typically survive pesticide applications aimed at other mite pests. [14]

Distribution

Balaustium mites are widespread throughout most agricultural regions in southern Australia with a Mediterranean-type climate (Figure 7). They are found in Victoria, New South Wales and South Australia. They are generally restricted to coastal areas and do not occur far inland or in the drier Mallee areas of Victoria and South Australia. *Balaustium* mites have been found in Tasmania; however, no systematic sampling has been conducted and the distribution across the state remains unknown.

Similar to other pest mites, long-range dispersal is thought to occur via the movement of eggs in soil adhering to livestock and farm machinery or through transportation of plant material. Movement may also occur if oversummering eggs are moved by summer winds.

[14] GRDC. Crop mites. Back Pocket Guide. GRDC, http://www.grdc.com.au/Resources/Publications/2012/06/GRDC-Crop-Mites-Back-Pocket-Guide

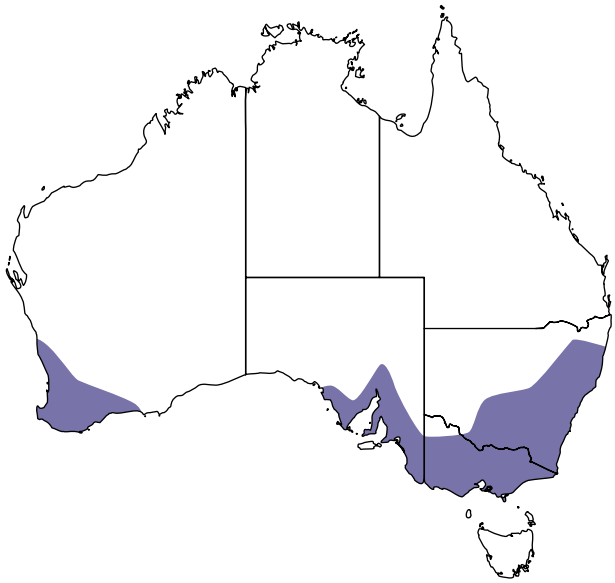

Figure 7: Distribution of Balaustium mite in southern Australia. (Source: Agriculture Victoria)

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 3–5 weeks after sowing.

Crops sown into paddocks that were in pasture the previous year should be regularly inspected. 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. They are difficult to find when conditions are cold and/or wet.

One of the most effective methods to sample mites is by using a D-vac, which is based on the vacuum principle, much like a domestic vacuum cleaner. Typically, a standard, petrol-powered garden blower/vacuum machine is used. A sieve is placed over the end of the suction pipe to trap mites vacuumed from plants and the soil surface. [15]

7.3.4 *Bryobia* mites

Description

Bryobia mites (also referred to as clover mites) are smaller than other commonly occurring pest mites, reaching ~0.75 mm in length as adults. They have an oval, flattened dorsal body that is dark grey, pale orange or olive and have eight pale-orange legs (Figure 8). The front pair of legs is much larger, about 1.5 times their body length. Nymphs are small with bright-red bodies with pale-coloured legs. [16]

The egg of the *Bryobia* mite is minute, globular and red. It can be distinguished from European red mite eggs by its smooth appearance and lack of a spike. The nymph looks like the adult but is smaller. [17]

More information

http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/balaustium-mite

[15] Agriculture Victoria (2010) *Balaustium* mite. AG1413. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/balaustium-mite

[16] GRDC. Crop mites. Back Pocket Guide. GRDC, http://www.grdc.com.au/Resources/Publications/2012/06/GRDC-Crop-Mites-Back-Pocket-Guide

[17] Agriculture Victoria (2000) The *Bryobia* mite and the pear-leaf blister mite. DEDJTR Victoria, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/the-bryobia-mite-and-the-pear-leaf-blister-mite

Many species of *Bryobia* mites are found in grain crops in Australia. They are found in high numbers in the warmer months from spring through to autumn. *Bryobia* mites prefer broadleaf plants such as canola, lupins, vetch, lucerne and clover, but they will also attack cereals. [18]

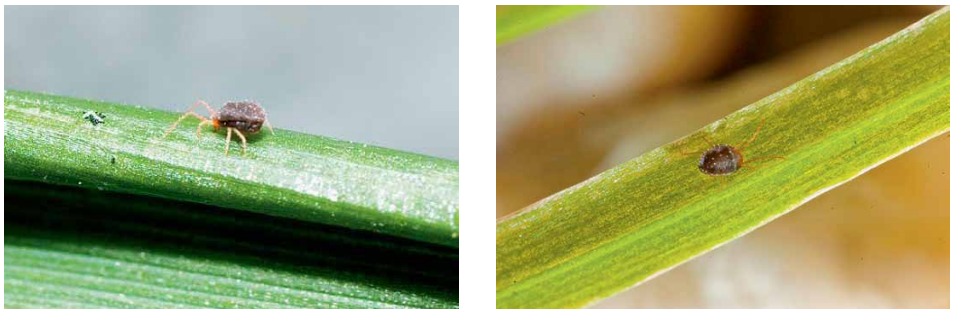

Figure 8: Bryobia mites. (Photos: A Weeks, **cesar***)*

Management

There are no known biological control options. Crops that follow clover-dominant pastures are most at risk, and should be monitored carefully. Early control of summer and autumn weeds, within and around paddocks, especially broadleaf weeds such as cape weed and clovers, will help to control populations.

Several pesticides are registered for use on *Bryobia* mites; higher rates are usually required than for redlegged earth mites and blue oat mites. *Bryobia* mites have a natural tolerance to several chemicals. [19]

More information

GRDC Back Pocket Guides: Crop mites

DAFWA: Diagnosing Bryobia mite

7.4 Lucerne flea

Lucerne flea is an important pest of establishing canola crops. The pest is identified by its action of jumping between plants rather than flying. Early-sown crops are more at risk of attack. Frequent crop inspection from the time of emergence, and early control measures, are important because of the impact of seedling vigour on crop performance. Ensure that monitoring is sufficient to detect localised patches or 'hot spots'. Seek advice on management and spray strategies. [20]

Figure 9: Adult lucerne flea (Sminthurus viridis). (Photo: **cesar***)*

7.4.1 Description

Adult lucerne fleas are globular, wingless insects, 2–3 mm long with green, brown and yellow markings (Figure 9). They appear yellow-green to the naked eye, although their

[18] GRDC. Crop mites. Back Pocket Guide. GRDC, http://www.grdc.com.au/Resources/Publications/2012/06/GRDC-Crop-Mites-Back-Pocket-Guide

[19] GRDC. Crop mites. Back Pocket Guide. GRDC, http://www.grdc.com.au/Resources/Publications/2012/06/GRDC-Crop-Mites-Back-Pocket-Guide

[20] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

globular abdomens are often a mottled pattern of darker pigments. They make jumping movements when disturbed. Nymphs resemble the adults except in size. [21]

7.4.2 Seasonal development and symptoms

Lucerne fleas hatch following periods of good, soaking autumn–winter rainfall and can cause significant damage to emerging crops and pastures at this time of year. They can also cause considerable damage to older crops if numbers build up under favourable conditions throughout the season. With the recent lack of rainfall experienced across much of south-eastern Australia, lucerne flea hatchings may be delayed and somewhat staggered in many regions.

Lucerne fleas have a wide host range. They will attack most broadacre crops, including canola, lucerne, pastures, cereals and some pulses. Feeding results in the appearance of distinctive transparent 'windows'. They are generally a problem in regions with loam or clay soils.

Crops should be inspected frequently at, and immediately following, emergence, when they are most susceptible to damage. Paddocks are most likely to have problems where they follow a weed-infested crop or a pasture in which the lucerne flea has not been controlled.

7.4.3 Impact

The cells of the upper surface of leaves and cotyledons are eaten, resulting in small 'windows' in the leaves. Severe infestations cause skeletonised leaves, with just the more fibrous veins remaining. This damage is quite distinctive and can be used to help identify lucerne flea as the key pest.

Canola is most susceptible during crop establishment. Damage is often minor, but severe damage can stunt or kill seedlings. Cumulative damage may be severe where crop growth is slowed by cold, wet or dry conditions [22]

7.4.4 Management

Only when infestations are severe should lucerne flea be sprayed. In some instances, spot spraying with registered chemicals may be adequate. Several natural enemies such as mites, beetles and spiders prey upon lucerne fleas. Blanket spraying is harmful to these natural control agents. Seed dressing can also be a useful technique to prevent damage by lucerne flea. [23]

Snout mites (which have orange bodies and legs) are effective predators of lucerne fleas, particularly in pastures, where they can prevent pest outbreaks. The complex of beneficial species (including snout mites) should be assessed before deciding on control options. [24]

Several options are available to growers for controlling the lucerne flea. Foliar insecticides can be applied approximately 3 weeks after lucerne fleas have been observed in a newly emerged crop. This will allow for further hatching of oversummering eggs but will be before lucerne fleas reach the adult stage and begin to lay winter eggs. If spraying is required, do not use synthetic pyrethroids.

In paddocks where damage is likely, a border spray may be sufficient to prevent movement of lucerne fleas into the crop from neighbouring paddocks. Lucerne fleas are often distributed patchily within crops; therefore, spot spraying is generally all that is required. Do not blanket spray unless the infestation warrants it.

More information

AOF: Insect pests of canola. Lucerne flea (p. 3)

GRDC Grain Research Advice: Knowledge, timing, key to lucerne flea control

NIPI IPM Guidelines: Lucerne flea in winter seedling crops

Agriculture Victoria: Lucerne flea

GRDC: Canola best practice management guide. Lucerne flea (p. 51)

NIPI: I Spy Manual. Lucerne flea (section 4, pp. 63–64)

[21] CropPro. Lucerne flea. Pests in canola. CropPro, http://www.croppro.com.au/cb_pages/pests_in_canola_-_in_crop.php?category_id=2374

[22] CropPro. Lucerne flea. Pests in canola. CropPro, http://www.croppro.com.au/cb_pages/pests_in_canola_-_in_crop.php?category_id=2374

[23] CropPro. Lucerne flea. Pests in canola. CropPro, http://www.croppro.com.au/cb_pages/pests_in_canola_-_in_crop.php?category_id=2374

[24] **cesar** (2010) Lucerne flea. PestFacts south-eastern, Issue 3, 21 May 2010. **cesar**, http://www.cesaraustralia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2010/pestfacts-issue-no-3-21st-may-2010/lucerne-flea/

7.5 Slugs

The main slug pests of canola crops in southern Australia are the grey-coloured reticulated slug (or grey field slug) and the black-keeled slug. Several other pest slug species are also found in canola. [25]

Canola sown into dense stubble or adjacent to grassy fence lines, creek banks or damp areas is at greatest risk of slug damage because these areas provide an ideal habitat for slugs to survive over summer. Heavy, cracking soils provide additional hiding places for slugs. Closely monitor crops at risk for 6–8 weeks after sowing, so that any infestation can be treated with Molluscicidal baits if required. [26]

7.5.1 Description

Typically, the grey field slug is 35–50 mm long and light grey to fawn, with dark brown mottling (Figure 10). When disturbed, it will exude a sticky, milky secretion over its body. The black-keeled slug is 40–60 mm long and uniform black or brown with a ridge (keel) down its back (Figure 11). It can burrow to 20 cm underground. [27]

Figure 10: Grey field or reticulated slug (Deroceras reticulatum). (Photo: M Nash)

Figure 11: Black-keeled slug (Milax gagates). (Photo: M Nash)

7.5.2 Seasonal development and symptoms

Slugs are hermaphrodites, therefore, both individuals of a mating pair lay eggs. They will breed whenever moisture and temperature conditions are suitable—generally from mid-autumn to late spring. Eggs are laid in batches in moist soils and they will hatch within 3–6 weeks, depending on temperature. Juveniles look like smaller versions of the adult.

[25] G Baker (2009) Pests of canola and their management. Ch. 9. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, https://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

[26] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

[27] GRDC (2013) Slug identification and management. GRDC Slug control Fact Sheet, March 2013, http://www.grdc.com.au/~/media/412EEE56898A4AFB8B50409EC87FEBFE.pdf

Slugs feed aboveground on stems and leaves, and belowground on seeds, shoots and roots. Damage is greatest when seedling growth is slow because of cool, wet or dry conditions. Grey field slugs are mainly surface-active, whereas black-keeled slugs burrow and can feed directly on germinating seeds. Slugs can be underestimated as pests because they are nocturnal and shelter during dry conditions, and therefore are not generally visible during daylight hours. [28]

More information

GRDC: Canola best practice management guide. Slugs (p. 51)

GRDC Fact Sheets: Slug control

NIPI: Slugs in seedling crops

NIPI: I Spy Manual. Slugs (section 4, pp.70–71)

7.5.3 Impact

Slugs damage newly sown crops and pasture, and damage is often difficult to detect or is incorrectly attributed to agronomic factors. Populations as low as 1 grey field slug/m^2 can inflict severe damage on canola at establishment. If the population is large, damage to seedlings can be extensive. The black-keeled slug is more problematic in drier environments such as South Australia, although it is widespread throughout south-eastern Australia. [29],[30]

7.5.4 Management

Cultivation prior to sowing, delaying sowing after summer cover has been sprayed out, stubble and weed removal, and baiting are all effective methods for reducing slug populations. When slug pressure is high, baiting alone may not provide total crop protection. [31]

7.6 Diamondback moth

Diamondback moth has been observed in canola crops for many years. Caterpillars of DBM do most damage when large numbers are present in seedling crops or when they move from leaves to graze developing pods during crop ripening. DBM has developed resistance to a range of insecticides. Future management will involve regular monitoring and careful selection of control methods. [32]

7.6.1 Appearance

Diamondback moths are 10 mm long and grey-brown. They have a white diamond-patterned stripe down the centre of the back when the wings are folded over the body (Figure 12). Eggs are pale yellow, oval and about 0.5 mm in length. DBM larvae grow to 12 mm long, are pale yellowish-green and are tapered at both ends (Figure 13). They wriggle when disturbed and often drop from the plant on a silken thread. Mature larvae pupate after spinning gauze-like cocoons, usually on the underside of leaves. The pupa changes colour from green to brown before emerging as an adult moth. [33]

[28] GRDC (2013) Slug identification and management. GRDC Slug control Fact Sheet, March 2013, http://www.grdc.com.au/~/media/412EEE56898A4AFB8B50409EC87FEBFE.pdf

[29] G Baker (2009) Pests of canola and their management. Ch. 9. In Canola best practice management guide for south-eastern Australia. (Eds D McCaffrey, T Potter, S Marcroft, F Pritchard) GRDC, https://www.grdc.com.au/uploads/documents/GRDC_Canola_Guide_All_1308091.pdf

[30] GRDC (2013) Slug identification and management. GRDC Slug control Fact Sheet, March 2013, http://www.grdc.com.au/~/media/412EEE56898A4AFB8B50409EC87FEBFE.pdf

[31] CropPro. Slugs. Pests in canola. CropPro, http://www.croppro.com.au/cb_pages/pests_in_canola_-_in_crop.php?category_id=2381

[32] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

[33] GRDC (2013) Diamondback moth is a sporadic but serious canola challenge. GRDC Diamondback moth Fact Sheet, July 2013, http://www.grdc.com.au/GRDC-FS-DBM

Figure 12: Diamondback moth (Plutella xylostella).

Figure 13: When larvae of the diamondback moth are disturbed, they will wriggle, and may drop from the plant by a silken thread. (Photo: DAFWA)

7.6.2 Seasonal development and symptoms

Diamondback moths are active at dusk and throughout the night, but usually do not fly far within a crop. However, they can migrate long distances on prevailing winds, especially when their host plant has died. DBM survive between growing seasons on summer *Brassica* weeds such as wild radish and Lincoln weed. Summer rainfall increases the 'green bridge' and DBM populations.

In autumn–early winter, DBM fly into canola crops. Female moths lay eggs singly or in small clusters along the leaf vein on both sides of plant leaves. Eggs hatch after 4–6 days. Development from eggs to moths is faster in warm weather and slower in cool weather; at 28°C, the life cycle takes 14 days, whereas at 12°C it takes >100 days. In warm weather, there is often overlap in generations and all life stages may be present in a crop at one time.

DBM populations can suddenly crash and the reason for this is only partially understood. One factor may be the outbreak of insect fungal diseases during wet, warm weather.

The damage caused by newly hatched larvae appears as characteristic pale-white traces. Older larvae often cause holes on the underside of the leaves with the upper surface intact, which creates a see-through window effect. Larvae can be found at any stage of a canola crop's development, with their numbers often increasing before flowering. Canola can tolerate considerable leaf damage before crop yield is affected. [34].

[34] GRDC (2013) Diamondback moth is a sporadic but serious canola challenge. GRDC Diamondback moth Fact Sheet, July 2013, http://www.grdc.com.au/GRDC-FS-DBM

7.6.3 Impact

Larvae of DBM can cause extensive damage to canola, but this does not happen in all years. Severe infestations of DBM larvae can cause complete defoliation and substantial yield losses. As flowering progresses, increasing numbers of larvae move to the floral buds, flowers and pods. Large larvae may feed on small young pods. Damage to mature plants during the late spring by increasing populations of DBM often causes visible scarring of the outer pod walls, although this rarely results in economic loss. [35]

7.6.4 Management

Monitoring and thresholds

Canola crops should be monitored by using an insect sweep-net at the first sign of damage and at intervals throughout the growing season from mid-July to late spring–early summer. Numbers of DBM are likely to increase quickly with early-season infestation and with prolonged warm weather allowing the pest to complete three or four generations.

Two sets of 10-sweep samples (i.e. 10 consecutive sweeps with a sweep-net) should be taken at each of a minimum of four locations within each canola crop. Empty the contents of each set of 10 sweeps onto a white or light-coloured surface, and count the larvae. Note the sizes of the DBM larvae and the presence of other insects. If no DBM or low numbers are detected, monitor again in 2 weeks. When DBM numbers increase, at least three estimates of larval density over 12 days are needed to determine how the population is changing. On each occasion, eight or more 10-sweep samples should be taken throughout the crop. Cool, wet, windy weather can reduce DBM numbers. Numbers of larvae can also be reduced by beneficial insects and insect diseases.

Economic thresholds vary from 30 to 200 larvae per 10 sweeps. Crop growth stage, grain price and cost of spraying need to be considered when deciding whether spraying will provide an economic return. Variation in regional and seasonal conditions also influences spray threshold levels. As canola develops, it can tolerate increasing numbers of DBM without significant yield loss.

The presence of many small larvae (<3 mm long) indicates that numbers are likely to increase further. Moisture-stressed crops are more susceptible to insect damage and a lower threshold may be used if extended dry periods are anticipated. In pre-flowering crops, spraying should be considered if the average number of larvae exceeds 30 in 10 sweeps.

Pesticides

Diamondback moth has developed widespread resistance to many insecticides, including synthetic pyrethroids and organophosphates. In 2012, two new insecticides were registered for DBM control in canola: Affirm® (Group 6) and Success™ Neo (Group 5). Together with the biological insecticide *Bt*, growers can now choose from three effective insecticide groups.

To reduce the risk of resistance developing to these newer insecticides, spray for DBM only when thresholds are exceeded, and alternate between insecticide groups from one season to the next. If sweep-netting indicates that DBM larval densities are at the spray threshold, a quick response with two spray applications (5–7 days apart) can give adequate control of larvae and reduce yield losses. Under typical temperature conditions, this strategy will ensure that DBM in life stages that survive the first application are controlled.

The period between applications may vary with choice of chemical. Growers should note that withholding periods before harvest and at windrowing are the same, and that they must abide by registration details on the product label.

[35] GRDC (2013) Diamondback moth is a sporadic but serious canola challenge. GRDC Diamondback moth Fact Sheet, July 2013, http://www.grdc.com.au/GRDC-FS-DBM

Good chemical penetration into a canopy crop is important, with ~20% of DBM larvae on the lower plant canopy. Under good spraying conditions, aerial (CP90 nozzles with 30 L/ha of water) and ground-based (flat-fan 11015 nozzles with 50 L/ha of water) applications can be equally effective in achieving good leaf coverage and spray penetration to lower leaves.

Where 'soft' chemicals (such as *Bt*) that are less disruptive to beneficial insects are used, the majority of larvae should be less than 5 mm in length at spraying. *Bt* is broken down by ultraviolet light, so the best results are achieved by dusk application.

More information

GRDC Fact Sheets: Diamondback moth in canola

Natural enemies

Several beneficial insects attack DBM, including parasitic wasp species. These wasps lay their eggs inside DBM larvae and/or pupae (depending on the wasp species). The parasitised DBM larvae or pupae fail to develop. Predators such as brown and green lacewings, several predacious bugs and a range of spiders will feed on DBM eggs, larvae and pupae. [36]

7.7 Aphids

More information

GRDC Fact Sheets: Reducing aphid and virus risk

FAQ

GRDC Fact Sheets: Resistance management strategy for the green peach aphid in Australian grains

GRDC Ground Cover: Unified attack on pests and diseases

GRDC Ground Cover: Insect pests—resistance, virus vectors and lessons from 2014

GRDC Back Pocket Guides: Crop aphids

Aphid flights can occur in autumn and winter and can infest young canola crops. Crops may need to be treated with insecticide to prevent transmission of virus diseases, and to reduce seedling damage and the risk of spring infestations. The green peach aphid is the major vector of *Beet western yellows virus* (BWYV), which caused significant crop damage in south eastern NSW in 2014. Seed treated with imidacloprid (e.g. Gaucho®), Poncho® Plus and Cruiser® Opti will protect seedling canola for up to 5 weeks. This is especially important in seasons and at sites where early infestation with aphids occurs. [37] Aphids flights are also commonly observed in spring and early summer.

7.7.1 How to identify key aphids

Life cycle diagrams are available from the National Invertebrate Pest Initiative for the following aphid groups (links to pdfs): cabbage aphid, cereal aphid, green peach aphid, turnip aphid, winter cereal aphid.

Turnip aphid

The turnip aphid (Figure 14) infests canola. It is generally restricted to crops and weeds within the cruciferous plant family. Alternative hosts are wild radish and wild turnip. It causes reduced podset, podfill and seed quality.

Figure 14: Turnip aphid (Lipaphis erysimi).

[36] GRDC (2013) Diamondback moth is a sporadic but serious canola challenge. GRDC Diamondback moth Fact Sheet, July 2013, http://www.grdc.com.au/GRDC-FS-DBM

[37] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

Cabbage aphid

The cabbage aphid (Figure 15) infests canola. It is generally restricted to crops and weeds within the cruciferous plant family. Alternative hosts are wild radish and wild turnip. It causes reduced podset, podfill and seed quality.

Figure 15: Cabbage aphid (Brevicoryne brassicae).

Green peach aphid

The green peach aphid (Figure 16) infests canola. Alternative hosts are wild radish and wild turnip, lupins, cape weed and others. It transmits BWYV and many other important plant viruses. It is an early-season pest with potential to affect yield through transmission of BWYV. It rarely persists to cause direct yield loss.

Figure 16: Green peach aphid (Myzus persicae).

7.7.2 Aphids in canola

The main aphid pests in canola are the turnip aphid, the cabbage aphid, and the green peach aphid.

Impact

Aphids will often colonize canola crops in autumn. Green peach aphids are most common at this time, but will only occasionally cause economic damage to canola through direct feeding. Severe infestations by aphids may cause death of young plants. Early infestations may continue to develop hotspots. Heavily infested plants will show signs of wilting. Wilting may be more severe if the crop is water-stressed. Aphids often infest plants on crop edges. Winged aphids can colonise plants throughout the field.

Early colonisation by virus-infected aphids can result in significant canola yield losses, as seen in 2014 with beet western yellows virus.

Aphids also infest crops in the spring, especially in years of moisture stress. Bud formation and flowering is the stage most sensitive to damage. Infestations reduce flowering and reduce or prevent podset and podfill on the infested racemes. Look for infestations amongst buds and flowers, and aphids on stems, lower leaves, buds and flowering heads. Warm dry spring promotes rapid population growth; moisture stress limits crop compensation, podset and podfill. Canola can compensate to some extent through larger seed in pods that are set and more flowering branches.

Large populations of aphids are more evident and potentially damaging in dry seasons. Monitoring for beneficial insects is important, because control may not be justified in some cases. If control is warranted, careful selection of an insecticide is essential to ensure that damage is not caused to nearby beehives or to beneficial insects within the crop. Be sure to adhere to the harvest withholding period (WHP) of the insecticide.

Monitoring and thresholds

Monitor from early bolting onwards. Monitor earlier in high-risk season, such as a wet autumn that promotes weed growth. Visually check stems, amongst buds, and flowering heads.

Check regularly at least 5 points in the field and visually inspect 20 plants at each point. Populations are often patchy (radiating from hotspots) and densities at crop margins may not be representative of the whole field.

Regular monitoring, on a weekly basis during flowering and podset, is required to detect rapid increases in aphid populations.

Aphid infestation can be reduced by heavy rain events. If heavy rain occurs after a decision to spray has been made but before the spray has been applied, check the crop again to determine whether the treatment is still required.

Monitoring for canola aphids is often done at the same time in spring (early flowering to harvest) as sweep netting for DBM caterpillars.

At each sampling visit, record:

- the aphid species present in the crop and relative abundance of the species (presence of green peach aphid may require a different approach to control—it is known to be resistant to some insecticides)
- number of heads counted, number of heads infested; calculate % infestation = (heads infested ÷ heads counted) x 100
- the size of the infestation on each head, in cm of stem infested—indicates how established the infestation is and can be used at repeat visits to determine how rapidly the population is increasing
- impact of the infestation on the crop
- presence of beneficials—number and species (including aphid mummies as an indication of parasitoid wasp activity)

The number of heads per plant infested within a crop is more important than the size of infestations when considering control. Small populations will prevent the head from flowering and setting pods normally.

Threshold recommendations to control:

- if >20% of plants infested with colonies, consider control (from Western Australia)
- if >50% of plants with clusters 25 mm long on stems or 4–5 stems/m^2 with clusters 50 mm long on stems (from NSW)

Compensation likely plays an important part in moderating yield loss in crops. Drought-stressed crops are more likely to suffer yield loss. However, the reduction in yield potential of stressed crops can make it uneconomic to control pests, even if they are causing visible damage to the crop.

Management

Beneficials

These include parasitoids (wasps, aphid mummies) and predators (ladybirds, hover flies and lacewings).

The earlier a decision to control aphids is made, the more important it is to preserve beneficials. The longer the period between aphid control and harvest, the greater the risk of aphid populations building up again. In this situation, the impact of beneficials on small, surviving aphid colonies can be significant.

Beneficials will suppress low to moderate aphid populations but will not control heavy infestations quickly enough to prevent impact on the crop. The number of beneficials required to control a population of aphids has not been studied in canola.

Beneficials may not arrive in crop early enough to prevent the buildup of aphid numbers to above threshold levels. However, they can be important in suppressing population buildup following control. For this reason, it is important to determine the potential impact of an insecticide used for aphid control on natural enemy populations. Preserve beneficial insects wherever possible by avoiding the use of broad-spectrum insecticides.

Cultural control

Control aphid hosts of wild turnip, wild radish and cape weed early in the season to prevent buildup of aphids. Because winged aphids may move large distances, weed control to minimise aphid outbreaks needs to be done on an area-wide basis.

In a season with warm, wet autumn and spring, the abundance of hosts and aphids will make the management of alternative hosts difficult. Sow crops early, where possible, to enable plants to flower and set pods before aphid numbers increase. Sow canola into standing stubble wherever possible, as this will deter aphid landings in autumn.

Chemical control

If chemical control is required, consider early application of aphid-specific products to preserve beneficials, particularly where the potential for reinfestation is high.

Seed treatments and border spraying (autumn–early winter) when aphids begin to colonise crop edges may provide sufficient control. Early control of aphid populations can delay buildup significantly, but it may be of little benefit in seasons when pest pressure is high and movement of aphids into the crop occurs over a long period.

Sow canola into standing stubble wherever possible, as this will deter aphid landings in autumn.

Green peach aphid has resistance to several insecticides, and this resistance is widespread across southern Australia.

Rotate chemical groups to minimise the development of resistance, particularly where a pest is treated more than once in the same crop.

Multi-pest considerations

The use of broad-spectrum insecticides (e.g. pyrethroids, methomyl) can flare aphid and DBM numbers because of the reduction in beneficial populations by these applications.

Communication

An area-wide management approach to the control of weed and volunteer hosts may be useful. Agronomist and growers can discuss:

- controlling aphid hosts in fallows and around the farm (e.g. weeds, volunteers)
- monitoring methods and frequency of checking
- control options for aphids and a likely sequence of insecticides to control other pests from establishment through to harvest, in particular the potential off-target effects of any broad-spectrum options and resistance-management strategies

More information

Agriculture WA: Aphid management in canola crops

Research Paper: Managing aphids in flowering canola in central west NSW

cesar: PestFacts south-eastern. Canola aphid

- keeping and reviewing crop records of aphid infestations over time to determine whether populations are increasing or decreasing

Industry publications provide up-to-date regional information about pest activity in crops. These include PestFax (WA) and PestFacts (Vic./NSW, SA) newsletters, and Beatsheet blog (Qld, NSW).

7.7.3 Resistance management strategies for green peach aphid

Green peach aphids are a widespread and damaging pest of canola and a range of pulse crops, causing damage by feeding and transmitting viruses.

Five chemical subgroups are registered to control green peach aphids in grain crops: carbamates (Group 1A), synthetic pyrethroids (Group 3A), organophosphates (Group 1B), neonicotinoids (Group 4A), and sulfoxaflor (Group 4C). Paraffinic spray oils are also registered for suppression of green peach aphids.

High levels of resistance to carbamates and pyrethroids are now seen across Australia. Moderate levels of resistance to organophosphates have been observed in many populations, and there is evidence that resistance to neonicotinoids is evolving. Transform™ (sulfoxaflor) is a new selective insecticide for control of early-season infestations of green peach aphid in canola. [38]

A strategy to manage insecticide resistance in green peach aphid populations is available for use by grain growers and their advisers. The strategy may vary across regions and industries to be effective.

More information

GRDC Fact Sheets: Resistance management strategy for the green peach aphid in Australia grains

GRDC Update Papers: Insect management in faba beans and canola recent research

7.8 Rutherglen bugs

7.8.1 Description

Rutherglen bug adults (Figure 17) are 4 mm long, have clear wings folded flat on the back, are grey-brown-black in colour and are very mobile. Nymphs are smaller and have a pear-shaped, red-brown body (Figure 18). The coon bug, *Oxycarenus arctatus*, is similar to this pest except that its nymphs are red and it is not as abundant or as damaging; the green mirid (*Creontiades dilutus*) is also similar. [39]

Figure 17: Adult Rutherglen bug (Nysius vinitor).

[38] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

[39] GRDC Ute Guide Rutherglen bug. GRDC, https://www.grdc.com.au/Resources/Ute-Guides/Insects/Bugs/West/Rutherglen-Bug

Figure 18: Growth stages of Rutherglen bug: winged adult (top left), nymphs (right).

Rutherglen bug is best known as a seed-feeding pest, attacking grain as it develops and fills. However, in some seasons, large numbers of nymphs and adults can cause damage to establishing winter or summer crops. RGB populations can build up in summer weeds, and move from these into the establishing winter crop, feeding on and killing small seedlings. Large numbers of RGB moving out of canola stubble pose a threat to nearby establishing summer crop.

7.8.2 Impact

Infestation of canola during flowering and grainfill decreases yield, oil content and oil quality. Adults may also be a grain contaminant. Young crops may be retarded when large numbers are present on weeds after summer rains.

Seedlings can be damaged by RGB nymphs in seasons where large numbers of nymphs survive in weeds over summer, that is, mild summer with rainfall to promote weed hosts such as wireweed and marshmallow. Seedlings can be killed by sheer feeding pressure caused by nymphs moving from weeds on field edges. Young crops may be retarded when large numbers are present on weeds after summer rains. Seed treatments will not protect seedlings against this extreme pressure. Damage is often confined to field margins.

Adults migrate into fields from local weed hosts, or from sources more distant in spring. Infestations can be large and the period of invasion prolonged.

Adults and nymphs feed on growing tips, buds, flowers, pods and seed, causing flower abortion and reduced podset and seed development. Feeding directly on developing seed affects oil quantity and quality and seed viability.

RGB can persist into windrows, and at harvest cause problems with seed flow through harvesters and by raising the moisture content of the grain above acceptable standard.

7.8.3 Monitoring and thresholds

Canola should be checked during podding. Weeds that germinate with summer rains and persist into autumn can host large populations of bugs. All young crops should be checked, especially those sown into paddocks that had summer weeds.

Check the crop from flowering to harvest at weekly intervals. Inspect flower heads visually or shake heads into a bucket. Examine 20 heads at 5–10 locations within the crop.

Distribution is typically patchy across the field, which means that the greater the number of samples taken, the greater the level of confidence in estimating the size of the infestation. In seasons with wet, mild summer and abundant weed growth, check weeds around the paddock that may be hosting RGB. In particular, wireweed is known to be a summer host. Capeweed is a common autumn–summer host for RGB.

Record the number of RGB adults and nymphs in each sample. Average the counts from across the paddock to get a field estimate of density. Note the presence of other pests and beneficials, crop stage, and proximity to maturity.

Thresholds for RGB are provisional: 10 adults or 20 nymphs per raceme at flowering–early podding. Higher numbers can be tolerated if moisture is not limiting.

7.8.4 Management

Cultural control

Control summer–autumn weeds around field edges and in fallows that may host RGB (e.g. wireweed). Invasion of RGB nymphs from weeds in autumn can be slowed by ploughing a deep furrow between the weeds and the crop, but the effectiveness of this approach remains uncertain.

At harvest, allow RGB to escape from open bins to reduce numbers in deliveries.

Pesticides

Repeated influxes of migrating adults can make repeat applications necessary. If spraying windrowed canola to control RGB, consider the WHP or chemical restrictions on spraying this late in the season.

The application of broad-spectrum insecticides in a strategic and targeted manner (e.g. spot or border spraying rather than whole-paddock applications) will help to avoid detrimental effects on natural enemies and maintain their contribution to the management of other pest species (e.g. aphids, DBM, *Helicoverpa*).

Natural enemies

The most commonly recorded beneficials attacking RGB are egg parasitoids wasps. Their major impact on RGB lies in reducing population size. They may have some impact on populations over summer or during winter, but have little capacity to control infestations in crops, particularly where infestations are driven by large influxes of adults. Little is known about the impact of predators, but spiders may be a predator of RGB.

Communication

Communication with agronomists and among growers should involve:

- management of weeds in proximity to canola crops (or paddocks where it will be sown) over summer and into autumn
- checking weeds in autumn to assess risk of RGB populations moving from weeds into seedling crops
- monitoring methods and frequency of checking, checking data over several weeks and what it means for management
- maintaining communication regarding influxes of RGB
- industry publications providing up-to-date regional information about pest activity in crops

More information

cesar: PestNotes southern—Rutherglen bug

IPM Guidelines: Rutherglen bug in canola

AOF: Insect pests of canola. Rutherglen bug (p. 5)

GRDC: Canola best practice management guide. Rutherglen bug (p. 58)

NIPI: Rutherglen bug in canola

7.9 *Helicoverpa punctigera* (native budworm)

7.9.1 Background

Native budworm is widely distributed throughout mainland Australia, and during winter, it breeds in semi-arid parts of South Australia and south-western Queensland. These vast inland areas are the sources of the moths that produce the spring generation of caterpillars. The moths are strong fliers and may be carried long distances by wind, to initiate infestations in localities far from where they developed as caterpillars.

The amount of damage caused by the native budworm and corn earworm varies considerably from year to year. Moth activity alone cannot be taken as a guide for spraying. In some years when moths are common, egg and caterpillar numbers are limited by adverse cool or cold, wet weather, parasitoids, predators and diseases, and damage may be restricted or insignificant. In other years, a relatively small moth population may produce many caterpillars and cause significant damage.

7.9.2 Description

Eggs

Budworm eggs can be found singly on the growing tips and buds of plants. Newly laid eggs are white or yellowish white, dome-shaped, flattened at the base, ribbed and 0.5 mm in diameter. They are visible to the naked eye on close inspection of the plant. Caterpillars hatch in 3–5 days in warm weather and 6–16 days in cooler weather.

Larvae and pupae

Newly hatched caterpillars (larvae) are 1–1.5 mm long with dark heads and dark-spotted white bodies. The newly hatched caterpillars are very small and are often easily missed when inspecting a crop. They will pass through six or seven growth stages or instars, until they are 35–40 mm long (Figure 19).

Young caterpillars up to about 15 mm long have dark heads and pale yellow, greenish or brownish bodies with conspicuous upper body hairs in dark bases and, often, narrow dark stripes down the back and along each side. Older caterpillars up to 50 mm long vary greatly in colour from yellow to almost black, often have a broad pale stripe along each side, and their upper body hairs are usually on raised processes, which makes the skin rough to touch (Figure 20).

Pupae are cigar-shaped, 12–22 mm long, and during development change in colour from a yellow-orange to a shiny dark brown.

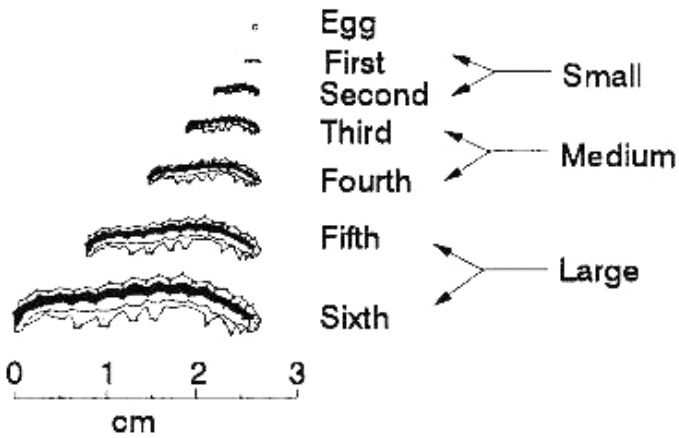

Figure 19: Approximate instar sizes of the native budworm (Helicoverpa punctigera).

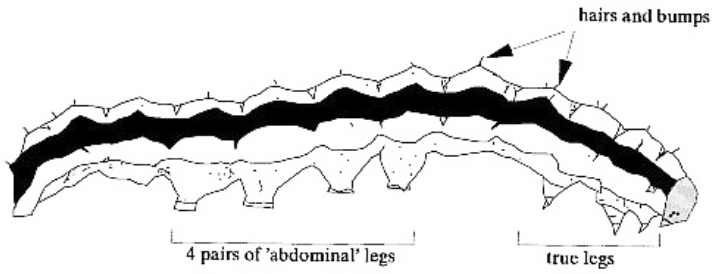

Figure 20: Distinguishable features of native budworm larva.

More information

Agriculture Victoria: Native budworm

Adults

Adult moths are medium-sized (wingspan 30–40 mm) and stout-bodied. The forewings are buff-olive to red-brown with numerous dark spots and blotches. The hind wings are pale gray with dark veins and a dark band along the lower edge. Moths are usually active during the evening and night.

7.9.3 Importance

The native budworm is native to Australia and is distributed, particularly during spring, throughout much of the central and southern regions of the country. It is the major pest of all grain legumes (although pea weevil is equally important in field peas). It also attacks most oilseed crops, some vegetables, particularly tomato and sweet corn, and various pasture species such as clover and lucerne.

Before deciding control, it is important to be sure that the caterpillars are native budworm. For example:

- Corn earworm (or cotton bollworm) has a very similar appearance to native budworm, but rarely occurs in significant numbers in Victoria, SA and Southern NSW grain legume or oilseed crops. It is nonetheless an important pest when it does occur in large numbers, because it may be resistant to many of the commonly used insecticides. The most obvious distinguishing features are two small dark patches on the segments above the true legs.
- Diamondback moths are frequently misidentified as native budworm. They are most easily distinguished from budworm by the absence of stripes, and by their vigorous wiggling movement when touched.

7.9.4 Seasonal development and symptoms

Adult migration and feeding

A notable feature of this pest is its capacity to migrate at high altitudes over large distances (100–1000 km) each night. The moths fly from areas where conditions do not favour another generation to site of abundant food plants for further breeding. Recent research has shown that the species will breed rapidly on flowering plants in the arid inland (desert) regions of Queensland, South Australia, Western Australia and New South Wales during winter, provided there has been adequate winter rain.

Once the new generation of moths has emerged from these breeding grounds, they fly up into the warm northerly or north-westerly winds and migrate to the southern and eastern cropping regions during late winter and early spring. Hence, the moths encountered in southern crops during early spring almost certainly have their origins somewhere in the inland of Australia.

Moths live for 2–4 weeks; they rest during the day and become active after sunset, feeding on nectar from flowers and laying eggs on many types of plants (weeds and crops). They fly from plant to plant throughout the night, feeding and laying eggs. They are also capable of flying from paddock to paddock and even from one region to another.

Egg laying

Female moths will begin laying eggs within 3 days of emergence, placing them singly on flower buds, young pods, foliage and stems. The moths prefer the more advanced and succulent portions of crops for egg laying and usually avoid poorly grown areas. Each female can lay about 2000 eggs over several days.

Egg laying is usually confined to the period from flower-bud formation until flowering ends. When moths are exceptionally abundant, infestation can be expected before flowering commences. [40]

Larval feeding and pupal development

After hatching, the larvae crawl around the plant, feeding from plant surfaces, particularly on tender tissue such as leaves, flowers or pods. They produce fine silken threads, which, with the aid of wind, may be used to distribute them from plant to plant. In some situations, such as adversely hot conditions, the small larvae may burrow straight into pods and seeds. However, they mostly graze on plant surfaces until they grow to 8–12 mm in length, when pod burrowing usually occurs. The larvae complete their development in 3–6 weeks (closer to 3 weeks during warm weather).

Fully grown larvae move off the plants and burrow in the soil from 20 to 150 mm in depth. They build chambers in which the pupae form. The pupal stage lasts about 2 weeks during spring. Late spring or summer pupae may enter a prolonged resting stage in the soil and not emerge until the following season.

7.9.5 Impact

The most notable damage by native budworm is on the pods and seeds. In most situations, pod attack commences with medium-sized larvae entering pods and eating all or part of the seed between pods. Small larvae generally do not enter pods, but 'graze' on the pod and leaf surfaces. Occasionally, the small larvae may enter the pods and remain inside for several days, particularly when conditions are hot and windy after egg hatch. These larvae remain protected from insecticides until they re-emerge. Hence, crop monitoring should include pod inspections.

Larvae will also attack growth points, but this is unlikely to cause major yield losses in grain legumes and oilseeds. Continual monitoring is warranted when high populations exist during early flowering.

7.9.6 Monitoring

Two sampling methods should be used to assess caterpillar numbers:

- Measure numbers on the crop using a sweep net or a beating tray or sheet (a white sheet or tray slid under the vines and shaken to dislodge the caterpillars).

Sampling should commence at early podding. Take a minimum of 5 sets of 10 sweeps. A single sweep of a net should cover an arc of 180° from one side of the sweeper's body to the other. The net should pass through the crop with the net tilted such that the lower lip travels through the crop marginally before the upper lip.

Each set of sweeps should be performed in a different, representative area of the crop. This will provide a more comprehensive estimate of native budworm numbers throughout the crop, avoiding local variations in larval numbers. Local variations (or hot spots) are a common feature of budworm distribution. After completing the sets of sweeps, counts should be averaged to give an overall estimate of abundance.

[40] K Hertel, K Roberts, P Bowden (2013) Insect and mite control in field crops. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0005/284576/Insect-and-mite-control-in-field-crops-2013.pdf

7.9.7 Management

Natural control

Surprisingly high levels of mortality of eggs and caterpillars exist in most situations. The presence of large numbers of moths does not necessarily result in significant crop damage; well over 90% of all eggs and young larvae may die without causing any damage. Eggs and larvae will die if they are dislodged from the plant by wind or rain, or if they are attacked by predators (such as spiders, carabid beetles or predatory bugs), parasites (wasps and flies) or diseases.

The most important natural enemies appear to be the parasites: tachinid flies, the larvae of which parasitise native budworm; and the egg parasite *Trichogramma ivalae*, a minute wasp. The extent of parasitism of native budworm eggs varies from year to year; in grain legumes, it has been measured as high as 60% and low as 5%. However, this egg parasitoid can reduce egg numbers by as much as 90%.

Decision to spray

Spray when caterpillar numbers are at or above the spray threshold. Comprehensive and dynamic economic thresholds have been developed for native budworm in Western Australia, which should also apply to south-eastern Australia. [41],[42] Note that these methods do not detect caterpillars inside the pod.

Usually, a range for rates is presented on the insecticide label to allow for varying conditions, such as size of caterpillar. Read the label.

Before deciding to spray, consider the following:

- likely extent and severity of the infestation
- ability of the crop to tolerate caterpillar damage without any significant loss or to replace leaves or fruiting parts lost to the caterpillars
- value or likely loss if the crop is left untreated
- cost of treatment [43]

7.10 Snails

Snail numbers can explode in seasons with wet springs, summers.

As a rule of thumb, if snail numbers are >5/m^2 in pulses and oilseeds, grain contamination is likely at harvest. Use header modifications and grain cleaning to eliminate snail contamination of grain.

Snails appear to build up most rapidly in canola, field peas and beans. However, they can feed and multiply in all crops and pastures. Baiting before egg laying is therefore vital. Timing and choice of controls will depend on the season. Baiting should be ceased 8 weeks before harvest to avoid bait contamination in grain.

Understand the factors that determine effectiveness of control. Monitor snails regularly to establish numbers, types, activity and success of controls. To control snails, you will need to apply a combination of treatments throughout the year.

More information

GRDC Fact Sheets: Snail management

GRDC Ground Cover: Paddock snapshots inform slug and snail control

7.10.1 Description

Snails are a mollusc with a rasping tongue and one single muscular 'foot' for movement. Much of their body is encased in a shell, which they secrete as they grow.

[41] G McDonald. Native budworm. PestNotes southern. **cesar**, http://cesaraustralia.com/sustainable-agriculture/pestnotes/insect/Native-budworm

[42] P Mangano, S Micic. Management and economic thresholds for native budworm. DAFWA, https://www.agric.wa.gov.au/grains/management-and-economic-thresholds-native-budworm?page=0%2C0

[43] G McDonald (1995) Native budworm. Agriculture Victoria, DEDJTR, http://agriculture.vic.gov.au/agriculture/pests-diseases-and-weeds/pest-insects-and-mites/?a=223411

More information

AOF: Pointed or conical (*Cochlicella acuta*) and small pointed (*Cochlicella barbara*) snails

GRDC: Canola best practice management guide. Snails (p. 52)

GRDC Fact Sheets: Snail management

NIPI: Snails in seedling crops

NIPI: I Spy Manual. Snails (section 4, pp. 65–70)

7.10.2 Symptoms

Snails consume cotyledons and this may resemble crop failure. Shredded leaves, chewed leaf margins, and irregular holes all occur as a direct result of feeding damage by snails.

7.10.3 Impact

Snails can cause damage to emerging canola seedlings, but are predominantly a grain or seed contaminant. The small pointed snail (*Cochlicella barbara*) is especially hard to screen from canola due to similar size.

7.10.4 Control

Free-living nematodes carrying bacteria that cause snail death may help to reduce populations under certain field conditions. Hard grazing of stubbles, cabling and/or rolling of stubbles, stubble burning, cultivation, and removal of summer weeds and volunteers are all effective management options. Molluscicidal baits are effective on mature snails, and IPM-compatible, but can be less effective on juveniles. [44]

7.11 Soil pests

Several soil-dwelling insect pests such as cutworms, wireworms, bronzed field beetle, cockchafers and false wireworms have caused damage to emerging canola seedlings in recent years. In severe cases, plant stands can be thinned to such an extent that the paddock requires re-sowing. Occurrence of these pests is difficult to predict, so advice on their control should be sought prior to sowing if any problems are foreseen. The most severe damage tends to occur in crops following pasture, or if stubble has been retained. [45]

More information

NIPI: Pests in canola. *Mandalotus* weevil in canola

NIPI: IPM Guidelines. False wireworms in canola/

NIPI: IPM Guidelines. Soil insects

7.11.1 Wireworms and false wireworms

Importance

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

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

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

7.11.2 False wireworms

In crops, they are mostly found in paddocks with high contents of stubble and crop litter. They may affect all winter-sown crops.

Description

There are many and varied species of false wireworm, but they share some general characteristics. Larvae are cylindrical, hard-bodied, fast-moving, golden brown to black-brown or grey with pointed upturned tails or a pair of prominent spines on the last

[44] CropPro. Snails. Pests in canola. CropPro, http://www.croppro.com.au/cb_pages/pests_in_canola_-_in_crop.php?category_id=2382

[45] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

body segment. Several common groups (genera) of false wireworms are found in south-eastern Australia:

- The grey or small false wireworm (*Isopteron* (*Cestrinus*) *punctatissimus*). The larvae grow to ~9 mm in length. They are grey-green, have two distinct protrusions from the last abdominal (tail) segment (Figure 21), and tend to have a glossy or shiny exterior. Hence, they are most easily recognised in the soil on sunny days, when their bodies are reflective. The adults are slender, dark brown and grow to ~8 mm in length. The eggs are <1 mm in diameter. There are several species of this pest genus, although *I. punctatissimus* appears to be the species most associated with damage.
- The large or eastern false wireworm (*Pterohelaeus* spp.). These are the largest group of false wireworms. They are the most conspicuous in the soil and grow up to 50 mm in length. They are light cream to tan in colour, with tan or brown rings around each body segment, giving the appearance of bands around each segment (Figure 21). The last abdominal segment has no obvious protrusions, although under a microscope, there are a number of distinct hairs. Adults are large, conspicuous and often almost ovoid beetles with black, shiny bodies (Figure 22).
- The southern false wireworm (*Gonocephalum* spp.) grows to ~20 mm in length, and has body colours and marking similar to the large false wireworm. Adults are generally dark brown-grey, oval beetles, which sometimes have a coating of soil on the body. Adults have the edges of the body flanged, hence the common name pie-dish beetles.
- The bronzed field beetle (*Adelium brevicorne*) are shiny dark brown, grow to 12 mm long, and are cylindrical with two distinct, upturned spines on the end of the body. Adults are shiny black with a slight bronze appearance, grow to 11 mm long and are present from spring to autumn. There is one generation per year.

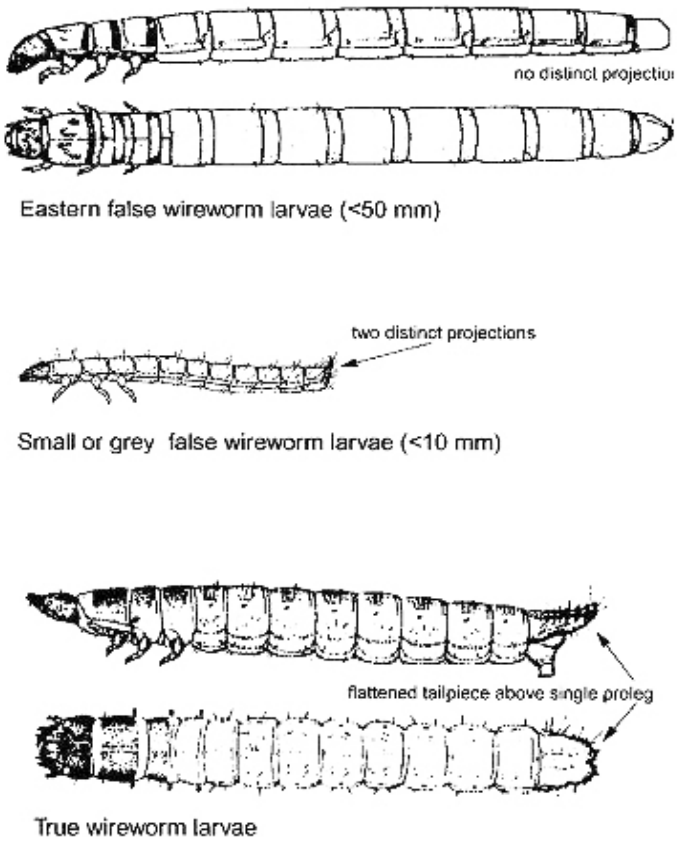

Figure 21: Two common false wireworm larvae and a 'generalised' true wireworm larva.

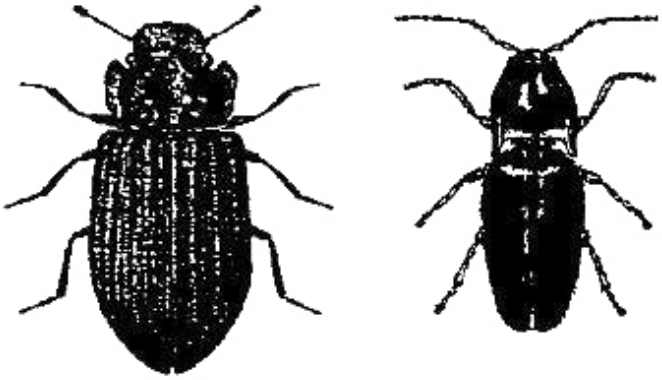

Figure 22: The adult (beetles) of the false wireworm (left) and true wireworm (right). [46]

Seasonal development and symptoms

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

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

Impact

Affected crops may develop bare patches, which can be large enough to require resowing. Damage is usually greatest when crop growth is slow in cold, wet conditions.

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

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

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

Sampling and detection

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

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

1. Soil sampling. Take a minimum of five random samples from the paddock. Each sample should consist of the top 20 mm of an area of soil 0.50 m by 0.50 m. Carefully inspect the soil for larvae. Calculate the average density per m^2 by multiplying the average number of larvae found in the samples by 4. Control should be considered if the average exceeds 10 small false wireworm, or 10 of the larger false wireworms.
2. Seed baits. Seed baits have been used successfully to sample true and false wireworms in Queensland and overseas but they have not been rigorously tested in Victoria. Preliminary work indicates that they can be used to determine the species of larvae present, and give an approximate indication of density. Pre-soak ~200–300 g of a large seed bait, such as that of any grain legume, for 24 h. Select 5–10 sites in the paddock, place a handful of the soaked seed into a shallow hole (50 mm), and then cover with about 10 mm of soil. Mark each hole with a stake, and re-excavate after ~7 days. Inspect the seed and surrounding soil for false wireworm larvae. This technique is most likely to be successful when there is some moisture within the top 100 mm of soil.

Control

Crop residues and weedy summer fallows favour survival of larvae and oversummering adult beetles. Clean cultivation over summer will starve adults and larvae by exposing them to hot dry conditions, thus preventing population increases. Suitable crop rotations may also limit increases in populations.

If damage occurs after sowing, no treatment is available, other than resowing bare patches with an insecticide treatment.

7.11.3 True wireworms

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

Description

Larvae grow to 15–40 mm, are soft-bodied, flattened and slow moving. This distinguishes them from false wireworms, which are hard bodied, cylindrical and fast moving. Their colour ranges from creamy yellow in the most common species to red brown; their head is dark brown and wedge-shaped. The tailpiece is characteristically flattened and it has serrated edges (Figure 21). Adults are known as click beetles, because of their habit of springing into the air with a loud click when placed on their backs. They are dark brown, elongated and 9–13 mm long (Figure 22).

Seasonal development and symptoms

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

Adult click beetles emerge in spring and summer, mate and lay eggs, and then may spend a winter sheltering under the bark of trees. The connection between trees and

adult beetles may explain why damage is often, but not always, most pronounced on tree lines. True wireworms have a long life in the soil and are active all year, even in winter.

Impact

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

Sampling, detection and control

See above discussion on false wireworm for full details. Wireworms and false wireworms can be controlled only if they are detected in the seedbed before sowing. Insecticide can be applied to the soil with fertiliser, or seed can be treated.

7.11.4 Weevils

In canola and related Brassica crops, common weevil pests include: vegetable, Mandalotus, small lucerne, Fuller's rose, grey-banded leaf, and spotted vegetable (or Desiantha) weevils (Table 5, Figure 23). Both adults and larvae of these species are capable of causing damage to canola.

Weevils are a diverse group of beetles that are commonly found in Australian grain crops. Adult weevils appear very different to the larvae. Adults have a hardened body, six prominent legs and an elongated, downward curved head forming a 'snout'. The larvae are legless, maggot-like in shape and may be confused with fly larvae. Weevil larvae possess a small, hardened head capsule. Crop weevils feed on vegetative parts of crop plants including the roots, stems, shoots, buds and leaves. Both adults and larvae can be damaging to plants, depending on the species, crop type and time of year. Typical feeding damage commonly observed is scallop-shaped holes along the edges of leaves. Weevils can be difficult to control with chemicals due to their secretive habits. Several species are also patchy in their distribution within paddocks. For some species, seed treatments and foliar insecticides can provide a level of control. Weevils are typically favoured by minimum tillage and stubble retention. Cultivation, burning and reducing the amount of stubble will reduce the suitable habitat for weevils and reduce their number. Identification of crop weevils is important when making control decisions. The distinctive appearance of weevils makes them unlikely to be confused with other beetles. However, distinguishing between the many species of weevil is challenging. This guide is designed to assist growers in identifying the most commonly observed weevils found in the southern and western cropping regions.[47]

Weevil damage can occur at any time of the season, but feeding during autumn and early winter is typically the most critical. Inspect paddocks and nearby weeds prior to sowing and monitor crops for signs of seedling damage and bare patches within paddocks. Look for signs of chewing damage on plants, often characterised by scallop-shaped holes along the leaf margins, ring-barking of seedlings, as well as a loss of plant vigour. Searches may need to be undertaken during the night. This is when weevils are most active.

More information

http://www.grdc.com.au/GRDC-BPG-CropWeevils

Weevils, particularly larvae, can be difficult to control with chemicals because of their subterranean habits, so they remain protected from insecticide exposure. Exceptions are the vegetable and grey-banded leaf weevils, whose larvae also feed on foliage. A limited number of registered products are available for the active stages of several weevil species. Reports suggest that canola paddocks sown with fipronil-treated seed experience less feeding damage from weevils. [48]

[47] http://www.grdc.com.au/GRDC-BPG-CropWeevils

[48] **cesar**. Weevil pests. PestFacts south-eastern, issue 2, May 2015, http://www.**cesar**australia.com/sustainable-agriculture/pestfacts-south-eastern/past-issues/2015/pestfacts-issue-no-2-22nd-may-2015/weevil-pests/

Table 5: Description of common weevil species

Weevil species	Adult length (mm)	Distinctive features of adult weevils	Larval head capsule colour
Fuller's rose	8	Yellow/grey stripe on thorax and also abdomen	Light
Grey-banded leaf	8	Pale band on rear of abdomen	Dark
Mandalotus	3-5	Dull brown, paddle-shaped bristles; short snout	Yellow/brown
Sitona	5	3 white strips on thorax; broad snout	Brown
Small lucerne	7	Less distinct lateral stripes than whitefringed	Light
Spinetailes	7	WIng covers taper to spine (females); longer snout	Yellow
Spotted vegetable	5-7	Mottled/specked; longer snouth	Brown
Whitefringed	10-15	LIght lateral stripes	Light
Vegetable	10	Light coloured 'V' at rear of abdomen	Brown

Figure 23: Small lucerne weevil (left) and Fuller's rose weevil (right). (Source: **cesar***)*

More information

cesar: PestFacts south-eastern. Weevil pests

7.11.5 Earwigs

There are increasing reports of European earwigs (*Forficula auricularia*) causing significant damage to emerging crops. Stubble retention, in combination with wet springs and summers and an early autumn break, appear to favour the buildup of these insects. The damage caused by earwigs can be difficult to identify, and because control can also be difficult, growers should seek advice if they suspect or see earwigs. [49]

More information

GRDC Fact Sheets: European Earwigs

Correctly identifying earwig species is important because they have different roles as pests or beneficial species. Not all earwigs found in crop paddocks are pests (Figure 24). Although European earwigs are renowned as pests, other earwigs can be benign or beneficial.

Other common earwig species include:

- Common brown earwig, *Labidura truncata*, which is a native and beneficial species. They are mostly red-brown in colour and range from 10 to 45 mm in length. This species is most common in sandy habitats but occurs across southern Australia and mainly feeds on soft-bodied insects such as caterpillars, lucerne flea and mites.

[49] P Matthews, D McCaffery, L Jenkins (2015) Winter crop variety sowing guide 2015. NSW DPI Management Guide. NSW Department of Primary Industries, http://www.dpi.nsw.gov.au/__data/assets/pdf_file/0011/272945/winter-crop-variety-sowing-guide-2015.pdf

It can be distinguished by an orange triangle behind its head on the elytra (wing cases). Males have long slender forceps with a distinctive tooth near the middle of the inner edge.

- Black field earwig, *Nala lividipes*, which is a minor pest species of broadacre agriculture, only occasionally attacking crops. They are smaller, at about 15 mm long, shiny black, and can be a pest of seeds and seedlings. Adults have wings and can fly; nymphs resemble adults but are wingless. The black field earwig is omnivorous, meaning they can be a pest and a predator. They are known to attack wheat, sorghum, maize and sunflowers. They eat newly sown and germinating seeds and the roots of crops, resulting in poor establishment. Black field earwigs prey upon a range of insects, including wireworms and *Helicoverpa* spp.
- *Euborellia* spp. are small, dark-coloured earwigs ranging from 10 to 25 mm in size. There are many subspecies, and they can be difficult to distinguish. They are flightless and appear to form mating pairs that maintain a small territory. Male and females will often be found together and, at times, with a brood of young earwigs. Early research has indicated they may not be plant feeders and are likely to be more predatory.

Figure 24: Top left: European earwig, Forficula auricularia—a pest species. Top right: common brown earwig, Labidura truncata—a native and predatory species. Bottom left: black field earwig, Nala lividipes—a predatory species and minor pest. Bottom right: Euborellia earwig—native and predatory species. (Photos: Denis Crawford, GRAPHIC SCIENCE)

Seasonal development

European earwigs complete one generation per year, although females can produce two broods in some years. They can survive in a range of environments and the length of their life cycle depends on temperature. At 25°C, development from egg to adult takes 9–10 weeks but at 15°C it takes up to 5 weeks longer. In winter, adult females lay batches of 20–80 white oval eggs in burrows in the topsoil, which hatch in 2–3 weeks.

In some years, under favourable environmental conditions, earwigs may lay eggs in late spring to produce a second summer brood. There are several nymphal instars (stages between moults). Female earwigs remain in the burrow, protecting the eggs and nymphs.

Impact

European earwigs mainly attack canola but will also attack cereals, lupins and some legume crops. Damage can be scattered because of their patchy distribution. Earwigs

chew the stems and cotyledons of emerging seedlings, killing plants or slowing plant development. As the plant grows, foliar damage includes shredded leaf tips and jagged holes in leaves.

Earwigs can completely defoliate young seedlings leaving only stems or bare ground in patches. They can also chew through seedpods. Earwigs feed together at night, and in many cases, damage will start along the edges of a paddock. Earwig damage to plant leaves closely resembles feeding damage caused by slugs. Damage has been reported mainly in the medium- and high-rainfall zones including South Australia's Mid North and South East regions, Victoria's Western Districts and the South West Slopes of New South Wales. Nearly all cases of damage have occurred in paddocks where minimum or no-till practices were used with high stubble loads, and often on heavier soils.

Management—windrowing and harvesting

Grain with high numbers of earwigs may require cleaning to meet delivery standards. Trials have shown that earwigs are more likely to be found sheltering under windrowed crops than in standing crops. If windrows are harvested during the heat of the day, the number of earwigs found in the grain is not significantly different from that in a standing crop. During the hottest part of the day, the earwigs remain on the soil surface under the windrows. At night, earwigs move out from under the windrow into the top of the windrow. As a result, grain harvested at night is more likely to contain earwigs and require cleaning.

When windrowing crops, maintain the correct windrow height, ensuring that the swath remains above the ground. If windrows are sitting close to, or are on, the ground, earwigs are more likely to be harvested with the grain. If these windrows are harvested using crop lifters, there will be significantly more invertebrates, such as earwigs, present in the harvested grain than in grain harvested using a belt pick-up front.

Monitoring

It is important to distinguish earwig species in order to make the most appropriate management decision and accurately assess the risk of attack to emerging crop seedlings. Native earwig species can have an important role in IPM and in the control of other insects. Monitoring for earwigs is best conducted at night, using a torch, because they are nocturnal feeders.

Another approach is to set pitfall traps—a small plastic cup buried flush in the soil. A small amount of liquid in the bottom will help to contain the insects that fall into the trap. Traps should be left for at least 24 h and are useful for catching invertebrates.

7.11.6 Black Portuguese millipedes

In the last 5–10 years, the black Portuguese millipede (*Ommatoiulus moreleti*) has been emerging as a sporadic but damaging pest of broadacre agriculture, particularly canola.

The increase has been linked to stubble retention, no-till farming practices and improvements in soil organic matter, which have provided a more favourable habitat for millipedes to survive and reproduce. Recent wet summers have contributed to a population buildup in some parts of southern Australia, and planting of more vulnerable crops has led to increased damage.

The black Portuguese millipede is native to Europe and has been accidentally introduced to other countries, including Australia, where it is now common across south-eastern Australia.

Figure 25: Black Portuguese millipedes (Ommatoiulus moreleti) generally feed on organic matter; however, their populations and the incidence of crop attack have increased in recent years. (Left photo: © NICK MONAGHAN, LIFEUNSEEN.COM; right photo: © WA Agriculture Authority)

Description

The smooth, cylindrical body of the black Portuguese millipede (Figure 25) distinguishes it from other native species, which often have rougher and more uneven bodies. They are part of the same family as several native Australian millipedes and centipedes, called myriapods, meaning 'many-legged'. Measuring 30–45 mm, adult millipede bodies consist of up to 50 segments with each segment having two pairs of legs. When disturbed, they either curl up in a tight spiral or thrash to escape.

Native millipedes are widespread in low numbers but black Portuguese millipedes are found in large numbers and are quite mobile for their size, especially after opening autumn rains. They can move several hundred metres in a year.

They are transported between properties and to new regions in plant material, infested soil and farm machinery. [50]

Seasonal development and symptoms

Black Portuguese millipedes start mating in March and April and lay most of their eggs in April and May. Mature females lay about 200 yellowish-white eggs the size of a pinhead, in a small hole they make in the soil.

An immobile, legless stage hatches from each egg and develops into the first active stage of the life cycle after about 7 days (Figure 26). This first stage has only three pairs of legs. Millipedes grow through a series of moults. At each moult, the millipede adds more legs and body segments until it is mature.

During the first year of life, millipedes are quite small and easily overlooked. After the first year, juveniles reach the seventh, eighth or ninth stage of development and they will be about 1.5 cm long. After this, they moult only in spring and summer.

During moulting, millipedes are vulnerable because the new cuticle (outside skin layer) is soft and easily damaged. Black Portuguese millipedes usually mature after 2 years when they are in the tenth or eleventh stage of growth.

Millipedes feed on leaf litter, damp and decaying wood, fungus and vegetable matter such as tender roots, mosses, pollen or green leaves on the ground. They can play a role breaking down organic matter in the soil. As a result, they occur in greater numbers in undisturbed leaf litter and organic mulch and in areas where winter weeds, such as sour sobs and Salvation Jane, form a mostly continuous ground cover. Millipedes are not numerous in cultivated areas or bare ground.

[50] GRDC (2013) Millipedes and slaters in no-till systems. GRDC Black Portuguese millipedes and slaters Fact Sheet, October 2013, http://www.grdc.com.au/GRDC-FS-Millipedes-Slaters

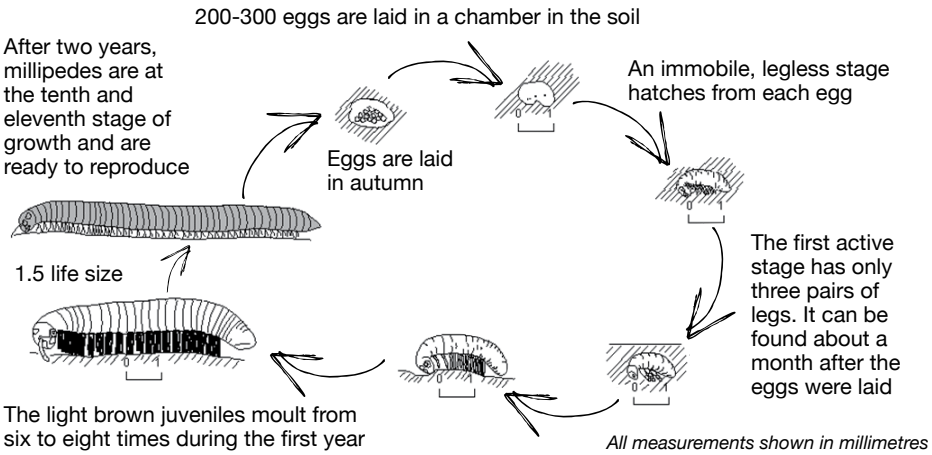

Figure 26: Life cycle of black Portuguese millipede.

Impact

Because black Portuguese millipedes generally feed on organic matter, crop feeding damage is relatively rare. Black Portuguese millipedes occasionally attack living plants by chewing the leaves and stems. It has been suggested that they feed on crop plants when they are seeking moisture, but this has not been confirmed.

Most of the reported damage has occurred in emerging canola crops on black organic soils with heavy stubble loads, but damage has also been observed on lighter soils.

In canola, millipedes remove irregular sections from the leaves and can kill whole plants if damage is severe. Damage to cereals can also occur where the stems of young plants are chewed (Figure 27).

In the southern region, damage has been reported in the medium- and high-rainfall zones including near Wagga Wagga and Henty in New South Wales; the Mid North, Yorke Peninsula and Kangaroo Island in South Australia; and the Western Districts and Wimmera areas of Victoria. In many cases, damage has been worst in areas with high volumes of retained stubble or where plant matter from the previous year was present.

The presence of black Portuguese millipedes does not always mean damage. In many instances, no damage has occurred despite large millipede populations. Millipedes are mostly active and feed at night, which is the best time to check whether they are causing damage to canola plants. [51]

Figure 27: Seedling damage from millipedes. (Photo: K Perry, SARDI)

[51] GRDC (2013) Millipedes and slaters in no-till systems. GRDC Black Portuguese millipedes and slaters Fact Sheet, October 2013, http://www.grdc.com.au/GRDC-FS-Millipedes-Slaters

Management

Control options for millipedes are limited but some measures will curb populations. There are no insecticides registered to control millipedes in broadacre agriculture.

Cultural

Reducing the amount of trash and stubble over summer and early autumn is likely to be the most effective way to reduce millipede numbers. Other factors to consider in management of crops and rotations include:

- Canola sown into paddocks with high organic matter has a greater risk of millipede damage.
- Burning stubbles may reduce millipede populations.
- Early sowing of high-vigour varieties at a higher seeding rate will help to compensate for seedling losses from pest damage.

Biological

Millipedes have very few natural predators. Their bodies contain rows of glands that secrete a pungent yellowish fluid when they are agitated, and this fluid makes millipedes distasteful to predators such as birds.

More information

GRDC Fact Sheet: Millipedes and slaters

A parasitic native nematode, *Rhabditis necromena*, attacks and kills millipedes by reproducing in the millipede's gut. However, the use of nematodes is unlikely to be economically viable for broadacre crop release.

Some spiders and beetles will eat millipedes but these predators will not significantly reduce large populations.

7.11.7 Slaters

Slaters perform an important recycling role in the environment. However, native and introduced slaters have become an increasing pest of broadacre crops and pastures. The move to minimum or no-tillage and stubble retention is likely to have created a more favourable environment in cropping paddocks for slaters. Stubble provides a cool, moist habitat, while crumbly clay soil surfaces and cracking clays aid their survival.

Description and development

Slaters are also known as woodlice, sowbugs and pill bugs. They are crustaceans, related to crabs, lobsters and prawns but are adapted to living on land. They have a hard skeleton on the outside of their bodies, seven pairs of jointed legs, and two pairs of antennae (Figure 28).

Most slaters are detritivores, meaning they feed on decaying vegetation and associated fungi, as well as on dead animal matter such as insects. They can eat living plants, such as seedlings and root vegetables, but only rarely.

Slaters need damp conditions and they will die if exposed to open and dry situations. They tend to be active at night when the risk of dehydration is low.

Female slaters keep their eggs in a pouch until the young hatch. Hatchlings then leave the parent and are completely independent. Slaters grow through a series of moults in which the outer rigid skeleton is shed, allowing growth to the next larger stage and finally to adult stage. When moulting, slaters shed in two stages: the top half of their body first, followed by the remaining half 2 days later. During moulting, the slater is very vulnerable and must find shelter. [52]

[52] GRDC (2013) Millipedes and slaters in no-till systems. GRDC Black Portuguese millipedes and slaters Fact Sheet, October 2013, http://www.grdc.com.au/GRDC-FS-Millipedes-Slaters

Figure 28: Like black Portuguese millipedes, slaters generally feed on organic matter, and their populations and the incidence of crop attack have increased in recent years. (Photo: © NICK MONAGHAN, LIFEUNSEEN.COM)

Species

Several slater species are found in Australia including:

- Common slater (*Porcellio scaber*). Originally introduced from Europe, the species is widespread in Australia. The common slater can grow up to 20 mm in length and is usually pale grey; however, brown, yellow or orange hues have been observed.
- Pill bug (*Armadillidium vulgare*). This is also a European species, introduced to Australia, and gets its name from its ability to roll into a ball when disturbed. It can grow up to 18 mm and is dark brown to black.
- Flood bug (*Australiodillo bifrons*). Populations of flood bugs have increased in parts of New South Wales. The flood bug is ~7–8 mm long and 4 mm wide with an oval-shaped and flattened body, light brown, with darker irregular spots and a dark-brown stripe down the middle of the back. It is a lowland, swampy-soil species. Areas worst affected in the past by flood bugs are prone to flooding (Figure 29).

Figure 29: Top left: common slater (Porcellio scaber). Top right: pill bug (Armadillidium vulgare); when moulting, slaters shed in two stages—the top half of their body first followed by the remaining half two days later. Bottom: flood bug (Australiodillo bifrons). (Photos: © NICK MONAGHAN, LIFEUNSEEN.COM)

Symptoms

Little is known about the biology of slaters and their potential to become a widespread agricultural pest in Australia.

Slaters can cause significant feeding damage, particularly on canola, leading to seedling mortality and stunted plant growth. In some situations, crops or parts of paddocks may need to be re-sown. Often, symptoms resemble feeding damage caused by lucerne flea.

Slater feeding on plants results in an uneven, rasping-type damage that can appear similar to slug and snail damage. They can chew the tops of emerging cotyledons or leaves of crop seedlings, leaving only the seedling stumps.

The flood bug in particular has potential to cause rapid damage to crops because of its ability to swarm. A consistent mass of slaters moves along the soil surface, climbing trees or moving into logs or posts (Figure 30). Swarms can contain >100,000 individuals, sometimes up to 1,000,000, and include all life stages, from juveniles to adults.

The size of swarms varies and is likely to be influenced by the time of day, weather conditions and surrounding vegetation. Thousands of seedlings can be eaten in a very short time when swarms are large enough.

Impact

It is uncommon for slaters to attack broadacre crops; however, problems with slaters have increased considerably in the last 5 years. In south-eastern Australia, slaters have caused damage to wheat, oats, canola, lentils and pastures.

The presence of slaters, even in high numbers, in a paddock does not always mean crop damage will occur, because slaters generally feed on decaying organic matter. Feeding on emerging crop seedlings is relatively rare. It is not known what makes slaters suddenly prefer to eat seedlings rather than organic matter.

In south-eastern Australia, damage has been reported in the medium- and high-rainfall zones including South Australia's Mid North and Yorke Peninsula, Victoria's Wimmera and Western Districts, and central New South Wales. In many cases (but not all) damage has been reported where there was an accumulation of stubble or other plant matter, or cracked soils. [53]

Management

Management options are limited after crop emergence, so prevention is a key part of control. No insecticides are registered to control slaters. Slaters are relatively unaffected by many foliar applications of synthetic pyrethroids and organophosphates to control other crop-establishment pests, even when applied at very high rates.

Managing stubble is likely to be the most effective strategy to reduce slater numbers. Some growers have had success managing slaters ahead of canola rotations by burning crop residues.

[53] GRDC (2013) Millipedes and slaters in no-till systems. GRDC Black Portuguese millipedes and slaters Fact Sheet, October 2013, http://www.grdc.com.au/GRDC-FS-Millipedes-Slaters

Figure 30: Typical swarming behaviour of flood bug (Australiodillo bifrons) moving across a wheat paddock. (Photo:: A Weeks, **cesar***)*

More information

GRDC Fact Sheets: Millipedes and slaters