



# Influence of black-tailed prairie dogs (*Cynomys ludovicianus*) on short-horned grasshoppers (Orthoptera: Acrididae) on the shortgrass steppe of Colorado



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## ABSTRACT

Black-tailed prairie dogs (*Cynomys ludovicianus*; hereafter simply prairie dogs) strongly influence the structure and function of ecosystems, affecting several other species. Yet we know little about how arthropod populations respond to changes caused by prairie dogs. In this study, we examined the effects of black-tailed prairie dogs on the abundance and diversity of short-horned grasshoppers (Orthoptera: Acrididae) on the shortgrass steppe of the Pawnee National Grasslands in northeastern Colorado. We compared the abundance and diversity of grasshoppers on prairie dog colonies and comparable off-colony sites using hoop nets. We further sampled vegetation at all sites using Daubenmire frames. We captured significantly fewer grasshoppers on prairie dog colonies than on control plots. At the sub-family level, we found that prairie dog colonies supported significantly more grasshoppers in the sub-family Oedipodinae, while off-colony sites had a non-significant trend toward more Gomphocerinae grasshoppers. We found very similar mean site diversity (i.e., alpha diversity) on colony and off-colony sites, but relatively large differences in beta diversity (i.e., diversity across sites), suggesting that prairie dog colonies have an impact on short-horned grasshopper abundances and species composition on short-grass steppe habitats.

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## 1. Introduction

Black-tailed prairie dogs (*Cynomys ludovicianus*; hereafter simply prairie dogs) strongly influence the structure and function of ecosystems they inhabit through their burrowing activities, preferential foraging on grasses, and clipping of tall vegetation (Hoogland, 1995; Detling, 2006). As a result, prairie dog colonies provide unique habitat patches, especially in the mixed-grass prairie colonized for a decade or longer. Within such colonies, perennial grasses may be virtually eliminated and replaced with forbs and sub-shrubs, canopy height declines by >65%, live leaf nitrogen concentration increases, plant cover decreases, bare soil cover increases, and soil mounds surrounding burrows cover 4–6% of the area of a colony (Coppock et al., 1983; Detling, 1998, 2006). Similar, but often less dramatic, prairie dog-induced changes have been reported for the semi-arid shortgrass steppe (Bonham and

Lerwick, 1976; Guenther and Detling, 2003). Studies in the short-grass steppe have also shown differences in aboveground plant biomass between prairie dog mounds and surrounding areas, with the areas directly surrounding active burrows having the lowest biomass (Alba-Lynn and Detling, 2008).

The differences that prairie dogs create on ecosystems they inhabit affect other species and may be especially important for species of conservation priority (Lomolino and Smith, 2004). For example, the endangered black-footed ferret (*Mustela nigripes*) depends upon prairie dogs as prey and for the habitat prairie dogs provide (Miller et al., 1994). Several other species, such as burrowing owls (*Athene cunicularia*) and mountain plovers (*Charadrius montanus*), exhibit strong dependence on prairie dog colonies (Miller et al., 1994; Kotliar et al., 2006). Still others, such as bison (*Bison bison*) and pronghorn (*Antilocapra americana*), utilize prairie dog colonies preferentially at least during some seasons (Coppock et al., 1983). The reasons for such preferential use differ among species, but apparently relate to one or more prairie dog-induced changes in biotic or abiotic components of their habitat (Kotliar et al., 2006; Shipley and Reading, 2006; Slobodchikoff et al., 2009).

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We know less about how arthropod populations respond to changes in vegetation and habitat caused by prairie dogs (Stapp, 1998). In this study, we examined the effects of black-tailed prairie dogs on the abundance and diversity of short-horned grasshoppers (Orthoptera: Acrididae) on the shortgrass steppes of Colorado.

Because short-horned grasshoppers can affect nutrient cycling, primary productivity, and plant standing crop (Mitchell and Pfadt, 1974; Belovsky and Slade, 2000, 2002) and represent prey for many vertebrate species (Plumpton and Lutz, 1993), knowing how they interact with other species helps our understanding grassland dynamics. In a study in the mixed-grass prairie, Russell and Detling (2003) found substantially higher grasshopper densities on prairie dog colonies except for one late season sample date when they were more abundant off colonies. In contrast, two other studies in mixed-grass prairie found substantially lower densities of grasshoppers on prairie dog colonies compared to off-colony sites (O'Meilie et al., 1982; Agnew, 1983). In a Chihuahuan Desert study, Davidson and Lightfoot (2007) found that different grasshopper species utilized prairie dog mounds compared to areas away from mounds. In their mixed-grass study, Russell and Detling (2003) also documented differences in the species composition of short-horned grasshoppers between prairie dog colonies and nearby grass-dominated sites.

To our knowledge, no studies have compared grasshoppers on and off of prairie dog colonies in the shortgrass steppe. However, researchers have studied the relationship between cattle grazing (where grazing may be less intensive than on prairie dog colonies) and grasshopper populations in the shortgrass steppe. These studies found higher grasshopper densities on ungrazed or lightly grazed areas than on more heavily grazed areas (Capinera and Sechrist, 1982a; Welch et al., 1991) and associations between certain sub-families or feeding groups with areas that experienced different grazing histories and habitats, regardless of overall grasshopper abundances (Capinera and Sechrist, 1982a).

Plant species composition and even minor changes in plant architecture affect grasshopper abundance and community composition (Quinn and Walgenbach, 1990). Existence of oviposition sites (often bare ground) (Isely, 1938), thermoregulatory sites (Anderson et al., 1979), and areas for predator evasion (Isely, 1938; Joern and Lawlor, 1980) may be as important for habitat selection as the existence of food plants. Since prairie dogs provide a different habitat for grasshoppers than that found in the surrounding grassland, we predict affects to grasshopper species composition.

## 2. Study area and methods

We conducted our study at five sites in the western half of the Pawnee National Grassland (PNG) in Weld County, northeastern Colorado, USA (40° 45'N, 104° 41' W; elevation 1650 m). The U.S. Forest Service (U.S. Forest Service allotments and colony numbers: Coal 51, Owl 66, 69 and 80, and Roe 79) manages this shortgrass steppe habitat, as pasture for cattle grazing during the growing season. The study area was also part of the Shortgrass Steppe Long-Term Ecological Research site. Mean annual precipitation from 1939 to 1990 was 322 mm, ranging between 107 and 588 mm (Lauenroth and Milchunas, 1991). Approximately 70% of precipitation falls from April to September, with the highest mean precipitation in June (Lauenroth and Milchunas, 1991). In 1997, the first year of this study, annual precipitation was 490 mm, with large (22 mm–67 mm) rainfall events in late June, late July and early August. In 1998, yearly precipitation was 348 mm, with many small rainfall events in May and only two rainfall events >20 mm in early June and late July. Mean monthly temperatures for the winter (November through February) are between –4° and 4 °C

(Lauenroth and Milchunas, 1991). For both winters preceding our sampling, the mean monthly temperature ranged from –3° to 3 °C. During our study years, mean temperatures from May–September ranged from 13° to 22 °C, similar to the long-term means of 12° to 22 °C (Lauenroth and Milchunas, 1991).

Each of our five study sites consisted of a prairie-dog colony that had been occupied for more than 5 years and a nearby area on a similar soil type with no known history of prairie dog occupation. All sites were open to grazing by cattle and in this study area cattle neither preferred nor avoided prairie dog colonies as locations to graze (Guenther and Detling, 2003). Prairie dog colonies covered 1–52 ha (mean = 21.4 ha) of active burrows (surveyed in 1997 by U.S. Forest Service). Within each colonized and uncolonized site, we sampled within one 45 m × 75 m plot.

In 1997, we conducted abundance sampling 15–16 July, 4–5 August, 18–19 August and 13–14 September, with on- and off-colony pairs sampled within approximately 1 h of each other. In 1998, we collected samples at 4 week intervals from 16 June through 15 September with paired sites sampled at the same time on consecutive days. Within each plot, we sampled grasshopper abundance by counting the number of grasshoppers flushed from twenty 0.8 m<sup>2</sup> hoops placed within a 4 × 5 hoop grid with 15 m between hoop centers. This method generally followed Onsager and Henry (1977), but used larger hoops because of a lower density of grasshoppers at our sites. In 1998, we sampled for species composition during the same sampling periods, sweeping with a 38-cm diameter sweep-net to capture approximately 20 grasshoppers within each on- and off-colony plot. We identified individuals, both nymphs and adults, to the genus, and where possible, species level (Capinera and Sechrist, 1982b; Pfadt, 1994). For analyses, we designated species we could not identify as genus sp1, genus sp2, etc. We identified nymphs using descriptions and photographs of Pfadt (1994). We grouped species as grass-, forb-, or mixed-feeders according Scoggan and Brusven (1972), Capinera and Sechrist (1982b), and Pfadt and Levine (1982).

We conducted vegetation sampling on each of the colony and off-colony plots in late July, 1997 and early August, 1998 using a Daubenmire frame (Daubenmire, 1959) on 20 random points within each plot. We estimated percent cover of bare ground, litter, and individual species for each frame. If a random point fell onto a prairie-dog mound, we assigned another point. We measured aboveground plant biomass by clipping all vegetation within five random 0.25 m<sup>2</sup> circular frames on each plot. We separated plants by species, dried the plants at 55 °C, and weighed them. For analysis, we consolidated species into the functional groups of forbs and grasses.

We calculated relative abundance (number of individuals captured each year), species richness, Shannon-Weaver diversity index, and an evenness index for each study site, as well as for all colonies combined, all off-colony sites combined, and across the study area (colonies and off-colony sites combined). We computed the Shannon-Weaver index as

$$H' = - \sum p_i (\ln p_i),$$

where  $p_i$  = the proportion of individuals of the total sample belonging to the  $i$ th species. We computed the evenness index as

$$e = H' / \ln S,$$

where  $H'$  = the Shannon-Weaver index as above and  $S$  = the number of species in the sample.

We compared species richness and evenness using Kruskal–Wallis and Mann–Whitney  $U$  tests. To test for differences in

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