# Slugs – why did they appear in 2023 and are they likely to persist?

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**Key words**

canola establishment, crop protection, integrated pest management, slugs, molluscicide baits

**GRDC code**

DAS00127 & DAS00134, MAN2204_001SAX

**Take home message**

- To manage we must understand a pest's ecology
- Unlike insects, slugs do not have a set lifecycle, they breed when conditions are favorable: for example, during the recent triple La Nina event; and
- Dry spring conditions may have reduced slug breeding in 2023, however as slugs can live for two years, they are likely to still pose a risk in 2024.

## Background

Research conducted supported by GRDC and industry indicates that the timing of bait applications is critical to protect emerging crops from slugs. Understanding when individual species are active, mating and breeding underpins successful management of slugs.

Slugs are hermaphrodites: both mating individuals can produce eggs that are laid in batches into moist soil. All slugs can delay breeding when conditions are dry, hence should be considered adaptive strategists. Although all slugs require moist environments to feed and breed, each have specific biology that determines when they are active, what time they breed, and when is the best time to apply baits to protect crops when they pose a threat.

The other factor to consider is that black keeled slugs can live for over five hundred days, with research indicating that they are capable of breeding in the second year of their life. The current recommendation is to be prepared to bait to protect emerging crops from slugs again next year. To support this, continuing GRDC investments aim to develop decision support tools to aid seasonal projections of likely slug risk.

### *Some key points from 2022 that enabled successful management of slugs in 2023*

1. High soil moisture is the main predictor of high slug activity.
2. Wet winters extending into long cool springs, combined with bulky crops, provide ideal conditions for breeding.
3. Proactive management strategies gave the best results and return on investment. Long-term monitoring of slugs in spring is vital to provide information on population dynamics.
4. The use of a long-lasting slug and snail bait that is resistant to rainfall, attractive, palatable, and capable of being spread uniformly was found to be effective at protecting establishing crops.

## Results and discussion

Large populations of slugs were observed up until harvest 2022. These observations highlighted the population's ability to increase numbers in wet spring conditions. Contrary to previous knowledge, black keeled slugs do breed late into spring (end of November) when conditions are favourable. Some learnings from an extremely high-pressure year (2023), as predicted from spring 2022 monitoring of slugs, snails, and spring weather conditions, are presented below.

1. Growers that did not order baits and have them on hand were often unable to source product in a timely manner, causing poor results.
2. A full moisture profile throughout summer and autumn led to slugs being active much earlier than other seasons, leading to some growers applying an early knockdown. However, due to high densities of slugs feeding, follow-up applications were required. Due to the high numbers, wet conditions and continued emergence of slugs from the soil long-lasting baits were found to be more effective than continual re-application of short-lasting baits.
3. A wave of black keeled slugs emerged in June, despite the absence of late autumn rain. Large numbers were already active from early April where there was a full moisture profile. This pattern suggests that black keeled slugs, like grey field slugs, exhibit an extended period of emergence from the soil over several months, with not all individuals in the population becoming active at the soil surface at the same time.
4. Many growers that waited to apply bait after sowing, or after the first application was consumed, had to resow some areas.
5. Monitoring bait remaining 1–2 days after the first application gave the best results.
6. Bait rate was the most crucial factor in 2023 for successful crop establishment; sufficient metaldehyde had to be applied in response to the large numbers of slugs observed actively feeding at the soil surface.
7. Baiting must be part of an integrated approach; rolling after sowing and before the first application of bait led to improved results.
8. Slugs can also damage lentils, faba beans and cereals, with an unprecedented amount of molluscicides applied to those crops in 2023.
9. Slugs were found damaging crops in regions and soil types not traditionally associated with slug damage: that is, on better quality soils away from creek lines in NSW and in new areas across the northern Wimmera of VIC.

**Effective bait rate**

With new molluscicide products continuing to being registered, choosing what to apply becomes increasingly challenging. Examples to add to the list (from Nash 2023):

- Sluggit Prima 30 Slug and Snail Bait (30 g/kg metaldehyde) #91239 3 kg/ha
- 4Farmers Iron Chelate Snail and Slug Bait (60 g/kg iron EDTA complex) #90221 5–16 kg/ha
- OCP™ eco-shield® Organic Snail & Slug Killer (10 g/kg iron powder) #90408 5–16 kg/ha
- MethioSHIELD™ Snail & Slug Bait (20 g/kg methiocarb) #92530 5.5 or 11-22 kg/ha

So, to revisit *What makes a good bait* (adapted from Nash 2022[c]), for baits to work, some basic principles are relied upon:

Individuals must first encounter a pellet, which requires:

- Individual activity – slugs must be actively searching for food.
- The number of baits to be distributed evenly – pellets/$m^2$. Pellets need to be evenly applied across the full width of application. Consistent pellet size, weight and density ensure no area is missed. Patchy control can occur when products with high variability in pellet weight are used and/or application equipment is not calibrated or able to spread the full width.
- Attractiveness of bait – individuals display non-random movement towards attractive pellets (true definition of bait). For example, grey field slugs are attracted to bran-based baits from 4 cm away, whereas modern products claim grey field slugs are attracted from 6 cm away.

Once individuals have encountered a bait, they must consume a lethal dose, which requires:

- Palatability – addition of feeding enhancers ensures individuals consume enough active ingredient to ingest a lethal dose. In the case of metaldehyde, which causes paralysis, consumption of a sub-lethal dose can be an issue with some products, because individuals cannot ingest enough to destroy their mucous cells.

- Enough bait for the target population – if product does not remain after a couple of days following application, it is usually due to large pest populations consuming it all. Re-application to those 'hot spots' will be required.
- Enough toxicant in the bait – the loading of active ingredient determines the amount consumed; hence low loadings require more total product to be applied. In wet conditions, small pellets with greater surface area to volume ratios lose more active ingredient, hence less toxicant will be consumed.

**RATE & ATTRACTIVENESS ARE IMPORTANT, not just pellet points.**

Some manufacturers have focused on producing small pellets in order to increase the chance of encounter, hence some of these products do not rely on attractiveness as a factor for individuals to find pellets. This theory assumes that slugs and snails randomly encounter pellets. Research (SARDI) has demonstrated Italian snails have non-random ($Chi^2$ test, $P < 0.01$, n = 100) movement towards bait. Hunter & Symonds (1970) calculated the probability of encounter was related to the attractiveness of a bait (x), a grey field slug's movement (y), and the pellet area or attractiveness (A):

$$P = 1 - e^{-2xy/A}$$

Where attractiveness (x) = 4 cm, movement (y) = 0.85 m/overnight and the pellet area (A) = 0.04 $m^2$, the commonly advised pellets/$m^2$ of 30 would achieve a probability of encounter of 95% (Figure 1). Thus, the probability of encounter can be calculated based on the manufacture's claims regarding attractiveness. Actual values calculated are presented in Figure 2, with a product that claims no attractiveness (e.g. Metakill®) resulting in lower probability of encounter, despite having a greater number of pellets/$m^2$ when applied at its label rate, compared to other products that claim to be attractive: for example, Metarex Inov® x = 6 cm, Snailex x = 4 cm.

To increase probability of encounter some manufacturers have decreased their pellet's size, hence increased the surface area to volume ratio. These smaller pellets have reduced efficacy after rainfall due to greater loss of metaldehyde (Nash 2023). That loss of active ingredient can result in an increased probability of delivering a sub-lethal dose. In 2023, it was evident that the quantity of metaldehyde applied was important. This was primarily due to the high numbers of active slugs.

Table 1 is provided to demonstrate, in theory, the effective probability of encounter and the number of slugs that could be killed by each product based on an amount of metaldehyde delivered at minimum label rates and the lethal dose required for black keeled slugs: that is, $LD_{50}$ 190 – 210 µg/g. The more expensive wet extruded products that contain optimal levels of metaldehyde (e.g. Axcela®, Metarex Inov®) when applied at minimum label rates ensure an optimal probability of encounter when compared to cheap bran-based products (e.g. Snailex) or products that are not attractive (e.g. Metakill®) (Table 1).

Observations in 2023 support research that fewer slugs are killed by applying low rates of molluscicide. Greater slug numbers in 2023 often needed frequent reapplication of baits, especially where low rates were used. In some instances, products were applied four times to protect canola from slug damage. In cases where these products were less effective, the cumulative rate of metaldehyde applied significantly exceeded European metaldehyde stewardship guidelines. These guidelines recommend a maximum of 700 g metaldehyde/ha/calendar year, with no more than 210 g/ha/application.

Growers adhering to the International Sustainability & Carbon Certification (ISCC EU 202-2 or ISCC Plus 202-02) programs and use products containing metaldehyde, need to ensure they meet the requirements for maximum application rates, in accordance with these programs.

**Table 1.** Comparison of commonly used metaldehyde baits demonstrating effective baits/m$^2$, baits/m$^2$ at minimum label rate and the number of black keeled slug individuals (BKS) killed at the minimum label rate.

| Product | A.I. (g/kg) | APVMA # | Label rate (kg/ha) | Bait/m$^2$ Pr 90% | Bait/m$^2$ | No of BKS killed |
|---|---|---|---|---|---|---|
| Snailex | 15 | 68580/139802 | 5–7.5 | 34 | 12 | 54 |
| Axcela® | 30 | 87576/134693 | 5–7 | 29 | 37 | 71 |
| Delicia® Sluggoff® | 30 | 60931/116048 | 3 | 29 | 28 | 48 |
| Metarex Inov® | 40 | 88160/120463 | 4–5 | 23 | 24 | 84 |
| Imtrade Metakill® | 50 | 64990/117488 | 5–8 | 135 | 29 | 95 |
| IA Transcend® | 50 + 1.5 fipronil | 88733/130091 | 2–8 | 135 | 14 | 48 |

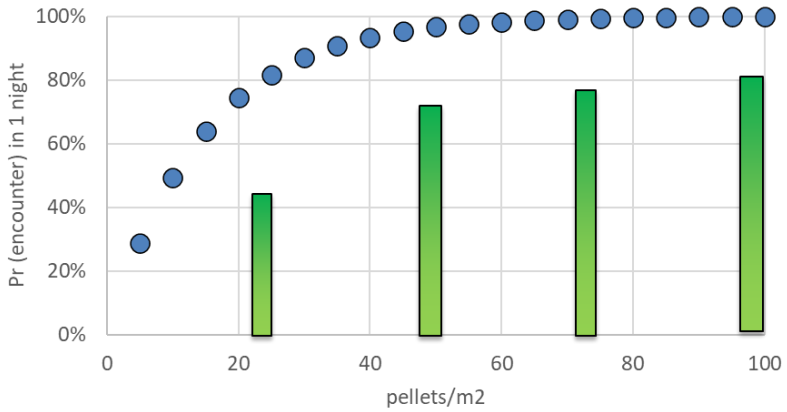


**Figure 1.** The probability of an individual grey field slug encountering a bran-based bait in one night as estimated by the equation $P = 1 - e^{-2xy/A}$ (dots) compared to data obtained from SARDI trials using round snails and bran-based bait (columns).

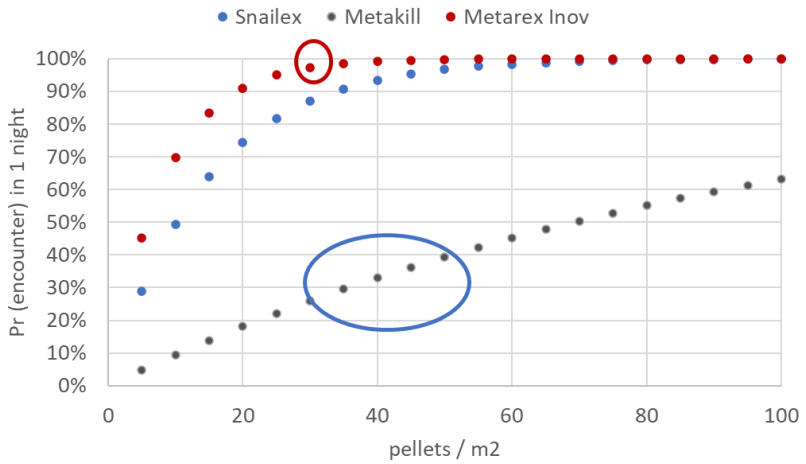


**Figure 2.** The theoretical probability of an individual slug encountering different products in one night as estimated by the equation $P = 1 - e^{-2xy/A}$ based on manufacturers claims regarding attractiveness. Note: despite a smaller pellet leading to greater pellets/m$^2$ because the pellet is not attractive the chance of encounter (marked by large blue ellipse) is lower than a true bait that is attractive (marked by small red ellipse).

## Conclusions

What can we predict for 2024? One would hope for lower slug numbers considering the lower-than-average late winter early spring rainfall. However, observations in southern NSW indicated that black keeled slugs were still active in September. Another observation is that high numbers of small slugs are damaging establishing fodder crops, despite the dry sowing conditions.

Understanding when individual slug species are active in your patch underpins successful management of them. Knowledge of pest population dynamics will avoid molluscicide supply shortfalls by ordering bait early, thus facilitating proactive baiting.

## References


Hunter PJ and Symonds BV (1970) The distribution of bait pellets for slug control. Annals of Applied Biology 65: 1-7.

Nash M (2022[a]) Slug Control Fact Sheet - Successful crop protection from slugs. https://grdc.com.au/resources-and-publications/all-publications/factsheets/2022/slug-control-identification-and-management

Nash M (2022[b]) Slugs In Crops: The Back Pocket Guide ISBN: 978-1-922342-31-7 https://grdc.com.au/resources-and-publications/all-publications/publications/2022/slugs-in-crops-the-back-pocket-guide

Nash M (2022[c]) Slugs – what can we learn from 2022. GRDC Update Papers 27 Jul https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2022/07/slugs-what-can-we-learn-from-2022

Nash M (2023) How do new molluscicide products perform in wet conditions. GRDC Update Papers 22 Feb 2023 https://grdc.com.au/resources-and-publications/grdc-update-papers/tab-content/grdc-update-papers/2023/02/how-do-new-molluscicide-products-perform-in-wet-conditions


## Acknowledgements


The author would like to thank GRDC, growers, retail agronomists and commercial clients that supported the research presented in this paper. The author would also like to thank GRDC for support of extension of this research.


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## Date published


February 2024