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EFFICACY AND COSTS OF FOUR RODENTICIDES FOR CONTROLLING COLUMBIAN GROUND SQUIRRELS IN WESTERN MONTANA

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ABSTRACT: Efficacy and costs of four rodenticides for the control of Columbian ground squirrels were compared in western Montana. Reductions in surface ground squirrel activity and costs per 100 burrows treated for the various treatments were: 1080 oat groats 99.6%-$3.11, gas cartridges 72.2%-$26.57, strychnine oats 64.2%-$3.06, zinc phosphide cabbage 60.9%-$8.48, zinc phosphide oats 41.3%-$3.15, and strychnine cabbage 14.4%-$9.58. Surface deaths associated with 1080 amounted to 2.35 ground squirrels per 100 burrows treated. Above ground death rates for the remaining treatments were negligible or nonexistent for both target and non-target species. One white-footed deer mouse was found dead on the strychnine cabbage treatment site. Results of this study indicate that 1080 is the most effective agent for the control of Columbian ground squirrels.

INTRODUCTION

Due to increasing populations, the Columbian ground squirrel (Spermophilus columbianus) has become one of the most economically harmful rodent species (causing about $800,000 damage in 1973) in western Montana (Seyler 1973). Most of the damage problems arise from competition with livestock for forage (Fitch 1948, Howard et al. 1959, Shaw 1921).

From 1948 to 1971, sodium monofluoroacetate (Compound 1080) grain bait was used to limit agricultural damage below the economic injury level (where damage to agricultural resources exceeds the cost of reducing or preventing the damage). In 1972, Compound 1080 became unavailable for application on federal lands. The Environmental Protection Agency then declared that 1080 was not registered for use in Montana. Since then, efforts to prevent agricultural damage with alternative rodenticides, mainly strychnine, have not yielded effective results. Bait efficacy tests conducted by the Montana Department of Livestock demonstrated insufficient control by strychnine grain bait (Record 1976).

OBJECTIVES

Primary objectives of this study were 1) to compare the efficacy of alternative rodenticides, namely, gas cartridges, and zinc phosphide and strychnine in both cabbage and grain bait forms, 2) to compare the cost effectiveness of these treatments, and 3) to monitor above ground mortality of target and non-target species.

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METHODS AND MATERIALS

Maximal activity periods for ground squirrel observability were determined for all study sites prior to the pre-treatment census. Ground squirrel activity was observed at the study sites for 3 days (13-15 July 1979) before poisoning (17-18 July 1979). Post-treatment census periods began on the second day after treatment.

During the morning activity period (0730-1030) counts were obtained at 3 consecutive 5-minute intervals using 10x35 binoculars. The largest number of squirrels observed was then recorded. The same procedure was repeated during the early evening activity period (1630-2030). Animals were counted at approximately the same time on each study site throughout the study. The arithmetic means of the maximum number of ground squirrels observed in each of the 6 pre-treatment counting sessions constituted the pre-treatment activity index. The post-treatment activity index was obtained by the same procedure.

Efficacy of the various rodenticides was evaluated by comparing the pre- and post-treatment activity indices for each study site in the following equation:

$$\text{PERCENT CONTROL} = 1 - \frac{\text{mean high count post-treatment}}{\text{mean high count pre-treatment}} \times 100$$

Strychnine-treated oats (0.5% active ingredient), zinc phosphide-treated oats (2.0% a.i.) and gas cartridges were obtained from the U.S. Fish and Wildlife Service Supply Depot, Pocatello, Idaho. The Kings County Department of Agriculture, California, formulated the 1080-treated oat groats (0.05% a.i.). Strychnine and zinc phosphide cabbage baits (0.29% and 0.8% a.i., respectively) were mixed on the study site immediately prior to application according to procedures outlined in Clark (1975).

Grain baits were scattered at burrow entrances utilizing a calibrated dipper at a rate of 6.25 g per burrow hole. Cabbage baits were applied at a rate of 1 handful (8-10 pieces of chopped cabbage) to each burrow entrance (O'Brien 1978). A single cartridge was placed in the main burrow entrance which was then plugged with dirt. All other burrow holes from which gas arose were sealed with dirt.

If a natural physiographic barrier did not exist for a study site, a buffer zone extending 136 m outward on all exposed sides of the site was also baited to retard immigration of ground squirrels from outside.

To monitor aboveground mortality of target and non-target species, thorough carcass searches were conducted on all treatment sites. Carcasses lying on the ground surface or visible in burrow entrances were counted.

Both temperature and wind velocity were stable throughout most observation periods. However, on 22 July, a light rain fell during the morning observation period at the gas cartridge treatment site. The rain tended to reduce ground squirrel activity aboveground. For statistical reasons, the mean of the previous 4 counts was substituted to avoid missing values in the data set.

STUDY AREA

Regional Description of Study Area

One problem area regarding Columbian ground squirrel damage to agricultural crops in western Montana includes a portion of the Clark Fork Valley between Clinton and Drummond (Fig. 1). Elevation varies from 1060 m in Clinton to 1215 m in Drummond (60 km distant). The area's agricultural land is a mixture of sprinkler irrigated hayfields and grain crops intermingled with open pastureland used for summer grazing. Populations of Columbian ground squirrels are found throughout the valley.

Selection of Specific Study Sites

The following criteria were used in the selection of specific study sites (Table 1): 1) The study site should be representative of agricultural land in the region in quality and quantity of vegetation present, 2) These sites should contain a ground squirrel population that approximates a maximum population density for the area, 3) The site should be relatively accessible but with some natural barriers to prevent immigration of ground squirrels, and 4) A site should be fully and clearly visible with binoculars or the naked eye for accurate counting of ground squirrels.

RESULTS

Table 2 shows the percent reduction in ground squirrel activity on the 7 treatment sites. A 3-way analysis of variance disclosed significant differences between pre- and post-treatment activity ($F=161.79$, d.f.=1/56, $P < 0.001$) and among treatment types ($F=7.693$, d.f.=6/56, $P < 0.001$). There was no significant difference in ground squirrel activity due to time of day (morning vs. evening) ($F=0.205$, d.f.=1/56, $P > 0.65$).

Duncan's Multiple Range Test was used to determine the means between which significant differences existed. It was found that the pre- and post-treatment activity means differed significantly ($P < 0.05$) from one another. Dunnett's multiple comparisons procedure was used to test the null hypothesis that no difference existed between the pre-treatment control mean count and the other pre-treatment mean counts (Dunnett 1955). No significant differences ($P > 0.05$) were found. The same procedure was repeated for the post-treatment data and all treatment mean counts were significantly different than the control mean count.

Since the strychnine cabbage site was overrun by cattle and irrigated by sprinklers during 5 of the pre-treatment census counts, reliable census data are not available. Census taking began on this site on 13 July. The only valid count obtained from this site consisted of 44 squirrels. Only 3 days earlier (10 July), counts of 53 and 52 animals were recorded using the same censusing scheme. These data, together with other visual observations of this site, indicated that at least 40 to 53 squirrels occupied the strychnine cabbage site. Assuming the mean of the maximum number observed is equal to 46.5 individuals, this would have produced a 14.4% decline in activity.

The cost of applying the rodenticides was based on payments of $4.00/hr. for labor, $0.66/kg for zinc phosphide oats, $0.85/kg for zinc phosphide cabbage, $1.28/kg for strychnine oats, $1.44/kg for strychnine cabbage, $0.82/kg

KEY

Δ = cabbage baits
■ = grain (oat) baits
● = control
▲ = gas cartridges

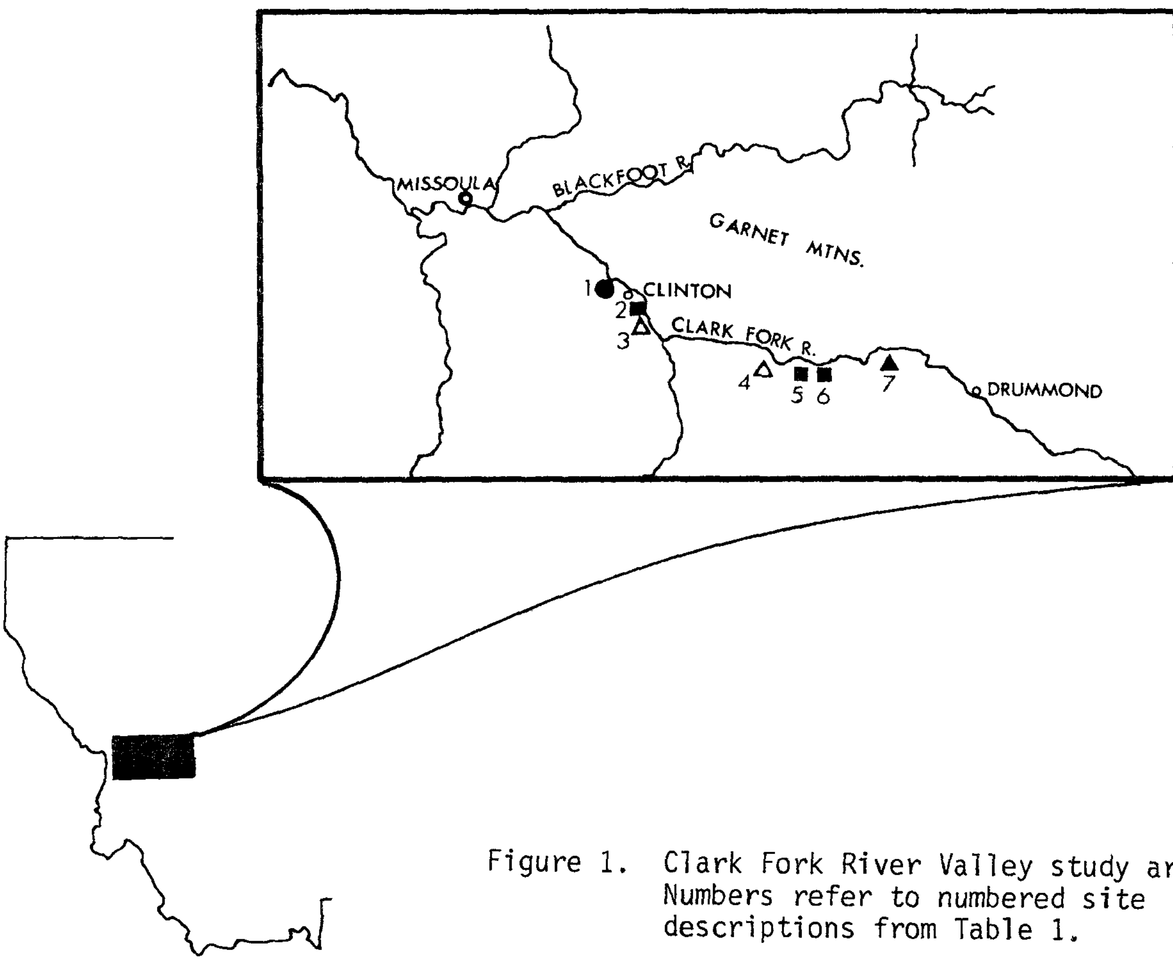

Figure 1. Clark Fork River Valley study area. Numbers refer to numbered site descriptions from Table 1.

Table 1. Description of individual study sites.

Site	Description	Sprinkler Irrigated	Size* (ha)	Bait Treatment
1	Alfalfa	No	1.34	None -- Control
2	Alfalfa	Yes	4.66	2.0% Zinc Phosphide Oats
3	Alfalfa	Yes	2.02	0.8% Zinc Phosphide Cabbage
4	Alfalfa	Yes	2.02	0.29% Strychnine Cabbage
5	Pasture	No	4.78	0.5% Strychnine Oats
6	Pasture	No	3.77	0.05% 1080 Oats
7	Pasture	Yes	2.02	Gas Cartridges

* Excludes surrounding buffer zone.

Table 2. Percentage reduction in ground squirrel activity based on visual census data.

Treatment	Pre-treatment			Post-treatment			
	Max. Counts	Mean	Std. Dev.	Max. Counts	Mean	Std. Dev.	Percent Decline
1080 Oats	6	54.0	12.9	6	0.2	0.4	99.6
Gas Cartridges	6	34.2	4.6	6	9.5	1.5	72.2
Strychnine Oats	6	45.5	4.6	6	16.3	3.9	64.2
Zinc Phosphide Cabbage	6	46.0	4.8	6	18.0	5.3	60.9
Zinc Phosphide Oats	6	46.0	9.2	6	27.0	3.8	41.3
Strychnine Cabbage	6	20.5*	13.2*	6	39.8	13.9	14.4*
Control	6	41.8	3.4	6	36.8	2.7	12.0

*Pre-treatment data is not representative of actual population density due to presence of livestock and operation of sprinkler system during 4 counting sessions. Percent decline was estimated on the basis of a pre-treatment mean of 46.5 instead of 20.5.

for 1080 oats, and $0.17/gas cartridge. Table 3 displays the results of a cost analysis performed on the basis of area. The average percentage of total cost attributed to labor was 72.1%, ranging from 52% to 87%. For the 3 grain baits, 81.5% of the total cost was accounted for by labor, while the cabbage baits required 60% for labor.

In the present study, the use of gas cartridges was the most expensive control method at $62.66/ha. This method proved to be very tedious, labor intensive and sometimes hazardous. Several people on the baiting crew reported burned fingers at the end of the day. There is also a potential fire hazard when treating holes surrounded or covered by dry shrubs during the fire season. Application of gas cartridges required 550% more man-hours per hectare than the average amount of labor necessary in the conventional hole-to-hole application of grain or cabbage.

Jameson (1958) reported that hand-baiting grain usually required 1.98 man-hours/ha. Labor requirements in this study averaged 1.36 man-hours/ha in the grain treatment sites against 4.14 man-hours/ha in the cabbage treatment sites. All hand baits combined averaged 1.93 man-hours/ha.

Table 4 discloses an alternative method of comparative cost analysis of the 6 treatments used in this study. Hand baiting costs depend on several variables including ground squirrel population densities, amounts of ground vegetation, terrain, and the quality and experience of the baiting crew. Consider the difference in burrow densities in Table 4 among the grain treatment sites (149.6-360.6). It would appear more logical to compare treatment costs on the basis of some factor other than area, which would eliminate the individual site-to-site variability. Cost per 100 holes baited accomplished this objective. By this method, gas cartridges remained the most expensive treatment at $26.57/100 holes. This method required more than 7 times the average labor required for grain baits and more than 3 times that of cabbage baits. Application costs of cabbage baits averaged $9.03/100 holes versus $3.11 for the grain baits, or 291% greater than the latter. The least expensive treatment type was strychnine oats, but all three grain treatments were similar in cost.

Target Species

The numbers of dead ground squirrels recovered above ground on each treatment site are presented in Table 5. Since population densities differed on each site, the number of surface deaths is expressed as per 100 holes baited as well as per hectare. Of the total number of dead squirrels, 75% were found within 48 hours following application of bait. Messner (1979) found 88.9% of the total number in the same time span.

The number of surface deaths associated with 1080 appears relatively high when compared to the other treatments. A linear regression analysis describing percent reduction of ground squirrel activity and number of carcasses found showed that a strong significant relationship ($r=0.904$, $P < 0.05$) exists. The number of 1080-associated surface deaths lay very close to the overall trend line. It is probable that had the other treatments in our study achieved a level of efficacy equivalent to that of 1080, surface deaths would have increased accordingly.

Table 3. Comparative cost analysis of 6 rodenticide treatments (per hectare basis).

Treatment	Hectares* Treated	Man-Hours	Man-Hours/ Hectare	Bait (kg)	Bait/ Hectare (kg)	Total Cost ($)	Cost/ Hectare ($)	Labor Cost (%)
Oats								
1080	12.35	12.0	0.97	11.48	0.93	57.41	4.65	83.6
Zinc Phosphide	10.93	15.0	1.37	13.59	1.24	68.97	6.31	87.0
Strychnine	6.88	14.0	2.03	15.50	2.25	75.84	11.02	73.8
Cabbage								
Zinc Phosphide	4.37	18.0	4.12	39.83	9.11	105.86	24.22	68.0
Strychnine	3.36	14.0	4.17	35.73	10.63	107.45	31.98	52.1
Other								
Gas Cartridges	4.13	44.0	10.65	487#	117.9#	258.79	62.66	68.0

*Includes surrounding buffer zone.

#Number of cartridges.

Table 4. Comparative cost analysis of 6 rodenticide treatments (per 100 hole basis).

Treatment	Hectares* Treated	No. Holes Treated	No. Holes/ Hectare	Man-Hours	Man-hours/ 100 Holes	Bait (kg)	Cost/ 100 Holes ($)
Oats							
Strychnine	6.88	2481	360.6	14.0	0.56	15.50	3.06
1080	12.35	1848	149.6	12.0	0.65	11.48	3.11
Zinc Phosphide	10.93	2187	200.1	15.0	0.69	13.59	3.15
Cabbage							
Zinc Phosphide	4.37	1248	285.6	18.0	1.44	39.83	8.48
Strychnine	3.36	1121	333.6	14.0	1.25	35.73	9.58
Other							
Gas Cartridge	4.13	974@	235.8	44.0	4.52	487#	26.57

*Includes surrounding buffer zone.

@Estimated number of holes.

#Number of cartridges.

Table 5. Numbers of Columbian ground squirrels found dead aboveground within 4 days after treatment.

Treatment	Plot Size* (ha)	No. Holes Baited	No. Found Dead	Dead/ Hectare	Dead/ 100 Holes
1080 Oats	3.77	511	12	3.19	2.35
Strychnine Oats	4.78	1160	6	1.26	0.52
Zinc Phosphide Cabbage	2.02	719	3	1.49	0.42
Zinc Phosphide Oats	4.66	1206	4	0.86	0.33
Gas Cartridges	2.02	450#	0	0.00	0.00
Strychnine Cabbage	2.02	738	0	0.00	0.00

*Excludes surrounding buffer zone.

#Estimated number of holes baited.

Non-target Species

Magpies were, at times, seen feeding on carcases but were not observed dead. The only known incident of non-target death occurred on the strychnine cabbage treatment site. Approximately 42 hours after bait was applied, one white-footed deer mouse (Peromyscus maniculatus) was found within 15 cm of a baiting spot.

DISCUSSION

A 90% reduction of a rodent population is the minimum acceptable level of control to reduce economic damage (Marsh 1967). Otherwise, the population can be expected to return to or exceed the original level within a single reproductive season. With a satisfactory reduction in ground squirrel numbers, baiting may not be required for 2-3 years. Thus, a reduction exceeding 90% will result in reduced environmental contamination, lower damage control costs to agriculturalists associated with ground squirrel control operations, and reduced hazards to non-target species.

Dana (1962) and Hegdal et al. (1978), working with California ground squirrels (S. beecheyi) in California, and O'Brien (1978), with Belding's ground squirrels (S. beldingii) in Nevada, reported an exceptionally high degree of effectiveness in controlling local ground squirrel populations with Compound 1080. Tietjen (1976) claimed 1080 to be the most efficient acute toxicant ever developed for control of field rodents.

Results of the present study tend to substantiate other reports of high efficacy levels attained using 1080 against Columbian ground squirrels in western Montana. Beebe (1947) and Bateman (1946) reported 100% reductions of ground squirrel numbers in the Whitefish River area, while Grand (1948) averaged 95-98% control in his studies. In field efficacy tests conducted by the Montana Department of Livestock, 95% and 99% reductions in ground squirrel densities were achieved on two separate test sites (Record 1976). These data offer clear evidence that 1080 grain bait was the most effective treatment for reducing Columbian ground squirrel populations in western Montana.

The 64% control obtained by using strychnine oats agrees with past efficacy tests conducted in western Montana. Record (1976) achieved 64-81% control with strychnine oats. Data obtained from the Flathead County Rodent Control Supervisor indicated that control averaged 70-75% (Montana Dept. of Livestock 1977). A number of explanations exist for the lack of more effective control by strychnine baits: 1) animals may become sick and stop feeding before a lethal dose is ingested (short latent period); 2) the bitter taste of strychnine alkaloid may be objectionable; and 3) strychnine is a "pouch" poison, that is, it is more potent when ingested through the cheek pouch linings than the walls of the gastro-intestinal tract. Because very little pouching has been observed in Columbian ground squirrels, this phenomenon may decrease strychnine's overall effectiveness.

Increased risks of environmental contamination due to various logistic problems associated with cabbage baits are evident. These risks include: 1) transportation of the technical product to the baiting site; 2) on-site mixing of bait; 3) care and disposal of contaminated mixing implements; and 4) human contamination during baiting and preparation. O'Brien (1978) reported having a light headache at the end of the day of baiting with zinc phosphide cabbage.

Hegdal et al. (1978), based on carcass searches for California ground squirrels conducted up to 14 days post-treatment with 1080 grain bait, reported 3.0 squirrels per hectare were found dead 1 to 2 days post-treatment, and 2.7 squirrels per hectare 14 days post-treatment. In a separate 1080 study conducted simultaneously with the present study but in the Blackfoot River drainage, 2.0 squirrels per hectare were found dead up to 3 days post-treatment (J.C. Malloy, pers. comm.). Based on Table 5, 3.2 squirrels per hectare were found dead on the 1080 study plot.

Since ground squirrel densities differ from site to site, comparisons should be more meaningful by relating numbers found dead to the amount of bait applied to burrows, or simply, the number of burrows baited. Accordingly, in Tulare County, California, Hegdal et al. (1978) found 1.36 squirrels (S. beecheyi) per 100 burrows using 0.075% 1080 versus 2.35 per 100 burrows in the present study.

LITERATURE CITED

BATEMAN, R.E. 1946. Annual Rodent Control Report. U.S. Dept. of Interior, Div. of Predator and Rodent Control, Billings, Montana.

BEEBE, E.K. 1947. Rodent report, May-July 1946, Western Montana District. U.S. Dept. of Interior, Div. of Predator and Rodent Control, Billings, Montana.

CLARK, D.O. 1975. Vertebrate Pest Control Handbook. California Dept. of Food and Agriculture.

DANA, R.H. 1962. Ground squirrel control in California. Proc. First Vertebrate Pest Control Conf., pp. 126-143.

DUNNETT, C.W. 1955. A multiple comparisons procedure for comparing several treatments with a control. J. Am. Stat. Assoc. 50:1096-1121.

FITCH, H.S. 1948. Ecology of the California ground squirrel on grazing lands. Amer. Midl. Nat. 39(3):513-596.

GRAND, E.F. 1948. Rodent Control Report. U.S. Dept. of Interior, Div. of Predator and Rodent Control, Billings, Montana.

HEGDAL, P.L., T.A. GATZ, K.A. FAGERSTONE, J.F. GLAHN, and G.H. MATSCHKE. 1978. Hazards to rabbits, seedeating birds, mammalian predators and raptors associated with 1080 baiting for California ground squirrels. Final report to EPA. EPA-IAG-D7-0449. 57 pp.

HOWARD, W.E., K.A. WAGNON, and J.R. BENTLEY. 1959. Competition between ground squirrels and cattle for range forage. J. Range Manage. 12(3):110-115.

JAMESON,E.W. 1958. Cost and effectiveness of controlling Microtus by zinc phosphide. J. Wildl. Manage. 22(1):100-103.

MARSH, R.E. 1967. Aircraft as a means of baiting ground squirrels. Proc. Third Vertebrate Pest Conf., San Francisco, CA, March 7-9, pp. 2-6, Publ. University of California, Davis.

MESSNER, J.J. 1979. Unpublished data.

MONTANA DEPARTMENT OF LIVESTOCK. 1977. Special local need registration application for sodium monofluoroacetate (Compound 1080) grain bait.

O'BRIEN, J. 1978. Chopped cabbage baits for ground squirrel control in Nevada. Proc. Eighth Vertebrate Pest Conf., Sacramento, CA, March 7-9 (W.E. Howard, ed.), pp. 25-27, Publ. University of California, Davis.

RECORD, C.R. 1976. A field evaluation of strychnine and sodium monofluoroacetate (Compound 1080) grain baits for Columbian ground squirrel (Spermophilus columbianus) control in Montana. Montana Dept. of Livestock report.

SEYLER, K. 1973. Rodent damage and control survey of 50 Montana counties, 1973. Montana Dept. of Livestock report.

SHAW, W.T. 1921. Washington's annual losses from ground squirrels. Wash. Agric. Exp. Sta. Pop. Bull., No. 99. 8 pp.

TIETJEN, H.P. 1976. Zinc phosphide - its development as a control agent for black-tailed prairie dogs. USDI, Fish and Wildlife Serv. Special Scientific Report - Wildlife, No. 195. 14 pp.