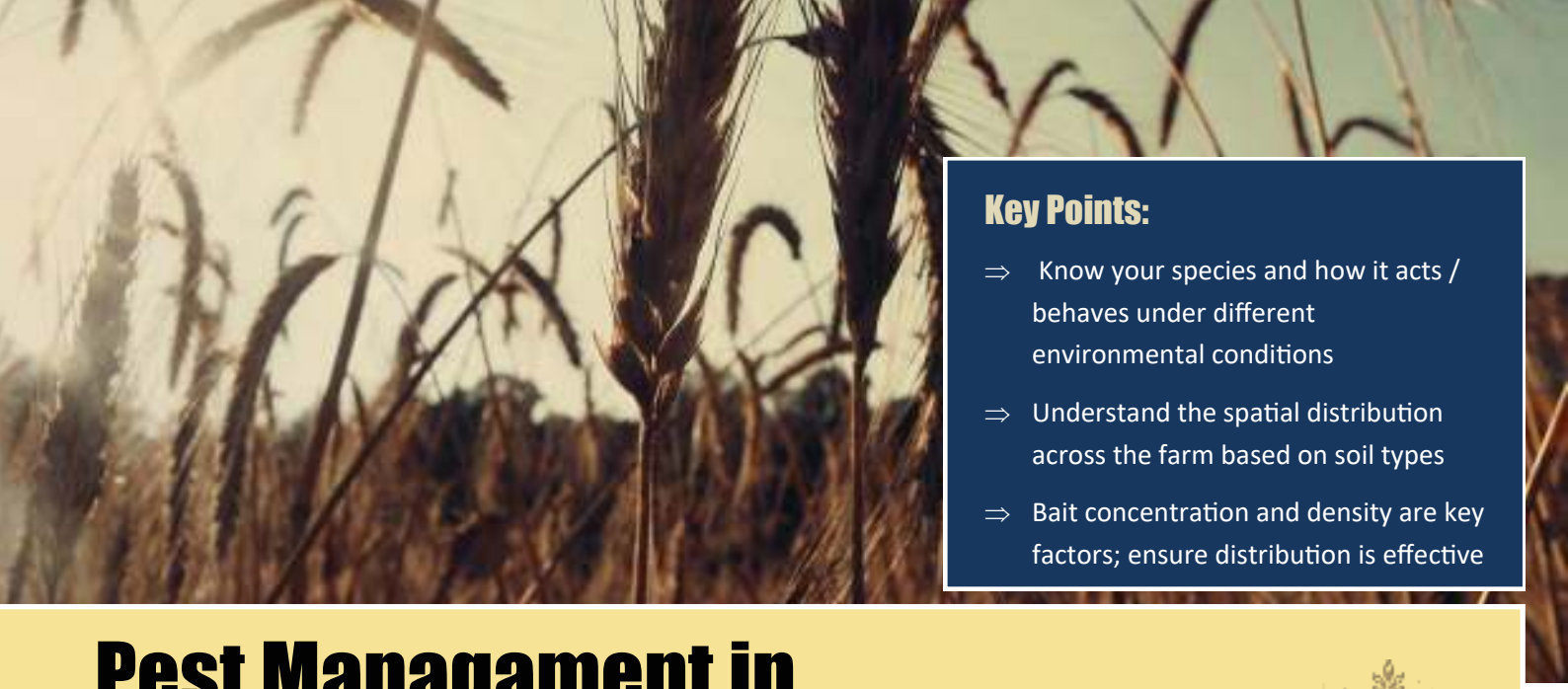

Key Points:

- ⇒ Know your species and how it acts / behaves under different environmental conditions
- ⇒ Understand the spatial distribution across the farm based on soil types
- ⇒ Bait concentration and density are key factors; ensure distribution is effective

Pest Managament in Retained Stubble Systems

Background

Pest management, in particular the management of snails and slugs, challenge growers who aim to retain stubble in their system. Terrestrial molluscs such as *Cernuella virgata* (common white vineyard snail), *Theba pisana* (white italian snail), *Cochlicella acuta* (conical or pointed snail), *Prietocella barbara* (small pointed or small conical snail), *Deroceras reticulatum* (grey field slug) and *Milax gagates* (black keeled slug) have the potential to affect crops at all stages (initial germination, development, maturity and grain development), with snails also having the potential to contaminate grain at harvest.

Understanding what snail and/or slug species are present and their behaviour is critical. This can determine the most effective control methods in retained stubble systems. In some instances, based on species information, may result in the decision that removing and/or destroying the stubble is the most effective control option.

Key factors that need to be considered when discussing snails and slugs include: paddock history, soil type, environment, weather conditions, existing stubble, stubble management, and crop management including time of sowing, seed source and potential seeding treatments.

Introduction

This guideline has been developed for the MacKillop Farm Management Group (MFMG) as part of the project "Maintaining Profitable Farming Systems with Retained Stubble in the South-East and KI regions", funded by the Grains Research and Development Corporation (GRDC) as part of the Stubble Initiative.

The Stubble Initiative involves farming systems groups in South Australia, Victoria, southern and central New South Wales and Tasmania, collaborating with research organisations and agribusiness to address challenges associated with stubble retention, including weeds, pests, disease, nutrition and the physical aspects of managing stubble.

Snail Ecology

Different snail species have different habitats and preferred food sources (Table 1). These habitats, as well as the local conditions on-farm all impact on the ability to manage the snails over the summer and fallow period. All snails have the ability to delay breeding and as such can either have a one or two year lifecycle.

Table 1. Common pest snails and their preferred habitat, as indicated by shaded cells (M.Nash, 2017)

	Snail Habitat				Preferred Food
Species	Above ground	Below ground	pH	Rainfall (mm)	
Cornuella virgata (common white snail)		cracking	alkaline	>300	dead
Theba pisana (Italian snail)			alkaline	>300 coastal	green
Cochlicella acuta (pointed or conical)			alkaline	>300 coastal	both
Prietocella barbara (small pointed or small conical)			acid	>450	green

Snail Species Identification

Figure 1 and Figure 2 show the most common snails found in the South-East region of South Australia, the Italian snail and the Small pointed or small conical snails. Additional identifying features are shown in the Bash'Em, Burn'Em, Bait'Em resource[1].

Figure 1. Italian snail (*Theba pisana*)

Figure 2. Small pointed or small conical snails *(Prietocella barbara)*

From 2013-2017 a site was established at Lake Hawdon where cameras were installed to try and understand more about the life-cycle and ecology of snails. The key focus were the Italian snail and the small pointed snail. These cameras monitored the snails every 1-5 minutes, 24 hours a day and allowed information to be fed back into the GRDC project "Improved Management of Snails and Slugs" (DAS00134)[2]and the Ag Excellence Alliance project "Innovative Monitoring to Improve Snail Control and Increase Soil Protection[3]".

Key outcomes of this research included understanding the environmental conditions at which snails become active. During summer, snails became active at a relative humidity (RH) of 90 %. As soon as this level was reached, the Italian snails became active moving down from stubble, while small pointed snails generally waited about 30 minutes after 90 % RH had been reached before they moved out from refuge areas that included cracks in the ground, or from under rocks and crowns of plants onto the soil surface where individuals moved to regain moisture or feed. During the autumn period, the snail activity occurred at RH levels of 80 %.

Another key finding from this research, which was supported by research conducted by the Lower Eyre Agricultural Development Association (LEADA) group[4], was different species responded differently to bait based on their lifecycles. Bait was most effective when applied prior to egg laying and again in late spring when individuals were actively feeding.

Slug Ecology

There are differences in slug ecology and habitats that affect the management of the different species that have the potential to impact broadacre agriculture across the region (Table 2).

Table 2. Preferred habitat of common agricultural slug varieties and life-cycle (M.Nash, 2017)

	Slug Habitat			
Species	Above ground	Below ground	Rainfall	Life cycle
Grey field slug	Lay eggs	Uses cracks	>500mm	Annual
Black keeled slug	Only to feed	Lays eggs	>450mm	Bi-annual

Slug Species Identification & Management

Figures 3 and 4 illustrate the two main slug species present across the South-East and KI regions of South Australia, the grey field slug and the black keeled slug. The grey field slug is 30-50 mm long and light grey to fawn in colour. The black keeled slug is 40-60 mm long and black or brown with a ridge down its back. The easiest way to tell the difference is to pierce the membrane of the slug. The grey field slug will release a white exudate telling it apart from other slug species, which will release a clear or only very small amount of exudate. Black keeled slugs can have a 2-year life cycle, whereas grey field slugs only live for the one year.

Figure 3. Grey Field Slug (*Deroceras reticulatum*)
(Photo courtesy of M.Nash)

Black keeled slugs are difficult to monitor using surface refuges as they burrow into the soil more than surface refuges, such as stubble. This makes their management more difficult with burning being a less effective control method of the black keeled slug.

Figure 4. Black Keeled Slug (*Milax gagates*)
(Photo courtesy of M.Nash)

Grey field slugs use cracks in the soil and stubble as moist refuges, and as such tend to be more on the surface making them easier to monitor using surface refuges. Their above ground activity makes burning a more effective control method, along with tillage and/or rolling that results in a fine seedbed limiting surface refuges (soil clods) for grey field slugs. Rolling after seeding also makes it harder for slugs to find seeds due to the soil compaction.

The use of hybrid seed and/or grade open pollinated seed to > 2 mm in the case of canola to get early, quick emergence is another strategy to beat slugs[1].

Surface application of baits is most effective for all species of slugs as most feeding and activity is above the ground.

Monitoring & control of Snails & Slugs

Monitoring in the autumn prior to seeding for snail and slugs is unreliable with changes in population at different monitoring times highlighting the importance of knowing which species poses the largest threat to your enterprise. Due to their life cycles, problems experienced are often a result of favourable breeding conditions during the previous season.

Figure 5 shows the variation in slug species abundance over a three year period at a site on the Fleurieu Peninsula. It shows how difficult the monitoring process can be, as in two subsequent wheat crops, there is a large difference in the abundant species.

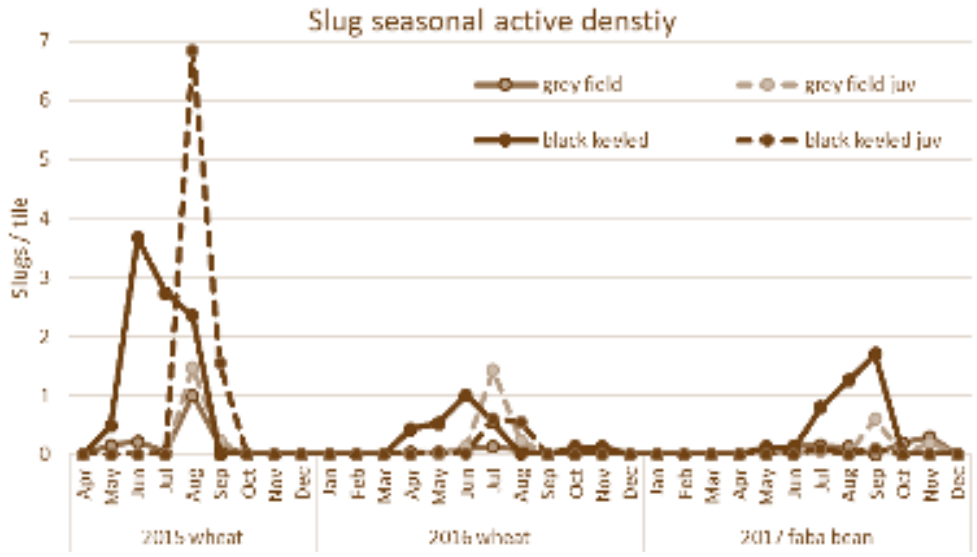

Figure 5. Different slug species relative abundance, Fleurieu Peninsula 2015-2017. (Data courtesy Helen Brodie SARDI, GRDC project DAS00160)[5]

Distribution across paddocks is highly variable with soil type having a major impact on snail distribution – this was shown at Lake Hawdon where snail numbers were monitored in a wheat crop prior to harvest in December 2015 (Figure 6a-6b). The highest numbers of snails (the white areas) were associated with limestone outcrops. The areas in black have no snails present. What is interesting to note, is the differences in distribution patterns between Fig.6a and Fig. 6b, with the small pointed snails having a skewed distribution into other areas. These high levels of snails or "hotspots" will often require reapplication of baits.

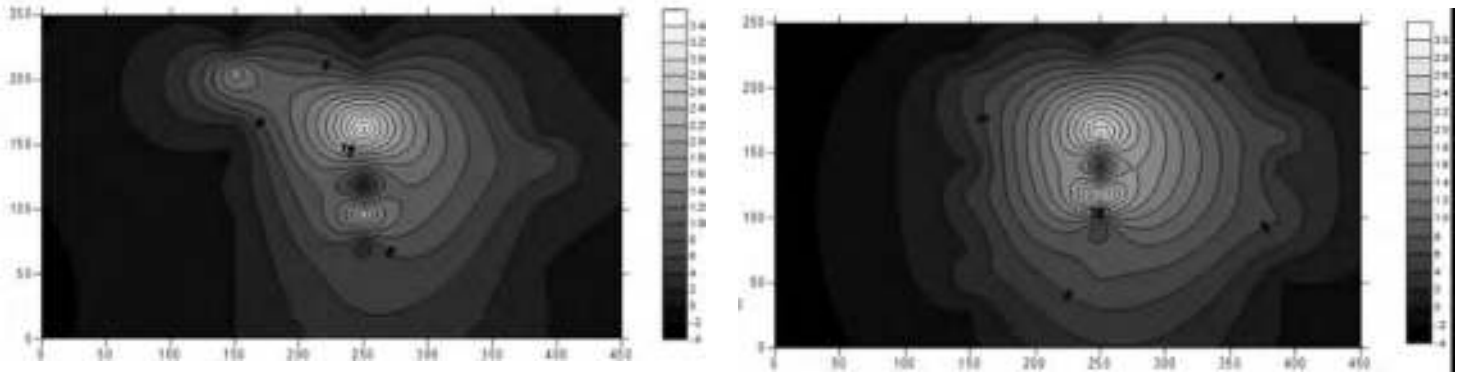

Figure 6. Snail Distribution prior to harvest (Dec 2015) at Lake Hawdon with highest densities (snails / refuge) indicated by white areas and 0 snails observed as black areas.
(a) Small Pointed Snails (b) Italian Snails

Indicative growing season thresholds exist for snails (Table 3). Due to the high variability of snails it should only be used as a guide when developing cropping programs aimed at growing less susceptible crops. Harvest tolerance thresholds should be taken into account, with zero tolerance for snails in some crops due to market restrictions.

Table 3. Indicative growing season snail thresholds for various crops

	Canola	Pulses	Winter cereals
Round snails	5/ m^2	5/ m^2	20/m^2
Conical snails	20/m^2	Not established	40/m^2
Grey field slug	0.5–1.5/m^2	1-2/m^2 (exc faba beans)	5–15/m^2
Black keeled slug	<1/m^2	1-2/m^2 (exc faba beans)	1-2/m^2

Cultural Control Methods

Various control methods have been used across the region. These generally have been –based on the Bash'Em, Burn'Em, Bait'Em[1] principles. Challenges arise in coastal environments where air temperatures do not reach 35°C, and if they do, it may only be for short periods of time. In these environments, paddock scale burning and baiting is effective in controlling snails (particularly when small pointed snails are present). Novel methods are currently being utilised by farmers – particularly prior to sowing canola. An integrated approach to pest management is required with control methods, crop and cultivar selection all having a part to play. Windrow burning does provide some control of round snails that move under rows, however it does not provide effective control of small pointed snails in most cracking soils found across areas of the South-East.

Bait Distribution

When using bait for control, the distribution of pellets and concentration of active ingredient is critical. Slugs and snails must first find a pellet before an individual can consume a lethal dose. Pellets must be applied evenly to ensure equal chance of individuals encountering product. You must calibrate your spreader for the product of choice.

For further information please see https://grdc.com.au/resources-and-publications/all-publications/factsheets/2015/01/snail-bait-application.

If the product used is not attractive European guidelines indicate 30 pellets/m^2 are required for slugs to encounter a pellet, with Australian experiences indicating 25 pellets / m^2 being an absolute minimum density. Figure 7 shows the product rate for various baits, and the bait points resulting from this rate compared to the 25 baits / m^2 that is required for an 80 % chance of encounter by a slug.

Greater pellet numbers are thought to be required for snails compared to slugs. However, this exceeds many products maximum label rate. The rate of product applied to ensure all snails receive a feed in areas of high numbers (hotspots) is often above label rates, hence the need to re-apply in those areas.

Research by LEADA combining cultural controls that make it easier for snails to find pellets has led to improved control of round snails, but this has not been demonstrated with small pointed snails.

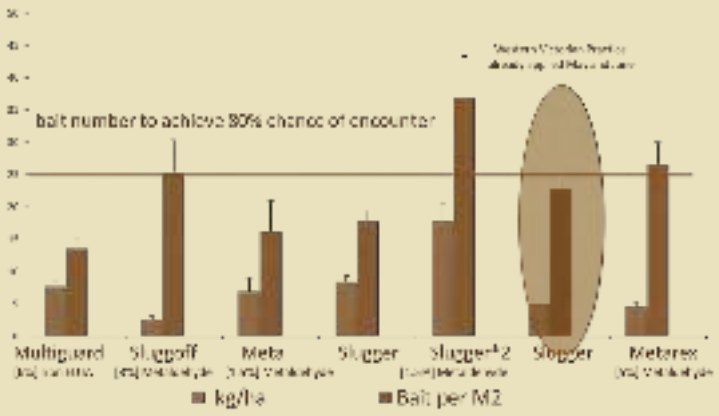

Figure 7. Bait points per square metre required for slug control at various application rates (M.Nash, 2016)

To ensure individuals consume a lethal dose of active ingredient:

⇒ Understand the conditions in which the bait is being applied
  - feeding activity and availability of alternative food for slugs and snails
  - life stage of snail

⇒ Apply at the right time
  - before egg lay for snails
  - directly after sowing for slugs
  - moist conditions, hence use a product that is effective after rain

⇒ Use a metaldehyde bait with a minimum of 3 % concentration of active ingredient

⇒ Ensure correct rate of product is applied
  - need to re-apply to "hot spots"
  - need to re-apply where product has been eaten

⇒ Monitor after application to ensure crop is protected

More information regarding product choice can be found at http://www.pir.sa.gov.au/__data/assets/pdf_file/0004/286735/Snail_and_slug_baiting_guidelines.pdf

There are many factors that influence pest control in retained stubble systems. Management pre-harvest, throughout the harvest period, during the fallow period and at seeding, as well as the crop rotation and weed management all have an impact on level of pests that may be experienced in the system. Some of these are known, and some of the effects are unknown. Table 4 summarises some of the stubble (and other) factors that are likely to influence pests and their impact.

Table 4. Factors influencing pest control in retained stubble systems (Developed by M.Nash for Stubble Initiative)

Factors that can influence pests	Italian snails	Small pointed snails	Black keeled slugs	Grey field slug
Stubble retained	Increased	Increased	Increased	Increased > 5 t/ha biomass
Stubble management – fallow period	Re harvest or mulch stubbles Jan-Feb when snails are up reduces	Harvest short – remove excess stubble may improve bait efficacy	Unsure	Remove excess stubble – e.g. bale
Stubble management - grazing	Sheep can reduce numbers	Unsure	No direct impact – may reduce available habitat due to surface compaction of the soil	
Stubble management – weeds	Always remove broadleaf weeds that act as refuge for snails over summer		Thistles – indicator of soil types more favourable to slugs	
Stubble management – crop sequences	Canola / peas increases, chickpeas decrease pest build up		Canola / faba beans / peas increase, linseed decrease pest build up	
This crop seedling most susceptible	Canola 2-4 leaf	Canola 2-4 leaf	Canola 6 leaf Wheat seed	Canola 4 leaf
Soil management	Liming, spading of sandy soils increases	Liming increases	Liming increases	Liming increases, Gypsum to address sodicity decreases
Tillage	Reduces	Retards egg laying, may improve bait efficacy	Un-sure, may retard egg laying if > 50mm.	Reduces 1-2 years, ploughing buries but can re-emerge heavier soils
Burning	Hot burn reduces	Windrow burning only on sandy soil reduces	No impact	Reduces
Rolling & cabling for snails	Reduces when >35 °C	Unsure	At sowing; reduces activity, improves crop establishment, reduces seed damage	

Factors that can influence pests	Italian snails	Small pointed snails	Black keeled slugs	Grey field slug
Weather (seasonal)	Wet autumn /winter increases numbers	Not sure	Good break (>100mm) increases activity. Wet cool spring increases population for next season	
Bait timing	March/April .	April - apply to bare soil if possible.	At sowing following rolling.	
Always apply when conditions are moist, & individuals are actively feeding	Spring	At sowing – to protect susceptible seedlings.	Repeat application if crop is slow to emerge, high numbers and/or using cheap bran-based products	
		Spring to early summer	In low risk situations when individuals emerge late May / early June if canola < GS 1.6	
Conditions following application	Night time < 25 °C & >85% rH for most of the following week	Night time < 25 °C & >90% rH	Night time temperatures below 0°C limit activity.	Minimum temperatures below 4°C limit activity and feeding
		To be confirmed		
	SE SA winter temperatures often result in a poor kill using products with metaldehyde (green pellets). Recommend using products with 3-5% active when temperatures are colder than 14 °C			
Bait rate	Max label rate.	Max label rate. Repeat in areas of high numbers high (> 640 m^2)	Rate to achieve min pellet density of 25 /m^2	
	Repeat in areas of high numbers (> 320 m^2)		Adjust rates depending on slug numbers	
Insecticides that disrupt natural enemies of snails and slugs			Seed treatments and overuse of Lorsban at 1 lt/ha reduces beetles that reduce slug numbers	
	Pellets (blue) that contain methiocarb are very harmful to natural enemies that predate on pests			

Acknowledgements

- Michael Nash
- Andrew Ware, Amanda Pearce and SARDI New Variety Agronomy Team, Struan
- Jenny Stanton, Keith Bolto, AgKI

References

[1]https://grdc.com.au/resources-and-publications/all-publications/bookshop/2010/11/bashem-burnem-baitem-integrated-snail-management-in-crops-and-pastures

[2]DAS00134 "Improved Management of Snails and Slugs", SARDI

[3]Innovative Monitoring to Improve Snail control and Increase soil protection, Ag Excellence Alliance

[4]LEA00002 "Profitable Farming systems with retained stubble on Lower EP"

[5]DAS00160 "BA Biology and management of snails and slugs in grain crops", SARDI

Further Information

Guideline produced by Felicity Turner and Michael Nash for the MFMG

fturner@mackillopgroup.com.au

www.mackillopgroup.com.au