SMALL MAMMALS ASSOCIATED WITH COLONIES OF BLACK-TAILED PRAIRIE DOGS (*CYNOMYS LUDOVICIANUS*) IN THE SOUTHERN HIGH PLAINS

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Abstract—We compared diversity and abundance of small mammals at colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) and paired non-colony sites. Of colonies of black-tailed prairie dogs in our study area, >80% were on slopes of playa lakes; thus, we used sites of colonies and non-colonies that were on slopes of playa lakes. We trapped small mammals on 29 pairs of sites. Overall abundance did not differ between types of sites, but some taxa exhibited associations with colonies (*Onychomys leucogaster*) or non-colonies (*Chaetodipus hispidus*, *Reithrodontomys*, *Sigmodon hispidus*). Diversity and evenness of small mammals did not differ between colonies and non-colonies in 2002, but were higher on non-colonies in 2003. Although we may not have detected some rare or infrequently occurring species, our data reveal differences in diversity and evenness of more common species among the types of sites. Prairie dogs are touted as a keystone species with their colonies associated with a greater faunal diversity than adjacent lands. Our findings contradict several studies reporting greater diversity and abundance of small mammals at colonies of prairie dogs. We suggest that additional research across a wider landscape and incorporating landscape variables beyond the immediate trapping plot may further elucidate interspecific associations between black-tailed prairie dogs and species of small rodents.

Resumen—Comparamos la diversidad y abundancia de mamíferos pequeños entre colonias de perritos llaneros de cola negra (*Cynomys ludovicianus*) y áreas similares sin perritos llaneros. Más del 80% de las colonias de perritos llaneros se encontraron en las márgenes de humedales (lagos playa) por lo que los sitios de comparación se eligieron también en las márgenes de este tipo de humedales. Colectamos mamíferos pequeños en 29 pares de sitios. La abundancia en total no fue diferente entre los dos tipos de sitios, pero algunas taxa mostraron asociación con las colonias de perritos llaneros (*Onychomys leucogaster*) y otras con sitios sin perritos (*Chaetodipus hispidus*, *Reithrodontomys*, *Sigmodon hispidus*). La diversidad y equidad de mamíferos pequeños no fueron diferentes entre sitios con y sin colonias en 2002, pero los valores fueron más altos en sitios sin colonias en 2003. A pesar de que es posible que no se detectaran algunas especies raras o poco frecuentes, nuestros datos revelaron diferencias entre los dos tipos de sitios en diversidad y equidad de las especies más comunes. Los perritos llaneros son considerados una especie clave, con sus colonias asociadas con mayor diversidad y abundancia de mamíferos pequeños que las áreas aledañas. Nuestros resultados no concuerdan con los de unos otros estudios que registran mayor diversidad y abundancia en las colonias de los perritos llaneros. Sugerimos que más investigaciones que incluyan paisajes más amplios e incluyan variables a una escala mayor a las inmediaciones de la parcela de trampeo, podrían elucidar mejor las asociaciones inter-especificas entre los perritos llaneros de cola negra y otras especies de roedores pequeños.

Prairie dogs (*Cynomys*) often are touted as a keystone species within the Great Plains ecosystem. If adhering to the definition of a keystone species as one whose impact on its community or ecosystem is disproportionately large relative to its abundance (Power et al., 1996), prairie dogs do appear to be keystone species (Kotliar et al., 1999). Prairie dogs are not high in the trophic chain, but they substantively influence their ecosystem (Kotliar et al., 1999). Burrowing and grazing by prairie dogs results in continual disturbance in and around the colony (Hansen and Gold, 1977; Whicker and Detling, 1988). These activities result in a mosaic of grasses and forbs by bringing nutrient-rich soils to the surface and preventing encroachment of woody shrubs on rangelands (Hansen and Gold, 1977; Whicker and Detling, 1988; Weltzin et al., 1997). Grazing by prairie dogs also keeps vegetation on colonies at a lower and more nutritional seral stage (Birch, 1977; Agnew et al., 1986). This is believed to account for preferential grazing on colonies of prairie dogs by elk (*Cervus elaphus*), pronghorns (*Antilocapra americana*), and bison (*Bison bison*; Coppock et al., 1983; Knowles, 1986; Assal, 2001). This vegetative growth stage also is believed to be selected by several species of small rodents (e.g., *Peromyscus maniculatus*; Birch, 1977).

Burrows of prairie dogs provide refuge and shelter for burrowing owls (*Athene cunicularia*) and numerous species of small mammals, reptiles, and amphibians (Campbell and Clark, 1981; Sharps and Uresk, 1990; Kotliar, 2000; McCaffrey, 2001). In general, colonies of prairie dogs are associated with a higher diversity and abundance of fauna compared to non-colonized grasslands (Hansen and Gold, 1977; Miller et al., 1994; Kotliar et al., 1999). Several studies have reported that densities of small mammals tend to be greater on colonies than on non-colony sites (Agnew, 1983; Agnew et al., 1986; Ceballos et al., 1999). However, differences in measures of species richness between colonies and non-colony sites have been inconsistent among studies (Agnew, 1983; Agnew et al., 1986; Stapp, 1998).

The historic distribution of prairie dogs in Texas is primarily the southern Great Plains region, including the southern High Plains. Prior to agricultural development, the southern High Plains was dominated by short-grass prairie. Within this area, densities of playa wetlands approach 1/2.6 km^2 (Smith, 2003). With rare exception, these shallow circular depressions are ephemeral, only filling with water through precipitation and runoff from agricultural irrigation (Smith, 2003). Playas become completely dry during periods of little rainfall, but can rapidly flood during rainy periods; thus, agricultural interests often consider playas unsuitable for production of agricultural crops and leave them uncultivated (Schwiesow, 1965; Smith, 2003). As a result, many playa basins and their grassland slopes function as oases of wildlife habitat in an otherwise inhospitable mosaic of agricultural crops (Haukos and Smith, 1992; Smith, 2003). Playa wetland basins and grassland slopes have become habitat refuges for small colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) in the region (Pruett et al., 2009). Our objective was to assess associations of small mammals at colonies of prairie dogs and at non-colony sites on playa wetlands in the southern High Plains of Texas.

Materials and Methods—We conducted this study in nine counties within the southern High Plains of the Texas Panhandle: Carson, Castro, Floyd, Hale, Hockley, Lamb, Lubbock, Randall, and Swisher counties during summers 2002 and 2003. The study area was generally level with elevation ranging from 1,002 m at the southern end to 1,099 m at the northern end. Along the east side of the study area is the Caprock Escarpment, an abrupt elevation change of 30 m to >300 m, which separates the southern High Plains from the lower-elevation Rolling Plains.

During 2001–2003, average precipitation was 38.8 cm, with the wettest months being May (4.1 cm) 2001, October (3.8 cm) 2002, and June (5.6 cm) 2003. Driest months were October (0.1 cm) 2001, September (2.2 cm) 2002, and July and December (both 0.0 cm) 2003. Average low and high temperatures were 4.2 and 27.7°C, respectively, with lowest and highest recorded temperatures of −12.8 and 41.7°C, respectively; coldest months were January and February, and hottest months were July and August. Climatic data were obtained from the National Climate Data Center (http://www7.ncdc.noaa.gov/IPS/cd/cd.html).

Historically, the region was composed of short-grass and mid-grass prairie, consisting primarily of buffalograss (*Buchloë dactyloides*), blue grama (*Bouteloua gracilis*), sideoats grama (*Bouteloua curtipendula*), little bluestem (*Schizachyrium scoparium*), and sand dropseed (*Sporobolus cryptandrus*), with some low shrubs, especially honey mesquite (*Prosopis glandulosa*), and cholla and prickly pear cactus (*Opuntia*; Savage, 2004). Much of the land was dominated by agricultural crops and cattle grazing, but also with some areas enrolled in the Conservation Reserve Program.

We randomly selected 29 colonies of black-tailed prairie dogs within our study area to survey for small mammals. Random selection of sites was constrained by selecting only colonies located on the grassland slope and basin of a playa wetland large enough to contain a 100-m^2 trapping array. Additional constraints were willingness of landowners to allow access to their property and that the area was not being grazed by livestock during our trapping session. We then paired each colony with the nearest possible non-colony site at a playa lake given the same conditions and constraints as those used for colonies. To reduce possible effects of weather and climate on diversity of vertebrates, our paired sites were ≤3.2 km apart.

We sampled diversity and abundance of small mammals at paired sites during June–August 2002 and 2003. We sampled small mammals with 100-trap grids of collapsible Sherman live traps (H. B. Sherman Traps, Inc., Tallahassee, Florida) arranged with traps spaced at 10-m intervals (Davis, 1982; McCaffrey, 2001). We attempted to configure grids in a 10 by 10-trap arrangement; however, this was not always possible due to shape of colonies and landscapes around playas. Thus, we modified shape of grids as necessary to keep the entire grid within the colonies and within the same landscape at non-colonies. Edges of grids were ≥10-m from the colony or edge of the landscape to reduce the influence of other types of land uses and landscapes.

We trapped at paired sites for 3 consecutive nights each year (McCaffrey, 2001), with paired sites being trapped on the same nights. We sampled at 16 pairs of sites in Carson, Hale, Hockley, and Lubbock counties in 2002. In 2003, we sampled all but one of the paired sites used in 2002, and sampled an additional 13 paired sites in Castro, Floyd, Hockley, Lamb, Randall, and Swisher counties for a total of 28 pairs of sites. The excluded pair was due to a change in landownership and an inability to access the property. We baited and set traps with a mixture of safflower seed and oatmeal in the evening. At first light, we checked traps for animals and closed them during the day. An assumption inherent to our study was equal probability of capture of a species independent of whether the grid was at a colony or non-colony.

We attempted to identify all captured animals to species. We measured length of tail, length of ear, length of hindfoot, and determined mass, age, and sex of each captured animal. However, it was not possible to differentiate some genera to species. i.e., *Perognathus*, *Reithrodontomys*, and *Peromyscus*.

We calculated relative abundance of small mammals using the catch-per-unit-effort method (Lancia and Bishir, 1996) using number of captured individuals divided by number of traps available [trap nights per session − (closed traps + traps occupied by recaptured animals)]. We standardized abundance across sites as number of individuals/100 trap nights. We calculated diversity at the genus level using the complement to Simpson's index (Krebs, 1989) and assessed evenness with Pielou's evenness index (Ludwig and Reynolds, 1988). We assessed differences in overall diversity and evenness and abundance of individual species in terms of captures per trap nights between paired colonies and non-colonies with paired *t*-tests (Zar, 1999).

RESULTS—We captured 15 species of small mammals during this study. We captured less than five individuals of *Baiomys taylori*, *Cryptotis parva*, *Microtus ochrogaster*, and *Mus musculus* (Table 1). We did not include these in analyses of abundance of individual species, but we did include them in measures of diversity and overall abundance. Similarly, we had insufficient captures of *Sigmodon hispidus* and *Spermophilus tridecemlineatus* in 2002 and insufficient captures of *Perognathus* in 2003.

We captured 130 individuals at colonies and 222 individuals at non-colonies in 2002 (t_{15} = 2.117, $P = 0.051$) and 182 individuals at colonies and 287 at non-colonies in 2003 (t_{27} = 1.50, $P =$ 0.145). The differences of 92 animals (2.2/100 trap nights) between colonies and non-colonies in 2002 and of 105 animals (1.3/100 trap nights) between colonies and non-colonies in 2003 (Table 1) suggest there may be biological relevance to the difference in abundance of small mammals between colonies and non-colonies.

Most species appeared more abundant on non-colony sites. In 2002, we captured 5 *Chaetodipus hispidus* on colonies and 32 at non-colonies ($t_9 = 2.70$, $P = 0.024$). Similarly, we captured 7 *Perognathus* on colonies and 17 on non-colonies ($t_9 = 2.31$, $P = 0.082$), and 4 *Reithrodontomys* on colonies and 35 on non-colonies ($t_9 = 1.58$, $P =$ 0.159). Although not significantly different, based on differences in numbers captured on colonies and non-colonies, we suspect the observed differences in *Perognathus* and *Reithrodontomys* may have biological relevance obscured by small samples.

In 2003, we captured 8 *C. hispidus* on colonies and 57 on non-colonies ($t_{19} = 4.61$, $P < 0.001$), and 2 *Reithrodontomys* on colonies compared to 32 on non-colonies ($t_{14} = 4.12$, $P = 0.001$). We captured no *S. hispidus* on colonies, but 41 were captured on non-colonies. In contrast, *Onychomys leucogaster* was captured more often on colonies ($n = 54$) than non-colonies ($n = 4$; $t_{14} = 5.96$, $P < 0.001$).

We evaluated diversity and evenness at the genus level for all pairs of sites using the complement to Simpson's diversity index and Pielou's measure of evenness. We detected no difference in diversity (D) or evenness (J) between colonies (D = 0.60, J = 0.65) and non-colonies (D = 0.71, J = 0.68; D: $t_{15} = 0.02$, $P = 0.981$; J: $t_{15} = 0.32$, $P = 0.754$) in 2002. In contrast, we noted differences in diversity and evenness between colonies (D = 0.69, J = 0.74) and non-colonies (D = 0.74, J = 0.76; D: t_{27} = 2.89, $P = 0.007$; J: $t_{27} = 2.68$, $P = 0.012$) in 2003.

DISCUSSION—While prairie dogs undoubtedly have a major effect on their immediate

TABLE 1—Small mammals captured on colonies of black-tailed prairie dogs (*Cynomys ludovicianus*) and paired non-colony sites at playa wetlands in the southern High Plains of Texas, June–August 2002 (n = 16 pairs) and 2003 (n = 28 pairs).

Taxon	2002		2003		Total
	Colony	Non-colony	Colony	Non-colony	
Baiomys taylori	0	1	0	0	1
Chaetodipus hispidus	5	32	8	57	102
Cryptotis parva	0	1	0	0	1
Microtus ochrogaster	2	0	0	3	5
Mus musculus	0	1	0	0	1
Onychomys leucogaster	29	19	54	4	106
Perognathus	7	17	4	7	35
Peromyscus	76	107	77	124	384
Reithrodontomys	4	35	2	32	73
Sigmodon hispidus	0	6	0	41	47
Spermophilus tridecemlineatus	7	3	37	19	66
Total	130	222	182	287	821

environment, assessments of their influence on other species has been equivocal (Hansen and Gold, 1977; Clark et al., 1982; McCaffrey, 2001). Based on size of effect, we detected evidence that abundances of some species of small mammals differ between playa sites with and without black-tailed prairie dogs. *Peromyscus* was the most abundant genus in our study plots. Species within *Peromyscus* are considered generalist (e.g., Lackey et al., 1985) and our study indicates *Peromyscus* was ubiquitous across colonies and non-colonies. In contrast, *O. leucogaster* was the only species clearly associated with colonies of black-tailed prairie dogs (Table 1). Similar to our study, Stapp (2007) also reported that *O. leucogaster* tended to be more abundant on colonies of black-tailed prairie dogs in Colorado. *Onychomys leucogaster* primarily is insectivorous (McCarty, 1978), but will also prey upon small herpetofauna and rodents. This species also is known to use burrows of prairie dogs for nesting and shelter (McCarty, 1978) and the short vegetation of colonies may facilitate foraging activities of *O. leucogaster*.

The reason for association of *C. hispidus*, *Reithrodontomys*, and *S. hispidus* with non-colonized sites is unclear. *Chaetodipus hispidus* and *Reithrodontomys* have both been reported to occupy habitat consisting of denser vegetation in which bare soil is <40% of the area (Webster and Jones, 1982; Wilkins, 1986). Based on this alone, colonies of black-tailed prairie dogs in our study area would be ill-suited to these species as, on average, bare soil and litter account for 45% of ground cover (Teaschner, 2005). Diet of *S. hispidus* primarily includes grasses and shrubs (Cameron and Spencer, 1981) similar to prairie dogs (Hoogland, 1995); it is unlikely *S. hispidus* would be able to effectively compete with prairie dogs. These three species of small mammals were more abundant on non-colonized sites in Colorado, which is believed to be due to presence of taller grass (Stapp, 2007).

Our trapping at each pair of sites was for 3 consecutive nights (e.g., McCaffrey, 2001; McCaffrey et al., 2003), so our diversity index may not account for less-detectable and rarer species. However, our consistent sampling effort and resulting measures of diversity and evenness should be valid for comparisons between colonies and non-colonies within our study. In contrast to other studies reporting higher diversity on colonies of prairie dogs (Hansen and Gold, 1977; Ceballos et al., 1999), but similar to the findings of Stapp (2007), we determined the diversity of small mammals on our study area was higher and more even on non-colonies.

A possible explanation for the patterns we observed is the intensive cultivation of the landscape around the playa lakes, and hence colonies, in our study area (Smith, 2003) compared to open grasslands and grazing lands present throughout much of the range of black-tailed prairie dogs. The small size of patches and pattern of dispersal of playas (Smith, 2003) may explain the small size of colonies in our study (median = 8.8 ha) and the average inter-colony distance of 2.8 km (Pruett et al., 2009). Although playas provide most of the remaining natural habitat, and have high floral and faunal diversity, in this area of the southern High Plains (Smith, 2003), the agricultural landscape between them likely is a difficult barrier to dispersal. Thus, species that do not cope well with prairie dogs could become reduced or extirpated from playas with prairie dogs. Maintenance or recolonization of populations by immigration to these areas, even if prairie dogs were removed, may be limited by the surrounding landscape. However, we had no knowledge of historic grazing or efforts to control prairie dogs on our study plots, or how these may have influenced diversity and abundance of small mammals. It is possible that the lack of difference in diversity and evenness between colonies and non-colonies in 2002 was due to having data only from 16 pairs of sites, rather than the larger sample of 28 pairs used in 2003. Our study area had less precipitation during January–June 2002 (average = 18.3 cm) than January–June 2003 (average = 20.8 cm; http://www7.ncdc.noaa.gov/IPS/cd/cd.html). We believe it unlikely that this difference provides a suitable explanation for differences we detected in diversity and abundance of small mammals between years. Regardless, it is apparent that diversity at the genus level was higher and more evenly distributed across species on non-colony sites than sites inhabited by prairie dogs.

Black-tailed prairie dogs frequently are cited as a keystone species in grasslands and prairies (Kotliar et al., 1999; Miller et al., 2000), but there have been contradictory views (e.g., Stapp, 1998). Our report is not an entry into that debate, but presentation of data on associations and dissociations between black-tailed prairie dogs and small rodents at the ecologically rich areas of playa lakes (Haukos and Smith, 1992; Smith, 2003). The only positive association we detected between prairie dogs and small rodents was with *O. leucogaster*. We determined that prairie dogs may have a negative influence on some small mammals such as *C. hispidus*, *Reithrodontomys*, and *S. hispidus*. Our data are not consistent with several other studies suggesting diversity and abundance of small mammals is greater in colonies of prairie dogs. We suggest that additional research across a wider landscape and incorporating landscape variables beyond the immediate trapping plot may further elucidate interspecific associations between black-tailed prairie dogs and small rodents. However, we reiterate that our study focused on a relatively narrow range of associations between prairie dogs and small rodents, not prairie dogs and the range of flora and fauna that they may influence.

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