EFFECTS OF BLACK-TAILED PRAIRIE DOGS ON REPTILES AND AMPHIBIANS IN KANSAS SHORTGRASS PRAIRIE

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ABSTRACT—Species diversity and abundance of reptiles and amphibians were measured on and off black-tailed prairie dog (Cynomys ludovicianus) colonies to determine the extent to which herpetological species composition in a shortgrass prairie ecosystem is affected by presence of black-tailed prairie dog colonies. Ten species of reptiles and 3 species of amphibians were captured. Total amphibian and reptile abundance did not differ between prairie dog colonies and non-colonized shortgrass prairie sites, but species composition did. Mean species richness, evenness, and diversity for reptiles and amphibians were not different between treatments; however, diversity of both treatments combined was considerably higher than diversity on shortgrass prairie without prairie dogs. The mosaic pattern of prairie dog colonies enhances landscape heterogeneity and contributes to greater reptile and amphibian diversity in the shortgrass prairie biome of western Kansas.

RESUMEN—Se midieron la diversidad y la abundancia de los reptiles y anfibios dentro y fuera de colonias de perritos llaneros de cola negra (Cynomys ludovicianus) para determinar hasta qué punto la presencia de las colonias influye en las especies de herpetológicas en un ecosistema de hierba corta. Diez especies de reptiles y tres de anfibios fueron capturadas. La abundancia total de estos animales fue igual dentro de las colonias como en los sitios no colonizados, pero la composición de las especies fue diferente. El promedio de la riqueza, la diversidad, y el emparejamiento de las especies herpetológicas no diferó entre los tratamientos. Sin embargo, hubo mayor diversidad en ambos tratamientos combinados que en pradera de hierba corta sin perritos llaneros. El patrón mosaico de las colonias de perritos llaneros aumenta la heterogeneidad del paisaje y contribuye a una diversidad más amplia de reptiles y anfibios en el ecosistema de hierba corta en el oeste de Kansas.

Prior to European settlement, prairie dogs (Cynomys) were among the most numerous and widespread herbivores on North American grasslands. However, abundance and distribution of the 5 species of prairie dogs have been reduced dramatically over the past century (Summer and Linder, 1978; Miller et al., 1990). In 1902, there were an estimated 810,000 ha of black-tailed prairie dog (C. ludovicianus) colonies in Kansas (Lantz, 1903). During the period 1990 to 1992, black-tailed prairie dogs in Kansas covered only 18,843 ha, a reduction of approximately 98% from the original distribution (Vanderhoff et al., 1994). The area represented less than 0.5% of non-cultivated farmland and rangeland in Kansas (Clements, 1990). Reduction of prairie dog colonies has come about largely as a result of government-supported eradication programs, habitat destruction, and disease (Cully, 1993; Miller et al., 1994).

Black-tailed prairie dogs are capable of dramatically altering vegetation communities of grasslands that they occupy (Koford, 1958; Bonham and Lerwick, 1976; Coppock et al., 1983; Agnew et al., 1986; Archer et al., 1987; Weltzin et al., 1997). In mixed-grass prairies, prairie dog colonies also influence species composition and densities of mammals, birds, arthropods, and soil nematodes (O’Meilia et al., 1982; Ingham and Detling, 1984; Agnew et al., 1986). Although many studies in mixed-grass prairies have identified large numbers of animal and plant species in prairie dog colonies, there has been little work to identify the degree to which prairie species are dependent
on presence of black-tailed prairie dogs (Stapp, 1998; Winter, 1999). This has led to concern that the tremendous reduction in abundance and distribution of prairie dogs over the last century has put a portion of the biotic diversity of the shortgrass prairie at risk.

Grazing, fire, logging, and other ecological disturbances alter abundance and diversity of reptiles and amphibians in a wide variety of habitats (Jones, 1981; Ballinger and Jones, 1985; Mushinsky, 1985; Lunney et al., 1991; Greenberg et al., 1994; Ballinger and Watts, 1995). However, there is a paucity of information regarding herpetological communities in shortgrass prairies, and little more than anecdotal reports and faunal surveys exist regarding response of reptiles and amphibians to habitat modifications by prairie dogs (Klauber, 1982; Collins and Collins, 1991; Collins, 1993). We suggest that habitat modifications caused by black-tailed prairie dogs in shortgrass prairie will favor a different suite of reptile and amphibian species than that found on unmodified prairie. Furthermore, the habitat mosaic of colonies on the prairie should yield increased diversity over shortgrass prairie habitat without prairie dogs. The purpose of this research was to determine the extent to which herpetological species composition in a shortgrass prairie ecosystem is affected by presence of black-tailed prairie dogs.

Methods and Materials—Study Area—Study sites were established on the Cimarron National Grassland in Morton Co., Kansas (37°7'30"N, 102°00'00"W), from 28 June to 6 August 1996 and 15 April to 21 July 1997. Mean annual precipitation (1901 to 1996) recorded at the Elkhart weather station in Morton Co. is 44.75 cm (National Weather Service Cooperative Observer Network, M. Knapp, pers. comm.). Precipitation varied greatly during the 2 years of this study. For the 12 months preceding the 1996 sampling period, precipitation was 34.35 cm, 77% of the long-term mean. During the 12 months preceding the 1997 sampling, precipitation was 67.97 cm, 150% of the long-term mean.

Two treatments were established: in 1996, sites were selected on 5 black-tailed prairie dog colonies and 5 areas in pastures not colonized by prairie dogs (control). During the 1997 trapping season, 2 more study sites were added to each treatment, for a total of 7 study sites within each treatment. All study sites were located north of the Cimarron River on flat upland areas dominated by shortgrass prairie plant species. Study sites from each treatment were intermixed across the landscape, and were not paired. Maximum distance between any 2 study sites was 24 km.

Sites occupied by prairie dogs were selected because they were among the largest prairie dog colonies on the Cimarron National Grasslands; they varied from 30 to 73 ha. Similar-sized areas were selected from control pastures without prairie dogs. Control sites were selected where vegetation was a shortgrass community type dominated by buffalograss (Buchloë dactyloides) and blue grama (Bouteloua gracilis). Study sites from both treatments had similar topography, land-use history, and soil types, which were commonly dominated by Ulysses silt loam and Richfield silt loam types (Dickey et al., 1963). In June 1997, plague (Yersinia pestis) was confirmed on 1 of the prairie dog colonies (Cully et al., 2000). Adult and juvenile prairie dogs were present there in late April, but by the end of May 1997 we were unable to locate any prairie dogs at this study site. Despite this circumstance sampling continued at this site in 1997.

This study was conducted in concert with a similar study examining influence of prairie dogs on plant community structure and composition (Winter, 1999). We used a nonparametric Wilcoxon exact test ($\alpha = 0.05$) to statistically test for differences in canopy cover of live grass and live forbs, canopy cover and frequency of each plant species, and percent bare ground on and off prairie dog colonies during the periods 1 July to 18 July 1996 and 18 June to 2 July 1997, and vegetation height and density during 27 May to 18 June 1997. Only values obtained from study sites that corresponded between this study and Winter’s (1999) study were used to characterize vegetation differences between the two treatments.

Sampling—Reptiles and amphibians were sampled using pitfall and funnel trap arrays. Trap arrays were located in each study site by randomly choosing locations on aerial photograph/grid overlays. Criteria (e.g., distance between traps; distance from study site boundary) were not used when determining trap locations. During summer 1996, 2 trap arrays were randomly located in each of the 10 study sites for a total of 20 arrays. Traps were continuously operated at each study site from 28 June through 6 August 1996. In 1997, two more study sites were added to each treatment, and the number of trap arrays was increased to 3 arrays per study site, for a total of 42 arrays. These traps were continuously operated at each study site from 15 April through 21 July 1997.

Trap arrays consisted of 3 5-m drift fences, arranged 120 degrees apart, each converging at a central 5-gallon pitfall trap. Funnel traps were located at the outer ends of the drift fences. Shade boards were used over the pitfall traps and cotton sheets were wrapped around funnel traps to shelter cap-
tured animals from the sun but still allow circulation of air through the trap.

Traps were checked and captured animals were released daily. Before release, captured lizards, toads, and salamanders were marked by toe clipping as described by Martof (1953), with the exception that thumbs were not clipped on toads and long hind toes were not clipped on lizards; snakes were marked by belly scale clipping (Brown and Parker, 1976); and turtles were marked by notching marginal plates of the carapace (Cagle, 1989). Individuals that were recaptured were counted only once.

**Analysis**—Relative abundance (number of individuals captured per 100 trap array days), species richness, Shannon’s diversity index (H) and evenness measure based on Shannon’s diversity index (J) were calculated for each study site. Data from 1996 and 1997 were analyzed separately, and mean values were compared statistically between treatments using a nonparametric Wilcoxon exact test (z = 0.05) computed by SAS v. 6.11 (1996). Diversity index equations were obtained from Brower et al. (1990). Species that were captured only once were excluded from analysis.

Horn’s index of community similarity (R_H) was used to determine the degree of likeness between the two treatments. Horn’s index varies from 0 to 1 with low values if species are mostly different, and a high value when the species composition and relative abundances are similar (Horn, 1966; Brower et al., 1990).

**RESULTS**—In 1996, black-tailed prairie dog colonies differed from control sites in that they had higher percent cover of live forbs (P = 0.03), greater percent cover and increased frequency of purple three-awn (Aristida purpurea; P = 0.008; P = 0.04), and lower percent cover and frequency of blue grama (P = 0.008; P = 0.008). In 1997, prairie dog colonies had lower vegetation height (P = 0.004) and density (P = 0.007), greater percent cover and frequency of purple three-awn (P = 0.002; P = 0.01) and tumblegrass (Schedonnardus paniculatus; P = 0.04; P = 0.001), reduced frequency of sand dropseed (Sporobolus cryptandrus; P = 0.02), and lower percent cover of prairie coneflower (Ratibida columnifera; P = 0.03). As a result of prairie dog burrowing activities, large amounts of bare soil were exposed, but total amount of bare ground was not significantly different between prairie dog colonies and control sites (Winter, 1999).

During 1996 and 1997, we captured 327 reptiles and amphibians (Table 1). These included 10 species of reptiles and 3 species of amphibians. Nine reptile and 3 amphibian species were recorded on the prairie dog colonies, whereas 6 reptiles and 3 amphibians were found on the control sites. The most common species observed, in both prairie dog colonies and control sites, was the plains spadefoot toad (Spea bombifrons) representing 29.7% and 94.9% of all captures in 1996 and 1997, respectively. In 1996, 9 species were recorded.

**TABLE 1**—Total number of individuals captured in trap arrays in prairie dog colonies and non-colonized control sites, Cimarron National Grasslands, Morton Co., Kansas, during the periods 28 June to 6 August 1996 and 15 April to 21 July 1997. In 1996, each treatment included 5 sites, each with 2 arrays (20 arrays total). In 1997, each treatment included 7 sites, each containing 3 arrays (42 total arrays). One each of Cnemidophorus sexlineatus, Eumeces obsoletus, and Lampropeltis triangulum was captured in the prairie dog colonies, and Tantilla nigriceps was captured once on the control plots.

<table>
<thead>
<tr>
<th>Species</th>
<th>1996</th>
<th>1997</th>
<th>Totals</th>
<th>1996</th>
<th>1997</th>
<th>Totals</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Ambystoma tigrinum</em></td>
<td>4</td>
<td>3</td>
<td>7</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Spea bombifrons</em></td>
<td>6</td>
<td>54</td>
<td>60</td>
<td>9</td>
<td>41</td>
<td>50</td>
</tr>
<tr>
<td><em>Bufo woodhousii</em></td>
<td>3</td>
<td>0</td>
<td>3</td>
<td>0</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td><em>Terrapene ornata</em></td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><em>Holbrookia maculata</em></td>
<td>5</td>
<td>11</td>
<td>16</td>
<td>0</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td><em>Phrynosoma cornutum</em></td>
<td>0</td>
<td>17</td>
<td>17</td>
<td>10</td>
<td>21</td>
<td>31</td>
</tr>
<tr>
<td><em>Coluber constrictor</em></td>
<td>2</td>
<td>8*</td>
<td>10*</td>
<td>6</td>
<td>76*</td>
<td>82*</td>
</tr>
<tr>
<td><em>Pituophis catenifer</em></td>
<td>2</td>
<td>6</td>
<td>8</td>
<td>3</td>
<td>5</td>
<td>8</td>
</tr>
<tr>
<td><em>Crotalus viridis</em></td>
<td>1</td>
<td>13*</td>
<td>14*</td>
<td>1</td>
<td>1*</td>
<td>2*</td>
</tr>
</tbody>
</table>

* Indicates a significant difference (P < 0.05) between the control plots and the prairie dog colonies as measured by the Wilcoxon Exact Test.
prairie dog colonies, with 5 species, tiger salamander (*Ambystoma tigrinum*), Woodhouse’s toad (*Bufo woodhousii*), ornate box turtle (*Terrapene ornata*), lesser earless lizard (*Holbrookia maculata*), and a six-lined racerunner (*Cnemidophorus sexlineatus*, *n* = 1), recorded only on the prairie dog colonies. Five species were recorded on control sites, with one species, Texas horned lizard (*Phrynosoma cornutum*), recorded only on control sites.

In 1997, 10 species were recorded on prairie dog colonies, with 3 species, ornate box turtle (*T. ornata*), Great Plains skink (*Eumeces obsOLETus, n* = 1), and milk snake (*Lampropeltis triangulum*, *n* = 1), recorded only on prairie dog colonies. Nine species were recorded on control sites, with 2 species, Woodhouse’s toad (*B. woodhousii*) and plains blackhead snake (*Tantilla nigriCeps, n* = 1), recorded only on control sites.

In 1996, numbers of reptiles and amphibians captured were relatively low, so it was difficult to detect differences in relative abundance of individual species. Larger sample sizes and higher capture rates in 1997 resulted in detection of statistical differences in species composition between treatments. During 1997, fewer eastern yellowbelly racers (*Coluber constrictor; P = 0.02*) occurred on prairie dog colonies than on control sites. Woodhouse’s toads, found only on prairie dog colonies in 1996, only occurred on control sites in 1997. Conversely, prairie rattlesnakes (*Crotalus viridis*) were more abundant (*P = 0.005*) on prairie dog colonies than on control sites.

During 1996, tiger salamanders and lesser earless lizards were unique to prairie dog colonies, whereas in 1997 they were found on both treatments. Texas horned lizards were only found on control sites in 1996, but were common on both treatments in 1997.

Total amphibian and reptile relative abundance was not different (*P > 0.05*) between the prairie dog colonies and control sites for either 1996 or 1997. Mean species richness, evenness, and diversity did not differ (*P > 0.05*) between the prairie dog colonies and control sites for 1996 or 1997; however, when data from both treatments were pooled across all study sites, total diversity was 0.85 (compared to 0.36 on prairie dog colonies and 0.33 on control sites) in 1996, and 0.72 (compared to 0.48 and 0.47) in 1997 (Table 2). Horn’s index values of community similarity for prairie dog colonies and control sites were relatively low to moderate, with index values of 0.53 and 0.73 for 1996 and 1997, respectively.

**Discussion**—Collins and Collins (1991) verified the occurrence of 31 species of reptiles and amphibians on the Cimarron National Grasslands in Morton Co., Kansas. We did not capture any species new to the Cimarron National Grasslands; however, we did capture 3 species (*E. obsOLETus, C. constrictor*, and *L. triangulum*) whose occurrence has not been documented previously on black-tailed prairie dog colonies (Reading et al., 1989; Kotliar et al., 1999).

Black-tailed prairie dogs create areas of habitat that are clearly different from surrounding non-colonized shortgrass prairie of western Kansas. It is difficult to collect sufficient numbers of reptiles and amphibians from xeric grassland habitats to draw sure conclusions about similarities or differences in communities that result from habitat modifications caused by prairie dogs or other sources of disturbance. Although we captured more than 300 animals, some species were rare; 3 species were represented by a single specimen. Despite the modest samples of many species, we were able to identify measurable effects of prairie

<table>
<thead>
<tr>
<th>Variable</th>
<th>Year</th>
<th>Prairie dog colonies mean ± SE</th>
<th>Control sites mean ± SE</th>
<th>Treatments combined</th>
</tr>
</thead>
<tbody>
<tr>
<td>Richness</td>
<td>1996</td>
<td>2.80 ± 0.58</td>
<td>2.60 ± 0.51</td>
<td>9.00</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>4.43 ± 0.75</td>
<td>4.29 ± 0.36</td>
<td>9.00</td>
</tr>
<tr>
<td>Evenness</td>
<td>1996</td>
<td>0.73 ± 0.18</td>
<td>0.71 ± 0.18</td>
<td>0.89</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>0.70 ± 0.13</td>
<td>0.75 ± 0.03</td>
<td>0.75</td>
</tr>
<tr>
<td>Diversity</td>
<td>1996</td>
<td>0.36 ± 0.11</td>
<td>0.33 ± 0.09</td>
<td>0.85</td>
</tr>
<tr>
<td></td>
<td>1997</td>
<td>0.48 ± 0.10</td>
<td>0.47 ± 0.04</td>
<td>0.72</td>
</tr>
</tbody>
</table>
dogs on reptile and amphibian species and communities, and some of these effects differed between years.

The racer was the only reptile or amphibian species we observed that appeared to be negatively influenced by black-tailed prairie dogs. Tiger salamanders and Woodhouse’s toads were only found on prairie dog towns at the end of a drought in 1996. Prior to sampling in 1997, fall and spring precipitation increased more than 56% from the previous year. During 1997 sampling, tiger salamanders were found on both treatments, whereas Woodhouse’s toads were captured only on control sites. Plains spadefoot toads did not differentiate shortgrass prairies altered by the presence of prairie dogs and their burrows.

Earless lizards appeared only on prairie dog towns in 1996, and only one was taken on a control plot in 1997. Earless lizards prefer areas with loose soils and little or no vegetation, and will use mammal burrows to escape extremely hot temperatures (Collins, 1993). In Cheyenne Co., Kansas, Knight and Collins (1977) found this lizard most abundant around prairie dog colonies. In the Nebraska sandhills, these lizards were associated with blowout/washout areas, and a drastic reduction of earless lizards occurred after the elimination of cattle grazing (Ballinger and Jones, 1985; Ballinger et al., 1990; Ballinger and Watts, 1995). Vegetation and soil disturbances, which are typical of prairie dog colonies, appear to be critical habitat features for earless lizards.

Texas horned lizards were not found on prairie dog colonies in 1996. In 1997, number of horned lizards captured was similar on and off prairie dog colonies despite lower height and density of the vegetation on prairie dog colonies (Winter, 1999). Spatial distribution of horned lizards is influenced by vegetative structure and, to a lesser degree, by the presence of harvester ants (Pogonomyrmex). Some studies have reported that horned lizards selected disturbed areas with less vegetative cover (Whiting et al., 1993; Fair and Henke, 1997). Harvester ants are the horned lizard’s primary food source, and in 1997 total density of harvester ant mounds was not different between prairie dog colonies and non-colonized shortgrass prairie sites on the Cimarron National Grasslands (Kretzer and Cully, 2001).

The eastern yellowbelly racer was the most abundant snake trapped, with 92 individuals captured during 1996 and 1997. The species is common throughout grasslands of Kansas (Collins, 1993; Fitch, 1993). Prior to this study, only 6 specimens of racer were collected in Morton Co., Kansas, despite a number of intensive collecting expeditions (Collins and Collins, 1991). This species was 8 times as abundant on control sites compared to prairie dog colonies. Structural difference in vegetation between treatments is likely responsible for the racer being more abundant on control sites. Fitch (1963) reported that grazed, mowed, or burned grasslands do not provide adequate food or shelter for the racer. Prairie dog colonies may be attractive hunting grounds for raptors and mammalian carnivores (Campbell and Clark, 1981; Clark et al., 1982; Sharps and Uresk, 1990; Hoogland, 1995), and the racer may be particularly vulnerable to predation on prairie dog colonies that lack substantial cover. Raptors were observed carrying snakes on 2 occasions in 1997. Of the 8 racers captured on prairie dog colonies in 1997, 5 were captured on the prairie dog colony site infected with a plague epizootic where height of the vegetation was greater than that of other prairie dog colony sites (J. E. Kretzer, pers. obser.).

Prairie rattlesnakes and bullsnakes were less abundant than racers but similar in abundance to each other. Bullsnakes appear to be indifferent to the presence of prairie dog colonies. In contrast to racers, prairie rattlesnakes were captured more often on prairie dog colonies. The prairie rattlesnake is probably not as vulnerable to predation as the racer because of its secretive behavior and poisonous bite. Consequently, the lack of overhead canopy cover on prairie dog colonies may not have a negative influence on rattlesnakes. Cox and Franklin (1989) found that rattlesnakes in Nebraska were commonly associated with shorter, sparser vegetation than were racers. Additionally, rattlesnakes are more sensitive to heat than racers (Fitch, 1963), and will use prairie dog burrows to escape extreme daytime ambient temperatures (Klauber, 1982; Collins, 1993).

All of the 13 species captured in this study have been reported to use mammal burrows and other below-ground habitats to escape extreme temperatures (Collins, 1993). Klauber (1982) reported use of prairie dog burrows by
rattlesnakes as hibernation dens. Perhaps a number of species use prairie dog burrows as hibernation sites during winter months and then disperse across the landscape after spring emergence. Future research may demonstrate that prairie dog burrows provide critical refuge for other species of reptiles and amphibians dependent on below-ground habitats for winter survival.

Use of prairie dog altered habitat by individual species varied by year. Horn’s index value of community similarity also indicate dissimilarity between prairie dog colonies and surrounding shortgrass habitat. The combination of prairie dog colonies and control sites resulted in considerably higher species diversity values in the shortgrass prairie ecosystem than either treatment had on its own. This comparison demonstrates that reptile and amphibian diversity on prairie dog colonies at the individual colony scale is similar to the shortgrass prairie matrix. However, a mosaic patchwork of prairie dog colonies on a shortgrass prairie matrix increases landscape heterogeneity and contributes to greater reptile and amphibian diversity patterns than would occur in the absence of prairie dogs.

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