Efficacy of Strychnine and Zinc Phosphide Cabbage Baits in Controlling Ground Squirrels in Diamond Valley, Nevada

John Balliette
JBR Environmental Consultants, Elko, Nevada
John M. O'Brien
Nevada Department of Agriculture, Reno, Nevada
John D. Eisemann
USDA APHIS Wildlife Services, National Wildlife Research Center, Fort Collins, Colorado

ABSTRACT: A field trial was conducted to determine the efficacy of strychnine and zinc phosphide cabbage baits for controlling ground squirrels in Diamond Valley, Nevada. The reduction in aboveground ground squirrel activity was 83% for strychnine and 70% for zinc phosphide. Similar results were found for reductions in burrow activity: 88% for strychnine and 70% for zinc phosphide. Strychnine appeared to be slightly more effective than zinc phosphide, but both appeared to be effective for ground squirrel control.

KEY WORDS: alfalfa, efficacy, ground squirrels, Nevada, rodenticides, *Spermophilus* spp., strychnine, timothy, zinc phosphide

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INTRODUCTION

This report summarizes a field trial on the efficacy of strychnine and zinc phosphide cabbage baits for controlling ground squirrels in Diamond Valley, Nevada. JBR Environmental Consultants, Inc. (JBR) conducted this evaluation on behalf of the Diamond Valley Rodent Control District and the Nevada Department of Agriculture (NDOA). Both Richardson ground squirrels (*Spermophilus richardsonii*) and Piute ground squirrels (*S. mollis*) occur in the study area. These species have similar behavior and habitat requirements (Askham 1994). Typically, ground squirrels in Diamond Valley emerge from their burrows in early spring, breed, and rear young. They are diurnal and forage primarily in the mornings. By mid to late summer, squirrels return to their burrows to estivate and eventually hibernate. Both species are attracted to succulent vegetation such as irrigated alfalfa (*Medicago sativa*). Hay production in Diamond Valley is an important sector of the local economy and a sustainable tax base. Ground squirrels are a major pest of hay production, foraging on large amounts of hay, and their burrows adversely affect hay quality and cause damage to machinery (Balliette *et al*. 1994).

Objective

The Environmental Protection Agency (EPA) has reviewed the use of Strychnine Alkaloid Paste (Special Local Need Registration NV-830009) in Nevada. In order to continue the use of this product on ground squirrels, the EPA indicated efficacy data for in-burrow application would be required. Zinc Phosphide Concentrate (EPA Registration 56228-06) is labeled for ground squirrel control; however, there are no data on its effectiveness on ground squirrels in Nevada. The objective of this study is to examine the efficacy of these products in controlling ground squirrels.

MATERIALS AND METHODS

This evaluation was conducted in Diamond Valley, Nevada, which is approximately 10 miles north of Eureka, Nevada (Figure 1). The elevation of the valley floor is approximately 5,900 feet above mean sea level.

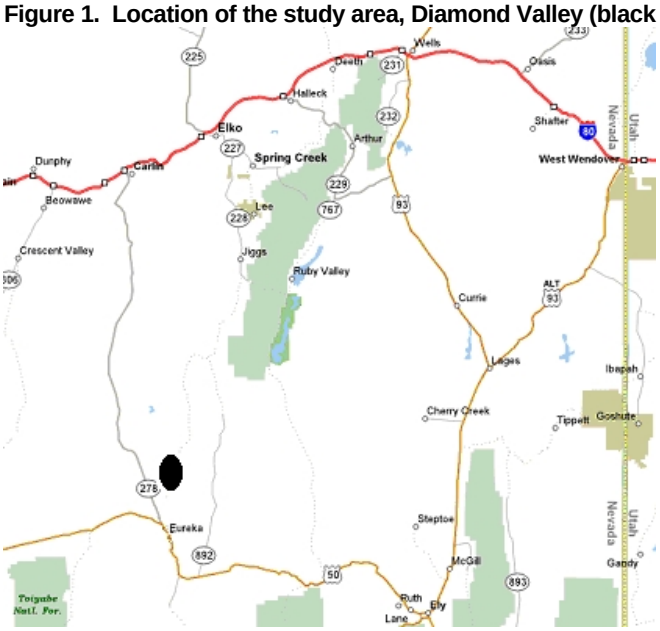
Soils

Soils in the study area are primarily well-drained loams. The treated plots of this study were located on two different soil series, the Alhambra Series and the Silverado Series. The soil associations include Alhambra fine sandy loam, hummocky; Alhambra-Kobeh complex; Silverado sandy loam, 0 to 2% slopes; and Silverado sandy loam, 2 to 4% slopes (Soil Conservation Service 1980).

Vegetation

Native vegetation adjacent to the croplands is dominated by Wyoming big sagebrush (*Artemisia tridentata wyo-ming-*

Figure 1. Location of the study area, Diamond Valley (black oval), approximately 10 mi north of Eureka, Nevada.



ensis) with a bunchgrass understory. Bunchgrasses in the area are dominated by Sandberg's bluegrass (*Poa sandbergii*), bottlebrush squirreltail (*Elymus elymoides)*, and Nevada needle grass (*Achnatherum nevadense)*. Herbaceous plants include desert globemallow (*Sphaeralcea ambigua*) and phlox (*Phlox* spp.). Vegetation in the plots located on farmed fields consisted of alfalfa (*Medicago sativa*) and timothy (*Phleum pratense*). Vegetation in plots adjacent to the fields include crested wheat (*Agropyron cristatum*) and numerous weed species such as bur buttercup (*Ranunculus testiculatus*), Russian thistle *(Salsola kali)*, halogeton (*Halogeton glomeratus*), clasping pepper weed (*Lepidium perfoliatum)*, cheatgrass (*Bromus tectorum*), kochia (*Kochia scoparia*), tansy mustard (*Descurainia pinnata*), and purple loosestrife (*Lythrum salicaria*).

STUDY DESIGN

The methodology for this trial was based on methodology used by O'Brien (1985). Three treatments were evaluated: 0.2% strychnine cabbage bait formulated from a 3.2% alkaloid paste (SLN no. NV-830009); 2% zinc phosphide cabbage bait formulated from 63.2% Zinc Phosphide Concentrate for Rodent and Lagomorph Control (EPA Reg. No. 56228-6); and untreated chopped cabbage (control). These 3 treatments were replicated 3 times. Figure 2 shows how the plots were laid out in relation to each other.

Prior to mixing the bait, three 1-gallon bottles of strychnine paste were mixed and a representative sample taken for analysis by the NDOA. The percent strychnine of the mixed sample was 2.91%, which is 90.93% of the labeled 3.2% concentration. This is slightly below certified limits (40 CFR 15.175), but the efficacy study demonstrated the product was still effective.

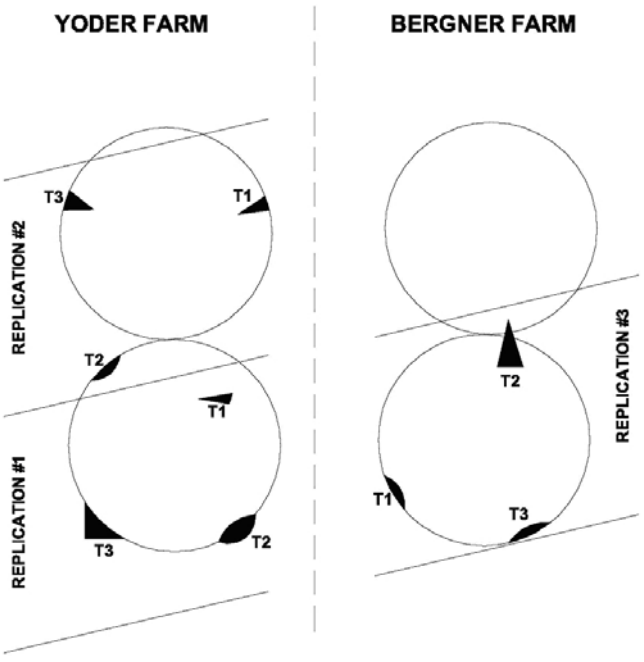


Figure 2. Relationship of the study plots to each other and in relation to the center pivot irrigation systems. T1 = strychnine bait treatment, T2 = zinc phosphide bait treatment, T3 = control.

From March 24 to March 28, 2005, plots were chosen with the goal of locating delineable areas that contained a minimum of 20 to 25 ground squirrels, as counted in visual surveys. Two different farms were surveyed and each had 2 center pivot sprinklers for irrigation. Each pivot irrigates approximately 135 acres. Six plots were sited on the Yodder Farm (Section 35, T21N, R53E, MDBM) and 3 on the Bergman Farm (Section 18, T21N, R53E, MDBM). The Bergman farm is approximately 5 miles northeast of the Yodder Farm. The estimated plot sizes ranged from 0.75 acres to 2 acres. Observation points were marked with 42-inch-long wooden posts that were painted fluorescent orange. Plot boundaries were marked with the same posts painted fluorescent orange and white. Plots were organized into groups of 3 based on proximity, and each group was considered a replicate. Within replicates, each plot was randomly assigned one of the 3 treatments (strychnine, zinc phosphide, or control).

On March 29, 2005, all active burrows within the plot boundaries and adjacent buffer zones were raked over to hide any sign of squirrel activity. Starting at the plot boundary closest to the observation point and traversing towards the farthest plot boundary, 25 active burrows were marked with 18-inch wooden survey stakes numbered 1 through 25. The top of each stake was painted fluorescent orange and white. All staked burrows were at least 25 feet apart. Criteria for designating a burrow as active included the presence of fresh mounding, tracks, and excrement.

On March 30, 2005, all active burrows within the plot boundaries and adjacent buffer zones were pre-baited with plain chopped cabbage that was scattered aboveground near the burrow openings. An attempt was made to have 200-yard buffer zones around the treatment plots to reduce migration from untreated areas. In areas where landowner permission was absent, some buffer zones were approximately 100 yards. These included control rep 1, strychnine rep 2, and strychnine rep 3. Observations of these adjoining areas indicated few ground squirrels were present. The cabbage was chopped by 2 local farmers, in order to mimic local methods. Before pre-baiting, all 3 people applying cabbage within the boundaries of the plots compared their cabbage "pinch size" several times in an attempt to standardize the amount of cabbage placed in each burrow. During pre-baiting, the numbered stakes at any inactive burrows were moved to adjacent active mounds. Baiting occurred from approximately 9:00 a.m. to 1:00 p.m.

On March 31, 2005, pre-treatment aboveground counts of squirrels were initiated. Counts were taken using binoculars at the established observation points. Observations consisted of counting and recording the number of ground squirrels during 6 scans across the plot boundaries using binoculars. The highest number of squirrels counted during a single scan was later used in the analysis. Pre-treatment counts were also taken on April 1 and 2, 2005. Counts were conducted by the same person at the same time of day (approximately 7:00 a.m. to 9:30 a.m.) and in the same sequence.

Burrow activity measurements were also conducted from March 31 through April 2, 2005. The numbers on the stakes marking the burrows were recorded as active or inactive. Active burrows (as well as those not staked in the plots and buffers) were raked over to conceal previous activity. Burrow measurements were also conducted by the same person at approximately the same time of day and in the same sequence. Approximately 6 hours each day was required to complete the burrow activity measurements.

Rodenticide treatments were applied on April 3, 2005. Cabbage baits were chopped and mixed by 3 local farmers, to help mimic local methods. Controls were treated first, strychnine second, and zinc phosphide last. It was determined by local experience that zinc phosphide cabbage baits should be mixed and applied promptly, due to the evolution of phosphine gas from moisture in the bait. Product label instructions were reviewed and followed during the mixing and application of the rodenticides. The strychnine bait was placed down into the burrow openings. Zinc phosphide bait and control bait were scattered next to the burrow openings.

Before treating the plots, all three people applying cabbage within the boundaries of the plots again compared their cabbage "pinch size" several times in an attempt to standardize the amount of cabbage placed in each burrow. These 3 people also kept a running tally of the burrows they treated. The same 3 people applied cabbage bait for both the pre-baiting and treatment application. Only active burrows were treated. The control plots received untreated cabbage. When completed with each plot, 5 pinches of bait were weighed for each of the 3 people applying cabbage baits within the boundaries of the plots. This was used to determine the average amount of cabbage and rodenticide applied per burrow. Buffer zones were also treated. Baiting occurred from 7:00 a.m. to approximately 2:00 p.m.

Typically, post-treatment counts are conducted 3 days after treatment to ensure the ground squirrels have sufficient time to find and consume the treated cabbage. However, weather forecasts indicated a cold front and winter storm was approaching the area. We decided to shorten the waiting period by 1 day to allow post treatment counts to be finished before anticipated arrival of the storm on April 8th.

Post-treatment counts were conducted on April 5, 6, and 7, 2005. The methodology used for these counts was the same as the pre-treatment counts. Burrow activity measurements were also collected during this period. The counts and burrow activity measurements were also conducted by the same person at the same time and in the same sequence.

Count and burrow activity data were organized by treatment, and means and standard deviations were calculated. Percent changes of observed ground squirrels and their activity were computed for each treatment. No substantial changes were noted in the control treatments, and it was determined that calculating adjusted means was not necessary. Because of the relatively small sample size, it was determined that complex statistical analysis was not warranted. A schedule of field activities for the 2005 field test is provided in the Appendix.

RESULTS

Environmental conditions during the study reflected the typical unstable weather patterns common to the study area. Minimum 24-hour temperatures ranged from 8.10°F. to 31.80°F. Maximum 24-hour temperatures ranged from 36.80°F to 69.04°F. Precipitation occurred on 7 of the 15 days and ranged from 0.01 to 0.10 inches. Average 24-hour wind speeds ranged from 2.58 to 14.54 mph. Average 24-hour gusts ranged from 10.96 to 41.65 mph.

While traversing the plots to record burrow activity and rake the mounds, time was taken to look for non-target mortality. No mortality was noted. Non-target species observed in the area included numerous common ravens (*Corvus corax*), numerous species of raptors, several coyotes (*Canis latrans*), one badger (*Taxidea taxus*), and several black-tailed jackrabbits (*Lepus californicus)*.

Table 1 presents the number of burrows per plot and average amount of bait placed per burrow. Approximately 65% less burrows were treated in zinc phosphide study sites, because these plots had fewer burrows. The amount of bait applied per burrow is based on the average "pinch size" of the 3 bait applicators. The average bait applied per burrow ranged from 5.9 grams per burrow (first plot treated) to 13.3 grams per burrow (last plot treated). However, there was no

Table 1. Amount of cabbage bait placed per burrow in the various treatments.

Replication/Treatment	No. Burrows Treated	Cabbage Bait/Burrow (g)	Active Ingredient per Burrow (g)	Treatment Order
R1 Strychnine	324	9.356	0.0468	4
R2 Strychnine	700	12.474	0.0624	5
R3 Strychnine	228	9.639	0.0482	3
Mean	*417*	*10.490*	*0.0524*	-
Standard Deviation	-	*1.724*	*0.0086*	-
R1 Zinc Phosphide	173	13.325	0.1684	9
R2 Zinc Phosphide	324	9.639	0.1218	8
R3 Zinc Phosphide	306	7.655	0.0968	7
Mean	*268*	*10.206*	*0.1290*	-
Standard Deviation	-	*2.877*	*0.0364*	-
R1 Control	446	5.954	-	1
R2 Control	238	9.638	-	2
R3 Control	589	9.072	-	6
Mean	*424*	*8.222*	-	-

Standard Deviation	-	*1.984*	-	-

Table 2. Pre- and post-treatment application aboveground counts of ground squirrels in Diamond Valley, Nevada.

Treatment	R1			R2			R3			M	SD
	D1	D2	D3	D1	D2	D3	D1	D2	D3		
Pre-application											
Strychnine	15	17	20	23	23	24	28	30	30	24	5.4
Zinc Phosphide	14	23	24	20	20	16	15	19	21	20	3.5
Control	15	15	16	14	19	21	14	15	18	17	2.4
Post-application											
Strychnine	2	1	4	3	3	4	4	5	6	4	1.5
Zinc Phosphide	6	6	6	7	3	6	6	3	6	6	1.4
Control	20	14	17	20	14	20	18	16	16	18	2.4

Note: Number represents the number of individual animals counted during each counting period.
R = Replication; D = Day; M = Mean; SD = Standard Deviation

Table 3. Pre- and post-treatment application burrow activity of ground squirrels in Diamond Valley, Nevada.

Treatment	R1			R2			R3			M	SD
	D1	D2	D3	D1	D2	D3	D1	D2	D3		
Pre-application											
Strychnine	25	25	24	23	25	23	23	25	24	25	0.9
Zinc Phosphide	25	25	25	23	25	24	24	25	24	25	0.7
Control	25	25	25	24	23	23	22	22	25	24	1.3
Post-application											
Strychnine	2	4	2	4	3	3	3	2	2	3	0.8
Zinc Phosphide	5	5	5	8	5	5	5	4	5	6	1.1
Control	25	25	24	25	24	24	24	24	24	25	0.5

Note: Number represents the number of individual animals counted during each counting period.
R = Replication; D = Day; M = Mean; SD = Standard Deviation

trend of increasing bait weights over time. Burrows in strychnine and zinc phosphide treated plots received an average of 10.4 grams and 10.2 grams of bait, respectively. However, each of these treatment regimens had one plot that was treated substantially heavier than the other 2. Control plots were baited with an average of 8.2 grams of bait per burrow. Burrows in the strychnine and zinc phosphide treated plots received an average of 52.4 and 129.0 milligrams of active ingredient per burrow, respectively.

The number of ground squirrels observed aboveground in the strychnine and zinc phosphide treatment areas declined considerably, while the aboveground number observed in the control plots increased (Table 2).

The level of burrow activity was similar to the aboveground counts. Both rodenticides resulted in a decline of burrow activity while the control experienced an increase (Table 3). Table 4 presents the results in terms of percent reduction. Again, the rodenticide-treated areas decreased and the controls increased.

DISCUSSION AND CONCLUSIONS

The decline in the aboveground number of ground squirrels following application of the rodenticides appeared to be considerable, as did the decline in burrow activity. Strychnine may be more effective; however, zinc phosphide also yielded acceptable results. The slight increase in post-application squirrel numbers and burrow activity in the control plots did not appear to be significant.

Table 4. Percent change of ground squirrel activity by treatment in Diamond Valley, Nevada.

Treatment	Percent Change	
	Counts	Burrow
Strychnine	-83	-88
Zinc Phosphide	-70	-76
Control	+5	+4

The average amount of cabbage applied to burrows appeared to be fairly consistent. However, the difference between the highest dose and the lowest dose appeared to be substantial.

As noted earlier, both Richardson ground squirrels and Piute ground squirrels occur in the study area. No attempt was made to differentiate the species in either the aboveground counts or the burrow activity observations. Determining species accurately is difficult at long distances or when only a portion of the body is visible. Species specific susceptibility can not be determined from this study. However, it does seem likely that the rodenticides performed equally well on each species. Previous rodenticide efficacy studies in Diamond Valley have given similar results.

There were no non-target animals found dead after treatment. No dead ground squirrels were found in the zinc phosphide or control plots. Three dead ground squirrels were found above ground in strychnine plots.

The 2-day gap versus a 3-day gap in aboveground counts after treatment application had no noticeable impact on the efficacy of the rodenticides. The aboveground counts appeared fairly consistent; the same was true for the burrow activity observations. The presence of bait was noted in a field book, and by the third day no bait was observed. This was probably a combination of high bait acceptance by ground squirrels and desiccation of the cabbage, which may reduce its attractiveness to ground squirrels.

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Appendix

Schedule of Activities for the 2005 Field Test

Prior to Study, March 24 through 28, 2005

- Met with Rodent District Board to discuss study methods.
- Toured potential study sites again with rodent control officer.
- Received permission to use two farms.
- Pre-study aboveground counts.
- Established plot boundaries.

Day 1, March 29, 2005

- Staked and raked active mounds.

Day 2, March 30, 2005

- Prebaited plots and buffers.

Days 3-5, March 31 through April 2, 2005

- Pre-application above ground counts and measurement of burrow activity.

Day 6, April 3, 2005

- Applied treatments to plots and buffers.

Days 8-10, April 5 through April 7, 2005

- Post-application above ground counts and measurement of burrow activity. Removed stakes after last counts and measurements.