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ABSTRACT: The effectiveness of bait and the effectiveness of operational baiting were both evaluated for controlling forest pocket gophers (*Thomomys* spp.) with strychnine oat groat bait and diphacinone paraffin block bait. Radio-telemetry monitoring and recovery of pocket gophers showed that control of individual pocket gophers 1 month after baiting was 72% for strychnine bait and 62% for diphacinone bait. Reduction in pocket gopher activity from operational baiting was based on censusing activity in sample plots. After 1 month the reduction in activity was 61% for strychnine oats and 36% for diphacinone blocks. Bait blocks implanted with radio transmitters were extensively moved and fed on by pocket gophers. Pocket gopher activity was not significantly reduced by either treatment 6 months or 1 year after baiting.

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INTRODUCTION

Pocket gophers continue to be a problem on National Forests and state and private lands, causing reforestation losses on hundreds of thousands of acres. Few control materials or methods for controlling forest pocket gopher damage are available. Reductions in pocket gopher abundance can be achieved for short time periods in some areas with strychnine grain bait (J. Evans and D. L. Campbell unpublished report, Denver Wildlife Research Center, 24 pp. 1989, Evans et al. 1990). Repeated treatments may be required within 1 year because of rapid reinvasion of burrow systems. Identification of active burrow systems for treatment is difficult during spring planting periods because gophers have not yet begun making fresh mounds. As a consequence, new tree seedlings may be heavily damaged even when rodenticide treatments are in use because the appropriate baiting sites cannot be easily recognized. In some sites in southern Oregon the application of strychnine treated oat bait was ineffective for reducing pocket gopher activity in reforestation units that had been previously baited (D.L. Campbell, J. Evans, and R. M. Engeman, unpublished report, Denver Wildlife Research Center, 6 pp. 1989).

Possible advantages of using toxicants in long-lasting, moisture-proof formulations have been considered for some time (Marsh and Plesse 1960, Tunberg et al. 1984) because rapid reinvasion of treated areas by these rodents is one of the key management difficulties. Earlier studies have examined such materials for control of pocket gophers in agricultural areas using paraffin bait formulations of diphacinone (Marsh 1987, Sullivan and Sullins 1987).

The present study was conducted to evaluate paraffin bait blocks containing 0.005% diphacinone conditionally registered by the Environmental Protection Agency (EPA) for J. T. Eaton and Co., Inc. in June 1989 (EPA Registration No. 56-57). Use of this material was compared with treatments using a 0.50% strychnine alkaloid oat groat bait formulation manufactured by ORCO, Inc., (EPA Registration No. 9691-8-5042 (OATS)) which has been widely used in pocket gopher control. Use of tradenames for identification purposes in this paper does not indicate any endorsement by the authors, the U. S. Department of Agriculture, or cooperating agencies. Radio-telemetry and monitoring of opened burrows and mound building by gophers were used in evaluations of pocket gopher activity for 1 year after baiting. The study was conducted on the Rogue River National Forest in southwestern Oregon with the assistance of Forest Service (FS) personnel.

METHODS AND MATERIALS

Study Area

Twelve reforestation units, (T36S, R3E & R4E WM), mainly shelterwood units in Cascade-mixed-conifer habitat with the overstory removed, were selected because of a history of pocket gopher damage to several species of conifers. Elevation of the study units was approximately 1,600m and ranged in size from about 4.8 ha to 14 ha. Slopes were gentle to moderate with soil and moisture conditions adequate for production of high quality large timber that existed adjacent to the units. Snow cover was normal in the area from November through March.

Telemetry and Bait Application

Bait treatments were applied to units selected randomly from those available. Four of these units also were chosen randomly to be studied with radio-telemetry. Transmitters weighing about 7g and numbered leg bands were attached to 13 pocket gophers (weighing about 72g) on each unit (except 1 unit which had transmitters on 14 pocket gophers) about a week prior to baiting in October 1990. Animals were monitored before baiting to assure activity, and for up to 2 months after baiting to monitor changes in activity and to recover carcasses and transmitters. Animals were live-trapped or kill-trapped to recover transmitters.

Pencil-type radio transmitters weighing about 6g were inserted into 31 paraffin diphacinone bait blocks with an average weight of 129g. The bait blocks, measuring (10.5cm x 4.5cm x 3cm) fit tightly into most burrows. Soil was placed behind the blocks to prevent entry of light. The movement and consumption of bait blocks was monitored and blocks or block fragments were recovered at the transmitter location.

Treated diphacinone blocks were dyed green; placebo blocks without diphacinone were dyed red.

All 12 units were baited similarly with either diphacinone treated or untreated bait blocks or strychnine treated or untreated oats. All bait was applied by APHIS and FS staff. Bait blocks were placed in at least 3 active burrows (with 1 or 2 blocks in each location) in each 0.027ha (9.3m radius) sample plot representing an active pocket gopher. One teaspoonful (3.36g) of green dyed oats, either strychnine treated or untreated, was placed in at least 5 burrows in each sample plot in those units. Bait was placed in active burrows that were at least lm apart. Active burrow systems throughout each unit were similarly baited.

Paraffin blocks and oat groat baits were placed inside wire mesh baskets inside burrows to monitor decomposition while being protected from rodents. These were examined at 1 month, 6 month, and 1 year intervals after baiting to determine their condition.

Determination of Activity

Indexing of pocket gopher activity in the fall of 1990 was made by opening 2 burrows in each sample plot and checking for plugged burrows after 48 hours. Twenty-five plots, each containing active burrow systems, were located on each unit baited. Each sample plot was spaced at least 30m apart and at least 30m from the outside edges of the units. Plot activity was determined about 3 days before baiting and 1 month after baiting. Activity in plots at 2 months after baiting could not be determined because of snow cover.

Gopher activity was again determined on the same plots about 6 months later, soon after snow melted in the spring of 1991. We used 3 burrows on each plot for these assessments because lack of mound building activity at this season made location of active burrows difficult. All mounds selected within sample plots were smoothed, then checked for activity in 48 hours. In these spring assessments, we used counts of soil casts in snow as a third indicator of overwinter activity by pocket gophers. Similar procedures, except for counting soil casts, were used in the fall of 1991.

Chemical Analysis

Assays were conducted on both diphacinone bait blocks and strychnine oat groat bait prior to baiting to determine rodenticide content. A triplicate assay for diphacinone by Hazelton Laboratories showed a mean value of 0.005% active ingredient. Assay of 2 batches of strychnine oat bait conducted by our colleagues at the Denver Wildlife Research Center showed values of 0.49 ± 0.03% and 0.47 ± 0.05% active ingredient.

Pocket gopher carcasses recovered from strychnine baited units were examined for strychnine residues. Before preparation of a carcass for analysis, the head and skin were removed to minimize contamination by uningested bait material. Suitable methods had not yet been developed for parallel study of diphacinone residue in gopher carcasses.

Carcass Searches

All 25 plots on each unit and areas between plots were searched for carcasses 1 to 2 days after baiting, and again at about 14, 28, and 56 days after baiting. Other checks were made during this period to determine the fate of animals with radio transmitters. Snow had covered the units by 56 days after baiting, limiting us to searches for radio-transmitters. Carcass searches were again made on the same areas in the spring and fall of 1991.

Data Analysis

Analysis of treatment effectiveness was based on the 3 blocks containing 1 unit of each treatment and 25 activity plots within each unit. Activity data were examined for 1 month, 6 months, and 1 year after baiting. Plots were considered inactive if all monitoring methods showed no activity. Determination of bait effectiveness was made by examination of radio-telemetry data from the 13 or 14 pocket gophers on each of the 4 units. Pocket gophers taken by predators were excluded from calculations in the radio-telemetry data.

RESULTS

Strychnine Bait

Results of radio-telemetry indicated that 72% (8 of 11 based upon activity, recovery of carcasses, and predation of at least 2 animals) were killed by treatment on the plots where strychnine oat groat baits were used. Most pocket gophers died within about 1 week after baiting. Six of 9 (66%) pocket gopher carcasses recovered from underground burrows or nests contained detectable strychnine residues. The amounts of strychnine in tissue assayed ranged from 0.15ppm (the limit of detection) to about 18ppm. One pocket gopher found dead above ground showed no detectable strychnine. Two other gophers recovered underground showed no detectable strychnine residues in tissue. Only the transmitters were recovered when animals were taken by predators.

Four pocket gophers, dead from unknown causes, were recovered after about 2 months from burrows or nests from plots where untreated oat bait was applied. Seven pocket gophers from these plots showed no detectable strychnine residues when the carcasses were examined.

Diphacinone Bait

Radio-telemetry data indicated that 61.5% (8 of 13 based upon activity, recovery of animals, and predation of at least 1 animal) of the pocket gophers were killed in diphacinone baited plots. One was located but not recovered from under large rocks. This animal had been active for about 20 days during monitoring and was calculated as a bait kill. All of the animals recovered were located in nests or burrows. Most pocket gophers died within 28 days, but did not appear to be affected by diphacinone before about 20 days after baiting.

Effectiveness of Operational Baiting

Reduction in pocket gopher activity 1 month after baiting, based on plugged burrows, showed considerable variation. The highest reduction in pocket gopher activity was 76% on the Biberstadt 2 unit (Table 1) which was baited with 0.50 strychnine treated oat groats. The highest reduction in activity was 44% on the West Rye Progeny 1 unit baited with the diphacinone bait blocks (Table 1). At the same time, gopher activity on the Barley West Rye 8 unit baited with untreated oat groats and the Willow Barley 9 unit baited with untreated paraffin blocks declined 29% and 24%, respectively (Table 1). Snow prevented determination of plot activity 2 months after treatment, but pocket gophers equipped with transmitters were recovered from as deep as 2m below the ground surface.

Table 1. Pocket gopher activity following treatments with four bait formulations in October 1990. Formulations were untreated paraffin bait blocks, paraffin bait blocks containing 0.005% diphacinone, untreated oat groats, and oat groats containing 0.50% strychnine alkaloid.

Block	Unit	Size (ha)	Bait (%)	Per Ha (kg)	Reduction in Activity 1 Mo (%)	6 Mo (%)	1 Yr (%)
1	[a]Vino 1, 2, 3	10.0	0.0 Diph	5.69	16.0	0.0	0.0
	Brandy 8	10.8	0.005 Diph	4.96	32.0	0.0	8.0
	Bar W Rye 8	14.0	0.0 Stry	0.14	29.0	16.0	0.0
	Bar W Rye 7	8.8	0.50 Stry	0.19	65.0	22.0	4.0
2	High Wap 1C	7.6	0.0 Diph	3.63	8.0	16.0	0.0
	High Wap 5	11.2	0.005 Diph	4.09	32.0	12.0	4.0
	High Wap 1A	12.0	0.0 Stry	0.08	16.0	4.0	12.0
	Biberstadt 2	13.6	0.50 Stry	0.16	76.0	20.0	4.0
3	Will Bar 9	5.2	0.0 Diph	7.15	24.0	0.0	0.0
	W Rye Pro 1	8.0	0.005 Diph	14.60	44.0	8.0	0.0
	Sec 33 South	4.8	0.0 Stry	0.25	4.0	0.0	0.0
	Sec 33 North	8.0	0.50 Stry	0.13	44.0	8.0	4.0

[a]Radio-telemetry was used for study of pocket gophers and bait blocks in this block of units.

Estimates of percent reductions in pocket gopher activity based on plugged burrows were generally lower than those based on telemetry data. This may have been caused by rapid reinvasion of sample plots despite the treatment of the entire units, or may reflect limitations in this method of assessing activity. Observations of radio-equipped gophers showed that some did not plug holes within 48 hours. In other plots pocket gophers with radio transmitters were found dead, but their opened burrows were plugged by other gophers.

Determination of over-winter pocket gopher activity about 6 months after baiting and immediately after snow melt, showed considerable activity on most units. Soil-casts were found on 69% (208 of 300) of the sample plots. Soil-casts were constructed in snow in 68% (51 of 75) of the test plots in strychnine baited units, and in 62.7% (47 of 75) of the test plots in the diphacinone baited units. Of the units baited with untreated oats, 74.7% (56 of 75) had soil-casts; 72% (54 of 75) of those baited with untreated blocks contained casts. The greatest reduction in activity was 22.0% on Barley West Rye 7—a unit baited with strychnine oat groats (Table 1). Few fresh mounds were made after snow melt by pocket gophers. For the 48 hour check during this period, only 3% (9 of 300) of the plots on all units had fresh mounds. During the same period, pocket gophers plugged opened burrows on 73% (218 of 300) of the plots. The fall activity check 12 months after baiting showed that nearly all plots (88 -100%) were occupied on all units regardless of bait treatment applied (Table 1).

Comparison of Treatments

Statistical comparison of pocket gopher activity associated with treatments showed significant reductions one month after baiting on plots treated with strychnine bait (61.33%) and diphacinone bait (36.00%) compared with untreated controls (Table 2).

In the spring, about 6 months after baiting, gopher activity was no longer significantly different among bait treatments (Table 2). At this period, the greatest mean reduction in activity was 16.00% for the strychnine baited units. Analysis for re-occupancy of plots showed that differences from pretreatment ($P < 0.05$). Ninety-five percent confidence intervals were calculated for mean percent re-occupancy and only the units treated with 0.50% strychnine bait produced confidence intervals that excluded 100%.

In October 1991, about 12 months after baiting, there were no significant differences among bait treatments (Table 2). There was no measurable reduction in activity caused by baiting the previous fall. Plot activity was 96% for both the 0.50% strychnine and 0.0% strychnine treated units. Plot activity for diphacinone bait units was also 96% and the control was 100%.

Table 2. Reduction of pocket gopher activity on sample plots in twelve baited forest units, at 1 month, 6 months, and 12 months after treatment

Treatment[a] (%)	Mean Reduction in Activity (%)[b] 1 Mo. (%)	6 Mo. (%)	12 Mo. (%)
0.0 Diphacinone	16.00 a	5.33 a	0.00 a
0.005 Diphacinone	36.00 b	6.67 a	4.00 a
0.0 Strychnine	16.22 a	6.76 a	4.05 a
0.50 Strychnine	61.33 c	16.00 a	4.00 a

[a]Each treatment was applied to 3 different forest units in October, 1990.

[b]Means with no letter in common are significantly different at $P < 0.05$.

Fate of Bait

Radio transmitters placed in paraffin bait blocks allowed tracking and recovery to determine their condition (Farley and Campbell 1991). About one-half of the 31 bait block transmitters and block material were recovered after about 25 days; the remainder were recovered after about 51 days. Five of the diphacinone block transmitters were recovered from burrows with no bait remaining on or near the transmitters. One transmitter, without a bait block, was recovered above ground. Six diphacinone treated blocks, with original weights averaging 134.8 ± 9.8g were partly eaten, with 65.2 ± 43g missing from each block. Diphacinone treated blocks and fragments recovered from a food cache and a burrow weighed 8.3g and 43.2g more, respectively, than when placed because parts of other blocks had been carried to the locations; 5 untreated blocks and fragments also weighed more when recovered. The condition of bait blocks varied considerably from remaining intact to being mushy and moldy, all within the same time period.

Bait blocks secured inside wire baskets remained intact to 1 year after placement, but generally became moldy. The condition of the diphacinone in the blocks was not determined. Most oat bait inside wire baskets sprouted within a month after placement. The seed coats were generally fragmented. The condition of strychnine on the seed coats was not determined.

Predators and Non-Target Hazards

Both mammalian and avian predators killed or scavenged pocket gophers on plots baited with both treated and untreated oat groats and paraffin bait blocks. At least 1 pocket gopher from a diphacinone bait block plot and 1 from a strychnine oat groat plot were apparently taken by mammalian predators; parts of these carcasses were recovered on the surface. Another pocket gopher from a plot baited with strychnine oats was carried about 400m by a bird. Two other gophers were apparently killed by birds and were recovered 57m and 73m from their normal locations. At least 3 pocket gophers from untreated oat bait plots were killed or eaten by predators. One of these was apparently taken by a bird and the transmitter was recovered 220m from the pocket gopher nest. Most losses to predators did not occur before about 1 month after baiting and predation did not appear to affect measurement of baiting effectiveness during this first assessment period, based on our observation of radio-equipped animals.

Unexplained mortality of 4 radio-equipped pocket gophers on plots treated with placebo oat groat bait occurred after 1 month; carcasses were recovered after about 2 months. The possibility that the 7g transmitters may make pocket gophers (averaging 74.5 ± 8.3g) more susceptible to predation should be determined. Only 2 of 52 radio transmitters were lost; 2 others became detached from pocket gophers. The only carcass other than those of gophers found during searches was a long-tailed weasel (*Mustela frenata*). This animal was recovered 21 days after baiting in the Biberstadt 2 unit which had been treated with 0.50% strychnine oat bait. No cause of death was evident and no methodology was available to examine the carcass for strychnine residues.

DISCUSSION

Evaluation of 2 bait formulations using radio-telemetry showed that both the strychnine oat groat bait and the diphacinone paraffin bait were effective in killing pocket gophers on test plots. About 72% of the radio-equipped gophers on the strychnine baited plots and about 62% of these on the diphacinone baited plots died following treatment.

Evaluation of operational baiting was conducted by assessing pocket gopher activity at 3 intervals after the October 1990 treatments. Plots baited with strychnine-treated oat groats showed reductions in pocket gopher activity averaging 61% at 1 month after baiting. Plots baited with diphacinone-treated paraffin bait blocks showed an average of 36% reduction in activity. No significant effects on reduction of pocket gopher activity on the plots were found 6 months or 12 months after treatment. Pocket gopher activity after 6 months was lower on strychnine baited units than on those baited with diphacinone, but the effect was not significant. Rapid reinvasion of treated plots by gophers from within and from outside the treated units was the probable explanation for these results.

There was considerable apparent activity of predators or scavengers on plots where radio transmitters were used to determine the mortality of pocket gophers. Although there was minimal predation on gophers during the first month after baiting, the increased losses later in the study suggested that the possible effects of transmitters on pocket gopher susceptibility to predation should be investigated.

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LITERATURE CITED

EVANS, J., G. H. MATSCHKE, D. L. CAMPBELL, P. L. HEGDAL, and R. M. ENGEMAN. 1990. Efficacy data for registration of strychnine grain baits to control pocket gophers (*Thomomys* spp.) In: Proc. 14th Vertebr. Pest Conf. (L. R. Davis and R. E. Marsh, Eds.), Univ. of Calif., Davis 14:82-86

FARLEY J. P., and D. L. CAMPBELL. 1991. Movement of radio transmittered paraffin diphacinone bait blocks by forest pocket gophers *(Thomomys* spp.) Northwest Sci., 65(2):71

MARSH, R. E. 1987. The role of anticoagulant rodenticides in pocket gopher control. In: Proceedings, Animal Damage Management in Pacific Northwest Forests. Spokane, WA pp 87-92

MARSH, R. E., and L. F. PLESSE. 1960. Semipermanent anticoagulant baits. The Bulletin. Calif. Dept. of Agric, Sacramento. 49(3): 195-197

SULLIVAN, O., and M. SULLINS. 1987. Use of diphacinone-treated bait blocks for control of the northern pocket gopher. Mont. Dept of Agric. Tech. Report 87-3. 5pp.

TUNBERG, A. D., W. E. HOWARD, and R. E. MARSH. 1984. A new concept in pocket gopher control. In: Proc. 11th Vertebr. Pest Conf. (D. O. Clark, Ed) Univ. of Calif., Davis, 11:7-16