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Can Bait Boxes Help Control Voles in Oregon Seed Production Systems?

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ABSTRACT: For grass and legume seed producers in the Willamette Valley, Oregon, the gray-tailed vole can cause yield losses of 50% or more. A study was conducted in the spring of 2023 to evaluate the effectiveness of diphacinone and chlorophacinone rodenticide baits applied in tamper-proof bait boxes for controlling voles. Eight treatments (5 rodenticide baits, non-toxic chicken feed, untreated control, and grower standard) were tested in a commercial tall fescue seed production field in a randomized complete block design with four replicates. Motomco Titan bait boxes with IQ trays were used, which allowed activity inside each box to be detected. Boxes were placed in the damaged areas of the field in mid-April. Pre-weighed bait was replaced, and activity data was downloaded weekly for eight weeks. Crop growth was monitored with drone aerial imagery collected before, during and after the bait box treatments. To evaluate the impact of vole damage on yield, seed was harvested from 50 cm sections of a crop row in damaged (n=16) and undamaged (n=16) locations. While signs of vole activity continued throughout the study, there was little to no clipping of reproductive tillers by voles – a major cause of yield loss in vole-infested fields. Bait consumption and activity in boxes was observed in all boxes. No differences between treatments were detected. Aerial imagery data correlated strongly with seed yield and tiller counts from the yield plots. Interestingly, the strongest correlation with yield was found for the flight conducted before the bait box treatments were applied, suggesting that damage caused before the start of the experiment had a lasting effect on crop yield.

KEY WORDS: aerial imagery, bait box, drone, grass seed, gray-tailed vole, *Microtus canicaudus*, Oregon

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INTRODUCTION

The gray-tailed vole (*Microtus canicaudus*) is endemic to the Willamette Valley of western Oregon, and is primarily found in grassland, cropland and pasture habitats (Goertz 1964). Like many vole species, gray-tailed voles undergo substantial population fluctuations (Krebs and Meyer 1974), which can cause substantial damage to agricultural crops. The Willamette Valley is also home to nearly 350,000 acres of cool season grasses grown for seed, with perennial species accounting for approximately 66% of this acreage (Oregon State University 2021). These production fields are commonly inhabited by voles, and population eruptions of the gray-tailed vole caused grass seed crop losses estimated at $35 million in 2005 and $50 million in 2020 (Christie 2005, McClain 2021).

Grass seed producers have few options for vole control. Zinc phosphide rodenticide baits are the only registered rodenticide products available for vole control in grass seed crops in Oregon. These baits may be used for burrow baiting throughout the year, but this requires substantial labor to cover the affected acreage. Broadcast bait applications are limited to the period between May and September to protect migratory geese (Bildfell et al. 2013). Only 26% of growers reported being satisfied with the effectiveness of zinc phosphide baits (Verhoeven and Anderson 2021). While cultural practices such as crop rotation and tillage can reduce vole populations (Steiner et al. 2007), these practices are currently utilized when feasible but are limited by other production constraints. For example, growers are reluctant to terminate a perennial crop earlier than necessary because the cost of production is primarily incurred during crop establishment (Silberstein et al. 2010).

Unlike previous population eruptions, the 2020 peak in vole populations was followed by an extended period of elevated vole population numbers before vole numbers subsided in early 2023. This event highlighted the need for additional control options for growers. Registration of alternative rodenticide products for grass seed crops will likely require application methods that mitigate the risk of non-target 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 (Salisbury and Anderson 2021a,b) showed that voles were willing to enter bait boxes and feed on chicken feed and other rodenticide baits, especially in the spring. This study tested five rodenticide bait products containing diphacinone and chlorophacinone in tamper-proof bait boxes in a first-year tall fescue field for eight weeks.

METHODS

Overview

The study was conducted in a vole-infested tall fescue stand in Linn County, Oregon, 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. Each colony consisted of an area approximately 1-3 m across with several burrow entrances and severe plant defoliation. Vole colonies were selected along four, 107-m transects spaced 30 m apart. Colonies used in the study were approximately 15 m apart and within 7.6 m of the transect. Boxes were placed in the field on April 13, 2023, and monitored for eight weeks.

Treatments

Five rodenticide baits and three control treatments were tested in this study. The bait treatments included Ramik Green (diphacinone, Neogen, Lansing, MI), Ramik Brown (diphacinone, Neogen), PCQ-Ag (diphacinone, Motomco, Windsor, WI), Rozol (chlorophacinone, Liphatech, Milwaukee, WI), and Double Tap (chlorophacinone, Liphatech). All baits contained 0.005% active ingredient. The controls included a non-lethal control (a bait box with pelleted Payback Egg Layer chicken feed, CHS, Inver Grove Heights, MN), no-box control (vole colony that was monitored, with no bait box), and a grower standard (Neogen Prozap zinc phosphide pellets placed in burrows).

Bait Box and Vole Activity Measurements

Motomco Tomcat Titan bait boxes with Tomcat Titan iQ trays (Motomco) were used for this trial. Titan boxes have a heavy brick in the base and a locking mechanism. Each iQ tray contains a capacitive sensor that is triggered when an animal enters the box. An activity "event," including time and date information, is recorded when the sensor is triggered. After an event, the device has a 30-minute waiting period before another event can be recorded. The waiting period is designed to record a single event if a single animal triggers the sensor repeatedly (e.g. an animal enters the box, moves around, feeds, and exits the box), but multiple animals interacting with the box during a 30-minute window are recorded as a single event. Event data can be downloaded from the iQ tray over a Bluetooth connection. Event counts were used as a measure of how often animals interacted with the bait box. 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, pre-weighed bait each week. All plots were inspected for signs of vole activity and photographed each week.

Previous studies (Salisbury and Anderson 2021a,b) showed that baits can gain or lose moisture, causing an increase or decrease in weight, independent of 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 so voles could not enter. After collection in the field, all bait samples were stored in a zip lock bag with a desiccant packet until they reached a constant weight. Weight loss by the experimental samples was adjusted by subtracting the average weight change observed in the moisture check samples for the corresponding bait type.

Measuring Crop Damage

Previous work demonstrated that aerial imagery can be used to measure vole damage (Tanner 2023), so aerial imagery was collected throughout the study to monitor the crop response to vole bait treatments. The aerial imagery was collected using a DJI Matrice 210 V2 drone (Los Angeles, CA) carrying a multispectral camera (MicaSense RedEdge MX (Measur, Calgary, AB, Canada) and a natural color digital camera (Sony a6000, Sony Corp., New York, NY). Location data was collected with a post processing kinematic GNSS system (Emlid Reach RS+ and M+, Emlid Tech Kft., Budpest, Hungary) for ground control points and all vole colonies, and drone photos were geotagged. Drone flights were conducted on April 13, May 3, May 25, and June 27, 2023. Imagery was processed using Pix4D Mapper (Pix4D Inc., Denver, CO) and ArcGIS Pro (Esri, Redlands, CA) to produce maps of crop canopy height (from digital surface models) and normalized differential vegetation index (NDVI). Average NDVI and average crop canopy height was calculated for a circular area, 2 m in diameter, surrounding each vole colony included in the study. 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. Data from a flight on June 27, 2023 was not used to evaluate vole damage because changes in crop appearance due to maturity (lodging and color changes) were difficult to distinguish from the effects of vole damage.

To evaluate the effect of vole activity on seed yield, seed heads were collected from small quadrat plots at crop maturity. Each quadrat was designed to enclose a 0.5 m long section of one crop row, with crop rows spaced 0.38 m apart. Quadrat samples were collected for each plot from two of the four replicates. For each plot, one sample was collected from the damaged area within the vole colony area, and a second sample was collected from an adjacent area that appeared to be undamaged for a total of 32 samples total. The location of each quadrat was recorded using post processing kinematic GNSS equipment. The samples were dried to a constant weight and the seed was hand threshed and cleaned using a Clipper Office Tester seed cleaner (Hoffman Mfg. Co, Corvallis, OR). Means of canopy height and NDVI were calculated in ArcGIS Pro for the areas corresponding to the quadrats.

Statistical Analysis

Statistical tests were performed in R statistics software. A one-way test was used to determine if there were differences between treatments in the total bait consumption and the total number of activity events recorded for each bait box. This test allowed for un-equal variances. Analysis of variance was used to test for differences in crop response in the aerial imagery data. To evaluate the relationships between aerial imagery measurements and seed yield across multiple flight dates, pearson's correlation coefficients and p-values were calculated for these variables using the Hmisc package (Harrell et al. 2019). Due to the large number of correlations evaluated, P-values were adjusted for multiple comparisons using the Bonferroni method (Dunn 1961).

RESULTS

Signs of vole activity such as droppings, clipped leaves, and fresh digging were present throughout the study period. A summary of the activity events and bait consumption over the full study period is shown in Table 1. The boxes recorded averages of 33 to 119 total events over the eight-week study period and 16 to 58 g of bait consumption. Neither events nor bait consumption differed significantly between treatments. It was common for bait boxes to have few or no events or little to no bait consumption in a given week, but large numbers of events and relatively high bait consumption were also common. Events and

Table 1. Summary of bait box data. 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 four bait boxes per treatment were checked weekly for 8 weeks, totaling 32 observations. Observations with visits and observations with bait consumption show the percentage of observations where there was at least one event recorded by the bait box, bait consumption greater than zero (after correcting for moisture loss).

Bait	Total visits (mean ± SD)	Total bait consumption (g) (mean ± SD)	Observations with visits (%)	Observations with bait consumption (%)
Chicken feed	42 ± 3	16 ± 4	81	75
Ramik Brown	119 ± 74	39 ± 29	81	44
Ramik Green	89 ± 57	56 ± 52	94	44
PCQ Ag	100 ± 59	36 ± 29	81	75
Rozol	33 ± 13	45 ± 17	78	63
DoubleTap	99 ± 38	59 ± 28	94	84

some bait consumption were recorded for all boxes over the eight-week study period. Seven boxes recorded >50 events in a week and bait consumption of at least 20 g in one week was observed for 15 boxes. Events and bait consumption occurred throughout the study period.

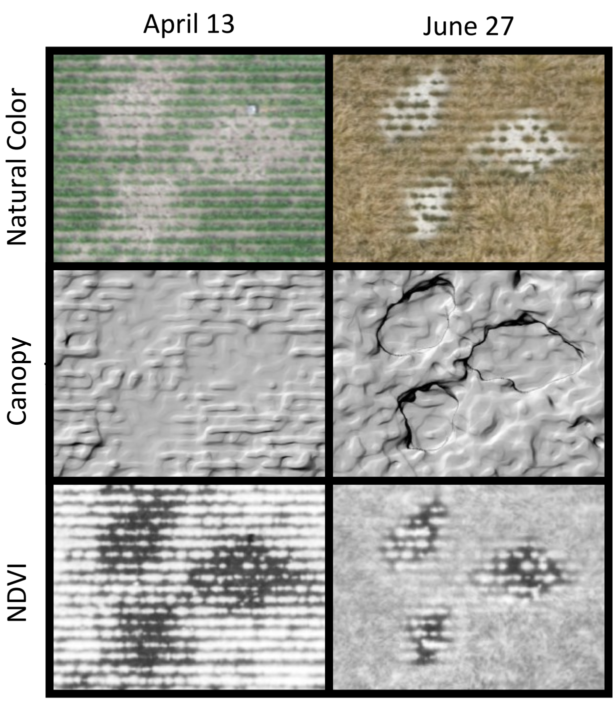

Figure 1. Example aerial imagery of one vole colony with a bait box from the beginning (April 13, left) and end (June 27, right) of the study. Natural color (RGB) imagery, crop canopy height, and normalized differential vegetation index (NDVI) are shown in the top, middle and bottom panels respectively. Crop canopy height is depicted using grayscale hill shade symbology from ArcGIS pro. NDVI is shown in gray scale with white indicating high values (green plant material) and black representing low values (bare soil).

Crop growth was stunted in the severely damaged vole colony areas (Figure 1). These areas remained shorter than the surrounding crop, and bare soil continued to be visible between the crop rows. Nearby areas with less severe vole damage appeared to recover by harvest time, showing increases in crop height and canopy closure, and producing a strong stand of seed heads. There were no differences in crop growth between treatments (data not shown).

Seed yield in damaged and undamaged quadrats differed significantly ($p < 0.05$) with an average yield loss of 66% in damaged areas. Seed yield was highly correlated with multiple aerial imagery measurements. Average NDVI measured on April 13 was the best predictor of seed yield overall (Figure 2, $R^2 = 0.79$, $p < 0.05$). Crop canopy height

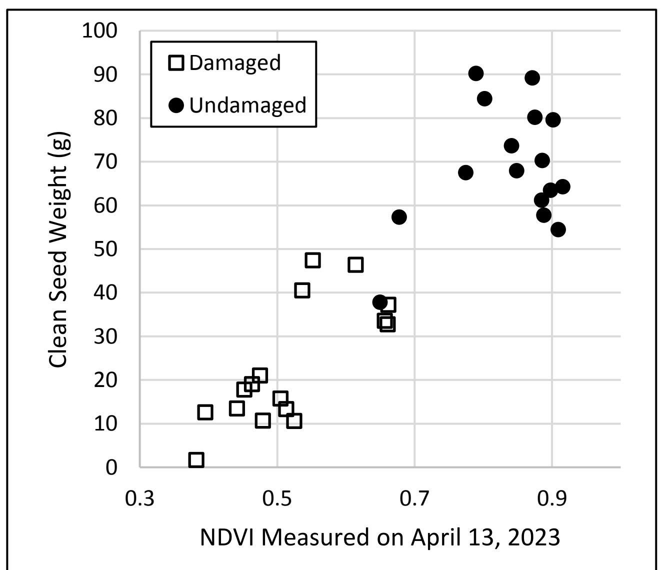

Figure 2. Scatter plot showing the relationship between clean seed yield per quadrat and average NDVI of the quadrat area measured on April 13, 2023. Samples collected from damaged areas (within vole colonies) are shown as empty squares, and samples collected from areas without visible damaged are shown as solid circles.

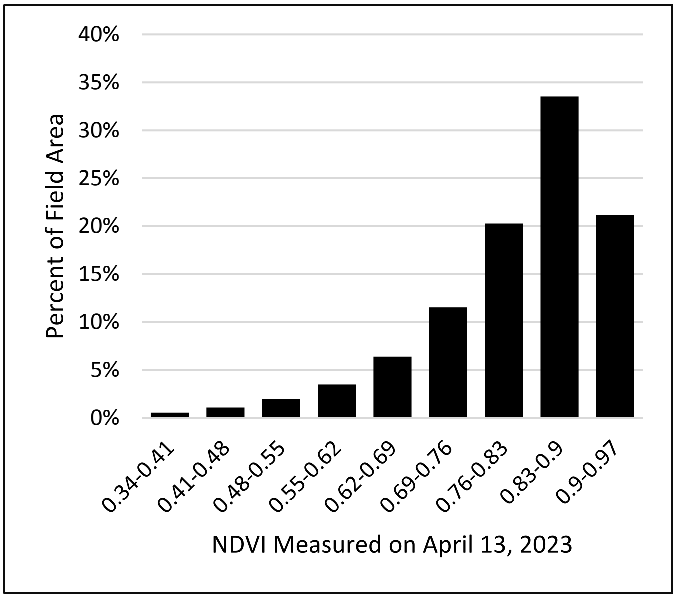

Figure 3. Histogram showing the distribution of NDVI values measured on April 13, 2023, for the entire study area. The majority of the field displayed NDVI values consistent with undamaged areas.

was also predictive of seed yield, with the strongest correlation observed on May 3 ($R2 = 0.62$, $p < 0.05$). While the yield impact on damaged portions of the field was substantial, only a small portion of the field had NDVI values similar to damaged plots (Figure 3).

DISCUSSION

This study showed that gray-tailed voles would enter bait boxes and feed on bait. However, the amount of bait consumption was relatively low, and there was little evidence of successful control. Byers (1978) evaluated the toxicity of chlorophacinone and diphacinone baits in pine voles and reported mortality of 40-100% when 4.5-11.3 g of chlorophacinone bait (0.005% active ingredient) was consumed over a 1- to3-day period, respectively. Diphacinone bait (0.005% active ingredient) consumption of 7.8 g of bait over a 2-day period did not cause mortality, but 10.6-10.9 g of bait over 3-5 days caused 40-90% mortality. This suggests that the average number of voles controlled by each bait box over the 8-week study period was likely in the single digits. Considering the high population densities the gray-tailed vole can achieve (Edge et al. 1995), this level of control is likely not sufficient during vole population eruptions. While bait consumption rates were low, event data suggests that voles are willing to enter bait boxes. A self-resetting trap station that killed voles upon entry could be an effective alternative to bait boxes.

This study was conducted during a period when regional vole population numbers were falling. In 2021 and 2022, I observed many fields with large areas (10-30 m across) where voles had clipped the majority of seed heads during the reproductive growth age of the crop. The use of bait boxes in the spring was intended to prevent substantial seed head removal, but no patches of seed head removal were found in the study area in 2023. The treatments did not result in any detectable differences in crop growth in aerial imagery. The lack of differences could be due to a lack of damage across all treatments, or a lack of effectiveness of the rodenticide treatments, resulting in similar rates of damage in rodenticide and control treatments.

At the start of the trial, vole colony areas showed significant vegetative crop damage, with many plants grazed to near soil level. This damage had a lasting effect on the crop as evidenced by the strong correlation between seed yield and NDVI measured at the start of the study. This study provided an opportunity to measure the effect of severe vole damage during the vegetative growth stage in the absence of tiller clipping during the reproductive stage. An improved understanding of the impact of vole damage on yield will help growers weigh the costs of treatment against potential yield losses.

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