MITIGATING SNAILS, SLUGS AND SLATERS IN SOUTHERN WESTERN AUSTRALIA

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Mitigating Snails, Slugs and Slaters in Southern Western Australia
Grower Case Studies

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Acknowledgements
Thank you to the growers in Western Australia and South Australia who took time away from their businesses to share their experiences with managing these pests.

Brent Pritchard, Farmanco, Albany

Michael Richards, Ag Excellence Alliance, SA

Andrew Heinrich and Monica Field, Farm and General, Esperance

Title: Mitigating Snails, Slugs and Slaters in Southern Western Australia

ISBN: 978-1-921779-83-1 (online); 978-1-921779-82-4 (print)

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Design and production: Coretext, www.coretext.com.au

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INTRODUCTION

The move to no-till farming practices, which has increased the amount of retained crop residues on farms, has resulted in substantial improvements in soil health and crop productivity and enhanced farm business viability. However, the change has also favoured some pests that thrive in these environments, including snails, slugs and slaters. Crop damage caused by these pests has increased in the past 10 to 15 years across Western Australia's grain-growing regions since the adoption of no-till farming.

Snails are the most widespread of these pests in Western Australia (WA). They cause damage to grain crops at germination and can potentially cause a costly downgrade of harvested grain if not carefully managed. Slug damage is steadily increasing across the medium to high-rainfall zones with emerging canola crops being particularly vulnerable. Slaters have been in farming systems for some time but have only recently begun to damage emerging canola crops in specific conditions.

Work on the ecology and control of snails and slugs has been underway in the eastern states for more than a decade and more recently in WA. Less is known about slater behaviour and control, with reports of damage still relatively limited compared with the other pests. Our understanding of slaters so far relies on anecdotal reports of damage from growers and agronomists.

The aim of this booklet is to combine research and grower experiences from Southern Australia (SA), the eastern states and southern WA and share it with WA growers in an easy-to-read format, with information that can help growers to reduce the numbers of snails, slugs and slaters on their farms. The booklet provides a consistent approach to integrated pest management throughout the year that should help to reduce numbers and damage to manageable levels and prevent these pests from becoming a more significant problem.

BEST PRACTICE MANAGEMENT

Snails

Species

There are four species of snails in WA that can cause damage to broadacre crops: the small conical snail; the pointed snail; the vineyard snail; and the white Italian snail. While these species are present across south-west WA, they cause the most significant losses in the higher-rainfall areas where the relatively cool, wet summers allow them to survive.

Small conical snail

Small conical snails (*Prietocella barbara*) are the most widespread species in WA and are more likely to affect grain quality due to their size, which is usually less than 10 millimetres. The snails are conical in shape with seven or eight whorls and have variable shell colour: pale yellow to off-white to grey with brown banding or spots.

Small conical snails seem to live more comfortably in acidic soils than other pest snail species, although anecdotally their populations increase where acidic soils have had lime applied. In summer they can be found on, and inside, stubble stalks and sheltering under rocks and stumps. They can burrow up to a depth of about 50mm (DPIRD, 2018). They will climb up fence posts, vegetation and crop stalks over summer, which is why they can cause problems at harvest.

Small conical snail *Prietocella barbara*. PHOTO: DPIRD

Small conical snail shells with scale. PHOTO: PESTS AND DISEASE IMAGE LIBRARY (PADIL), AUSTRALIA

Pointed snail

The pointed snail (*Cochlicella acuta*) is a pest species mostly found in SA, but isolated populations occur in WA and New South Wales (NSW). This species also has a conical shape and is similar in colour to the small conical snail, but its mature length is 18mm. The two conical species can be distinguished by comparing the ratio of the shell length to the base width. In small conical snails this is always less than two, for example the conical shape appears short and wide, whereas in the pointed snail the ratio is always greater than two, that is the conical shape appears slender. Reports of crop damage or grain contamination by this species in WA have not been confirmed.

Pointed snails with scale. PHOTO: PADIL, AUSTRALIA

Pointed and small conical snails on stubble. PHOTO: CSIRO

Vineyard snail

The vineyard snail, also known as the common white snail (*Cernuella virgata*), occurs in isolated areas along coastal cropping areas of WA. This species has a round shell that is six to 19mm high and eight to 25mm wide. The shell colouration is generally a creamy white with continuous pale to dark brown markings around the spiral. Vineyard snails prefer alkaline soils with high calcium content, mainly near the coast; liming paddocks can aid their survival. This species prefers to climb fence posts and vegetation, including crop stalks, to get off the hot ground in summer and so can be harvested with the grain. The shape of this snail means it can be easier to clean from grain, but this depends on the age of the population (which will dictate shell size) and the crop being harvested.

Vineyard snail (*Cernuella virgata*).
PHOTO: DPIRD

A comparison of the vineyard (*C. virgata*) and white Italian snail *(T. pisana*).
PHOTO: PADIL

White Italian snail

The white Italian snail (*Theba pisana*) is very similar to the vineyard snail and occurs in small pockets along WA's south coast. It has a round yellow-white shell, with or without a broken brown band around the spiral, and can grow to between 13 and 30mm high. The white Italian snail is slightly flatter (low spire) than the vineyard snail and the hole in the centre of the shell (umbilicus) is normally more closed off.

This species prefers alkaline soils with high calcium content and populations can increase with applied lime. Similar to other species, it avoids hot ground over summer by climbing posts, vegetation and into the crop canopy, and so presents a risk for grain contamination. Like the vineyard snail, the shape of the white Italian snail means it can be easier to clean from grain, but this depends on the age of the population (which will dictate shell size) and the crop being harvested.

White Italian snail (*Theba pisana*).
PHOTO: DPIRD

White Italian snails shelter on weeds over summer. PHOTO: PADIL

TABLE 1: Calendar with the snail and slug life cycle and on-farm management.

	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
	Harvest				Seeding			Spreading	Spraying		Swathing	
Snails and slugs	Inactive. Lodged in crop canopy or under stubbles, rocks or stumps			Becoming active	Actively feeding and breeding Egg laying and hatching		Juveniles also feeding			Moving into crop canopy or under stubbles, rocks or stumps		
Integrated management	Summer weed control											
	Stubble rolling, cabling, slashing											
			Stubble burning									
				Baiting paddocks and fencelines						No baiting before harvest		
	Grain cleaning											
Monitor	In grain and on header fronts		Around sheds and under/in stubbles		In emerging and established crops					In heads and under swaths		

Note: for slug information, refer to the slug section on page 21.

SOURCE: ADAPTED FROM *BASH 'EM, BURN 'EM, BAIT 'EM: INTEGRATED SNAIL MANAGEMENT IN CROPS AND PASTURES*, SARDI, GRDC, 2003.

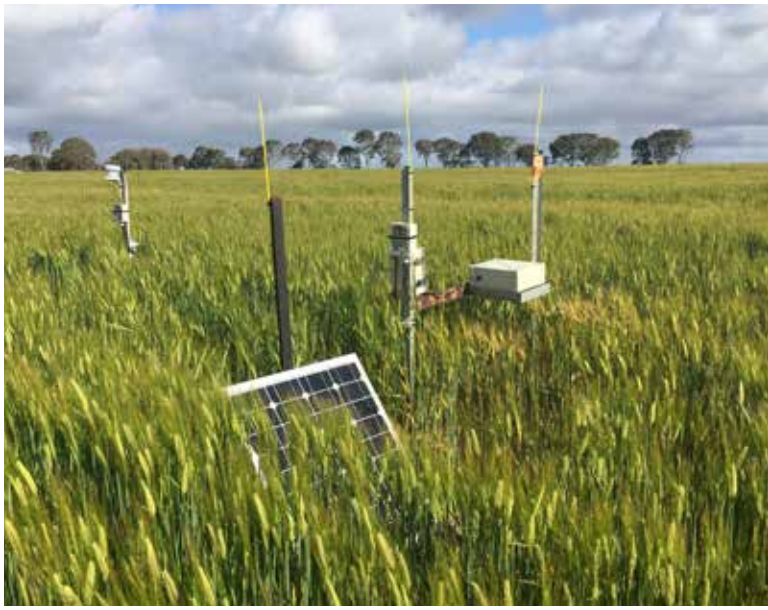
Life cycle

A calendar of the snail's and slug's life cycles is summarised in Table 1, demonstrating how it relates to farming activities and snail mitigation practices (for slug management, refer to page 21). It is important to understand the snail life cycle and the environmental triggers for its behaviour for control measures to be most effective.

Snails are inactive or dormant during summer when the weather is hot and dry. Round and small conical snails will generally climb up stubbles, fence posts and vegetation. Small conical snails will also burrow underground or under rocks and stubbles. While snails are generally inactive during summer, camera studies have shown that with summer rain and 90 per cent relative humidity, round snails will become active (Richards et al., 2016). In the cooler month of March, 80 per cent relative humidity is enough for snails to begin moving and feeding. Egg laying will occur if the topsoil remains moist; egg clusters are usually laid at the soil surface. If conditions remain favourable, eggs can be laid as early as April, meaning control methods need to start earlier in March to stop the breeding cycle and ensure both snails and eggs are destroyed.

The albumen glands of snails swell during reproductive activity and larger glands indicate active egg laying. Snail dissections, in conjunction with paddock camera observations, are being used by entomologists to determine if snails are ready to mate to guide baiting programs (DPIRD PestFax, Nash et al., 2016).

All snail species are hermaphrodites with each individual snail having both male and female sex organs and able to lay eggs. Snails can lay about 400 eggs per season with eggs hatching two to four weeks after laying. Round snail hatchlings will be about 1.5mm in length and small conical hatchlings will be 1mm in length. Juvenile snails feed over winter but are not sexually mature until the following autumn.



A snail/slug camera in a paddock provides timely information on the movement of these pests to inform control options. PHOTO: STIRLINGS TO COAST FARMERS

Snails and crop damage

Snails eat emerging seedlings and can cause large areas of crop damage and reduced yields if left uncontrolled. Snails climb under swathes and into grain heads over summer, which can cause problems during harvest, resulting in load rejections and extra costs for grain cleaning. Snails can affect grain quality, which presents a serious threat to our reputation in high-value international grain markets.

Small conical snail damage to barley.

Evidence of snail damage can include bare patches in crops, irregular pieces chewed from leaves, shredded leaf edges or stumps. At crop emergence, where seedlings have been chewed down to the ground, it can be difficult to diagnose snails as the pest. Snails do not normally damage seed, but they can damage germinated seeds close to the soil surface. Snails may be difficult to find on the soil surface during the day, preferring to hide inside or under stubbles, rocks or stumps. You may be able to see them more easily at night when they are most active. Snails are most damaging to canola but can also damage cereal crops if numbers are high enough.

Snail monitoring and control options

There is no 'silver bullet' for controlling snails and they cannot be entirely eradicated. Options for snail mitigation are presented as part of the annual calendar in Table 1. Snail mitigation activities need to occur throughout the year to reduce numbers and minimise crop damage and maintain grain quality. Activities that target snails at the beginning of the year, before they can breed and lay eggs, will determine numbers at seeding, harvest and the following autumn. Therefore, it is important to understand snails' behaviour and life cycle during summer and autumn. Implementing one mitigation strategy, such as baiting, is unlikely to provide adequate control in the long term.

The growers interviewed for the case studies in this booklet found that with no control and the right environmental conditions, snail numbers can build up quickly, so consistency and timing are important.

Monitoring

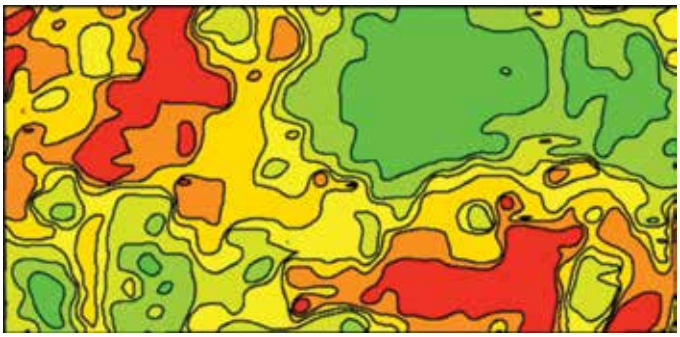
Growers interviewed for these case studies recommend looking for snails as often as possible so control can start early when populations are still small or in an isolated area. Looking during harvest or at the beginning of the year, well before seeding, gives you more options for control later.

Many growers first noticed snails around their sheds, presumably brought in on vehicles or machinery. Others found them collected on the header or swather fronts during harvest. In the paddock, look for snails on fence posts and under stumps, rocks or stubble. Snails are more active in summer and autumn after rain or at night. Start looking for snail activity on moist, cool nights or for slime trails in the morning.

Small conical snails sheltering on rocks over summer.

One way to estimate how many snails are present is to count the number of snails in a 10 centimetre by 10cm square. Do this in at least 50 spots in the paddock and multiply by two to give the number per square metre. Taking lots of sampling points within paddocks known to have snails will give a good indication of their numbers and where they are mostly found. Live snails are those that are moist when squashed. Growers with experience of snails indicate they are rarely distributed evenly across a paddock and often occur in 'hotspots'. This is demonstrated in Figure 1, which shows the density of snails mapped across a paddock including areas of very high concentrations (Moore et al., 2018).

FIGURE 1: The density of small conical snails mapped across a paddock showing how populations can occur in high-density 'hotspots' (Moore et al., 2018).



MOORE ET AL., 2018

The WA Department of Primary Industries and Regional Development (DPIRD) estimates more than 20 small conical snails per square metre in canola and pulses, or 40/m^2 in cereals will cause economic damage (DPIRD, 2018). For round snail species, more than 5/m^2 in canola or pulses, or 20/m^2 in cereals will result in damage (DPIRD, 2018). Snail counts should be taken across the paddock to establish how many are present per square metre.

Growers advise acting quickly to manage any snails found, even if numbers are low or populations are mostly found around sheds and buildings rather than in crops. Do not wait for crop damage or problems at harvest to act. Snail numbers can build quickly and spread, which means any areas where snails are found should be baited thoroughly and checked regularly to contain spread.

Snails accumulating on a swather front.

Managing the green bridge

Snails use green weeds and regrowth over summer (the green bridge) for food and shelter, which aids their survival during hot, dry weather. Green material in the paddock can also reduce the effectiveness of any stubble 'bashing' activities, impede stubble burning and compete with baits. Spraying or grazing green material early in the season can reduce snail survival over summer and increase the effectiveness of other snail mitigation activities. If it is not possible to control weeds over summer, ensure they are sprayed at least two months before seeding. Controlling weeds along fencelines and around dams, troughs and sheds is equally important so they do not harbour snails.

Small conical snails sheltering under green vegetation over summer.

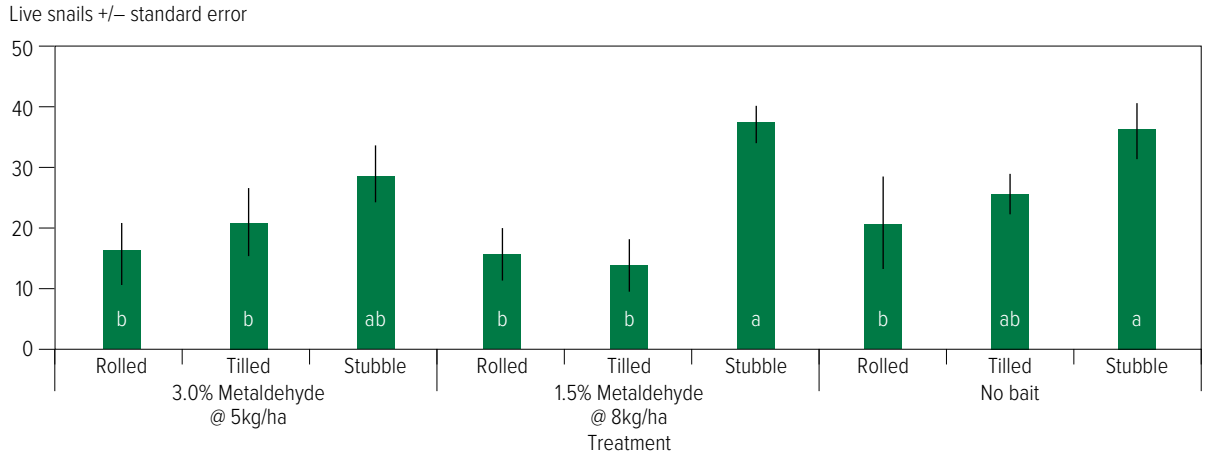
Stubble management

Stubble retention after harvest is a major factor in snails becoming a cropping pest in recent years. Stubbles provide food and shelter to snails during summer and inhibit snail contact with bait points closer to seeding. Retained stubbles also maintain soil moisture over summer, preventing snails from drying out (desiccating). Moist soils are also favourable for egg laying and survival. Reducing stubble loads can help to reduce snail numbers.

Stubble that was rolled or lightly tilled was shown to have lower round snail numbers than where stubble was retained (Gontar and Nash, 2017). Lightly tilling kills some snails, but if this was followed by baiting, more snails were killed. In areas where stubble was retained, untouched baits were found several weeks later, whereas after rolling or light tillage the baits were more accessible to the snails, so they were all consumed. Both stubble treatments were carried out in February in temperatures greater than 35°C and low humidity. Note that removing or damaging stubbles will decrease soil moisture and expose soils to potential wind and rain erosion later in the season.

Cabling, chaining, rolling or slashing stubbles are all techniques used to knock snails off stubbles and expose them to the hot soil surface to dehydrate and kill them. Some techniques cause rocks, stumps and plant roots in the paddock to be up-ended to expose small conical snails hiding underneath. The pros and cons of stubble bashing techniques are listed in Table 2.

FIGURE 2: Number of live round snails after three stubble treatments at Coulta, SA* (corrected for initial population density).



* Treatments: 1) rolling with a ribbed stubble roller; 2) light tillage with a speed tiller; and 3) retained stubble and two baiting treatments. Note that letters indicate statistical differences, e.g. 'a' is statistically different to 'b', while 'ab' is not significantly different to either 'a' or 'b'. Bars indicate standard error.

SOURCE: GONTAR AND NASH, 2017

TABLE 2: Considerations for using stubble-bashing techniques to control snails.

Pros of stubble-bashing techniques	Cons of stubble-bashing techniques
High kill rate for round snails; 50% to 90% killed when conditions are right	Effect on small conical snails is less well understood due to different behaviour in hot weather
Rolling is less weather dependent	Several hot, sunny days over 35°C required for cabling or chaining
Most effective if there is no green material in the paddock	All stubbles need to be flattened, which may require repeating the treatment
Part of an integrated control program, reducing reliance on baits	Less effective in dense cereal stubbles
Relatively cheap and can cover a lot of ground quickly	Cabling or chaining may pose a fire risk
	Removing standing stubble can increase the risk of aphids colonising seedling crops

SOURCE: ADAPTED FROM BASH 'EM, BURN 'EM, BAIT 'EM, SARDI, GRDC, 2003

Small conical snails shelter on canola stubble.

A stone roller used for crushing stubbles. Stubble management is normally done before seeding. PHOTO: KINGSWAY WELDING

Stubble and windrow burning

Burning paddocks will reduce stubble loads and kill any sheltering snails at the same time. Burning is normally conducted in late summer or early autumn, as close to seeding as is practical to avoid wind erosion. It is very effective on round and conical snails, although some small conical snails may escape the burn if they have burrowed underneath rocks or roots and the burn is not hot enough.

Burning the whole paddock will be hotter and, provided it is even with no unburnt patches, will thoroughly remove all stubbles and kill high numbers of snails. Summer weeds should be thoroughly desiccated and browned off before burning or else they may provide shelter. Growers may consider turning rocks or roots over by cabling or fire harrowing to expose snails hiding underneath.

Achieving an even, controlled burn over the whole paddock requires good weather conditions, and time and attention to ensure the burn is even and does not escape. There is the risk of wind or rain erosion on the bare paddock before seeding, particularly on lighter soils. However, when snail populations are large, burning the whole paddock every three to four years may be worth the effort and risk. Burning stubbles can be less effective for controlling snails in 'cracking soils' where small conical snails shelter in the cracks (Turner and Nash, 2018; DPIRD PestFax, June 2017).

Burning windrows can kill 90 per cent of small conical snails in canola stubble while reducing the potential impact on soils (Micic et al., 2016). Narrow windrows, created during harvest by installing chutes behind the header, burn hotter and are particularly effective for killing snails. Windrows can also be created later in the season by raking stubbles before burning; however, the longer the windrows sit on the ground the better the kill rate as it gives snails more opportunity to move into the windrow before burning. Having minimal stubble or green material in between rows also increases the number of snails in the windrow. Creating windrows can cause uneven nutrient distribution within the paddock.

Chutes fitted to header to create narrow windrows in canola stubbles.

Dead snails left after burning a canola windrow. PHOTO: DPIRD

Tillage

Given that snail populations appear to have increased with the adoption of no-till and stubble retention farming practices, reintroducing light tillage might help to reduce their numbers. Tillage can bury snails, which may result in death and disturb egg clusters. Burying stubbles with tillage may also reduce snail numbers by disrupting their summer shelter. Tillage should be done in early autumn, before juvenile snails can hatch.

Trials have shown that wide points or full-cut discs are most effective and can reduce snail numbers by 40 to 60 per cent (*Burn 'em, Bash 'em, Bait 'em*, 2003). Narrow points are not as effective and may need multiple passes. There has been an increase in light tillage to cut and incorporate heavy stubbles into the soil. Gontar and Nash (2017) showed that using a speed tiller to approximately 5cm depth (offset disc and cage roller) significantly reduced snail numbers on its own and improved the effectiveness of the later baiting program.

Any tillage will increase the risk of soil erosion, especially on lighter soils, and can damage soil structure and reduce soil moisture. Therefore, the benefits of snail control need to be weighed against these risks. No growers in this booklet's case studies use tillage regularly for snail control.

Grazing

Grazing animals can knock snails from stubble to the ground in a similar way to cabling, break up stubble refuges and trample or consume snails accidentally. Grazing can also reduce stubble loads in paddocks, reducing shelter for snails over summer and stubble competition for snail baits. *Burn 'Em, Bash 'Em, Bait 'Em* (SARDI, GRDC, 2003) reported grazing resulted in a 32 per cent reduction in snails on a lentil stubble.

Baiting

Baiting remains a key tool for all growers interviewed for these case studies, whether it is in patches for those with new snail infestations, or on a wide scale for farms where snails are established. Generally, growers are baiting earlier in the season and/or post-seeding, pre-emergence. They prefer metaldehyde-based baits, choosing the brands that provide the highest number of bait points per square metre. Using baits alone will never provide complete control of snails and should be used in conjunction with weed control and stubble management.

Controlling snails using sprays has been shown to be ineffective. A review of local and international trials testing molluscicide sprays has shown they provide inconsistent and poor control of snails (Nash et al., 2013; Micic et al., 2013). This is because of the difficulty of getting the sprays to make adequate physical contact with snails, which either hide under stubbles or retract into their shell and remain dormant as soon as the hostile chemical is detected.

Timing

Baiting is an expensive activity, with growers estimating the cost at $25 to $30 per hectare (for two metaldehyde applications at the registered rate), so it is worth baiting effectively to get the best value. Timing is crucial; for baits to work the snails need to be active and feeding. Baiting adult snails before they can breed and lay eggs will have the biggest impact on protecting crops and reducing snail populations. Juvenile snails are less responsive to baits and are most likely to cause damage to emerging crops and end up in the grain at harvest.

With adequate moisture, round snails often started mating after mid-March, so the first egg laying could be in early April. While conical snail activity was slightly behind that of the round species, it still indicates that growers may need to start baiting earlier in the season to prevent egg laying.

To determine whether snails are active, growers can start looking for snail movement if there is a period of cooler, wet conditions. Snails are more active at night and some growers look for snail trails on the ground in the morning to indicate whether they have been active. Otherwise, baiting a small area and checking for dead snails a few days later is a good way to confirm snails are active and feeding.

Weather-fast baits

Nash et al. (2016) showed that metaldehyde baits can degrade when exposed to temperatures above 30°C to 40°C for more than two weeks, either in the paddock or in storage. Therefore, metaldehyde baits should be stored carefully and not applied until the cooler months of late summer or autumn, which is when snails are more likely to be active and feeding. The iron chelate baits tested in the same trial were not affected by high temperatures.

Rain-fast baits will be more effective if heavy rain is expected as they will remain intact for longer in the paddock than bran-based baits, which can be broken down and become less likely to deliver a lethal dose of the active ingredient (Nash et al., 2016; McDonald and Micic, 2017). All baits can degrade in the paddock and develop mould, although this does not necessarily reduce their consumption or the concentration of active ingredient (Nash et al., 2016).

Increasing bait interception by snails

Snails do not seek baits out by sight or smell, but come across baits randomly (Baker, 2018; McDonald and Micic, 2017). Increased stubble loads or a soft seedbed can reduce the chance of snails encountering bait. Any green weeds or crop in the paddock will provide an alternative source of food and reduce bait effectiveness.

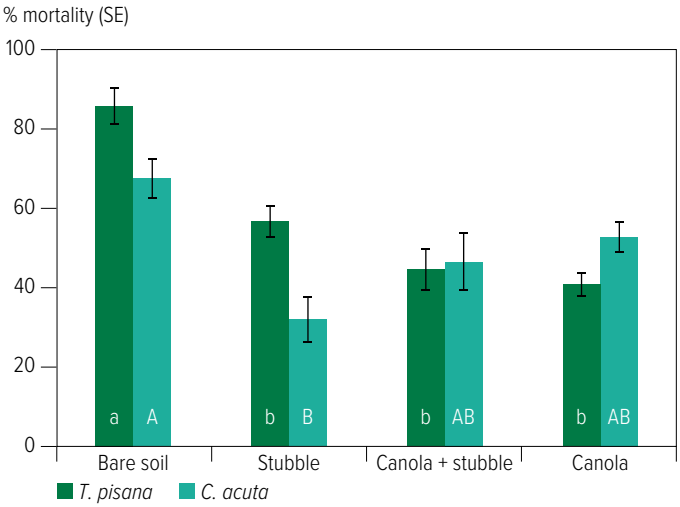
Trials have demonstrated that stubble cover and alternative food sources reduce the chances of snails encountering baits (Baker and DeGraaf, 2014). Snail mortality was highest on bare soil compared with plots with stubble cover and/or canola seedlings (Figure 3).

A minimum of 30 bait points per square metre – and up to 60 bait points per square metre in highly infested areas – should provide the best chance of a snail encounter (Nash et al., 2016). Where labels do not allow such high rates, growers may repeat applications over a period of time. Thick stubbles or loose soil increase the surface area, so the number of bait points may have to be increased accordingly.

Snail mortality after baiting.

PHOTO: DPIRD

FIGURE 3: Mortality of juvenile round (*Theba pisana*) and large conical (*Cochlicella acuta*) snails exposed to Mesurol (two per cent methiocarb) baits in laboratory trials.*



* Trials were conducted on 1) bare soil, 2) stubble, 3) canola seedlings and stubble and 4) bare soil and canola seedlings. (Different letters of same format indicate significant differences within species, Tukey HSD test).

SOURCE: BAKER AND DEGRAAF, 2014

Where to bait and how often

The DPIRD thresholds for round and small conical snail numbers that require control are provided on page 11 in the 'Monitoring' section. Growers interviewed for these case studies suggest that if snails are only just beginning to move into a property, baiting should occur even at very low numbers to prevent their spread.

Growers with an established snail population are more flexible and base their baiting program on a paddock-by-paddock and season-to-season basis. They use crop damage the previous season, snails in grain or on machines over harvest, and the crop rotation to decide whether to bait and how many applications are necessary. Growers in SA and some parts of WA routinely bait their whole farm once or even twice a year, normally in early autumn and after seeding, before crop emergence. This is always combined with other control methods, including weed control and stubble management early in the season.

The use of mobile phone app technology to map snail and slug densities in paddocks has been trialled (Moore et al., 2018). This could facilitate variable-rate baiting for localised snail densities within paddocks to reduce costs. More information is presented in the DPRID case study in this booklet.

Baiting in spring is not cost effective. A higher proportion of the snails in spring are juveniles that do not travel large distances and are less likely to encounter baits. There is also ample green feed available to compete with the baits. If snails are found in mature crops, harvest snail control should be implemented to maintain grain quality (see 'Managing snails at harvest') and snails managed over summer and autumn the following year.

Bait spreaders

WA growers use a variety of methods to distribute baits over paddocks including ute or quad-mounted spreaders for patching out areas, conventional fertiliser spreaders, three-point linkage spreaders for improved accuracy and aerial baiting by a plane. All growers caution the need to calibrate any machines with baits to get the most even spread without fragmenting the baits. Trials conducted on different methods for spreading baits and the results can be found in the *Snail Bait Application Fact Sheet* on the GRDC website. The key points identified are:

- the more even the bait is spread, the more likely snails will randomly intercept a bait;
- the size and density of bait pellets determines the distance it is spread;
- fertiliser spreaders will not spread baits (which are lighter) as far as fertiliser;
- if spreaders are run too fast, baits can be fragmented or 'powdered', reducing their effectiveness;
- calibrate spreaders to get the best coverage of baits; and
- ute spreaders give a less even distribution of baits and are better suited to fencelines or patching out smaller areas.

DPIRD have developed an app called SnapBait which assists in the process of calibrating your snail bait spreader and can estimate the number of baits points per metre square. For more information visit www.agric.wa.gov.au/apps/snapbait.

Managing snails at harvest

Predicting snail numbers at harvest can be difficult as it depends on several factors including:

- snail numbers in the paddock during the year;
- the size and shape of the snails compared with the grain;
- the maturity of the snails, as well as the species, which affects their size in comparison to the grain;
- their location within the crop canopy; and
- the temperature and soil/crop moisture at harvest.

The maturity of the snail population can determine the risk of grain contamination, for example, if there are snails the same size as the grain. PHOTO: DPIRD

Both conical and round snails will climb crop stems and go into the canopy as the weather warms, which means they can enter the header at harvest and affect grain quality. This can result in grain loads being downgraded or rejected because they do not meet grain receival quality standards. There are three main strategies to maintain grain quality at harvest:

1. Minimise snail intake into the header.
2. Maximise snail and grain separation within the header.
3. Clean grain after harvest.

Growers should be looking for snails in their crop canopy three to four weeks before harvest to estimate the risk of problems at harvest.

Small conical snails in the grain head at harvest. Small conical snails can be quite difficult to dislodge from grain heads. PHOTO: DPIRD

Timing of harvest and swathing

The time of day and weather conditions can determine whether snails will be higher in the crop canopy (Micic, 2017). Round snails are more likely to climb up into the crop during hot weather and go back down to the ground when it is cool, so harvesting crops with round snails on cooler days or at night reduces the risk of them entering the header.

Small conical snails are more likely to descend to the ground and shelter under stubble or roots when it is hot and climb up into the crop when it is cool, moist or at night time. They may also be easier to dislodge from crop heads after light rainfall. Harvesting paddocks with high numbers of small conical snails during the hottest part of the day may reduce header intake.

Snails will move into the windrows of crops swathed to dry, such as canola. The longer a swathe sits in the paddock, or the lower the swathe is to the ground, the greater the number of snails that will shelter in it (Micic, 2017).

Swathing barley and immediately picking it up with a header can reduce the number of round snails in grain by 55 to 75 per cent by knocking snails off the grain heads onto the ground (*Snail Management Fact Sheet*, 2012).

No sprays have consistently or effectively deterred or repelled snails from crop canopies at harvest time (Baker et al., 2017).

Header modifications

Header modifications, while effective at reducing snail contamination, will generally have a trade-off, such as slowing header speed, increasing grain losses or causing grain damage (Baker et al., 2017). The booklet *Bash 'Em, Burn 'Em, Bait 'Em: Integrated snail management in crops and pastures* (2003) provides detailed information on preventing snails entering headers and describes header modifications that can be made to maximise grain and snail separation.

One method of reducing snail intake into the header is using a stripper front with a higher cutting height to avoid snails in the lower parts of the canopy and vibrating the standing heads to dislodge snails before they go into the header. This can remove up to 50 per cent more snails than a conventional front and is most effective on large round snails in medium to heavy crops (*Bash 'Em, Burn 'Em, Bait 'Em*, 2003). Lifting the cutting height of an open front machine may have a similar effect. While some growers use stripper fronts and find them to be very effective at reducing snail numbers in the grain, they have to weigh this advantage against managing the standing stubble mass next season.

Dislodger bars, rotary brushes or flexible fingers attached to the header front can knock snails off the grain heads before they enter the header. These devises are generally more effective on round snails than small conical snails, which are smaller and can shelter in narrow crevices in the crop heads, making them harder to dislodge. These tools are most effective early in the season or in areas of high infestations such as the paddock perimeter, reportedly providing an 80 per cent reduction of snails in cereals and a 60 per cent reduction in tall pulse crops (*Bash 'Em, Burn 'Em, Bait 'Em*, 2003). Any modification to the header front that will dislodge snails from crop stalks will also have the potential to cause head loss, so needs to be considered carefully.

A dislodger bar fitted to the front of a header. PHOTO: GRDC

Growers can also make modifications to their headers to increase the separation of snails and grain within the header. This includes increasing thresher intensity to crush snails within the header, with the shells being removed from the grain later using air separation. Again, this is more effective on larger round snails but can clog parts of the header with dead snail mass and physically damage the grain.

Where snails are significantly different in size to the grain, fixed aperture sieves may improve the separation of snails through physical screening or scalping, rather than relying on air separation. Their success relies on choice of sieve design (punch hole, slotted or woven mesh) and hole size. More information on the use of fixed aperture sieves is available in *Bash 'Em, Burn 'Em, Bait 'Em* (2003) and the *Snail Management Fact Sheet*, both available via the GRDC website. Fixed aperture sieves can reduce the header capacity.

Cleaning grain

There is little current research into the best methods of cleaning snails from grain (Sharma, 2002; *Bash 'Em, Burn 'Em, Bait 'Em,* 2003). A 2017 grower survey of harvest and summer snail mitigation highlighted the value of snail-crushing rollers in the Yorke Peninsula and the need to expand this technology to other snail-affected regions (Baker et al., 2017). The survey showed SA growers have been successfully using a combination of rotary screen grain cleaners and snail rollers to clean their grain for several years. Some WA growers are also cleaning their grain using rotary screen grain cleaners.

Cleaning snails from grain relies on exploiting different physical properties between the snails and the grain, such as size, weight/density, strength and shape, to separate them. The three main methods of cleaning grain use gravity, air and screening or scalping. The information below is summarised from *Bash 'Em, Burn 'Em, Bait 'Em* (2003).

Gravity separation, or air tables, uses differences in bulk density to separate grain from debris. It requires a significant difference between the bulk density of the grain and snails being separated to work successfully. This can be enhanced by storing grain so that snails dry out, desiccate and become lighter. Gravity separation has been shown to remove round (3 to 12mm diameter) and conical (2 to 8mm length) snails from canola, barley, peas and lentils based on their relative bulk densities.

However, while gravity separation is employed by professional seed cleaning companies, it has not been widely adopted by growers, perhaps because of the cost of equipment. An inclined belt separator can separate small conical snails from canola grain, but again there are trade-offs as they are slow and, to current knowledge, this method has not been further developed.

Air separation uses differences in terminal velocity to remove particles from grain. Unfortunately, using air separation to remove snails from barley, canola and lentils can result in grain losses as the grains and snails have similar terminal velocities (*Bash 'Em, Burn 'Em, Bait 'Em*, 2003). Air separation can be useful after grain rolling should it be necessary to remove dried snail meat and shell from grain.

Screening and scalping grain uses sieves to remove debris. Screening removes particles smaller than the grain and scalping removes particles larger than the grain. Screening and scalping are usually done with a rotary screen grain cleaner. This method relies on snails being a different shape or size to the grain, which can vary with crop, snail species and seasonal conditions. Even within a single snail species, snail size can vary significantly depending upon maturity. If there is a large proportion of snails that is the same size as the grain it will be difficult to clean effectively using rotary screens alone. SA growers use a combination of rotary grain cleaners and snail rollers to clean their canola (see 'Snail-crushing rollers').

A rotary screen cleaner can be used to scalp small conical snails from canola.

WA and SA growers use rotary screen grain cleaners to remove round and conical snails from canola. These cleaners work by scalping the larger snails from the grain. The rate of success depends largely on the size of the snails compared with the canola seed, which can vary within parts of the paddock and from year to year. Most growers interviewed for the case studies in this booklet in 2018 are using 2 to 3mm slotted screens (expanded metal mesh), although some plan to experiment with round (punch hole) screens. A large, four-barrel seed cleaner using

2.5mm slotted screens can clean canola at 25 tonnes per hour. One consideration when choosing screens for canola is that the different canola varieties can have quite different seed sizes.

Cleaning during harvest requires a system of field bins and augers and may need logistical juggling if the grain cleaner is slower to turn off grain than the header. Cleaning grain after harvest requires adequate storage space to accommodate grain until it can be cleaned, but may offer the advantage of snails desiccating during storage, which makes them easier to separate. The cost of getting grain cleaned professionally needs to be proportional to the cost of downgrading grain due to snails. Whichever method is chosen, cleaning grain is an added burden to growers that requires significant cost, time and organisation during, or immediately after, the busy harvest period.

Unfortunately, the bulk of snail removal has to be undertaken by individual growers who clean grain during or after harvest, either on farm or with a contracted grain cleaner. A 2002 grain cleaning study (Sharma, 2002), showed that it would be more efficient if snail removal were done cooperatively on a large scale by a group of growers rather than by individuals. This would allow several different types of grain cleaning processes to be used for maximum effect and efficiency and would likely result in a much more uniform grain product most suitable for grain markets.

Snail-crushing rollers

Snail rollers are used in parts of SA to crush round and conical snails in cereals, canola, lentils, peas and faba beans. These snail rollers exploit the difference in strength between the snail shell and grain hardness. Grain is augured into the hopper and passes through two rollers of 250mm diameter. As the grain passes through the rollers it is placed under pressure, causing the surrounding grain to crush snails into pieces. The two rollers have different surfaces, with one having a striated metal surface and the other a rubber-coated surface. The distance between the rollers is normally less than 1mm, although this depends upon the size and strength of the grain being handled.

The speed of the roller depends on the grain being processed; for example, processing canola is slower than cereals. Running the roller faster does not crush more snails and can cause the rollers to heat up and sustain damage. There are now larger snail rollers available with double the number of rollers that can process about 40 to 50t/h of cereal grains compared with the original single roller at 20 to 30t/h. A prototype grain roller is being tested in SA that is expected to process cereals at 75t/h (pers. comm., Chris March Engineering, 2018).

Snail rollers cost approximately $25,000 (+GST) for a single model and $48,000 (+GST) for the double model. The major operating cost is having the rollers resurfaced and a set of replacement rollers costs about $2500 (+GST).

The Stirlings to Coast Farmers (SCF) group in WA demonstrated a small snail-crushing grain roller during the 2018-19 harvest to provide more information for local growers on their use. The roller used was a Kingsway Welding single grain roller (with one rubber and one metal roller). The first grain tested was Granger® barley.

The roller was run empty at lower revolutions per minute (RPM) (tractor power take-off (PTO)) to warm it up for about 10 minutes. It was then run at a higher RPM with a full hopper of grain (SA growers report rolling cereals at about 550 RPM to give a maximum flow rate without damaging the rollers). Initially the roller was tested with the rollers 3.5mm apart and this was progressively reduced to get the maximum snail crush without damaging the grain. This was achieved when the rollers were less than 1mm apart. The roller processed the grain at 20t/h. SCF used a tractor to run the snail roller PTO and the in-loading auger.

The barley tested in this trial had fewer than five snails per half-hectolitre in it before rolling and grain measurements showed that after rolling there were zero snails per half-hectolitre. Anecdotally, SA growers report that wheat with up to 30 snails per half-hectolitre could be cleaned with a similar roller to reduce snail numbers to zero.

The barley used in the SCF trial was incidentally stored for several weeks before rolling and this appeared to make the snail shells drier and more brittle. This mirrors anecdotal reports from SA growers that storing grain before rolling can provide a better snail crush. However, SA growers also routinely roll grain in the paddock at harvest with good results.

SCF also demonstrated the snail roller cleaning canola during the 2018-19 harvest. While running a 25t sample of canola through the snail roller adjustments were made to the flow of grain onto the rollers, the gap between rollers, and the PTO speed to compare the effect on snail removal and grain quality. Grain samples were collected after each adjustment and tested with the cooperation of DPRID.

Data from the demonstration was still being processed at the time of publication and will be available at from the Stirlings to Coast Farmers website (www.scfarmers.org.au). However, early

The single model snail roller used to remove snails from barley in the 2018-19 SCF demonstration. PHOTO: SCF

results indicate that while admixture percentage and the number of damaged seeds was slightly higher in the rolled canola, the grain still met the 2018/19 receival standards for the highest canola grade.

Preliminary snail counts show that while the snail roller did reduce the number of snails in the rolled canola compared to the unrolled canola, it did not reduce them to zero. This may be because the canola was not cleaned with a rotary grain cleaner prior to rolling which is the common practise for cleaning snails out of canola in SA. SCF plan to do more comprehensive trials with the snail roller during 2019.

SA growers interviewed for this booklet use a combination of rotary screen grain cleaners and snail rollers to remove snails from canola. They report that this method can reduce snail numbers from 30 snails per half-hectolitre to zero without damaging the grain. Canola was rolled at about 400 RPM.

Snail biosecurity

Snails can arrive on farms from machinery, grain or forage entering the property from other snail-contaminated farms. Snails can also migrate from paddocks on neighbouring farms. Many growers interviewed for this booklet expressed a sense of frustration and futility in trying to prevent snails from spreading between farms and from paddock to paddock. Snails are extremely good at hitching a ride on vehicles, machinery, augers, silos and other equipment moving between farms. Growers report snails moving onto farms from graders working on roads and via drains or waterways. Snails can shelter in tree lines and road verges over summer and move into crops during autumn.

Areas where vehicles and machines are routinely parked or stored are key conduits for infestation and should be monitored for snails regularly and baited as soon as snails are seen.

Grain and fodder brought onto a farm should be inspected carefully to make sure they do not contain snails. Try to feed out forage in the same locations so these areas can easily be monitored for snails and baited if necessary.

Monitor drains and waterways regularly to see if snails come in during wet weather. Bait paddock borders along tree lines and verges to kill snails before they enter the paddock.

Harvest operations are a key source of grain contamination between paddocks and farms. Headers and swathers collect snails from the crop canopy and redistribute them with the grain into silos, augers and trucks. During harvest, machines, silos and augurs are routinely parked in paddocks for long periods of time, enabling snails to emerge at night and drop off into new areas. The following procedures can be used to minimise contamination at harvest:

- During swathing, harvest and seeding try to move operations from clean to suspect to dirty paddocks and vice versa as needed.
- Blow down machines and park up for the night before moving, if possible. Check for snails the following morning to see if more have emerged.
- After harvest, regularly monitor for snails in parts of the paddock where harvest operations were based.

Many growers speak of having seen a few snails around the farm years before they became a serious problem and believe earlier action could have prevented their spread. This emphasises the need for growers to look for snails regularly and react quickly to bait affected areas, even for low numbers of snails.

Small conical snails on tyres.

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Slugs

Slug populations have increased in WA's high-rainfall cropping regions with the introduction of no-till and stubble retention practices. Some growers, however, have found snail control practices also have a beneficial effect on slug control, as the two molluscs can be present in the same paddocks at the same time and have similar life cycles and behaviour.

Species

The reticulated (grey field) slug and the black keeled slug are the two most common species found in broad-acre agriculture in high-rainfall regions of WA. This booklet focuses on these two species, but there are several other slug species in WA described in GRDC's *Slugs in Crops: The Back Pocket Guide* (2011). Reticulated and black keeled slugs can occur separately or their populations can overlap. Their habitat and behaviour are slightly different and knowing which species is present in the paddock can assist in making the best control decisions.

Black keeled slug (bottom) and reticulated slug (top). PHOTO: DPIRD

Reticulated slug

The reticulated slug (*Deroceras reticulatum*), also known as the grey field slug, can grow up to 50mm long. It has dark brown netted markings on a light grey to fawn background. It can breed any time of the year with suitable conditions, but generally produces two generations per year in autumn and spring. Found mainly at night on the soil surface, it shelters under rocks, logs or in loose soil or cracking clays during the day. It does not burrow like the black keeled slug but can move through loose soil. Reticulated slugs produce a large amount of milky slime if disturbed.

Black keeled slug

The black keeled slug (*Milax gagates*) can grow between 40 to 60mm long. It is black to brown with a ridge down its back. It can burrow up to 200mm deep, which helps it survive over summer and feed on crop seed. It will come to the soil surface with significant rainfall and cooler temperatures. It lays its eggs in tunnels below the soil surface (Terrestrial Mollusc Tool, 2018). Black keeled slugs produce clear slime.

Life cycle

Slugs are hermaphrodites, which means that all individuals can fertilise and lay their own eggs without a mate. Breeding generally occurs in late autumn to late winter but can be opportunistic given the right temperature and moisture. Reticulated slugs can breed all year round if conditions are favourable, whereas black keeled slugs lay eggs in autumn to winter. Slugs can produce between 200 to 1000 eggs per couple. Eggs hatch three to six weeks after being laid, depending on temperature, but cannot survive hot, dry conditions. Slug juveniles look like smaller versions of adults and usually become sexually active after one year.

Slugs breed in response to soil moisture, so in a wet summer two generations can develop between harvest and sowing (Midwood, 2014). In favourable conditions populations can increase rapidly, with reticulated slugs producing up to 1000 eggs per year.

Immature black keeled slug on soil surface. PHOTO: DPIRD

Slug distribution and damage

Slugs are less widely distributed in WA than snails and are generally found in higher-rainfall regions and on heavier soils with a higher clay content, including shallow duplexes. Twenty-five per cent of growers in the Albany and Esperance port zones reported having slugs on their properties in 2017 and these were most likely to be found on clay (77 per cent) or duplex soils (45 per cent) (McDonald and Micic, 2017). DPIRD entomologist Svetlana Micic has reported slugs surviving in lighter soils over summer if there is enough moisture in the soil profile (DPIRD PestFax, June 2018).

Black keeled slugs, because of their burrowing habit, are reported surviving in drier areas more so than reticulated slugs, but their range can overlap with reticulated slugs. Slugs are more active after wet seasons or wet summers and need moist soils or habitats to survive over summer. This was evident in southern WA in 2016, where a wet summer and a wet start to the cropping season provided ideal conditions for slug populations to increase. The timing of emergence for reticulated slugs and snails is very similar so baiting programs can control both species.

Black keeled slugs found in a young cereal crop with heavy soils.

One black keeled slug per square metre is enough to cause significant damage to a seedling canola crop. Signs of slug damage can include bare patches in paddocks, seedlings gnawed off to stumps, and chewed or shredded seedlings. Slugs feed on emerging crops and may feed on non-germinated seeds in the furrow, especially legumes. Slugs can eat mature crops, but damage is most costly at emergence when reseeding may be required.

Canola is the crop most susceptible to slug damage and, once the growing point (which is above the ground) has been damaged, it cannot regrow. Slugs will also feed on cereals but these can outgrow slug damage provided the growing point is undamaged. Black keeled slugs are more likely to eat seed and cereals than reticulated slugs.

Crops sown into dense stubble or adjacent to grassy fencelines, rock piles, creek banks or shaded, damp areas are at greater risk because these areas provide ideal habitat for slugs to survive over summer. Heavy, cracking soils and soil clods provide additional hiding places.

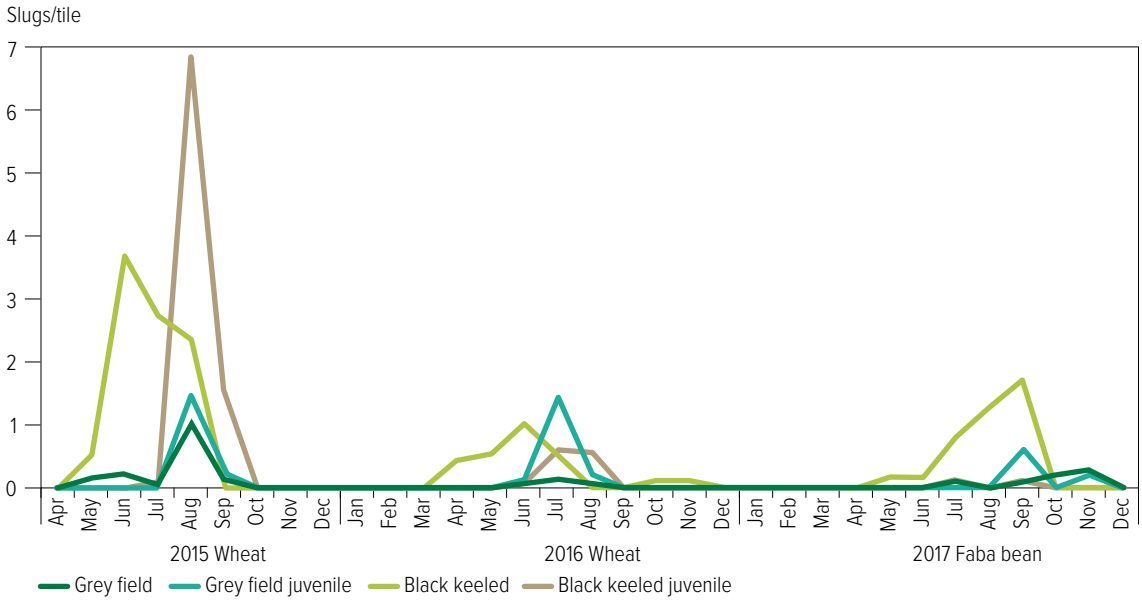
Monitoring

Monitoring for slugs can difficult be because:

- they are hard to find during the day – monitoring is best done at night;
- populations are often localised and in clumps;
- slugs are only active if the soil is moist, which can be later in the season compared with other pests; and
- small numbers of slugs can still cause significant crop damage.

Crop damage from slugs can be caused by favourable breeding conditions in the past year or over summer. The variation in numbers for the reticulated and black keeled slugs over three seasons is illustrated in Figure 4, which shows how difficult predicting slug numbers can be before seeding.

FIGURE 4: Adult and juvenile slug populations over three years on the Fleurieu Peninsula, SA.



SOURCE: TURNER AND NASH, 2018

Providing surface refuges by laying out tiles or wet carpet squares across the paddock and monitoring these can be useful to determine when slugs are active. Because slugs often occur in clumps, growers either need to lay out refuges where they know slugs are likely to occur or use large numbers of refuges to get an accurate indication of where the slug clumps will be. Refuges are less effective in attracting slugs in paddocks with high stubble loads and/or very cloddy soils (pers. comm., B. Pritchard, 2018).

In a normal season, the crop may already be in the ground before the soil becomes moist enough for slug activity, making it difficult to plan slug management early on. Forward planning by monitoring crops in spring the previous season can be effective to estimate slug species, locations and numbers.

Paddock cameras were used to monitor slug movement and compare activity with time of day, local temperature and humidity (Micic et al., 2018). The cameras reported that slugs were 30 times more likely to be photographed during the night (Figure 5). Monitoring for slugs at these times will provide a more accurate estimation of numbers than during the day.

Paddock camera data also showed that increased slug activity was related to humidity and temperature (Micic et al., 2018). Slugs were most active when relative humidity was between 80 and 90 per cent, air temperature was 6°C to 10°C and soil temperature was 11°C to 13°C.

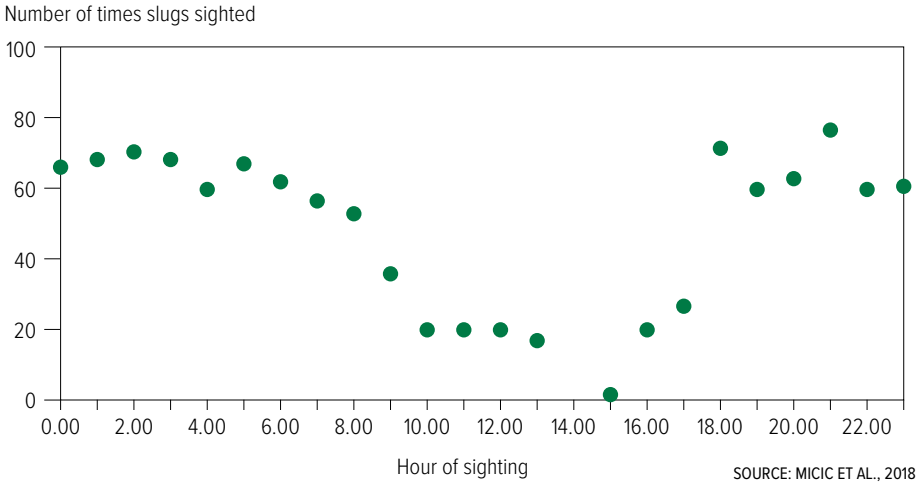
Growers often use their knowledge of paddock history with observations of slug presence, the crop, soil type and rainfall leading up to sowing, to determine the risk of slugs in a particular year. Throwing out test handfuls of baits and monitoring for dead slugs can also give an indication of whether slugs are active and feeding.

DPIRD recommends control where there are one to two black keeled slugs per square metre in canola, cereals or pulses. For reticulated slugs, control should be implemented where there are one to 2/m^2 in canola or pulses and 5/m^2 in cereals.

Slug control methods

Slugs may require more moisture to become active and emerge later in the growing season than snails, so baiting programs are generally required later and for longer than those required for snail control. Stubble 'crunching' techniques used to reduce snail numbers are unlikely to kill slugs and more severe stubble management by burning or tillage may be necessary.

FIGURE 5: Number of times slugs were sighted based on time of day.



SOURCE: MICIC ET AL., 2018

Green bridge

Green weeds or crop residue left in paddocks over summer can provide food and shelter to slugs and should be removed at least two months before seeding. This can be managed by spraying summer weeds and crop residues or heavy grazing. Spray weeds along fencelines, around dams, drains and boundaries to reduce other slug habitats. Rock heaps or stumps can also harbour slugs over summer so ensure weeds around these are sprayed out or, if possible, the rocks and stumps are removed.

Stubble management

Stubbles provide slugs with a moist, cool habitat over summer, so stubble management is a key opportunity to reduce numbers going into seeding. The brown areas in Figure 6 show bare soil where slugs have eaten out the canola. They follow the windrows from the previous year's crops that sheltered slugs over summer.

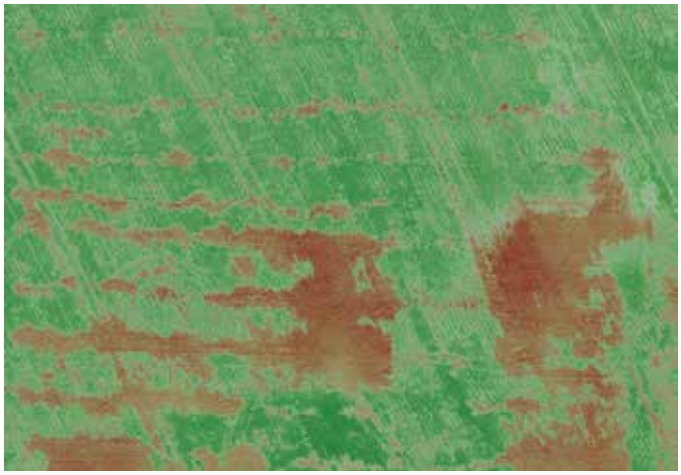
Burning and tillage are used in the high-rainfall areas of south-east SA and western Victoria to manage slugs before sowing canola (Nash et al., 2016). These methods are not used regularly by WA growers, possibly because slugs occur in smaller, isolated clumps that are manageable with baiting.

Disturbing stubbles in summer through fire or tillage exposes slugs to the hot soil and helps to dry out the soil profile. While stubble disturbance may kill reticulated slugs that live on the soil surface,

FIGURE 6: Normalised Difference Vegetation Index (NDVI) image of a canola crop affected by slugs.*

* Green is healthy crop, brown is bare ground. The horizontal brown bands are the previous season's stubble rows where slugs were harbouring over summer. They then moved out into the adjoining crop in autumn.

PHOTO: COURTESY MOORE ET AL. (2018)



it is less likely to directly kill black keeled slugs, but may destroy their burrows. If stubble management is done early in the season the soil will have time to dry out sufficiently to kill both species. Tillage does not necessarily mean full cut and multiple passes (Midwood, 2014). Light, shallow tillage can still provide slug control. Removing stubbles can also make baits more accessible to slugs at seeding.

Slugs occur on heavier soils, which may have a lower risk of soil erosion following burning and tillage. However, the risk of soil erosion must be weighed against the benefits of slug control. Although burning and tillage can dry out the soil to make slug mitigation easier, it can also limit soil moisture for cropping in autumn, which can be good or bad for later crops depending on average rainfall and the incidence of waterlogging.

For no-till growers adverse to burning or tillage, baling stubbles may be an option to reduce stubble loads and compromise slug habitats.

Rolling

Rolling is used to manage slugs in western Victoria after seeding. It consolidates loose soil and increases seed/soil contact, making it harder for slugs to find seed. It can also crush clods that harbour slugs and flatten stubbles to effectively reduce the surface area for baiting. Rolling the seedbed can also improve crop establishment if tillage has been used earlier in the season.

When done well, rolling is a relatively cost-effective control method that restricts slug movement (Midwood, 2014). Steel (or land) rollers will provide more pressure than rubber tyre rollers and provide better seedbed consolidation (Midwood and Horne, 2014). Some growers in western Victoria have attached a bait spreader behind their roller (Midwood and Horne, 2014).

Rolling has not been adopted widely in WA, probably because slug damage here is often occurring in clumps rather than at the whole-paddock scale and rolling becomes less economical.

Managing slugs in canola

In some parts of south-eastern SA and western Victoria, growers have opted not to sow canola because of the crop's susceptibility to slug damage. Growers have also reported anecdotally that slug populations seem to build up on canola compared with other crops. Lab trials compared reticulated slug populations on different crops to determine if crop choice influenced slug survival, growth and the number of offspring (Nash et al., 2016). Canola and field peas led to the largest increase in slug population, cereals had only a moderate effect on numbers, whereas linseed and faba beans had the least effect.

After a wet summer or autumn, sowing a cereal crop into paddocks with a history of slugs will be less risky than canola or field peas. This will not necessarily be possible with an existing rotation and, if sowing canola into wet paddocks, growers are advised to bait at sowing and monitor slug numbers closely.

If the season start is dry, sowing canola early may give the crop a chance to establish before slugs emerge. Modern hybrid and open-pollinated varieties with large seeds are more vigorous. Monitoring should start immediately the soil becomes moist.

Slug damage to canola growing in heavy soil in wet conditions.

Baiting for slugs

Baiting for slugs may be better later in the season than for snails, because slugs may require more moisture to become active. Slug baiting is normally done at, or immediately after, seeding to provide crop protection.

Baiting as soon as possible after seeding and again eight to 10 days later was most effective in trials in western Victoria (Midwood, 2014). Baiting before slug damage is seen will be more effective than waiting for damage and baiting reactively.

Crops are most susceptible up to the four true leaf stage in canola and GS14 in cereals (Midwood, 2014). Monitor emerging seedlings every few days and watch for new attacks:

- from slugs emerging with further rain;
- if the population increases from breeding earlier in the season; or
- if crop growth is delayed by cold conditions.

Repeat baiting of problem areas may be required. If unsure, throw test handfuls of bait into crop to see if slugs are active and eating and follow up with wide-scale baiting if dead slugs are found.

Trials in Hamilton and Inverleigh (Victoria) showed that at the very early emergence stage of canola only reticulated slugs were causing plant damage. But, as moisture penetrated deeper into the soil profile, the black keeled slugs became active (Midwood, 2014). In situations where two or more slug species are present, be aware they may become active at different times and more monitoring and multiple bait applications could be needed at different timings.

Baits

Baits should be applied at a minimum of 25 to 30 bait points per square metre to provide an 80 per cent chance of slugs encountering the bait (Nash, 2016). The presence of cracks, soil clods and high stubble loads will increase the soil surface area and a higher rate may be needed to get the same number of bait points per square metre (pers. comm., B. Pritchard, 2018).

See the snail section of this booklet for more information about bait integrity under different environmental conditions. In short:

- metaldehyde baits may be less effective when temperatures drop below 10°C, particularly on smaller slugs (Nash et al., 2016);
- rainfall erodes bran-based baits; more expensive rain-fast baits will last longer;
- mould on baits does not reduce their consumption or efficacy; and
- temperature, not light, degrades metaldehyde-based baits, so do not store or spread these baits if temperatures are likely to exceed 35°C for more than two weeks.

Using precision agriculture (PA) to place baits on the canola row is no more effective in controlling slugs than broadscale spreading of baits (Nash and Pilkington, 2016).

If using a spreader, pellets must be applied evenly to ensure slugs have the best chance of encountering a pellet and consuming a lethal dose. Calibrate your spreader to the bait product you are using as different spreaders and bait types will throw differently (*Snail Bait Application Fact Sheet*, 2015). If applying baits in patches, ensure you bait a large enough area around the patches to allow for slug movement from these areas.

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Slaters

Slater damage is a relatively recent problem in Southern WA and so far is confined to specific locales. Information about slater behaviour and management is limited when compared with snails and slugs. For this reason, the information provided here relies on PestFax reports from WA and the eastern states and conversations with local agronomists and growers.

Species

Slaters are also known as woodlice, sowbugs and pill bugs. They are a crustacean rather than a true insect and have a hard skeleton on the outside of their bodies, seven pairs of jointed legs and two pairs of antennae.

The common slater (*Porcellio scaber*) is widespread in Australia, coming originally from Europe. It grows up to 20mm in length and is usually pale grey but can be brown, yellow or orange.

The pill bug (*Armadillidium vulgare*) gets its name from being able to roll up into a ball for protection. It can grow to 18mm in length and is dark brown to black in colour.

The common slater (*Porcellio scaber*). PHOTO: DPIRD

The pill bug slater (*Armadillidium vulgare*). PHOTO: DPIRD

Life cycle of slaters

Slaters are commonly present in some cropping systems and play an important role in recycling stubbles. Slaters need moist soil and stubble conditions for shelter and food. They are omnivores and normally feed on decaying materials such as vegetable matter, fungi and insects. Although slaters can occur in large numbers, they rarely damage crops. Slaters will die if exposed to open, dry situations (DPIRD, 2018) and are more active at night when it is cooler and there is less chance of dehydration.

Females carry their eggs in a pouch until the young hatch after about 40 to 50 days. Hatchlings will leave the breeding pouch and become independent. The females can produce 12 to 36 young per brood. Juveniles look like smaller, lighter-coloured adults. They will shed their rigid outer skeletons (moult) as they grow until they reach their adult size after about three months.

In comparison to slugs and snails, relatively little is known about slater behaviour. Since slaters normally feed on decaying matter it is unclear why slaters may switch to eating crops. GRDC and CSIRO have invested in research to determine why slaters switch from eating decaying materials to emerging crops and a summary of their initial work is included with the research updates.

Slater distribution and damage

Slaters are an emerging pest in the southern regions of WA, SA, Victoria and NSW (cesar PestFacts, May 2017). The discussion here refers to the environments where slater damage has been reported in Southern WA. Within this region, slater damage appears to be confined to heavier soil types including red and grey clay loams. Slaters' survival may be aided by the presence of crumbly soil clods and cracking clays, which provide additional shelter over summer (Hangartner and McDonald, 2015).

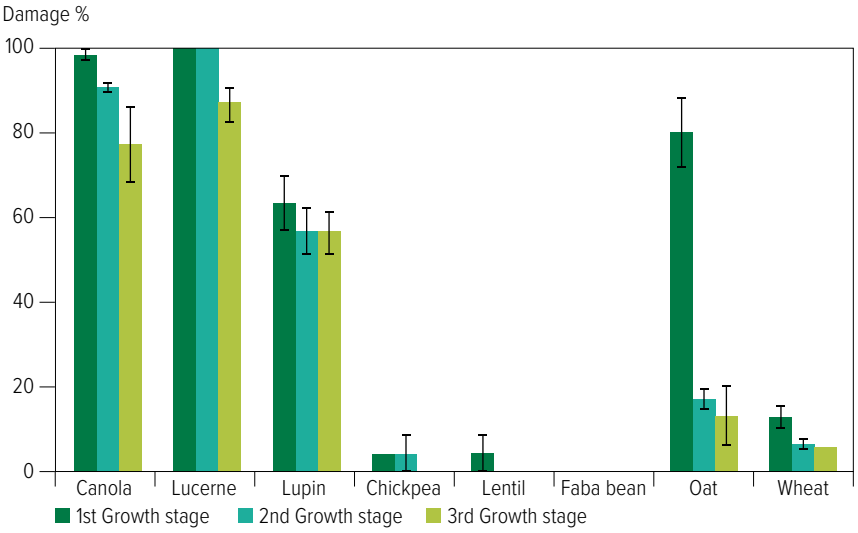
Unlike slugs and snails, slater activity or damage does not appear to be directly related to rainfall events; nor does the time of seeding crops seem to alter risk of damage (pers. comm., B. Pritchard, 2018). Slaters do require moist habitats over summer to prevent them from drying out and thick stubbles are conducive to this.

Slater populations appear to have increased following several wet summers and high-yielding cereal crops with heavy stubble loads (pers. comm., M. Field, 2018; DPIRD, 2018). The practice of chaff lining or decking for weed management concentrates stubbles into lines rather than spreading them in a thin layer over larger areas. This could potentially harbour slaters over summer and extend their habitat into hotter, drier environments (pers. comm., M. Field, 2018).

Slater damage tends to occur in isolated patches within paddocks on heavier soil types. Slaters can be present in these paddocks in high numbers for some time before they start to damage crops. Once a slater population starts to cause damage, however, it can continue to be a problem at crop establishment, particularly when canola is grown. The original area of slater damage may increase over time, but it is relatively slow when compared with the spread of snails (pers. comm., B. Pritchard, 2018).

Slaters in three-leaf cereal crops. PHOTO: DPIRD

FIGURE 7: Percentage of damage done by slaters (*Armadillidium vulgare*, common pill bug) to seedlings of crops when introduced at three different stages of growth.*



* First growth stage = nine days after seeding (canola had unfolding cotyledons); second growth stage = 11 days after seeding (one true leaf for canola); third growth stage = 12 to 13 days after seeding (2–3 true leaves for canola).

DOUGLAS ET AL., 2017

The trend to seed crops earlier, when weather conditions are warmer and insects more active, may mean crops are emerging when pests such as slaters are most active.

Slater damage on the south coast has predominantly been in canola, first detected by bare patches occurring in emerging crops. Evidence of damage can be seedling stumps where the emerging growing points have been eaten off or seedlings that have been shredded. Slaters can also destroy canola plants at the two to three-leaf stage by ringbarking them and chopping the whole plant off (pers. comm., M. Field, 2018).

There have been instances of slaters causing damage to cereal crops on the south coast (DPIRD Pest Fax, June 2017), but this is uncommon. Slaters have been observed crawling up cereal seedlings and chewing out the growing tips (*Slaters Factsheet,* DPIRD 2013). Slaters have caused damage to wheat, oats, lentils and pastures in parts of NSW, Victoria and South Australia (cesar PestNotes, June 2017).

Shade house trials compared slater damage across various crops at early growth stages with reports of crop damage from various PestFax services in the past 10 years (Douglas et al. 2017). In trials slaters caused significant damage to canola, lucerne and lupin crops in all early growth stages. Oats were damaged at the first leaf stage but were more resistant to slater damage later. Wheat, chickpeas and lentils showed only minor damage while faba beans had no damage (Figure 7).

From the 69 PestFax reports collected, 70 per cent of slater damage occurred in canola with half classed as severe damage (more than 10 per cent crop loss) and in a few instances the whole paddock had to be reseeded. Lucerne, lentils, chickpeas and field peas all had one to two reports each of severe damage, while lentils had several reports of less severe patches of damage. There were one to two reports of minor damage to wheat, barley and oats. The slaters' preference for canola and lupins is likely due to the selective breeding of these crops to reduce chemicals, which are natural deterrents to predators (Douglas, 2017).

Estimating numbers in crops

Crop damage by slaters can look similar to damage caused by snails, slugs and earwigs, making the diagnosis difficult. The presence of slaters, even in high numbers, does not necessarily mean they will cause seedling damage (Johnson et al., 2012). Slaters are most likely the culprit if there are large numbers of slaters in areas with heavier soil types and good stubble cover and slugs have been ruled out.

Slaters, slugs and snails are most active at night, so monitoring crops after dark is the best way to confirm if slaters are causing the damage. DPIRD advises that if slaters are easily seen, with at least three per 10 square centimetres, then they may cause crop damage, particularly in canola.

Interviews with growers and agronomists by SCF in 2018 indicate that growers who have experienced slater damage become familiar with the areas of their paddocks where this is most likely to occur, which can help guide mitigation of the pest each season.

Slater mitigation options

Mitigation options for slaters are limited as damage is a relatively recent development and still only occurs in some canola crops in niche environments. This makes it difficult to derive patterns from their behaviour and develop effective control methods. In addition, there are few pesticide products registered for slaters in broadacre crops.

Stubble management

There is limited information about whether stubble management is effective at controlling slater populations and whether this leads to less crop damage. Slater populations appear to have increased with the adoption of no-till and stubble retention practices in cropping systems in Australia, the United States, South America and South Africa (Douglas et al., 2017). The relationship between stubble loads, slater populations and the risk of crop damage, however, is not clear. There is plenty of anecdotal evidence

from growers, agronomists and researchers to suggest that slater numbers are higher in thick, heavy stubbles, but slater damage does not always occur where there are heavy stubbles. Reducing or disturbing stubbles over summer should reduce slater populations by exposing them to the hot soil and desiccating them. However, slaters are also feeding on stubbles and so removing their food source close to sowing may lead to surviving slaters turning to seedlings for food (Douglas, 2017).

Burning

Burning stubbles to reduce slater numbers is practised in parts of SA and Victoria and the US (cesar PestFacts, May 2015; Johnson et al., 2012) but is not a regular practice in WA. Interviews with growers and agronomists indicate that burning stubbles to reduce slaters numbers in WA has produced mixed results. For example, paddock-burning wheat stubbles did reduce slater numbers but also dried out the soil profile, resulting in uneven canola germination. Slaters have been able to survive stubble burning by sheltering in soil clods or cracks in the ground and can still damage crops at germination (DPIRD PestFax, June 2017).

Tillage

There is limited information about the effectiveness of tillage in controlling slaters in Australia, although extension material from Kansas (US) indicates that using tillage every other year has been useful to reduce slater populations that cause damage to soybean crops (Whitworth et al., 2008).

There is only one report of tillage used specifically to control slaters in Australia. A grower on the south coast used speed tillage to incorporate stubble into the top soil to help with slater control, but this did not prevent damage (pers. comm., M. Field, 2017).

Baiting

There are currently no bait products registered for use on slaters in broadacre crops in Australia; however, at least one company is developing a potential bait to control slaters in broadacre crops. Being able to patch-out baits in slater-prone areas before canola germination would be a timely and effective option.

Other chemical controls

Fipronil seed treatments can prevent slater damage at moderate population levels. There are no insecticides registered to control slaters in broadacre situations (DPRID, 2018; Douglas, 2017; Hangartner and McDonald, 2015).

Anecdotal evidence of the effectiveness of foliar insecticides to protect canola against slater damage is mixed. Slaters are crustaceans, so they may respond differently to foliar insecticide sprays than other insects (cesar PestFacts, May 2015; Whitworth et. al., 2008). Slaters are nocturnal and shelter and feed under stubbles, so getting adequate spray contact may be another reason that foliar insecticides are not always effective.

Residual insecticide sprays have had some success in protecting germinating canola crops from slater damage (DPIRD PestFax, June 2017). This technique has been effective in managing other insects and may also control slaters.

While slaters are common in farming systems, they only damage crops in quite specific soil types.

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RESEARCH UPDATES

Effective baiting options for small conical snails on the south coast

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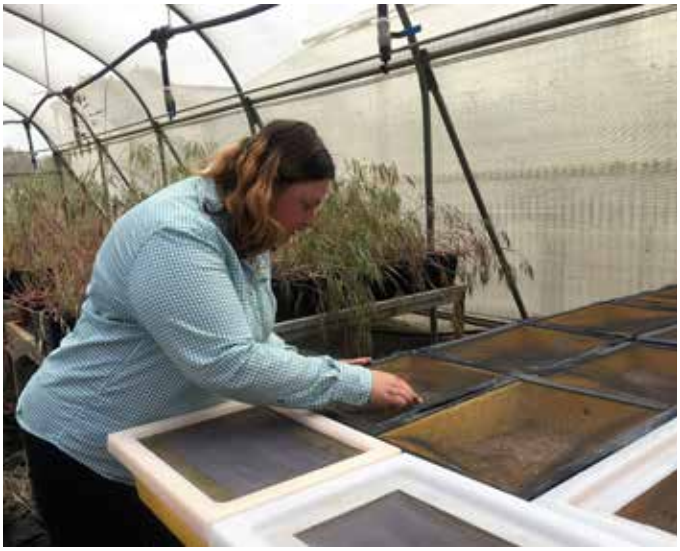


Kathi McDonald, communications officer, Stirling to Coast Farmers observing caged baiting trials to test the efficacy of several commercial snail baits.

PHOTO: SCF

Background

Small conical snails can cause significant damage to emerging crops. A lot of work has been done in SA on snail control options, but there is limited knowledge of the optimal timing of baiting and bait choice for small conical snails in WA's farming systems. This Stirlings to Coast Farmers (SCF) project aimed to address the knowledge gap.

Recommendations

- If baits are applied early in the season, then follow-up baiting is recommended to ensure crop protection at the time of emergence.
- Growers who are planning to bait only once should use rain-fast baits, which will achieve a longer period of control. Non-rain-fast baits applied several times may also be effective.
- Baiting early if snails are actively moving may decrease the incidence of egg laying and reduce snail populations. However, this will need to be followed up by baiting around the time of seeding to prevent damage to emerging crops.
- The number of bait points is important; the more bait points per square metre, the better the kill. Calibrate spreaders to ensure an even spread of baits across the paddock to increase the likelihood of snails coming across them and feeding.

Grower survey

A survey of baiting practices was completed by 120 growers in Southern WA. The main findings were as follows:

- Small pointed conical snails were an increasing problem, with almost half of the survey respondents indicating the snails were present on their farms. Almost 60 per cent of those with snails reported a level of infestation that required a baiting program.
- Most growers had only recently become aware of the problem, although some had recognised snails as an issue for more than five years.
- Canola and barley were the crops most affected by snails.
- Snails were found across all soil types on respondents' farms.
- Of those respondents who had applied baits in the past five years, most applied baits only once in the year, although 40 per cent applied baits twice. Most baits were applied in the post-seeding period, but some were also applied pre-seeding. Generally, growers who applied baits twice a year applied them pre and post-seeding.
- The level of snail infestation was the greatest consideration for respondents on whether to apply baits.
- Metaldehyde-based baits were the most commonly used. These were also the most widely available with the largest range.
- Baits were mostly applied using fertiliser spreaders. Some growers reported spreading baits with the fertiliser or by plane.
- Respondents were mixed on whether they considered baits to be an effective control for snails, with almost 60 per cent being unsure.
- Apart from baiting, burning (of windrows and whole paddock) and good farm hygiene/biosecurity were considered as control measures.

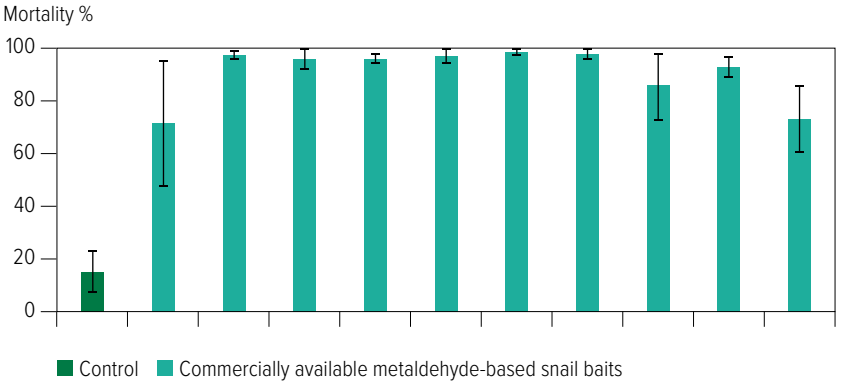
Caged baiting trials

In caged bait trials, all active ingredients were equal in causing mortality to snails. The amount of active ingredient per bait in these trials did not influence mortality. However, increasing the number of bait points per square metre increased the likelihood of snails coming across the baits and eating them, which increased snail mortality.

Up to 14 days after application, the 'rain-fastness' of baits did not affect snail mortality. However, after 14 days in wet conditions non-rain-fast pellets begin to lose their integrity and decompose, meaning snails would be unlikely to consume a lethal dose.

There was no difference between the iron-based formulations for causing snail mortality. There did appear to be differences between metaldehyde-based products in causing snail mortalities. Within the metaldehyde range, six of the 10 commercially available snail baits tested caused more than 95 per cent mortality (Figure 1).

FIGURE 1: Percentage (%) of mortality in snails at day 14 after being exposed to different metaldehyde-based baits.



Note: error bars represent the standard error of the mean.

SOURCE: MCDONALD AND MICIC, 2017

TABLE 1: Average number of live snails at Wellstead for all plots counted 14 days after final bait application.

Time of bait application	Control	Non-rain-fast bait	Rain-fast bait
Post-harvest	25.0	42.5	51.7
Pre-seeding	12.5	24.2	51.7
Pre-emergent	44.2	33.3	6.7
Post-emergent	87.5	8.3	10.0

Note: The post-emergent treatment had significantly (p=0.017) lower snail numbers as a result of bait treatments.

SOURCE: MCDONALD AND MICIC, 2017

Field trials

Field trials comparing rain-fast and non-rain-fast baits with a no-baiting control were conducted at Kendenup, Woogenellup and Wellstead beginning in March 2017 and concluding six weeks post-crop emergence. It was not possible to regularly monitor the number of live snails at each site, as snails could move between plots. Therefore, a single snail count was conducted at the end of the trial at each site. There were different population densities of live snails at each site, with Woogenellup, Wellstead and Kendenup having an average of 149, 159 and 56 snails per square metre respectively. The trials showed no difference in the number of live snails or crop damage between the different bait treatments and the plots that were not baited. This was possibly because of the difficulty in preventing snails from moving between plots in a field-based study.

The Kendenup trial site had relatively low snail numbers, potentially due to dry conditions not being conducive to snail movement or breeding.

The Wellstead site did show a significant interaction in the treatments. There were significantly lower snail numbers post-emergence as a result of bait treatments (Table 1). Also, when conditions were wet (180mm in April), the plots with rain-fast baits had significantly lower snail numbers than either the control or the non-rain-fast bait plots. This may indicate that at times of high/intense rainfall events, non-rain-fast baits may be compromised and not deliver a lethal dose.

In the field trials, fewer snails were found in plots with baits applied up to two weeks before crop germination. Baits applied four or more weeks before crop germination need to be reapplied to suppress snail damage to germinating crops.

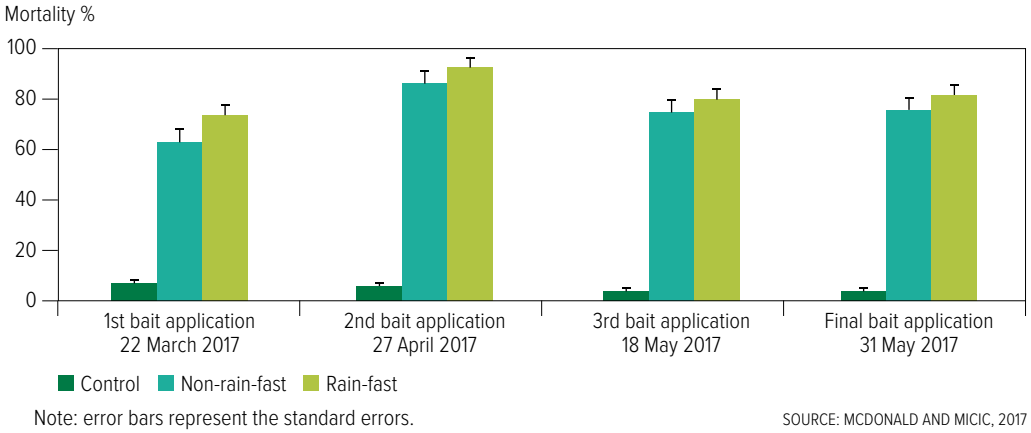
Field cage trials – snail mortality

Large snail-proof plastic tubs with the ends cut out were dug in to the ground along the fenceline adjacent to the field trial at Kendenup in the late summer. Snails were collected and placed, along with bait treatments, in the cages at the same time as baits were applied in the adjacent field trial. Baits applied in late April caused higher snail mortality than baits applied at any other time (Figure 2).

From the results of the caged and field trials, it can be concluded that for crop protection at emergence, growers should be baiting close to the time of crop germination. Cheaper non-rain-fast baits can be as effective as rain-fast baits. However, if the non-rain-fast baits lose their structure in heavy rain they will be less effective, and rain-fast baits will be a better choice for long-term crop protection.

Further work to follow-up on snail populations later in the season and at the time of harvest would be beneficial to determine the impact of single versus multiple bait applications on snail population numbers.

FIGURE 2: Percentage mortality in small pointed snails exposed to baits after four different times of baiting.



Note: error bars represent the standard errors.

SOURCE: MCDONALD AND MICIC, 2017

Phone app images used to map snails for targeted baiting

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The DPIRD crop protection group in Albany has had a long-term focus on snails and slugs in southern Western Australia, working closely with growers to produce valuable research and extension on the behaviour and management of these pests. This article describes the group's most recent work using mobile phone technology to map snail and slug populations in the paddock to potentially guide variable rate bait application.

Key messages

- At three widely separated sites, the distribution of snails was sufficiently patchy to allow targeted controls.
- Mobile phone app technology might be able to be used in the future to map snail densities in a paddock.
- Applying this technique using snail baits as an example showed that costs could be reduced, or more effective controls could be achieved.
- Mapping slugs was more challenging early in the year and required night-time surveillance.

Background

Baiting is an expensive process with variable results due to factors such as snail habits and bait degradation (McDonald and Micic, 2017). Knowing where slugs and snails are located within a farm allows for targeted control or special treatment of infested areas. This project aimed to determine the potential of using smart phone apps, such as WheelCam and GrainCam, attached to agricultural vehicles to map snail distributions and densities for targeted control.

Method

Image analysis of slugs and snails is a two-step process: image capture and image analysis.

Image capture

Small pointed snails (*Prietocella barbara*) were mapped at three locations along the south coast at Mt Barker, Green Range and Gairdner using the WheelCam or GrainCam applications on smart phones. The WheelCam app instructs the smart phone to take a photo when the phone is aimed at the ground. Attaching it to a wheel on a header, autonomous rover or other vehicle reduces motion blur.

Snail mapping was done using the WheelCam (Figure 1) attached to an autonomous rover at Gairdner, a header at Mt Barker and a spray ute or hand wheel at Green Range. At Gairdner the autonomous rover was set on a predefined path using Mission Planner. Mission Planner is open-source software (http://ardupilot.org/planner) used mainly for programming drones. In Mission Planner the area of interest is outlined using outside waypoints and then internal waypoints are generated within the area at set distances apart. The Gairdner area of interest was 2ha in size and mapped at 10m row spacings. This information was then sent to the autonomous rover using a radio link and the rover followed this path using GPS.

Normalised Difference Vegetation Index (NDVI) maps were created using a multispectral camera on a quadcopter to investigate slug damage in an infested canola crop at Mt Barker.

FIGURE 1: The WheelCam attached to a Case header (left) and the GrainCam attached to the bubble auger (right).

Snail image analysis

After image capture was completed, the images were downloaded from the smart phones. Images were then analysed manually, as well as being sent to Mapizy at the University of Western Australia to develop image analysis techniques. Once snail densities for each photo were known, maps were produced using Ag Leader Spatial Management Software (SMS). Location and densities were read into the SMS, creating points with densities that were colour coded. The points were smoothed into contour maps by kriging using an automatic variogram with a 3m grid size. This produced a snail density map that was used to create the bait prescription map.

Estimating snail densities

Snail densities from photos were determined manually while image analysis techniques are being developed. However, this will only identify snails that are visible in the photos. Ten snail counts using 0.1 square metre grids were taken across the site together with the top zero to 2cm of soil, which was sieved to provide the below-surface snail counts. These counts were compared with the paired image counts to account for the unseen snails and determine the reliability of the techniques.

The GrainCam (Figure 1) takes images from the bubble auger on the header during harvest. This has the advantage of only sampling live snails but may miss patches when the snails have not migrated up the stubble to harvest height. This was used at Mt Barker and Green Range but not at Gairdner.

Results

Gairdner (snails)

The WheelCam app allowed the smart phone to capture 611 useable images while it was attached to the autonomous rover (Figure 2). Manual analysis of photos showed the highest number of snails in an image was 21 and the average number of snails per image was 0.87. When calibrated to get a measure of snails/m^2 the average was 3.5 snails/m^2. The snail counts from quadrats in densely infested areas produced an average of 140 snails/m^2 for the surface counts and 150 snails/m^2 for the below-surface counts determined by sieving soil collected from 0.1m2 quadrats.

When mapped in the SMS the contour map in Figure 3 was produced. This contoured snail density map was used to generate a snail bait prescription map using the rates of 0, 5 and 10 kilograms per hectare (Figure 4). Out of the 2.09ha surveyed, 0.51ha was assigned high levels of control, 0.95ha was assigned normal control and 0.63ha was assigned no control.

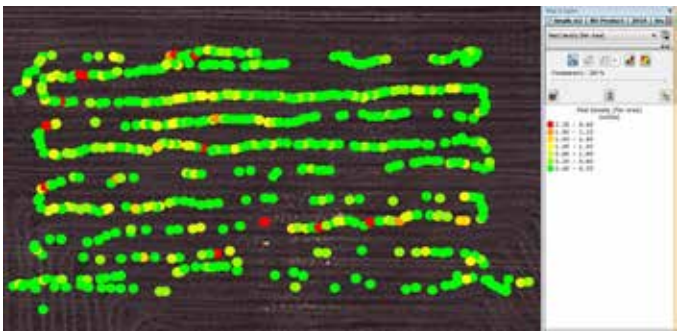

FIGURE 2: Manually assessed snail densities at each of the WheelCam image locations at Gairdner.

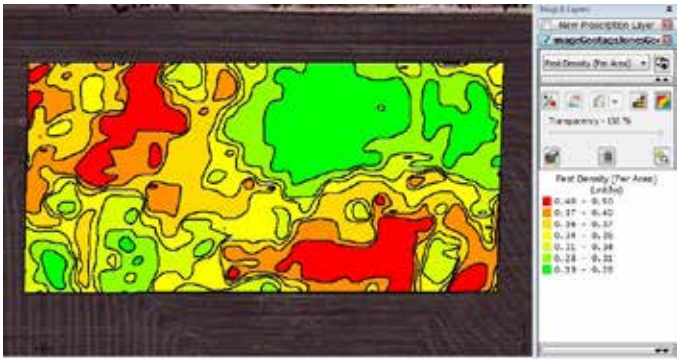

FIGURE 3: Contoured snail density map created by kriging using an automatic variogram at a 3m grid at Gairdner.

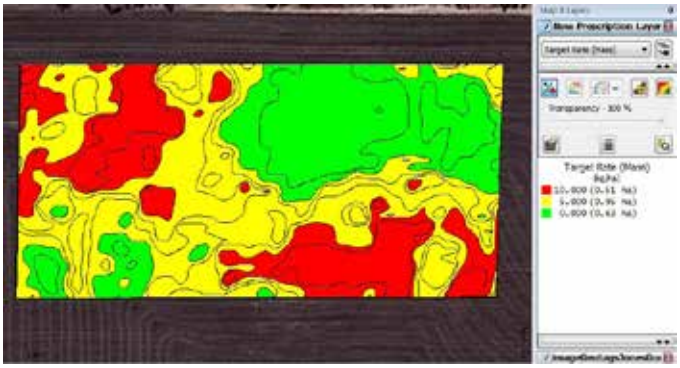

FIGURE 4: Snail control prescription map generated using the contoured snail density map with high levels of control defined by red, normal control by yellow and no control defined by green for the Gairdner site.

Mt Barker (snails)

At Mt Barker Research Station (MBRS) the GrainCam was used to conduct surveillance for small pointed snails on two paddocks (Figure 5). On one paddock the WheelCam was also used to collect images of the ground during harvest and 54 physical one-litre samples of approximately 800 grams were taken about every two minutes during harvest.

These samples were brought back to the laboratory and the number of snails in each sample was counted and another set of GrainCam images taken of the samples. The snail counts were overlaid onto a Google map using the SMS (Figure 6). On this paddock, 13.74ha were surveyed: 3.4ha had high levels of snails, 3.45ha had moderate levels of snails and 6.89ha had no snails in the samples or images. This was then allocated the control levels shown in Figure 7.

FIGURE 5: Locations of WheelCam images at Mt Barker (red markers indicate images that were unsuitable for image analysis).

At MBRS the number of live snails was determined by image analysis of the GrainCam images and verified by counts in the physical samples and data from the WheelCam. This compared live snails from the GrainCam with the total number of snail shells on the ground taken by the WheelCam. The correlation between the various methods determined whether the easy-to-use and inexpensive WheelCam provided an adequate estimate of the density of snails being recorded at harvest compared with the more expensive GrainCam.

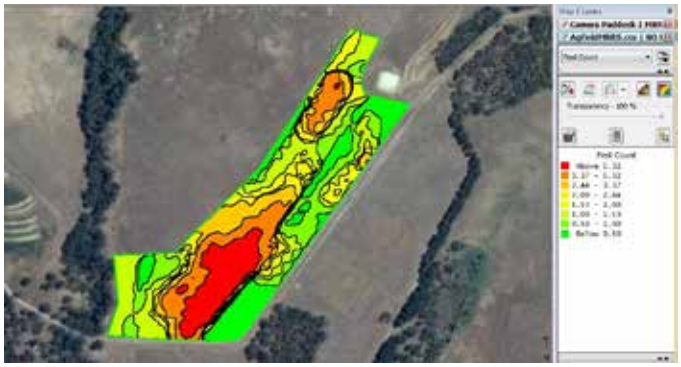

FIGURE 6: Contoured snail density map created by kriging using an automatic variogram at a three-metre grid at Mt Barker from snail counts in grain samples.

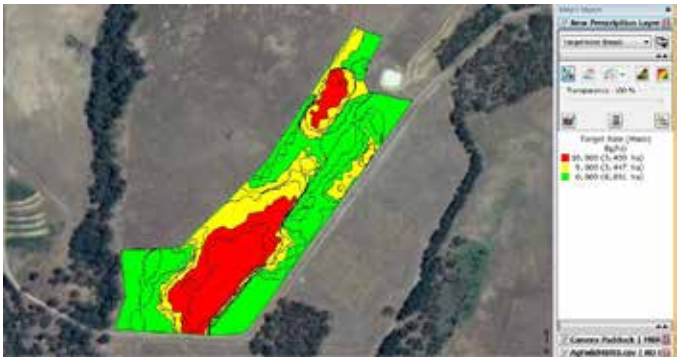

FIGURE 7: Snail control prescription map generated using the contoured snail density map with high levels of control defined by red, normal control by yellow and no control defined by green for the Mt Barker site.

Mt Barker (slugs)

NDVI imagery of a slug-infested area of a seedling canola crop at Mt Barker clearly showed the lack of canola growth (see Figure 8). Ground truthing indicated slugs were the cause of crop loss and affected about a third of the area. The horizontal orange bands in the image are the previous season's stubble rows where slugs were harbouring over summer and then moved out into the adjoining crop in autumn. The vertical green bands correspond with good canola growth and correlate with the area that was protected by baiting.

Conclusion

Understanding the density of snails across a paddock allows growers to target their control more effectively. At Gairdner, if the grower was using metaldehyde baits that cost $1.54 per kg (Moore and Moore, 2017) and the paddock was spread at 5kg/ha, the total cost for the two hectares would be $15.40. However, using the prescription map the grower could apply a single application on the medium-density areas and two applications on the high-density areas, which would be slightly cheaper but provide enhanced control. Alternatively, as a second strategy, the grower could apply the minimum label rate of 5kg/ha on the 0.95ha that was moderately infested and the maximum label rates of 7.5kg/ha on the 0.51ha that was heavily infested. This would result in both better snail control and a saving of $2.90/ha.

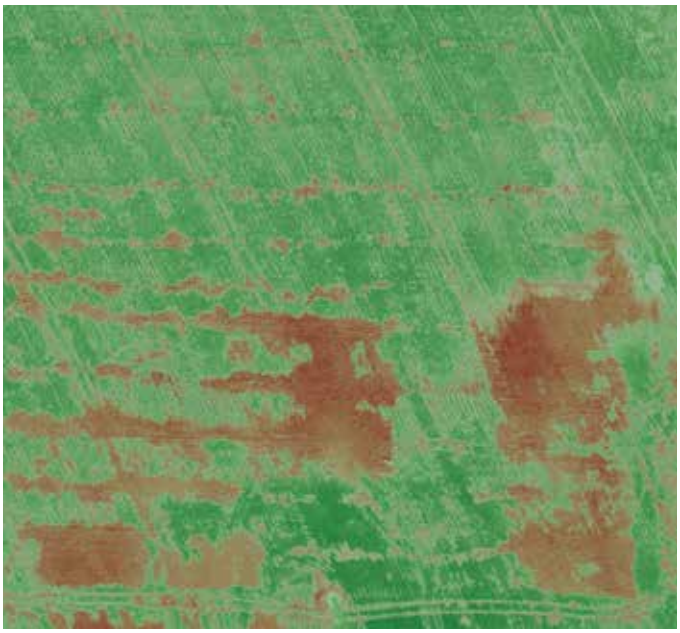

FIGURE 8: NDVI image of a canola crop affected by slugs (green areas are good canola growth and the orange areas are bare ground).

At Mt Barker, if similar strategies were applied there would be greater savings due to larger areas with no detected snails. The second strategy of applying baits at label rates only to areas with snails gave a net saving of $10.60/ha with the advantage of better overall snail control.

Thus, over two widely separated sites, where snail densities were high, significant savings could be made and greater savings expected on paddocks with lower levels of infestation, or more aggregated infestation within smaller areas.

More importantly, this technology allows growers to conduct easy surveillance on paddocks that are thought to be clean, as it will pick up small patches that can be treated before they spread to levels where the infestation is obvious or costly.

Slugs are challenging to effectively map because they tend to be active at night and the NDVI mapping in this case was too late to save the crop. Earlier surveillance or night monitoring using the autonomous rover may be more effective.

Acknowledgements

We would like to acknowledge Boosting Grains R&D and GRDC for funding for this work; the Invasive Species directorate of DPIRD for use of equipment; growers who provided valuable input and the use of their machinery and land; together with various members of Stirlings to Coast Farmers Inc.

Project numbers: DPIRD Boosting Grains FFPj01-2315966 Improving the efficiencies of slug and snail control; DAW00256 Building crop protection and production agronomy R&D capacity in regional Western Australia.

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Improved management of snails and slugs: a summary of SARDI research

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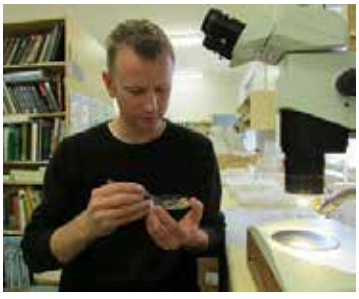
Background

The SARDI entomology group has been working on improving knowledge of slugs and snails under a GRDC project (DAS00134). The group's aim was to provide the Australian grains industry with refined guidelines for managing snails and slugs and so reduce associated effects and losses. Key areas studied were the pests' distributions, feeding and reproductive patterns, and the effective use and integration of chemical, biological and cultural controls.

Key findings

- Uptake of mechanical approaches to manage snails at harvest is often poor due to associated losses in operating speed, versatility and grain yield.
- Baiting efficacy can be highly variable and sometimes poor. It depends on complex interactions between environmental conditions, snail species, activity, size and physiology.
- To optimise baiting efficacy, a minimum of 30 to 60 bait pellets should be applied for snail densities up to 160 round snails per square metre or 320 pointed snails per square metre to maximise the chance of encounter and ensure adequate bait points are available for an effective dose. This needs to be worked out for each product to ensure it is within registered rates.
- Applying baits after controlling weeds, reducing stubble and before crop emergence is likely to increase bait efficacy by increasing the chance that snails encounter the bait.
- Ambient temperatures during feeding on baits may influence the efficacy of a given rate of bait against snails and slugs.
- Autumn is the ideal time to bait snails in order to precede autumn reproduction and avoid sub-optimal temperatures (high summer and low winter temperatures) and rainfall-induced degradation of baits.
- Effective control of slugs in no-till, full stubble retention systems is achievable. A set of recommendations has been identified including crop rotation, time of sowing, baiting timed to coincide with slug activity and the need to protect seed and emerging seedlings.



SARDI entomologist Kym Perry examines snails as part of this project.
PHOTO: GRDC

Species distributions

A survey of the distribution of snails and slugs in the grain-producing areas of Australia has identified factors affecting the spread of the main pest species. Road transport appears to be a major factor in the spread of pest snails. Several climatic and soil-type conditions were identified that correlate with the occurrence of the key pest snail and slug species. Soil carbon, for example, was a key factor that may indicate why no-till and stubble retention cropping systems are especially at risk from small conical snails and slugs.

Survey of harvest and summer snail management practices

A 2014 grower survey determined the uptake of *Bash 'Em, Burn 'Em, Bait 'Em* (2003) recommendations and identified harvest and post-harvest processes that could be improved. The survey revealed growers were aware of mechanical approaches to manage snails at harvest, but uptake was poor due to associated losses in operating speed, versatility and grain yield. Specific areas identified for potential improvement were:

- stubble height and rolling management, with a focus on pointed snails;
- publicise the value of grain-cleaning rollers in regions beyond Yorke Peninsula; and
- determine and promote the efficacy of windrow versus whole-paddock burning.

Snail-crushing grain rollers are used to remove snails from grain in parts of SA.
PHOTO: STIRLINGS TO COAST FARMERS

Improving snail-baiting efficacy and decision making

Baiting juvenile snails

We demonstrated that juvenile snails are killed by baits, but that crop plants and stubble significantly reduce the effectiveness of juvenile baiting in both early winter and spring. Therefore, targeting adults before egg laying/juvenile recruitment occurs is the best strategy.

Importance of applying adequate bait rate

To improve bait recommendations, a series of caged field trials were conducted in 2014-15 to compare the interaction between application rate and field densities of four snail species using three registered products. We found baits do not attract snails, so baiting efficacy is reliant on snail activity and the chance of encountering a bait pellet.

In trials where all baits were consumed as a result of high snail densities, efficacy was limited by the baits available. This highlights the need to estimate the pest density before baiting in order to ensure enough active ingredient (kg/ha) is applied for the given snail and bait type, and to consider multiple bait applications where snail densities are excessive.

In general, baiting trials showed high variability in efficacy for a given rate of bait. The variation between baits, snail species and paddock conditions make it difficult to provide a guideline for the number of pellets per square metre. However, we consider rates less than 30 pellets per square metre should be avoided, and for many field situations nearer 60 baits per square metre should be the target. Where label rates do not permit this, a repeat application should be considered.

Effect of ambient temperature on bait

Trials on the two round snail species using Eradicate® and Metarex® found that the efficacy of a given bait rate was higher when snails fed at higher temperature across the tested range (10 to 22°C). Similarly, for slugs, efficacy was higher when feeding at 14°C than at 10°C. The results support autumn (when conditions are warmer) rather than winter as the optimal time for baiting snails and slugs.

Causes of bait degradation

We found exposure to high temperatures (above 30 to 40°C), not light, degrades metaldehyde baits. This occurs in storage as well as in the paddock. As a result, metaldehyde baits should be applied once snails become active in autumn and hot conditions have passed. The efficacy of iron chelate bait was not affected by high temperatures.

With field weathering, all bait types degraded and developed mould. However, mould does not affect bait consumption or the concentration of active ingredient remaining in the bait.

Rainfall erodes the physical integrity of baits, in particular the iron chelate products tested. We do not recommend applying iron-based products when 10mm or more rain is forecast. The effect of rainfall on the efficacy of metaldehyde and methiocarb baits tested was more variable, but generally they performed better than the iron chelate baits.

Dead round snails after baiting.
PHOTO: SARDI

Environmental triggers for reproduction

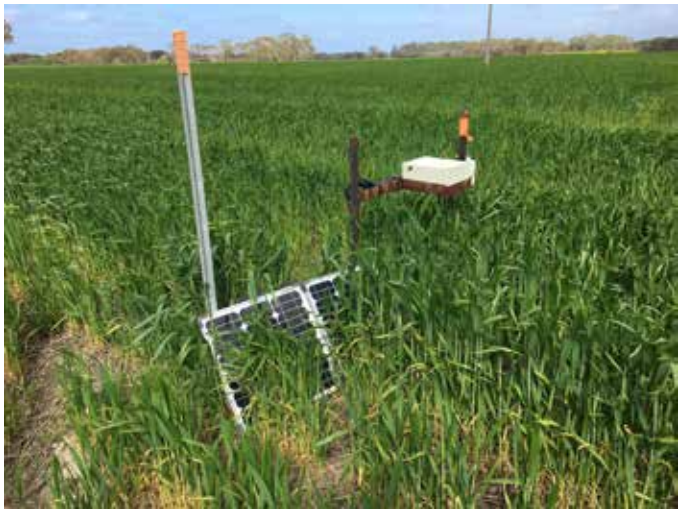
Work to determine the environmental triggers of snail reproduction included:

- dissecting snails and slugs to observe their reproductive stage;
- time-lapse cameras to record paddock activity;
- feed trials, including placebo baits and gut dissections; and
- measuring key weather information.

Moisture is a primary driver of snail and slug activity, but better understanding of their response to light rain events and their propensity to consume baits under these conditions is needed and is the subject of ongoing research that aims to optimise bait timing.

Slug risk factors and management

Studies aimed to understand slug activity, feeding triggers and seasonal factors that lead to greater pest numbers. To further improve slug baiting programs, it is necessary to target the application of baits to protect seeds and seedlings from actively feeding slugs.



Paddock cameras provide time-lapse imagery of snail and slug activity and behaviour.
PHOTO: SCF

Conditions for the emergence of adult slugs at the soil surface are species-specific. Reticulated slug activity at the soil surface was found to be associated with soil moisture penetrating to 50 to 60cm depth. Black keeled slug activity appeared to be triggered by moisture deeper in the soil; it is likely that 75 to 100mm of rain is required over a three-week period in autumn for them to become active.

Crop types were found to influence slug abundance and so contribute to yearly fluctuations in slug populations in the paddock. Crop rotation choices may assist with slug management. Trials found slug populations increased in the canola phase of the rotation.

To summarise, effective control of slugs in no-till, full stubble systems is achievable. Ensure quick crop establishment; with canola, sow early using either hybrid seed or graded open-pollinated varieties. We recommend rolling then baiting at sowing to protect the crop from seed loss and seedling damage. The timing of slug activity and feeding will vary depending on paddock and seasonal conditions and the species present. Monitor emerging seedlings every couple of days and re-bait problem areas as needed depending on weather.

Novel chemical and microbiological products/controls

As part of this research project some novel approaches to snail control were tested, including two potential snail bait products. A new flour-based bait, formulated to absorb moisture rapidly to allow snails to consume it sooner than other commercially available baits, was compared with the standard bait Metarex® and either exceeded or gave equivalent snail control to the standard in lab and field trials.

Another novel molluscicide was trialled in a bait pellet formulation against *Theba pisana* (white Italian snail) adults. This treatment was ineffective at killing these snails.

Attempts have been made to trial novel bacterial treatments but there are technical issues with producing baits containing stable bacterial isolates. It was later determined that these treatments did not contain *B. subtilis*. Further investigation of bacterial molluscicides for control of Mediterranean snails has been suspended until consistency of bacterial isolates can be assured.

Sprays were tested in a desiccated field pea crop to repel common white snails already lodged in the canopy and to inhibit or repel further snail movement into the crop canopy. No treatments caused significant mortality and/or had a repellence effect on the resident snail population.

A slug feeding on a canola seedling. Trials found slug populations increased in the canola phase of the rotation. PHOTO: MICHAEL NASH, SARDI

Fly parasitoid research for biological control of conical snails

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CSIRO, Health and Biosecurity

Four species of introduced Mediterranean land snails cause major damage to broadacre crops in Australia. Controlling land snails is challenging. Due to the limited management options for snails, a biological control program was instigated in the 1990s. Classical biological control is the reunification of a pest with its natural enemies, which are absent in the introduced environment. To avoid risks to Australian fauna, only highly specific natural enemies can be used as biological control agents. Biological control can be very successful to control certain pests. However, it is not a silver bullet and often needs to be used in conjunction with other management strategies.

Researchers first studied the snails in their native Mediterranean habitats to identify natural enemies. Most of the natural enemies were found to be generalists and could not be introduced to Australia as there would have been risks to native species. Only one natural enemy was host-specific enough to be considered as a biological control agent: *Sarcophaga villeneuveana* (then known as *S. penicillata*), a fly parasitoid of the conical snail *Cochlicella acuta*.

The fly parasitoid lays larvae on the shells of snails aestivating off the ground. Fly larvae enter the snails, feeding and remaining inside until they have completed their development, killing the snails in the process. The fly is active throughout summer and has several generations. It is not expected that the fly parasitoid will control the small conical snail (*Prietocella barbara*) in Australia as *C. acuta* is its preferred host, but it can sometimes use this snail as a host in the native range.

After strict specificity quarantine tests were passed, *S. villeneuveana* was introduced in the early 2000s on the Yorke Peninsula, South Australia. While it has established successfully, it has spread little in the past 15 years and parasitisation levels remain low, not keeping snail populations under economic threshold. Considering that fly parasitisation rates can be very high in the native range, the reason behind this low success in Australia is unclear.

Recent work using molecular tools showed *C. acuta* snails introduced in Australia are more closely related to *C. acuta* snails found in Morocco and Spain than the ones in France. As the *S. villeneuveana* that was introduced in Australia was collected in France, could there be a mismatch between the snail and the fly parasitoid? If the fly parasitoid was collected from the origin of the Australian snails, could the fly strain be more efficient at controlling *C. acuta* in Australia?

CSIRO is trying to answer these questions by assessing the efficiency of different strains of *S. villeneuveana* on Australian *C. acuta* under different conditions. If these new fly strains are shown to be more efficient than the ones already present in Australia, they may be introduced.

S. villeneuveana **being reared in the laboratory.** PHOTO: CSIRO

Conical and round snails aestivate over summer on stubbles. PHOTO: CSIRO

Crop feeding preference of slaters

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CSIRO

JOSH DOUGLAS
University of Melbourne

It is not uncommon to see large numbers of slaters in low-tillage or no-till farming systems across southern Australia. Retaining stubble improves the crop environment for species, such as slaters, that usually feed on dead and decaying plant material. More recently damage to cereals, pulses and oilseed crops by slaters has been reported, but we cannot say when and why they decide to feed on growing crop seedlings.

In theory, feeding on live plants that have inbuilt chemical defence compounds should be a lot more challenging for these species. Slaters are used to consuming plant material that has already had some microbial breakdown.

To address this issue, University of Melbourne PhD student Joshua Douglas conducted experiments using the slater *Armadillidium vulgare* (common pill bug). He constructed artificial enclosures with different crop seedlings and added slaters for several days. He then recorded which parts of the seedlings and how much were eaten by the slaters.

Both the type of crop and the growth stage of the seedling influenced the amount of feeding by slaters (for the full results see the link below to the paper). Lucerne and canola were the most susceptible crops in the very early growth stage; chickpeas, lentils and wheat only had small amounts of feeding damage. No damage was observed on faba beans.

If these results reflect what occurs in a real crop field, chickpeas, lentils and wheat seedlings would be vulnerable for a very short period of time. We suspect that because faba beans have much thicker plant tissues they may be physically harder for slaters to consume. Conversely, lucerne, with its slender stems, can easily be fed on by slaters.

Understanding which crops and at which growth stage slaters are likely to cause damage is the first step in developing management strategies for these species. Next, we need to understand how the environment affects their decision to feed on crop seedlings (temperature, rainfall and other food sources), and what growers can do to protect seedlings during the vulnerable time period.

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Understanding which crops slaters prefer in the laboratory is the first step to determining why they switch from their normal diet of decayed plant matter to crop seedlings.

PHOTO: DPIRD

GROWER CASE STUDIES

GRDC

Monitoring rainfall is key to slug and slater control

SNAPSHOT

LOCATION: south-west Western Australia

PESTS: slugs, slaters and earwigs

ANNUAL RAINFALL: 350mm (290mm average growing season rainfall)

SOIL TYPES: 20 per cent heavy cracking clays, 80 per cent loamy clay

LIVESTOCK: Dohne Merinos, lambing ewes and hoggets

CROPPING ROTATION: pasture (basic unit)/wheat/canola/wheat/maybe barley. Generally, wheat back to pasture but there are some paddocks of heavy country that have been cropped continuously as part of the farm's ryegrass control strategy

Monitoring rainfall in the weeks before and after seeding is key to controlling slugs, slaters and earwigs in establishing canola and pasture paddocks on this mixed farm in the south-west.

"We have learned that rainfall determines when we need to treat for slugs, rather than the number of slugs in the paddock," the grower says. "Their eggs need 40mm of rainfall to hatch. The critical time of year to treat canola and pastures is post-seeding pre-emergent for protection against slugs, slaters and earwigs."

Bare patches in canola

"We have been no-till since 1996 and make a big effort to keep trash to help with moisture retention on both our red country and grey clay," the grower says.

"We started noticing that slugs were a problem the first time we put canola in; at about the three-leaf stage, bare patches were appearing in the canola. The first really bad year was 1997. Once it was noticed, everyone was out with their torches at night, but by then the damage was done. We did put out some pellets, treating the margins of the affected patches to try to contain the slugs. Some farmers even tried using garden spreaders to throw pellets from the back of their utes to patch out the slugs, but it was too late."

The grower realised the retained crop stubble that increased soil organic matter, retained soil moisture and protected the soil surface against wind erosion also provided an environment that allowed slug numbers to increase.

In about 1998, the family purchased a Marshall multi-spreader, which was then used every year to spread metaldehyde pellets to treat slugs in canola.

Slaters also emerged as pests. "We tried using fipronil (Cosmos®) on canola seed at 400 millilitres per 100kg of seed but we were still losing canola seedlings in some areas," the grower says. "However, in 2017 we started treating those areas for slugs with the more expensive methiocarb pellets and they also seem to repel slaters.

"We have also lost Scimitar medic seedlings on heavy soil. At first, we put it down to SU [sulfonylurea] damage, but we found that it was in fact slugs and slaters, because in dry years the medic survives. The plants that survived didn't look like they'd been touched up by SU; the missing plants were being taken out when they were young."

In 2017, the grower tried burning the wheat stubble on all paddocks before seeding canola, because stubble provides shelter for the pests. He found that where the fire reduced the stubble it did reduce the slaters, but also dried out the soil. "We saw different canola germinations depending on how well the stubble had been burned. It made a difference [to slater numbers] but it also made a difference to the moisture retention in the soil in a year where we had summer rain and a dry autumn. Burning the stubble only ended up drying out the country, so we are going away from this now to sprays and baits."

Rainfall is key

The benefits of no-till to productivity on this farm are significant enough that the grower maintains his stubble cover and manages slugs, slaters and earwigs with pellets and sprays on about 20 per cent of the farm each year as part of the farm program.

"About 20 per cent of the total farm area has a slug problem and only when those areas are planted to canola. We thought the slugs were getting worse, but we have decided that it is slaters and earwigs on the clays in canola and pasture, so we treat both phases with insecticide in those areas where we know we get problems."

The grower has found that while damage to establishing canola and pasture can be caused by slugs, slaters or earwigs, slugs tend to occur only on red country while slaters and earwigs are found on both the red and grey clay soils. He has noticed that slugs, slaters and earwigs do not occur on areas of lighter, sandy soil on the farm. "The pests seem to need stubble for moisture and a crumbly textured soil that allows them to hide in the cracks," the grower says.

The grower plants using a Morris Concept 2000 bar at 25cm spacing. The aim is to strategically apply just one bait or spray to get the crop or pasture through the establishment phase. "We want to keep the pests at bay until the canola has four true leaves or the pasture has established."

If 40mm of rainfall has been received within a week and the canola has been seeded, pellets are applied evenly across each canola paddock. "By treating after seeding we get the plants past the danger period. Slugs will seek out the pellets, which makes it easier to kill them than if they didn't. We aim for a density of 5.5kg/ha of pellets." This costs $40/ha for the treatment in canola.

"To calibrate the spreader, we put a known quantity (20kg) in the spreader and adjust the door to where we think it should be for the 20kg of pellets we have put in. We then see how many hectares that weight of pellets covers and we adjust the door, so we get about 5.5kg/ha, or just over that. We use a tractor with autosteer and a map to check visually that all the area has been covered.

"We generally spread at a 24m width, which is well within the range of the spreader, and someone drives across afterwards to ensure a nice even spread of pellets."

The grower aims to maintain a high seeding rate in canola for many reasons, including pest predation. “We calculate our seeding rate to get 50-plus plants per square metre in canola for good weed suppression; allowing for things like insect predation, we end up with between 30 and 45 plants.

“Hybrids are better at out-growing slugs due to hybrid vigour. We do try to grow hybrids on the heavier country for this reason, but there is a higher cost of the seed which increases the risk. Only 20 per cent of our plantings of canola are hybrids.

“This year the lower rainfall meant we didn’t get 40mm in one hit and the crop was well and truly established before the slugs got going. Baiting was still worth doing because the rainfall resulted in uneven germination of the canola.”

In pastures, slaters and earwigs are more of an issue than slugs. “This year the pastures weren’t baited but received a good spray of insecticide. We are finding that with a good spray we are holding insects at bay and getting good establishment of Scimitar medic. The spray goes on when we feel there will be a germination of the sown pasture.

“Slugs and slaters don’t seem to be associated with particular weeds so we don’t need to manage them by fenceline weed control, and grazing affected paddocks doesn’t seem to make a difference,” the grower says. “We sometimes notice slugs under rocks during rock-picking. The slugs are always there in the red country, just waiting for rain.”

This season the drier conditions affected pest activity. “This year it really was the lack of rain that defeated the slugs; they’re not a problem in a dry season. We found this year that if we can spray slaters and earwigs in pasture when there is enough moisture around to make them active, and then it dries out, the population falls markedly and they don’t come back.”

Biosecurity is important

The establishment of small conical snails along the south coast and their movement north is concerning for grain growers.

“That is why we bait heavily, even in a dry year like 2018, because we know that we have snails coming,” the grower says. “We have also had white Italian snails come in from the road where dirt had been moved for major road construction. It is important that we maintain good hygiene, particularly of machinery.”

A good strike of Scimitar medic following spray treatment.

Black keeled slugs (*Milax gagates*) shelter under rocks.

Turning over residues reveals slugs. PHOTO: DPIRD

Slaters.

Time-effective slug control achieved by blanket treatment after sowing

SNAPSHOT

LOCATION: south-west Western Australia

PEST: Slugs

ANNUAL RAINFALL: 416mm (285mm average growing season rainfall)

SOIL TYPES: red clay, grey clay, red loam, sand over clay duplex, and deep sands

ENTERPRISES: 75 per cent cropping, 25 per cent pastures

LIVESTOCK: Merino ewes and White Suffolk rams

CROPPING ROTATION: Lighter soil – wheat/barley/lupins / wheat or cereal/canola
Grey clay – wheat/barley/balansa clover/wheat or cereal/canola
Red clay and loam – vetches/canola/wheat/barley/barley

Managing slugs by blanket pellet application after seeding canola, rather than using reactive treatments, is the most time-efficient option on this mixed farm in the south-west. The grower schedules preventive slug treatment into the cropping program, where stubble retention and no-till practices are critical to overall productivity.

Impact of slugs on canola establishment

The grower says slugs first became an issue more than 15 years ago, not long after he started growing canola. “The crop was post-emergent, and we were probably a bit slow because we didn’t know what was going on with the slugs. It may even have been into June when we were seeing these bare patches in canola at the home farm,” the grower says. “I started going out with a bucket and spreading pellets for slugs by hand.”

The grower says reactive treatments are inefficient. “I used to find that when you were looking for slugs, you’d find a patch here that you’d see, and you’d treat that, then a week later you’d find another patch and you’d treat that. And while you were focusing on that, another patch would appear on the heavy soil. They used to start as bare patches about 1.5m across, then the slugs would get on the march. I don’t know how much each slug eats but I have read that they repopulate at a huge rate.”

He estimates about 10 per cent of the farm – the red heavy soil – is affected by slugs and he has realised that slugs are on the farm throughout the year. “I see the slugs all year round,” he says. “Last summer I’d be walking down the driveway in the morning when it was damp and walking over slugs. We had floods that year. This year is drier and I haven’t seen them recently, but all year round you can turn a rock over on that red soil and you will see their slime.

“I do think the slugs are spreading. We never had slugs at the other farm before, although we had grown canola there. Then three years ago we had a patch appear that got bigger and bigger. It was on redder loam, not what I’d term as being slug country based on our previous history. The other farm is seven or eight kilometres away as the crow flies, with very similar weather. The paddock is along the river; maybe there were transfers of slugs down the river in floodwater. That’s when we decided to do a blanket application on all the canola on both farms; even paddocks that haven’t had slugs before get the lower label rate.”

Time management

For the past three years, knowing how fast slugs can reproduce under ideal conditions, the grower has managed slugs during canola establishment by blanket application of pellets. “Straight after we plant the canola, we spread it.” He finds this enables effective time management.

“It may be a tad excessive, costing maybe from $7000 to $8000, but time management at that time of year is crucial. It is so time-consuming looking for bare patches and checking numbers of slugs. When the canola is so small and you are looking for patches, you might miss a patch that you find two weeks later and the damage is done. The blanket application means the slugs are dealt with.”

The grower baits in late April or early May straight after seeding as a single application of 5kg/ha of pellets on the more susceptible areas, reducing to 2kg/ha in the less susceptible areas.

“We use rain-fast slug pellets of metaldehyde through a SlugMaster spinner with a 60-foot (18m) throw that we sit on the back of the ute,” he says. The hopper of the SlugMaster is marked to show 25kg of pellets, and through trial and error the grower has found that driving 15km per hour achieves 5kg/ha and he can apply 2kg/ha by driving 30km/h.

“I haven’t observed that the slugs are more active after rain. My initial thought was that wetter summers would affect slug numbers. However, three years ago we had a really dry summer and autumn and I thought it would really stuff the slugs up and I’d get away without spreading pellets, but then it rained and there were plenty there. I’m wondering whether a dry winter might slow them down.”

The grower says he is convinced that stubble makes a difference to slug numbers. “For the last 20 or 30 years we have been retaining all the stubble and we never had slugs before on that sort of country. Just as stubble retention has created an environment for earwigs and other things, it creates a perfect environment for slugs.

“Sometimes we have needed to burn heavy stubbles to get through with the seeding bar, but we don’t do it for slug management. I don’t think that it would kill them; I would think it makes less habitat for them. Quite often we burn the whole paddock then put in the canola straight away. Slugs are in the ground during the day and out and about at night, so they are in the ground when we are burning in the daytime.”

Fenceline weeds are managed as part of whole-farm weed control. “In my experience the slugs are not coming from the fencelines. They just pop up in the middle of the paddock,” he says.

“We don’t grow summer crops and grazing slug-affected paddocks hasn’t affected slugs. If we graze them over the

Stubbles provide shelter for slugs. PHOTO: DPIRD

Stubble and soil clods can reduce slug contact with baits. PHOTO: DPIRD

summer time and then plant canola we still need to manage slugs."

The grower believes management could be simplified if a slug spray could be applied with the post-seeding pre-emergent insecticide spray on the canola. "The slug pellets are not cheap, at $25/ha and a worker's time to apply. We do insecticide spraying at night, and slugs are out at night. It would be good if there was a spray that cost less than pellets that you could put on at night, especially if we could spray slugs [at the same time as] the insect spray we do post-emergent."

The grower only planted around 100ha of canola in 2018 and there was no real slug damage.

Other insect management

The grower uses an insecticide spray in July when he plants lucerne and may spray canola on vetch stubble for false wireworm, but other crops are treated only when there is some damage.

In early stages of canola growth, he goes out at night to see what is there. "If there is not much activity, I might check only once or twice. Our threshold for treating depends on crop damage – as soon as I see plants missing. It's hard because sometimes you don't know whether it is damping off of the canola seed.

"If we see insects and they are doing crop damage we will give them a night-time spray of 1L/ha of chlorpyrifos, which I think more slows them down so the crop can get away. The only time we had earwig damage was last year in some lupins on sandy soil at the other farm. We may have had a few slaters in crops at the home farm."

Vetches for weed control

On his red soil, the grower uses vetches in the rotation as a weed control measure. "The vetches are grazed off," the grower says. "They are a bitter variety. We plant them and once they are established the sheep go in to eat the weeds and they won't eat the vetches. Then we spray them out mid-October with 2L/ha of glyphosate and 3g/ha of Ally® and then they become palatable. They sweeten up once they are sprayed, and then the sheep will eat them. Just as long as we don't get too much rain, because that turns the vetches into cardboard. You have to stock them early otherwise the vine gets woody and not as palatable. Initially the sheep do well on it when we spray it out, and we get the good weed control."

Tackling snails early in the season gives a clear advantage to this SA business

SNAPSHOT

LOCATION: coastal South Australia

PESTS: small conical snails, conical snails, white Italian snails, vineyard snails

ANNUAL RAINFALL: 350 to 400mm

SOIL TYPES: calcareous sands, some quite shallow

LIVESTOCK: Murray Grey cattle, about 5 per cent of operation

CROPPING ROTATION: lentils/faba beans, canola, wheat/barley. Canola is the most profitable crop

Retaining stubbles is crucial to maintaining a productive cropping system on this coastal farm in SA, so snails are managed without burning or tillage. Instead, this farming family uses the heat of the summer to maximum effect by cabling or rolling to knock snails onto the ground where they desiccate. This is followed up with a consistent baiting program early in the season and again pre-emergence. Seed cleaners and snail rollers are used to clean grain after harvest.

No-till favours crops but also snails

The family has been managing multiple snail species for several years. The shallow calcareous soils and cool, moist summers create an ideal environment for snail populations. “Snails have been around for years, but it’s only since we’ve moved to no-till that they have caused crop damage,” the grower says. “However, stubble retention has been so valuable for us, we can’t go back; we just had to learn how to manage the snails.”

Four species of snails – small conical, large pointed, white Italian and vineyard – cover most of the property. “Most of our paddocks are surrounded by scrub and the snails spend the summer in the scrub and return to the paddocks in the spring, which makes it very difficult to manage their numbers,” he says.

“Initially the larger round snails were a problem, but they have been easier to control than the smaller conical snails.”

The grower finds that snail numbers increase after a wet summer because they become active earlier and have more time to feed and breed.

While the grower is managing to keep snail numbers steady, he believes they will probably never get rid of them. Instead, snail management is seen as a normal part of the farming system and every opportunity to reduce snail numbers must be taken because populations can “balloon out so quickly”.

The grower has observed that snails which appear dormant can move a surprising distance overnight. “In February and March, when the evenings become cooler and dewy, I start looking for the round snail trails on bare ground around gateways or fencelines; it means they are moving and ready to bait.”

Early stubble management crucial

The family’s strategy is to reduce snails early in the season beginning with harvest. “During harvest we cut stubbles at Coke-can height and redistribute the straw over the paddock,” the grower says. “Anything that reduces stubble height or brings stubbles closer to the ground is tough on snails over summer.

“Stubble retention is worth $50/ha in nutritional value alone for us, without the other benefits of moisture retention and less soil erosion. So stubble burning or tillage aren’t used to manage snails.”

Controlling green weeds over summer that can shelter snails is important. “Sometimes this means spraying paddocks straight after harvest or multiple times over the summer period.” The family also tries to maintain a 4m strip of bare ground around paddocks, particularly those bordered by scrub. This makes it harder for snails to move from the cool shelter of the bush to paddocks without drying out.

Reducing green material in paddocks also improves the effectiveness of cabling, which is an important part of the stubble management. “Soil or ground temperatures need to be 68 to 70°C for cabling to work and this needs a long spell of hot days. However, with cabling you can cover a lot of ground relatively quickly.” The grower runs a 300m chain or cable between two utes, travelling at 30 to 40km/h. The cable will be run up and back over the paddock if there is time, to get the more resistant stubbles to fall over. This technique can be less useful for conical snails, but the grower still feels it has an effect.

The family also runs steel rollers over the paddocks, which are less temperature dependent, to flatten stubbles and squash some snails. This rig has 3x5m rollers and can move at 12 to 15km/h. “We only roll the paddocks in one direction as it can make the soil quite fragile and prone to erosion,” the grower says. The newer rollers have ribbed steel surfaces that can cut up the stubbles and may reduce erosion by ‘pressing’ the stubbles into the soil. The grower notes that “if we missed rolling a paddock for some reason, there were always more snails later on”. While rollers seem to work better on round snails than the conical snails, the grower feels “it all adds up”.

Baiting early to prevent breeding

Once the nights become dewy in February and March, the grower will throw out handfuls of test baits. If there are dead snails around the baits in the next few days the family will start its pre-seeding baiting program.

All cropping paddocks are usually baited twice a year. The initial pass is done when snails first become active and start feeding and the second is done after seeding, before the crop comes up. “Baiting snails before they breed is crucial – it stops the snail population from blowing out and reduces the number of snails in the crop during the year and at harvest.”

Metaldehyde-based baits are used at the highest registered rate, with the grower finding that the number of bait points is important – the more points per square metre the better.

Paddocks are rolled after seeding to lightly compact the soil, which makes the second application of baits more accessible. The grower emphasises the need to get the baits out before the crop is up, “to make the most of your baits, you don’t want them competing with seedlings”.

“We use a Bailey® spreader for baiting, which can be accurately calibrated to lower rates,” the grower says. “While the spreader would normally spread fertiliser over 30m, you would only expect to get about 24m of coverage with snail baits as they are much lighter.”

Snail roller used at harvest

The family has had problems in the past with grain loads being rejected for snails. Some header modifications have been tried, such as ‘bash bars’ to reduce the intake of snails in the header, but the family now feels its efforts are better directed at managing snails earlier in the season. “If you are only managing snails at harvest it means they have been eating your crop all year … it’s like shutting the gate after the horse has bolted,” the grower says.

The family uses a combination of grain cleaners and snail-crushing rollers to remove snails from grain after harvest. The small conical snails are the hardest to remove because they are a similar size to the grain. Most of the grain is snail-rolled in most years and the family uses the snail roller for all crop types – canola, cereals, lentils and faba beans.

“During harvest the grain goes from the chaser bin into the ‘dirty’ bin,” the grower says. “From there canola goes through a Hannaford rotary screener before being augured into the snail roller. We use [approximately] 2mm slotted screens for the canola, although we have tried [approximately] 2mm round-hole screens in the past. These did a better job at removing the snails but there was too much grain wastage. For all other crops, the grain goes from the ‘dirty’ bin directly into the snail roller then into a ‘clean’ bin ready for carting.”

The snail roller is a four-roller model with two rubber and two steel rollers. The grower runs the snail roller as tight as he can without damaging the grain and generally it is run slower and tighter for canola. There is a trade-off between running the roller tight and removing more snails, and damaging the rollers if they become too hot. Replacing a roller costs about $1200, which, aside from the harvest logistics, is the biggest cost of operating the roller. “If there are too many snails in the roller it becomes gummy and you will know straight away if something is not right.” The rollers run at about 540 power take-off (PTO) revs for cereals and 400 PTO revs for canola.

The snail roller is started early in the day while headers are getting cleaned down and trucks are filled, and runs all day to keep up with headers.

A steel roller is used to crunch stubbles and knock snails onto the ground over summer.

Dead snails in a canola crop after an early baiting program.

Grain cleaning set-up during harvest: grain goes from storage silo into grain cleaner, then through the snail roller and finally into a clean silo or straight onto a truck.

Early season management and use of snail rollers provides control in no-till SA system

SNAPSHOT

LOCATION: South Australia, one southern farming area near the coast and another further north

PESTS: small conical snails, white Italian snails, vineyard or common white snails

ANNUAL RAINFALL: 400 to 450mm

SOIL TYPES: calcareous sands on southern farm, grey loam on northern farm

LIVESTOCK: 250 Murray Grey cattle and 1000 Merino sheep

CROPPING ROTATION: beans or lentils/canola/wheat

This farming family is operating a large cropping and mixed livestock program over two locations and managing snails regularly throughout the season. Although it does not want to use any practices that could cause erosion of fragile soils, the family has still managed to reduce snail numbers using a variety of management options that have not negatively affected soil management.

Snails decimate canola crop

Snails have been in SA for a long time, probably due to the combination of early introduction, calcareous alkaline soils and cooler summer conditions. However, this family, which farms in two locations, has found snails are slowly working their way into hotter and drier areas with heavier soil types. This may be related to the overall increase in snail numbers in the region that appears to have followed the widespread adoption of no-till farming and stubble retention.

While snails have been part of this farming system for more than 30 years, the family only started to rethink its approach when the first serious problems with snails in crops emerged. “We had a canola paddock almost wiped out by snails eating it … canola yields of 2.5t/ha were reduced to 1t/ha because of snail damage,” the grower says.

Now he estimates the whole southern block is affected by snails and they are also present in lower numbers in the northern block. The family has also had snails affecting grain quality, so managing snails throughout the cropping program has become important.

The grower finds that snail populations fluctuate throughout the cropping rotation and adapts management practices accordingly. Not surprisingly, the broadleaf crops such as canola, field peas and lentils increase the reproduction of snails. By harvesting the stubble low in the wheat crop, pressure on lentils the following season is reduced. Similarly, although wheat is not normally a crop that snails enjoy, the grower knows that when it comes after canola in the rotation the snail numbers will be higher – and he acts accordingly. In the pasture paddocks oats is now preferred rather than vetch, where snail numbers are likely to increase.

The family finds that snails prefer to shelter in roadside vegetation over summer and will move into cropping paddocks as soon as the weather cools and there is green food on offer.

The snails seem to prefer the light, calcareous soils and moist conditions on the coast compared with heavier soils and drier conditions further north, but the snails still cause problems on this property.

Cabling and stone rollers used pre-seeding

Management starts early in the season with stubble management coming out of the header. Stubbles are cut lower in paddocks where the family thinks there will be higher snail numbers.

Summer weed control reduces snail food and shelter and further improves the effectiveness of other management techniques such as cabling and baiting later in the season. Snail pressure is higher in pasture paddocks where green material has been retained for stock, compared with the cropping paddocks that are kept bare. “We find that where weed control was poor at the start of the season the snails are definitely worse,” the grower says.

The family does not do any burning or tillage because the paddocks’ soils are too light and wind erosion is a concern. “A speed tiller might bury snails and kill some, but it provides no cover to soils and it needs to be done early in the season, which exposes soils to wind erosion,” the grower says. While disc chains can dig up and bury snails there is the timing to consider: “Too early in the season and it can cause soil erosion, too late it creates a ‘fluffy’ seedbed giving poor germination.” For this family the yield benefits of no-till farming and stubble retention outweigh the potential benefit of managing snails through burning or tillage.

The family uses cabling (chaining) over summer, when the weather allows, to knock down stubbles and force snails onto the hot ground. “We are on the coast so don’t often get a run of hot, dry weather, but when we do we’ll take the opportunity to do some cabling. We can move pretty quickly and cover a lot of hectares, so it’s worth a go.”

More suited to the southern farm’s climate are the flat land rollers, which knock down stubble stalks and squash the residues into the ground, crushing some snails in the process. This technique works better on heavier soils and round snails, with a 60 to 70 per cent kill rate. The rollers can operate at 18 to 20km/h and are 15.24m (50 feet) wide.

Baiting done consistently

The devastating effect snails have had on crops in the past provides a strong incentive to bait paddocks consistently and repetitively. Every paddock is baited at least once a year, even if numbers are low, because the family knows how quickly the snail population can increase.

Baiting is carried out as pre-sowing strategy any time after harvest and right up to seeding, usually following heavy dews or a rain event. The aim is to decimate adult snails before egg laying starts, to have the maximum impact on the overall population. The number of baits and regularity depends on the density and reproductive potential of the snails at that particular time of year. This can also be influenced by favourable weather conditions (moist and cool).

Baits are spread at rates of 5 to 10kg/ha depending on the density of the infestation and repeated as required. Applying large quantities of bait in one spreading has not achieved a good result, with considerable waste as baits deteriorate over time. In-crop baiting has been unsuccessful as the snails have alternative food sources and are not as attracted to the baits. Juvenile snails are mostly not attracted to baits and therefore evade the system, enabling the snail cycle to continue.

On the coast, where snail numbers are high, paddocks may be baited several times a year, whereas the northern block would only usually be baited twice a year.

A conventional spreader is used for baiting and there is a focus on known hotspots such as ridges, fencelines and the lighter soils where snails are worst. Bait is spread at 50ha/h and the whole farm program takes approximately two weeks.

Grain cleaners and rollers integral to harvest

In the early years of managing snails, the family had some wheat samples containing 160 snails per half-hectolitre. This experience provided a very strong incentive to manage snails early in the season rather than wait until harvest. The family has tried a stripper front on its header; the header without a stripper front had 20 to 30 snails per half-hectolitre compared with the header with a stripper front, which had only one to two snails per half-hectolitre. However, use of the stripper front was discontinued as it left too much stubble behind, which lodged and made seeding difficult the following season.

Larger snails are normally removed by the header in the harvesting process, but some come through. “Some guys are inserting extra blanking plates in their headers to try and hold the grain in the header for longer to crush the snails. This can result in some higher screenings, though,” the grower says.

Canola is cleaned using a combination of a Shmik® grain cleaner and a double snail-crushing roller. The canola goes through the grain cleaner using a 2.5mm slotted screen to remove the larger snails. The cleaner is very effective at removing snails from the grain, but the family still likes to run the canola quickly through the snail roller for a final clean. The roller speed is set to match the grain cleaner (about 45 to 50t/h) for a more effective flow of grain during harvest. While the snail roller could be run slower and tighter, the family’s method can get 30 to 40 snails per half-hectolitre down to very low levels.

Canola used to be run through the snail roller first to crush the snails and then put it through the cleaner. The problem with this method was that a lot of the smaller pieces of snail shell went straight through the cleaner and ended up in the grain. The process was reversed to get rid of the larger snails by scalping them, before rolling to crush the smaller snails.

Wheat is run through the double snail roller at approximately 60t/h. Grain samples with fewer than 30 snails per half-hectolitre are usually bought down to zero at this rate. Once a grain sample has more than 30 snails per half-hectolitre, it becomes difficult to clean. In these cases the best solution is to roll the wheat again.

In the past two seasons the family tested a prototype snail roller that has the potential to process cereals at 90t/h. Performance was very good and the manufacturer is addressing some final technical concerns before this machine is released commercially.

This farming family run two headers at harvest time, so it is difficult to find a snail roller that can keep up to both. A 100t field bin is used for ‘clean grain’, which can be moved to utilise the full capacity of the storage. The snail roller is the first machine turned on in the morning and the last turned off at night. By operating some extra hours over and above the harvesters, the prototype snail roller was able to keep up to two large-capacity Gleaner® headers.

The family stores its lentils and beans and delivers throughout the year. The grower has noticed that silo bagging grain before rolling tends to dry the snails out, which makes the rolling process easier and more efficient. Lentils and beans are cleaned quite hard and the screenings are sent for cleaning by a commercial seed cleaning company.

Despite using many different management strategies to reduce snail numbers, two strategies have the greatest impact. The management plan is spearheaded by the liberal application of snail baits early in the season. This is the most effective way to reduce snail numbers and their impact on the growing crops, as well as reducing snails to a manageable number in the harvested grain.

During harvest, use of the snail roller is essential to ensure grain delivered to the family’s handler is not discounted. Despite using most management options available, this family still needs to use the snail roller for every paddock in most years. Without the snail roller, grain could not be delivered without a significant discount.

Round and conical snails present a challenge for South Australian growers. This photo was taken on a roadside verge.

Grain cleaner set-up with a large field bin.

Snails cleaned out of grain in foreground and snail roller operating in background.

Flexibility needed to manage small conical snails in a mixed farming system

SNAPSHOT

LOCATION: south coast of Western Australia

PEST: small conical snails

ANNUAL RAINFALL: 450 to 700mm

SOIL TYPES: mostly duplex soils with sand over gravel, over clay, and some heavier clay country. Lighter country has been clayed

ENTERPRISES: two-thirds cropping, one-third livestock

LIVESTOCK: Merino ewes, cross-bred lambs, Angus cattle, pastures are mix of clover, serradella and balansa clover

CROPPING (2017): 45 per cent barley, 40 per cent canola, 15 per cent wheat

A combination of narrow windrow burning, targeted baiting and grain cleaning have evolved as the best system to reduce small conical snails in this mixed farming system on the south coast. This farming family has been managing small conical snails for several years. Although the family still finds it hard to predict when and where snails will be a problem, it believes a flexible approach works best.

Missed opportunity to control snails early

The grower first saw small conical snails on the farm 15 to 20 years ago, mainly around sheds and in a paddock with freestanding limestone. However, snails did not become a problem until about nine years ago when they started eating out large patches of emerging canola. “Looking back, there were probably signs that snail numbers were building up for some time,” the grower says, “but as we weren’t actively looking for them, we missed an opportunity to act much earlier. We wouldn’t have stopped their spread, but we could have delayed it.”

The grower thinks snails tend to build up quickest in the canola phase of the rotation. “Generally, cereals aren’t that badly affected early on.

“Not long after snails first started to cause damage, we found patches of barley chewed off to ground level. The paddock was planted to canola the year before and we didn’t have any trouble with snails then, so it was a shock.

“It is difficult to predict when and where they are going to be a problem. Often you will find snails where you weren’t expecting them, for example, in the grain at harvest on a paddock where there was no damage earlier on.” The grower believes wet conditions, in any season, can cause snail numbers to build up quickly.

The family has been liming for more than 10 years and the grower thinks there may be “a possible connection” between liming and snail numbers. “Our permanent pasture paddocks have less snails and haven’t had too much lime compared to the continuous cropping paddocks (which have more snails). But whether that is because of cropping or because of lime, you couldn’t say.”

The grower looks for snails throughout the year, under rocks, stumps, up dead thistles, inside canola stalks and in the crop canopy. Snail management is determined on a paddock-to-paddock basis, using observations of snail damage to the previous crop, snail numbers during harvest, and dead snails under burnt windrows to make decisions.

Grazing and windrow burning to reduce stubbles

The family uses a combination of grazing and spraying to manage the green bridge over summer. The grower has observed that snail numbers build up in paddocks with radish, broadleaf weeds and volunteer canola, so they are routinely sprayed out early. Cereal volunteers are kept and grazed over summer until March when all cropping paddocks are sprayed out. “There’s no doubt that snails have an effect on pasture, although it is less than for crops … we’ve had areas of clover and grasses eaten out by snails in the past.”

The grower believes any method that reduces the heavy stubbles improves snail control: “Less stubble makes it easier for the snails to find the baits and makes the baits more effective.”

For two years the grower has consistently burnt narrow windrows in every canola paddock and he feels this has made a significant difference to snail control. “We’re finding a lot of dead snails under the burnt row and having less trouble with cereal establishment at seeding. But we can still occasionally find snails in the grain at harvest, which is frustrating.”

The family has cautiously burnt cereal stubbles on heavier soil types but is unlikely to expand this practice because of the potential for soil erosion. Burning on the south coast has been a challenge, with rain in summer and autumn making it difficult to find an opportunity for a good burn. “You don’t want a lot of green material in paddocks before a burn as it lures snails out of windrows and they won’t get burnt.”

Baiting based on previous year’s snail numbers

The grower uses observations from the previous crop and harvest to determine which paddocks to bait. For example, if the paddock is going into cereals and the previous canola crop had a very high number of snails, then the grower will use windrow burning and bait in autumn.

If the paddock had moderately high snail numbers, then he will bait post-seeding and pre-emergence. Emerging canola crops are watched closely for damage, but baiting paddocks post-crop emergence is only done if significant damage is found.

In choosing baits the aim is to have 30 to 40 baits (bait points) per square metre at the least cost. “We have found that our best option is to bait with non-rain-fast baits as most snails are killed in the first night or two. While it is disappointing to bait a paddock only to have heavy rain straight after, we can respread baits on that paddock a week later if needed.”

The family uses a conventional fertiliser spreader to spread baits. It did try a bait slot that fits over the trapdoor of the spreader, but it worked poorly. Using the conventional spreader, the belts are slowed down, using the slowest gear possible, and the trap door is shut until baits are just coming out. “You can’t have spinners going too fast as it breaks the cheaper baits up too much and they turn to powder.” Through trial and error, he has found that a small adjustment on the trap door makes a very big difference to the rate of baits going out.

The cost of baiting is significant; the grower estimates $25.50/ha ($1.30/kg for the bait, two applications of 7.5kg/ha, plus $6/ha to run the spreader). One to two bait applications may be required to get the crop established, but occasionally bad patches will be baited a third time.

Grain cleaning a part of harvest

Most frustrating for the family has been keeping small conical snails out of the canola at harvest. They use a rotary screen grain cleaner to process all their canola. “This is as quick and simple as anything, but it can be challenging if snails are the same size as canola seeds,” the grower says. The cleaner has slotted screens with 2.5mm holes; 2.1mm screens were tried to remove smaller snails but too much grain was lost in the process. The seed falls where cereal seconds would normally fall and snails stay in the screens and come out the other end. The grain cleaner can manage about 25t/h of canola.

So far, the family has not had to clean any cereals. “I know they are using snail-crushing rollers in SA and this is something we may have to look into down the track. But it is just another hassle at harvest and it would be better to avoid it in the first place.”

The family has found containing snails to be very difficult. “Once we found snail damage it was probably too late to contain them – the snails had already moved from farm to farm,” the grower says. “I think we just have to accept that snails will always be a part of our farming system and we just need to find a way to keep their numbers down.

“Snails have added a real cost to our business. There is the obvious cost of control and downgrading (grain) at harvest, but also the added pressure logistically to farm management.”

The grower recommends starting with windrow burning in canola because snails appear to build up fastest in this crop. “It is a similar principle to weed seed management; you have got to keep the numbers low, to keep the numbers low.”

Piles of dead snails under a narrow windrow after burning.

Snails in an emerging barley crop.

Cabling, baiting and seed cleaning used to mitigate snail damage and control slugs

SNAPSHOT

LOCATION: south coast of Western Australia

PESTS: small pointed conical snails and black keeled slugs

ANNUAL RAINFALL: 450 to 500mm

SOIL TYPES: sandplain soils, with the majority over duplex clay

LIVESTOCK: Merino and self-shedding meat sheep

CROPPING: cereals (barley) and canola

The farming family on this mixed farm on the south coast uses multiple strategies during the year to control slugs and snails and keep numbers down. The family uses a combination of cabling and burning early in the year to reduce stubble habitats, followed by a double baiting program. Finally, harvest logistics are managed to avoid grain discounts.

"Managing snails is a lot like managing herbicide resistance; it is a numbers game, you've got to keep the numbers to a minimum," the grower says.

Small conical snails first found in canola at harvest

The family first noticed small conical snails on the farm in 1985, but they did not become a problem until the 1994-95 harvest when snails were found in the canola seed. When that paddock went back into canola the family started baiting and has continued baiting on and off ever since.

"Canola seems to be affected by snails the most," the grower says, "particularly during crop emergence, but now we have had to start baiting paddocks going into barley, too." Aside from snails' preference for canola, the grower does not think they prefer any soil types and their spread has not had any definite pattern, although he feels swathing and harvesting has accelerated their movement between paddocks and farms.

The family looks for snails in grain and during harvest "to see if they are gathering on the header or swather fronts during operation" to make management decisions for the next season.

Burning and cabling effective in the past

Keeping paddocks free of green weeds over summer is a high priority, even if it means spraying only four weeks after harvest. Fencelines are kept bare for up to 2.5m to prevent snails sheltering in these areas over summer.

The family has done some burning on cereal paddocks with very high stubble loads, choosing paddocks with a heavier soil type and burning the whole paddock. In the past three years canola windrows have also been burnt. "Burning the whole paddock was very effective for dry, thick cereal stubbles. After burning, the paddocks that were the worst for snails, we had zero snails in the grain at harvest, and there was no need to bait the following canola rotation." In comparison, the grower found narrow windrow burning of canola was only about 20 to 30 per cent effective, although more likely to kill bigger snails, especially when used in conjunction with baiting. This may have been because snails were still sheltering in the standing canola stalks in-between rows.

The family has done some cabling in past years to try to reduce snail numbers, but the south coast rarely has the long hot spells of weather required to make the strategy effective. "It needs to be hot in the days before cabling so snails climb up into residue stalks, then hot for at least 48 hours after cabling so that snails are desiccated on the ground. It's hard to estimate the impact this has on snail numbers, but I feel that every little bit helps."

A speed tiller has been used to help manage stubbles by chopping up the crop residues and burying them. While speed-tillage is uneconomical for managing snails alone, it did reduce numbers by about 30 to 40 per cent so could be said to be a happy side-effect of this practice.

Baiting after crop damage is too late

While the family used to bait paddocks after the seedlings had started to emerge, it is trying to move away from this. "Reactive baiting is too late as you have already lost the crop, then there is the cost of reseeding and lost yield potential," the grower says.

Every paddock that has had snails in it is now baited, plus the family patches out paddocks where it thinks snails are moving into based on observations at harvest.

Most baiting is pre-seeding or at seeding, placing baits on soil at the top of the furrow. "We use a separate bin in the airseeder and a separate airstream places the bait on top of the furrow," the grower says. A telehandler is used to load baits into the airseeder, rather than an auger, as the auger can break up or 'powder' the baits, making them less effective.

Over time, bait rates have been increased from 3 to 4kg/ha to 7.5kg/ha and switched to metaldehyde-based baits. If rain is forecast, water-repellent baits (30 per cent) are blended in for longevity. Although using smaller-sized bait pellets maximises the contact points for snails, if the baits are too small they can get buried in the looser soil or lost after the first rain, so medium-sized baits are a good compromise.

The family uses an Amazone® spreader for broadcasting baits, for optimum precision. Using catch trays, it has determined this machine gets a 26m spread as opposed to a 12m spread in a conventional top-dresser. “Compared to fertiliser, baits are hard to throw and break up easily, so we need to make sure baits are spread evenly and the pellet size will deliver a fatal dose (to snails).” The family would like to investigate aerial baiting using heavy rates over a short timeframe.

“We avoid spraying out insecticides after baiting as it puts the snails off the baits – probably by contaminating the pellets with an off-putting taste or smell,” the grower says.

The family tries to sow canola early in the season on snail-affected paddocks so that it has a chance to emerge and “get away” before juvenile snails (which are not usually responsive to baiting) can eat the crop.

Plan harvest to avoid snails

“Harvest and swathing definitely increase the spread of snails and it is very difficult to clean the machines of snails completely,” the grower says.

“We aim to sow canola early in snail-affected paddocks, so they can be swathed earlier at harvest. This can prevent the swathes sitting in the paddock (for long periods of time) and gathering snails.”

For this reason, swathing starts in the ‘dirtiest’ paddocks then moves to the ‘suspect’ paddocks that might have snails, before going to the cleaner paddocks. Before moving between ‘dirty’ and ‘clean’ paddocks, machines are cleaned down in the afternoon or evening and then left until morning. It may then need another cleaning to rid it of snails that have emerged overnight.

The grower has observed there are more small conical snails in the crop early and late in the day compared with the middle of the day. To take advantage of this, the grower tries to harvest areas with higher snail densities in the middle of the day.

The family also has seed destructors fitted to its headers, so the grower thinks any snails coming out of the header are likely to be killed before returning to the paddock. A slimy residue gathers in the mills of the seed destructors in snail-affected paddocks, which lends weight to this idea.

The family uses a rotary grain cleaner to remove snails from canola. “We normally use 2.5mm slotted screens, but this harvest we also tried a combination of 2 and 3mm round-holed screens. Unfortunately, the round-holed screens caused too much grain loss, so we’re sticking to the slotted screens. One difficulty we’ve had screening canola is the difference in seed size between canola varieties can make the choice of screens difficult.”

The grower likens snails to weed management; they need a consistent, year-round approach to reduce the numbers. His key strategies are:

- control summer weeds in paddocks and along boundaries and fencelines;
- bait early, as soon as snails start moving in February and March;
- use mechanical control, such as cabling or stone rolling, based on weather and opportunities available; and
- use a 100 per cent burn as a last resort.

Fewer slugs with snail control

This family also has some issues with slugs eating emerging crops. “They are more likely to occur after a wet season and on the heavier country, but they do seem to appear quite randomly,” the grower says. While the slugs feed on both canola and cereal crops, they have the biggest impact on emerging canola.

The grower has noticed that since they have been managing snails, slug numbers have also been lower. Slugs feed and shelter in crop residues so any practices to reduce residues (burning and cabling) are likely to limit slug numbers, too.

“We’ve noticed that slugs seem to burrow underground when it is dry on the surface. By sowing canola dry, the canola can emerge early in the season before the slugs come up with the moisture. By the time the slugs emerge the canola plants are more established and so the slugs do less damage to the crop.”

As a rule, the grower will usually bait paddocks with heavier soil types and a history of slugs.

The family tries to grow summer crops in water recharge areas, primarily to dry these soils out over summer and prevent waterlogging the following winter. But it has found the practice also reduces slug numbers the following year. “Normally, having green material over summer would encourage slugs but, possibly, the summer crops are drying the soil profile out enough that the slugs can’t survive through the autumn.”

Dead small conical snails in stubble after early baiting.

Slugs are found on heavier country in some seasons only.

Managing white Italian snails, slugs and slaters in the cropping program

SNAPSHOT

LOCATION: southern Western Australia

PESTS: white Italian snails, some small conical snails, black keeled slugs and slaters

ANNUAL RAINFALL: 550mm on the home block, 500mm on the heavy country

SOIL TYPES: the home block has typical sandplain, sand over gravel over clay. The second block has heavier clay country with self-mulching cracking clay to sandy gravel loams

LIVESTOCK: cattle at the home block, but no livestock on the heavy clay block

CROPPING ROTATION: canola/wheat/barley/canola

This farming family is managing several pests, generally on heavy clay soils, with the snails and slaters causing the most damage to emerging crops. The family uses a combination of green bridge control over summer and early baiting to prevent snails from breeding and causing crop damage. Slaters are managed through a combination of canola seed dressings and night-time foliar sprays after germination.

White Italian snails explode after summer wet

"We first noticed the white Italian snails about 10 years ago, on a very small area of the property," the grower says. "We spread a few baits and thought we had it under control for a year or two. Then, over a wet summer, the paddock went from having a few snails along the edge to being completely covered with snails sitting on the stubbles. We ended up burning the paddock and it did a very good job."

The white Italians snails originated from a neighbouring property, introduced there by a contractor. Now the snails cover about half of the heavy clay block, with lower numbers in the areas with lighter soils. When the grower bought the farm, he says he did not realise how quickly snails could spread. The grower originally spread four or five little bags of baits a year but is now spreading 30 to 40 tonnes a year.

"The small conical snails only occur in hotspots, on about 20 per cent of the heavy country, but I think they will be a bigger problem for us in the long run," the grower says. The small conical snails originally spread from around sheds, fencelines, bush and creeks, and overlap with the white Italian snails in places. "We first found the small conical snails over summer in the stubbles and thought we would just spread a few patches with baits. In the end we spread a lot of baits and still wish we had done more."

The grower finds snail damage is worse in canola and peas as they decimate the whole plant. They also damage the cereals, but not to the same degree. However, snails affect grain quality in any crop, the family still baits snails in cereal crops.

The white Italian snails occur on both the sandy gravel loams and the heavier soils, but are worse on the heavier soils, which have a higher pH. Even within a paddock the grower can see that snail numbers, of both species, are worse on the areas with heavier soils. There are small conical snails on the heavier clay block and the lighter, gravelly block. But the white Italian snails only occur on the heavier clay block.

"Since we have started liming the light gravelly soils the snail numbers have built up with the increase in soil pH. Liming increases the calcium in the soil and it appears to help them breed."

Controlling the green bridge

The family sprays paddocks for weeds as soon as possible after harvest and up to three summer sprays may be needed depending on rainfall. "The white Italian snails climb up the stubble stalks over summer and don't come down again until they are ready to breed," the grower says. "So that is the key, having paddocks clean and bare in late autumn so all they have to eat is the bait.

"One year the wireweed didn't die after a summer spray and stayed green until autumn when we sprayed it again before seeding. Not long after seeding we found patches eaten out of the canola around each wireweed plant. The snails had moved in and around the wireweed plants over autumn then emerged after seeding to hammer the canola. It really shows how the green bridge can sustain snails over summer."

At harvest the family cuts stubbles to Coke-can height and anything higher, such as canola, is slashed later to help with stubble flow and seeding the following year. Although it is not done to help manage snails, anything that brings stubbles closer to the hot ground over summer helps to desiccate round snails and potentially small conical snails.

"We have only burnt the stubbles once for snail control and that was at the very beginning when the number of white Italian snails exploded," the grower says. "It was in autumn on a cereal stubble going into canola and was very successful in reducing snail numbers. However, to be effective you have to burn every square inch of stubble, which leaves the paddock very bare. Even though it was on the heavy country, the following canola crop struggled from the exposure, so we haven't burnt stubbles since. I prefer to keep the stubbles for mulch."

Baiting triggered by snail activity

Baiting is the family's main method to control snails, so it is planned carefully to get the best possible kill. "In autumn we put a picket in the ground as a marker and spread some snail baits around it," the grower says. "As soon as the snails start to go for it, we bait. This tends to be around late autumn and is usually a week or two after rain. Depending on how much rain we've had and the snail numbers, we spread between five to 10kg/ha for the white Italian snails. The white Italian snails seem to be active earlier in the season than the small conical snails, which need to be baited a bit later. Again, this is determined by putting baits on the ground and seeing what is feeding. The baits won't kill anything unless they are feeding. This is also about the time they start breeding, too.

"We don't bait every paddock every season, but each year we are baiting more and more, because numbers are increasing. They can do a huge amount of damage if they are not controlled. We had a canola crop that we didn't think had any snails, and it wasn't until a month after seeding that we realised that 20 hectares had been eaten out. You do have to be vigilant."

The pre-seeding bait is often followed up with another 5kg/ha on the canola after seeding or just after germination. Known hotspots also get a second bait regardless of the crop. To determine the snail pressure, a handful of test baits is thrown out to see if snails are still feeding. Often with canola the snail damage is quite easy to spot so baiting is done without testing first.

"We choose baits based on the price, because with the right time of application you can get a very successful kill rate," the grower says. "We know if we are using the non-rain-fast baits that as long as they have three days without rain they will remain effective." The grower uses an Amazone® three-point linkage spreader that can spread at very low rates (1.5kg/ha for mouse baits) and has auto shut-off.

The family tried aerial baiting early on and it was very effective, but the cost, on top of the baits, made it uneconomic for regular use. One advantage of aerial baiting is the ability to get into inaccessible areas such as tree lines and verges.

"Where we think we have snails we spread everything, including the areas where they may be breeding up and moving from, like trees or creek lines," the grower says. "We have got rid of any fencelines on the cropping block as the snails can survive over summer by climbing the fence posts."

Biosecurity key at harvest

Before harvest the grower baits areas that are heavily trafficked during harvest, such as silo pads, around the sheds and anywhere they are handling grain regularly. Sheds and silos are washed down before harvest. The grower finds biosecurity is most difficult over harvest as machines and gear sit in the paddock for longer periods than at seeding and snails climb on board and are transported around the farm. They use belt fronts for harvesting cereals, which collect snails but are very difficult to clean. Silos can also sit in the paddock for some time and snails will congregate all over the wheels and under the rim.

Direct heading helps to avoid snails

The family has only had a few instances of snails in its grain, with small conical snails found in canola, so the grain was cleaned before being delivered. They have not had issues with snails in cereal grains.

The family switched to direct heading canola about five years ago because of trouble with stones and sand in the grain. Now there are more snails on the farm in general, but there are fewer snails in the grain because the family is not swathing.

The use of a vario-type front for canola allows it to be direct headed. While there are benefits for harvesting, it also made the front easier to clean, with fewer components for the snails to climb into compared with the draper front.

"To be honest we are never going to get rid of the snails, so the question is about management," the grower says. "What works for us is to keep the paddocks bare of weeds and bait the snails. If you think you know where the snails are, bait that area twice and bait heavily and continuously. You must remain vigilant especially after summer rain, which is when the numbers really explode."

Slater damage on dark, heavy soils in canola rotation

"We first noticed the slaters when something was eating the canola," the grower says. "They had chewed right through the stem. We had a good look at night and the slaters were everywhere, there were millions of them."

Slaters will also chew the leaves off barley and reduce its vigour, but the grower finds they can devastate a canola crop. Slater damage is normally confined to the dark, loamy soils with high carbon content, which comprise about 30 per cent of the farm.

The grower has not noticed that slater numbers, unlike snails, are related to wet summers. He thinks the switch to no-till, combined with the particular soil type, has provided slaters with an ideal habitat to survive and breed over summer.

"The more stubble you have, the more issues you will have with slaters on those soil types," he says. "If you have high-yielding cereal crops year-on-year, you will build up huge amounts of residues that provide them with ample food, cover and the perfect environment to breed up."

The family is keeping slater numbers at manageable levels year-on-year and they are not spreading like the snails. Each season is slightly different, though, and the toughest years are when dry conditions follow germination and the canola cannot outgrow the slater damage.

The family does not normally treat cereal paddocks for slaters as there may only be significant damage every six to eight years. If the paddock is going into canola and has a history of slater damage, a residual insecticide may be added to the knockdown spray before seeding as a general crop protectant. Fipronil seed dressing is used on the canola, but this alone will not protect the seedlings from high slater numbers, as slaters can eat several plants before they get a lethal dose. A combination of insecticides is applied as a foliar spray to protect the canola just after germination. This is normally applied at night, when slaters are most active, to get the best spray contact.

White Italian snails perch high on stubbles over summer.

PHOTO: CSIRO

Slater damage is confined to heavy soils with dark organic matter.

Slugs

While slugs are a problem, they are relatively insignificant compared with slaters and snails. The grower finds slug damage occurs on the river country where there is hard-setting heavy clay containing a poorer balance of calcium and magnesium, making it sticky. The slugs seem to occur in the lower areas that feed into the creek and, as these areas can dry hard over summer, he wonders if the slugs move down into the creek over summer and return in autumn once the soils wet up again.

"Slugs still need to be controlled, as in bad years they can eat out a patch of crop which is about half to one hectare in size," the grower says. "The slugs will kill cereals as well as canola, but again, they will generally do more damage to canola than they do to cereals.

"Initially it was hard to work out what was causing the crop damage as slugs are difficult to see during the day. You need to dig around and look under rocks to find them. The patches of damage also look a little different, as slugs will start eating an area and slowly work their way out. They will even kill canola after it has cabbaged and they strip the leaves like you have let the chooks or the ducks out.

"We seed our canola a bit higher in areas where there are slugs and slaters, keeping the rate at 3.5kg/ha rather than 2.5kg/ha, so the crop has a better chance of getting away."

Snail baits also kill the slugs so any hotspots for slugs get a second baiting after seeding. "The slug numbers were worse 10 years ago than they are now so maybe that is a result of baiting the snails... we are keeping the numbers low and they are no longer really a problem."

An immature black keeled slug.

PHOTO: DPIRD

Bait strategically to control small conical snails in a zero-till cropping system

SNAPSHOT

LOCATION: southern Western Australia

PEST: small conical snails

ANNUAL RAINFALL: 500mm on coast and 400mm inland

SOIL TYPES: sandplain soils on coast and duplex to clay loams inland. Sandplain has been clayed and limed

ENTERPRISE: 100 per cent cropping

CROPPING ROTATION: canola/wheat/barley or canola/wheat/wheat

Baiting is an important tactic for controlling small conical snails in this zero-till, controlled-traffic farming system. “Stubble retention is so valuable for us, so baiting is the most effective control we have,” the grower says. “We bait strategically to get the most effective control at a reasonable cost. And if they are moving to a new area, we don’t just bait a patch here or there, we do the whole area to prevent their spread.”

Snails thrive with soil amelioration

“We first noticed small conical snails on a tank that arrived from town about 10 to 15 years ago,” the grower says. “It came off the truck covered in snails and while we removed as many as we could and baited the area, snails seemed to spread out from there.”

While he saw some snails after this time, they did not cause any damage until about eight years ago. “We had a barley crop that was really struggling,” he says. “We found the small conical snails were eating it out so we baited the paddock about three times, but the numbers were so high it made no difference … they were absolutely decimating the crop. We ended up spraying it out and baited again a number of times during the year. That’s when we knew we had a problem.”

After that the snails seemed to spread out quickly. This farming family has been liming its coastal paddocks for 12 years, spreading approximately 10 to 12t/ha during this period. “Where we had limed and there was summer moisture there was always a lot of snails; their numbers just seemed to take off. They spread so much faster than you would think,” the grower says.

Now most of the coastal property has snails, while inland they affect about a quarter of the property. “Initially we aerial baited the whole farm, including waterways and tree lines, to try to get on top of the problem. But knowing what we know now, this only just held them in check, really.”

Although the arrival of snails on the tank seemed significant at the time, the family now wonders if snails have always been around and whether it is changes in farming practices that have created the environment for the explosion in numbers. “The harder, more hostile soils seem to have less snails, but everything we are doing to improve our soils – claying, liming and keeping stubbles – creates a nice environment for snails.”

Several wet summers also seem to have favoured the snail populations. “Their spread seems more related to summer moisture than soil type,” the grower says. “Dry summers are never as bad, and they have been slower to spread inland where summers are hotter.”

The family’s farming system is zero-till, using a disc seeder and controlled-traffic practices with full stubble retention. Sowing is done on the inter-row to avoid problems with stubble at seeding. Residues from the headers go down onto the controlled-traffic lines or in chaff lines, and straw is spread out behind the header. While some snails probably migrate under the chaff lines, they do not seem to be significantly worse there.

Given the zero-till system, burning and tillage to control snails is not an option. “We have never burnt stubbles to control snails; the stubble is too valuable a resource,” the grower says.

Strategic baiting developed through trial and error

“Originally we were baiting as soon as it rained in summer, but this just wasn’t financially viable,” the grower says. “Baiting is a significant cost to the business so we have learnt to be strategic. We bait just before seeding and again straight after seeding.”

A double baiting program is used on all paddocks that have a history of snails and paddocks where snails appear to be moving in. “If it is really wet in March we might do a bait then, but definitely in the late March/early April period we’ll bait after the knockdowns when everything is dead. Then we will follow the seeder with baits.”

Metaldehyde-based baits are spread at 8 to 10kg/ha using multiple applications in areas where snail numbers are higher. The grower feels this is a good balance between protecting the crop and keeping costs to a minimum. He aims to choose bait that is big enough to throw out evenly and provide adequate bait points per square metre for good coverage. He also aims to use a consistent product so the spreader calibration remains accurate.

The family previously used a trailer spreader, which gave an 18m spread of baits. Now a three-point linkage Amazone® spreader is used with 24m coverage. It has weigh-scales for greater accuracy and is faster. Given that baiting is now such a large part of the business, the change has significantly increased productivity.

The family initially tried aerial spreading and it worked well, but cost an extra $9 to $10/ha. It did provide extra coverage of inaccessible areas such as drains and tree lines, but no overall extra benefit.

“At this stage our baiting program has worked,” the grower says. “We haven’t got rid of them but we’re keeping numbers down. We get our crops out of the ground without too much snail damage and our costs are manageable.”

Occasionally the family finds patches of damage after baiting that need to be baited again, or snails may have moved into a new paddock and they need to bait later. “But otherwise there’s no point baiting in a green crop – it is a waste of money. We’re much better at recognising snail damage now and get onto it immediately.”

Machinery can spread snails

The family has observed that graders can spread snails throughout the farm when grading laneways. “Headers are the worst, but any machine can spread snails, including silos and augers. They all need careful attention when cleaning down,” the grower says. He has also noticed that snails can move down drains in wet years, between paddocks and across boundaries.

Grain cleaning at harvest

During harvest the family has noticed there are fewer snails in the crop canopy when the weather is hot. “But if there has been rainfall before harvest and cooler weather then there seems to be a lot more snails in the canopy,” the grower says. These environmental factors during harvest seem to determine if snails are in the crop canopy, but it is not always easy to predict. The family used to swathe canola into rows but found the swathes were full of snails – “they just gravitate towards the swathe; it is cooler over summer”. Now all canola is direct headed using vario-style fronts.

A large DE Engineers grain cleaner fitted with 3mm round-hole scalpers is used to remove snails from canola. “It is quick to use … keeps up with two class 8 headers, although we run it flat out. We clean canola from any paddock that has snails. We don’t bother looking for them, it just automatically gets cleaned,” the grower says.

The family has tried to clean small conical snails out of cereals, but it is a challenge; the size and shape of the snails is too similar to the grain. So far there has not been a regular need to clean cereals, but the family is interested in learning more about snail-crushing rollers used in SA. “Cleaning grain is just an added cost at harvest and double-handling these large volumes of grain is daunting. It would be better if we could prevent the snails getting into the canopy in the first place.”

Challenges ahead

“We’ve noticed the stigma of having snails on your farm has reduced over time and it’s good that growers are beginning to talk about the problem,” the grower says. “But at the same time the marketers are tightening their receival standards, so it’s getting harder.”

The family is concerned about the reliance on baiting to control snails. “We don’t have much in the toolkit to control snails now,” he says. “You don’t want to go back to the old days of burning and cultivation … it would be terrible given the dry windy autumn we have just had.” He believes resistance to baits is inevitable if growers rely on this one tactic alone and hopes more research into the issue will deliver better control methods.

Dead snails under the crop canopy after baiting at seeding.

Crops established evenly with minimal snail damage thanks to baiting pre and post-seeding.

Early action prevents crop damage by white Italian snails

SNAPSHOT

LOCATION: southern Western Australia

PEST: white Italian snails

ANNUAL RAINFALL: 450mm

SOIL TYPES: sand over gravel over clay, some gravel over clay

LIVESTOCK: 1200 ewes

CROPPING ROTATION: canola/wheat/barley/pastures. Some country is 100 per cent cropping

Baiting, burning and occasional cabling are used to control white Italian snails in this farming family's mixed sheep and grain enterprise. These strategies have managed to keep snail numbers low and avoid crop damage and grain discounts.

Snails arrived on machinery

"The snails came from a property we were share farming about 15 years ago, probably on a machine," the grower says. "We first noticed the snails sitting on the top of stubbles in summer and since then they have spread through the farms, again by moving machines that weren't, or couldn't be, cleaned well enough.

"We didn't bait the first year we found them but started baiting the second and following years. Our agronomist told us to start baiting early and don't wait for them to cause damage."

The family has not seen a preference of the white Italian snails for one soil type over another, although there are slightly higher numbers on the heavier country. The grower does think that, snails are favoured by applying lime to the soils. "We do a lot of liming, have done for 20 years, and we have definitely noticed that as our soil pH improves so do the snail numbers."

The home farm, with sheep and cropping, is only slightly affected by snails, compared with other properties that are 100 per cent cropping where snails are a problem across approximately half of the area.

Dead white Italian snails along a fenceline from earlier baiting.

Strategic burning provides control

The family has used strategic burning to control snails when numbers were building up, but this has only happened perhaps three times in the past 15 years. "If we burn, it is on the wheat stubbles in the wheat/barley/canola rotation," the grower says. By following the wheat burn with barley, which is more resilient as a seedling, snail numbers can still be reduced without sowing canola into a bare paddock at risk of being sand blasted.

The whole wheat paddock is burnt, not just the chaff lines. On the properties that are 100 per cent cropping, where crops are grown in 550ha blocks, this means the whole wheat block is burnt before seeding.

The family only runs sheep on the home farm, so generally there is no green material left in the paddocks before the burn. "To make the burn effective you can't leave any little bit of stubble standing," the grower says. "You have to get it all so the snails have nowhere to hide.

"In the cropping paddocks we try to reduce the amount snails have to eat over summer. Weeds are sprayed out and paddocks kept brown all summer. At that time when we seed and bait, the only green material they have to eat is the baits.

"We have noticed that on the farm where we run sheep the snail numbers appear to build up more slowly. Whether that is because of the sheep trampling the snails and knocking down the stubbles, I'm not sure, but they just don't seem to build up as fast."

The family has also done some stubble bashing, using a cable towed between two tractors on a hot day to knock down the canola stubble. Only canola stubbles have been treated so far as the grower is concerned that, as the cable gets quite hot due to friction, it could start a fire. "If there is a canola paddock with large numbers of snails, and we get the opportunity, then we will cable it." He aims to pick a couple of hot days to do the cabling when it works in with other farm activities. "Our aim is to knock them down and give them nothing to stand on," he says. "We've been looking at pea rollers or a land roller that could do the same job without as much friction."

Consistent baiting

The grower monitors his stubbles over summer to determine the number of snails in a paddock and plan for baiting at seeding. "If we see any snails we will bait the whole paddock; it really doesn't take many for them to build up very quickly. Early on we tried to patch baits out, but it just didn't work, so now we do the whole paddock."

In the past two years the grower had planned to bait earlier in the year, after high summer rainfall. However, he did not see enough snail activity to warrant it. At present all baiting is done after seeding when the paddocks are bare. "If the snails are moving before seeding, I would like to try a split baiting … one early to try to stop them breeding and then after seeding to protect the crop."

In the past, baits have been spread using an old Morris airseeder bin. It has a Raycol fertiliser spreader on the back and uses air pressure from the seeder. This has spread the baits to about 18m across. This year the equipment was upgraded to a Bredal® spreader for lime and gypsum, which can also spread snail bait at rates as low as 1kg/ha to a width of 24m. "My aim is to still get an

even spread with the lighter weight of the snail baits, while trying not to smash them up too much," he says.

The grower is using a metaldehyde-based bait at a rate of 10kg/ha, with multiple applications if needed for better control. "When we are baiting, we will make sure our first lap is right on the edge, overlapping into the bush to control any snails coming out of there."

The grower does not use rain-fast baits but tries to avoid baiting before rain to prevent the baits deteriorating and not delivering a lethal dose.

Machinery hygiene is a priority

"We are now more diligent with our hygiene before we move from one farm to another," the grower says. "We check everything before moving, silos, tyres, the lot, particularly because one farm has more snails than the other. The biggest issue is our header fronts that have guards and parts underneath them, making it very hard to clean them out properly without taking them apart. We're pretty sure that is how we got snails in the first place, so it's very important to us."

Snails have even been found on the inside of a truck tyre, "which had come all the way from town at 100km/h, just waiting to drop off at our place".

Early action helps at harvest

While snails have affected grain quality occasionally, it has not been a regular problem. No grain has been discounted for snail infestation. "One year we had larger snails (about the size of a five-cent piece) in our canola grain," he says. "I think it was because we had the sieves in the header open quite wide to increase the header capacity and that let them in." They were relatively easy to clean out of the grain due to their size.

The low snail numbers at seeding and harvest reflect the family's early response to snail control. "Bait snails as soon as you see them on your property, even if there are only a few. If the snails are active early, I recommend a split-baiting before and after seeding. Ignore the cost of the bait and just get it out there."

Crops clean of white Italian snails with consistent baiting post-seeding.

White Italian snails on a post.

Narrow windrow burning to manage small conical and white Italian snails

SNAPSHOT

LOCATION: southern Western Australia

PESTS: small pointed conical snails and white Italian snails

ANNUAL RAINFALL: 400mm at home block, 450 to 500mm on southern block

SOIL TYPES: deep sand, to sand over gravel, heavier country and limestone on the home block. Sand over gravel on southern block

LIVESTOCK: runs sheep for about three months over summer on the wheat or barley stubbles, but not heavily stocked

CROPPING ROTATION: wheat/barley/canola/faba beans (introduced in 2018) on the home block. Wheat/canola on the southern block

Narrow windrow burning of canola stubbles followed by baiting going into the wheat rotation has been used by this farming family to control small conical and white Italian snails in its cropping enterprise. Early intervention has so far prevented damage to emerging crops and the need for grain cleaning.

Small conical snails difficult to detect

"We first noticed the white Italian snails about 10 years ago on the home farm, along a fenceline next to a road verge," the grower says. "They may have been spread by the shire graders along the road. They have since moved into the paddock from there.

"I barely noticed the small conical snails on the southern block as they are a lot harder to find. But one year we were harvesting canola and I saw a few around. We parked up overnight and when we came back the next day they were all over the machine and I thought 'this is becoming a problem'."

A third of the farm is now affected by snails. The grower thinks snail numbers fluctuate with the season rather than crop type, as snails are a lot more active and occur in higher numbers when there is a wet summer.

"The small conical snails are worse on the southern block because of the lighter soil type and the higher rainfall," the grower says. "The soil can be moist there for nearly 12 months of the year, whereas at the home block we have a longer dry period providing less feed and causing higher snail mortality."

The grower has not noticed a link between applied lime and snails, but snail numbers are always higher in an area with exposed limestone.

Burning narrow windrows manages weeds and snails

The family has been burning canola windrows on the southern block for almost 10 years for weed management. "We found windrow burning was killing the snails purely by accident," the grower says. "We must have had a drier summer than average and the snails all went in under the rows for protection from the heat. Then after we had burnt the rows you could see the rows were white where the dead small conical snails were.

"We put sheaths on the back of the header at harvest and disconnect the chopper to dump everything into a narrow windrow. This makes the burn hotter and more effective and only takes 30 minutes per machine, so is relatively quick.

"Now we burn canola windrows every second year on the southern block to control the small conical snails. I estimate it kills 80 to 90 per cent of the snails and is particularly effective if we follow it up with baiting.

"Burning is quite time-consuming and sometimes there can still be a lot of wheat stubble remaining after the canola rotation and that ends up burning, too, which is not ideal; we don't burn cereal stubbles because of erosion."

The family sprays paddocks over summer to control weeds and remove the green bridge, with the timing and number of sprays depending on the season and summer rain. The grower thinks it helps with snail control because it reduces the availability of food.

The family has not used any stubble management specifically for snail control, but it tries to cut at ankle height during harvest to keep stubbles low. This can slow harvest but helps with weed management and seeding into the stubble the following year. Keeping stubbles low also keeps snails close to the ground over summer, which can help desiccate them, particularly the round snail species.

Baiting early when snails are active

"The secret to baiting is getting it out when the snails are moving," the grower says. "There is no point just baiting in March every year unless you have had rain and they are moving and feeding. We will have bait on hand and after a rainfall event, when the snails start moving, we go out and bait."

The snail populations are still relatively low so the decision to bait is based on estimates of snail numbers at harvest. Generally, baiting is alternated between farms every other year.

"We usually try to burn windrows and bait in the one year coming out of the canola phase," the grower says. "We don't generally bait going into a canola phase because we don't have the numbers to warrant it."

Narrow windrows created for a hotter burn.

Dead white Italian snails from burning and baiting before the cereal rotation.

Baiting is usually done pre-seeding based on the weather and local paddock camera information. “From March on we monitor the paddocks and put some test baits out. Then, once the snails start feeding on the baits, we bait the rest of the paddocks from there.”

The grower has not noticed a large difference in early activity between the small conical and white Italian snails and baits for both at the same time.

At this stage baiting is not needed as a follow-up after seeding as snail numbers are still quite low. Baits are applied regularly along fencelines and hotspots, such as around dams, using a small spreader on the motorbike or the back of the ute. Baits are spread along shire verges where the numbers are bad.

“We always spread the baits 100m past where you saw the last snail and sometimes that is not far enough,” the grower says. “But with mapping on the tractors nowadays it is easy to see where you have been.

“We spread paddocks with a Marshall multi-spreader that can get down to a rate of 10kg/ha and spread relatively evenly. We calibrate it by just winding it down and using a bit of trial and error, but the scales make it a lot easier.”

Snail numbers remain low at harvest

Thanks to early intervention the family has not had problems with snails in grain and has not had to alter its harvest practices to avoid snails or clean grain.

“You do notice that heavy dew makes the snails of both species more active at harvest and they collect on the swather fronts,” the grower says, “whereas in hot weather the white Italian snails will sit at the top of the crop canopy.”

To prevent snails from spreading, machines are blown down during harvest using a large compressor. “You will still only remove 90 per cent of snails depending on how much time you give it,” the grower says.

“Narrow windrow burning is our go-to snail control, especially in the canola phase, and a good place to start. Monitor numbers after the burn and bait going into the cereal crop the year after. The canola crop has less residues on the ground than your cereal crops, so it is easier to monitor and bait for snails.

“So far we have kept their numbers relatively low. But going forward we might have to bait the cereals year-on-year if they get worse. And possibly a second baiting behind the seeder if they start to damage emerging crops.”

Healthy canola establishment.

Aerial baiting and targeted burning to prevent damage from small conical snails

SNAPSHOT

LOCATION: southern Western Australia

PEST: small conical snails

ANNUAL RAINFALL: 475 to 500mm

SOIL TYPES: all sandplain, sand over gravel or sand over clay

ENTERPRISE: 100 per cent cropping

CROPPING ROTATION: canola/wheat/barley. Lupins or field peas included at times

This farming family started managing small conical snails early to try to prevent crop damage and the need for grain cleaning. It has found burning stubbles and pre-seeding baiting to be most effective at keeping snail numbers down.

Snails found early before numbers grew

"Dad was the first to notice small conical snails in the paddock some years ago," the grower says. "He raised the issue with consultants but as there didn't seem to be any damage and no one really knew much about snails at the time (or thought they were a concern) it wasn't followed up.

"In 2013 our header driver noticed a lot of small conical snails on the header front in some canola crops. We have been managing them since then and so far we haven't had any obvious crop damage from snails or problems with quality due to snails in the grain."

The snails are present in all paddocks on the home block and about 25 per cent of another block. They have a third block where small conical snails were contained to an area around some tanks, but have recently been found in a paddock on the other side of the property.

"The small conical snails seem to be more noticeable in canola compared to cereal crops," the grower says. "Whether that is because the numbers are higher there, or because the damage is more obvious, it is hard to say. We haven't had to reseed crops because of snail damage yet, although we have had some thin patches. We couldn't determine if that was from snails or another issue such as non-wetting soils, but we prefer to act before damage really becomes a problem."

The grower has not noticed a difference in numbers of small conical snails between the sandplain soils and an area of Mallee country to the north. However, he has spread four to 6t/ha of lime on the blocks over the past 20 years and thinks this has made snails more resilient, with tougher shells helping them to survive hot summers.

"If we think snails are moving into a new area, we generally look around the tanks and sheds where trucks, utes and machinery are normally parked. That is where they have spread out from in the past," the grower says.

"The moment we notice snails we will start managing them. Whether there is one or 100, the numbers don't matter as we don't want to wait for numbers to build up enough to cause damage."

Burning has been effective but needs care

"This year was the first time we attempted to burn a 700ha block of cereal stubble. We achieved an 85 per cent burn over the whole area, which significantly reduced snail numbers. Prior to burning it would take about 10 to 15 minutes to collect 100 snails. After the burn it took an hour to find 25 snails, and this was near a small unburnt patch.

"We will definitely burn again but in the future will be more strategic to avoid the wind erosion we had this year. As it was, we left the burning as late as we could prior to seeding and sowed the barley into good subsoil moisture. It established well but we didn't get any substantial rain until July and the strong winds cut it off a few times until it finally got going.

"This harvest we will drop the barley chaff and straw into windrows, which will hopefully attract snails over summer. Then we will try to burn the windrows in front of a rain event. Hopefully that will reduce the risk of erosion and we won't have any snail problems in the following canola crop."

The family always does a summer weed spray, but the timing can be different based on the amount of subsoil moisture and risk of waterlogging later in the year. In the past few years the summer weeds have been used to draw up soil moisture after a couple of big summer rain events and then sprayed out before getting too big.

For the past 10 to 15 years the family has been chaining the canola stubbles to prevent them entering the header with the following year's crop. Chaining stubbles can significantly reduce the number of round snails as they shelter on the top of stubbles over summer. The effect of chaining on small conical snails, which also burrow under stubbles, rocks and roots in summer, has not been measured. In this case the grower has found it hard to estimate the mortality rate as snail control is not his primary motive for chaining.

Dead small conical snails in stubbles following an early baiting program.

Barley crops established after earlier paddock burning to control snails.

Aerial baiting early is most effective

"We bait all snail-affected paddocks each year using a plane," the grower says. "We air bait everything … trees, dams and even along the neighbour's side of the fence. Aerial baiting provides good coverage, even in inaccessable areas, and we have found it to be as effective as any other method. The cost is higher, but it is quick as the plane can spread 1000ha in a day.

"Normally we will apply baits in February to March. While we would rather leave it until March and April, time constraints become a factor and we want to get the baits out several weeks prior to seeding so the snails have a chance to eat them. If we have a good rain event in February, we will bait after that."

The family only applies baits before seeding as it has not had problems with snails damaging emerging crops. If problems with canola emergence become apparent or snails cause problems at harvest, then the grower says he would start baiting a second time after seeding.

Metaldehyde-based baits are used at the highest registered rate to provide the most bait points per square metre for maximum coverage.

Snails spread out from sheds

The family has found that snails have radiated out from sheds and places where machinery and vehicles are parked. Therefore, these places are monitored closely for snails and baited accordingly. At harvest, headers and fronts are blown down before moving blocks to try to prevent snails spreading. There have not been as many problems with snails on the seeding equipment, probably because the seeder keeps moving and rarely sits in paddocks long enough to collect snails. The seeding machine's wheels and tracks are still checked, especially if it is moving into paddocks that do not have snails.

No grain contamination yet

The family's early and proactive approach to snail management has likely prevented them being an issue at harvest. In addition, the grower thinks a modification to the header sieves may help sieve out snails from canola. "We have a slightly different screening set-up in our header for canola, using an aftermarket expanda-mesh sieve," he says. "The change was originally to keep the sample clean irrespective of snails, but perhaps it has helped.

"We have knocked the numbers down considerably since we have started control methods, but they are still spreading, I am convinced of that. I recommend that growers start baiting straight away and if you know of any hotspots, like around sheds and houses, baiting there once a month or so. Don't wait because with snails it's not a case of *if* they will cause damage, but *when*."

Chaining and early baiting reduce snails, but slater damage a concern

SNAPSHOT

LOCATION: southern Western Australia

PESTS: small conical snails, white Italian snails, vineyard snails and slaters

ANNUAL RAINFALL: 445mm

SOIL TYPES: sand and loam duplexes with areas of free limestone

ENTERPRISE: 100 per cent cropping

CROPPING ROTATION: canola/wheat/barley

This grower has trialled several methods to control round and small conical snails in his cropping business, including tillage, burning and chaining. He is using a combination of opportunistic chaining and baiting early in the season to prevent snails from breeding. The grower is also working out the best methods to reduce slater damage in canola on his heavier country and has not ruled out burning as a potential tool.

Snails occur in hotspots

"Snails can move over long distances and build up very quickly," the grower says. "They moved about 350m across a road and through bush verges into our place. In one season we went from not seeing any snails to having a canola paddock with thousands of snails in it; every stalk had a round snail on it."

Three snail species – small conical snails, white Italian snails and vineyard snails – occupy about 10 to 20 per cent of the property. There are hotspots in paddocks and around sheds and buildings.

"Small conical snails weren't really a problem on the farm until we started applying lime to the paddocks," the grower says. "Prior to that they couldn't survive the hot summers. Now the snails seem to have stronger shells and occur over a much larger area.

"I find the round snails are relatively easy to manage with bashing and burning, but the small conical snails are harder to control. They are more likely to end up in the grain at harvest, too. They are the ones we really need to watch."

A proactive approach to management

The grower has investigated new ways to manage snail numbers. By trialling different tillage methods, he has found that you only need to bury snails 50mm deep to kill them. "We first tried burying the snails with a two-way plough, which didn't work, but then we used a rotary hoe which was very successful, burying 95 per cent of snails."

The grower says the treatment does leave the paddocks quite bare on the surface so there is a risk of wind erosion. "Tillage can also do more harm than good if you have shallow soils and bring up too much clay."

The grower has done some stubble chaining in the past when the opportunity has presented and found it to be very effective. "Chaining needs to be done on a very hot day, which is often during a vehicle movement ban or when you would rather be on holidays," the grower says. "If we do get a chance to bash the stubbles we go fast and hard, knocking the stubbles down three times in one day to be effective."

The grower has found chaining to be more effective on round snails than small conical snails, as they can burrow under stubbles or stumps during summer.

He has burnt standing wheat stubbles to control snails and found it very effective at killing them. The burnt paddock was harvested high because of frost damage and the resulting hot burn left the paddock very bare. Although barley was sown into the paddock, it was still damaged by wind.

"I do like the idea of burning every now and then as part of the rotation to keep the paddocks clean," the grower says. "We have just put mills (seed destructors) on the headers so will be harvesting low to get all the weed seeds. Hopefully this will result in a cooler burn next time and keep the stalks intact to hold the ground together better."

Baiting early to prevent breeding

The grower has not had crop damage caused by snails, so his baiting program is aimed at reducing numbers rather than crop protection.

"We have found that even though the snails seem to occur in hotspots in the paddock it's worth getting a decent machine that will spread baits evenly and do the job properly," he says. The grower uses a urea spreader that delivers 10kg/ha of metaldehyde-based baits at 30km/h with a 20m spread.

Baits are spread early in the season once snails are active to prevent their breeding. "If rain is coming, I get the small hand spreader out and put out a few test patches to see if the snails are active. Once I see dead snails around the baits, I will start baiting the paddocks.

"Round snails are very good at finding baits and are pretty active after rain. Whereas the small conical snails are not as predictable … it's harder to know when they will become active and start feeding."

Canola germination has been protected from snails by early baiting.

Small conical and white Italian snails shelter from the sun.

Slaters can be difficult to see during the middle of the day until you dig under the stubbles.

Snails delivered from town

The grower baits around sheds regularly as this is often where the snails have originated, coming in on vehicles, machinery and deliveries from town.

"Snails can come onto the farm on fencing wire, chemical shuttles, pallets and machinery," the grower says. "Once you have snails you become very good at spotting them. Once we had some silos ready to come out to the farm and I found 80 to 90 snails on each silo. Imagine how many snails have been delivered in one year if all the silos had that many snails?

"Headers are the worst for spreading snails and it only needs a couple to drop off in paddock for a problem to develop." The grower cleans header fronts at the end of the day to remove snails and prevent their spread.

Small conical snails the challenge at harvest

"I don't think the round snails are really an issue because they can be separated from grain in the header," the grower says. "We harvested some canola last year where we could see round snails on the stems, but they didn't end up in grain because the headers screen them out."

The grower feels that small conical snails will be more difficult to deal with. "We have a grain cleaner ready to go and, while we haven't had to use it yet, I can see it might be needed.

"I feel we are winning against the round snails as they respond well to stubble bashing and baiting and don't seem to end up in the grain at harvest.

"Snails are just another pest we have to manage and there shouldn't be a stigma associated with them. There is a lot of good information coming out of SA on snail management and we should try to learn as much as we can about them."

Slaters

Slaters have become more of a problem in recent years, causing damage in emerging canola in areas with heavier loam soils. "We first noticed slaters in a canola crop which was well established and looked very good," the grower says. "Then when we went to spread it with the first urea top-up, we found there was no canola down one end of the paddock. The slaters had come in their thousands and were just working their way through the paddock."

The grower confirmed it was slater damage just by their huge numbers. "We had a look in the middle of the day and thought 'oh there's nothing there' until you'd pick up a bit of straw and they all are there, balled up underneath, in huge numbers. It's the canola phase that is most vulnerable to slaters. They don't seem to bother the wheat or barley."

The grower has found the slaters are only in damaging numbers on some heavier loam soils, which can form cracks over summer. Earwigs, also a problem in canola, tend to prefer the lighter soils.

After the first slater damage, he used a mix of alpha cypermethrin and bifenthrin sprays to allow the reseeded canola to germinate. Now the grower is more proactive; when sowing canola into paddocks with a history of slater damage he sprays a residual insecticide post-seeding, pre-emergence to prevent crop damage at germination.

"Slaters aren't spreading, they just seem to be in higher numbers on the heavier soils. We are keeping them in check but, as with every new pest, it just adds to the cost of production."

Soil disturbance and targeted baiting minimise slug impact on canola

SNAPSHOT

LOCATION: southern Western Australia

PEST: black keeled and reticulated slugs

ANNUAL RAINFALL: 500 to 600mm

SOIL TYPES: loamy gravels over clay with some granite

LIVESTOCK: 9000 Merinos over 60 per cent of area

CROPPING ROTATION: 50 per cent canola (hybrids, GMs and TT) and 50 per cent barley

This grower runs a large Merino program and crops barley and canola over one-third of the property. Slugs are damaging his canola, causing yield losses and requiring costly control. Although the severity of damage varies each year, he believes slugs are a growing problem. He combines physical changes to the slugs' environment, through burning stubbles and disturbing the soil, with targeted baiting in the "right place at the right time".

Slug damage increased with move to no-till

The grower first noticed slugs were damaging his crops in 2003 and identified two species: the reticulated (or grey field) slug and the black keeled slug. He estimates slugs cause damage on up to 25 per cent of each paddock under crop each season.

The slug damage became a problem after the grower moved to no-till/minimum-till farming. The lack of soil disturbance has provided the slugs with a better environment for burrowing and breeding.

The slugs become active as soon as seedlings emerge, with damage largely on the canola. Older canola varieties, with a slower growth rate that keeps them closer to the ground for longer, are most vulnerable.

"The cereal crops seem to be less adversely affected by the slugs as they get up and grow away quicker," the grower says. "The infestation of slugs is also more noticeable in soil types where clay lies just underneath the surface, as they seem to need this type of soil structure for burrowing."

The larger areas of damage occur on west-facing slopes and under trees with shaded conditions and little sunlight, where the soil takes longer to dry out. The damp, cool soils seem to allow slugs to remain active for longer. Stump holes and rock piles provide shelter. "I've only seen them active when the soil is wet or moist and never in the sunlight or on dry soil," the grower says. Summer rain or an early seasonal break will increase slug activity and numbers significantly.

There has been minimal slug damage to the grower's crops in the 2018 growing season, which was unusual since the first rains on 22 April would normally provide ideal conditions for slug activity. The grower speculates that lower rainfall early in the year and a drier period following the April break may have limited slug activity. "There are only patches of table-sized damage this year, whereas in previous years I've had to reseed up to 10 per cent of canola crops due to slug damage."

Burning for stubble management

The grower burns the stubble in every crop paddock in March to April to reduce moisture, destroy habitat and improve slugs' access to baits. A rake is used in the canola paddocks to create windrows for a faster and easier burn.

"Exposure of the soil after burning is not such an issue due to our high rainfall and using stubble cover to maintain soil moisture is not as necessary as in marginal areas," he says.

Soil disturbance and physical changes

Breaking ground with a scarifier and using the knife points in opposite directions are very effective as they disturb the soil, which disrupts the slugs' environment and interrupts the breeding cycle. However, it is an expensive and time-consuming method; the grower concentrates on using it in areas where slugs have been seen previously.

The grower believes this method of physically disturbing the soil pre-seeding could solve 80 per cent of his slug problem, but the time required to go over the country twice is inefficient and costly. Therefore, scarifying only makes up 10 per cent of his overall slug management strategy.

The grower tried rock rolling after seeding to see if it had any effect on reducing slug numbers, but the results were not good enough to make it worthwhile, given the time required. "Rock rolling the area only helps to a certain point at the end of the day; unless you disturb the soil it will never be a long-term solution," he says

Baiting based on slug history and rotation

The grower only baits when paddocks are in canola as it is most susceptible to slug damage. He treats the same paddocks each year, based on the soil type (clay near surface) and previous crop losses. This generally works and saves time and effort that would otherwise be spent monitoring.

“Once you see evidence of slug damage it’s too late to stop the loss, so the decision then becomes whether to reseed,” he says.

The amount of bait used will depend on rainfall and whether the ground is wet when the crop is due to emerge. “The optimal time to bait is after the first big rainfall event in the cooler months (autumn), when the ground gets wet and remains moist over an extended period, as this is when the slugs are most active.”

The grower uses a few test baits as an attractant directly after seeding to see how many slugs surface. “If I find dead slugs it’s a good indication that there is a problem and we need to act accordingly.”

When slug numbers are higher, the grower will reapply baits, especially around the patches of crop that have been damaged, to prevent slugs spreading further. After that he inspects paddocks every few days after seeding and continues to bait even when slug numbers are low.

The grower uses the metaldehyde-based Metarex® at $40 per 25kg at the label rate, spread two to three times per season depending on slug numbers. He finds Metarex® works well and is more attractive to slugs.

He uses a spreader attached to his motorbike for smaller patches, or a tractor with a pull-along spreader, depending on the size and scale of the area to be baited.

To increase efficiency and improve time management, the grower is considering adding another bin to his airseeder as this would allow him to apply the bait on top of the furrow during seeding.

Paddock with soil type and tree shade where slugs have been sighted and treated.

Applying some test baits with fertiliser has had some success; if dead slugs are seen immediately after application, he reapplies more bait. However, he does not feel this is a consistent enough method to deem it successful. The grower has also tried applying bait down the chute with the seeds, but has found the slugs do most of the damage on the surface when the plants are emerging from the soil.

The grower feels that regular burning, selective soil disturbance and baiting affected areas has helped keep slug damage to a minimum. Going forward, he is considering trial baiting in the barley rotation during spring, when the slugs are present but not adversely affecting yield.

“I think if we bait the slugs when they are still active in the cereals it may reduce the numbers and the likelihood of an outbreak in the subsequent canola crop, where damage can be significant,” he says.

Slugs are most commonly a pest in germinating canola.

PHOTO: DPIRD

Managing black keeled slugs using baits and incorporating stubbles

SNAPSHOT

LOCATION: southern Western Australia

PEST: black keeled slugs

ANNUAL RAINFALL: 600 to 700mm

SOIL TYPES: clay/gravel loam

ENTERPRISES: 50 per cent cropping and 50 per cent livestock (sheep and cattle)

CROPPING ROTATION: higher cropping country is continually cropped to cereal/canola

Black keeled slugs are damaging germinating canola in this mixed cropping and livestock business. The grower is managing slug damage by baiting consistently and modifying the slugs' habitat through incorporating stubbles and removing rock sanctuaries.

Slugs shelter in rock piles

Black keeled slugs first became a management problem in 2014, when the grower says: "They wiped out the canola plants at the cotyledon stage, in a circle pattern from rock piles. Now the slugs have spread rapidly and are in all the cropping paddocks, affecting about 50 per cent of the property. But they only damage post-emergent canola. Cereals are not affected." The grower also notes the narrow window of slug damage: "It is only a small timeframe from when the canola is at the cotyledon phase to when the plant starts to cabbage. After this time there seems to be no effect on the plant from slugs."

Slug populations vary across the property with higher numbers found on heavy clay paddocks that have granite outcrops. "The slugs like to hide under the rocks over summer in the cooler, moist environment," the grower says.

The grower observes the "timing and amount of opening season rainfall does affect the slug numbers. In 2018, with the dry start, slugs didn't seem to be as destructive compared to previous seasons with normal opening rains". Slug numbers are estimated for management by checking areas where slugs typically shelter, which is under the granite rocks in the heavier clay parts of the paddock.

Crops comprise 50 per cent of the grower's enterprise, with the more suitable higher paddocks, which have heavier soil types, planted continually to crop on a canola/cereal rotation. There are two exceptions to this cropping program: when a paddock has weed problems it is taken out to be grazed or turned to hay; and when a paddock from the livestock enterprise requires soil stimulation to promote pasture growth, it is added to the cropping program for a season.

Stubbles managed with grazing and crunching

Stubbles are managed at harvest and with a combination of grazing and stubble crunching. No stubbles are burnt as the grower is keen to retain all organic matter.

During harvest the grower tries to cut the cereal crops as close to the ground as possible. For canola crops this is not an option, as they are too heavy and the grower does not want too much trash through the header. Sheep are grazed on both cereal and canola stubbles after harvest and they flatten the stubbles to a degree, as well as eating any summer weeds or crop volunteers.

To further break down the stubbles each paddock is stubble crunched before the season's opening rains. This is done by cutting the straw into 2.5cm sections, rather than incorporating the straw into the soil, and is primarily to prevent the seeder bar blocking. It is difficult to estimate whether grazing and using the stubble cruncher reduces slug numbers, as this is a standard practice for all cropping paddocks, but the grower thinks it would disturb the moist environment provided by stubbles before seeding.

The boundary of each crop is sprayed along the fencelines and bush edges for fire management and weed seed control. As a side effect this removes any green material that could provide slugs with a summer habitat. To further reduce the slug habitat, granite rocks are hand-picked. The grower prefers this to rock rolling as he is concerned about wear and tear on the seeder bar.

Baiting protects crops at cotyledon phase

Baiting is the main form of slug control, using a blanket application to all canola crops at the cotyledon phase. Cereal crops are not badly damaged by slugs and do not require baiting. The grower uses Meta® at a rate of 4 to 6kg/ha. Depending on the rainfall and the number of visible baits left in the paddock, a second bait application may follow.

Baits are applied with a regularly calibrated Bredal fertiliser spreader over the whole paddock from the fenceline to the bush edges. The only risk with the baiting program is if rain dissolves the baits too quickly. "This control method has definitely helped in reducing the slug population and damage to the post-emergent canola plants," the grower says. "As a side note, baiting for slugs may be controlling the snail population as none have been found on the farm."

Waiting for slug damage is too late, in the grower's opinion, saying you need to "adopt a standard practice of baiting canola at the cotyledon phase across your whole canola program". The grower is interested in learning more about the life cycle of slugs as this knowledge may give options for more affordable control measures that could be complemented with targeted baiting.

Ideal slug habitat with heavy clay soil and granite rock.

Cereal planted onto canola stubble. Note the clean firebreak.

Burning canola windrows and baiting manage small conical snails

SNAPSHOT

LOCATION: southern Western Australia

PEST: small pointed conical snails

ANNUAL RAINFALL: 580mm

SOIL TYPES: forest loam/sandy loam

ENTERPRISES: 100 per cent cropping and intensive feedlot

CROPPING ROTATION: canola/wheat/barley. Low areas planted to hay

After initial trials using push bars on headers and a speed tiller to incorporate stubbles, this grower has found a combination of canola windrow burning and double baiting has successfully reduced small conical snail numbers to a manageable level.

Snail numbers escalated rapidly

The grower's family crops all arable land using a canola/wheat/barley rotation. As the property is in the high-rainfall zone, low areas prone to waterlogging are more suitably planted to hay.

Implementing snail control measures is a relatively recent activity. "Around seven years ago I noticed the odd small conical snail, at first in areas of rank grass on non-arable land and then in grain samples at harvest time," the grower says. "The following year, perhaps because I was more aware of their existence, the snails seemed to have spread everywhere and two years later numbers had built up to become a serious problem." This was evident to the grower through large-scale damage at the canola cotyledon stage of growth, followed by snails found in grain samples at harvest.

Snail management starts in March, when the grower assesses snail numbers in each paddock using a metre square, focusing on their preferred habitats such as heavy stubbles and trash piles. This count provides a snapshot of snail numbers and indicates the effectiveness of last season's baiting program. "Given how quickly snail numbers have grown in the past, control measures are initiated in clean paddocks as soon as a snail is found or, in areas where they are already established, once snails become active after early rain," the grower says.

Canola stubble sacrificed for snail control

The grower makes the most of the pre-seeding period from March onwards to implement control measures with an emphasis on stubble management and baiting.

The grower uses stubbles from cereal crops in his intensive feedlots, so considers it too valuable to burn for snail control. However, for the past two years the grower has sacrificed the canola stubble by burning the windrows. The grower says "I justify this burn as it has an added ryegrass seed control".

Another stubble management tool trialled was a speed tiller. "I've trialled a speed tiller for snail management as it turns 80 per cent of the soil, burying snail eggs," the grower says. "But I found it was a quick fix rather than a long-term strategy and that if you bait early you shouldn't see eggs. Unfortunately, the speed tiller did not set up the seedbed well, leaving the forest-loam to sandy-loam paddocks very sloppy. As a result, I will not use one again."

For fire breaks and weed management, all fencelines and anything that is not in crop is either sprayed or burnt in spring. This also reduces the green material available to snails over the warmer months.

Consistent baiting before and after seeding

Since 2016, baiting has been the primary control strategy used by the grower with baits applied pre-seeding and again post-seeding, pre-emergence.

The pre-seeding baiting is started after the March opening rains to target the snails once they are moving and before laying eggs. This round of baiting is done using a plane to get the baits out and cover the whole property quickly.

While the grower stresses "the key is to be consistent with timing of the baiting program and repeat it every year", this can sometimes be difficult given the seasonal conditions. In 2018, due to the dry season and late start, the grower dropped the pre-seeding baiting as there was not a good opening rain and he felt snails were unlikely to be responsive to an early baiting. "In hindsight I regret this decision, as the spring inspection has shown higher snail numbers than in previous years," the grower says.

The second round of baiting tackles any surviving snails before the crop comes up. Five years ago, the grower started using a calibrated Lehner SuperVario® seed and bait spreader for this second round. This spreader has a 120kg carrying capacity and the flexibility of its electric motor allows it to be operated from a tractor, airseeder or ute.

Meta® pellets are applied at the highest registered rate to provide the maximum bait points per square metre. The grower says "it is important to check the weather forecast and allow a week of fine weather after application, as rain and this type of bait don't mix well".

Snails found in cereal crop in low numbers.

Managing green weeds by spraying paddock edges.

Header modifications come at a cost

A 'push bar' attached to the header was trialled for barley to dislodge snails from the grain heads. "While it did reduce the number of snails coming into the header, there was too much head loss to justify the benefit," the grower says.

While the grower has heard that snails can be dislodged by maximising the threshing intensity of the harvester, he says "we need to retain as much straw of a high quality to bale for use in the intensive feedlots, so this is not an option for us". Increasing the threshing intensity of the header can also physically damage the grain.

To maintain good weed hygiene across the property, grain kept for seed is cleaned by contract seed cleaners after harvest using a standard set-up. Should the grower have trouble with snails in his grain, this would be his next step, but his aim is to target snails early in the season and avoid this.

Biosecurity is a priority for the grower and when a harvest contractor has been required, the grower ensures their equipment is clean. Biosecurity is also observed by the grower for anything going off farm; for example, he refuses to sell grain seed farmer-to-farmer, despite cleaning, because of the risk of passing on snails.

Using this two-pronged approach of burning canola windrows and baiting before and after seeding has been effective. "I've managed to reduce the small conical snail population to a level where it does not affect my product delivered to market. It will be an ongoing issue for our business, but for now I feel it is well managed."

An immature small conical snail.

Stubble incorporation and seed cleaning part of management strategy for small conical snails

SNAPSHOT

LOCATION: southern Western Australia

PEST: small conical snails

ANNUAL RAINFALL: 500mm

SOIL TYPES: sandy gravel/gravel loam

ENTERPRISES: 65 per cent cropping and 35 per cent livestock (sheep)

CROPPING ROTATION: canola/cereal (wheat or barley)/pasture/pasture

This grower is managing small conical snails using a combination of selected burning, baiting canola pre-emergence and cleaning grain at harvest before delivery. Although this has worked well, the grower is trialling speed tillage and a ripple roller to add another level of control to his program.

Background

The grower moved to the farm from another district in 2012. Two-thirds of all arable land is cropped, including low areas, generally on a four-year rotation of canola/cereal/pasture/pasture. This is varied occasionally when a paddock is sown to lupins in the cereal phase for nitrogen replacement and sheep fodder or for paddocks with better soils (granite loam), which are continuously cropped.

"In our first year at this property I noticed a few small conical snails in the header grain tank at harvest time, despite not seeing any signs of crop damage earlier in the year," the grower says. The following year the grower noticed there were higher snail concentrations along the creek edges and in a canola paddock that bordered an olive plantation, making him wonder if they arrived on the seed pallets.

Snails now occupy about 65 per cent of the property and in 2013 the grower started to actively manage snails to decrease the risk of load rejections at harvest. The grower cautions other growers to bait repeatedly when early signs of snails are noticed as this will stop the population's build-up and widespread damage.

Pre-seeding management

Pre-seeding snail management starts in spring by spraying any green weeds around the crops. For this grower, removing snail habitat is not the primary reason for this spray; rather, it is to reduce weed contamination and harvest fire risk. The green bridge is further managed after harvest when sheep are grazed on the stubble and any summer weeds that have germinated are sprayed. The grower values his livestock's contribution to snail population control saying: "Sheep grazing on the stubble paddocks over summer eat anything green and there must be a percentage of snails squashed through hoof compaction."

The type of stubble and the paddock plan for the next season determine how the stubble is managed. Paddocks with cereal stubble to be planted back into crop are blanket burnt and those with canola stubbles are crunched. Cropping paddocks being returned to pasture are harvested as high as possible then speed tilled to incorporate the stubbles. The grower sowed a summer crop of sorghum in October 2018. It will be an interesting test to see how snails respond to baiting on an emerging crop in spring. The grower hopes the treatment will reduce snails in a paddock that has a relatively high snail population.

In 2019, before the opening rains in February–March, the grower will speed-till pasture paddocks and follow this with a ripple stone roller that has been modified to make sure no dirt is collected in the grooves. Hopefully the stubble incorporation, followed by compaction, will destroy the snail habitats and kill snails before egg laying.

Baiting after seeding

Baits are applied to all canola crops immediately after seeding to maximise the number of days for snails to encounter a pellet before emergence. Cereals are closely monitored and baited post-emergent as the need arises. The grower says: "The whole paddock, including the fencelines is covered. A secondary application may be applied to hotspots depending on the number of visible baits left on the ground."

Meta® baits are applied at the highest registered rate because of their affordability and effectiveness. The grower tries to avoid putting baits out ahead of rain. Baits are applied with a SlugMaster® fitted to the back of a utility and a Kubota twin-disk, three-point linkage spreader, using standard practice calibrations to ensure an even spread of pellets.

"Be vigilant and conduct regular inspections across your property following seeding to monitor crop germination then act quickly to bait," the grower says.

Canola cleaned at harvest

"All canola harvested on the property is cleaned prior to delivery. To date snails haven't been found in the cereal grain." To logistically manage the grain cleaning at harvest, the grower has set up three designated locations for field bins. Grain is carted from the header to these sites and all canola is cleaned through a DE Engineers grain cleaner. These large areas have been gravelled and are kept weed free throughout the year, which means all snails removed from the grain can be disposed of and are not at risk of contaminating more paddocks. As a bonus, these gravel areas also reduce the risk of fire damage to machinery. Using cereal stubble burning and a strategic baiting program has reduced small conical snail populations to a point where the grower says: "I'm confident that the snail numbers are under control. Obviously I need to continue to monitor the hotspots but overall it seems to be working well." Into the future, the grower plans to introduce more sheep into his farming program and reduce the cropping side.

Kubota bait spreader.

A home-manufactured stubble cruncher showing blades that break up stubble and incorporate it into the ground, disturbing the snails' habitat.

Ripple stone roller with modified part to dislodge dirt.

A snail moving up a cereal crop stem.

A DE Engineers grain cleaner is used to remove snails from canola at harvest.

Notes

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