Department of Primary Industries and Regional Development

GOVERNMENT OF WESTERN AUSTRALIA

GRDC GRAINS RESEARCH & DEVELOPMENT CORPORATION

Effect of delayed baiting on small conical snail on the Esperance Sandplain (2019ES17)

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Introduction

Small conical snail (*Cochlicella barbara*) is an introduced pest in southern Australian grain production areas contaminating grain at harvest and damaging crops at emergence. In Western Australia, receival standards 2019/2020, have tightened notably the CANS/CAGS classification from having no maximum snail limit, to having maximum of 10 per 500g sample. According to CBH much of the grain received in the CANS segregation in 2018 would not meet new criteria and local grain cleaners cannot guarantee that they could deliver grain to the new standards (Carmody 2019).

The main way growers currently control snails is by baiting in autumn, at the time of sowing or immediately post-sowing, before the crop is established (Carmody 2019). The aim is to kill snails before they can lay eggs thus breaking the snail lifecycle thereby reducing the contamination of grain at harvest, and persistence at high numbers into following seasons. The key to effective baiting is to know when snails are actively feeding and to spread baits during this period, but before they reach sexual maturity and lay eggs.

Snails become dormant over dry periods during summer and increase in feeding activity as humidity increases during autumn. In a three-year study that monitored the feeding behaviour of snails over the course of the growing season feeding increased after extended periods of relative humidity above 85% (Unpublished Micic, Lui, Belli, van Burgel). Shortly after a period of active feeding egg lay can occur. Growth of the albumen gland, which secretes a nutritive secretion onto fertilised eggs, is used as method to determine timing of egg lay.

Decision on when to spread snail baits depend on competing farm logistics and factors influencing bait efficacy. These include snail lifecycle and environmental conditions at time of baiting. As such growers will often spread baits a few days prior, or immediately after sowing a paddock (Carmody 2019). In the rain-fed broad acre cropping of south-west Australia grain crops are typically sown in autumn between mid-April and June. Conditions and timing of seeding are often aligned with that of heightened snail activity, sexual maturity, and increased efficacy of metaldehyde baits (Brodie *et al.* 2020). Additionally, currently available bait products easily degrade after heavy rain and exposure to high temperatures (Nash *et al.* 2016). The presence of green plant matter can distract snails away from baits. Therefore, baiting must also occur during conditions that maximise bait efficacy.

Research Aim

The current study aims to investigate the effect of delayed baiting on snail mortality immediately post baiting and the longer-term impact on presence of smaller snails during the harvest period. A better understanding of these interactions could help prioritise management decisions.

Methods

Site details

The experiment was established on grazed canola stubble at the Esperance Downs Research station, a mixed cropping-sheep farm in Gibson, Western Australia. The paddock has high incidence of small conical snails and has never been baited. It was sown to barley in June 2019 and received rainfall in the decile 1 range (calculated from 1970 to 2019). Receiving 16 mm from 1 January – 31 March 2019 and 280mm from 1 April to 31 December 2019.

Plot design

Small plots (2 x 1.5m) enclosed with Whites 300mm x 8m Recycled Garden Edging dug 150mm into the soil and supported by wooden stakes. Copper tape was fixed on the inside surface of the edging around the perimeter of the plots approximately 15cm from the top of the soil, forming a continuous barrier to keep snails in the plots. Copper tape was replaced fully once with regular maintenance of the barrier throughout the duration of the experiment. Three replicates were positioned in sections of the paddock that were observed to contain a high density of snails and had even distribution of ground cover.

Bait application and timing

Bran-based rain fast pelletised bait treatments were applied at high label rates of 8 kg/ha Imtrade Metakill baits, containing 50 g/kg metaldehyde, and Imtrade placebo baits. The rate equated to 63 bait points /m^2 for metaldehyde baits and 82 bait points /m^2 for placebo baits. Baits were spread by hand.

There were two bait timings, bait timing 1 (BT1) was applied on 14 May 2019 and bait timing 2 (BT2) on 28 May 2019.

Monitoring of snail mortality and size

Plots were scored at 7, 14, 45, 70, 100, and 126 days post baiting. At each monitoring time all snails within a 20 x 20 cm quadrat were collected and the size of shell (<4mm, 4-6mm, >6mm) and whether they were dead or alive was recorded. Live snails were returned to the quadrat area and dead snails were removed. A total of four quadrat counts was completed per sampling time, two quadrats in areas of high ground cover (stubble or green weeds) and two quadrats in areas of low ground cover (sparse stubble load or bare ground).

Where it was uncertain whether snails were dead or alive, they were placed onto a wet surface (e.g. damp paper towel) for up to 12 hours. If they began moving then they were alive, if not then they were scored as dead.

Albumen gland development

Albumen gland development of the snail population was measured by random sampling of at least 20 snails larger then 6mm from the paddock (outside of the plot area) fortnightly from 2 April to the end of the experiment. Snails were drowned in water overnight and then preserved in ethanol until dissection to determine the albumen gland length (mm).

Albumen gland length of 20 live snails >6mm shell height was measured seven days post baiting from within plots.

Data analysis

Quadrat counts of snail size and mortality were combined per plot and time point (days post baiting). Snail mortality was then analysed in terms of proportion of dead/live snails of the total number of snails counted per shell size range. Effect of bait type and timing was analysed by ANOVA in terms of abundance of dead snails >6 mm height up until 45 days post baiting using Genstat. Cumulative number of live snails 4-6 mm height was calculated from the mean of live snails of this size range at each sample time.

Results

Effect of bait type on snail mortality

Metaldehyde baits increased snail mortality compared to the placebo baits at both bait timings. There was a higher proportion of dead snails to live snails when baited with metaldehyde, compared to placebo baits. This pattern was consistent at both timings (figure 1). The proportion of dead snails 14 days post baiting was 80% and 64% for BT1 and BT2 respectively, for metaldehyde treatments, and 16% and 23% for placebo bait treatments.

Baiting was effective on snails larger than 6mm

Bait treatment affected snails differently depending on their shell height (figure 2). Metaldehyde baits had most effect on snails larger then 6mm (figure 2E and 2F) compared to snails smaller than 6 mm (figures 2A-D). Persistence of greater proportion of dead to alive snails in metaldehyde treatments reflect the nature of the quadrat sub-sampling meaning dead snails continued to be picked up throughout the monitoring period up to 70 days post baiting. Comparison of snails smaller than 6 mm showed the proportion of dead and alive snails were similar regardless of whether snails were treated with placebo or metaldehyde baits. Snails of 4-6 mm height had greater proportion of dead snails over time at both bait treatments and timings (figure 2C and 2D). Snails <4 mm height the proportion of live snails over time was consistently greater for BT-2 (figure 2B). For BT-1 there was no clear pattern in proportion of live/dead snails (figure 2A). Quadrat counts of snails of this size was highly variable due to the non-targeted nature of sampling and clustering behaviour of snails of this size. Clusters of snails <4mm often had high counts favouring one of either dead or alive snails. At some time points, no clusters were present within the quadrats meaning a count of zero was recorded. For example, BT-1, 45 days post baiting where no snails <4mm were counted in plots treated with metaldehyde baits. These results suggest environment may have a greater effect on snail survival than bait treatment for smaller sized snails.

Baiting reduced snail mortality of snails larger than 6mm

Bait treatment affected the abundance of dead snails >6 mm height at 7, 14, and 45 days post baiting. Treatment with metaldehyde baits had significantly higher number of dead snails compared to placebo baits at both bait timings ($p < 0.001$). There was no difference in bait timing between metaldehyde baited treatments or placebo baited treatments (figure 3).

Albumen gland size of snail population at time of baiting and 7 days post treatment

At the time of baiting mean albumen gland length of snails larger than 6 mm collected from the surrounding paddock was 2.91 mm and 2.84 mm for BT-1 (14 May) and BT-2 (28 May) respectively. Increase in albumen gland length began after 16 April, plateauing by 9 May (figure 4).

Distribution of albumen gland length of live snails sampled within plots 7-days post bait treatment was similar. As there was no observed difference between replicates, gland length was combined per treatment (data not shown). Median gland length was 3.0 mm for all treatments except BT1 metaldehyde bait treatment, 3.05 mm (figure 5). Furthermore, similarities in interquartile range indicate dispersion of gland length was not dissimilar between surviving populations of snails exposed to the different bait treatments.

Baiting decreased abundance of small snails later in the season

Cumulative number of live snails between 4-6 mm height, showed abundance of snails of this size increased after 70 days post baiting for timing 1 (23 July – 22 Aug) but occurred between 45 and 70 days bait timing 2 (between 12 July – 6 August), 10 days earlier then bait timing 1 (figure 6).

Discussion

Mortality of snails due to consumption of metaldehyde baits can vary due to multiple factors relating to weather, stage of the pest lifecycle (the snail), and bait application. In this study, baiting with metaldehyde baits resulted in approximately 50-60% mortality. At the time of baiting, the snail population in this experiment had similar proportion of snails with developed albumen glands at both timings. Research on the common white snail (*Cernuella virgata*) suggest that efficacy of baits is linked to the stage of lifecycle, an increase in mortality coinciding with snail reproduction (Brodie *et al.* 2020). Similarities in gland development of the snail population in this experiment pre- and post- baiting and between placebo versus metaldehyde treatments indicate that dose of metaldehyde did not disproportionately affect snails of a certain development stage. Hence, lifecycle stage of snails in this experiment did not influence results.

There is evidence that rainfall and greenbridge in summer result in earlier gland development though albumen gland length consistently reaches its peak by the first week of May regardless of seasonal differences over three years across 4-7 sites (Micic *et al*. 2020). Sampling of the snail population two weeks prior to BT1 showed that mean albumen gland length had not yet reached the peak. Albumen gland length is used as an indicator that snails have the ability to lay eggs though it is still unknown when egg lay actually occurs. Similarities in gland length at the time of baiting in both bait timings mean that the snail population had a similar structure in terms of albumen gland development. Although at BT2 snails would have had developed glands for longer potentially having an effect on egg lay before baiting occurred and hence the persistence of snails and impact on snail management into harvest. A decrease in rate of accumulation of snails between 4-6mm until 70 and 45 days post baiting for timing 1 and 2 respectively compared to placebo treatments suggest that baiting may have had an effect on snails this size, causing some mortality by consumption of baits and by delaying egg-lay. This highlights the need for research investigating the growth rates, clutch size and timing of hatching, and survival of juvenile snails in the active period after they hatch and over dormant periods in summer.

Warm, dry conditions were experienced in the 7 days following the second bait timing. In a separate, simultaneous experiment snail movement and microclimate were monitored using time-lapse cameras and weather sensors. Results show that there was reduced snail activity in response to low relative humidity until 6 June 2019, 9 days after bait timing 2 (figure 7). This may explain the slight decrease in mortality of snails 7 days post baiting between BT2 and BT1 although after 14 days, the mortality was the same.

Data on snails <4 mm height was confounded by environmental factors and the methodology used was not suitable to monitor these snails due to their clustering behaviour and greater susceptibility to environmental conditions such as temperature and type of ground cover. Decile 1 rainfall and above average daily temperatures experienced in autumn and early winter in 2019 and lack of available refuges for snails <4mm height could explain some of the variability in results and high mortality in both metaldehyde and placebo treatments.

In addition, a test of the copper tape barriers using time-lapse cameras revealed that when conditions became unfavourable for extended periods of time (e.g. hot, windy conditions) snails could move over the copper tape or perished. This test was conducted in much smaller scale and high snail density and hence snails in the experiment in question were more likely to escape by moving away from the copper tape rather than across it. While monitoring was planned to continue into 2020, it was abandoned prematurely due to concerns the plot barrier was unable to contain and maintain snails for the length of the trial. Of most concern was the durability of copper tape and ability to accurately replicate ground cover between treatment plots in the same replicate block over time.

Currently, baiting aims to reduce snail numbers in the year of baiting to reduce crop damage and break the snail lifecycle to reduce snail abundance in future seasons. Hence, the timing of baiting has aimed at targeting the small timing window that coincide with weather conditions that increase the likelihood of snails encountering and dying from baits but before egg lay. This often occurs at a time in the season when competing management priorities and variable weather conditions introduce uncertainty. Given the low efficacy of baiting the question remains whether bait timing can have an impact on snail population dynamics, having implications for integrated management strategies post-harvest when growers may not be able to clean smaller snails out of grain. In addition, whether there is a pay off or downside risk of delayed baiting when managing competing priorities or missing ideal baiting windows. Research into the growth rates and fecundity of snails under different environmental conditions and availability of sources of food and refuges would assist in answering these questions.

References

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Nash, M., DeGraff, H. & Baker, G. 2016. Snail and slug baiting guidelines. https://pir.sa.gov.au/__data/assets/pdf_file/0004/286735/Snail_and_slug_baiting_guidelines.pdf

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Tables

Appendix B. Diary of treatment applications and sampling times.

Activity	Bait timing 1	Bait timing 2
Bait application	15 May	28 May
7 days post treatment & plot sampling for albumen gland size	21 May	4 June
14 days post treatment	28 May	11 June
45 days post treatment	28 June	16 July
Glyphosate	28 June	
70 days post treatment	23 July	6 August
100 days post treatment	22 August	4 September
126 days post treatment	17 September	1 October

Figures

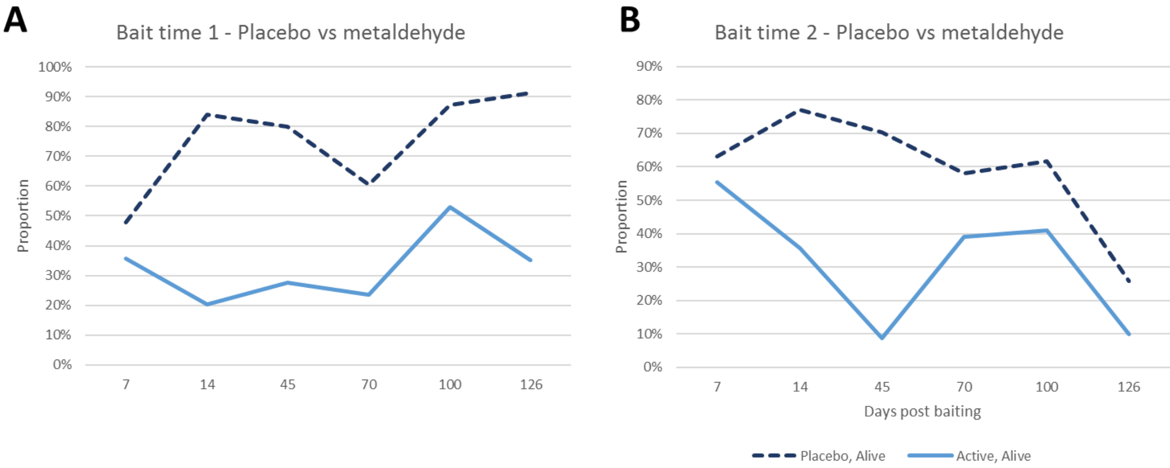


Figure 1. Snail response to bait type (placebo or metaldehyde) in terms of proportion of snails counted at each sampling time that were alive. **A.** Bait timing 1, baits applied 14 May 2019; **B.** Bait timing 2, baits applied 28 May 2019.

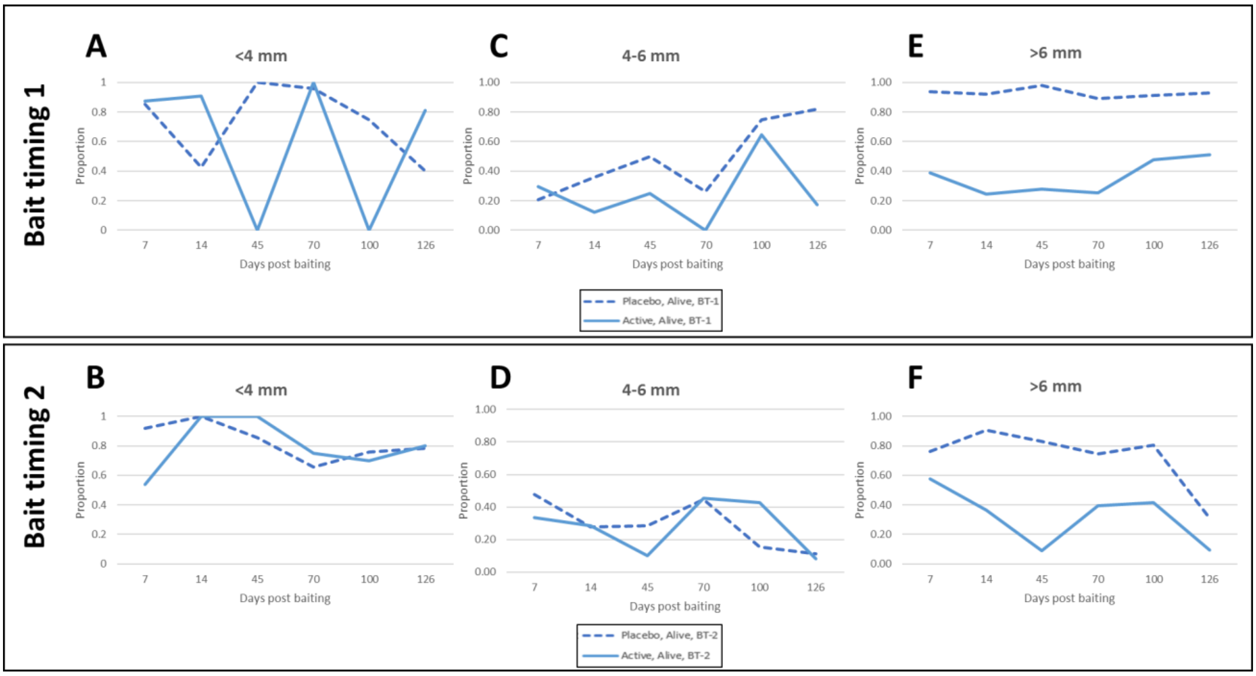


Figure 2. Response to bait type (placebo or metaldehyde) of snails of different shell height (mm). Live snails as a proportion of the total number of snails (dead plus live) counted at each sampling time. **A & B.** Response of snails <4mm shell height. **C & D.** Response of snails 4-6 mm shell height. E **& F.** Response of snails >6 mm shell height.

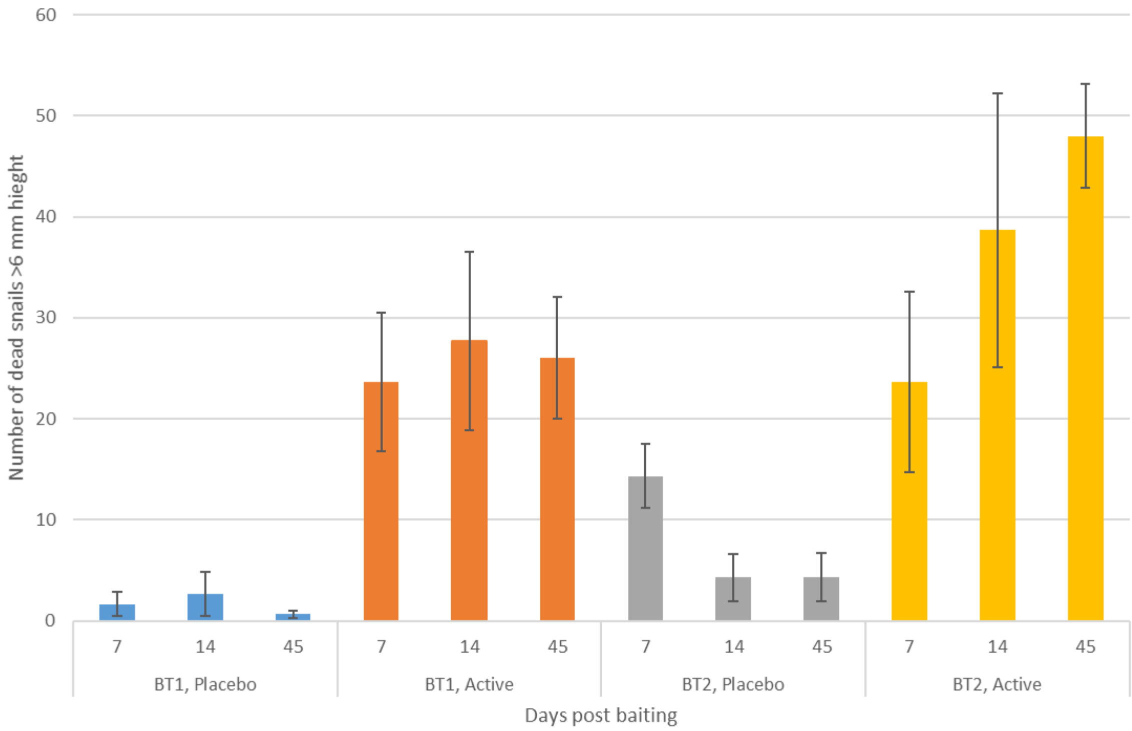


Figure 3. Mean number of dead snails under different bait timings, 1 (BT1) and 2 (BT2), and bait types (placebo or metaldehyde). Treatment with metaldehyde baits had significantly higher number of dead snails compared to placebo baits at both bait timings (ANOVA; $p < 0.001$). Error bars represent S.E.M.

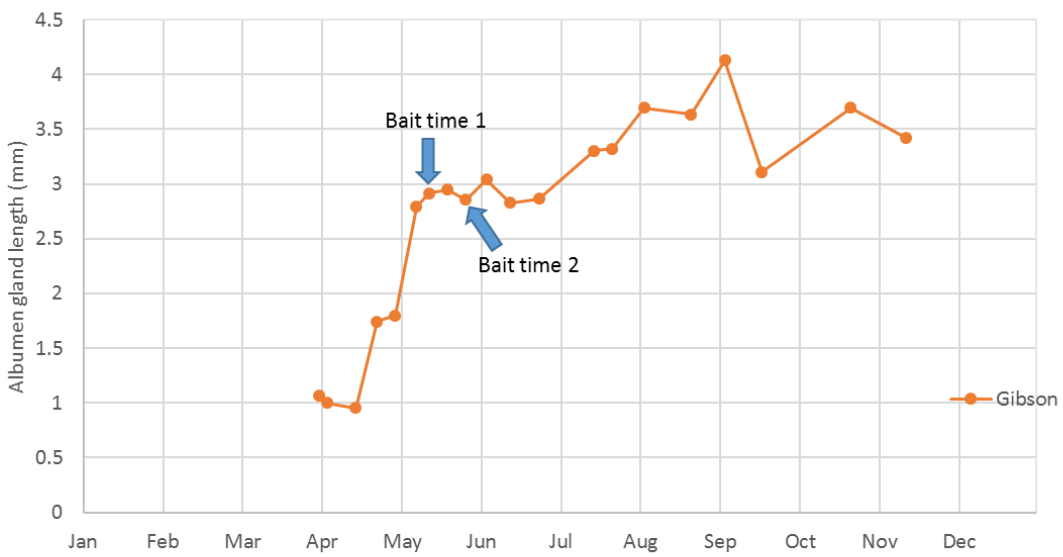


Figure 4. Mean albumen gland length (mm) of snails >6 mm shell height sampled from outside of the trial plots, within the same paddock. At least 20 snails were sampled at each time point.

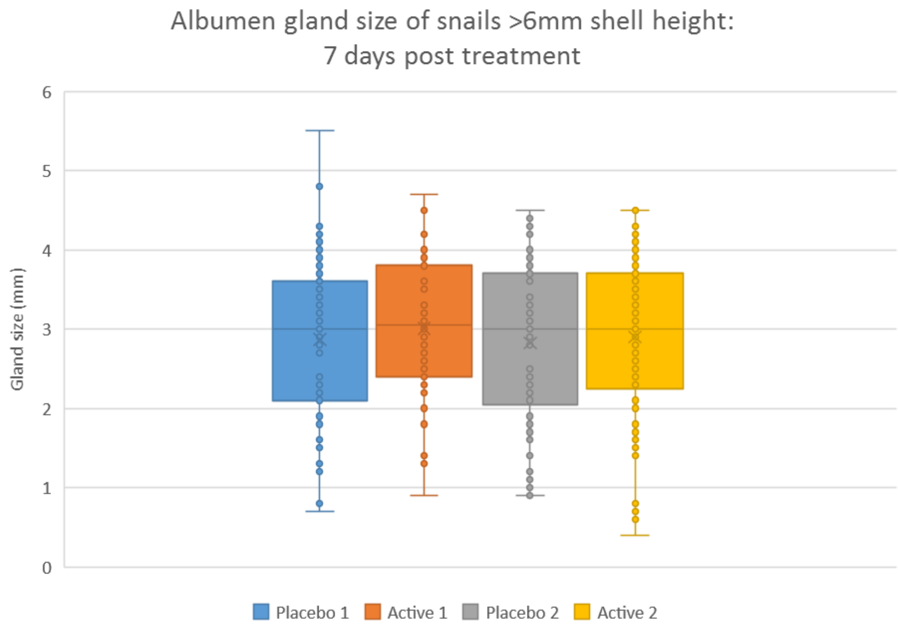


Figure 5. Distribution of albumen gland length (mm) of snails >6 mm sampled from each plot 7 days post treatment application.

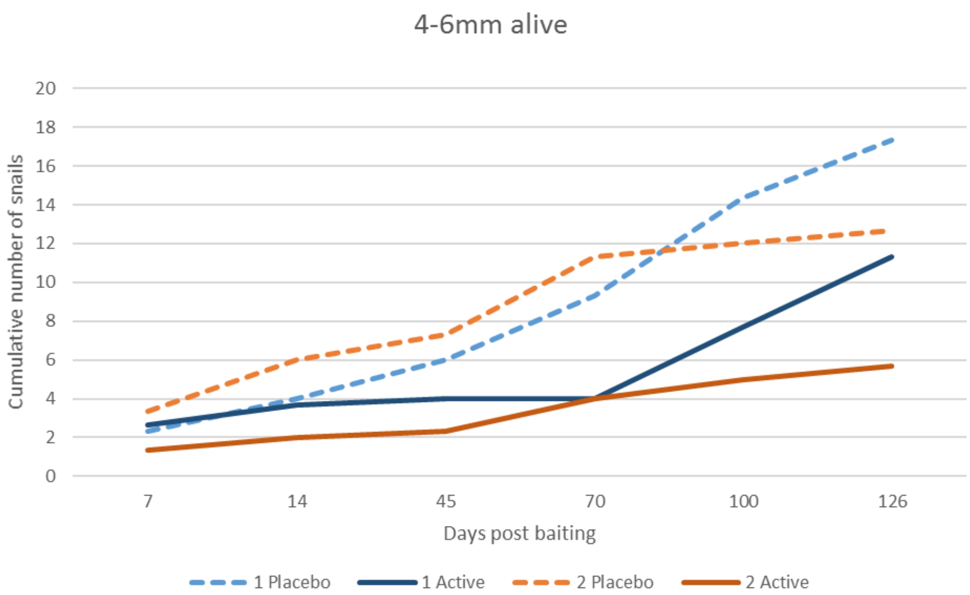


Figure 6. Cumulative number of live snails between 4-6 mm shell height. Dotted lines represent placebo bait treatments; solid lines represent metaldehyde bait treatments.

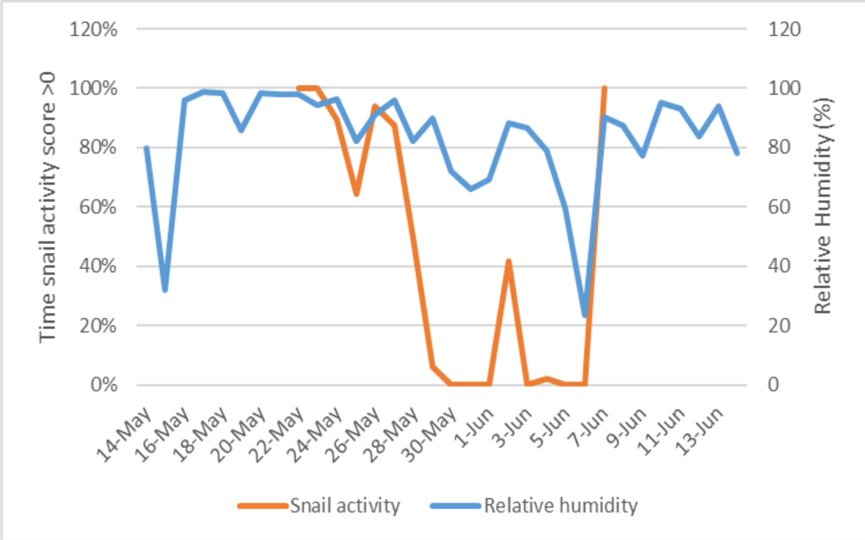
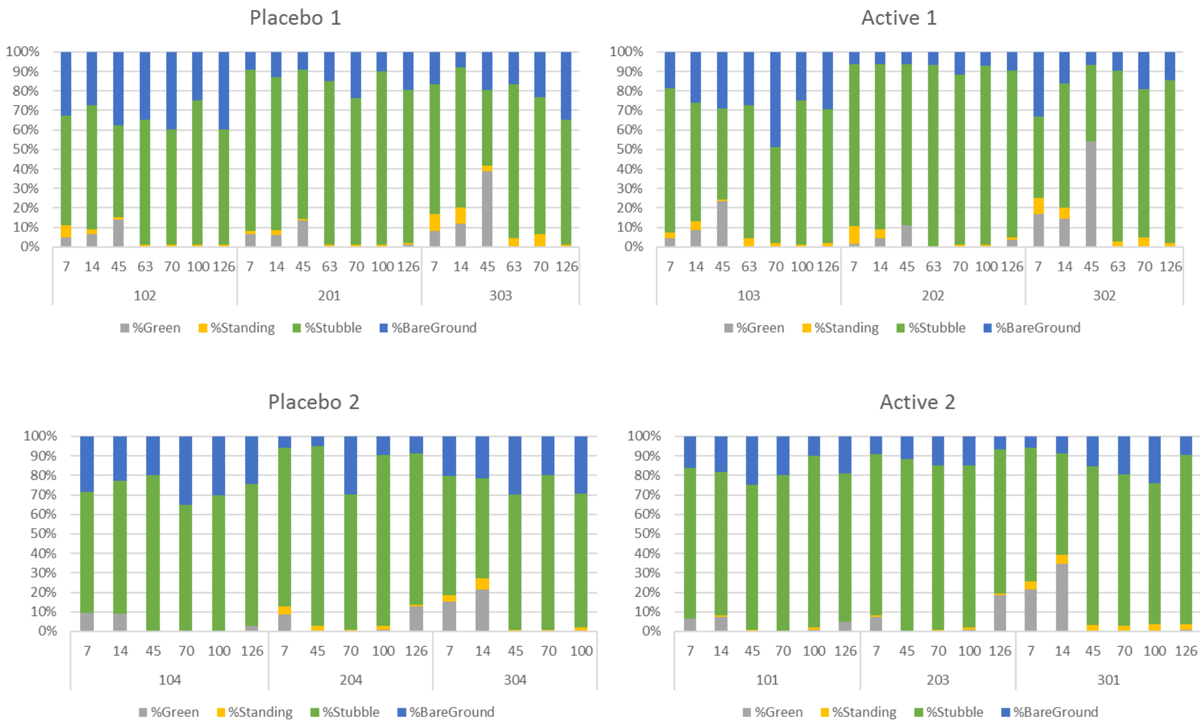


Figure 7. Mean relative humidity (RH) and snail activity of snails between 6pm and 6am monitored at a co-located site at the same time as the bait timing experiment. Snail movement was scored 0-3 every 15 minutes; 0 being no movement, and 3 being high levels of activity. Multiple weather parameters were logged every 15 minutes (RH, air temperature, soil temperature, leaf wetness, and soil water content). Movement was found to be most correlated with RH. An extended period of decreased snail activity coincided with the 7 days following bait timing 2 (from 28 May).



Appendix A. How much cover/refuges were available to the snails. An estimate of percent growing plants, standing stubble, stubble on ground, and bare ground was made throughout the duration of the experiment.

Important disclaimer