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THE ANNUAL CYCLE OF THE MEXICAN PRAIRIE DOG (*CYNOMYS MEXICANUS*)

JULIÁN TREVIÑO-VILLARREAL[1]

Mexican prairie dogs (*Cynomys mexicanus* Merriam, 1892) (Fig. 1), or "perritos llaneros," are endemic to northeastern Mexico (Ceballos-G. and Wilson, 1985) with a restricted, relictual distribution of less than 800 square kilometers in the Mexican states of Coahuila, Nuevo León, San Luis Potosi, and Zacatecas (Fig. 2). The species is confined to valleys, prairies, and intermontane basins at elevations between 1600 and 2000 m.

Where it occurs, *Cynomys mexicanus* plays an important ecological and economic role, both as a link in the food chain and as a modifier of soil structure through fossorial activity. Prairie dogs are considered to be pests by many cattle raisers and agriculturists. Jiménez-Guzmán (1976) reported that farmers and ranchers from Tokio, Galeana, Nuevo León, frequently shot and poisoned prairie dogs. Also, placing obstacles such as tree branches in burrow openings is often an effective and inexpensive control method.

Little biological information is available on *C. mexicanus*, except for a single laboratory study of growth (Pizzimenti and McClenaghan, 1974). Mexican prairie dogs are listed as vulnerable by the IUCN and as endangered by the USDI, and the species is on Appendix I of CITES (Nowak and Paradiso,

[1]Division of Mammals, Museum of Natural History, Dyche Hall, and Department of Systematics and Ecology, Haworth Hall, The University of Kansas, Lawrence, Kansas 66045-2454, USA. Present address: División de Recursos Naturales, Instituto de Ecología y Alimentos, Universidad Autónoma de Tamaulipas, 13 Boulevard Adolfo López Mateos 928, Ciudad Victoria, Tamaulipas, México.

Fig. 1. A Mexican prairie dog (*Cynomys mexicanus*) in summer pelage.

1983). The purpose of this study was to gather baseline information on the reproduction, growth, development, molt patterns, and colony organization of *Cynomys mexicanus*.

METHODS AND MATERIALS

A colony of Mexican prairie dogs occupying a 9.55 ha area was chosen for study. Sixty-four animals (18 adults or adult-size yearlings, 25 young born in late May 1985 that became yearlings in mid-May 1986, and 21 young born in early March 1986) were trapped over 24 sampling periods (Table 1), marked, and released from early October 1985 to late September 1986. In the analyses reported below, the 18 adult-size animals captured from October 1985 to April 1986 were assumed to represent adults, although some may have been yearlings that had already achieved adult size. Thirty-six additional animals (5 adults or adult-size yearlings and 35 young born in late January 1987) were also marked and released from early October 1986 to late January 1988. Colony residents were captured in National live traps baited with whole oats and alfalfa. Prairie dogs residing outside the study colony were captured by flooding their burrows and capturing them as they emerged. Every trapped individual was marked with Nyanzol-A fur dye (Fitzwater, 1943) for field identification and with a numbered tag in each ear. Any lost ear tags were

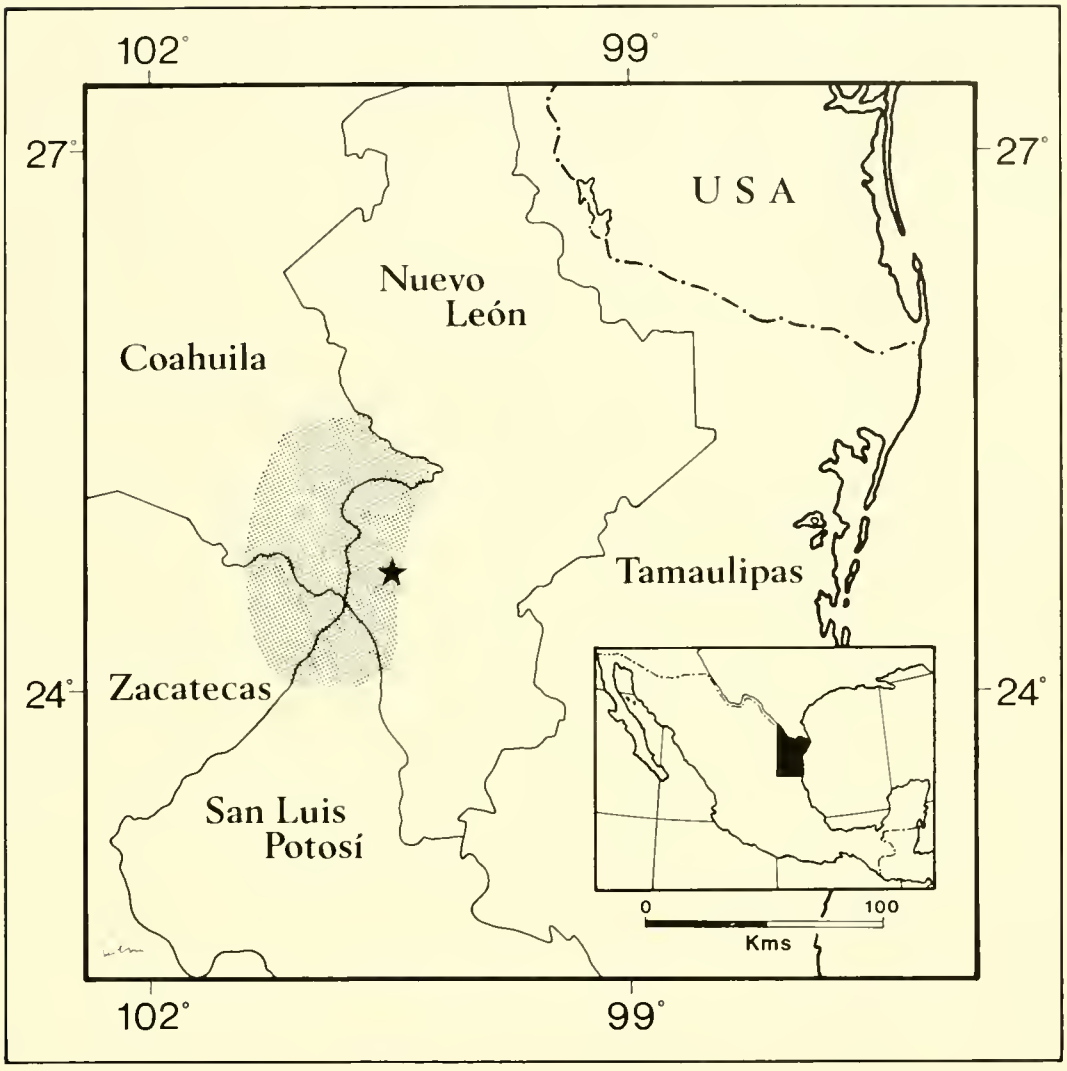

Fig. 2. The distribution of the Mexican prairie dog (*Cynomys mexicanus*). The star (★) indicates the location of the study site at El Tokio, Nuevo León, Mexico.

replaced upon next capture. Before release, each animal was examined to determine its sex, reproductive status, weight, tail length, and details of pelage condition. All active burrows in the study colony were mapped to facilitate recording of movement. Weather data (precipitation, temperature, days of frost) were recorded at the study site. Long-term weather trends were obtained from three nearby weather stations. Weather data from 1985 to September 1986 were obtained from the El Potosi weather station. Weather data from October 1986 to January 1988 were obtained from the Rancho San Roberto weather station, which has a similar climatic pattern to the closer El Potosi weather station; the El Potosi weather station has not issued a weather report since October 1985.

Vegetation was sampled on randomly distributed 1 m^2 exclosures. Vegetation samples, cut to 3 cm above the soil surface, and notes on vegetative growth were made every month from November 1985 to October 1986. Dry weight

Table 1. Dates of sampling of a colony of Mexican prairie dogs from El Tokio, Galeana, Nuevo León, Mexico.

Sampling period	Date	Sampling period	Date
1	16–19 October 1985	13	18–23 July 1986
2	4–8 November 1985	14	8–13 August 1986
3	25–29 November 1985	15	6–10 September 1986
4	16–21 December 1985	16	25–29 September 1986
5	20–25 January 1986	17	20 December 1986
6	12–17 February 1986	18	27–28 January 1987
7	4–10 March 1986	19	21 February 1987
8	24–29 March 1986	20	11–13 April 1987
9	14–18 April 1986	21	1–4 June 1987
10	5–7 May 1986	22	23–25 August 1987
11	25–29 May 1986	23	11–15 October 1987
12	13–16 June 1986	24	20–22 January 1988

of vegetation was obtained by oven-drying samples at 60°C for 48 hours. Percent ground cover was estimated by using a Modified Step Transect Method called "100 in 500" (Avalos-Marín, in prep.). Transects of 500 steps were traversed, and notes on vegetation were taken at contact points every 5 steps.

Percentage vegetative cover was obtained by the formula:

$$\% \text{ Cover} = \frac{\text{Total number of plant contacts} \times 100}{\text{Total number of points}}.$$

Prairie dogs were placed in three age classes (Rayor, 1985): (1) young, during the first summer of life; (2) yearlings, during the second summer of life; and (3) adults, two years of age or older.

For emergent young, means of measurements for the total litter and for each sex were plotted against estimated age in days (using the technique of Pizzimenti and McClenaghan, 1974). Student's *t*-tests were used to test sexual dimorphism. The instantaneous growth rate (IGR) was calculated for each phase of constant growth (Brody, 1945).

DESCRIPTION OF THE STUDY SITE

Ejido El Tokio ("Ejido" is an agricultural unit, established by Mexican law, which cannot exceed 10,000 ha) is located in Galeana County, Nuevo León,

Mexico, at 24°38' to 24°44' N and 100°11' to 100°17' W. Mean elevation is 1865 m. Ejido El Tokio is in the Sierra Madre Oriental geomorphic zone, and sediments from the Upper Jurassic, Lower Cretaceous, and Middle Cretaceous occur there (Mulleried, 1944). The soil of the study area is a xerosol (DETENAL, 1975), characterized by a soft, saline surface horizon.

Grasslands at Ejido El Tokio can be classified into three zones (DETENAL, 1975). Zone I was relatively undisturbed, and Mexican prairie dogs were abundant. The 9.55 ha study site, located in this zone, was a halophyte grassland (DETENAL, 1975) dominated by *Muhlenbergia villiflora* and *Frankenia gypsophila*. Annuals began appearing by April in 1986 (Avalos-Marín, in prep.). Small patches of shrubs such as *Koeberlinia spinosa*, *Opuntia imbricata*, *Larrea tridentata*, and *Condalia ericoides* also occurred in this zone (Treviño-Villarreal, 1981). Zone II also was a halophyte grassland (DETENAL, 1975) dominated by *Muhlenbergia villiflora*, *Aristida barbata*, *Frankenia gypsophila*, and *Bouteloua chasei* (Fig. 3). Annuals began appearing by May in 1986 (Avalos-Marín, in prep.). All of the species of shrubs found in Zone I also occurred in Zone II (Treviño-Villarreal, 1981). In late January 1988, the study site and most of Zone I were plowed, and the entire colony of Mexican prairie dogs disappeared. In Zone II agriculture has spread rapidly in recent years, and populations of Mexican prairie dogs are being limited by human control. Zone III contains most of the human population of the Ejido, and the area is devoted solely to agriculture. Mexican prairie dogs no longer live in Zone III. Old residents of El Tokio say that Mexican prairie dogs were

Fig. 3. Grassland Zone II. Cerro San Juan is on the left.

numerous in this region before extensive agriculture was established. Zone III was so altered by agriculture that native vegetation no longer occurred there (DETENAL, 1975).

Climate

Two subtypes of climate occur on the grasslands of El Tokio, according to the Secretaría de Programación y Presupuesto climate map (SPP, 1981), which is based on a Köppen climate classification as modified by García (1973). Zones I and III have a climate classified as BS_1 kx' and belong to the temperate semi-dry climate subtype. Zone II has a climate classified as BS_0 kx' and belongs to the temperate dry climate subtype. A second type, Cx' (cold dry climate), occurs in the area occupied by desert thicket and montane vegetation of the Ejido.

General weather trends were obtained from the weather stations nearest each zone—El Potosi and Rancho San Roberto (temperate semi-dry), and Raices (temperate dry). Two short periods of rainfall, one in August and the other from October to January, occur in Zones I and III. Precipitation occurs in an irregular manner and is often torrential. December is the wettest month of the year with 45.9 mm of precipitation, while March is the driest with 6.8 mm. The annual mean temperature is 16.2°C. In Zone II a pronounced dry season occurs from October to April. Precipitation in this zone is also irregular and often torrential. August is the wettest month with 44.0 mm of precipitation and March is the driest with 11.6 mm. The annual mean temperature is 16.7°C. Frost occurred on the study site between 5 November 1985 and 27 March 1986 (Treviño-Villarreal, 1988).

RESULTS

Reproduction

By the third week of December 1985 all three adult male prairie dogs captured on the study site had begun to exhibit scrotal testes. All five captured in the last week of January 1986 had fully scrotal testes. Testes of adult males remained enlarged until mid-July 1986. Likewise, all six young male Mexican prairie dogs born in late May 1985 had enlarged testes by the end of March 1986, and they remained enlarged until mid-July. In contrast, young male prairie dogs born in early March 1986 did not exhibit enlarged testes during the reproductive season of 1986.

Adult female prairie dogs had well-developed nipples and swollen vulvae from mid-February to mid-June 1986, when nipples regressed to a barely visible state and vulvae exhibited almost no swelling. Yearling and young female prairie dogs never displayed nipple or vulvar development during the reproductive season of 1986.

Seven of eight marked adult females had litters of young in 1986, with a total of 28 young emerging above ground (Table 2). The number of emergent young per litter averaged 4.0 for 1986. Emergence of young began in mid-April 1986. The mean age for the young at first capture was estimated to be 45 days (range, 43–47), suggesting that they were born by early March 1986. A young male prairie dog, not caught at the study site but in the same zone, was the same age as the young on the study site.

In contrast, a young male captured in Zone II on 1 July 1986 was estimated to be 31 days old, suggesting birth in late May 1986. A male and a female young, captured in Zone II on 19 July 1986, were estimated to be 49 days old, suggesting birth at the end of May. These age data suggest that prairie dogs in Zone II bred about 2½ to 3 months later than those in Zone I in 1986. Two adult and seven yearling Mexican prairie dogs captured on the study site by the second week of April 1987 exhibited fully scrotal testes. In contrast, young male prairie dogs that were born in late January 1987 did not develop scrotal testes in their first year of life. Adult and yearling female prairie dogs had well-developed nipples and swollen vulvae from mid-April to early June 1987.

All 6 adult and 14 yearling females marked in 1987 had litters of young,

Table 2. Numbers of lactating females, litters, and sexes of captured young, by groups, in 1986 and 1987. See text for further discussion of groups.

Group	Lactating			Young				Mean no.
no.	Adults	Yearlings	Litters	♂	♀	Unmarked	Total	young/litter
				1986				
I	4	—	4	6	7	3	16	4.0
II	1	—	1	1	2	1	4	4.0
III	0	—	0	0	0	0	0	0
IV	1	—	1	2	2	0	4	4.0
V	1	—	1	0	1	3	4	4.0
VI	0	—	0	0	0	0	0	0
Total	7	—	7	9	12	7	28	4.0
				1987				
I	3	5	8	9	5	23	37	4.6
II	0	2	2	1	0	7	8	4.0
III	0	2	2	1	2	7	10	5.0
IV	1	3	4	4	3	12	19	4.8
V	1	1	2	1	0	7	8	4.0
VI	1	1	2	6	3	0	9	4.5
Total	6	14	20	22	13	56	91	4.5

with a mean litter size of 4.5 (Table 2). The mean age of young at first capture at the study site was estimated to be 74 days (range, 69–79), implying birth by late January 1987. The mean age of seven male and five female young in Zone I first captured on 3 and 16 October 1985 was estimated from weight and tail length data (Table 3) to be 130 days, corresponding to a birth date of late May 1985. While this estimate is subject to more variation than estimates of age of younger *Cynomys*, it suggests that mean date of breeding in Zone I varied by several months from year to year.

Size and Growth

Young

Body weight and tail length were recorded from 104 Mexican prairie dogs at the study site, and 10 additional animals from four other localities. Young males born in late May 1985 were always heavier than females (Table 4). The mean weight of young males and young females did not differ significantly from mid-October 1985 to early March 1986, except for 191 days of age (mid-December 1985; $t = 3.1$, $P < 0.02$). The difference became statistically significant at 288 days of age (late March 1986; $t = 2.2$, $P < 0.05$). Sexual dimorphism of tail length of these young Mexican prairie dogs was statistically significant at 269 days of age with male tails being 5.6% longer than those of females (early March 1986; $t = 2.3$, $P < 0.05$).

The mean weight of young males born in early March 1986 ($n = 9$) always exceeded that of females ($n = 12$). The difference became statistically significant at day 140 (mid-July 1986; $t = 2.3$, $P < 0.05$), when males averaged 69.4 g

Table 3. Mean weights and tail lengths of young male and female Mexican prairie dogs (cohort born early March 1986) from mid-April 1986 to late September 1986. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling period	Mean weight (g)[a]		Mean tail length (mm)	
	Young ♂♂	Young ♀♀	Young ♂♂	Young ♀♀
9	159.6±25.2(5)	141.4±12.4 (5)	56.2±2.8(5)	54.0±6.7 (5)
10	244.2±27.8(9)	235.7±21.2(10)	69.8±4.9(9)	68.3±3.0(10)
11	404.1±31.2(8)	396.0±22.7 (7)	83.0±5.1(8)	81.7±3.9 (7)
12	524.5±37.6(6)	479.6±32.4 (9)	92.8±4.0(6)	88.1±3.7 (9)
13	713.8±48.3(8)	644.4±34.2 (9)	105.8±3.5(8)	97.1±2.7 (9)
14	812.9±66.5(8)	686.1±46.4 (7)	106.3±3.4(8)	98.0±3.8 (7)
15	957.2±67.0(6)	819.7±43.1 (6)	108.0±3.7(6)	100.2±2.0 (6)
16	987.3±65.4(7)	863.0±37.5 (7)	108.0±2.9(7)	101.4±1.8 (7)

[a] ± 95% confidence limits

Table 4. Mean weights and tail lengths of young male and female Mexican prairie dogs (cohort born late May 1985) from mid-October 1985 to late May 1986. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling	Mean weight (g)[a]		Mean tail length (mm)	
period	Young ♂♂	Young ♀♀	Young ♂♂	Young ♀♀
1	635.9±45.0(7)	608.0±84.3(5)	83.4±12.1(7)	83.4±3.8(5)
2	661.8±47.9(8)	625.1±54.2(7)	88.9± 4.9(8)	81.9±6.1(7)
3	683.6±48.1(8)	630.4±41.4(8)	94.3± 3.5(8)	87.8±3.9(8)
4	699.3±73.1(4)	593.0±28.3(6)	94.8±13.4(4)	87.8±3.7(6)
5	672.4±49.7(8)	643.0±35.9(8)	96.1± 5.9(8)	90.0±3.3(8)
6	693.0±41.4(7)	674.3±45.1(7)	99.6± 7.3(7)	94.3±2.4(7)
7	764.4±32.8(7)	730.5±27.6(6)	102.3± 2.4(7)	95.0±2.5(6)
8	797.2±61.2(6)	718.0±38.6(7)	104.2± 1.2(6)	98.7±3.8(7)
9	851.6±69.5(7)	733.7±45.7(7)	103.7± 2.2(7)	99.0±3.8(7)
10	865.8±61.4(7)	733.0±70.9(6)	103.7± 2.2(7)	100.7±4.0(6)
11	885.9±56.3(7)	755.5±56.2(6)	104.1± 2.1(7)	102.0±2.5(6)

[a] ± 95% confidence limits

heavier than females. Sexual dimorphism of tail length also was significant at day 140 ($t = 3.8$, $P < 0.01$) (Table 3).

The mean weight of young males born in late January 1987 ($n = 22$) always exceeded that of females ($n = 13$); the difference became statistically significant at day 126 (early June 1987; $t = 2.4$, $P < 0.05$). At this age males averaged 101.3 g heavier than females (Table 5).

The combined instantaneous growth rates (IGR) of young males and females born in early March 1986 generally decreased with age; however, there were some exceptions (Table 6). The combined IGR of young males and females born in late January 1987 decreased with age (Table 7).

Table 5. Mean weights and tail lengths of young male and female Mexican prairie dogs (cohort born late January 1987) from mid-April 1987 to late January 1988. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling	Mean weight (g)[a]		Mean tail length (mm)	
period	Young ♂♂	Young ♀♀	Young ♂♂	Young ♀♀
20	343.2± 22.6 (9)	320.4± 36.8 (5)	73.9±3.9 (9)	69.6± 3.4(5)
21	685.5± 45.0(10)	584.2± 75.1 (5)	97.7±4.0(10)	92.6± 4.6(5)
23	866.7± 68.1(10)	788.7±126.2(7)	99.5±3.0(10)	92.3± 7.1(7)
24	815.3±144.2 (4)	719.0±147.2(4)	99.8±2.7 (4)	94.3±11.5(4)

[a] ± 95% confidence limits

Table 6. Instantaneous growth rates of weights and tail lengths of young Mexican prairie dogs (cohort born early March 1986) from mid-April 1986 to late September 1986 calculated using the technique of Brody (1945).

Age (days)	Rate (%)		
	Young ♂♂& ♀♀	Young ♂♂	Young ♀♀
	Weight		
45–65	2.35	2.15	2.55
65–86	2.43	2.38	2.48
86–104	1.25	1.44	1.05
104–140	0.85	0.86	0.83
140–162	0.43	0.59	0.27
162–190	0.61	0.57	0.64
190–209	0.21	0.16	0.26
	Tail length		
45–65	1.13	1.10	1.15
65–86	0.84	0.81	0.84
86–104	0.56	0.61	0.50
104–140	0.31	0.36	0.25
140–162	0.05	0.05	0.05
162–190	0.04	0.04	0.04
190–209	0.05	0	0.10

Table 7. Instantaneous growth rates of weights and tail lengths of young Mexican prairie dogs (cohort born late January 1987) from mid-April 1987 to late January 1988 calculated using the technique of Brody (1945).

Age (days)	Rate (%)		
	Young ♂♂& ♀♀	Young ♂♂	Young ♀♀
	Weight		
74–126	1.24	1.15	1.33
126–257	0.20	0.22	0.18
257–357	–0.08	–0.09	–0.06
	Tail length		
74–126	0.58	0.58	0.58
126–257	0	0	0
257–357	0	0	0

Yearlings

The minimum mean weight of yearling (1986 cohort) males and females in 1986 occurred in mid-June, and the maximum occurred in late September, indicating continuing growth during June, July, August, and September (Table 8).

The minimum mean weight of yearling (1987 cohort) males occurred in late January 1988, whereas the maximum mean was in late August 1987 (Table 9). The lowest mean weight of yearling (1987 cohort) females occurred in early June 1987 and the maximum in late August 1987.

Sexual dimorphism of tail length was not significant at any date. Among 17 yearlings captured from mid-June to late September 1986, males were heavier and had longer tails than females (Table 8). Among 12 yearlings captured from mid-April 1987 to late January 1988, males were heavier and had longer tails than females (Table 9).

Adults

The lowest mean weight of adult males occurred in mid-February 1986, while the highest mean weight was found in late December 1986 (Table 10). The minimum mean weight of adult females occurred in early May 1986 and the maximum mean weight occurred in late January 1987 (Table 10). Variation in mean weight of adults during this study reflects seasonal variation, but because samples varied in size and individual composition, similar trends were not always seen when trajectories of weight of individuals caught in different capture periods were calculated (Table 11).

Tail lengths and weights of adult males and females differed significantly (Table 12). Adult males had longer tails than females during the study (Table

Table 8. Mean weights and tail lengths of yearling male and female Mexican prairie dogs (cohort born late May 1985) from mid-June 1986 to mid-April 1987. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling	Mean weight (g)[a]		Mean tail length (mm)	
period	Yearling ♂♂	Yearling ♀♀	Yearling ♂♂	Yearling ♀♀
12	913.8± 48.0 (6)	843.0±196.0(2)	105.8±3.9 (6)	104.5±2.9 (2)
13	980.0± 28.1 (5)	898.0± 58.8(5)	104.6±4.0 (5)	106.6±7.5 (5)
14	1053.0± 82.1 (7)	956.3± 26.7(6)	106.1±2.7 (7)	104.7±2.4 (6)
15	1072.5± 78.7(10)	1005.0± 28.8(6)	104.8±2.6(10)	107.5±2.7 (6)
16	1166.3± 96.1 (6)	1034.7± 38.0(6)	107.3±3.4 (6)	105.0±3.7 (6)
20	1093.0±104.0 (4)	981.3± 53.9(6)	108.0±1.8 (4)	106.0±1.0 (6)

[a] ± 95% confidence limits

Table 9. Mean weights and tail lengths of yearling male and female Mexican prairie dogs (cohort born early March 1986) from mid-April 1987 to late January 1988. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling	Mean weight (g)[a]		Mean tail length (mm)	
period	Yearling ♂♂	Yearling ♀♀	Yearling ♂♂	Yearling ♀♀
20	1143.0± 98.0(3)	955.0±84.2(5)	108.1±1.7(3)	101.4±0.7(5)
21	1123.7± 89.0(3)	884.0±44.9(5)	108.0±1.7(3)	99.6±1.5(5)
22	1260.0 (1)	1060.0 (1)	108.0 (1)	103.0 (1)
23	1223.0±137.2(2)	1002.2±69.8(6)	106.5±1.5(2)	100.5±1.5(6)
24	1064.0 (1)	929.0±42.7(3)	105.0 (3)	98.3±2.9(3)

[a] ± 95% confidence limits

10), and they were also heavier than females, except when females were pregnant and in early lactation (for example, from mid-February to late March 1986 and late December 1986 to late February 1987).

Weight Variation

Yearling (1986 cohort) and adult weights did not differ significantly by mid-June in females and late July in males. Yearling (1987 cohort) and adult weights did not significantly differ by mid-April 1987. Mean weight of adult males exceeded that of females during most of this investigation, the only exceptions being from mid-February to late March 1986 and in late February 1987 (Table 11).

Patterns of Molt

There were two complete pelage renewals (winter and summer) and two transition pelage periods (spring and autumn) from early October 1985 to late September 1986.

Winter pelage, worn from late September to mid-March, was characterized by long, soft guard hairs. The spring transition pelage was characterized by shedding of winter hairs and the appearance of short, coarse summer hair in an anterior–posterior direction. This pelage lasted from late March to late May in most adults. However, in most young born in late May 1985, the transition pelage terminated in early May 1986, just before they became yearlings (Table 13). During April 1986, the pelage of young that were born in early March 1986 also could be considered transitional (Table 13). In these young the renewal of pelage from winter to summer was in a posterior–anterior pattern, instead of the anterior–posterior pattern seen in adults.

Table 10. Mean weights and tail lengths of adult male and female Mexican prairie dogs from mid-October 1985 to late January 1988. See Table 1 for dates of sampling periods. (Sample size given in parentheses.)

Sampling	Mean weight (g)[a]		Mean tail length (mm)	
period	Adult ♂♂[b]	Adult ♀♀	Adult ♂♂	Adult ♀♀
1	918.0± 28.3(4)	851.3± 43.2 (3)	96.3± 8.8(4)	76.7± 9.6 (3)
2	951.3± 16.3(3)	843.0± 00.0 (2)	96.7±12.4(3)	89.0±11.8 (2)
3	938.0± 50.0(5)	830.5± 25.0 (4)	95.6± 7.1(5)	95.5± 3.0 (4)
4	934.7± 43.2(3)	830.5± 17.7 (2)	99.3±12.0(3)	90.5± 8.8 (2)
5	913.0± 66.5(5)	836.8± 46.4 (4)	98.2± 8.3(5)	95.0± 3.4 (4)
6	824.3± 32.9(5)	873.0± 50.0 (5)	101.8± 6.1(5)	95.4± 6.4 (5)
7	926.4± 43.2(3)	947.2± 19.7 (6)	105.4±10.3(3)	93.7± 6.3 (6)
8	898.0± 59.7(5)	914.4± 34.5 (7)	102.6± 6.5(5)	93.6± 5.8 (7)
9	948.0± 52.3(5)	838.8± 65.0 (6)	102.6± 6.5(5)	97.8± 6.3 (6)
10	895.0± 78.2(5)	756.3± 70.7 (6)	102.6± 6.5(5)	97.2± 6.4 (6)
11	936.8± 23.5(4)	775.8± 25.6 (9)	101.3± 3.8(4)	97.6± 4.7 (9)
12	976.8± 34.3(4)	797.0± 15.8 (5)	105.3± 7.3(4)	99.6± 7.5 (5)
13	1038.0± 82.3(4)	909.7± 40.8 (6)	106.0± 7.8(4)	98.8± 6.8 (6)
14	1065.0± 59.6(5)	931.3± 35.2 (6)	104.8± 6.6(5)	100.5± 8.9 (6)
15	1095.0± 94.8(5)	991.0± 35.5 (6)	105.5± 6.1(5)	100.5± 8.9 (6)
16	1151.3±126.7(4)	1079.0± 58.4 (5)	102.3± 2.7(4)	101.2± 4.7 (5)
17	1303.0 (1)	1313.0 (1)	101.0 (1)	107.0 (1)
18	1001.0±199.9(2)	1343.0 (1)	100.0± 1.0(2)	107.0 (1)
19	1143.0 (1)	1293.0± 19.6 (2)	101.0 (1)	106.5± 0.5 (2)
20	1133.0±156.8(2)	1011.3±118.3 (6)	103.0± 2.0(2)	101.5± 1.9 (6)
21	1089.0± 51.4(5)	956.6± 50.9(11)	107.2± 2.6(5)	101.3± 2.4(11)
22	1122.0± 72.7(5)	1082.0± 83.0 (4)	106.4± 2.4(5)	105.3± 0.6 (4)
23	1085.9± 72.4(7)	1030.5± 69.7(10)	105.3± 1.6(7)	103.1± 2.4(10)
24	981.5± 73.5(2)	894.0± 67.9 (3)	101.5± 0.5(2)	106.3± 0.9 (3)

[a] ± 95% confidence limits

[b] Adults and yearlings before April 1986; all adults thereafter

Summer pelage was characterized by short, coarse hair. Adults displayed this pelage from early June to late August. Summer pelage was found in yearlings from late May to late August. In young that were born in early March 1986, summer pelage occurred from early May to late July (Table 13). The summer–winter pelage transition was characterized by the appearance of long, soft hair in an anterior–posterior direction in prairie dogs of all ages. The transition period was brief, from early September to mid-September in adults and yearlings, and from early August to mid-September in young (Table 13).

Table 11. Variation in weight of adult Mexican prairie dogs from mid-October 1985 to late January 1988. See Table 1 for dates of sampling periods.

Sampling period	Adult ♂♂[a]			Adult ♀♀[a]		
	$\bar{x}_i \pm 1 - \bar{x}_i$[b]	D[c]	n[d]	$\bar{x}_i \pm 1 - \bar{x}_i$	D	n
1	33.0	25.0	3	–8.3	25.0	1
2	–13.3	8.3	3	–12.5	0.0	1
3	–3.3	–25.0	3	0.0	0.0	1
4	–21.7	25.0	3	6.3	25.0	1
5	–88.7	–108.3	4	36.2	18.8	4
6	102.0	75.0	3	74.2	70.0	5
7	–28.3	8.3	3	–32.8	–125.0	6
8	50.0	50.0	5	–75.6	–65.0	5
9	–53.0	–53.0	5	–82.5	–109.0	5
10	41.8	41.3	4	19.5	31.7	6
11	40.0	28.3	3	21.2	28.3	3
12	61.2	61.3	4	112.7	111.0	5
13	27.0	67.5	4	21.6	31.0	5
14	30.0	30.0	5	59.7	52.0	6
15	56.3	55.8	4	88.0	57.5	4
16	151.7	7.0	1	239.0	225.0	1
17	–302.0	–200.0	2	30.0	30.0	1
18	143.0	40.0	1	–50.0	–60.0	2
19	–10.0	70.0	2	–281.7	–300.0	6
20	–44.0	–68.5	5	–54.7	–38.0	11
21	33.0	16.0	5	125.0	42.7	4
22	–36.1	–37.0	4	–51.5	–42.3	10
23	–104.4	–156.5	2	–136.5	–164.7	3

[a]Adults and yearlings before April 1986; all adults thereafter

[b]$\bar{x}_i$ is the mean of the first sampling period, $\bar{x}_i \pm 1$ is the mean of the second sampling period

[c]D is the mean of the differences in weight of individuals caught in both sampling periods

[d]n is the number of individuals used in calculating D

Disappearance Rates

Of 18 adult Mexican prairie dogs captured and marked from early October 1985 to late September 1986, 3 (17%) disappeared between early November 1985 and late March 1986, and 1 (6%) disappeared between early April 1986 and late September 1986. Among 20 marked young (born in late May 1985), 6 (30%) disappeared by March 1986, and 1 (5%) disappeared between April and late May 1986. Of 17 yearlings captured and marked as young, 1 (6%)

Table 12. Weight and tail-length characteristics of adult Mexican prairie dogs from mid-April 1986 to late January 1988.

Measurement	Mean[a]	Range	SD	t-test[b]
	Males ($n = 61$)			
Tail length (mm)	104± 1.4	97–117	5.6	—
Total weight (g)	1045±28.3	868–1303	112.8	—
	Females ($n = 87$)			
Tail length (mm)	101± 1.6	85–109	7.4	4.49
Total weight (g)	943±31.5	758–1343	150.1	2.68

[a] ± 95% confidence limits
[b] $P < 0.05$

disappeared between mid-June and September 1986. Of the 21 young (born in early March 1986), 3 (14%) had disappeared by late September 1986.

There were 31 observations of ferruginous hawks (*Buteo regalis*) on or adjacent to the study site from early November 1985 to late March 1986, and some fed on prairie dogs. In late November 1985, I observed five ferruginous hawks fighting over the remains of one prairie dog on the study site. During the winter months, I observed three captures and eight additional capture attempts of prairie dogs by ferruginous hawks, but no marked prairie dog was captured. Although red-tailed hawks (*Buteo jamaicensis*), golden eagles (*Aquila chrysaetos*), and coyotes (*Canis latrans*) also were observed attempting to capture *C. mexicanus*, ferruginous hawks were the main diurnal predator during the winter. The disappearance of adult and yearling prairie dogs during winter was probably due to predation, although undocumented emigration may have accounted for some losses.

Activity and Social Organization

Mexican prairie dogs are strictly diurnal. Two periods of maximum above-ground activity occurred daily at the study site from mid-spring to early fall 1986. The first started at approximately 0730 h and lasted until 1230 h or 1300 h, when air temperature reached its maximum (mean maximum = 28°C). The second started at approximately 1500 h, as air temperature declined, and continued until just before sunset. From late fall 1985 to early spring 1986, Mexican prairie dogs showed only one daily period of maximum surface activity, beginning at approximately 0900 h and lasting until sunset. All above-ground activity stopped during rain; water standing on the ground

Table 13. Molting pattern of specimens captured from mid-October 1985 to late September 1986.

Sampling date	Adult ♂♂ [a]				Adult ♀♀ [a]				Young ♂♂ '85				Young ♀♀ '85				Young ♂♂ '86				Young ♀♀ '86			
	W[b]	TS	S	TW	W	TS	S	TW	W	TS	S	TW	W	TS	S	TW	W	TS	S	TW	W	TS	S	TW
3 Oct. 85	2	0	0	0	0	0	0	0	3	0	0	0	1	0	0	0								
18 Oct. 85	4	0	0	0	3	0	0	0	7	0	0	0	5	0	0	0								
7 Nov. 85	3	0	0	0	2	0	0	0	8	0	0	0	7	0	0	0								
27 Nov. 85	5	0	0	0	4	0	0	0	8	0	0	0	8	0	0	0								
19 Dec. 85	3	0	0	0	2	0	0	0	4	0	0	0	6	0	0	0								
22 Jan. 86	5	0	0	0	4	0	0	0	8	0	0	0	8	0	0	0								
15 Feb. 86	5	0	0	0	5	0	0	0	6	1	0	0	7	0	0	0								
7 Mar. 86	3	0	0	0	3	2	0	0	6	1	0	0	6	0	0	0								
26 Mar. 86	1	4	0	0	1	5	0	0	2	4	0	0	2	6	0	0								
16 Apr. 86	0	5	0	0	0	6	0	0	0	7	0	0	0	6	1	0	0	4	1	0	0	2	3	0
6 May 86	0	4	1	0	0	6	0	0	0	7	0	0	0	5	1	0	0	4	6	0	0	4	6	0
26 May 86	0	3	2	0	0	8	1	0	0	3	4	0	0	2	4	0	0	2	6	0	0	1	6	0
14 June 86	0	1	3	0	0	2	3	0	0	0	7	0	0	0	2	0	0	0	6	0	0	0	9	0
20 July 86	0	0	4	0	0	0	6	0	0	0	5	0	0	0	5	0	0	0	9	0	0	0	9	0
11 Aug. 86	0	0	5	0	0	0	5	1	0	0	6	1	0	0	5	1	0	0	3	5	0	0	2	5
8 Sept. 86	1	0	1	3	0	0	2	4	0	0	0	10	0	0	0	6	0	0	0	6	0	0	0	6
27 Sept. 86	5	0	0	0	5	0	0	0	6	0	0	0	5	0	0	0	7	0	0	0	9	0	0	0

[a]Adults and yearlings before April 1986; adults thereafter

[b]W = winter pelage, TS = winter–summer transition pelage, S = summer pelage, TW = summer–winter transition pelage

surface reduced but did not stop activities.

Tactile communication in *C. mexicanus* involved a "kiss" similar to that described for black-tailed prairie dogs (*Cynomys ludovicianus*) by King (1955). The "kiss" occurred in young–mother and young–young relations. If an adult Mexican prairie dog adopted the "alarm" posture (sitting up and peering around), other prairie dogs in the immediate vicinity did likewise. Mexican prairie dogs at the study site commonly used two distinctive calls that can be termed an "alarm bark" and "elation call." Both calls were used by young, yearling, and adult *C. mexicanus*. The olfactory stimulation described by King (1955) for black-tailed prairie dogs was not noted for *C. mexicanus*.

The 9.55 ha study site was initially occupied by five groups (coteries) of prairie dogs; by late September 1986, the site held six distinct groups. Groups usually consisted of one or two adult males and one to four adult females, similar numbers of both yearling males and females, and young of the year (Table 14). Dominance behavior was difficult to identify; however, when it occurred it was exhibited by a single reproductive male toward the entire social group. Following the breeding season, behavioral antagonism was observed within the groups. Adult females did not permit adult males in or near the nesting burrow. This agonistic behavior ended with the emergence of young in mid-April 1986. Young were very sociable within their groups, but they rarely approached group boundaries. By early June movements of adult and yearling prairie dogs between groups within the colony were evident; these movements lasted until early September 1986. One movement of particular interest occurred in early June 1986; a yearling male moved away from its original group (I) to another group (IV) dominated by an adult male. During a period of 15 days, the yearling male succeeded in displacing the adult male from its original group to another site, where the adult established a new group (VI) with an adult female, a yearling male, and a yearling female. Intergroup movements involved not only single prairie dogs, but also groups of prairie dogs. In early June 1986, three yearling males and two adult males simultaneously moved away from their original group (III) to join another group (V) consisting of two adult females, one yearling male, and two yearling females. Apparently movement of both individuals and groups of prairie dogs occurs when they reach adult size; this coincides with the suggestion of Armitage (1981) that sexual maturity and dispersal in large-bodied social ground squirrels are dependent on the age at which immatures attain adult weight.

DISCUSSION

Reproduction

Since 1892, only three reports on reproduction in *Cynomys mexicanus* have been published (Merriam, 1892; Baker, 1956; Pizzimenti and

Table 14. Group composition of Mexican prairie dog colony by age and sex.

Group no.	Adult[a] ♂	Adult[a] ♀	Yearling ♂	Yearling ♀	Unmarked adult–young	Young ♂	Young ♀	Unmarked yearlings	Total
October–December 1985									
I	1	1	—	—	5	2	2	—	11
II	1	1	—	—	2	2	3	—	9
III	2	0	—	—	3	4	1	—	10
IV	2	2	—	—	1	1	2	—	8
V	0	1	—	—	5	0	0	—	6
VI	0	0	—	—	0	0	0	—	0
Total	6	5	—	—	16	9	8	—	44
January–March 1986									
I	2	3	—	—	2	2	2	—	11
II	1	1	—	—	2	2	2	—	8
III	2	0	—	—	2	4	2	—	10
IV	1	1	—	—	1	0	2	—	5
V	0	2	—	—	1	1	2	—	6
VI	0	0	—	—	0	0	0	—	0
Total	6	7	—	—	8	9	10	—	40

Group no.	Adult ♂	Adult ♀	Yearling ♂	Yearling ♀	Unmarked adult–yearling	Young '86 ♂	Young '86 ♀	Unmarked young '86	Total
April–May 1986									
I	2	4	2	1	1	6	7	3	26
II	1	1	1	2	2	1	2	1	11
III	2	0	4	1	2	0	0	0	9
IV	1	1	0	2	1	2	2	0	9
V	0	2	1	2	4	0	0	0	9
VI	0	0	0	0	0	0	0	0	0
Total	6	8	8	8	10	9	11	4	63
June–September 1986									
I	2	4	1	1	0	5	7	3	23
II	1	0	0	2	0	1	2	1	7
III	0	0	2	2	0	0	0	0	4
IV	0	1	2	2	0	2	2	0	9
V	1	2	4	1	0	0	1	3	12
VI	1	1	1	1	0	0	0	0	4
Total	5	8	10	9	0	8	12	7	59

[a] Adults and yearlings before April 1986; all adults thereafter

McClenaghan, 1974). Typically one litter is produced annually in the genus *Cynomys* (Clark et al., 1971; Pizzimenti and Hoffmann, 1973). However, Pizzimenti and McClenaghan (1974) suggested that Mexican prairie dogs may reproduce more than once each year, or alternatively that the reproductive season is extremely protracted. Ceballos-G. and Wilson (1985) mentioned that the length of gestation is unknown, but suggested it may be about one month as in other *Cynomys*. Van De Graaff and Balda (1973) noted that green vegetation in the diet contributed to increased body vigor in Merriam's kangaroo rat (*Dipodomys merriami*) and provided the extra energy required for reproduction. Reynolds and Turkowski (1972) found that for each additional 0.50 in. of December–January rainfall, initiation of the breeding season in round-tailed ground squirrels (*Spermophilus tereticaudus*) was advanced about 9 days. Conversely, low rainfall during winter delayed the breeding season. Koford (1958) reported that the breeding season in black-tailed prairie dogs (*Cynomys ludovicianus*) did not change from one dog town to another despite differences in food and weather. He concluded that the time of breeding was not determined by food, and thought that the determining factor might be day length. Anthony and Foreman (1951) found that light, darkness, and cold did not change the timing of the reproductive cycle in female black-tailed prairie dogs.

Although Zones I and II are in close proximity, the rainfall pattern is quite different between the two, with Zone I averaging more precipitation. The rainfall in Zone I was more uniformly distributed throughout the year. In Zone I, the highest biomass of green vegetation was recorded in December 1985; the highest biomass in Zone II was during the period May through July and averaged twice that found in Zone I. Because winters at Ejido El Tokio are mild, increased food availability during the late winter–early spring season is probably the stimulus that initiates reproduction in *C. mexicanus*. Therefore, it seems that differences in timing of breeding between Zone I and Zone II were due to differences in timing of food availability, which in turn results from differences in rainfall patterns. This hypothesis is supported by the capture of young prairie dogs in October 1985 and in April 1987 on the study site. Young prairie dogs captured in October 1985 were born in May. Delayed reproduction in 1985 can be attributed to the low rainfall on the study site from December 1984 to March 1985 (Treviño-Villarreal, 1988). Presumably green vegetation was scarce until April 1985. In contrast, young prairie dogs captured in April 1987 were born by late January. Early reproduction in 1987 can be linked to the high rainfall on the study site from October 1986 to January 1987; green vegetation probably was abundant in these months. Mild climatic conditions in the range of Mexican prairie dogs permit a longer reproductive season than in the other species of *Cynomys*, which either hibernate or are inactive much or all of the winter (Longhurst, 1944; Scheffer, 1947; King, 1955; Bakko and Brown, 1967; Rayor et al., 1987). Adult and yearling

females produced a single annual litter both on the study site and nearby. No pregnant yearling female was found from early October 1985 to late September 1986. On the other hand, all yearling females were lactating when they were captured in mid-April 1987. These results contradict the speculation by Pizzimenti and McClenaghan (1974) that breeding in Mexican prairie dogs might occur more than once each year.

Average litter size in *Cynomys leucurus* varies from 4.9 to 5.6 (Clark et al., 1971). A female *C. mexicanus* with three embryos was found on 4 March (Merriam, 1892) and another taken on 25 March contained three embryos averaging 23 mm in crown–rump length (Baker, 1956). On 26 May, five months after capture, one of two adult females housed with an adult male produced a litter of four males and two females (Pizzimenti and McClenaghan, 1974). Mean litter size increases with better nutrition in round-tailed ground squirrels (*Spermophilus tereticaudus*) (Reynolds and Turkowski, 1972). The present study covered two reproductive seasons (1986 and 1987) at one locality; therefore, it was only possible to determine that mean litter size of *C. mexicanus* varied from one year to another. The mean litter size in 1986 (4.0) differed from the mean litter size in 1987 (4.5) ($t = 2.6$, $P < 0.05$) (Table 2). This litter size difference may have been due to increased precipitation in fall and winter of 1986 in Zone I, which in turn increased food availability.

Emergence of young on the study site and in Zone II in 1986 coincided with the appearance of summer annuals, which provided food for early growth. Yearling Mexican prairie dogs did not exhibit evidence of reproductive maturity in 1986. Neither sex had achieved full seasonal adult weight by the time copulation occurred in late January and early February 1986. Young Mexican prairie dogs (born in early March 1986) approached minimum seasonal adult weight by early September 1986 (Table 3). Thus, on the basis of weight, *Cynomys mexicanus* could be capable of reproduction either in its first year or in its second year of life. Whether reproduction by yearlings or young ever occurs probably depends upon food availability and social interactions.

Size and Growth

Ceballos-G. and Wilson (1985) reported that weaning of *C. mexicanus* occurs between 41 and 50 days. The calculated age of young at first capture was 45 days in 1986 and 74 days in 1987 on the study site. Growth and development differed between the young studied by Pizzimenti and McClenaghan (1974) and the young studied in the two reproductive seasons in this study. For instance, Pizzimenti and McClenaghan (1974) found that the mean weight of C. *mexicanus* exceeded 1000 g by 19 weeks, whereas mean weight of free-ranging *C. mexicanus* was 925.1 g (SD = 94.56, $n = 14$) at 30 weeks of age. Pizzimenti and McClenaghan (1974) also stated that sexual dimorphism in weight of young was significant at 60 days ($t = 4.5$, $P < 0.02$)

and in tail length at 42 days ($t = 3.6$, $P < 0.05$). In 1986, significant weight ($t = 2.3$, $P < 0.05$) and tail-length dimorphism ($t = 3.8$, $P < 0.01$) between the sexes occurred at 140 days, whereas in 1987 significant weight dimorphism ($t = 2.4$, $P < 0.05$) between the sexes occurred at day 126. No significant tail-length dimorphism between the sexes occurred in these young throughout this study. Pizzimenti and McClenaghan (1974) found that at 140 days males averaged 293 g heavier than females. At this age males born in 1986 averaged only 69.4 g heavier than females. Young males born in 1987 averaged 101.3 g heavier than females at 126 days of age. The higher mean weight differences in the captive litter (Pizzimenti and McClenaghan, 1974) than in wild young from both 1986 and 1987 may have been due to higher nutritive value of food provided to and lower energetic demands on the captive litter. Mean weight differences between the young from 1986 and 1987 probably resulted from differences in food availability in 1986 and 1987 on the study site. An alternative hypothesis is that the young were the same age at first capture in both years, but that food availability and, therefore, growth rate were higher in 1987.

Weight Variation

The weights of 29 adult *C. mexicanus* recorded from museum specimens indicated that males were heavier than females (Pizzimenti and McClenaghan, 1974). Mean weight of adult males exceeded that of females during most of this investigation, the only exceptions being from mid-February to late March 1986 and in late February 1987. The period of pregnancy in 1986 occurred from mid-February to late March; in this period, adult females gained weight rapidly. Adult females also had high mean weights during the period of early pregnancy in 1987, which occurred in late February. The minimum mean weight of adult males occurred in mid-February 1986, probably due to decreased food availability (Treviño-Villarreal, 1988). The consistent weight gain by males from May to late September 1986 was associated with the seasonal maximum in standing crop of green vegetation (Treviño-Villarreal, 1988). The minimum mean weight of adult females occurred in early May 1986, subsequent to parturition and lactation. After young were weaned, females began to regain weight.

Dalquest (1953) noted that specimens taken in late September were fat and suggested that they might be preparing for hibernation; however, Ceballos-G. and Wilson (1985) believed that Mexican prairie dogs had no period of inactivity or hibernation in the winter. The high mean weight of all age classes of Mexican prairie dogs in late September 1986 should not be interpreted as preparation for hibernation, as Dalquest (1953) suggested. All individuals of *Cynomys mexicanus* were active throughout the study period, and they achieved peak mean weight in late September 1986 because food availability was high on the study site prior to that time (Treviño-Villarreal, 1988).

However, all adult males, yearlings, and young lost weight from October 1987 to March 1988, but not in the winter of 1985–1986. Thus, stored fat may be used in those winters when food is inadequate to sustain growth and maintenance. In this regard, *C. mexicanus* is more similar to *C. ludovicianus* than to *C. leucurus* or *C. gunnisoni*.

Patterns of Molt

Although the molting pattern has not been described in detail for *Cynomys mexicanus*, it was reported to be complex (Ceballos-G. and Wilson, 1985). Hollister (1916) declared that molting in *C. mexicanus* differed from other species of prairie dogs in that the coat is irregularly and patchily renewed rather than renewed in a regular anterior–posterior fashion, and that two or possibly three complete pelage renewals occur annually in adults (Hollister, 1916; Baker, 1956). Molting in *C. mexicanus* pups also may be complex, involving four or more overlapping phases and, as in adult molt, may be a unique pattern for the genus (Pizzimenti and McClenaghan, 1974). In the present study, molting of adult and yearling *C. mexicanus* occurred in an anterior–posterior pattern. In contrast, young prairie dogs exhibited a posterior–anterior pattern in their first pelage renewal in summer, but the second pelage renewal in autumn occurred in an anterior–posterior pattern. This pattern differs from the irregular, patchy pattern reported by Pizzimenti and McClenaghan (1974), which may reflect abnormal conditions in captive animals.

Disappearance Rates

Kit foxes (*Vulpes macrotis*) are effective predators on *C. mexicanus* (Jiménez-Guzmán, 1976). Likely additional predators are badgers (*Taxidea taxus*), coyotes, long-tailed weasels (*Mustela frenata*), golden eagles, red-tailed hawks, and rattlesnakes (*Crotalus* sp.) (Ceballos-G. and Wilson, 1985). The high disappearance rate of adult and young prairie dogs from October 1985 to March 1986 probably was due to predation primarily by ferruginous hawks (*Buteo regalis*). However, other causes and/or emigration of prairie dogs cannot be ruled out. From early April 1986 to late September 1986, the disappearance rate of prairie dogs was lower than from October 1985 to March 1986. Individuals that disappeared probably were emigrants. During this period some prairie dogs moved from one group to another within the colony. Moreover, fewer diurnal predators were observed on the study site, although nocturnal predators could have been significant. López-Soto (1980) found remains of *C. mexicanus* in 13 of 40 scats of badgers, while Vallejo-Gamero (1981) found a young *C. mexicanus* in the stomach of a rattlesnake (*Crotalus scutulatus scutulatus*). Both badgers and rattlesnakes occurred near

the study site, but badger or rattlesnake activity were not observed on the study site throughout the year.

Activity and Social Organization

Adult and yearling Mexican prairie dogs spent much of their day during the summer months in behaviors concerned with social integration of the groups.

The "identification kiss" (King, 1955) was used by *C. mexicanus* for recognition and seems to play a major role in social organization. The alarm bark of *C. mexicanus* is a single-syllable, repetitious bark. This call functions as an "alert" to danger (Pizzimenti and McClenaghan, 1974). In the "elation call," the body may be thrown back on the first syllable, then downward onto the forefeet on the second syllable (Pizzimenti and McClenaghan, 1974). This "elation call" could be interpreted as an "all-clear" signal as Waring (1970) stated in his work on *C. ludovicianus*. Other sounds made by Mexican prairie dogs in the colony, and by animals marked and handled, included growls and screams. Young, while playing or being handled, and adults and yearlings, when confined in traps or handled, uttered both sounds.

Behavior of *C. mexicanus* during the reproductive season seems to be similar to other members of the genus *Cynomys*. Female *C. ludovicianus* become territorial and aggressive around the parturition burrow during gestation and lactation and do not resume social contacts with other members of the colony until young are weaned and above ground (King, 1955). Female *C. gunnisoni* also are more territorial during the reproductive season (Longhurst, 1944). Female Richardson's ground squirrels (*Spermophilus richardsonii*) show similar aggressive behavior and territoriality during the reproductive season (Clark, 1970). Coteries of black-tailed prairie dogs (King, 1955), Gunnison's prairie dogs (*C. gunnisoni*) (Rayor, 1988), and Mexican prairie dogs (this study) are typically composed of one or two adult males, one to four females, and a variable number of young and yearlings.

All the species of the genus *Cynomys* are diurnal (this study; Tileston and Lechleitner, 1966; Clark et al., 1971; Pizzimenti and Hoffmann, 1973; Pizzimenti and Collier, 1975). Only *C. mexicanus* (this study) and *C. ludovicianus* (Tileston and Lechleitner, 1966) are active throughout the year. Bimodal and unimodal daily activity periods occur annually in *C. mexicanus* (this study), *C. ludovicianus* (Tileston and Lechleitner, 1966), and *C. leucurus* (Clark et al., 1971). Bimodal daily activity periods occur in *C. mexicanus* from mid-spring to early fall, in *C. ludovicianus* during the summer, and in *C. leucurus* in mid-summer. A unimodal daily activity period occurs in C. *mexicanus* from mid-fall to early spring, in southern populations of *C. ludovicianus* during the winter, and in *C. leucurus* from February to April and again from September to November. Observed differences between the species in daily

activity periods are probably the result of the far less harsh climate in which *C. mexicanus* lives, compared to *C. ludovicianus* and *C. leucurus* on the Great Plains or valleys of the intermountain West.

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SUMMARY

Biological characteristics of Mexican prairie dogs (*Cynomys mexicanus*), including reproduction, growth, development, molt pattern, and colony organization were studied at Ejido El Tokio, Galeana, Nuevo León, Mexico, from October 1985 to January 1988. The reproductive season was lengthy and varied from one locality to another, as well as from year to year, depending upon food availability. Females produced only one litter annually. Growth rates in this study of free-ranging animals were lower than those reported for captives by Pizzimenti and McClenaghan (1974). The molt pattern consisted of two complete pelage renewals and two transition pelage periods annually. Individual prairie dogs disappeared from the study site due to both mortality and emigration. Mexican prairie dogs remained active above ground throughout

the year, and were strictly diurnal. Bimodal daily activity periods occurred annually from mid-spring to early fall. Unimodal daily activity patterns occurred annually from mid-fall to early spring. Prairie dogs within the colony were organized into groups (coteries) consisting of one or two adult males, one to four adult females, and a variable number of young and yearlings. After prairie dogs reached adult size, individual movements were pronounced.

RESUMEN

Se examinaron algunas características biológicas (reproducción, crecimiento, desarrollo, patrón de muda de pelo, y organización colonial) de los perritos mexicanos de las praderas (*Cynomys mexicanus*) en el Ejido El Tokio, Galeana, Nuevo León, México, desde Octubre de 1985 hasta Enero de 1988. El período reproductivo fue prolongado y varió de una localidad a otra, asi como también de año con año dependiendo de la disponibilidad de alimento. Las hembras tuvieron sólo una camada por año. Las tasas de crecimiento en este estudio de animales silvestres fueron más bajas que las reportadas por Pizzimenti y McClenaghan (1974) para animales en cautiverio. El patrón de muda consistió de dos cambios completos de pelaje y los períodos de transición del mismo por año. La desaparición de los perritos de las praderas del área de estudio fue debido tanto a mortalidad como a emigración. Los perritos mexicanos de las praderas permanecieron activos sobre la superficie durante todo el año, y fueron estrictamente diurnos. Los períodos de actividad diaria bimodal ocurrieron anualmente desde mediados de la primavera hasta principios del otoño; mientras que los períodos de actividad unimodal también ocurrieron anualmente, pero en este caso ocurrieron desde mediados del otoño hasta principios de la primavera. Los perritos de las praderas estuvieron organizados dentro de la colonia en grupos (coteries) los cuales consistieron de uno o dos machos adultos, de una a cuatro hembras, y un número variable de subadultos e infantiles. Los desplazamientos individuales de los perritos de las praderas fueron pronunciados después de que alcanzaron la talla de adultos.

LITERATURE CITED

Anthony, A. and D. Foreman. 1951. Observations of the reproductive cycle of the black-tailed prairie dog (*Cynomys ludovicianus*). Physiol. Zool. 24:242–248.

Armitage, K. B. 1981. Sociality as a life-history tactic of ground squirrels. Oecologia 48:36–49.

Avalos-Marín, M. L. B. A. thesis in prep: Productividad y bromatología del pastizal gipsofilo del Ejido El Tokio, Galeana, Nuevo León, México. Universidad

Autónoma de Nuevo León, Monterrey, Nuevo León, México.

Baker, R. H. 1956. Mammals of Coahuila, Mexico. Univ. Kansas Pub. Mus. Nat. Hist. 9:125–335.

Bakko, E. B. and L. N. Brown. 1967. Breeding biology of the white-tailed prairie dog, *Cynomys leucurus*, in Wyoming. J. Mamm. 48:100–112.

Brody, S. 1945. Time relations of growth of individuals and populations, pp. 484–574. In: S. Brody (ed.), Bioenergetics and Growth. Reinhold, New York.

Ceballos-G., G. and D. E. Wilson. 1985. *Cynomys mexicanus*. Mamm. Species 248:1–3.

Clark, T. W. 1970. Richardson's ground squirrel (*Spermophilus richardsonii*) in the Laramie Basin, Wyoming. Great Basin Nat. 30:55–70.

Clark, T. W., R. S. Hoffmann, and C. F. Nadler. 1971. *Cynomys leucurus*. Mamm. Species 7:1–4.

Dalquest, W. W. 1953. Mammals of the Mexican state of San Luis Potosi. Louisiana State Univ. Studies, Biol. Ser. 1:1–229.

DETENAL. 1975. Dirección de Estudios del Territorio Nacional. Carta G14 C66 Edafologica y uso del suelo. San José de Raices. Escala 1:50,000.

Fitzwater, W. D. 1943. Color marking of mammals with special reference to squirrels. J. Wildl. Mgt. 7:190–192.

García, E. 1973. Modificaciones al sistema de clasificación climatica de Koppen, Ed. U.N.A.M., México.

Hall, E. R. 1981. The Mammals of North America, 2nd ed. John Wiley & Sons, New York. 1:1–600 + 90.

Hollister, N. 1916. A systematic account of the prairie dogs. N. Amer. Fauna 40:1–37.

Jiménez-Guzmán, A. 1976. Los perros de la pradera (*Cynomys mexicanus* Merriam) y su influencia en la agricultura en Nuevo León, México. Fac. de Ciencias Biológicas, Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México. Pp. 567–574.

King, J. A. 1955. Social behavior, social organization and population dynamics in a black-tailed prairie dog town in the Black Hills of South Dakota. Contrib. Lab. Vertebrate Biol. Univ. Mich. 67:1–123.

Koford, C. B. 1958. Prairie dogs, white-faces and blue gramma. Wild. Monogr. 3:1–78.

Longhurst, W. 1944. Observations on the ecology of the Gunnison prairie dog in Colorado. J. Mamm. 25:24–36.

López-Soto, J. H. 1980. B. A. thesis: Datos ecológicos del tlalcoyote *Taxidea taxus berlandieri* en el Ejido El Tokio, Galeana, Nuevo León, México. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México. 34 pp.

Merriam, C. H. 1892. Description of a new prairie dog (*Cynomys mexicanus*) from Mexico. Proc. Biol. Soc. Washington 7:157–158.

Mulleried, F. K. 1944. Geología del estado de Nuevo León. Anal. Inst. Invest. Cientif. U.N.L. 1(2) Mty. Pp. 55–63.

Nowak, R. M. and J. L. Paradiso. 1983. Walker's Mammals of the World, 4th ed., Vols. 1, 2. The Johns Hopkins Univ. Press, Baltimore, Maryland. Pp. 1–1362.

Pizzimenti, J. J. and G. D. Collier. 1975. *Cynomys parvidens*. Mamm. Species 52:1–3.

Pizzimenti, J. J. and R. S. Hoffmann. 1973. *Cynomys gunnisoni*. Mamm. Species 25:1–4.

Pizzimenti, J. J. and L. R. McClenaghan, Jr. 1974. Reproduction, growth and development, and behavior in the Mexican prairie dog *Cynomys mexicanus* (Merriam). Amer. Midl. Nat. 92:130–145.

Rayor, L. S. 1985. Effects of habitat quality on growth, age of first reproduction, and dispersal in Gunnison's prairie dogs (*Cynomys gunnisoni*). Can. J. Zool. 63:2835–2840.

Rayor, L. S. 1988. Social organization and space-use in Gunnison's prairie dog. Behav. Ecol. Sociobiol. 22:69–78.

Rayor, L. S., A. K. Brody, and C. Gilbert. 1987. Hibernation in the Gunnison's prairie dog. J. Mamm. 68:147–150.

Reynolds, H. G. and F. Turkowski. 1972. Reproductive variations in the round-tailed ground squirrel as related to winter rainfall. J. Mamm. 53:893–898.

Scheffer, T. H. 1947. Ecological comparisons of the plains prairie dog and the Zuni species. Trans. Kans. Acad. Sci. 49:401–406.

SPP. 1981. Secretaría de Programación y Presupuesto. Sintesis Geografica de Nuevo León, Anexo Cartografico: Carta estatal (climas).

Tileston, J. V. and R. R. Lechleitner. 1966. Some comparisons of the black-tailed and white-tailed prairie dogs in north-central Colorado. Amer. Midl. Nat. 75:292–316.

Treviño-Villarreal, J. 1981. B. A. thesis: Datos ecológicos de la ardilla de tierra *Spermophilus spilosoma pallescens* Howell (1928), en el Ejido El Tokio, Galeana, Nuevo León, México. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México. 42 pp.

Treviño-Villarreal, J. 1988. M. A. thesis: The annual cycle of the Mexican prairie dog (*Cynomys mexicanus* Merriam, 1892). Univ. Kansas, Lawrence, Kansas. 35 pp.

Vallejo-Gamero, J. L. 1981. B. A. thesis: Taxonomía y distribución de la famila Crotalidae en el estado de Nuevo León, México. Universidad Autónoma de Nuevo León, Monterrey, Nuevo León, México. 49 pp.

Van De Graaff, K. M. and R. P. Balda. 1973. Importance of green vegetation for reproduction in the kangaroo rat, *Dipodomys merriami merriami*. J. Mamm. 54:509–512.

Waring, G. H. 1970. Sound communication of black-tailed, white-tailed, and Gunnison's prairie dogs. Amer. Midl. Nat. 83:167–185.

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