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August 30, 1971

To the Graduate Council:

I am submitting herewith a thesis written by William Hart Baker entitled "Seasonal Patterns of Reproduction and Body Condition in Prairie Voles (Microtus ochrogaster) on the Cumberland Plateau." I recommend that it be accepted for nine quarter hours of credit in partial fulfillment of the requirements for the degree of Master of Science, with a major in Wildlife Management.

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Major Professor

We have read this thesis and recommend its acceptance:

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Accepted for the Council:

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SEASONAL PATTERNS OF REPRODUCTION AND BODY CONDITION IN PRAIRIE VOLES (MICROTUS OCHROGASTER) ON THE CUMBERLAND PLATEAU

A Thesis

Presented to

the Graduate Council of

The University of Tennessee

In Partial Fulfillment

of the Requirements for the Degree

Master of Science

by

William Hart Baker

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ABSTRACT

The study was conducted within the 675.5 square mile area of Cumberland County, Tennessee, on the Cumberland Plateau. The objects of this study were: (1) to determine reproductive patterns of populations of prairie voles (*Microtus ochrogaster*) on the Cumberland Plateau, Tennessee, and (2) to determine fluctuations in body fat and adrenal size and weight in relation to seasonal changes and reproductive status.

Animals were collected by kill-trapping on sites within Cumberland County that supported moderate to high densities of prairie vole populations.

An apparent decline in breeding of males was manifested by: (a) a decline in testicular weight, (b) a decline in seminal vesicular weight, and (c) a decline in the proportion of males judged fecund. The decline of testicular and vesicular weights, and proportion of fecund males was most marked during December.

Female reproductive activity was gauged by the percentage of females pregnant in each monthly sample. Minimum sexual activity was noted in December when less than one-fourth of the females were pregnant.

Fat analysis indicated no significant difference in male and female (pregnant and nonpregnant) body fat content. Seasonal differences were absent also.

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CHAPTER I

INTRODUCTION

The prairie vole (Microtus ochrogaster) occupies a range in North America generally coincident with grassland habitat in central North America (Hall and Kelson, 1959) (Figure 1). Though typically associated with the grassland biome, it is also commonly found in herbaceous associations in the deciduous forest biome, occurring as far southeast as east Tennessee and northern Alabama (Dimmick, 1969; Whitaker and Zimmerman, 1968). In Tennessee the eastern border of the prairie vole extends to the eastern edge of the Cumberland Plateau (Figure 2).

Several studies on prairie vole biology have been accomplished in central and northern portions of its range. Studies by Jameson (1947), Martin (1956), Fitch (1957), and Gier and Cooksey (1967) were conducted in Kansas. Corthrum (1967) and Keller and Krebs (1970) studied vole populations in Indiana. Populations in Missouri were studied by Richmond (1967). The investigations of breeding patterns of prairie voles by Gier and Cooksey (1967), and Richmond (1967) utilized captive specimens. Studies by Jameson (1957), Martin (1956), Fitch (1957), Corthrum (1967), and Keller and Krebs (1970) examined breeding patterns of wild populations.

This study was undertaken to determine reproductive patterns of populations of prairie voles on the Cumberland Plateau, Tennessee, near

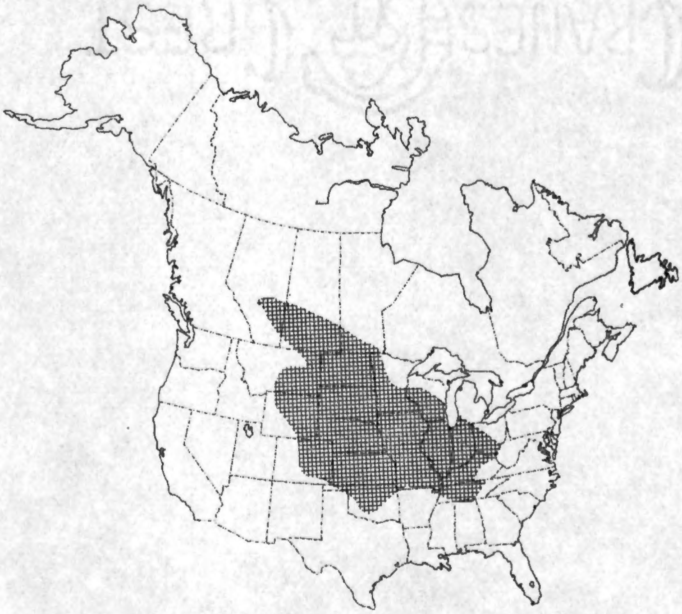

Figure 1. Distribution of Microtus ochrogaster in North America.

Source: W. H. Burt and R. P. Grossenheider, A field guide to the mammals (Boston: Houghton Mifflin Co., 1964), 284 pp; R. W. Dimmick, "The distribution of Microtus ochrogaster in Tennessee," J. Mammal. 50(1):126 (1969); J. O. Whitaker, Jr., and E. G. Zimmerman, "Microtus ochrogaster in Alabama and Tennessee," J. Mammal. 49(2):328 (1968).

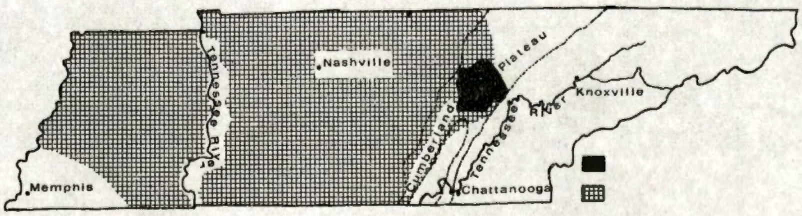

Figure 2. Distribution of Microtus ochrogaster in Tennessee.

Source: R. W. Dimmick, "The distribution of Microtus ochrogaster in Tennessee," J. Mammal. 50 (1):126 (1969).

the southeastern limits of this species' geographical range. This research was a cooperative study, supported by Hiwassee Land Company, Calhoun, Tennessee, and The University of Tennessee, Forestry Department.

CHAPTER II

DESCRIPTION OF THE STUDY AREA

A. LOCATION

Voles utilized in this study were trapped in Cumberland County, Tennessee (Figure 3). Cumberland County occupies 675.5 square miles in the central part of Tennessee and is situated almost entirely on the Cumberland Plateau (Matzek, 1950).

B. TOPOGRAPHY

Cumberland County is characterized by comparatively smooth land for about half the area, but in the eastern and southwestern portions of the county, stream dissection has cut valleys 100 to 400 feet deep. The elevation of the county ranges from 950 feet at Sequatchie Valley in the south to 3,048 feet at Hinch Mountain, about a mile northeast. Three-fourths of the county drains into the Tennessee River and the remaining portion into the Cumberland River (Matzek, 1950).

C. CLIMATE

The climate of Cumberland County is temperate and continental with short, moderate winters and mild summers. Long frost free periods and a uniformly distributed, moderately high annual precipitation make the area well suited for general farming. Temperature extremes of

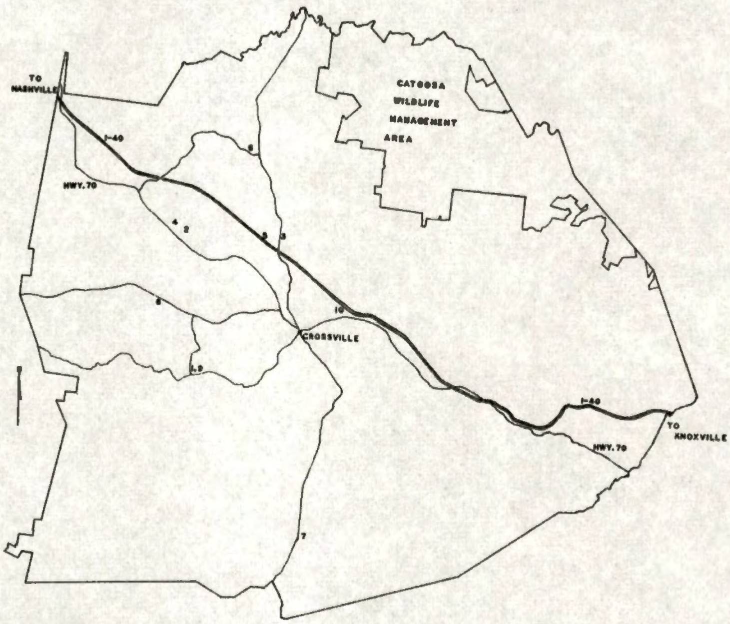

Figure 3. Location of trapping sites in Cumberland County, Tennessee.

103 F to -18 F were recorded during the period 1938 to 1971, but these occurred infrequently (Matzek, 1938-1950, U. S. Weather Bureau, 1950-1971). During the period 1938 to 1950, the mean annual temperature was 55.6 F. Mean seasonal temperatures were 38.7 F in winter and 72.1 F in summer. Mean annual precipitation during the same period was 54.2 inches. The wettest month was March (5.9 inches) and the driest month was October (3.2 inches). Generally, precipitation is highest in the summer and lowest in the fall (Matzek, 1950).

The mean monthly temperature for this study period was 53.3 F. The warmest month was August with a mean of 72.2 F, 0.8 F cooler than normal. The coldest was January with a mean of 31.9 F, 5.0 F cooler than normal. Mean monthly precipitation during this study period was 5.10 inches. The wettest month, April (11.1 inches), was 6.7 inches above normal rainfall. May was the driest month with 2.1 inches, 1.8 inches below normal (Table I).

D. SOIL

Most of the soils of the county are uniform in color, texture, structure, natural fertility, and parent material. About 95 percent of them were formed from weathered material of sandstone and shale. In more than 95 percent of the county the soils are low in phosphate and organic matter necessary to proper plant growth. The texture of the soils is prevailing fine, about 88 percent was fine sandy loam (Matzek, 1950).

TABLE I

TEMPERATURE AND PRECIPITATION (RECORDED AT THE U. T. PLATEAU EXPERIMENT STATION) FOR THE PERIOD DURING WHICH THIS STUDY WAS CONDUCTED (U. S. WEATHER BUREAU, 1970-1971)

Year	Month	Mean Temperature	Departure from Mean[a]	Total Precipitation	Departure from Mean[a]
1970	Apr.	55.8	0.9	11.05	6.68
	May	62.8	0.8	2.08	-1.82
	June	67.7	-3.0	6.79	2.76
	July	70.6	-3.2	3.60	-1.06
	Aug.	72.2	-0.8	8.29	3.89
	Sept.	70.0	2.5	3.83	0.43
	Oct.	56.7	-0.3	3.84	1.01
	Nov.	42.6	0.0	2.12	-1.91
	Dec.	39.5	1.7	4.58	-0.90
1971	Jan.	31.9	-5.0	6.54	0.71
	Feb.	33.0	-5.2	4.64	-0.98
	Mar.	37.9	-6.9	3.86	-1.59

[a]Means are climatological standard means based on the period 1931-1960.

E. VEGETATION

All trapping sites except three were located in fields with herbaceous cover. These fields were vegetated in grasses, the most common being fescue (*Festuca* sp.) and timothy (*Phleum pratense*). Two sites were in experimental plots of pine (*P. strobus* and *P. virginiana*) and one was in an apple (*Malus* sp.) orchard. Herbaceous plants in these sites included grasses (*Panicum* sp., *Setaria* sp., *Sorghum halepense*, *Andropogon virginicus*), goldenrod (*Solidago* sp.), and Queen Ann's lace (*Daucus carota*).

CHAPTER III

MATERIALS AND METHODS

Animals were collected by kill-trapping on sites within Cumberland County that supported moderate to high densities of prairie vole populations. Snap traps (Museum Specials) baited with a mixture of peanut butter and oatmeal were used to capture the specimens.

Specimens were placed in individual plastic bags and kept on ice for transport to the laboratory. The animals were then frozen and stored until dissection and examination was accomplished.

A. TRAPPING

Animals were collected from April 1970 through March 1971. During the period of April through September, two trapping sessions per month were accomplished. Trapping sessions were reduced to one per month during the remaining months of October through March. These trapping sessions ranged in duration from one to four days each. Twenty males and 20 females were set as minimum monthly quotas.

B. LABORATORY PROCEDURES

Prior to dissection, total weight and standard measurements were recorded. The weights and measurements were obtained by using a Mettler (H6T) balance and vernier calipers, respectively. Animals were aged as adult or juvenile by pelage characteristics. Condition of the vulva (perforate or imperforate) and teats (small, enlarged, or lactating) was noted for females.

Each animal was then mounted on a small dissecting board, venter up and limbs extended. The initial incision was longitudinal from lower abdomen to neck exposing the abdominal viscera. The gastrointestinal tract from lower esophagus to rectum was then removed, exposing the reproductive organs.

Males

The position of each testis (retracted or descended) was noted. The testes were removed and placed on a paper towel to dry surface fluids. Their weight, length, width, volume and consistency (turgid or flaccid) were recorded. Epididymides were inspected for the presence or absence of convolutions, the presence of which may indicate the presence of viable sperm (Hamilton, 1941). Slide smears of epididymal contents were made from every 25th male (Jameson, 1950). These slides were stained with Wright's Stain in order to differentiate sperm present in seminal fluid (Christian, 1950). Both testes and their respective seminal vesicles were fixed and stored in Mossman's AFA (50 percent distilled water, 30 percent (95 percent) ethyl alcohol, 10 percent formalin, and 10 percent glacial acetic acid).

Females

The reproductive status of female specimens was assessed by the condition of the uterine horns and the ovaries. Uterine horns were examined with aid of a dissecting microscope for the presence of implanted young, placental scars and resorbed young. The ovaries were removed from each horn and dissected from the bursa ovarii, the portion of the oviduct completely surrounding the ovary. The numbers of corpora lutea and corpora albacantia were then recorded for each ovary. Weights, lengths and widths of the ovaries were determined. Left and right ovaries and their respective uterine horns were stored separately in vials containing Mossman's AFA. The embryos and fetuses were retained to establish the time of conception. (Embryos and fetuses from the months of January and February were inadvertently destroyed.) Adrenal glands were removed, weighed, and stored in Mossman's AFA.

<u>Fat Analysis</u>

A total of 48 specimens was examined to study total body fat content. A subsample was taken from each monthly sample for this analysis. Each carcass was homogenized in a blender with approximately 300 ml of 50 percent ethyl alcohol. This homogenized animal matter was then flushed from the blender with 50 percent ethyl alcohol into a beaker. The sample was desiccated at 65 C for one to three weeks. This desiccated material was cut into sections so that the whole animal could be fitted into paper thimbles used in the extraction unit. Fat extraction was accomplished within the soxhlet apparatus by the recycling of petroleum ether over the animal matter. After four hours of extraction, the flask containing the extracted fat and the thimbles containing the residue were placed in an oven at 65 C for 12 hours. The ether was thereby evaporated.

Both calculated and measured fat content were recorded. The calculated fat content was derived by subtracting weight of the desiccated carcass from the weight of the carcass prior to desiccation. The weight of the calculated fat and the weight of the measured fat, obtained through extraction, were compared to the original weight of the dried vole. The percentages yielded by this ratio were used to express the total body fat content. Percentages based on measured fat were used as final criterion for comparing fat content of voles.

C. STATISTICAL ANALYSES

All statistical tests were run at the 0.05 level of probability. A paired t-test was used to examine the weight relationship between right and left individuals of paired reproductive and accessory organs. This preliminary analysis indicated that significant differences existed in the weights of right and left members of paired organs. Consequently, weights of paired organs were expressed as the mean of the right and left members. Duncan's Unequal Multiple Range Test was used to examine monthly and seasonal trends in data.

CHAPTER IV

RESULTS

A total of 638 prairie voles were examined in this study (Table II). Of this sample 463 were adults. Sex ratio of the adults was 242 (52.2 percent) females to 221 (47.8 percent) males. Of the 175 juvenile 94 (53.7 percent) were female and 81 (46.3 percent) were male.

A. ADULT MALES

Body weight of adult males ranged from 22.2 grams to 57.9 grams ($\bar{x}$ = 39.3 g). Total body weight ranged from a mean of 35.3 grams in May to 45.7 grams in January (Table III). A trend toward lower weights during the warmer months of March through October, and higher weights during the cooler months of November through February appeared evident, but was not statistically significant. Total body length did not vary seasonally.

The testes of all adult males examined were turgid. Neither retracted nor descended testes were predominant during any month.

Mean weights of right and left testes (337.8 mg and 341.8 mg) were not significantly different. Consequently, mean weight of the paired organs was utilized for this study. Mean weight of all paired testes was 339.8 mg. Weights of testes were heaviest in April (418.8 mg) and lightest in December (236.5 mg) (Table III). A decline initiated in October terminated in December with a mean testicular weight

TABLE II

SEX AND AGE RATIOS OF PRAIRIE VOLES CAPTURED DURING APRIL 1970 TO MARCH 1971 IN CUMBERLAND COUNTY, TENNESSEE

		Number of Captures				
	Number of	Male		Female		
Month	Trap Nights	Adult	Juvenile	Adult	Juvenile	Total
Apr.	811	25	8	18	8	59
May	530	22	9	13	6	50
June	351	18	19	23	2	62
July	374	10	10	14	7	41
Aug.	400	18	5	18	6	47
Sept.	425	13	6	17	5	41
Oct.	276	19	8	16	9	52
Nov.	250	16	6	22	8	52
Dec.	260	20	10	22	15	67
Jan.	280	18	2	26	3	49
Feb.	105	25	8	28	12	73
Mar.	333	17	3	25	0	45
Totals	4395	221	94	242	81	638

TABLE III

BODY WEIGHT AND REPRODUCTIVE ORGAN WEIGHTS OF ADULT MALE PRAIRIE VOLES CAPTURED DURING APRIL 1970 TO MARCH 1971 IN CUMBERLAND COUNTY, TENNESSEE

Year	Month	N	Total Body Weight (g)	Adrenal Weight (mg)	Testes Weight (mg)	Seminal Vesicle Weight (mg)
1970	Apr.	25	37.6	7.9	418.8	--[a]
	May	22	35.3	6.0	302.0	--
	June	18	37.4	5.4	385.5	--
	July	10	35.6	4.9	325.9	--
	Aug.	18	37.1	5.4	370.1	186.0
	Sept.	13	38.8	6.2	392.3	242.1
	Oct.	19	36.9	6.1	296.6	100.5
	Nov.	16	40.9	6.9	276.1	82.2
	Dec.	20	44.8	7.1	236.5	51.4
1971	Jan.	18	45.7	7.2	315.7	99.3
	Feb.	25	41.8	7.3	368.7	140.4
	Mar.	17	38.5	7.5	389.5	196.2
Totals and Means		221	39.3	6.5	339.8	137.2

[a]Weights not obtained.

of 236.5 mg. Weights increased in the following months of January, February, and March.

The presence of macroscopic tubules of the cauda epididymides was determined to be indicative of the presence of sperm in the epididymides. Eight males, judged to be adult on the basis of pelage characteristics, contained macroscopic tubules; sperm were detected by microscopic examination of the tubules' contents. Several adult males without visibly convoluted cauda epididymides were similarly examined. None of these contained sperm in their epididymides. Four juvenile males displayed no visible tubules, and their epididymides were devoid of sperm.

The presence of sperm was considered an indication that the animal was fecund. The proportion of adult males which was fecund ranged from 100 percent in June, September, October, February, and March to 75 percent in December (Figure 4).

Weights of seminal vesicles were obtained from 141 adult males collected during August to March (Table III). Mean weights of left and right seminal vesicles were not significantly different. Mean weight of paired seminal vesicles was 137.2 mg. Weights ranged from 51.4 mg in December to 242.1 mg in September (Figure 4). The differences in monthly means were significant.

Mean weight of 220 paired adrenals was 6.5 mg (Table III). Adrenal weights ranged from 4.9 mg in July to 7.9 mg in April. Adrenal weights were heaviest in the cooler months, November through April, and lightest during the warmer months of May through October.

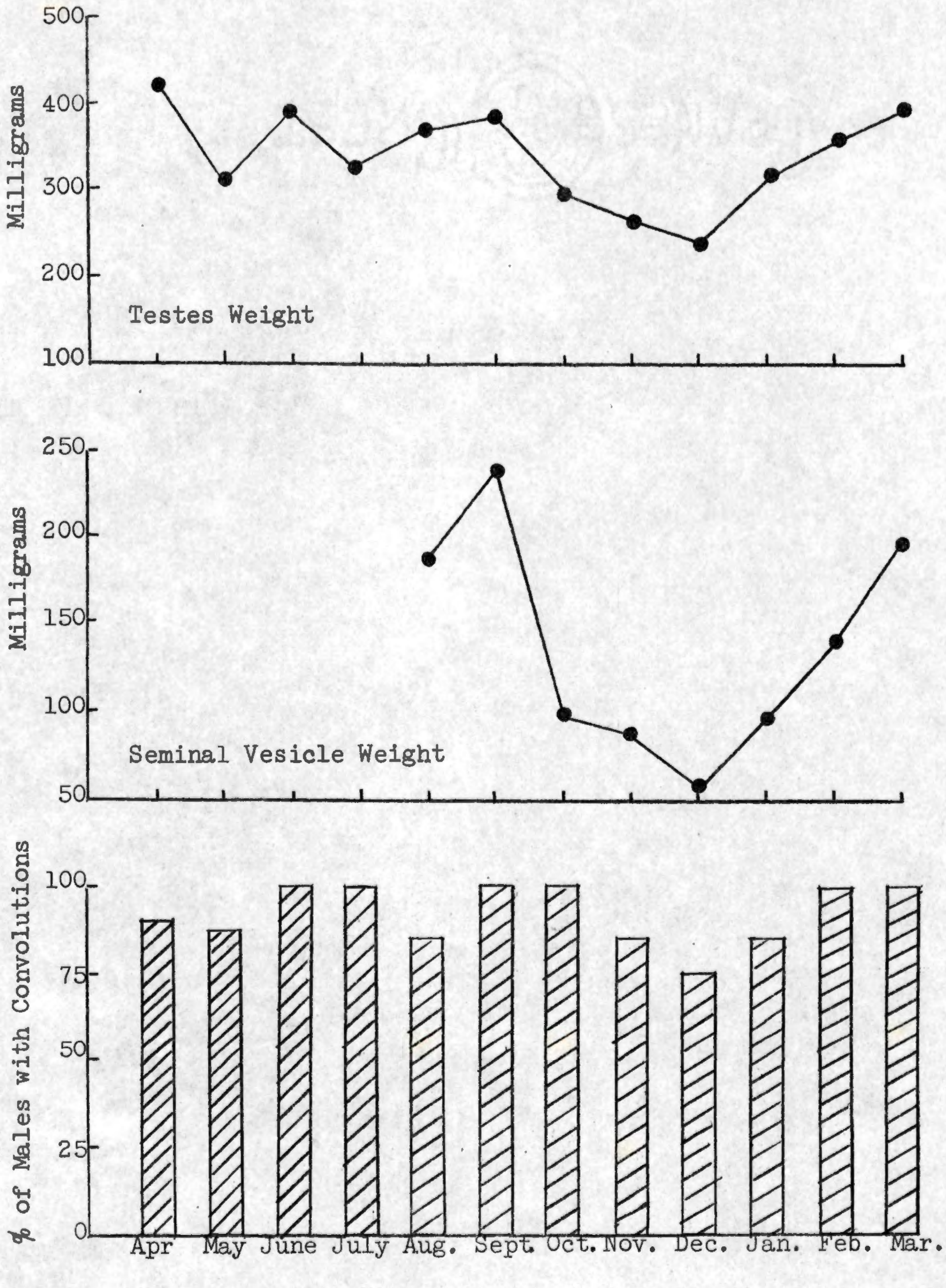

Figure 4. Mean weight of testes and seminal vesicles, and percentage of males displaying apparent convolutions of the cauda epididymides.

B. ADULT FEMALES

Three categories of adult females, based on reproductive status, were apparent: (1) pregnant females; (2) nonpregnant females with corpora lutea; (3) nonpregnant females without corpora lutea. The presence of implants within the uterine horns was the criterion used for establishing pregnancy (Valentine and Kirkpatrick, 1970). Using this criterion resulted in exclusion of some pregnant females from the appropriate category, as a period of approximately six days occurs between fertilization and implantation (Hoffmann, 1958).

Pregnant Females

Of the 242 adult females captured, 134 were pregnant. The proportion of adult females which was pregnant ranged from 23 percent in December to 92 percent in May (Table IV).

Mean number of embryos and fetuses in 134 *in utero* litters was 3.4, ranging from one to five during the study period (Table IV). Mean litter size ranged from 2.7 young in July to 4.5 young in April, but did not vary significantly between months.

Body weight of pregnant females ranged from 24.2 g to 68.4 g ($\bar{x}$ = 44.3 g) (Table V). Mean weights ranged from 37.3 g in March to 54.7 g in October. Mean body weight of pregnant females was not significantly heavier than mean weights of nonpregnant (with and without corpora lutea) females.

Ovaries of pregnant females weighed from 1.7 mg to 15.2 mg ($\bar{x}$ = 6.7 mg) (Table V) (Figure 5). The mean weight of ovaries of

TABLE IV

NUMBER OF IMPLANTS AND CORPORA LUTEA PER PREGNANT FEMALE AND PERCENT OF NONPREGNANT FEMALES DISPLAYING CORPORA LUTEA

			Pregnant			Nonpregnant		
Year	Month	Number of Adult Females	No.	Number Implants Per Female	Corpora Lutea Per Female	No.	Percent with Corpora Lutea	Corpora Lutea Per Female with Corpora Lutea
1970	Apr.	18	11 (61%)	4.5	5.9	7	42	3.6
	May	13	12 (92%)	3.2	3.3	1	0	---
	June	23	15 (65%)	3.5	3.5	8	37	4.6
	July	14	7 (50%)	2.7	3.7	7	14	2.1
	Aug.	18	12 (67%)	2.8	3.5	6	33	3.5
	Sept.	17	11 (65%)	3.3	3.4	6	33	3.5
	Oct.	16	7 (44%)	3.9	4.3	9	0	---
	Nov.	22	11 (50%)	3.5	4.0	11	45	3.2
	Dec.	22	5 (23%)	3.0	3.0	17	29	3.0
1971	Jan.	26	14 (54%)	3.7	4.6	12	50	1.8
	Feb.	28	16 (57%)	3.2	3.4	12	41	3.8
	Mar.	25	13 (52%)	3.6	3.9	12	25	4.0
Totals and Means		242	134	3.4	3.9	108		3.3

TABLE V

BODY, ADRENAL AND OVARIAN WEIGHTS OF PREGNANT FEMALE PRAIRIE VOLES

Year	Month	Number of Animals	Total Body Weight (g)	Ovarian Weight (mg)	Adrenal Weight (mg)
1970	Apr.	11	42.7	7.7	9.2
	May	12	39.9	6.7	8.3
	June	15	40.6	6.3	9.1
	July	7	40.7	5.8	7.4
	Aug.	12	45.1	5.6	9.1
	Sept.	11	43.4	7.4	9.1
	Oct.	7	54.7	6.7	9.7
	Nov.	11	48.8	7.7	11.6
	Dec.	5	50.2	6.3	11.3
1971	Jan.	14	49.9	7.7	9.6
	Feb.	16	44.6	7.0	10.3
	Mar.	13	37.3	6.5	9.2
Totals and Means		134	44.3	6.7	9.4

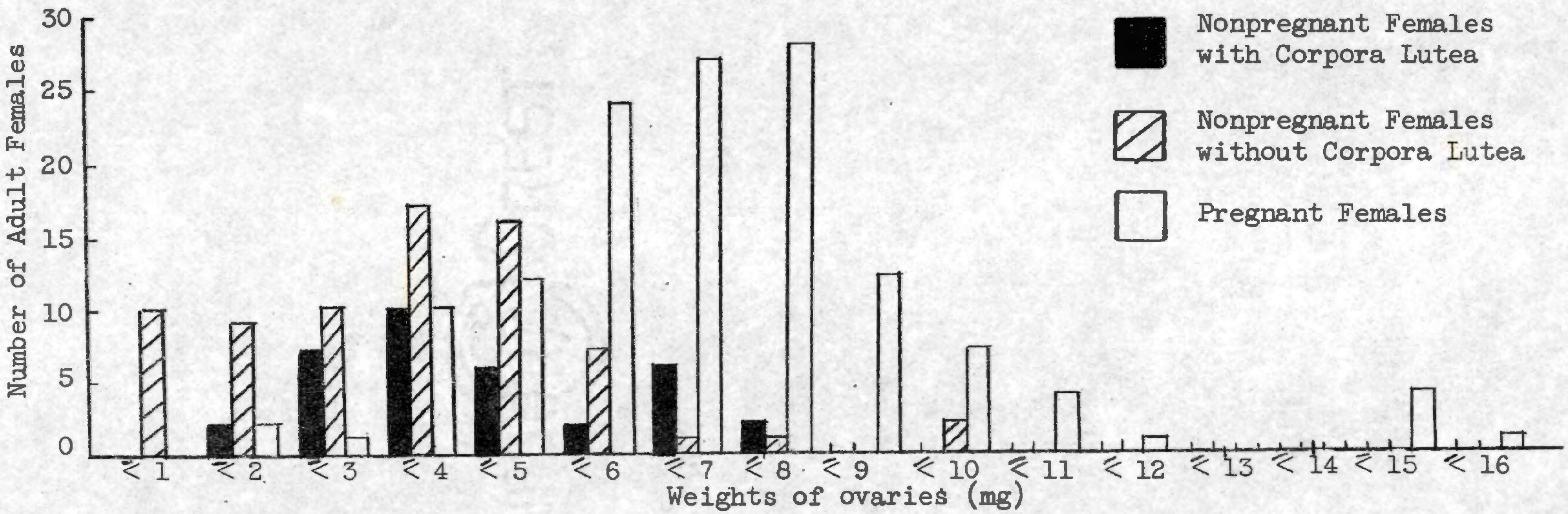

Figure 5. Frequency distribution of ovarian weights of nonpregnant females, with and without corpora lutea, and pregnant females captured during April 1970 to March 1971 in Cumberland County, Tennessee.

pregnant females was significantly heavier than the mean weights of ovaries of each of the two categories of nonpregnant females. Monthly mean weights of ovaries ranged from 5.6 mg in August to 7.7 mg in April, November, and January, but these variations were not statistically significant.

Adrenal weights of pregnant females ranged from 4.8 mg to 16.1 mg ($\bar{x}$ = 9.4 mg) (Table V). Adrenals of pregnant females were heavier than those of nonpregnant females. Adrenals of pregnant females were heaviest in November (11.6 mg), and lightest in July (7.4 mg).

Nonpregnant Females

Of the 108 females considered nonpregnant 32 displayed corpora lutea but no implanted young. The proportion of nonpregnant adult females displaying corpora lutea ranged from 0 percent in May, July, and October to 50 percent in January. The 32 females displaying corpora lutea and the 76 females without corpora lutea constituted the two categories of nonpregnant females. The probability is high that most or all of the 32 females with corpora lutea but no visible implanted young were in early stages of pregnancy, particularly if prairie voles are induced ovulators, as suggested by Clulow and Mallory (1970). Classifying this group of females as pregnant would increase the proportion of pregnant females in some months. The proportion pregnant would range from 41 percent in December to 92 percent in May. Differences in the proportion of pregnant females would have been lessened between months, but the pattern would remain similar.

Minimum weight for both categories of nonpregnant females was 21.9 g (Table VI). Maximum weights were 68.4 g and 62.6 g for females with and without corpora lutea respectively. Mean body weights for the two categories of nonpregnant females (with and without corpora lutea) were 37.2 g and 36.6 g respectively. These means were not significantly different. Mean weights ranged from 33.6 g in March to 40.5 g in December for nonpregnant females. Heaviest weights for nonpregnant and pregnant females occurred during the months of September through February.

Ovaries of nonpregnant females with corpora lutea ranged from 1.1 mg to 7.9 mg ($\bar{x}$ = 4.4 mg), while those of nonpregnant females without corpora lutea varied from 0.1 mg to 9.5 mg ($\bar{x}$ = 3.4 mg) (Table VI) (Figure 5, page 22). The mean ovarian weights of the two categories of nonpregnant females were not significantly different. Weights of ovaries did not vary seasonally for these two groups of females.

Adrenals of nonpregnant females with corpora lutea ranged from 3.6 mg to 16.3 mg in weight ($\bar{x}$ = 8.3 mg) (Table VI). Females displaying no corpora lutea possessed adrenals ranging from 2.9 mg to 17.0 mg ($\bar{x}$ = 7.7 mg). These mean weights were not significantly different, nor were seasonal variations evident.

C. JUVENILES

The percentage of juveniles in any month was regarded as an indicator of reproductive activity for the previous month (Figure 6). This proportion ranged from 6.6 percent in March to 41.5 percent in

TABLE VI

BODY, ADRENAL AND OVARIAN WEIGHTS OF NONPREGNANT FEMALE PRAIRIE VOLES

		With Corpora Lutea				Without Corpora Lutea			
Year	Month	Number of Animals	Total Body Weight (g)	Ovarian Weight (mg)	Adrenal Weight (mg)	Number of Animals	Total Body Weight (g)	Ovarian Weight (mg)	Adrenal Weight (mg)
1970	Apr.	3	41.2	5.1	8.2	4	34.0	3.9	6.6
	May	0	0	0	0	1	37.9	4.4	6.1
	June	3	43.1	5.6	10.1	5	31.2	3.4	6.9
	July	0	34.1	3.5	6.9	7	39.2	4.6	7.6
	Aug.	2	32.7	5.3	7.9	4	36.4	2.9	8.3
	Sept.	2	40.9	3.6	8.5	4	39.5	4.5	8.3
	Oct.	0	0	0	0	9	34.8	3.4	8.3
	Nov.	5	33.8	3.8	8.8	6	36.7	1.9	8.0
	Dec.	4	34.0	3.2	7.7	13	43.2	3.3	8.3
1971	Jan.	5	40.9	4.9	8.5	7	37.3	2.9	7.5
	Feb.	5	39.2	3.8	8.6	7	35.4	2.6	8.6
	Mar.	3	31.8	5.9	7.6	9	34.1	3.2	7.5
Totals and Means		32	37.2	4.4	8.3	76	36.6	3.4	7.7

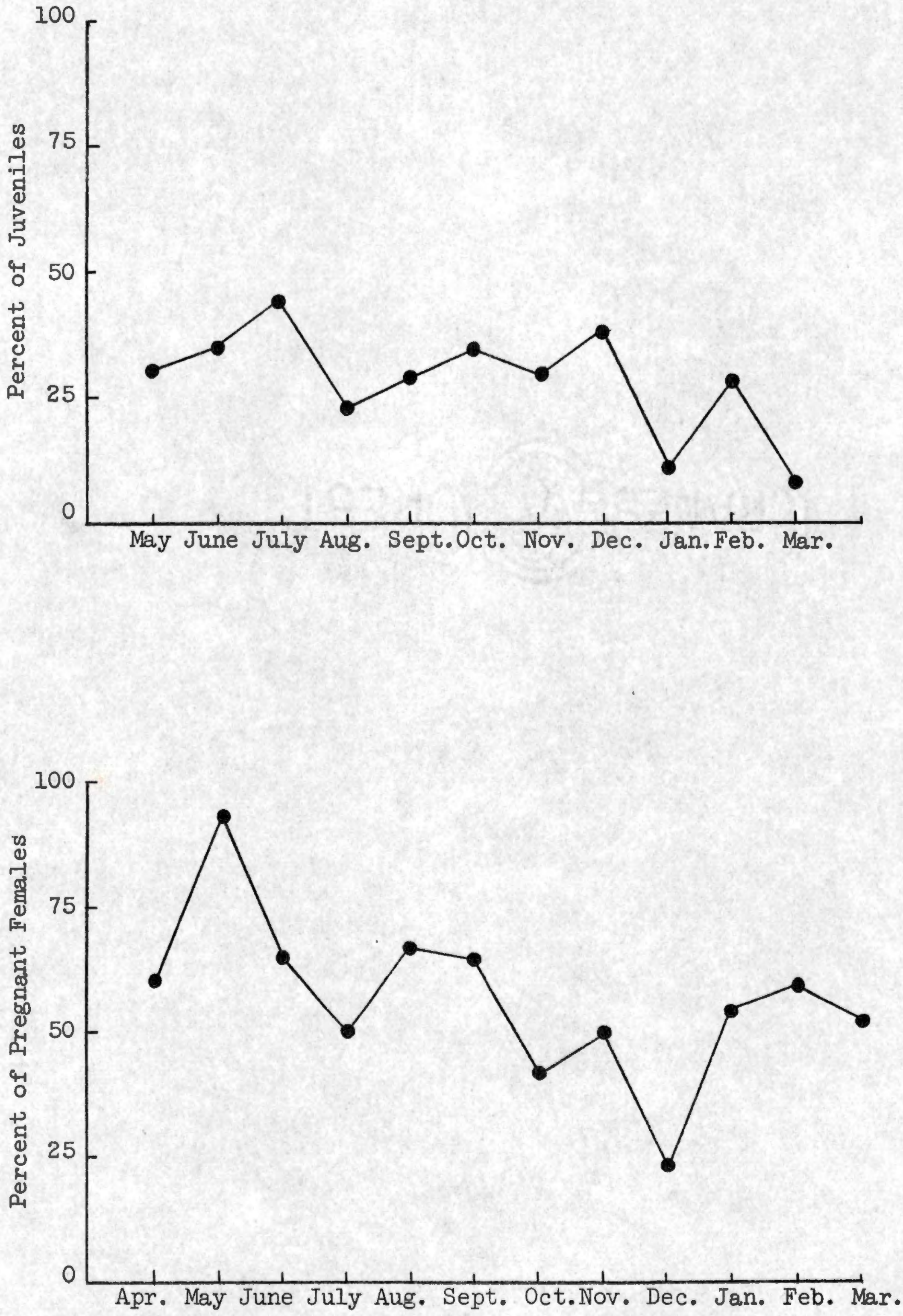

Figure 6. Percentage of juveniles and pregnant females per month.

July. These proportions appeared to correspond with the percent of females pregnant for the respective preceding months.

Males

Mean body weight of juvenile males was 24.3 g (Table VII). Total body weight ranged from 15.2 g in March to 27.6 g in December.

Testes of all juvenile males were turgid. Mean testicular weight was 44.7 mg, ranging from means of 10.4 mg in January to 88.7 mg in May.

Accessory structures were not developed. The cauda epididymides were opaque and displayed no tubules. Seminal vesicles were undeveloped and too small to obtain a critical weight on a Mettler balance.

Mean adrenal weight was 2.5 mg. Adrenal weight ranged from a mean of 1.5 mg in October to a mean of 4.1 mg in March. No seasonal variations were demonstrated.

Females

Total body weight of juvenile females ranged from 14.8 g in June to 26.4 g in December (Table VIII). Mean body weight of juvenile females was 18.3 g.

Ovaries displayed small developing follicles, giving the ovaries a granular texture. Mean weight of ovaries was 1.2 mg, ranging from a mean of 1.0 mg in June and November to 1.8 mg in February.

Mean weights of paired adrenals ranged from 2.0 mg in August to 4.6 mg in December. Mean adrenal weight was 2.9 mg. No seasonal variations were evident.

TABLE VII

TOTAL BODY WEIGHT, ADRENAL AND TESTICULAR WEIGHTS OF JUVENILE MALE PRAIRIE VOLES CAPTURED DURING APRIL 1970 TO MARCH 1971 IN CUMBERLAND COUNTY, TENNESSEE

Year	Month	N	Total Body Weight (g)	Adrenal Weight (mg)	Testes Weight (mg)
1970	Apr.	8	16.4	2.5	39.5
	May	9	22.2	2.6	88.7
	June	19	17.5	2.0	30.6
	July	10	23.9	2.3	72.2
	Aug.	5	21.7	2.7	62.5
	Sept.	6	24.2	2.9	58.3
	Oct.	8	15.5	1.5	22.0
	Nov.	6	22.9	2.5	38.6
	Dec.	10	27.6	4.1	31.8
1971	Jan.	2	18.9	1.8	10.4
	Feb.	8	21.4	3.4	50.8
	Mar.	3	15.2	2.1	31.7
Totals and Means		81	24.3	2.5	44.7

TABLE VIII

TOTAL BODY WEIGHT, ADRENAL AND OVARIAN WEIGHT OF JUVENILE FEMALE PRAIRIE VOLES CAPTURED DURING APRIL 1970 TO MARCH 1971 IN CUMBERLAND COUNTY, TENNESSEE

Year	Month	N	Total Body Weight (g)	Ovarian Weight (mg)	Adrenal Weight (mg)
1970	Apr.	8	17.7	1.5	2.7
	May	6	19.8	1.5	3.3
	June	2	14.8	1.0	3.6
	July	7	19.8	1.2	2.1
	Aug.	6	16.6	1.2	2.0
	Sept.	5	19.1	1.3	3.1
	Oct.	9	19.5	1.1	2.6
	Nov.	8	21.6	1.0	3.2
	Dec.	15	26.4	1.3	4.6
1971	Jan.	3	24.0	1.4	4.4
	Feb.	12	20.7	1.8	3.2
	Mar.	0	0	0	0
Totals and Means		94	18.3	1.2	2.9

D. FAT ANALYSIS

Of the 46 animals processed for total body fat content, 23 were males (Table IX). Fifteen of the 23 females were pregnant and eight were nonpregnant.

Mean body fat content for males was 14.0 percent, ranging from means of 12.5 percent in the spring to 15.0 percent in the fall. Body fat did not vary significantly between seasons.

Mean body fat contents for pregnant and nonpregnant females respectively were 14.2 and 14.8 percent. These means were not significantly different. Percentage of fat content for pregnant females ranged from 7.9 in spring to 20.5 in winter. These maximum and minimum values of body fat content were not statistically different. The body fat of nonpregnant females ranged from 11.7 percent in fall to 22.3 percent in summer, but differences between seasons were not significant.

TABLE IX

SEASONAL MEANS OF PERCENT BODY FAT CONTENT FOR FEMALES (PREGNANT AND NONPREGNANT), AND MALE PRAIRIE VOLES

			Females			
	Males		Pregnant		Nonpregnant	
Season	N	Mean Percent Body Fat Content	N	Mean Percent Body Fat Content	N	Mean Percent Body Fat Content
Spring	5	12.5	2	7.9	3	11.7
Summer	6	14.5	4	11.9	2	22.3
Fall	6	14.4	4	11.5	2	11.4
Winter	6	15.0	5	20.5	1	15.9
Totals and Means	23	14.0	15	14.2	8	14.8

CHAPTER V

DISCUSSION

Prairie voles on the Cumberland Plateau engaged in reproductive activity during all months of the year. Seasonal fluctuations in breeding activity were not marked, though a modest decline in sexual activity may have occurred in December.

An apparent decline in breeding of males was manifested by: (a) a decline in testicular weight, (b) a decline in seminal vesicular weight, and (c) a decline in the proportion of males judged fecund. The decline of testicular and vesicular weights, and proportion of fecund males was most marked during December (Figure 4, page 18). Similar reductions in testicular and vesicular weights were observed in pine voles (*Pitymys pinetorum*) during December by Valentine and Kirkpatrick (1970). Jameson (1947) reported that testicular weights of *M. ochrogaster* in Kansas declined from November to January. A study conducted in Indiana revealed that weights of testes of prairie voles were lowest during November and December (Keller and Krebs, 1970).

Female reproductive activity was gauged by the percentage of females pregnant in each monthly sample. Visual inspection of the reproductive tracts was the most reliable method for differentiating pregnant females from nonpregnant females. Minimum sexual activity was noted in December when less than one-fourth of the females were pregnant. Jameson (1947) noted that prairie voles apparently ceased breeding in December and January in Kansas; no pregnant females were captured during those months. In Indiana, prairie voles bred during all seasons, with the lowest percentage of pregnant adult females occurred during winter (Corthrum, 1967). Additional work in Indiana by Keller and Krebs (1970) indicated that the smallest percentages of pregnant females occurred in October and November.

Fitch (1957) and Martin (1956) in Kansas and Dietrick (1970) in Tennessee regarded perforate vaginal orifices and/or visibly swollen abdomens as indicators of pregnancy of live-trapped animals. Using these criteria, Fitch (1957) reported the lowest percentage of pregnant females occurred during summer. Martin (1956) stated that prairie voles on his study area in Kansas were least active sexually in December and January. Deitrick (1970) observed an apparent decline during the summer in Tennessee. These divergent patterns may have resulted from using criteria which are not accurate indicators of reproductive activity. The author found that the percentages of adult females demonstrating perforate vaginal orifices did not coincide with percentages of pregnant females in all monthly samples. In fact, the percentage of females displaying perforate vaginal orifices was diametrical to the percentage of pregnant females in several monthly samples, and therefore was not a valid criterion for pregnancy.

The percentage of juveniles trapped in any month served as an indicator for breeding activity of the preceding month (Figure 6, page 26). The greatest proportion of juveniles occurred in July and

December, and the lowest in January and April. These declines in January and April coincided with reduction of reproductive activity of adult males and females in December and May.

Mean litter sizes were not significantly different between months. Martin (1956) noted also that there were no significant differences in mean monthly litter sizes of prairie voles in Kansas. However, in Indiana litter sizes appeared to vary seasonally, with litter sizes in fall-winter-spring periods being significantly smaller (14 percent), than those occurring in summer (Keller and Krebs, 1970). Mean litter size of 134 *in utero* observed in this study was 3.4 young, well within the range reported elsewhere. Other investigators have reported litter sizes in *M. ochrogaster* as 3.4, from 58 litters in Kansas (Jameson, 1947); 3.2 from 65 litters in Kansas (Martin, 1956); 3.4 from 82 litters in Kansas (Fitch, 1957); and 3.9 from 134 litters in Indiana (Corthrum, 1967).

Mean weight of ovaries from pregnant females was significantly heavier than that of ovaries from either of the two categories of nonpregnant females. A large overlap existing in the frequency distributions of the individual ovarian weights of the three categories of females, however, precluded using ovarian weights as a criterion for reproductive activity for any individual (Figure 5, page 22).

Adrenal weights for females, both pregnant and nonpregnant, and for males were lowest in summer and highest during winter. Pregnant females displayed heavier adrenal weights than males or nonpregnant females. Chitty and Clarke (1963) found this relationship to exist in *M. agresti*. On the other hand, male pine voles were found to have heavier adrenals than pregnant or nonpregnant females (Valentine and Kirkpatrick, 1970). Christian and Davis (1966) suggested that changes in adrenal weights of meadow voles were due to changes in population size and not reproductive status or seasonal environmental changes. It has also been suggested that the quantity and quality of food may be related to the fluctuation of adrenal weights (Chitty, 1961). Fat analysis indicated no significant difference in male and female (pregnant and non-pregnant) body fat content. Seasonal differences in body fat content did not indicate a nutritional insufficiency of available foods during this study.

In summary, prairie voles have been shown capable of breeding throughout the year in the laboratory (Richmond, 1967; Gier and Cooksey, 1967) and in the field (Martin, 1956; Corthrum, 1967; Keller and Krebs, 1970). Therefore, a cessation or decline in breeding during any season likely would not be due to an internal rhythm as suggested by Calhoun (1945). Fluctuations are more likely produced by one or more environmental influences. Hamilton (1941) stated that dense populations of meadow voles (*M. pennsylvanicus*) were necessary for reproduction in this species during winter in New York. Martin (1956) stated that a correlation may exist between breeding activity of prairie voles and food availability. A tendency for ovulation rate to increase, or for ovulation to be repressed or stimulated in laboratory rabbits (*Oryctolagus cunniculus*) by manipulating feed levels has been observed (Short, Peters, and Casida, 1968). A reduction in either the quantity or quality of food was reported to have a depressing effect on reproduction in *Microtus montanus* in Nevada (Bailey, 1924).

Pronounced changes in the prairie vole's environment responsible for the decline in breeding activity were not detected. Perhaps the comparatively uniform breeding of prairie voles throughout the year in Tennessee is a reflection of the mild climate in this portion of its range.

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VITA

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