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BLACK-TAILED PRAIRIE DOG POPULATIONS ONE YEAR AFTER TREATMENT WITH RODENTICIDES

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Abstract.-Three rodenticide treatments, zinc phosphide with prebait, strychnine with prebait, and strychnine without prebait, were applied to black-tailed prairie dog (*Cynomys ludovicianus)* colonies in west central South Dakota. Results were compared immediately posttreatment and for one year after application. Zinc phosphide was the most effective for reducing prairie dog numbers immediately. When burrow activity levels of prairie dogs were initially reduced by 45% with strychnine only, they returned to untreated levels within ten months. When initial reductions were 95% with zinc phosphide, however, the number of active burrows was still reduced 77% in September the following year. Strychnine with prebait treatment showed initial reductions of 83% in burrow activity. Bait consumption by prairie dogs was highest for zinc phosphide.

Rodenticide-treated oats have been and are the primary tool for control of black-tailed prairie dogs *(Cynomys ludovicianus)* to prevent expansion of colonies on the plains. Widespread control programs for prairie dogs have been common on the Great Plains for over 100 years (Merriam 1902) and are still common practices (Schenbeck 1982). Strychnine, first introduced into the United States about 1847, has had varied success as a rodenticide (Crabtree 1962). The alkaloid form on grain was recommended by the U.S. Department of Agriculture at the beginning of the century. Two characteristics that may have impeded its acceptance by rodents are its bitter taste and the noxious effect of sublethal doses; attempts to circumvent these characteristics have failed. Strychnine also is considered hazardous to many nontarget species (Tietjen 1976a).

Zinc phosphide was introduced as a vertebrate pest-control agent in 1943 because of strychnine shortages during World War 11 (Crabtree 1962). However, use of zinc phosphide as a field rodenticide was limited until 1976, when it was developed specifically for black-tailed prairie dog control (Tietjen 1976a). Since then, zinc phosphide has been the only rodenticide federally approved for prairie dog control. Bioassays have shown that zinc phosphide causes no secondary poisoning of predatory or scavenging wildlife (Crabtree 1962, Tietjen 1976a).

The objectives of this study were to determine (1) seasonal activity of prairie dogs and (2) short- and long-term effects of zinc phosphide (with prebait), strychnine with prebait, and strychnine without prebait on prairie dog colonies during the one-year period following rodenticide application. Immediate effects of the three rodenticide treatments have been reported by Uresk et al. (1986).

STUDY AREA

The study was conducted in Badlands National Park and Buffalo Gap National Grassland in west central South Dakota. The climate is considered semiarid, with a 12-year average annual precipitation of 40 cm at the Cedar Pass Visitors Center, Badlands National Park. Approximately 80% of the total precipitation falls as thundershowers from April to September. Temperatures range from -5 C in January to 43 C in July, with an average annual temperature of 10 C.

Raymond and King (1976) described the soils on the study area as sedimentary deposits of clay, silt, gravel, and volcanic ash. Topographic features consist of rugged pinnacles, vegetated tabletop buttes, creek gullies, and grassland basins. Gently rolling grasslands in the northern portion of the study area ranged from 700 to 1,000 m in elevation.

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The vegetation comprises a mosaic of native grasses, forbs, shrubs, and isolated trees. Dominant grasses include blue grama *(Bouteloua gracilis)*, buffalograss *(Buchloe dactyloides)*, needleleaf sedge *(Carex eleocharis)*, and western wheatgrass *(Agropyron srnithii)* (Uresk 1984). Common forbs include scarlet mallow *(Sphaeralcea coccinea)*, American vetch *(Vicia americana)*, dogweed *(Dyssodia papposa)*, sage *(Salvia reflexa)*, and prairie sunflower *(Helianthus petiolaris)*. The dominant shrub is pasture sagebrush *(Artemisia frigida)*, and nonnative grasses include cheatgrass *(Bromus tectorum)* and Japanese chess *(B. japonicus)*.

Native herbivores inhabiting the Badlands region are the black-tailed prairie dog, mule deer *(Odocoileus hemionus)*, Rocky Mountain bighorn sheep *(Ovis canadensis)*, American bison *(Bison bison)*, pronghorn *(Antilocapra americana)*, black-tailed jackrabbit *(Lepus californicus)*, white-tailed jackrabbit *(L. townsendii)*, and eastern cottontail (*Sylvilagus floridanus)*. Small rodents include the deer mouse *(Peromyscus maniculatus)* and grasshopper mouse *(Onychomys leucogaster)*. Livestock are not present in the Park, but bison graze the area all year. Cattle are allowed to graze on the National Grassland for six months during the growing season each year.

METHODS

Eighteen sites on 15 prairie dog colonies were sampled in 1983 and 1984, with 9 designated as treatments sites and 9 as controls (Uresk et al. 1986). Sites were clustered into three major areas, one for each rodenticide treatment, containing three treatment and three control sites. Zinc phosphide was applied to the area within Badlands National Park because administrative restraints forbid the use of strychnine: four sites were clustered and paired on an approximately 600-ha prairie dog colony. The other two sites were located on prairie dog colonies northwest of the larger colony and northeast on a colony in the Buffalo Gap National Grassland. The other two treatments, strychnine with and without prebait, were randomly assigned to the two remaining major areas on the National Grassland. All treated and control sites were randomly assigned in the clusters. The area with prebaited strychnine was located in Conata Basin, and the area treated with strychnine only was located east and south of Scenic. All treatment and control sites were on isolated towns ranging from 12 to 283 ha. Within each treatment regime, treatment or control designation was assigned randomly except where administrative restrictions applied.

The open-burrow technique used to determine the effectiveness of the rodenticide treatments evaluated the number of active burrows (Tietjen and Matschke 1982). Burrow entrances in a 100 x 100-m area (1-ha) were filled (plugged) with soil to prevent egress/ingress by prairie dogs. Forty-eight hours later the reopened burrows large enough for prairie dogs to pass through were counted. Burrow activity for pretreatment periods was recorded in June, July, and early September 1983. Posttreatment counts were taken in late September 1983 (four days after poisoning) and in June, July, August, and early September 1984.

Treated and untreated steam-rolled oats were obtained from the U.S. Fish and Wildlife Service (USFWS), Pocatello Idaho Supply Depot. Poisons were applied in the field, in accordance with federal label instructions, when proper environmental conditions existed to insure optimum consumption of oats by prairie dogs (Tietjen 1976a, 1976b, Tietjen and Matschke 1982). Untreated oats (prebait) and the poisoned oats were applied on large areas from 3-wheel-drive, all-terrain cycles fitted with bait dispensers (Schenbeck 1982), and by hand with teaspoons on smaller areas.

At the six sites requiring prebaiting, 4 g of high-quality, untreated steam-rolled oats was applied as prebait at a minimum of 95% of the burrows. Three sites were prebaited on 20 and 21 September 1983. Prebait was applied (<0.01-m area) at the edges of prairie dog mounds.

Prebaited areas were examined before poisoned oat treatment to assure that the prebait was consumed by prairie dogs. Three days after prebait application (22 September 1983), three sites were treated with 4 g of 2.0% active zinc phosphide steam-rolled oats. Three additional sites were treated with 8 g of 0.5% strychnine alkaloid steam-rolled oats per burrow on 23 September 1983. The last three

TABLE 1. Average number of black-tailed prairie dog burrows/ha, active burrows/ha, and percent active burrows/ha (± standard error of the mean) on untreated areas for four sampling periods in 1983 and 1984 in west central South Dakota.

Sampling period	Total burrows/ha	Number active/ha	Percent active
1983			
June[a]	**121 ± 9**	**98 ± 8**	**81 ± 3**
July[a]	**117 ± 9**	**87 ± 8**	**74 ± 3**
Early September[a]	**113 ± 8**	**48 ± 5**	**43 ± 3**
Late September[b]	**104 ± 13**	**34 ± 4**	**35 ± 4**
1984[b]			
June	**103 ± 13**	**82 ± 12**	**77 ± 4**
July	**103 ± 14**	**66 ± 10**	**64 ± 3**
August	**97 ± 15**	**54 ± 11**	**55 ± 4**
Early September	**86 ± 15**	**66 ± 13**	**75 ± 3**

[a] n = 18 sites.
[b] n = 9 sites.

sites, which were not prebaited, were treated with strychnine oats on 24 September 1983. Three days after application the percentage of poisoned oats remaining on each burrow in a 1-ha grid on each treated site was estimated visually.

Statistical Evaluation

Analysis of covariance was used to compare each treated group (cluster) of sites with its respective control group. Applications of repeated measures were examined but required constant response through time—no interaction between time and treatment. These data did not show a constant response through time and had interactions; therefore, we used covariance adjustments. Pretreatment observations were used as covariates. Effect of rodenticide treatment for each time point was estimated as the covariance-adjusted difference between treated and control sites for each rodenticide. After obtaining an overall rejection of the hypothesis of no treatment effect, contrasts for each rodenticide treatment were evaluated for significance based on a variance estimated only from the sites in each cluster (because variance was heterogeneous among clusters). If the correlation between pretreatment and posttreatment observations was not significant ($\leq .20$), then the change was estimated as posttreatment minus pretreatment observation (repeated measures). This analysis uses the interaction between time and treatment as the indicator of a significant change due to treatment (Green 1979). Rodenticides were compared by forming pairwise contrasts of the contrasts obtained for the individual rodenticide treatments. Randomization procedures (Edgington 1980, Romesburg 1981) based on 10,000 random permutations of the data pairs among treatment groups were used to estimate statistical significance of the various contrasts.

Because omission of any effect due to poisoning was considered more serious than the potential incorrect declaration of a significant treatment effect, Type 11 error protection was produced by testing each contrast individually. However, some Type I error protection was afforded by testing individual contrasts only after first observing a significant ($P = .10$) overall test of treatment differences using analysis of covariance (Carmer and Swanson 1973). Individual contrasts were considered biologically significant at $P = .20$. Although admittedly unconventional for the number of sites available for study, this significance criterion produces a power (probability of detecting a true difference) of approximately 0.80 for a contrast twice as large as its standard error. This was considered a reasonable combination of Type I and Type 11 error protection for this study (Carmer 1976).

RESULTS

Prairie dog burrow activity declined during the summer months both years (Table 1). In June 1983 the number of active burrows was high (81%) and decreased steadily until late September, when 35% of the burrows were active. In June 1984 activity of prairie dog burrows was high (77%) and decreased through July and August, but increased to 75% in September.

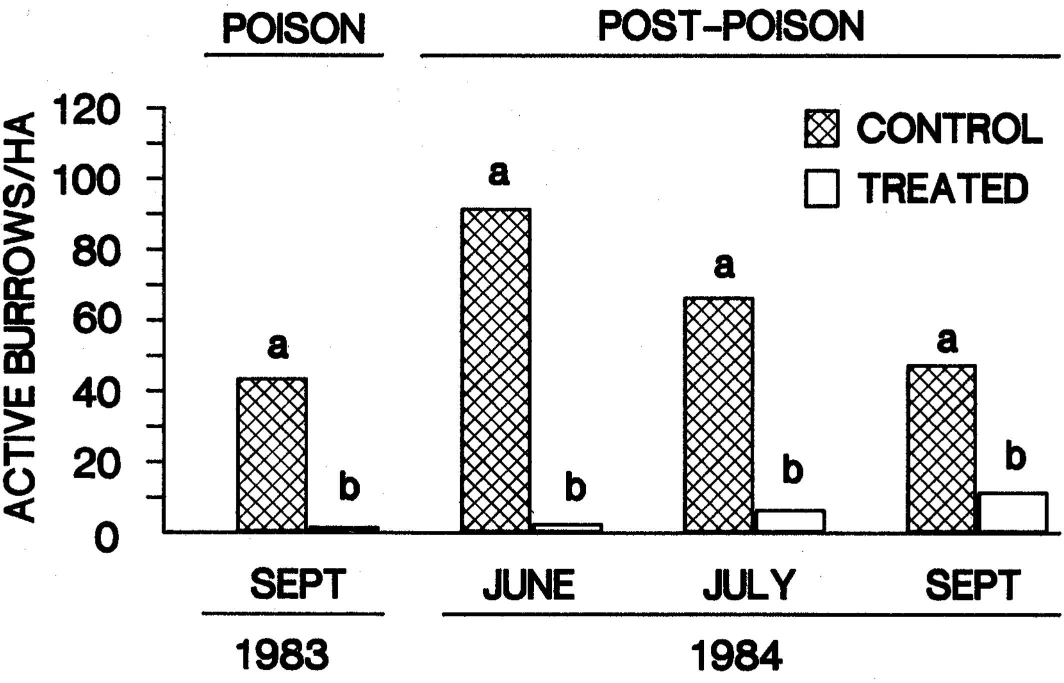

Fig. 1. Seasonal comparisons of active black-tailed prairie dog burrows on zinc phosphide-treated and control sites from initial treatment in September 1983 through September 1984. Means followed by the same letter by date are not significant at $\alpha = .20$ after F-protection at $\alpha = .10$ using analysis of covariance. (Data on September 1983 for initial poison are adapted from Uresk et al. 1986.)

In September 1983, immediately after treatment with zinc phosphide, the number of active prairie dog burrows was reduced 95% from the number on the 76 control sites ($P = .017$, Fig. 1). The reduction in the number of active burrows was maintained (96%) in June 1984 ($P = .002$). Reductions of active burrows in July and September were 92% and 77%, respectively ($P = .006$ and $.014$, respectively).

Treatment with strychnine only immediately reduced active burrows by 45% ($P = .164$, Fig. 2). In June 1984 active burrows on the treated sites remained 45% below the strychnine control sites ($P = .177$). By July, however, the number of active burrows on the treated sites was not different from the control sites ($P = .706$). The treated and control sites also showed similar burrow activity levels in September ($P = .637$).

Treatment with prebaited strychnine immediately reduced the number of active burrows by 83% ($P = .035$, Fig. 3). Burrow activity remained 85% below controls ($P = .019$) in June 1984. This reduced level of prairie dog activity compared with controls reached 99% in July and 95% in September 1984 ($P = .083$ and $.057$, respectively).

A comparison of the effectiveness of rodenticide treatments at initial poisoning of prairie dogs in 1983 showed that number of active burrows was reduced more with zinc phosphide than with strychnine alone ($P = .034$, Table 2). Burrow counts in June 1984 showed that towns with zinc phosphide treatment had fewer ($P = .006$) active burrows than those with strychnine only treatment. Similar results continued through July ($P = .035$) and September ($P = .039$) 1984.

Zinc phosphide had a greater initial effect than prebaited strychnine in reducing numbers of active burrows ($P = .075$, Table 2). There were no differences between the effects of the two rodenticides by 1984, however ($P = .20$).

When the two strychnine treatments were compared, reduction in active burrows was not different ($P = .391$) in September 1983 (Table 2). Strychnine compared with prebaited strychnine treatment in June 1984 showed a significant difference of 60 more

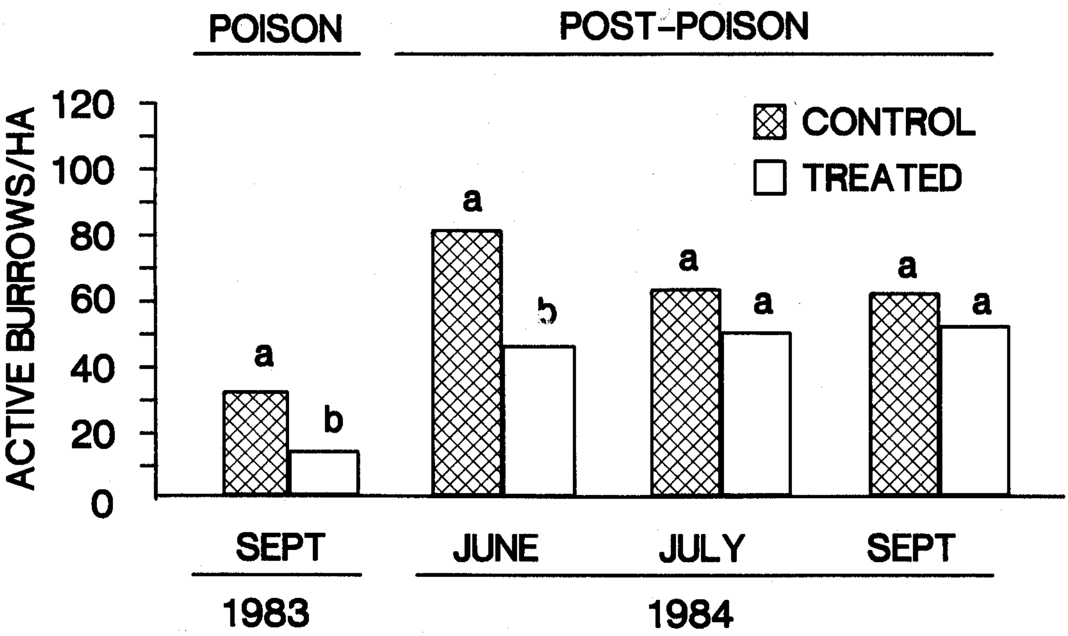

Fig. 2. Seasonal comparisons of active black-tailed prairie dog burrows on strychnine-only-treated and control sites from initial treatment in September 1983 through September 1984. Means followed by the same letter by date are not significant at $\alpha = .20$ after F-protection at $\alpha = .10$ using analysis of covariance. (Data on September 1983 for initial poison are adapted from Uresk et al. 1986.)

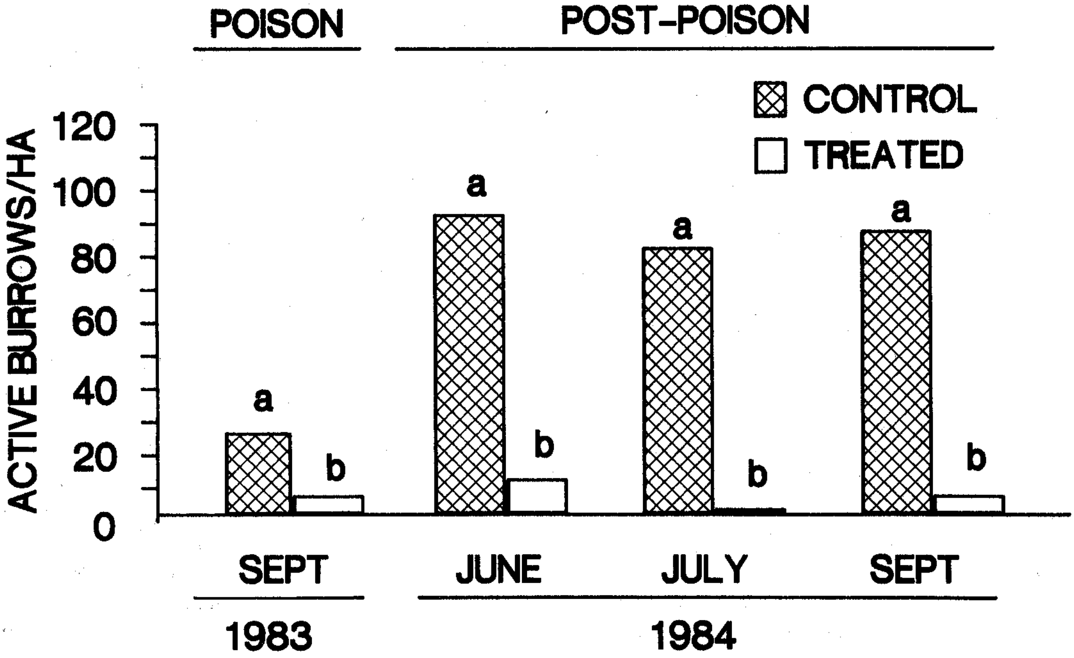

Fig. 3. Seasonal comparisons of active black-tailed prairie dog burrows on prebaited strychnine-treated and control sites from initial treatment in September 1983 through September 1984. Means followed by the same letter by date are not significant at $\alpha = .20$ after F-protection at $\alpha = .10$ using analysis of covariance. (Data on September 1983 for initial poison are adapted from Uresk et al. 1986.)

TABLE 2. Effectiveness of black-tailed prairie dog control with zinc phosphide (ZnP)compared with strychnine without prebait (S-9)and strychnine with prebait (PS-9), and strychnine without prebait compared with strychnine with prebait through time (active burrows/ha ± SE).

	Zinc phosphide versus strychnine only and prebaited strychnine								Strychnine only versus prebaited strychnine			
Period	ZnP[a]	S-9[a]	Main effect[b]	Signif[c]	ZnP[a]	PS-9[a]	Main effect[b]	Signif[c]	S-9[a]	PS-9[a]	Main effect[b]	Signif[c]
1983												
Sept	−45±9	−14± 8	−31±15	0.034	−45±9	-23± 6	−22±16	0.075	−14± 8	−23± 6	9±11	0.391
1984												
June	−86±2	−22±12	−64± 9	0.006	−86±2	−82±13	− 4± 9	0.872	−22±12	−82±13	60± 5	0.029
July	−59±1	10± 6	−69±7	0.035	−59±1	−67±32	9±33	0.775	10±6	−68±32	78±26	0.078
Sept	−42±4	− 7 ± 8	−38±10	0.039	−42±4	-77±28	−33±31	0.358	- 7± 8	-77±28	69±26	0.062

[a] Effect adjusted using analysis of covariance.

[b] Main effect calculated by difference of poisons.

[c] Probabilities calculated for contrasts in randomization test (a = .20)based on variance heterogeneity after a significant F-protection at $\alpha = .10$ by analysis of covariance.

active burrows ($P = .029$) .Similar results continued throughout 1984 in July ($P = .078$) and September ($P = .062$).

Four days after treatment, prairie dogs had consumed more zinc phosphide than strychnine ($P = .036$)or prebaited strychnine ($P = .012$).Prairie dogs consumed 72 ±7% (± SE) of the poisoned oats on burrows treated with zinc phosphide. Of oats treated with strychnine and prebaited strychnine, 16 ± 2% and 8 ± 1% were consumed, respectively.

DISCUSSION

Densities of black-tailed prairie dog burrows on our study areas were similar to those reported earlier for South Dakota and other western states (Bailey 1926, Koford 1958, Uresk et al. 1982, O'Meilia et al. 1982, Uresk and Bjugstad 1983). Activity levels of prairie dogs have not been reported in the literature but are greatest in the spring when young-of-the-year become active. However, by fall many prairie dogs leave their towns, resulting in a reduction in burrow activity.

Prairie dogs were reduced most effectively with the zinc phosphide treatment. The level of reduction in active burrows achieved with zinc phosphide in the fall of 1983 was maintained through September 1984. Tietjen (1967a), Knowles (1982), and Tietjen and Matschke (1982) reported similar levels of reduction with zinc phosphide immediately after poison application. When strychnine only was applied, burrow activity was moderately reduced, but recruitment of prairie dogs increased the number of active burrows to precontrol levels by the following summer. The strychnine application with prebait reduced burrow activity in 1983 more than strychnine only and maintained reduced populations through September 1984.

The level of prairie dog reductions achieved with the zinc phosphide and strychnine with prebait treatments allowed minimal prairie dog recovery on towns, while reductions in prairie dog activity with strychnine alone were inconsistent. Knowles (1982)stated that the intrinsic rate of growth for prairie dogs in poisoned colonies was higher than normal. Prairie dog colonies with complete control required five years or more to return to precontrol densities. However, when a colony was partially treated, precontrol densities returned in two years. More bait remained on the prairie dog mounds after poisoning with strychnine than on mounds treated with zinc phosphide. Crabtree (1962) related prairie dog consumption of oats treated with rodenticides to the “taste factor” that accompanies strychnine and zinc phosphide and the time factor involved before there is a toxic reaction after poison consumption. Prebait is applied to increase the acceptance of a foreign food (grain bait); however, prairie dogs do not consume large amounts of strychnine because of its bitter taste and fast toxic reaction (5–20 minutes, Crabtree 1962). Rodents are attracted to the strong, pungent, phosphorus-like odor of zinc phosphide, and the toxic reaction is slower (Crabtree 1962), thus allowing more consumption of grain.

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