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Efficacy of Brodifacoum Grain Bait on Plains Pocket Gophers

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Summary

We evaluated the efficacy of a new rodenticide, brodifacoum, for controlling the plains pocket gopher (*Geomys bursarius*). On four treated plots, we constructed parallel artificial burrows with a burrow builder, 20-23 cm below the surface, approximately 8 m apart. Approximately 2.6 g of bait were applied every 1.4 m, with about 928 bait spots per ha. We measured efficacy by both the open-hole technique which indicated 81% efficacy and radio telemetry which indicated 88% efficacy for the brodifacoum treatment. Thirty of 41 radioed pocket gophers were recovered dead. Four radio-equipped pocket gophers were known survivors; seven were either killed by predators or lost their radios post-treatment. The two efficacy values are similar to a published efficacy value for strychnine for the plains pocket gophers. Ninety percent of the radio-equipped gophers died below ground. Non-target mortality observed was limited to one vesper sparrow (*Pooecetes gramineus*); however, there were no specific efforts to evaluate non-target mortality.

I. Introduction

Strychnine baits have been ineffective in controlling populations of pocket gophers (*Thomomys* spp.) inhabiting irrigated alfalfa in Arizona (Tickes *et al.* 1982), California (T. Salmon, personal communication), Montana (Sullivan 1984), and New Mexico (C. Higgins, personal communication). At present, reasons for decreased effectiveness are unknown; however, because strychnine concentrations as high as 2.66% failed to achieve acceptable control, Tickes *et al.* (1982) speculates that gopher populations are becoming resistant to strychnine.

As part of the Denver Wildlife Research Center's continual efforts to develop new rodenticides, we had the opportunity to evaluate a relatively new anticoagulant, brodifacoum. Because it possesses acute rodenticide properties (Dubock & Kaukeinen 1978), we wanted to evaluate its potential for controlling pocket gophers. The objective of this study was to evaluate the efficacy of a 50 ppm brodifacoum grain bait applied underground for controlling populations of plains pocket gophers (*Geomys bursarius*).

II. Methods

Study Area

Efficacy of brodifacoum on pocket gophers was evaluated on the Sherburne National Wildlife Refuge in Sherburne County, Minnesota, where adequate populations of the gophers reside in old fields dominated mainly by mixed prairie grasses and forbs. Eight 11 ha study plots were established among these old fields, four treated and four control. Assignment of the four treated and four control plots was by random selection. Each plot was then divided equally into 11, one ha quadrants to assure the equal distribution of radio-equipped pocket gophers and active burrows needed for measuring efficacy.

Efficacy Estimators

(c) Radio-telemetry

We determined the fate of radio-equipped pocket gophers and monitored their activity post-treatment after brodifacoum treatment. On the four treated plots 50 gophers were live trapped using traps designed by and techniques outlined by Sargeant (1966), 13 on two plots and 12 on two plots. Each captured gopher was injected intramuscularly with ketamine hydrochloride, and equipped with a 164 MHz radio transmitter attached by a neck collar. After recovery from immobilization, gophers were released at the trap site. We attempted to locate the position of each radio-equipped pocket gopher daily. Post-treatment, if the gopher's underground position remained constant for two or three days, we dug to recover the gopher. Recovered dead gophers were weighed and their carcasses frozen for later necropsy and residue analysis.

We attempted to have one radio-equipped pocket gopher within each quadrant. Although traps were placed in each quadrant, gophers were not trapped in all quadrants. Among the 44 quadrants, we trapped zero, one, and two pocket gophers in each of seven, 24, and 13 quadrants, respectively.

Efficacy of treatment was estimated by the following formula:

$$\text{Percent Efficacy} = \frac{N - A}{N} \times 100$$

Where: N = number of pocket gophers with functional radios during post-treatment. A = number of radio-equipped pocket gophers with functional radios alive post-treatment.

After 21 days post-treatment, we set traps to recapture the surviving radio-equipped gophers. All gophers trapped, with or without radios, were collected, and frozen for later necropsy and residue analysis.

(d) Open-hole technique

The open-hole technique was the second method for evaluating brodifacoum treatment (Hansen & Ward 1966) by measuring changes between the pre- and post-treatment activity of gophers. Immediately before treatment on each treated and control plot, we marked 50 new ($<$24 h) pocket gopher mounds per plot, averaging 4.5 ± SE of 0.09 mounds per quadrant. At 21 days post-treatment (last day of treatment on each plot = day 1), we opened a burrow at each marked pocket gopher mound. At 24 and 48 h after opening the burrow, we recorded the number of burrows plugged with dirt, i.e. the number of active burrows. Wilcoxon rank sum test compared the difference in the number of active burrows between the treated and control plots (Hollander & Wolfe 1973).

Efficacy was estimated by the following formula:

$$\text{Percent reduction in pocket gopher activity} = 1 - \left[\frac{\text{Number of holes closed after 48h}}{\text{Number of holes opened x \% activity on control plot}} \right] \text{x } 100$$

(e) Bait Formulation

Brodifacoum, 3-(3-[4'-bromobiphenyl-4-yl]-1,2,3,4-tetrahydronaphth-1-yl)-4-hydroxycoumarin, at 50 ppm active ingredient by weight, was applied to whole milo grain in a concentrate form containing a solvent, stabilizer, and carrier (adhesive), propylene glycol. Rhodamine B (0.133%) was added as a marking agent for analysis of brodifacoum in the bait. Bait formulated for the control plots was the same except without brodifacoum. Treated and control baits were formulated on 13 July 1982. The bait proved to be 40.6 ppm when assayed by ICI Americas, Inc. (Koubek *et al.* 1979).

(f) Treatment

Bait was applied underground by an Elston's [a] gopher-getting machine, Minneapolis, Minnesota, trailer model, drawn by a tractor. This machine created an artificial burrow, approximately 5.1 cm in diameter, approximately 20 - 23 cm in depth and intersected with the burrows of the pocket gopher. When constructing the artificial burrow, approximately 2.6 g of bait was applied every 1.4 m or approximately 928 bait spots per ha. These artificial burrows were laid in parallel lines the length of the plot approximately 8 m apart. To prevent post-treatment reinvasion, we also treated a buffer zone around each plot where natural barriers were non-existent. The buffer zones, covering up to 24 m, were made by constructing one to three parallel, artificial burrows around the outside of the plot boundaries. Treatment began on the eight plots on 25 September and was ended on 4 October 1982.

Mortality of Target and Non-target Animals

Mortality among pocket gophers and non-target animals was recorded and all carcasses were collected, and frozen for later necropsy and residue analysis. No systematic searches were conducted; instead searching was conducted during radio-tracking and other research activity on the plots.

Necropsy

Frozen pocket gophers were shipped to ICI Americas, Inc., Goldsboro, North Carolina 27530. Then, all unputrefied gophers were weighed, skinned, necropsied, and the livers removed. After necropsy all unputrefied carcasses and livers were packaged separately, and refrozen for residue analysis. Putrefied carcasses were weighed, but not skinned or necropsied, and refrozen for residue analysis.

a. Reference to trade names does not imply endorsement by the U.S. Government.

Residue Analysis

The frozen gophers were then shipped to Analytical Biochemistry Laboratories, Inc., Columbia, Missouri 65205. All samples were analyzed using ICI Americas, Inc. high pressure liquid chromatographic technique developed by Koubek *et al.* (1979). The lower limit of detection was 0.10 ppm for the liver samples and 0.05 ppm brodifacoum for the carcass samples.

III. Results

Radio Telemetry

Mortality began among the 41 radio-equipped gophers with functional radios on the four treated plots following the brodifacoum treatment (radio contact was lost with nine radio-equipped pocket gophers during the pretreatment period). Thirty (73.1%) radio-equipped gophers were recovered dead post-treatment and all were collected, and frozen for later necropsy and residue analysis. Four (9.8%) pocket gophers were known survivors of the treatment at 23 days post-treatment, one on plot 1 and three on plot 4. Four (9.8%) lost their radios by slipping out of their collars and their fate was unknown. Predators killed three (7.3%). Efficacy of treatment was estimated at 88.2%.

Radio-equipped gophers were recovered dead as early as day 4 post-treatment, and mortality continued as late as day 22 post-treatment, $\bar{x}$ 12.3 ± 3.2 days. Three (10%) of the 30 radio-equipped gophers died on the surface, one each on plots one, three, and four. Twenty-six dead gophers were located at depths less than 1 m, $\bar{x}$ = 0.31 ± 0.03 m. One gopher was found dead at a depth of 1.2 m.

Open-Hole Technique

Among the four brodifacoum-treated plots, fewer burrows were plugged post-treatment by the gophers than on the four control plots. Of 200 burrows opened on the four treated plots, the gophers plugged 28 (14.0%) compared to 146 (73.0%) plugged on the four control plots, yielding an overall reduction in pocket gopher activity of 80.8% between the treated and control plots. The reduction in activity between treated and control plots was significant ($p = 0.014$).

While opening burrows at mounds that were marked pretreatment, on the four treated plots, the number of new mounds observed were related to the activity recorded on that plot. On plots two and three no new mounds were observed and only five burrows were plugged out of the 100 burrows opened. On plot 1 fresh mounds were observed in quadrants five and 11, and three of the six plugged mounds on the plot occurred in these two quadrants. On plot four active mounds were observed in quadrants three through six. Sixteen of the 17 burrows plugged occurred in these four quadrants.

Non-Radio-Equipped Pocket Gopher Mortality

Four non-radioed pocket gophers were found dead post-treatment on the surface. Three died on treated plot 2, and one on treated plot 1, and were found dead at 7, 7, 8, and 12 days post-treatment, respectively.

Brodifacoum residues in the livers of three pocket gophers were 8.2, 6.4 and 4.8 ppm, with corresponding brodifacoum levels in the carcasses of 0.82, 0.48, and 0.37 ppm, respectively.

Non-Target Mortality

Three dead non-target animals were found post-treatment. A masked shrew (*Sorex cinereus*) and a vesper sparrow were found dead on plots 2 and 3 on days 12 and 13, respectively. A red-tailed hawk (*Buteo* *jamaicensis*) was found dead 1.2 km from the nearest treated area, plot 4, on 18 October 1982, 44 days post-treatment. This bird probably had been carried by a predator, as evidenced by teeth marks on the carcass.

The sparrow probably died from the brodifacoum treatment, i.e. the concentration of 0.18 ppm brodifacoum and symptoms of anticoagulant poisoning observed at necropsy. The shrew's death was probably not related to the brodifacoum treatment because this animal is not a seed eater and the brodifacoum, if present, was below the level of detection. Unfortunately, the shrew was not necropsied. The cause of death for the hawk must remain unknown. Because of its dessicated state no necropsy was performed. Also this would indicate death at or before the time of brodifacoum treatment.

Necropsy

All pocket gophers that died post-treatment on treated plots and were necropsied showed one or both of the following: (1) free blood present either internally or externally or (2), hematomas present in the viscera or organs. On the other hand, five of 10 control gophers showed no bleeding. Of the five showing bleeding, three had free blood in the pericardium, one had blood on the nose and anus, and one had a hematoma (this gopher appeared to have been struck). Two pocket gophers trapped post-treatment on the treated plots showed no free blood or hematoma. Body weights of radio-equipped pocket gophers between time of capture and death showed that 48% of the gophers increased, whereas 52% decreased their weights.

Residue Analysis

Brodifacoum residues were present in 13 of 17 of the unputrified carcasses, but not detected in the putrified carcasses. In 12 of these 13 unputrified gophers, residues were recovered in both the carcass and liver, but one gopher had residues only in the liver. All gophers contained higher concentration of residues in the liver than the carcass. Mean brodifacoum residues values ± SE in the carcass and liver were 1.2 ± 0.25 ppm and 10.2 ± 2.79 ppm, respectively. No brodifacoum residues were found in either the carcass or liver of the remaining four unputrified gophers. However, when necropsied three gophers showed the classic symptoms of anticoagulant poisoning. The fourth animal showed some symptoms of anticoagulant poisoning; however, cause of death could not be determined. No brodifacoum (limit of determination 0.05 ppm) was detected in the 13 gophers that were putrified. Brodifacoum, if present, also was below the level of detection (<0.05) among nine control gophers collected away from the treated and control plots.

Among the four gophers dying on the surface, three were not putrified and contained residues in both the carcass ($\bar{x} = 0.56$ ppm ± 0.13 SE) and liver ($\bar{x} = 6.4$ ppm ± 0.98 SE). No brodifacoum (<0.05) was detected in the putrified fourth animal.

Of the surviving gophers that were trapped at 22 and 24 days post-treatment only one showed residue (0.39 ppm brodifacoum in the liver and 0.05 ppm in the carcass). The second gopher was radio-equipped from plot four and showed no detectable residue levels (limit of determination <0.05 ppm) of brodifacoum in the carcass or liver.

IV. Discussion

The anticoagulant brodifacoum, 40.6 ppm bait, effectively reduced populations of plains pocket gophers and should be considered for further development as an alternative to the acute toxicant strychnine for controlling these rodents. These results were within the range of the 87.5% reduction of plains pocket gophers following the underground application by a burrow builder machine of 1.4 kg/ha of a 0.50% strychnine bait also applied on the Sherburne National Wildlife Refuge in 1975 reported by Hegdal & Gatz (1976).

The overall efficacy of treatment was lowered primarily by survivors occurring on plot number four. Three of the four radio-equipped pocket gophers that survived treatment and 17 of the 28 burrows that were still active post-treatment occurred on this plot. These active burrows were not clumped, but 16 of the 17 occurred in four contiguous quadrants. Two of the four radio-equipped gophers inhabiting these four quadrants survived. This data suggest that there may have been a problem with the artificial burrow or with baiting in these four quadrants, although none was evident at the time of treatment.

Non-target mortality that we attribute to treatment was limited to a vesper sparrow. This bird probably died from feeding on the brodifacoum bait on the surface. This probably occurred when the burrow builder was removed to clear the debris buildup on the blade or when the machine was raised at the end of each burrow while moving.

The open-hole technique probably gave a lower efficacy estimate than actually occurred because of the 21-day lag between the marking and opening of the burrows. By 21 days post-treatment on the four control plots, we noticed little fresh activity within 3 m of any marked mounds. Gophers apparently had shifted their home range, evidenced by fresh mounds observed away from the pre-treatment marked mounds. Also, when we attempted digging into the marked mounds, many plugged burrows were found. The difference in the number of burrows plugged on the control plots 21 days post-treatment in our study and seven days post-treatment in Hegdal & Gatz's (1976) study was 11%. An 11% difference would have raised our efficacy estimate from 80.8 to 83.6%. In future studies with anticoagulant baits, we recommend one alternative to the open-hole technique: the plot-occupancy method for indicating pocket gopher abundance (Anthony & Barnes 1984).

The brodifacoum residue data suggest that in putrefied carcasses, the toxicant might have broken down to below the limit of detection (0.05 ppm) possibly by organisms involved in the putrefaction process. If this was the case, it could mean a reduced secondary poisoning potential to nontarget animals that consume the decomposing carcasses. Further research on this aspect is recomended, because putrefication may make the recovery of brodifacoum more difficult.

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