EVALUATING DIPHACINONE AND CHLOROPHACINONE RODENTICIDES IN BAIT BOXES FOR VOLE CONTROL IN GRASS SEED CROPS

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Introduction

Gray-tailed voles (*Microtus canicaudus*) are a major pest of grass seed crops in the Willamette Valley, OR (Verhoeven and Anderson, 2021). Like many vole species, gray-tailed vole populations cycle between periods of low numbers and periods of high numbers that cause substantial crop damage and yield losses. Zinc phosphide rodenticide baits are the only registered products for vole control in grass seed crops in Oregon, and only 26% of growers reported being satisfied with the effectiveness of zinc phosphide baits (Verhoeven and Anderson, 2021). An extended period of elevated vole population numbers occurred from 2019 through early 2023, illustrating the need for additional control options for growers.

Compared to other types of pesticides, rodenticides carry a higher risk of poisoning for humans, pets, and mammalian wildlife because these groups have many biological similarities to rodents. Birds can also be highly sensitive to rodenticides. Registration of alternative rodenticide products for grass seed crops will likely require application methods that mitigate the risk of nontarget poisonings. One option is to use tamper-proof bait boxes. These boxes are designed to allow rodents to enter the box and feed on bait, while preventing other wildlife, pets, and children from accessing the rodenticide. Previous work by Salisbury and Anderson (2021a, 2021b) showed that voles were willing to enter bait boxes and feed on chicken feed and other rodenticide baits, especially in the spring.

Diphacinone and chlorophacinone are two active ingredients used in rodenticides that have a different mode of action than zinc phosphide. When voles eat zinc phosphide-containing bait, it reacts with acid in the vole's stomach to produce toxic phosphine gas, which acts quickly by causing cell death in the heart, lungs, and liver. A vole can consume a lethal amount of zinc phosphide in a single feeding. Diphacinone and chlorophacinone interfere with blood clotting and cause death by uncontrolled bleeding. Rodents generally need to consume these baits over several feedings to receive a lethal dose. This study tested five rodenticide bait products containing diphacinone and chlorophacinone in tamper-proof bait boxes in a first-year tall fescue field for 8 weeks.

Materials and Methods

Study design

The study was conducted in a vole-infested tall fescue stand in Linn County, OR, that was planted in spring 2022. The study design was a randomized complete block design with four replicates. Each plot was a single vole colony with a filled bait box placed in the center, or a colony with no bait box. Vole colonies were selected along four 350-foot transects spaced 100 feet apart. Colonies used in the study were approximately 50 feet apart and within 25 feet of the transect. Boxes were placed in the field on April 13, 2023 and were monitored for 8 weeks.

Treatments

Five rodenticide baits and three checks were tested in this study. The bait treatments included Ramik Green (diphacinone; Neogen), Ramik Brown (diphacinone; Neogen), PCQ-Ag (diphacinone; Motomco), Rozol (chlorophacinone; Liphatech), and DoubleTap (chlorophacinone; Liphatech). The checks included a nonlethal check (a bait box with pelleted Payback Egg Layer chicken feed; CHS), no-box check (a vole colony that was monitored but had no bait box), and a grower standard (zinc phosphide bait applied below ground).

Bait box and vole activity measurements

Motomco Tomcat Titan bait boxes with Tomcat Titan iQ trays were used for this trial. Titan boxes have a heavy brick in the base and a locking mechanism. Rodent activity in the box is detected by the sensor in the iQ tray, and these data can be downloaded over a Bluetooth connection. Boxes were checked weekly. Activity data were downloaded, boxes were inspected for visible signs of vole activity, and the remaining bait was collected and replaced with fresh, preweighed bait each week. All plots were inspected for signs of vole activity and photographed each week.

Previous studies (Salisbury and Anderson, 2021a, 2021b) showed that baits can gain or lose moisture, causing an increase or decrease in weight, without any bait consumption. To control for these factors, additional samples (one sample of each bait type) were placed in moisture check bait boxes at the field site. The entrances of the moisture check bait boxes were covered

with window screen to allow air flow but prevent voles from entering. After collection in the field, all bait samples were stored in a ziplock bag with a desiccant packet until they reached a constant weight. Weight loss by the experimental samples was adjusted by the weight change observed in the moisture check samples.

Measuring crop damage

To evaluate the impact of the bait treatments on crop growth, aerial imagery was collected with a drone on April 13 and May 25, 2023, following the methods reported by Tanner (2023). The aerial imagery was used to measure changes in crop height and normalized differential vegetation index (NDVI), a measure of canopy closure and crop health, in a 6.6-foot diameter circular area surrounding each vole colony. Vole colonies had differing levels of damage, so the effect of treatments on crop growth was measured by subtracting values measured on April 13 (before treatment) from values measured on May 25 (during the study).

Statistical analysis

Statistical tests were performed in R statistics software. Data were not normally distributed and contained a large number of zeros and high outliers. Attempts to transform the data to meet normality assumptions of parametric statistical methods were not successful. Differences between treatments were tested with the nonparametric Kruskal-Wallis rank-sum test. The Dunn post-hoc test with Holm correction for multiple comparisons was used when the Kruskal-Wallis test indicated differences between groups.

Results and Discussion

Field observations

Signs of vole activity, such as droppings, clipped leaves, and fresh digging, were present throughout the study period. Combined with data from the bait box iQ sensors, it is clear that voles were present and active during the study. However, we did not observe any patches of clipped reproductive tillers in the field as harvest approached. In recent years, fields with heavy yield losses due to vole damage had large areas where voles had cut the majority of reproductive tillers. Growers and field agronomists reported that vole activity and crop damage declined sharply during the time of the study. The observations in this study likely occurred as populations were declining.

Box visits and bait consumption

Visits and bait consumption were recorded for all boxes over the 8-week study period. Cumulative data for the full study period are shown in Table 1. The boxes recorded averages of 33–119 total visits over the 8-week study period and 0.6–2.1 oz of bait consumption (Table 1). A summary of weekly vole visits and bait consumption is shown in Figure 1. It was common for bait boxes to have few or no visits or little to no bait consumption during a given week, but large numbers of visits and relatively high bait consumption were also common. Some boxes recorded very high numbers of visits, with 7 boxes recording more than 50 events in a week. Bait consumption of at least 0.7 oz in 1 week was observed for 15 boxes.

Table 1. Total bait box visits and bait consumption by gray-tailed voles in a vole-infested tall fescue stand, Linn County, OR, 2023.[1]

Bait	Total visits (mean ± SD)[2]	Total bait consumption (mean ± SD)[2]	Observations with visits	Observations with bait consumption
	(no.)	(oz)	(%)	(%)
Chicken feed	42 ± 3	0.6 ± 0.1	81	75
Ramik Brown	119 ± 74	1.4 ± 1.0	81	44
Ramik Green	89 ± 57	2.0 ± 1.8	94	44
PCQ Ag	100 ± 59	1.3 ± 1.0	81	75
Rozol	33 ± 13	1.6 ± 0.6	78	63
DoubleTap	99 ± 38	2.1 ± 1.0	94	84

[1]Total visits and total bait consumption are the average total number of visits or total amount of bait consumed, respectively, per bait box throughout the 8-week study period (n = 4 bait boxes per bait treatment). Each of the 4 bait boxes per treatment was checked weekly for 8 weeks, totaling 32 observations. Observations with visits and observations with bait consumption show the percentage of observations with at least one event recorded by the bait box or bait consumption greater than zero (after correcting for moisture loss).
[2]SD = standard deviation

Statistical tests for differences in visits produced conflicting results. Kruskal-Wallis test was significant, but Dunn post-hoc test was not significant after correcting for multiple comparisons. Some evidence suggested a difference between DoubleTap and Rozol (Figure 1, left, $P < 0.1$), but more data are needed to conclude that any bait performed better than the others. There was greater consumption of DoubleTap than Ramik Brown (Figure 1, right, $P < 0.05$), but no other statistical differences between treatments. Based on consumption data in Table 1, there is no evidence that any of the baits was less attractive than the chicken feed check.

Drone data

Crop growth was stunted in the severely damaged vole colony areas, as evidenced by minimal changes in crop canopy height and NDVI values during the study period. These areas remained shorter than the surrounding crop, and bare soil continued to be visible between crop rows. Nearby areas with less severe vole damage appeared to recover by harvest time, with increases in crop height and NDVI and a strong stand of seed heads. There were no differences in crop growth among treatments (data not shown). The lack of differences among treatments is likely due to the lack of late spring tiller clipping observed in this study.

References

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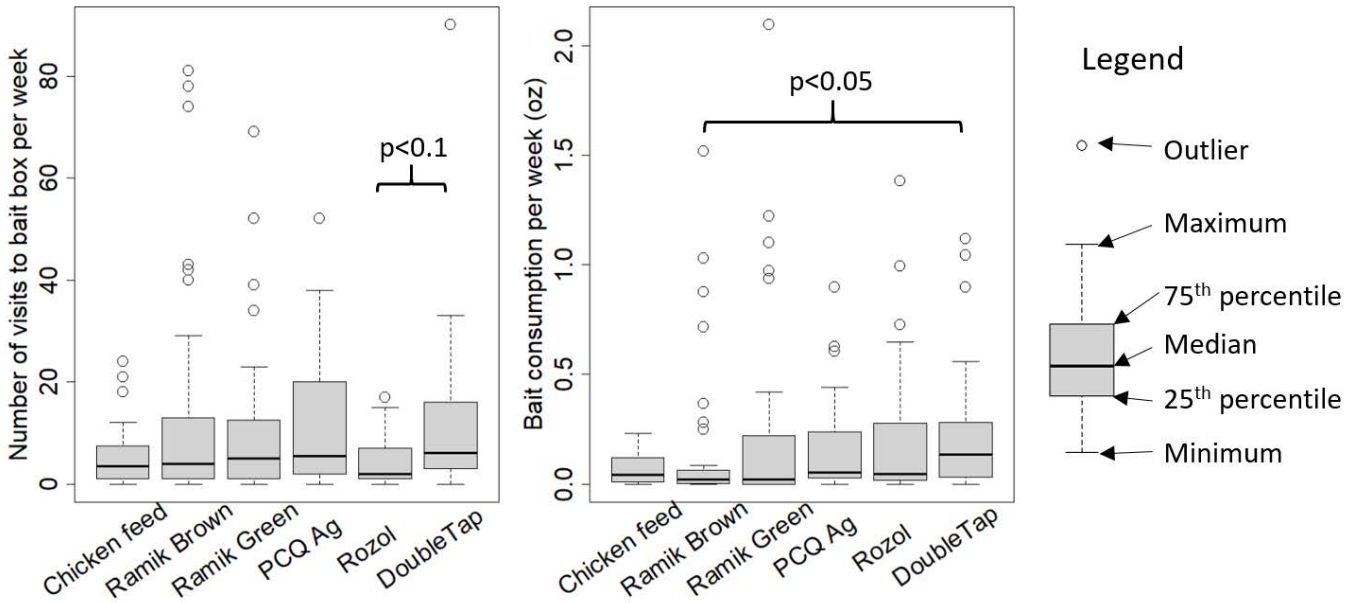

Figure 1. Box plots of the number of visits to the bait boxes (left) and amount of bait consumed (right) for each type of bait. Statistically significant differences between pairs of treatments are indicated with a bracket and significance level.