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Abstract: Mountain pocket gophers *(Thomomy's talpoides)* and plains pocket gophers (*Geomys bursarius*) are a problem to rangelands in Colorado. A new chlorophacinone (50 ppm) pelleted bait was applied to active burrow systems by hand baiting. Efficacy on the *Geomys* plot was 100%, while 94.73% of the *Thomomys* were controlled with the product.

Introduction

Pocket gophers, of the family Geomyidae, are indigenous to the western hemisphere from central Alberta to Panama (Turner et al. 1983). The mammalian group is represented by 8 genera, 30 species, and about 300 subspecies (Hall and Kelson 1959).

Of the 4 species of pocket gophers found in Colorado, the northern pocket gopher *(Thomomys talpoides) is* the principal species found on mountain rangelands. Others include the southern pocket gopher (*T. umbrunus),* plains pocket gopher *(Geomys bursarius)* and the yellow-faced pocket gopher *(Pappageomys castanops).* According to Hansen and Reid (1973), the 4 species are almost entirely allopatric in distribution, but in some areas, 2 species do overlap. Although interspecific intolerance is evident (Vaughan 1967), similar ecological requirements apparently prevents sympatric distribtuion and suggests intense interspecific competition (Miller 1964).

Pocket gophers *(Thomomys spp.)* are considered among the most serious problems in damaging conifer seedlings and hampering reforestation efforts in the western U.S. (Tunberg et al. 1984, Black 1970, Barnes 1973). As a result of pocket gophers feeding on seedling roots below ground surface, we have observed cases of up to 80% tree mortality in 1-year old planted tracts in Idaho. Government agencies, such as the U.S. Forest Service, are now required to contract for gopher control in clearcut or burned areas before planting seedlings. Failure to consider gopher control can often result in a waste of time and money paid to contractors.

On rangelands, pocket gophers play an important role in burrowing and pushing soil to the surface, thus promoting vertical cycling and mixing of soil constituents. Richens (1966) estimated that 75 gophers per hectare, an average on mountain rangelands, may move 38 tons of soil in one year. However, where abundant, gophers can cover up to one-fourth of the ground surface with mounds and castings in 1 year (Turner 1973). Grinnel (1923) observed, however, that coverage of 5-15% is more common. During the late summer and early fall, gophers tend to burrow more extensively in search of underground food During this time, caching of plants tends to increase and continues even after snowfall. Casting may cover more ground area than mounds.

A study on Grand Mesa, Colorado indicated that where gophers were controlled, ground cover increased about 20% prior to gopher reinvasion (Turner 1973). It is often difficult to detect the reduction of foilage an the ground surface due to gopher activity. However, the net result of too much gopher activity is the reduction of herbage available to livestock. Turner (1960) estimated that gophers reduced about 225 kg of herbage per hectare (about 209b). Studies in California demonstrated gopher potential for reducing herbage yields by 259:0 (923 kg per ha) over an 85-year period (Filch and Bently 1949). A study by Richens (1965) in Utah showed that gopher control in rangelands produced 568-680 kg more herbage per hectare than untreated plots.

Pocket Gopher Control

Although certain predators, such as coyotes (Cants *latrans)* and. badgers *(Taxidea* taxis), feed on pocket gophers the effect on populations is negligible. Other carnivores, including skunks *(Mephitis mephitis),* fox (Vulpes spp.], bobcat (fells rufus), house cats (f. domestical, and hawks and owls, feed on gophers but with minimal influence on gopher numbers.

Studies have shown that the application of 2,4-D herbicide on rangelands to kill forbs reduced gopher populations by as much as 909b. The objective of such a program is to remove the main food supply which will affect breeding and survival rates in pocket gophers. Tietjen (1973) discusses a U.S. Forest Service project in Colorado in which the herbicide was applied to several thousand hectares of rangeland. By elimination of primary forts, the main food of pocket gophers, the animals declined dramatically in numbers per unit area for several years after spraying. Tietjen et al. (1967) demonstrated in the laboratory that when gophers shift from forbs to grasses in the diet, the animals experienced a weight loss, therefore supporting the idea that forb removal does indeed effect pocket gopher numbers.

Fumigants are becoming a popular means of pocket gopher control (Table 1). The penetrating ability of gases within complex burrow systems is not very efficient, therefore. control over large plots becomes cost-prohibitive.

Repellents, such as Rotran, are often used and have been shown to protect buried cable for up to 6 years. More recently, cable companies are using steel armor or spaced wire basket protectors around the cable to protest them from gopher damage.

Pest control operators and land owners often use traps to remove gophers in smaller areas. The Macabee trap is most popular and can also be modified to collect live burrowing rodents (Poche et a1 1983).

Rodenticide baits are the most commonly used method today of reducing damage to tree seedlings and rangelands by pocket gophers. The application of strychnine-treated grain within burrow systems is currently considered to be the most effective method to control pocket gophers (Tunberg et aL 1984). Hand baiting or the use of burrow builders (for large areas) involves the placement of bait directly into the tunnel (gopher or artificial). Tunberg et al. (1984) also demonstrated that even if gophers are controlled effectively in a given area, other animals moved from adjacent habitat to occupy the empty burrow systems. Within 1 day after removal, new-gophers were observed to move into unoccupied burrows.

Pocket gopher control can be a difficult undertaking, depending on the time of year, control method used, species involved, amount of toxicant used, and the area to be controlled. Ticker (1983) reported on areas in California where pocket gopher numbers

Table 1. Pesticides federally registered to control pocket gophers (Jacobs 1983).

TOXICANTS	
Arsenic trioxide	1.5%, 2% dry bait
Chlorophacinone (ROZOL)	0.005% dry bait
Gophacide	0.1%, 0.2% dry bait; 95% technical
Strychnine Alkaloid	0.3-0.52% dry baits
Strychnine Sulfate	0.3-0.5% dry baits
Zinc Phosphide	2% dry baits
FUMIGANTS	
Aluminum Phosphate (Phostoxin)	55-57% Tablets or Pellets
Carbon Disulfide	100% Liquid
Carbon Tetrachloride	50% Liquid
Gas Cartridges	Various a.i.'s
Magnesium Phosphide (Magtoxin)	34-49.6% Tablets or Pellets
REPELLENTS	
R-55	11.2-21.9% Concentrate
Naphthalene	20% Granular
Para-Dichlorobenzene	20% Granular

exceeded 500 per hectare. In the same study, extensive testing over 3 years using EPA registered todenticides was completed and the resulting data is presented in Table 2. Compounds used included strychnine, zinc phosphide, diphacinone, chlorophacinone, and brodifacoum. The average control level ranged from 0-18%. These poor results indicate the degree of difficulty in reducing gopher numbers along with poor acceptance of the baits.

Since chlorophacinone baits in pellet and grain forms resulted in an average control of 0%, we organized a preliminary study to test a new pelleted formulation of Rozol bait. The objective of the study was to determine the acceptability and effectiveness of the new formulation when used for pocket gopher control.

Methods

Study Areas

A **Rozol** bait was tested against 2 species of pocket gophers in northern Colorado in April and May of 1985. The 2 species included the mountain pocket gopher (*Thomomys taipoides*) and the plains pocket gopher (*Geomys bursarius*).

The *Geomys* site was located 25 km east of Ft. Collins and 8.3 km southwest of Windsor at as elevation of 1525 m. The area was pastureland and was occasionally stocked with cattle. Due to heavy grazing pressure is the past from both prairie dogs and cattle, the vegetation was quite sparse and consisted largely of bunch grasses and annual forbs. About 6 hectares of 1 pasture was populated with pocket gophers, as evidenced by the abundance of push piles. However, at the time this study was begun, only about 1.6 hectares showed signs of fresh gopher activity (mound building?, so the study was restricted to this area. No other comparable populations could be found in the vicinity.

The Thomamys site was located 33 km west of Ft. Collies, near Stove Prairie, at an elevation of 2135 m. A number of meadows in this area were used for hay production. The vegetation consists of native grasses interspersed with some alfalfa. A 4-hectare section of 1 large meadow showed signs of extensive pocket gopher activity. The area occupied by the gophers extended from the meadow into the adjacent forested areas. The gopher mounds in the meadow cause considerable problems with machinery during haying operations.

Censusing

Censusing was done by locating burrows with a metal rod (2 cm diameter, 1-m long). When a burrow was located, it was dug open. The following day, each opened burrow was checked to note if pocket gophers had plugged the openings. This was done at both sites immediately before baiting and 10-13 days post-treatment.

At the Geomys site, active mound building was underway when the study began. Only burrow systems with fresh mounds were probed and opened. No other fresh mounds were found in the area after the study had begun, indicating that all of the active burrow systems in the area had been located. Active burrow systems in this area were discrete, and each burrow system was dug open at only one point.

Only several fresh mounds were found at the *Thomomys* site when the study began. Therefore, many burrows were located and dug open to assure adequate coverage for both censusing and baiting. In addition, much of the meadow area was uniformly covered with

Table 2. Comparison of rodenticides field tested to control pocket gophers (from Tickes 1983).

Chemical	Concentration	Bait	Average control (%)
Strychnine	.35	Milo	12
Strychnine	.30	Wheat	13
Strychnine	.50	Oats	5
Zinc Phosphide	1.82	Wheat	10
Zinc Phosphide	2.0	Pellets	22
Zinc Phosphide`	2.0	Cracked Corn	17.5
Diphacinone	.005	Nuggets	5
Diphacinone	.005	Nuggets	7.5
Chlorophacinone	.005	Wheat	0
Chlorophacinone	.005	Pellets	0
Brodifacoum	.005	Pellets	13
Brodifacoum	.005	Milo	17.5

Table 3. Results of the pre- and post-treatment indices and the efficacy calculations. The fraction represents the number of burrows plugged by gophers (numerator) out of the total number dug open the previous day (denominator).

SITE	PRE-TREATMENT CENSUS	POST-TREATMENT CENSUS	EFFICACY ($)
Geom s (baited)	15/21 (April 10)	0/21 (April 20)	100.00
Thomomys (baited)	38/95 (April 12)	2/95 (April 25)	94.73
Thomomys (control)	11/38 (April 12)	13/38 (April 25)	18.18

mounds from last year. Burrow systems were not particularly discernable and since there was almost no new mound building, it was not always possible to be sure that only 1 burrow per burrow system was dug open. In the forested periphery, burrow systems were generally more identifiable.

An irrigation ditch divided the gopher population into 2 units, 1 of 2.2 ha and 1 of 0.8 ha. Therefore, the larger area was treated with the bait, and the smaller, 0.8 ha. area, was used as a control.

Baiting

The new Rozol bait formulation contained 50 ppm chlorophacinone, vegetable and powdered components, and synthetic attractants manufactured as 4.7 mm (3/16-inch) diameter pellets. Baiting was done by probing with a metal rod and locating the tunnels which had been dug open the previous day for censusing, regardless of whether a burrow had been plugged by a gopher or not About 50 g of Rozol bait was poured into the burrow through the hole left by the probe. The probe hole was then plugged with a piece of sod. Sod was replaced over the burrows dug open the day before if a gopher had not already plugged them. In most cases, burrows were baited at 2 points with 50 g of bait at each.

Efficacy

The effectiveness of control was calculated using the number of burrows which had been plugged by gophers after having been opened by the investigators the previous day, in both pre- and post-treatment censuses. Efficacy was calculated with the following formula:

$$\text{Efficacy} = \frac{\text{No. Pre-treatment Holes Plugged} - \text{No. Post-treatment Holes Plugged}}{\text{No. Pre-treatment Holes Plugged}} \times 100$$

Results and Discussion

On the *Geomys* site, 2.10 kg of Rozol bait was used to treat 21 burrows and 9.5 kg of the product was used to bait 95 burrow systems on the *Thomomys* study area. Table 3 presents the pre- and post-treatment census data, and the results of the efficacy calculation for each site. The bait proved very effective on both sites, with a 100°la reduction in activity at the *Geomys* site and a 94.73% reduction at the *Thomomys* site. The fact that there was a slight increase in activity at the control site reflects an increase in activity among the gophers as the season progressed.

No dead pocket gophers were found above ground on the study areas. The almost exclusively fossorial habits of pocket gophers would cause the majority of mortality to occur underground.

Although the results of this study are preliminary in nature, they do reflect excellent pocket gopher acceptance of the new pelleted product Additional research is underway to examine pellet size and hardness, moisture resistant characteristics, durability, and chemical stability of the Rozol pellets over time. We are also looking into the feasibility of pellet

size of the bait in relation to hardness and its potential use in burrow building equipment. Since many western states, such as Colorado and Montana, have extensive pocket gopher infestations, mechanical applications of such baits may be the only potential solution.

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