

Arthropod Consumption by Small Mammals on Prairie Dog Colonies and Adjacent Ungrazed Mixed Grass Prairie in Western South Dakota¹

W. Agnew², D. W. Uresk³,
and R. M. Hansen

Abstract: The percentage of arthropods and plants in the diets of seven small rodents captured on prairie dog colonies and adjacent mixed grasslands were estimated by microhistological techniques. Arthropod composition over the two year study averaged 51% and 37% on prairie dog colonies and mixed grasslands, respectively. Composition of arthropods on prairie dog colonies was greater during the summer than in late spring or late summer. Conversely, arthropods made up a considerably smaller percentage of small mammal diets in the summer on mixed grasslands. Nearly twice as many small mammals, excluding prairie dogs, were trapped on prairie dog colonies than on the adjacent mixed grasslands. Prairie dog colonies favor insectivorous rodent species. Prairie dogs, in creating habitat for insectivorous small mammals, may indirectly reduce localized arthropod outbreaks.

INTRODUCTION

The black-tailed prairie dog (Cynomys ludovicianus) originally inhabited prairies from southern Canada to Mexico and from the eastern foothills of the Rocky Mountains to the tallgrass prairie (Hall 1981). Prairie dog colonies may occupy large areas of rangeland. A single prairie dog colony occupied about 64,750 square kilometers in Texas (Merriam 1902).

Because prairie dog feeding and burrowing activities conflict with the interests of livestock producers and some assume that prairie dogs influence the habitat for wildlife (Merriam 1902, Uresk et al. 1981, Hansen and Gold 1977), control of prairie dog populations has become a common practice (Merriam 1902, Uresk and Bjugstad 1983, Collins et al. 1984). However, little or no information is available on small rodents or arthropods inhabiting prairie dog colonies or the impact of prairie dog control on associated fauna. The objectives of this study were to compare small

rodents, small rodent diets, vegetation, and arthropod populations on and off prairie dog colonies and provide baseline information on potential non-target impacts from prairie dog control programs.

STUDY AREA AND METHODS

The study area was located in Badlands National Park in west central South Dakota, 80 km east of Rapid City and 13 km southwest of Wall. The climate is semiarid-continental and is characterized by cold winters and hot summers. The average annual precipitation for the area is 40 cm, most of which falls as high-intensity thunderstorms during the growing season (April-September). Snowfall accumulations average 62 cm per year. Mean annual temperature is 10°C, ranging from -5°C in January to 26°C in July.

Soils are primarily sedimentary deposits of clay, silt, gravel and volcanic ash (Raymond and King 1976). The landscape includes steep gullies, sharp ridges, flat-topped buttes, spires, and pinacles that are partly covered with vegetation and upland areas of mixed-grass prairie. Gently sloping mixed-grass sites are scattered throughout the area and are the major sites occupied by prairie dogs. The elevation of the study sites ranged from 820 m to 900 m. The study area was neither farmed nor grazed by domestic livestock but portions have been grazed and farmed in the past. Native ungulates inhabiting the area are American bison (Bison bison), pronghorn (Antilocapra americana), mule deer (Odocoileus hemionus), and white-tailed deer (O. virginianus).

¹Paper presented at the 8th Wildlife Damage Control Workshop. (Rapid City, SD, April 28-30, 1987)

²W. Agnew is Environmental Engineer, Trapper Mining Inc., Box 187, Craig, CO 81626.

³D. W. Uresk is Research Biologist, USDA Forest Service, Rocky Mountain Forest and Range Experiment Station, SD School of Mines, Rapid City, SD 57701.

⁴R. M. Hansen is Professor, Department of Range Science, Colorado State University, Fort Collins, CO 80523.

The dominant grasses of the area are western wheatgrass (Agropyron smithii), blue grama (Bouteloua gracilis), buffalograss (Buchloe dactyloides), needleleaf sedge (Carex eleocharis), needle and thread (Stipa comata), and green needlegrass (Stipa viridula). Scarlet globemallow (Sphaeralcea coccinia), American vetch (Vicia americana), lanceleaf sage (Salvia reflexa), and prairie sunflower (Helianthus petiolaris) are the most abundant forbs; fringed sage (Artemisia frigida) is the dominant shrub.

Small rodents, vegetation, and macroarthropods were sampled in 1981 and 1982. Six permanent 80- by 80-m (0.64 ha) study sites were selected for sampling small rodent and macroarthropod densities and composition and vegetation characteristics. Three sites were established on prairie dog colonies and 3 sites on mixed-grass prairie adjacent to each prairie dog colony. The mixed-grass prairie sites were 200 to 1,000 m from the prairie dog colonies. Soils were fine, montmorillonitic, mesic Aridic Argiustolls of the Norrest-Blackpipe (silty clay loam) and Nunn (loam) series. Prairie dog colonies selected had similar burrow densities.

Estimates of small rodent (not including prairie dogs) densities were evaluated on unique captures from live trapping. Sixty-four Sherman live traps, spaced at 10-m intervals, were arranged in a grid design on each site. The grids were arranged so that a 10-m border of similar habitat surrounded each trapping grid. Trapping began in May and continued at 3-week intervals through September of each year. Each sample period consisted of 1 night of prebaiting followed by 4 consecutive nights of trapping. A mixture of peanut butter and rolled oats was used both inside and outside the traps to attract small rodents. Rodents were removed from the traps, identified as to species, assigned a unique number by toe amputation, then released at the capture site.

Fecal pellets were collected from small mammals captured in Sherman live traps, placed in paper envelopes and dried. The pellets were combined for each site by species and trap session. The arthropod composition in the diets was based on 40 points and 40 fields per sample (Flake 1973). The percentage of plants in rodent feces was estimated by the microhistological technique of Sparks and Malechek (1968). Invertebrates were identified by examining composite samples by species in a petri dish at 20 power magnification and plant identification at 100 power magnification.

Ground dwelling macroarthropods were sampled by using 15 x 15-cm metal can pitfall traps (Rogers et al. 1978). Forty-nine cans were buried flush with the soil surface in a grid at 10-m spacing on each site. Pit traps were set for 4 consecutive nights at three-week intervals. Wooden lids were used to cover the traps and removed when trapping was initiated. Macroarthropods were removed, classified and counted. Actual numbers per .1 hectare as reported were based on the area pitfall traps represented on each site and converted to the

hectare fraction (1/10 ha). Although this technique may underestimate less mobile arthropods and larvae (Thomas and Sleeper 1977) and flying arthropods, adequate results can be obtained for most species captured (Gist and Crossley 1973, Baars 1979).

Total plant canopy cover (2-dimensional) and annual aboveground biomass were estimated. Plant canopy cover was estimated in 150, 20 by 50-cm quadrats placed at 1-m intervals along 3, 50-m line transects at each site. Line transects were spaced 20 m apart. Canopy cover was visually estimated into 6 cover classes (Daubenmire 1959). Sampling was conducted in June (late spring), July (summer), and August (late summer) during 1981 and 1982. Aboveground biomass was calculated by harvesting 18, 1/8-m² circular plots each year at peak plant production on each site. In addition to sampling on grazed areas, small wire exclosures were established on prairie dog colonies and mixed grass sites in 1982 to determine the increased plant biomass with no grazing.

Factorial analyses of variance (Nie et al. 1975) were used to compare abundance of small rodents captured. One-way analyses of variance examined differences within year and treatment. Two-way analyses of variance included year by treatment. Paired T-tests were used for total percent canopy cover. Chi-square and Spearman's rank order correlation coefficient (Snedecor and Cochran 1973) were used to compare macroarthropods. Type I error level at $\alpha = 0.05$ was adapted for all tests unless stated otherwise.

RESULTS AND DISCUSSION

Small Rodents

Small rodent abundance was greater on prairie dog colonies than on mixed-grass sites (table 1). However, rodent species richness was higher ($P < 0.01$) on mixed-grass prairie sites than on the prairie dog colonies. Similar results were reported by O'Meila et al. (1982) in Oklahoma. Decreased plant canopy cover, mulch cover, biomass and vegetation height on prairie dog colonies influenced inhabitation by some small rodent species. Small rodents captured, in decreasing order of abundance, were deer mice (Peromyscus maniculatus), northern grasshopper mice (Onychomys leucogaster), prairie voles (Microtus ochrogaster), thirteen-lined ground squirrels (Spermophilus tridecemlineatus), western harvest mice (Reithrodontomys megalotis), hispid pocket mice (Perognathus hispidus), and house mice (Mus musculus). The abundance of small rodents did not vary significantly among seasons except for northern grasshopper mice.

Diet Analysis

Arthropods and plants (including seeds) were the major foods of rodents captured during the study (table 2). Arthropods represented 51% of small rodent diets on prairie dog colonies and 37% of rodent diets on mixed grass prairie sites. Arthro-

Table 1.--Mean¹ abundance (numbers/1000 trap nights) by years of small mammals on prairie dog colonies and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota during 1981 and 1982.

Species	1981		1982	
	Prairie Dog Colonies	Mixed Grass Prairie	Prairie Dog Colonies	Mixed Grass Prairie
deer mouse	17 ± 2 ^a	8 ± 3 ^b	41 ± 6 ^c	10 ± 3 ^b
northern grasshopper mouse	11 ± 2 ^a	4 ± 9 ^b	13 ± 3 ^a	2 ± 6 ^b
prairie vole	0 ± 0 ^a	<1 ± 1 ^a	0 ± 0 ^a	15 ± 2 ^b
thirteen lined ground squirrel	<1 ± 1 ^a	6 ± 2 ^b	<1 ± .07 ^a	5 ± .9 ^b
western harvest mouse	0 ± 0 ^a	1 ± .4 ^b	0 ± 0 ^a	3 ± .9 ^b
hispid pocket mouse	0 ± 0 ^a	1 ± .5 ^b	0 ± 0 ^a	2 ± .7 ^b
house mouse	<1 ± .07 ^a	<1 ± .07 ^a	<1 ± .07 ^a	0 ± 0 ^a
Total	28 ^a	20 ^b	54 ^c	37 ^d

¹Means within a row with the same superscript are not significantly different at (P < 0.01).

Table 2. Mean percentage of arthropods and vegetation in the diets of seven small rodents by season on prairie dog colonies and adjacent mixed-grass prairie sites in western South Dakota during 1981 and 1982.

Year	Late Spring				Summer				Late Summer			
	Prairie Dog Colonies		Mixed Grass		Prairie Dog Colonies		Mixed Grass		Prairie Dog Colonies		Mixed Grass	
	Arthropod	Vegetation	Arthropod	Vegetation	Arthropod	Vegetation	Arthropod	Vegetation	Arthropod	Vegetation	Arthropod	Vegetation
deer mouse												
1981	36.5	63.5	52.2	47.8	66.3	33.7	31.8	68.2	61.3	38.7	32.0	68.0
1982	15.3	84.7	53.3	46.7	51.8	48.2	13.0	87.0	55.4	44.6	78.9	21.1
Average	25.9	74.1(1)	52.8	47.2(2)	59.1	40.9(3)	22.4	77.6(4)	58.4	41.6(5)	55.5	44.5(6)
northern grasshopper mouse												
1981	48.8	51.2	56.0	44.0	82.5	17.5	42.2	57.8	45.8	54.2	58.2	41.8
1982	34.0	66.0	81.1	18.9	79.5	20.5	71.2	28.8	—	—	63.4	36.6
Average	41.4	58.6(7)	68.6	31.4(8)	81.0	19.0(9)	56.7	43.3(10)	—	—	60.8	39.2(11)
prairie vole												
1981			0.0	100.0			1.6	98.4			—	—
1982			17.0	83.0			19.8	80.2			44.3	55.7
Average			8.5	91.5(12)			10.7	89.3(13)			—	—
thirteen lined ground squirrel												
1981	29.7	70.3	33.4	66.6			51.8	48.2			32.0	68.0
1982	—	—	.8	99.2			65.8	34.2			49.5	50.5
Average	—	—	17.1	82.9(14)			58.8	41.2(15)			40.8	59.2(16)
western harvest mouse												
1981			79.0	21.0			15.0	85.0			77.8	22.2
1982			6.5	93.5			16.5	83.5			20.1	79.9
Average			42.8	57.2(17)			15.8	84.2(18)			49.0	51.0(19)
hispid pocket mouse												
1981			26.5	73.5			3.3	96.7			45.9	54.1
1982			—	—			1.0	99.0			2.4	97.6
Average			—	—			2.2	97.8(20)			24.2	75.8(21)
house mouse												
1981	0.0	100.0					9.5	90.5				
1982	—	—					—	—				
Average	—	—					—	—				

(1) % seeds is 42.4 (2) % seeds is 22.6 (3) % seeds is 34.0 (4) % seeds is 56.0 (5) % seeds is 30.2 (6) % seeds is 34.0 (7) % seeds is 35.0
 (8) % seeds is 25.0 (9) % seeds is 15.2 (10) % seeds is 25.6 (11) % seeds is 29.2 (12) % seeds is 15.0 (13) % seeds is 19.8 (14) % seeds is 48.8
 (15) % seeds is 16.6 (16) % seeds is 43.2 (17) % seeds is 51.6 (18) % seeds is 59.6 (19) % seeds is 32.8 (20) % seeds is 87.8 (21) % seeds is 68.3

pods were consumed in the greatest quantity during the summer of 1981 on prairie dog colonies (fig. 1). During the same sample period, arthropod composition was at a low on adjacent mixed grasslands. Arthropod composition on mixed grasslands was highest in the late summer of 1982 while arthropod composition on prairie dog colonies was lowest during the late spring of 1982. Generally, composition of arthropods during the late spring and late summer sampling periods were similar between prairie dog colonies and mixed grasslands, however arthropod composition on prairie dog

colonies increased significantly during the summer sampling period and decreased on mixed grasslands. Sieg et al. (1986) reported peak consumption of arthropods by deer mice occurring in the summer and the lowest consumption in the spring on bentonite mine spoils in Montana.

The most common arthropods in the diets of small rodents were of the orders Coleoptera, Hymenoptera, and Orthoptera (table 3). Johnson (1961) and Flake (1973) also reported the importance of these arthropods in small rodent diets in Idaho and Colorado, respectively.

The high proportion of arthropods consumed in this study (particularly prairie dog colonies) is related to the high density of carnivorous and omnivorous rodents occupying the area and is consistent with several studies (Johnson 1961, Whitaker 1966, Flake 1973, Hansen 1975, Hingtgen and Clark 1984, Sieg et al. 1986).

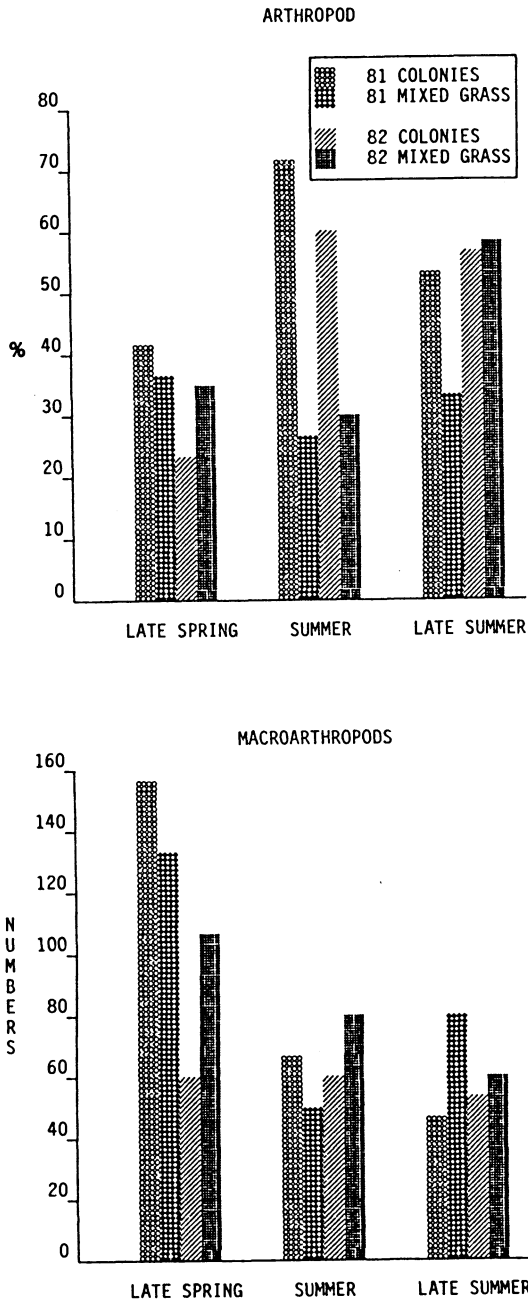


Figure 1.--Percent arthropod composition found in small mammal feces and mean abundance (numbers/.1 ha) of macroarthropods by season on prairie dog colonies and on adjacent mixed grass prairie without prairie dogs in western South Dakota during 1981 and 1982.

Table 3.--Composition of major arthropods found (%) in small rodent feces on prairie dog colonies and mixed grass prairie sites in western South Dakota during 1981 and 1982.

Arthropod Taxa	Prairie Dog Colonies	Mixed-Grass Prairie
Acari	0.6	0.0
Araneida	3.2	3.3
Coleoptera	61.2	37.9
Coleoptera larvae	0.0	0.3
Diptera	0.2	0.0
Hemiptera	0.0	0.3
Hymenoptera	16.1	25.4
Lepidoptera larvae	8.2	7.5
Orthoptera	9.5	20.9
Unknown	1.0	4.4
	<u>100.0</u>	<u>100.0</u>

Plants were consumed in greater quantity on mixed grass prairie sites having greater numbers of herbivorous small rodents. Composition of plant matter increased on prairie dog colonies from 1981 to 1982 while arthropod composition increased on mixed grasslands during the same period.

In 1981, vegetation standing crop averaged 1,024 kg/ha and 1,644 kg/ha on prairie dog colonies and mixed grasslands, respectively without cages. In 1982, the average production increased to 1,235 kg/ha and 3,177 kg/ha on prairie dog colonies and mixed grass sites. The increase in production was attributed to an increase in the amount of precipitation in 1982 (69%) over the same period in 1981. Precipitation in 1981 was 96% of normal. The average aboveground biomass in 1982 under wire exclosures was 1822 kg/ha (48% increase compared to outside exclosures) and 3111 kg/ha (2% decrease) on prairie dog colonies and mixed grass sites, respectively.

The increased plant biomass in exclosures on prairie dog colonies is not surprising as many studies have documented that prairie dogs clip vegetation in order to maintain an unimpeded watch for predators (Hall 1955, Koford 1958, Tileston 1961, Agnew 1983, Agnew et al. 1986). Plant canopy cover on mixed-grass prairie sites was significantly greater in late spring and late summer of 1982 compared to that on prairie dog colonies (fig. 2). Cover values were similar during 1981 and in summer 1982.

Macroarthropods

Macroarthropods are a dynamic but poorly understood component of the rangeland ecosystem (Hewitt et al. 1974). Macroarthropod captures on prairie dog colonies and mixed grasslands were highly variable throughout 1981 and 1982.

Borrer and DeLong (1971) reported macroarthropod distribution as species specific and highly variable between localities. O'Meilia et al. (1982) reported macroarthropod biomass was three times greater on areas without prairie dogs than on adjacent prairie dog colonies. Total macroarthropod densities in this study slightly favored mixed grasslands.

Macroarthropod numbers/.1 ha ranged from 156 in the late spring to 45 in the late summer in 1981 on prairie dog colonies (fig. 1). In 1982, the densities remained relatively constant at 61 in the late spring and summer, then declined to 52 in the late summer. Macroarthropods on mixed grass prairie sites ranged from 132 in the late spring trapping period to 50 in the summer and 79 in the late spring of 1981. This was the only instance where macroarthropod densities were greater ($P < .05$) in the late summer than the late spring or summer periods. In 1982, the abundance of macroarthropods ranged from a high of 107 in late spring to a low of 60 in the late summer. Total macroarthropod numbers for summer and late summer sample periods during both years were similar, however, overall macroarthropod taxa composition and abundance was quite different between sites (table 4).

A significant decrease in the number of macroarthropods captured in late spring 1982 may be related to above normal winter and spring moisture. Mills (1952) and Atkins (1976) reported that precipitation can act as a direct cause of insect mortality. Insect eggs and small larvae can be permanently washed from their host plants by heavy rain or may drown in saturated soils. Many other authors (Huddleston et al. 1975, Lavigne and Campion 1978, Thomas 1979) stressed the importance of reliable precipitation in the reproductive success of insects and for herbage production and subsequent food availability.

Sieg et al. (1986) reported an increase in arthropod consumption by deer mice during periods

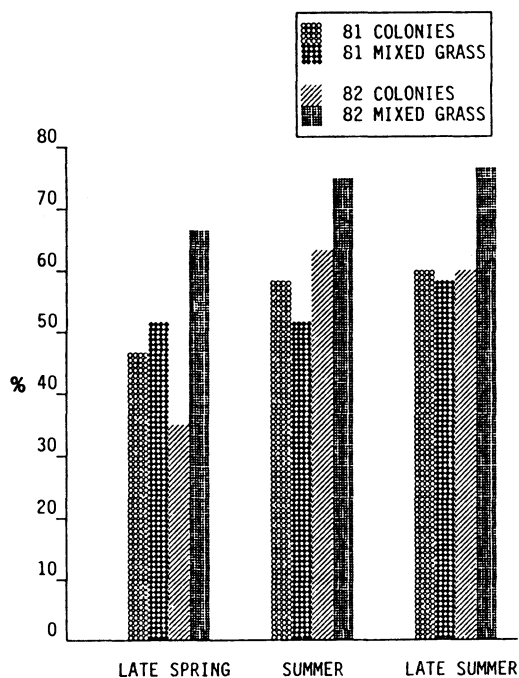


Figure 2.--Seasonal canopy cover of plants on prairie dog colonies and on adjacent mixed grass prairie without prairie dogs during 1981 and 1982.

Table 4.--Mean (\pm SE) abundance (numbers/.1 ha) of macroarthropods on prairie dog colonies and on adjacent mixed grass prairie sites without prairie dogs in western South Dakota during 1981 and 1982.

Macroarthropod taxa ¹	Prairie dog colony	Mixed grass prairie
<u>Class Insecta</u>		
Hymenoptera Formicidae	112 \pm 28	137 \pm 27
Coleoptera Histeridae	48 \pm 10	14 \pm 5
Coleoptera Carabidae	39 \pm 8	14 \pm 3
Coleoptera Tenebrionidae	18 \pm 4	21 \pm 5
Orthoptera Gryllidae	8 \pm 2	19 \pm 5
Diptera	5 \pm 1	12 \pm 6
Coleoptera Chrysomelidae	3 \pm 2	<1 \pm <1
Orthoptera Acrididae	2 \pm <1	16 \pm 6
Coleoptera Meloidae	1 \pm <1	<1 \pm <1
Lepidoptera	1 \pm <1	7 \pm 2
Coleoptera Silphidae	<1 \pm <1	5 \pm 2
Hemiptera Reduviidae	<1 \pm <1	2 \pm 2
<u>Class Arachnida</u>		
Aranedia Lycosidae	19 \pm 6	36 \pm 7
Aranedia Thomisidae	5 \pm 5	<1 \pm <1
Aranedia Clubionidae	2 \pm <1	2 \pm <1
Acarina	2 \pm 1	14 \pm 6
Araneida Theridiidae	2 \pm 2	1 \pm <1
Araneida Loxoscelidae	1 \pm 1	<1 \pm <1
<u>Class Crustacea</u>		
Isopoda	<1 \pm <1	2 \pm 1
<u>Class Chilopoda</u>		
	<1 \pm <1	<1 \pm <1
<u>Class Diplopoda</u>		
	<1 \pm <1	0
Total	267 ($\Sigma=33$)	295 ($\Sigma=36$)

¹Macroarthropods representing <1 per .1 ha include: Coleoptera Coccinellidae, Coleoptera Scarabaeidae, Hemiptera Lygaeidae, Coleoptera Curculionidae, Hymenoptera, Araneida Gnaphosidae, Hymenoptera Mutillidae, Hemiptera Anthocoridae, Hymenoptera Sphecidae, Coleoptera, Coleoptera Cerambycidae, Coleoptera Elateridae, Coleoptera Cinindelidae, Coleoptera Melyridae, Odonata, Phalangida.

of decreased moisture and plant production. Similarly, in this study, small rodents on prairie dog colonies increased arthropod consumption during periods of below normal precipitation, however, arthropod consumption decreased during periods of below normal precipitation on mixed grass prairie sites.

Higher than normal precipitation may have negatively impacted macroarthropod densities in 1982, however, the lower number of macroarthropods reported is also related to the near two fold increase in small rodents on prairie dog colonies and mixed-grass prairie sites.

Ants were the most commonly trapped macroarthropod on both treatments (table 4). Ant densities varied greatly between years and throughout the growing season, on and off of prairie dog colonies.

Ant abundance in late spring was higher ($P < .01$) on both prairie dog colonies and mixed grass sites in 1981 when compared to 1982. Other commonly trapped macroarthropods were beetles (Coleoptera), crickets and grasshoppers (Orthoptera), spiders (Araneida), flies (Diptera), butterflies and moths (Lepidoptera) and mites (Acarina). Macroarthropods trapped less frequently include true bugs (Hemiptera), daddy-long-legs (Phalangida), millipedes (Diplopoda), dragonflies (Odonata), saw bugs (Isopoda), and centipedes (Chilapoda).

The rank order of macroarthropod taxa on the two treatments was positively ($P < 0.1$) correlated ($r_s = .68$) for the two years. This indicates that composition (ranking) based on numbers of captures was somewhat correlated between the two treatments.

CONCLUSION

Prairie dogs act as ecosystem regulators by maintaining short-grass plant associations with less cover, lower vegetation height and production. These vegetative features, combined with high burrow densities, provide quality habitat for some species of small rodents, such as deer mice and grasshopper mice. However, vegetative manipulation by prairie dogs negatively impacts rodent species associated with dense vegetation of mixed-grass sites. The influence prairie dog activity has on the diets of small rodents inhabiting prairie dog colonies is evident in the greater percentage of arthropod fecal composition and the higher densities of insectivorous and omnivorous small rodents on prairie dog colonies. Yearly and seasonal differences in macroarthropod densities can be attributed to precipitation variations and associated vegetation changes and to increased small rodent densities.

Although the role of prairie dogs as ecosystem regulators is not fully accessed, these results indicate that prairie dogs influence small mammals, arthropods, and vegetation. Prairie dog control programs can influence the vegetation successional patterns on prairie dog colonies and create mixed grass plant associations. Associated prairie dog control impacts will also influence small rodents and arthropods common on prairie dog colonies.

LITERATURE CITED

- Agnew, W. 1983. Flora and fauna associated with prairie dog ecosystems. M.S. Thesis, Colorado State Univ., Ft. Collins.
- Agnew, W., D. W. Uresk, and R. M. Hansen. 1986. Flora and fauna associated with prairie dog colonies and adjacent ungrazed mixed grass prairie in western South Dakota. *J. Range Manage.* 39:135-139.
- Atkins, M. D. 1976. *Insects in perspective*, 1st ed. Macmillan Pub., NY.
- Baars, M. A. 1979. Catches in pitfall traps in relation to mean densities of carabid beetles. *Oecologia* 42:25-46.
- Borror, D. J., and D. M. DeLong. 1971. *An introduction to the study of insects*, 3rd ed. Holt, Rinehart and Winston, Inc., NY.
- Collins, A. R., J. P. Workman, and D. W. Uresk. 1964. An economic analysis of prairie dog (*Cynomys ludovicianus*) control. *J. Range Manage.* 37:358-361.
- Daubenmire, R. 1959. A canopy cover method of vegetational analysis. *Northw. Sci.* 33:43-65.
- Flake, L. P. 1973. Food habits of four species of rodents on a shortgrass prairie in Colorado. *J. Mammal.* 54:636-647.
- Gist, C. S., and D. A. Crossley. 1973. A method for quantifying pit-fall trapping. *Env. Ent.* 3:951-952.
- Hall, E. R. 1955. *Prairie dog*. Handbook of the mammals of Kansas. Univ. Kansas Misc. Publ., Mus. Natur. Hist. 7:67-69.
- Hall, E. R. 1981. *The mammals of North America*, 2nd ed. John Wiley and Sons, N.Y.
- Hansen, R. M. 1975. Plant matter in the diet of onychomys. *J. Mammal.* 56:530-531.
- Hansen, R. M., and I. K. Gold. 1977. Blacktail prairie dogs, desert cottontails and cattle trophic relations on shortgrass range. *J. Range Manage.* 30:210-214.
- Hewitt, G. B., E. W. Huddleston, R. J. Lavigne, D. M. Ueckert, and J. G. Watts. 1974. *Rangeland entomology*. Soc. Range Manage. Sci. Series 2:127.
- Hingtgen, T. M., and W. R. Clark. 1964. Impact of small mammals on the vegetation of reclaimed land in the northern Great Plains. *J. Range Manage.* 37:438-441.
- Huddleston, E. W., R. A. Shaw, and M. V. Riggs. 1975. Insect population dynamics studies of the Pantex Site, 1972. U.S. International Program, Grassland Biome, Tech. Rep. No. 260. Nat. Res. Ecol. Lab. Colo. St. Univ., Fort Collins. 44 p.
- Johnson, D. R. 1961. The food habits of rodents on rangelands of southern Idaho. *Ecology* 42:407-410.
- Koford, C. B. 1956. *Prairie dogs, whitefaces, and blue grama*. Wildl. Monogr. 3.
- Lavigne, R. J., and M. K. Champion. 1976. The effect of ecosystem stress on the abundance and biomass of carabidae (Coleoptera) on the shortgrass prairie. *Environ. Entomol.* 7:86-92.
- Merriam, C. J. 1902. The prairie dog of the great plains. *USDA Yearb.* 1901:257-270.
- Mills, H. B. 1952. *Weather and climate*. U.S. Dept. Agr. Yearb. 1952:422-429.
- Nie, N. H., C. H. Hall, J. G. Jenkins, K. Steinbrenner, and D. H. Bent. 1975. *SPSS: statistical package for the social sciences*. 2nd ed. McGraw-Hill, Pub. NY.
- O'Mealla, N. E., F. L. Knopf, and J. C. Lewis. 1982. Some consequences of competition between prairie dogs and beef cattle. *J. Range Manage.* 35:580-585.
- Raymond, W. H., and R. U. King. 1976. *Geologic map of the Badlands National Monument and vicinity, west-central South Dakota*. U.S. Geol. Survey. Map I-934.
- Rogers, L. E., N. Woodley, J. K. Sheldon, and V. A. Uresk. 1976. Darkling beetle populations (Tenebrionidae) of the Hanford Site in

- southcentral Washington. Battelle-Northwest. PLN-2465. Richland, WA 108 p.
- Sieg, C. H., D. W. Uresk, and R. M. Hansen. 1986. Seasonal diets of deer mice on bentonite mine spoils and sagebrush grasslands in southeastern Montana. *Northw. Sci.* 60:81-89.
- Snedecor, G. W., and W. G. Cochran. 1973. *Statistical methods*. 6th ed. Iowa State Univ. Press, Ames.
- Sparks, D. R., and J. C. Malecheck. 1968. Estimating percentage dry weight in diets using a microscope technique. *J. Range Manage.* 21:264-265.
- Thomas, B., Jr., and E. L. Sleeper. 1977. The use of pitfall traps for estimating the abundance of arthropods, with special reference to the Tenebrionidae (Coleoptera). *Ann. Ent. Soc. Amer.* 70:242-248.
- Thomas, B., Jr. 1979. Patterns in the abundance of some tenebrionid beetles in the Mojave desert. *Environ. Entomol.* 8:568-574.
- Tileston, J. V. 1961. Comparison of white-tailed prairie dog town with a black-tailed prairie dog town in north-central Colorado. M.S. Thesis, Colorado State Univ., Fort Collins.
- Uresk, D. W., J. G. MacCracken, and A. J. Bjugstad. 1981. Prairie dog density and cattle grazing relationships. p. 199-201. In: *Fifth Great Plains Wildl. Damage Control Workshop. Proc.* Oct. 13-15, 1981. Univ. Nebraska, Lincoln.
- Uresk, D. W., and A. J. Bjugstad. 1983. Prairie dogs as ecosystem regulators on the Northern High Plains. p. 91-94. In: *Seventh North Amer. Prairie Conference*, Aug. 4-6, 1980. Southwest Missouri State Univ., Springfield.
- Whitaker, J. O. 1966. Food of *Mus musculus*, *Peromyscus maniculatus bairdi*, and *Peromyscus leucopus* in Vigo County, Indiana. *J. Mammal.* 47:473-486.