Diest, food preference and reproductive cycles of some desert rodents

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1972 PROGRESS REPORT

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Northern Arizona University

Research Memorandum, RM 73-24

MAY 1973

Report Volume 3
Page 2.3.2.7.

ABSTRACT

This study considers the diets, seasonal food preferences, habitat selection, seasonal activity cycles, and reproductive cycles of *Perognathus amplus, P. penicillatus, P. baileyi, P. intermedius, Dipodomys merriami,* and *Peromyscus eremicus.*

The diets and food preferences were examined by a microscopic technique yielding relative frequencies of the dietary constituents. Cheek pouch contents of the heteromyids and stomach contents of all rodents indicate seasonal shifts in food usage. The rodents feed mainly on seeds, but some feed on insects during certain seasons.

Analysis of the plant communitites involving line transects, permanent 1 sq. meter plots and soil samples (for seeds) were taken at the animal capture sites.

The activity (percent trapping success) of the rodents was determined, as well as the age structure of the populations and their reproductive condition. The parameters will indicate much about the population dynamics of the rodents as well as how they divide their resources.

The foods used frequently by the rodents, the availability of the food, relative density of seeds in the soil, phenology of major plants, activity of rodents, and age structure and reproductive condition of rodent populations are summarized and presented in graphic form.

INTRODUCTION

Knowledge of the diets and food preferences of a rodent community is essential to an understanding of the ecological and energetic relationships of that community. The purpose of this study was to identify the diets of five desert rodent species and relate the diets to reproduction of the rodents and to food resources in the desert. Many of the dynamic aspects of the desert are dependent on the timing of seed production by annuals. The seeds provide a major portion of the diets of the rodents, as well as much of the new seasonal, above ground, vegetational biomass. It is hoped to establish the relationships between the phenology of desert plants, seed production, rodent reproduction, and rodent diets and preferences. This should provide a base from which to move into the study of other aspects of desert ecology, such as the use of seeds by birds and insects, and the impact of rodents on seasonal production of vegetation.

OBJECTIVES

1. To measure reproductive cycles of six species of desert rodents (*Perognathus amplus*, *P. intermedius*, *P. penicillatus*, *P. baileyi*, *Dipodomys merriami*, and *Peromyscus eremicus*) as functions of the weather and of phenology and productivity of vegetation at the Silverbell Site.
2. To determine seasonal activity patterns of desert rodents.
3. To measure phenology, standing crop, seed utilization, and composition of the vegetation at regular intervals throughout the year.
4. To measure the species composition of the diets of the five rodent species.
5. To relate dietary composition to the available food base and to determine the degree to which availability and preference determine foods consumed.
6. To calculate preference indices for the dietary components of each of the five mammalian species.

METHODS

Since June 1970, the principal investigators and the research assistants have spent a total of 684 man-days in the field. From June through August, semi-monthly samples of mammals were taken; monthly samples were taken during the winter and spring. When possible, a minimum of 50 individuals of each species of rodent under study were being taken during each sampling period.

Collection of phenological data (DSCODES A3UBB01 and A3UBB03)

Phenological data can be valuable in studying seasonal relationships between producers and consumers in any given biome. The bimodal pattern of rainfall in the Sonoran Desert (as defined by Shreve, 1951) is accompanied by a bimodal response of annuals present in this desert.

Early in the process study, it was determined that the rodents under investigation were primarily utilizing seeds collected from annual plants in the study area. Accordingly, phenological data were kept on all vegetation in the area to determine at what time(s) of the year peak production of fruits and seeds occurred, and when certain key plants set seed. Since green material was detected in some of the rodent stomachs, the dates that perennial species began to leaf out were also recorded.

The scheme used in gathering and organizing phenological data was adapted from Leith (1970). The vegetation was divided into four groups; herbs, shrubs, cacti, and trees. The observations made for each plant were: 1) vegetative stage; 2) production of culms; 3) flower and inflorescence buds; 4) flowering; 5) unripe seeds and fruits; 6) ripe seeds and dispersal; 7) yellowing of leaves; 8) leaves present; 9) plant not observed. The last two categories were added to Leith's scheme to include an important phenological event in the lives of perennial plants (8) and to include plants present in the study area but not always observed on a monthly basis (9).

Semi-monthly observations were made during the summers of 1970 and 1971 and monthly observations for the remainder of 1970-1971. Between 44-56 permanent vegetation plots were observed for each of the above time intervals, at which time field notes were made on the phenological conditions of the plant species observed. A number of "marker" plants were used to determine the status of that species' population in the study area. Also, the person recording vegetation at capture sites for the mammals noted significant phenological events for the plants present (e.g., *Larrea* flowering).

Data were then transferred from field notes and vegetation sheets to tables listing all the species present in the study area. Plants in flower were collected and preserved for the purpose of double checking the field data.

Analysis of permanent plots (DSCODE A3UBB03)

A series of 20 permanent meter-square plots were established in an area of the Sonoran Desert near Tucson, Arizona. These plots were approximately 30 m apart and marked with steel spikes and aluminum tags. Each plot was observed at least once a month. Observations were made on the number and kinds of annual plants present. Any change in the physical appearance of the plot (e.g., new ant hill) was also noted. The phenological status of each species of annual plant was recorded according to the method of Leith (1970).

Data from field notes were transferred to coding forms provided by the International Biological Program. Printouts of data received included the sample date, plot number, habitat, species taxon code, and absolute density of each species. These printouts were used to calculate seasonal differences in density and diversity of annual plants within the permanent plots.

Climatological data were furnished by the University of Arizona's Institute of Atmospheric Physics. Weather summaries utilized were those for Cortaro, Arizona (el. 610 m) and Silverbell, Arizona (el. 792 m). The permanent plots were located at an elevation of 701 m, approximately midway between the two weather stations. Climatograms (Tables 1 and 2) indicate the average monthly temperature (C) and monthly rainfall (mm).

Collection of seed data (DSCODE A3UBB02)

A major reason for collecting seed samples is that rodents under study are using seeds as main sources of food. They appear to be picking seeds from the soil long after the parent plants are dead. Ten random soil samples were collected semi-monthly during the summers of 1970 and 1971 and 10 samples were collected monthly throughout the rest of 1970 and 1971. Beginning in June of 1971, 10 samples of soil were collected at capture sites for each of the five species of rodents being studied. This technique will yield data on the quantity and quality of seeds available to the rodents.

Collection of soil samples

One-tenth m soil samples were collected to depths of 0-2, 2-4, 4-6 cm. The method consisted of randomly tossing a 1/10 m ring and collecting the soil enclosed by the ring. Each layer of soil was removed with a trowel and stored in a cloth bag for transportation to the laboratory. The date of collection, location of sample and name of collector were recorded for each sample. Data were also recorded on annuals present inside the sampling ring and the four nearest shrubs and/or trees to the sample sites.

Cain (1938) considers the number of samples (or plots) is adequate when a 10% increase in sample area, or in number of samples, yields an increase in number of species equal to 10% of the total. By calculating this percent increase it was determined that seven samples would be adequate. Ten samples per rodent species, per sampling period were taken.

Table 1. Monthly precipitation (centimeters) on rocky hills on creosote flats, recorded at Silverbell and Cortaro weather stations, respectively

	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Total
Rocky Hills													
1970-71	Trace	3.58	4.55	8.20	0.71	0.51	1.27	.08	1.50	Trace	.53	0	20.93
1971-72	Trace	2.29	15.88	7.32	7.98	0.28	2.90	3.78	2.03	1.27	0.91	0.74	45.38
Creosote Flats													
1970-71	0	1.78	3.20	8.81	0	0.41	1.14	1.80	2.24	0	1.19	0	20.57
1971-72	0	2.39	24.94	1.83	4.78	1.68	6.07	1.75	1.47	.97	0	1.70	47.58

Table 2. Mean monthly air temperatures and mean minimum air temperatures (C) on rocky hills and on creosote flats, recorded at Silverbell and Cortaro weather stations, respectively

		Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Rocky Hills													
1970-71	Avg.	30.0	31.0	---	26.8	20.5	---	---	---	13.9	12.1	18.2	---
	Avg. Min.	23.1	24.9	22.4	21.1	14.6	10.3	5.4	4.9	7.9	10.7	11.2	---
1971-72	Avg.	28.5	---	27.5	27.7	---	---	9.0	14.0	11.5	---	20.8	---
	Avg. Min.	21.9	---	21.2	21.5	---	---	4.0	8.8	5.0	---	13.5	---
Creosote Flats													
1970-71	Avg.	29.8	32.5	30.8	25.9	18.7	15.3	11.5	10.5	12.0	16.5	18.5	20.6
	Avg. Min.	20.4	24.8	23.4	17.6	9.1	5.4	1.8	.72	2.3	8.6	8.9	8.6
1971-72	Avg.	28.0	32.3	28.5	26.1	18.0	13.7	8.9	8.9	10.8	12.8	21.2	22.4
	Avg. Min.	17.8	24.6	21.6	17.5	8.5	4.8	0.9	-1.0	2.0	3.0	10.5	12.9

Extracting seeds from soil

Each soil sample was poured through a Tyler Soil Sieve with 0.495 mm openings and with 32 mesh to the inch. This size sieve was small enough to capture all of the smallest seeds except those of the Orchidaceae and the Solanaceae (personal communication, R. Hevly). The soil and seeds not passing through the sieve were returned to the original sample bags.

The soil-seed extracts were then put separately into a 2000 ml beaker and tap water was added until the material was thoroughly wetted. Ten ml of hydrochloric acid (10%) was added to this mixture in order to: 1) break up the caliche soil particles so that the seeds were released from the soil, and 2) bubble the seeds to the surface of the solution.

After bubbling had stopped, the remaining solution was poured through a 150 mm Buchner funnel fitted with Whatman filter paper (#1) on top of a 2000 ml suction flask. Air was pulled from the flask at a pressure of 20 psi with a vacuum pump. The water was then removed from the sample leaving a mixture of seeds and very fine soil on top of the filter paper. The filter paper was then air dried and placed in the original sample bag. The rocks and large soil particle mixture which was not dissolved by the acid was discarded, because examination of ten samples (Tables 3 and 4) showed that less than 15% of the seeds remained in this sediment. Table 4 also shows that 77% of the total seeds in the samples are removed by using the technique on only the 0.2 cm layer. Because of the time and effort necessary to extract the remaining seeds, efforts were concentrated on the upper (0-2 cm) layer.

Each sample was then re-sieved to remove the remaining fine soil. The seeds were then placed on a piece of graph paper and examined at magnification X10 with a binocular microscope. The seeds were separated into groups by genera, counted, and the number of each genus recorded on separate data sheets. Both known and unknown seeds were glued to a paper reference slide for identification or verification.

Table 3. Total number of seeds rocovered from 10 soil samples at three depths (July, 1970)

Depth	Rec.* 1	Rem.*	Rec. 2	Rem.	Rec. 3	Rem.	Rec. 4	Rem.	Rec. 5	Rem.
0-2 cm	310	0	466	225	175	0	175	0	249	17
3-4 cm	30	0	8	0	0	0	11	0	18	0
5-6 cm	8	0	0	0	27	2	3	0	5	0
Totals	348	0	474	225	202	2	189	0	272	17
	6		7		8		9		10	
0-2 cm	233	0	64	5	37	0	437	97	145	73
3-4 cm	12	2	11	0	9	1	76	0	16	0
5-6 cm	2	0	7	0	2	0	4	0	3	0
Totals	247	2	82	5	48	1	517	97	164	73

*Rec. = Recovered, Rem. = Remained

Table 4. Seed distribution and recovery methods for seeds recovered from 10 soil samples (July, 1970)

1. Total number of seeds rocovered = 2960
2. Number of seeds recovered by flotation = 2537
3. Percent of seeds recovered by flotation = 85.7%
4. Total number of seeds in top 0-2 cm layer = 2708
5. Percent of seeds in top 0-2 cm by flotation = 91%
6. Number of seeds recovered from top 0-2 cm by flotation = 2291
7. Percent of all seeds recovered by flotation in top 0-2 cm layer = 77.3%

Methods of sampling vegetation at capture sites

At most of the rodent capture sites, the vegetation was sampled using the line-intercept method. A 20 ft. steel tape was placed on the ground with the 10 ft. mark directly over the capture site. Alternate 1 ft. areas were considered a sample area. Within that 1 ft. area, all of the plants that touched the line or were within 1 cm of the line were recorded. These data are being used to calculate the relative frequency, relative density and relative dominance for each species. In addition, all cacti, shrubs and trees that intercepted the line were recorded. These data will be converted into a percent cover value for each species of plant.

A series of 44 permanent plots have been established in the study area. These include 20 plots in the creosote bush (*Larrea divaricata*) flats, 12 plots along washes, and 12 in the rocky hills. Each plot is circular and is 1 m^2 in area.

Monthly sampling of vegetation in these plots provides information from which absolute frequency and absolute density values can be calculated.

Diets of mammals (DSCODE A3UVC01)

The diets of the rodents are being studied by microscopically examining the stomach contents of specimens. The contents of each stomach are washed and mixed thoroughly in warm water. One microscope slide is made of material from each stomach using Hertwig's clearing solution (Baumgartner and Martin, 1939), and preparations are partially dried in a drying oven at 60 C. Twenty systematically located fields under 100-power magnification are studied on each slide. Food items are identified on the basis of distinctive epidermal features, using, for comparison, series of reference slides of known plant material (Davis, 1959; Croker, 1959; Storr, 1961). Each plant species present in each microscopic field is recorded and frequency percentages (the number of fields in which a plant species occurred out of 100 fields) are recorded for each specimen. Frequency percentages are then converted to particle density per field (using a Table by Fraker and Brischle, 1944). Relative dry weights of the food items are then accurately estimated by using the relative densities of the species (Sparks and Malechek, 1968). Similar procedures have been used in recent studies by Ward and Keith (1962).

Impact of rodents on seeds

In order to determine the number of seeds ingested per night by each rodent species, the relative density of those items over 1% for a two year period were used. Those items not over 1% were lumped into a miscellaneous category. Averages of those over 1% were extrapolated to the miscellaneous calculations. Relative density is proportional to dry weight of each seed species ingested (Sparks and Malechek, 1968), and was therefore multiplied by the calories per gram of each seed species. These products were summed and converted to relative figures. The relative figures (= relative contribution in calories by each seed species) were multiplied by the number of calories required by each rodent species per day, depending on the weight of the rodents. These requirements were determined from the literature or calculated on the basis of body weight using a metabolism formula ($kcal/day = 70 + 4w^{.75}$). The products were the relative contribution of absolute calories by each seed species. These were divided by the number of calories per seed to yield the number of seeds ingested per night. The calculations per seed were summed to give the the total number eaten per night. The calories per gram of the seeds species were determined by Dr. James MacMahon at Utah State University.

The assumptions made to determine the number of seeds used by the rodents include:

1. The rodents were 90% metabolically efficient (Schreiber and Johnson, 1972)
2. Rodent densities are those given by Cockrum (Thames et al., 1972) for the Silverbell Site.
3. Metabolism while in torpor = one third of active metabolism.
4. The weight used to calculate the number of calories required by each rodent species were representative of the population, including young animals.
5. The percent of the year active by each rodent species represents trapping data for two years, and is assummed to reflect the relative amount of time active.

Reproductive cycles (DSCODE A3UBE21, A3UBE22)

Body weights, lengths, pelage coloration, and tooth wear were used as criteria for distinguishing between adult, subadult, or juvenile animals. Counts of embryos and of placental scars were used to determine litter size; the timing of litter, the presence of recent placental scars, and the conditions of the mammary gland provided indications of the number of litters per year. Careful measurements were made of the horn and body of the uterus and length and width of ovaries in the females. Females were determined to be reproductively active if they were pregnant, lactating or in estrous, as determined by the condition of the vaginal orifice. The standard measurements of the male include the length and width of the testis and the length of the caudal epididymis and seminal vesicle. The caudal epididymis and seminal vesicle were also periodically checked for the presence of sperm. Animals with sperm in the caudal epididymis or seminal vesicle were considered reproductively active. Scrotal testes, elongated seminal vesicle, and general coloration of the reproductive organs were also good indicators of reproductive condition.

RESULTS AND DISCUSSION

Since field work began in June 1970, 89,229 trap nights (a trap night equals one trap set for one night) have been logged and 5,409 rodents representing 13 species have been taken. The six most abundant rodents in the study area and the numbers of each that have been taken are listed in Table 5. Although most of the trapping was done in the desert flats dominated by creosote bush (*Larrea divaricata*), traps were also set in the rocky hills during each sampling period. The hills form an important and widespread habitat in the study area. Of the six predominant species listed in Table 3, only *P. amplus*, *P. penicillatus*, and *D. merriami* are common in the creosote bush flats.

Table 5. Species, age and sex composition of total animals trapped at the Silverbell Site from June 1970 to June 1972. Reproductive data were calculated for only the first six species DSCODE—A3UBE21, A3UBE22

	Total Animals	Percent Male	Adult	Subadult	Juvenile
Dipodomys merriami	1572	53.8	1443	116	13
Perognathus amplus	1410	49.6	1085	282	43
Perognathus intermedius	1212	47.0	1039	151	22
Peromyscus eremicus	534	52.2	419	98	17
Perognathus baileyi	438	45.5	376	57	5
Perognathus penicillatus	187	57.2	157	26	4
Neotoma albigula	31				
Onychomys torridus	6				
Spermophilus tereticaudus	6				
Reithrodontomys megalotis	6				
Spermophilus harrisi	4				
Mus musculus	2				
Sigmodon hispidus	1				

Sampling of vegetation (DSCODE A3UBB01 and A3UBB03)

Vegetative data from 3740 capture sites (91% of the total capture sites) and seed content data from 414 soil samples have been recorded. To facilitate analyses, the data are being transferred to coding sheets and placed on file at the computer center. Although relatively little vegetative data have been analyzed to date (one computer program is in operation), certain points merit comment.

Vegetation: The results for a year and a half of phenological data are shown in Table 6. The percentages were calculated by dividing the total number of plants with ripe seeds and dispersing seeds, by the total number of plants in the study area. Note that there is a different "n" number for each set of plants.

Table 6. Percent of herb species (n=66), shrub species (n=23), cacti (n=11), and tree species (n=5) with ripe and dispersing seeds over an 18-month period

Month	Herbs (% of plants)	Shrubs (% of plants)	Cacti (% of plants)	Trees (% of plants)
	% of plants with ripe and dispersing seeds			
June 1970	20	20	50	60
July 1970	20	22	50	60
August 1970	20	22	30	20
September 1970	10	10	40	20
October 1970	30	10	30	20

Continued

Table 6. Continued

Month	Herbs (% of plants)	Shrubs (% of plants)	Cacti (% of plants)	Trees (% of plants)
	% of plants with ripe and dispersing seeds			
November 1970	30	10	20	20
December 1970	12	0	20	20
January 1971	4	0	20	0
February 1971	0	0	20	0
March 1971	0	0	0	0
April 1971	0	0	0	0
May 1971	0	0	0	0
June 1971	0	5	10	0
July 1971	0	10	20	20
August 1971	0	10	0	20
September 1971	20	20	10	20
October 1971	30	40	30	20
November 1971	30	30	30	40
December 1971	20	10	30	40

When the study was initiated in July of 1970, the density and diversity of the annual vegetation was comparatively high. Fifteen species were recorded, with three species averaging 90 or more plants per sq. m (Table 7). In october, after the summer rains had occurred, eleven species were observed with only one plant (*Plantago insularis*) having an average density of 90 or more. By March of 1971, after an interval of extreme dryness, the diversity had dropped to seven species, and only *Plantago* had an average density of 25 plants per sq. m.

During the second year of the study, maximum diversity in the plots was recorded in December, 1971. Nine species were found, but only two (*Plantago* and *Bouteloua aristidoides*) had densities above six plants per sq. m (Table 8). Maximum diversity was also found in February, 1972, when nine species were identified and four plants had average densities of two or more plants per sq. m. Minimum diversity and density occurred in June of each year which approximates the driest part of the year in the Sonoran Desert.

As indicated in Tables 1 and 2, 1970-1971 was a comparatively "dry" year in the study area. The summer rains ended abruptly in September of 1971. Rain gauges at the site did not record any rainfall from December 18, 1970, until July 27, 1971. Thus, summer rains occurred during 1970, but winter rains did not fall on this part of the desert during 1971.

In contrast, 1971-1972 was a comparatively "wet" year. Summer rains began in July, reached their highest levels in August, and leveled off in September. However, measurable rainfall did continue through December, 1971. No appreciable difference was noted in average temperatures for the two weather stations over the period of observation.

Table 7. Permanent plots (DSCODE A3UBB03)

Average Density/10m^2 of Annual Plants
1970-1971

	J	July	A	S	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Festuca octoflora		109.0			.9	5.9	4.0	.2	.8	.2		
Plantago insularis		314.8			97.9	66.7	53.1	62.7	38.3	19.4	13.4	25.4
Pectocarya platycarpa		94.2				.2	1.0	.8	2.2	3.2	1.2	1.4
Lepidium medium		2.1			.1	.1	.5	.2	.4	.1		.2
Plagiobothrys arizonicus		3.4				.2	.3	.3	.1	.1		.1
Lesquerella gordoni		.8				.1						
Chaenactis stevioides		.2										
Eriophyllum lanosum		8.9										
Bouteloua aristidoides		.9			5.6	.3	4.0	4.7	4.6	2.2	2.2	1.2
Cryptantha micrantha		1.9			.2			.1	.1		.1	
Thelypodium lasiophyllum		3.7				.5	.2	.4	.3	.3	.2	.2
Eriastrum diffusum		1.7										
Erodium cicutarium		14.8										
Chorizanthe rigida		.2			.1		.1					
Allionia incarnata		.1			2.9	1.0	1.0	.4	.2	.1		
Senecio monoensis					.2	.2	.2	.1				
Senecio longilobus					.2							
Bouteloua barbata					.3							
Euphorbia albomarginata					.7	.3	.5	.2	.5	.3	.2	.2
Eriochloa spp.							.1		.1			

Table 8. Permanent plots (DSCODE A3UBB03)

	Average Density/10m^2 of Annual Plants 1971-1972											
	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Festuca octoflora						.2						
Plantago insularis	24.6	.1			1.5	10.2	6.6	15.3	14.5	6.2	8.8	8.1
Pectocarya platycarpa	.8	4.5							.8			
Lesquerella gordoni								.1	.1	.2		
Bouteloua aristidoides	1.1	.4	5.0	6.1	7.6	7.3	7.1				5.9	5.9
Senecio monoensis			.1	.1	.1	.2	.1					
Euphorbia albomarginata	.4	.2	.5	.3	.5	.2	.3					
Thelypodium lasiophyllum	.2											
Grass spp. (unk.)		.7							2.0			
Poa bigelovii					.1	.1	.1					
Bouteloua barbata			.4	.9	.9	.5	.4					
Erodium cicutarium					.7	3.0	2.9	6.9	6.9	2.6	1.9	1.1
Tridens pulchellus							.1	.1	.1			
Tidestromia sp.							.1					
Plagiobothrys arizonicus									.1			
Lotus spp.									2.7	.1		
Monoptilon bellioides									.1			

Seeds in soil (DSCODE A3UBE02)

Tables 9-14 present data on seeds in the soil which are available to the rodents. Only those seeds species comprising more than 1% of the relative density of the samples are listed by species (MISCSP). Absolute densities are presented and relative densities for 1971-1972 for capture sites of each rodent species. A composite Table (9) is given for the first year of the study during which data were collected at random sites on the flats rather than at species-specific capture sites of rodents.

Calories per gram, seed weights, and calories per seed of the important seed species are presented in Table 15.

Comparisons of the seeds available to the rodent species are made in Tables 16 and 17.

Diets of rodents (DSCODE A3UVC01)

Preliminary data is available for the diets of live rodent species. These data are averaged for 1970-1971, 1971-1972, and 1970-1972, and are presented in Tables 18-22. Only those seed species making up more than 1% of the relative frequency of dietary items for the two-year period are included. Relative frequency figures are given for the stomach contents, relative densities for the cheek pouch contents. Percent usage figures indicate what percent of the rodents sampled used each species of seed.

Impact of rodents on seeds

The impact of the rodents on the seed reserves in terms of the number of seeds ingested is presented in Table 23.

Table 9. Densities of seeds in soil sample taken randomly in rodent habitat*

	Absolute Densities														Relative Density of Total	
	1971										1972					
	Jun	Jun	Jul (3)	Jul (10)	Aug (1)	Aug	Sep	Oct (10)	Nov (10)	Dec (10)	Jan (10)	Feb (10)	Mar (10)	Apr (10)	Total (83)	R.D.
Allonia				113											113	2.7
Eriochloa			36	27				18	10	3	8	6	4	14	126	3.0
Erodium			4	65				21	27	14	21	17	21	19	209	5.0
Festuca			31	351						2	4				388	9.2
Franseria			15	54								2	1	1	73	1.7
Larrea			2	353				57	21	21	11	17	5	4	491	11.7
Pectocarya			125	1241				215	50	78	12	24	5	9	1759	41.8
Plantago			21	97				145	106	100	110	76	64	69	788	18.7
Miscellaneous species															262	6.2
Total			244	2448	2			470	225	231	170	181	125	113	4209	100.0
Average# seeds/m^2			813.3	2448	20			470	225	231	170	181	125	113	507.1	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 10. Densities of seeds in soil samples taken at capture sites of *Dipodomys merriami*.*

	Absolute Densities																Relative Density of Total	
	1971												1972					
	May (19)	Jun (10)	Jun (14)	Jul (12)	Jul (9)	Aug (6)	Aug (11)	Sep (9)	Oct (9)	Nov (10)	Dec (10)	Jan (12	Feb (8)	Mar (10)	Apr (8)	May (10)	Total (167)	R.D.
Allionia	10	3	2	1	2		7		3	1	27	5	1	3	4	21	89	2.3
Chaenactis	22	11	5	2			40		2	2		4	2	4	1		95	2.5
Erodium	29	4	16	20	4	8	15		5	23	1	1		9	5	6	146	3.8
Franseria	21	4	9	11		4	38	17		8	1	2			6	11	132	3.4
Larrea	21	53	22	55	5	1	16	14	2	8	13	62	15	84		32	403	10.5
Legume	2						4	34	11	4	21	10	1	19	4	7	107	2.8
Pectocarya	391	263	254	258	14	24	150	185	21	11	11	44	5	6	4	9	1650	42.9
Plantago	25	29	29	95	31	7		2	4	4	2	4	2	6		9	249	6.5
Tridens	25	5	9	1		1	3	36	7	30	260	74	184	6	41	2	685	17.8
Miscellaneous species	32	10	5	14	14	1	6	19	7	10	5	65	1	13	14	61	286	7.5
Total	578	382	350	457	70	46	279	307	62	101	341	271	211	150	79	158	3842	100.0
Average # seeds/m^2	304.2	382	250	380.8	77.8	76.7	253.6	341.1	69.9	101	341	225.8	263.8	150	98.8	158	230.1	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 11. Densities of seeds in soil samples taken at capture sites of *Perognathus amplus**

	1971					Absolute densities							1972				Relative Density of Total	
	May (20)	Jun (10)	Jun (15)	Jul (13)	Jul (11)	Aug (12)	Aug (12)	Sep (11)	Oct (12)	Nov (11)	Dec (2)	Jan	Feb (4)	Mar (9)	Apr (11)	May (10)	Total (173)	R.D.
Allionia	35			2	4			1	18	4			2			6	72	2.1
Carnegia	1		2							1				1		63	68	2.0
Chaenactis	5	17	2	12	10	10	12	5	4	2	1			9	3	3	95	2.8
Erodium	32	3	15	11	3	6	13		10	22				1	7	7	130	3.9
Franseria	22	14	20	4	1	17	11	10	2	6	1			1	7	8	124	3.7
Larrea	40	60	39	81	7	14	6	9	1	26			2	42	7	9	343	10.2
Legume	2		1	1		2	1	7	27	4				23	19		96	2.9
Pectocarya	222	173	381	123	89	33	73	118	5	11	4			105	50	13	1400	41.8
Plantago	5	18	15	77	8	37	2						3	12		13	190	5.7
Tridens	57	12	12			1	1	170	18	20	15		111	17	141	8	583	17.4
Miscellaneous species	53	9	27	32	44	4	20	45	6				5	5	5	12	248	7.5
Total	474	306	514	343	166	124	129	365	91	96	21		123	216	239	142	3349	100.0
Average # seeds/m^2	273	306	342.6	263.8	150.9	103.3	107.5	331.8	75.8	62.7	105.0		307.5	240	217.3	142	193.6	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 12. Densities of seeds in soil samples taken at capture sites of *Perognathus baileyi*.*

	1971 Absolute Densities																Relative Density of Total	
	May (11)	Jun (10)	Jun (14)	Jul (12)	Jul (1)	Aug (4)	Aug (2)	Sep (5)	Oct (12)	Nov	Dec (9)	Jan (8)	Feb (7)	Mar (5)	Apr (2)	May (7)	Total (109)	R.D.
Allionia	2	10										9		34		2	57	2.1
Boerhaavia				2	1						24		3				30	1.1
Erodium		11	10	21				1	1			2		1			47	1.8
Euphorbia													2	15	1	18	36	1.3
Franseria	13	16	33	16		12	11	9	36		27	1	5	3	2	12	194	7.4
Larrea	8	36	29	14		2		6	1			9		5	5	3	118	4.4
Legume									11			19	9	13		3	55	2.1
Pectocarya	138	262	481	347		31		26	37			7	1	36	5	11	1382	52.0
Plantago	3	30	14	86		7	1		7			4		3		5	160	6.0
Tridens	12		7					38	21			113	55	92	4	33	375	14.1
Miscellaneous species	30	13	28	5	4	2	1	32	17		7		7	3	52	1	202	7.7
Total	206	378	602	491	5	54	13	112	131		58	164	82	205	69	88	2656	100.0
Average # seeds/m^2	187.3	378	430	409.2	5	135	65	224	109.2		64.4	205	117.1	410	345	125.7	243.7	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 13. Densities of seeds in soil samples taken at capture sites of *Perognathus intermedius**

	1971						Absolute Densities						1972			Relative Densities of Total	
	May (6)	Jun (11)	Jun (10)	Jul (10)	Jul (10)	Aug (11)	Aug (10)	Sep (9)	Oct (12)	Nov (9)	Dec (10)	Jan (7)	Feb (11)	Mar (6)	Apr (10)	May (12)	Total (153)	R.D.
Allionia	25	6				4	2	1		3				8		2	50	1.7
Boerhaavia				4	13			2			76	13	17	1	53		179	6.2
Chaenactis	5	8	4	5			1	6	1					1		5	36	1.3
Encelia		2	7		6	6				1			5		4	5	36	1.3
Erodium	10	4	1	3	1		1		5	8							33	1.1
Euphorbia			2		1	8	2	39		13		17		5		4	91	3.1
Franseria	7	8	6	26	28	16		7	2	69	14	54	8	7	7	29	288	10.0
Larrea	27	46	7	17	6	6	1	6	1	65	3		3	14		5	208	7.2
Legume					12		2	6	25	7	2	11	21	44	13	1	142	4.9
Lesquerella	11				1	1			1					5		9	28	1.0
Pectocarya	46	217	150	68	71	69	8	113		16	4	6	33	48	26	28	904	31.4
Plantago	35	11	7	27	3	4	4		3	3						9	106	3.7
Tridens	35					4	2	34	38	15	41	1	152	8	86	9	425	14.8
Miscellaneous species	5	6	1	16	54	12	57	38	3	4	13	48	34	21	31	8	351	12.3
Total	206	308	185	166	196	130	80	252	80	204	153	150	273	162	220	112	2877	100.0
Average # seeds/m^2	343.3	280	185	166	196	118.2	80	280	66.7	226.7	153	214.3	248.2	270	220	93.3	188	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 14. Densities of seeds in soil samples taken at capture sites of *Peromyscus eremicus**

	1971 Absolute Densities																Relative Densities of Total	
	May (5)	Jun (2)	Jun (2)	Jul (6)	Jul (9)	Aug (2)	Aug (1)	Sep	Oct	Nov (7)	Dec (10)	Jan (9)	Feb (3)	Mar	Apr (12)	May	Total (68)	R.D.
Boerhaavia				2	7	1					153	33	3		63		262	17.5
Carnegia	2			2	1	1				11	30				1		48	3.2
Daucus				79						1	11	10	4		15		120	8.0
Encelia	3	1	5		8	13				3					9		32	2.1
Euphorbia		5	1		1					2	5	117	1		10		142	9.5
Franseria	11			5	5	2	1			6	3	22	5		15		75	5.0
Larrea	4			3	5		2			1	1				7		23	1.5
Pectocarya	5	2	2	160	231	1				18	7	27	6		48		505	33.8
Plantago				22													22	1.5
Tridens	1	3								21	19	8	40		35		127	8.5
Miscellaneous species	6			26	17		1			22	22	23	12				137	9.4
Total	32	11	8	299	275	18	4			85	251	240	71		203		1493	100.0
Average # seeds/m²	64	55	40	498.3	305.6	90	40			121.4	251	266.7	236.7		169.2		219.6	

*Numbers in parentheses are sample sizes (DSCODE A3UBB02).

Table 15. Calories per g, seed weights in mg, and calories per seed for those seed species important to the rodents*

Plant species	Calories/gram	Seed Wt. (mg)	Calories/seed
Acacia constricta	4,912 (1.4%)	19.05	444.29
Boerhaavia spp.	4,487 (2.5%)	1.70	7.61
Crucifer	4,589 (.02%)	1.76	8.08
Eriochloa grandiflora	5,026 (.82%)	1.36	6.84
Erodium cicutarium	5,505 (1.2%)	1.62	8.89
Euphorbia spp.	2,521 (.37%)	0.35	0.88
Festuca octaflora	4,132 (1.9%)	0.49	2.00
Larrea divaricata	4,966 (.34%)	2.29	11.35
Lepidium medium	4,479(10.67%)	0.50	2.24
Lesquerella gordoni	5,297 (1.7%)	0.94	4.95
Opuntia spp.	4,652 (2.1%)	15.06	70.06
Pectocarya platycarpa	4,048 (.64%)	0.66	2.65
Plantago insularis	4,170 (2.2%)	0.93	3.84

*Numbers in parentheses are percent deviations

Table 16. Relative densities of seeds in the soil on flats at capture sites of *Dipodomys merriami* and *Perognathus amplus*——DSCODE A3UBB02

Seed species	1970-71 Composite	1971-72 *D. merriami*	1971-72 *P. amplus*
Erodium cicutarium	5.0	3.8	3.9
Franseria dumosa	1.7	3.4	3.7
Larrea divaricata	11.7	10.5	10.2
Pectocarya platycarpa	41.8	42.9	41.8
Plantago insularis	18.7	6.5	5.7
Tridens pulchellus	0.0	17.8	17.4
Total	78.9	84.9	82.7

Table 17. Relative densities of seeds in the soil on hills at capture sites of *Perognathus intermedius* and *Perognathus baileyi*——DSCODE A3UBB02

Seed species	*P. intermedius*	*P. baileyi*
Allionia incarnata	1.7	2.1
Boerhaavia spp.	6.2	1.1
Erodium cicutarium	1.1	1.8
Euphorbia spp.	3.1	1.3
Franseria dumosa	10.0	7.4
Larrea divaricata	7.2	4.4
Legume	4.9	2.1
Lesquerella gordoni	1.0	0.0
Pectocarya platycarpa	31.4	52.0
Plantago insularis	3.7	6.0
Tridens pulchellus	14.8	14.1
Total	85.1	92.3

Table 18. First year, second year, and two-year summaries of stomach contents, cheek pouch contents, and percent usage of those items occurring at a frequency greater than 1% for *Dipodomys merriami* (DSCODE A3UVC01)

	Rf Stomach			Usage Stomach			Rd Pouches			Usage Pouches		
	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72
Acacia	1.58	1.32	1.47	10.16	8.52	9.39	0.81	1.39	1.06	5.88	6.49	6.17
Eriochloa	1.88	3.72	2.62	9.45	11.76	10.53	1.06	7.14	3.65	0.89	5.07	2.85
Erodium	9.46	9.43	9.45	30.84	25.96	28.56	4.36	3.08	3.82	4.81	3.65	4.27
Euphorbia	6.85	12.88	9.29	24.95	29.61	27.13	0.06	7.16	4.01	2.26	2.84	3.22
Festuca	1.86	0.47	1.30	12.30	2.43	7.69	0.90	0.34	0.65	0.36	0.20	0.28
Insect	15.62	19.18	17.06	65.60	58.82	62.33	0.09		0.05	1.25		0.66
Larrea	8.58	9.68	9.02	46.70	39.55	43.35	27.88	0.57	24.04	38.68	0.20	35.48
Lesquerella	1.15	1.27	1.20	8.73	7.10	7.97	0.16	2.17	1.02	0.89	1.42	1.14
Opuntia	1.75	3.86	2.60	12.47	12.17	12.33	0.08	0.89	0.70	0.89	3.04	3.22
Pectocarya	26.35	12.51	20.76	73.44	31.44	53.80	10.88	1.30	6.80	14.26	2.43	8.73
Plantago	17.38	12.53	15.42	58.47	33.67	46.87	36.77	32.00	34.74	33.69	16.23	25.52
Tridens	1.10	1.62	1.31	10.87	6.29	8.73	2.84	1.00	2.06	1.07	0.81	0.95
Crucifer	0.60	2.70	1.45	6.95	10.55	8.63	1.67	7.12	3.99	9.80	11.16	10.44
Total	94.16	91.17	90.35				87.47	64.16	85.59			

Table 19. First year, second year, and two-year summaries of stomach contents, cheek pouch contents, and percent usage of those items occuring at a frequency greater than 1% for *Perognathus amplus*—DSCODE A3UVC01

	Rf Stomach			Usage Stomach			Rd Pouches			Usage Pouches		
	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72
	(339)	(375)	(714)				(223)	(212)	(435)			
Acacia	2.01	1.90	1.96	10.62	10.67	10.64	1.70	1.22	1.44	2.65	4.53	3.64
Erodium	11.69	14.79	13.22	38.94	37.60	38.24	0.36	0.99	0.70	3.24	2.93	3.08
Euphorbia	1.86	2.21	2.47	16.12	9.33	12.60	0.21	4.88	3.32	1.77	1.07	6.44
Insect	2.68	4.66	3.66	21.24	20.27	20.73	0.10	0.28	0.20	0.88	0.53	0.70
Larrea	34.93	30.09	32.55	76.70	60.27	68.07	34.03	31.97	32.91	45.72	42.13	43.84
Miscellaneous species	0.71	1.32	1.01	9.44	8.80	9.10		0.02	0.01		0.27	0.14
Opuntia	1.14	2.44	1.78	7.08	8.27	7.70	0.01	0.07	0.04	0.29	0.80	0.56
Pectocarya	22.74	15.10	18.97	56.05	37.33	46.22	3.02	9.98	6.80	7.96	10.40	9.24
Plantago	14.18	12.75	13.47	48.08	33.60	40.48	46.01	28.60	36.55	33.63	21.33	27.17
Crucifer	1.39	4.06	2.71	13.86	17.33	15.69	5.97	7.31	6.70	11.80	12.27	12.04
Total	93.33	89.32	91.80				91.41	85.32	88.67			

Table 20. First year, second year, and two-year summaries of stomach contents, cheek pouch contents, and percent usage of those items occurring at a frequency greater than 1% for *Perognathus baileyi*—DSCODE A3UVC01

	Rf Stomach			Usage Stomach			Rd Pouches			Usage Pouches		
	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72
	(186)	(144)	(330)				(89)	(55)	(144)			
Acacia	3.57	3.22	3.42	13.98	12.50	13.33	4.40	5.56	4.88	3.23	5.57	4.24
Boerhaavia	1.33	11.49	5.55	5.38	20.14	11.82	0.04	2.49	1.06		2.08	1.21
Eriochloa	0.99	2.49	1.61	3.76	4.17	3.94		23.36	9.72		2.08	0.91
Erodium	1.82	0.98	1.47	5.91	2.78	4.55						
Festuca	1.57	0.32	1.05	9.14	2.78	6.36	0.11		0.06	0.54		0.30
Fouquieria	2.09	7.54	4.36	6.99	12.50	9.39	0.67	1.71	1.10	1.08	2.78	1.82
Insect	9.41	8.27	8.93	37.63	22.92	31.21	0.15		0.09	1.61		0.91
Larrea	8.13	6.72	7.54	31.18	27.08	29.39	8.58	7.68	8.21	6.99	9.78	8.18
Opuntia	16.39	23.73	19.21	42.48	43.06	42.42		3.89	3.80		6.25	8.18
Pectocarya	25.51	23.82	21.47	61.83	50.00	47.88	24.52	44.86	29.70	23.12	13.89	16.97
Plantago	8.28	8.10	8.17	30.11		25.76	29.36		20.43	8.60		6.97
Tridens	11.30	0.30	6.60				8.06		4.71			
Total	90.39	96.99	89.38				75.89	89.55	83.76			

Table 21. First year, second year, and two-year summaries of stomach contents, cheek pouch contents, and percent usage of those items occurring at a frequency greater than 1% for *Perognathus intermedius*—DSCODE A3UVC01

	Rf Stomach			Usage Stomach			Rd Pouches			Usage Pouches		
	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72	70-71	71-72	70-72
	(371)	(412)	(783)				(113)	(129)	(242)			
Acacia	3.58	3.12	3.35	14.8	12.14	13.41	1.51	2.53	2.08	2.2	4.61	3.45
Boerhaavia	0.47	11.54	6.00	1.9	21.60	12.26	.08	11.57	6.35		2.91	1.66
Cercidium	2.68	0.87	1.77	7.6	3.40	5.36	0.26	0.47	0.38	1.4	1.46	1.40
Eriochloa	0.36	4.37	2.37	1.1	8.01	4.73	1.55	14.06	8.42	0.5	3.64	2.17
Erodium	0.56	1.87	1.22	4.0	4.61	4.34						
Festuca	10.29	2.54	6.41	26.4	6.55	15.84	18.21		8.21	2.4		1.15
Fouquieria	1.99	2.43	2.21	5.4	4.13	4.73	5.30	4.88	5.07	1.1	1.70	1.40
Insect	13.25	19.08	16.16	43.9	42.96	43.42		0.06	.03		0.49	0.26
Larrea	19.22	8.71	13.92	49.9	22.82	35.50	25.85	16.99	20.99	11.6	8.50	9.96
Miscellaneous species	1.53	1.14	1.34	19.9	11.41	15.45		0.16	.09		0.24	0.13
Opuntia	17.08	15.86	16.44	50.7	37.86	43.94		1.09	1.99		3.64	4.73
Pectocarya	14.00	7.70	10.68	41.2	20.39	43.81	25.49	3.86	19.52	5.1	2.67	10.22
Tridens	6.62	9.34	7.98	12.1	18.20	15.33	5.83	5.66	5.74	1.6	1.70	1.66
Total	91.63	88.57	89.85				84.08	61.33	78.87			

Table 22. First year, second year, and two-year summaries of stomach contents and percent usage of those items occurring at a frequency greater than 1% for *Peromyscus eremicus*---DSCODE A3UVC01

	Rf Stomach			Usage Stomach		
	70-71	71-72	70-72	70-71	71-72	70-72
	(239)	(244)	(483)			
Acacia	1.06	1.13	1.09	11.30	8.20	9.71
Boerhaavia	0.60	15.72	7.96	5.86	35.25	20.66
Fouquieria	5.07	2.73	4.06	13.39	7.38	10.54
Insect	56.80	59.70	58.29	94.56	96.31	95.45
Larrea	1.07	1.43	1.24	9.21	11.89	10.54
Miscellaneous species	2.00	1.29	1.65	21.76	12.30	16.94
Opuntia	16.41	10.14	13.32	51.05	29.92	40.29
Pectocarya	5.96	1.56	3.58	20.92	3.69	11.57
Tridens	3.37	0.81	2.12	11.30	6.97	9.09
Total	92.34	94.51	93.31			

Table 23. Seed usage by individuals and populations

Rodent Species(wt)	Seeds/Day	Seeds/Year Individual*	Seeds/Year Population**	Total For Sympatric Species/Year/Ha.
Dipodomys merriami (40g)	4053	1,411,470 (340 active 25 torpor)	8,609,967 @6.1/ha.	12,648,077/ha.
Perognathus amplus (11g)	1244	351,140 (241 active 124 torpor)	4,038,110 @11.5/ha.	
Perognathus baileyi (26g)	1824	590,304 (303 active 62 torpor)	944,486 @1.6/ha.	2,512,802/ha.
Perognathus intermedius (13g)	845	257,101 (274 active 91 torpor)	1,568,316 @4.5/ha.	

*Figures in parentheses indicate days active and in torpor

**Figures of density of rodents/ha taken from E. L. Cockrum in Thames et al., 1972.

ACTIVITY PATTERNS

Dipodomys merriami

Activity of *D. merriami* during the first year declined to its lowest level during July and August, the hottest part of the summer. A similar pattern was noted for *Dipodomys agilis* in southern California by MacMillen (1964). With the onset of summer rains and a second peak of reproduction, *D. merriami*'s activity reached its peak in November 1970. After the November peak, the activity leveled off, declining slightly in the spring, perhaps in response to the emergence of the other rodents (Table 24).

Table 24. Monthly trapping success for *Dipodomys merriami*—DSCODES A3UBE21,22

Month	Trap Nights	Animals Taken	% Success*
1970			
Jun	5741	145	2.5
Jul	5424	65	1.2
Aug	4590	49	1.0
Sep	2200	49	2.2
Oct	1900	97	5.1
Nov	1100	81	7.3
Dec	2400	76	3.2
1971			
Jan	2145	65	3.0
Feb	2125	79	3.7
Mar	1000	41	4.1
Apr	2225	61	2.7
May	2400	94	3.9
Jun	3670	93	2.5
Jul	4044	113	2.8
Aug	4325	91	2.1
Sep	1880	30	1.6
Oct**	1950	14	0.7
Nov	1000	29	2.9
Dec	990	49	4.9
1972			
Jan	875	52	5.9
Feb	840	68	8.1
Mar	900	63	7.0
Apr	998	12	1.2
May	600	56	9.3

*Trapping success equals $\frac{\text{number of animals trapped}}{\text{number of trap nights}}$.

**Rained all one night.

The activity of kangaroo rats during the second year (June 1971-June 1972) was significantly different from that of the first. The summer was not so hot (See Table 2) and consequently there was not a drastic decline in activity as in the previous summer. With the onset of autumn rains, more food was available, reproduction intensified, densities increased, and there was an increase in activity. There was a decline in activity again in the spring (April), repeating the trend of the previous year.

Dipodomys merriami was the largest rodent studied and apparently the best adapted to withstand the cooler winter months. A Spearman rank correlation co-efficient indicated a correlation at the .05 level between average body weight and surface inactivity for the winter months of the six species studied. Winter is generally considered a stressful time for rodents and many react through hibernation or torpor with consequent weight loss. This is not true for *D. merriami*, especially in years with adequate food supply. Activity of *D. merriami* (as indicated by trapping percentages) actually increased during the cooler months (Fig. 1), agreeing with the findings of Chew and Butterworth (1964) for this same species. As other rodents hibernated or reduced their activity, the kangaroo rat was able to expand its range and was trapped around the bases of the rocky hills previously occupied by pocket mice but not by kangaroo rats.

Perognathus baileyi

Perognathus baileyi was the fifth most abundant species in the area (Table 5). Its distribution was confined to an ecotonal area between the creosote flats and the rocky hills. Because of the limited habitat this species occupies, monthly trapping percentages may have been biased as ecotonal areas were not systematically trapped.

Although an accurate pattern of activity for *P. baileyi* is probably not represented by this data, seasonal trends can be noted (Fig. 2). The month in which the greatest number of animals were trapped (Table 25) was September 1970, immediately after heavy summer rains. Population densities were also high during October 1970. Population densities appeared fairly consistent throughout the remaining months of the first year with only a slight tapering off during winter months. Reynolds and Haskell (1949) also reported consistent numbers of Bailey pocket mice active during winter months. Apparently because of the large size of *P. baileyi*, it could withstand cold temperatures.

Table 25. Monthly trapping success for *Perognathus baileyi*—DSCODES A3UBE21,22

Month	Trap Nights	Animals Taken	% Success*
1970			
Jun	2766	51	1.8
Jul	2327	36	1.5
Aug	2230	34	1.5
Sep	1200	66	5.5
Oct	1300	53	4.1
Nov	2400	30	1.3
Dec	700	14	2.0
1971			
Jan	1045	2	0.2
Feb	1100	4	0.4
Mar	800	3	0.4
Apr	800	5	0.6
May	800	13	1.6
Jun	3720	12	0.3
Jul	2710	36	1.3
Aug	2634	16	0.6
Sep	1050	12	1.1
Oct	800	8	1.0
Nov	750	0	0
Dec	800	10	1.3
1972			
Jan	875	0	0
Feb	625	12	1.9
Mar	875	12	1.4
Apr	600	2	0.3
May	1000	7	0.7

*Trapping success equals $\frac{\text{number of animals trapped}}{\text{number of trap nights}}$.

The two months during the second year (November and January) in which no *P. baileyi* were trapped does not give evidence of dormancy (Fig. 2). Trapping in areas not inhabited by *P. baileyi* during these two months may be the explanation for lack of specimens. Aside from these two months, activity during the second year (Fig. 2) appeared stable as indicated by a consistent 1.1 trapping percentage. It is interesting and unusual that there were no increases in trapping percentages during the months of reproduction and when young animals augmented the population.

Perognathus intermedius

Activity in *P. intermedius* during the first year (Fig. 3) showed a response to lower winter temperatures. During three winter months (December, January, and February) in the first year, no *P. intermedius* were trapped. A peak in activity was recorded in July 1970 following an intense reproductive period in the spring. This peak was characterized by a large number of postpartum females and percent young in the sample (Table 26). There was a gradual decrease of numbers of animals active for the two months prior to their winter's dormancy (October, November, 1970) and a gradual increase in activity during the spring following the dormant period (March, April, 1971).

Table 26. Monthly trapping success for *Perognathus intermedius*—DSCODES A3UBE21,22

Month	Trap Nights	Animals Taken	% Success
1970			
Jun	2766	187	6.4
Jul	2327	110	6.8
Aug	2230	136	4.7
Sep	1200	58	4.8
Oct	1300	32	2.5
Nov	2400	6	0.3
Dec	700	0	0
1971			
Jan	1045	0	0
Feb	1100	0	0
Mar	800	11	1.4
Apr	800	13	1.6
May	800	37	4.6
Jun	3720	102	2.7
Jul	2710	147	5.4
Aug	2634	57	2.2
Sep	1050	42	4.0
Oct	800	20	2.5
Nov	750	31	4.1
Dec	800	27	3.4
1972			
Jan	875	65	7.4
Feb	625	25	4.0
Mar	875	36	4.1
Apr	600	55	9.0
May	1000	15	1.5

*Trapping success equals $\frac{\text{number of animals trapped}}{\text{number of trap nights}}$.

Activity patterns in the two years of the study differed. In the second year there was no period in which no animals were taken (Table 26 and Fig. 3). Temperatures were milder, rainfall plentiful and food more abundant during the second year; perhaps these conditions enabled *P. intermedius* to remain active all winter. April, 1972 was the month that yielded the highest trapping success of *P. intermedius* (9.0 %). This percentage is significant in that trapping percentages for the other five species were exceedingly low during this same month (Tables 1-4 and 6-7).

Although *P. intermedius* has not been reported to hibernate or become torpid during stressful environmental conditions, other species of *Perognathus* of approximately the same size become dormant during stressful periods. *Perognathus longimembris* and *P. formosus* are usually inactive above the ground for varying periods in the cooler autumn, winter and early spring (Chew and Butterworth, 1964; French et al., 1967). Some individuals of both species were found above ground during mild weather during these seasons, suggesting that these dormant pocket mice are sensitive to rapid temperature changes. Torpidity in *P. fallax* has been noted by MacMillen (1964) and discussed in more detail by Bartholomew and Cade (1957). Chew and Butterworth (1964) have evidence that hibernation in *P. longimembris* significantly enhanced its survival. Our data suggest that dormancy in *P. intermedius* occurs only in winter months when the food supply may be limited.

Peromyscus eremicus

Activity during the first year was remarkably consistent from month to month, with an overall trapping percentage around 1.2. No animals were trapped during September 1970, but in this month we did not trap in appropriate habitat for *P. eremicus*. The highest trapping success of the first year was 2.5% in June. In the following months, trapping percentages were lower but consistent (Fig. 4). This data contrasts with that of Lewis (1972) who trapped approximately 145 km to the north of our study site during 1967 and 1968.

Trapping during the second year revealed a striking contrast to the first year in the relative numbers of *P. eremicus* present (Fig. 4). During the summer months, trapping percentages were low, presumably due to low population numbers as the result of prolonged adverse environmental conditions. After intense summer rains, however, trapping percentages increased almost linearly from 0.4% in October, 1971 to a peak of 10.2% in February of 1972. Following the peak in February, there was a drastic decline in trapping success, and by May, 1972 no cactus mice were trapped during 1,000 trap nights in a suitable habitat.

The tremendous increase in cactus mice during the second winter could be the result of a combination of two factors: 1) the reduction in surface activity of the sympatric *P. intermedius* (Fig. 3) thus reducing suppression through competition, and 2) addition of young to the population (78% of 34 females trapped in November and December were reproductive) (Fig. 5).

The apparent population crash in the spring of the second year may have been the result of limited food. The high numbers of *P. eremicus* might have further been affected by the emergence of *P. intermedius* from winter dormancy.

MacMillen (1965) reports estivation in *P. eremicus* under adverse environmental conditions. Likewise, Lewis (1972) attributes his summer months of decreased trapping success to estivation of *P. eremicus*, explaining that estivation in cactus mice might be a response to a combination of aridity and high ambient temperatures. Lindeborg (1952) and MacMillen (1964) have shown *P. eremicus* to be better adapted to xeric conditions than other *Peromyscus*.

Summer estivation did not appear to occur among the cactus mice in our study area (Table 27 and Fig. 4). There were decreased percentages of animals trapped during the summer of the second year even after the summer rains began. This was, however, probably indicative of decreased population densities rather than estivation, as the preceding months were particularly stressful in terms of paucity of new vegetation.

Table 27. Monthly trapping success for *Peromyscus eremicus*—DSCODES A3UBE21,22

Month	Trap Nights	Animals Taken	% Success*
1970			
Jun	2766	69	2.5
Jul	2327	33	1.4
Aug	2230	27	1.2
Sep**			
Oct	1300	23	1.8
Nov	2400	21	0.9
Dec	700	4	0.6
1971			
Jan	1045	6	0.6
Feb	1100	20	1.8
Mar	800	13	1.6
Apr	800	5	1.0
May	800	8	1.6
Jun	3720	3	0.1
Jul	2710	25	0.9
Aug	2634	10	0.4
Sep	1050	1	0.1
Oct	800	3	0.4
Nov	750	29	3.9
Dec	800	35	4.4

Continued

Table 27. Continued

Month	Trap Nights	Animals Taken	% Success*
1972			
Jan	875	54	6.2
Feb	625	64	10.2
Mar	875	59	6.7
Apr	600	22	3.7
May	1000	0	0

*Trapping success equals $\frac{\text{number of animals trapped}}{\text{number of trap nights}}$.

**Traps not set in appropriate habitat.

Perognathus penicillatus

Perognathus penicillatus was not abundant in our study area and was restricted to arroyos. Trapping procedures that involved only occasionally trapping the ranges of *P. penicillatus* accounted for their scarcity in the samples of certain months. Seasonal activity patterns, size variation, and breeding characteristics can be interpreted with some degree of confidence, however, even though our total sample size was low (Table 28).

Dormancy during winter is typical of *P. penicillatus*. Arnold (1942) found *P. penicillatus* to be inactive during several winter months. Reynolds and Haskell, (1949), likewise, failed to trap this species from December to February in southern Arizona and speculated that it was in hibernation. Hudson (1964) found that under laboratory conditions, *P. penicillatus* became torpid in winter. In our study, the above-ground activity of *P. penicillatus* was also reduced through the winter season (Fig. 6 and Table 28). In the first year there were two months (November and December, 1970) in which no *P. penicillatus* were trapped. Trapping during the second year yielded three months (January, March and April, 1971) when no animals were taken.

Trapping during the seasons other than the winter, showed similar patterns for the two years. Late spring and early summer appeared to be a time of increased activity. Surface activity of *P. penicillatus* declined during both of the summers, probably in response to hotter, drier conditions. Following summer rains, there was an increase in activity with September, 1970 yielding the highest percentage of animals trapped and October, 1971 being the most productive of fecund animals.

Table 28. Monthly trapping success for *Perognathus penicillatus*——DSCODES A3UBE21,22

Month	Trap Nights	Animals Taken	% Success*
1970			
Jun	2766	33	1.2
Jul	2327	7	0.3
Aug	2230	9	0.4
Sep	1200	18	1.5
Oct	1300	5	0.4
Nov	2400	0	0
Dec	700	0	0
1971			
Jan	1045	1	0.1
Feb	1100	1	0.1
Mar	800	1	0.1
Apr	800	1	0.1
May	800	11	1.4
Jun	3720	27	0.7
Jul	2710	19	0.7
Aug	2634	12	0.5
Sep	1050	15	1.0
Oct	800	13	1.6
Nov	750	2	0.3
Dec	800	2	0.3
1972			
Jan	875	0	0
Feb	625	1	0.2
Mar	875	0	0
Apr	600	0	0
May	1000	9	0.9

*Trapping success equals $\frac{\text{numbers of animals trapped}}{\text{number of trap nights}}$.

Perognathus amplus

Perognathus amplus is not equally active above ground at all seasons. Trapping percentages for *P. amplus* were at their highest level during June, 1970, the first month of the study (Fig. 7). The highest temperatures of the year (Fig.7), recorded in July, were accompanied by a sharp decline in surface activity of *P. amplus*. This temporary reduction in surface activity by most of the individuals suggests that high ambient temperatures are stressful to small pocket mice and that periodic torpor is employed. There was an increase in activity again during the cooler and more humid period of late summer and fall. As temperatures dropped in the winter, so did the activity of *P. amplus*. The species suspended surface activity for a four-month period (December through March).

The activity of *P. amplus* during the second year (June 1971-June1972) was significantly different from that of the first. The summer was not as hot and consequently the reduced activity was not so pronounced as in the previous summer. In the autumn of 1971, following late summer rains, surface activity increased such that trapping percentages were 1.9%, as compared to 0.2 for November 1970. During only one month of the second year (January 1972) were no specimens of *P. amplus* trapped. The highest trapping percentages (5.7%) during the second year for *P. amplus* were in March 1972 (Table 29).

The rainfall pattern was distinctly different for the two years and correspondingly so were the trapping data for *P. amplus*. Apparently individuals of this species forage on the surface of the ground only when conditions are ideal. Surface activity may be reduced through a state of torpor, estivation or hibernation. There could be, however, activity within the burrow with the animals living on stored food materials.

Table 29. Monthly trapping success for *Perognathus amplus*—DSCODE A3UBE21,22

Month	Trap Nights	Animals Taken	% Success*
1970			
Jun	5741	398	6.9
Jul	5424	111	2.0
Aug	4590	164	3.6
Sep	2200	83	3.8
Oct	1900	18	0.9
Nov	1100	2	0.2
Dec	2400	0	0
1971			
Jan	2145	0	0
Feb	2125	0	0
Mar	1000	0	0
Apr	2225	16	0.7
May	2400	37	1.5
Jun	3670	164	4.5
Jul	4044	136	3.4
Aug	4325	115	2.7
Sep	1880	19	1.0
Oct	1950	33	1.7
Nov	1000	19	1.9
Dec	990	2	0.2
1972			
Jan	875	0	0
Feb	840	3	0.4
Mar	900	51	5.7
Apr	998	22	2.2
May	600	17	2.8

*Trapping success equals $\frac{\text{number of animals trapped}}{\text{number of trap nights}}$.

Perognathus amplus was the smallest rodent studied and apparently the most affected by cold temperatures. Laboratory studies of metabolic rates and activity patterns for *P. amplus* have not been conducted; however, studies have been done on related desert species (i.e., *P. californicus, P. longimembris*) which have approximately the same body weight (Chew et al., 1965; Chew and Butterworth, 1964; Bartholomew and Cade, 1957; Hayden, 1965). These authors have shown that smaller pocket mice (approximately 10 g) have a decreased metabolic rate with torpor ensuing if food is limited and/or ambient temperatures are decreased. French et al., (1967) suggested that reduced activity during stressful times of the year aids in the survival and longevity of pocket mice.

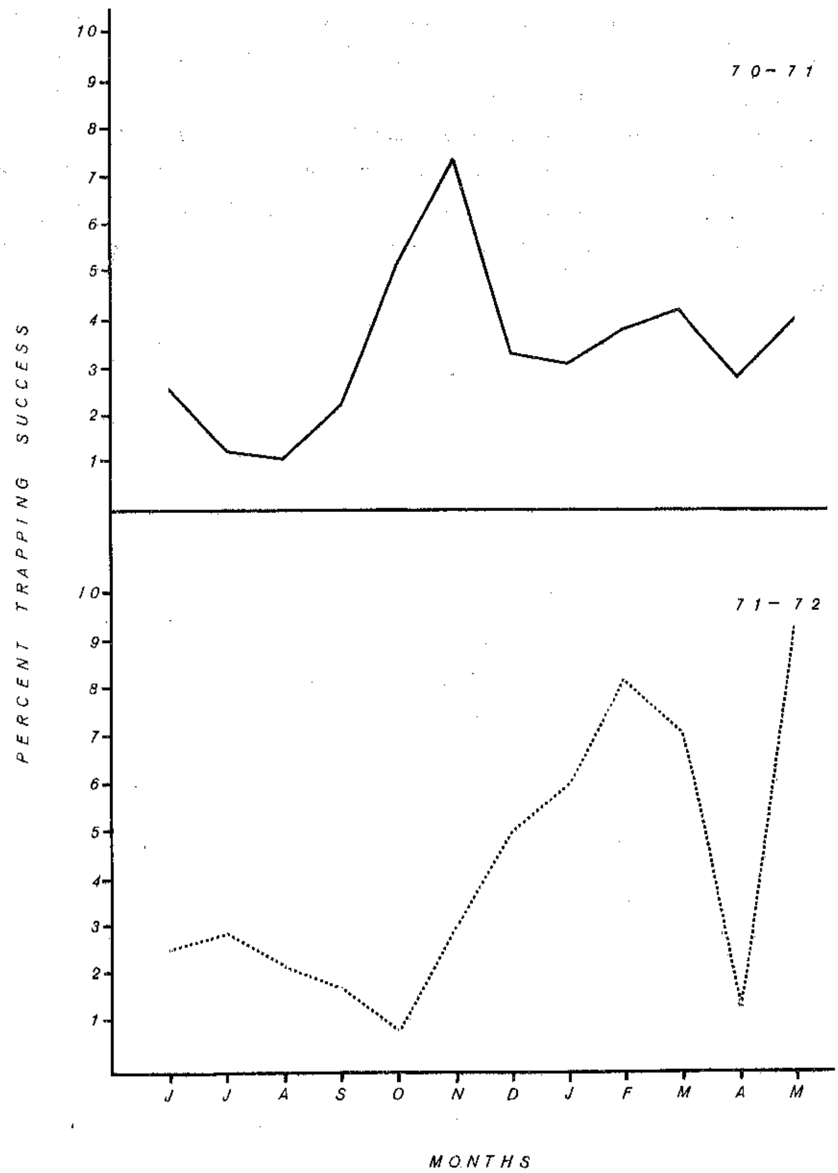

Figure 1. Percent trapping success of *Dipodomys merriami*. (DSCODE A3UBE21, BE22)

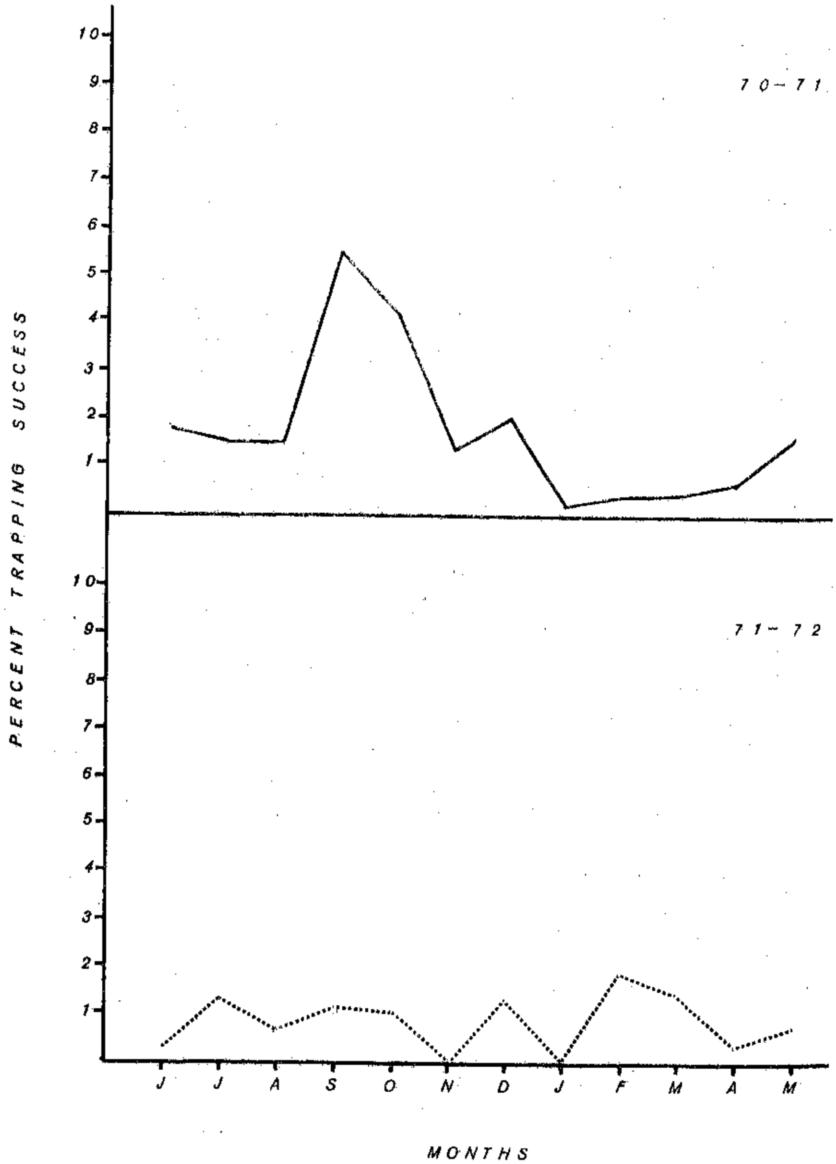

Figure 2. Percent trapping success of *Perognathus baileyi*. (DSCODES A3UBE21, BE22)

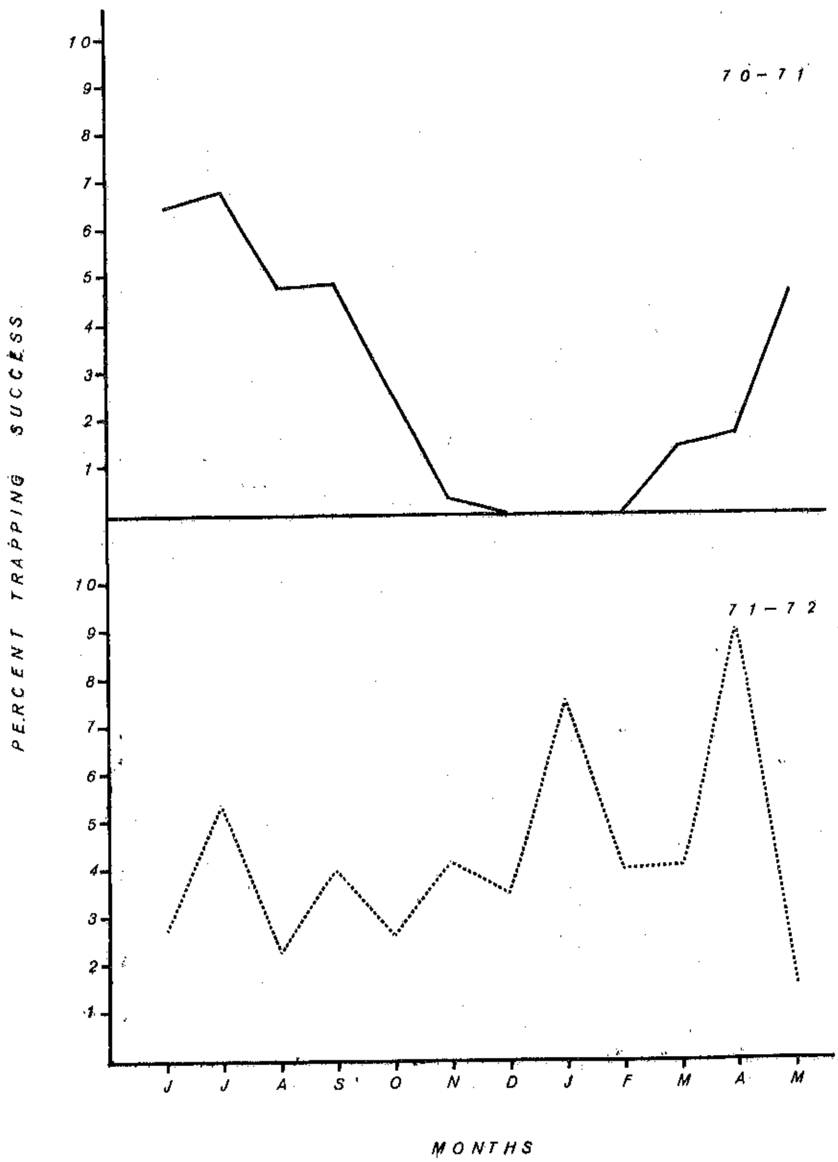

Figure 3. Percent trapping success of *Perognathus intermedius*. (DSCODES A3UBE21, BE22)

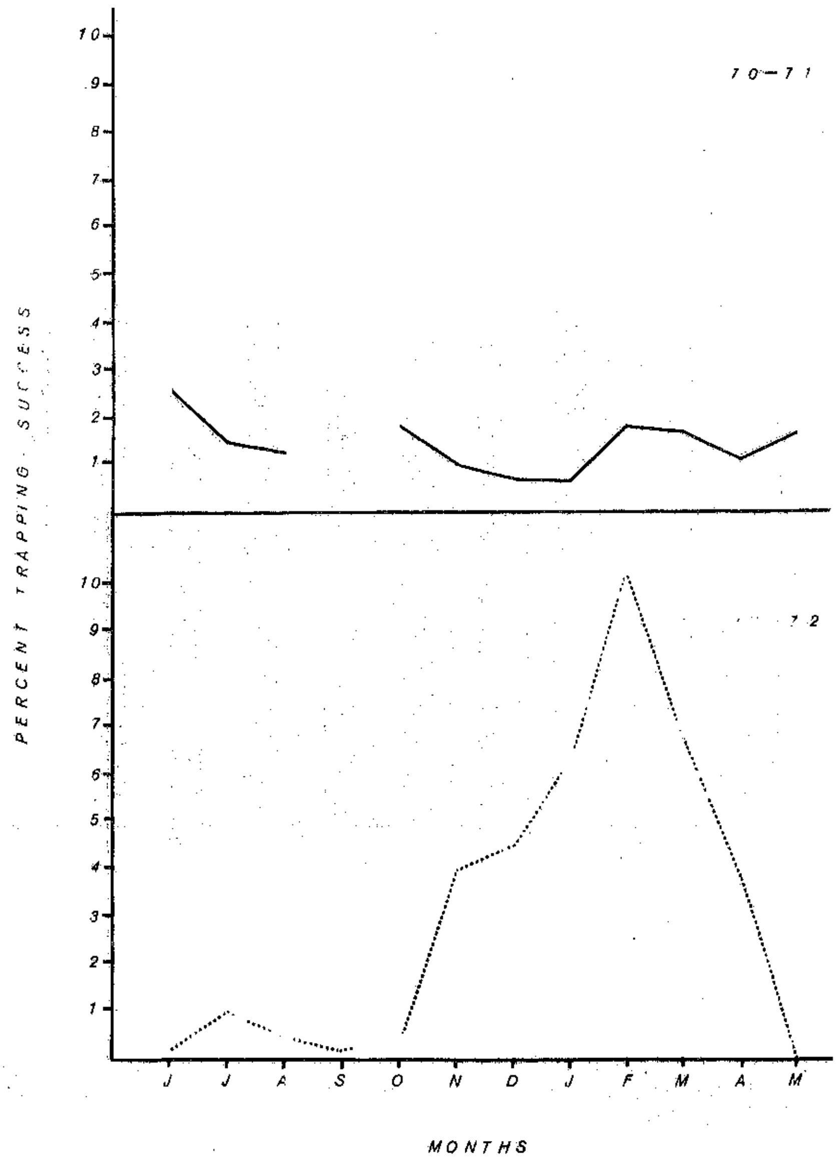

Figure 4. Percent trapping success of *Peromyscus eremicus*. (DSCODES A3UBE21, BE22).
* Traps not set in appropriate habitat.

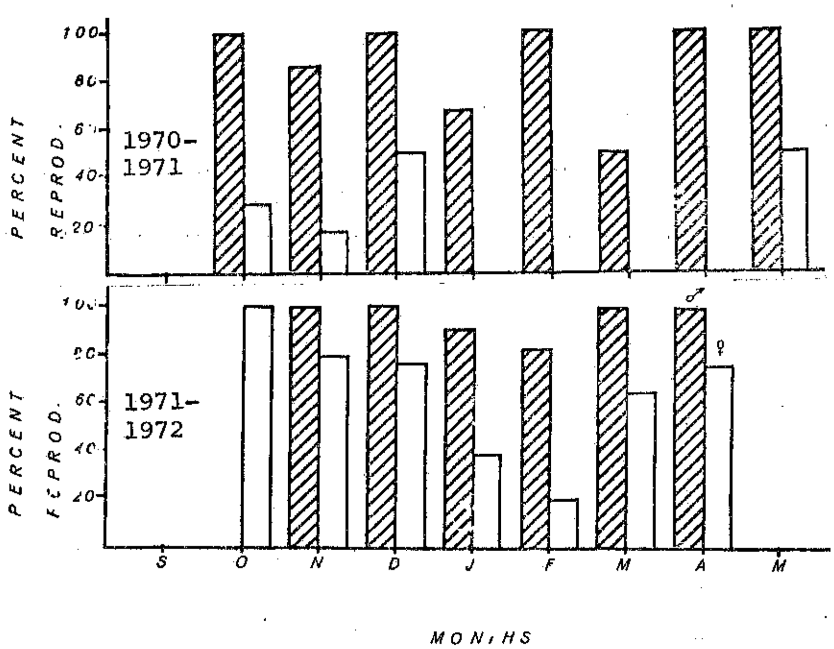

Figure 5. Summary of fecundity of adult male and female *Peromyscus eremicus*. Graph represents September through May of both years. (DSCODES A3UBE21, BE22)

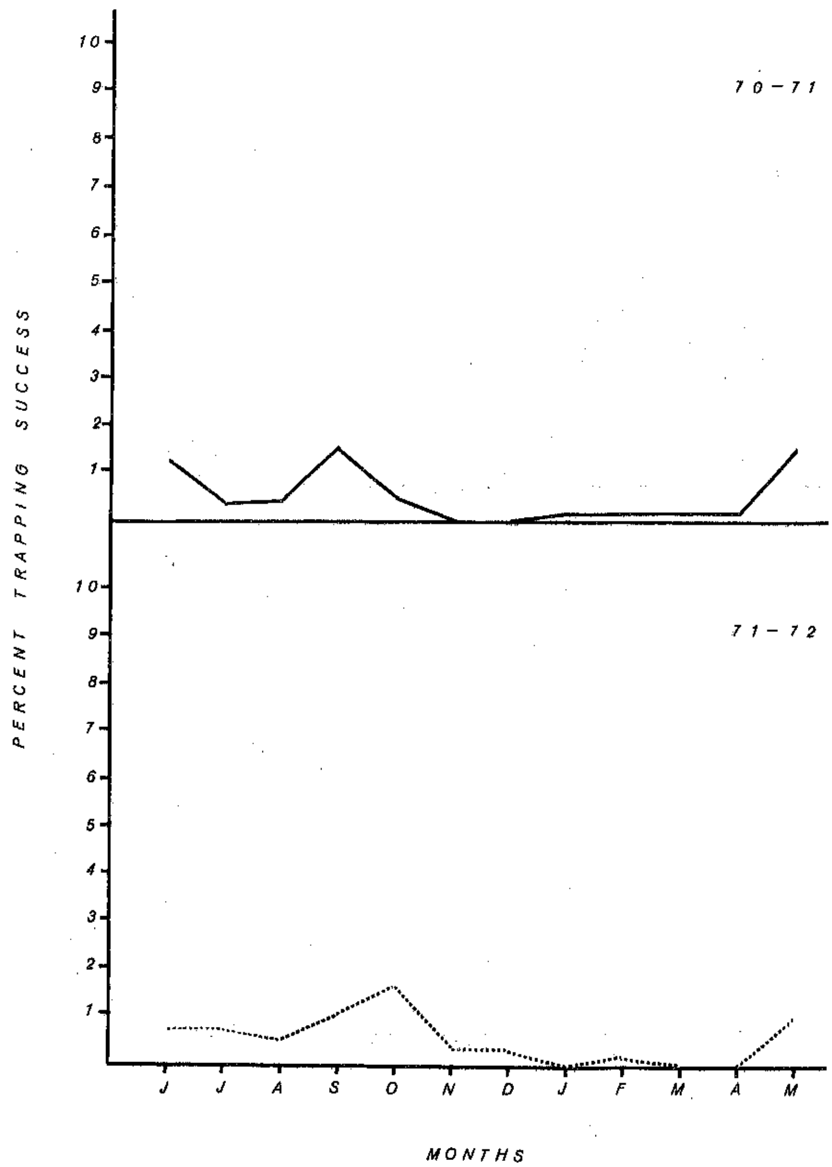

Figure 6. Percent trapping success of *Perognathus penicillatus*. (DSCODES A3UBE21, BE22)

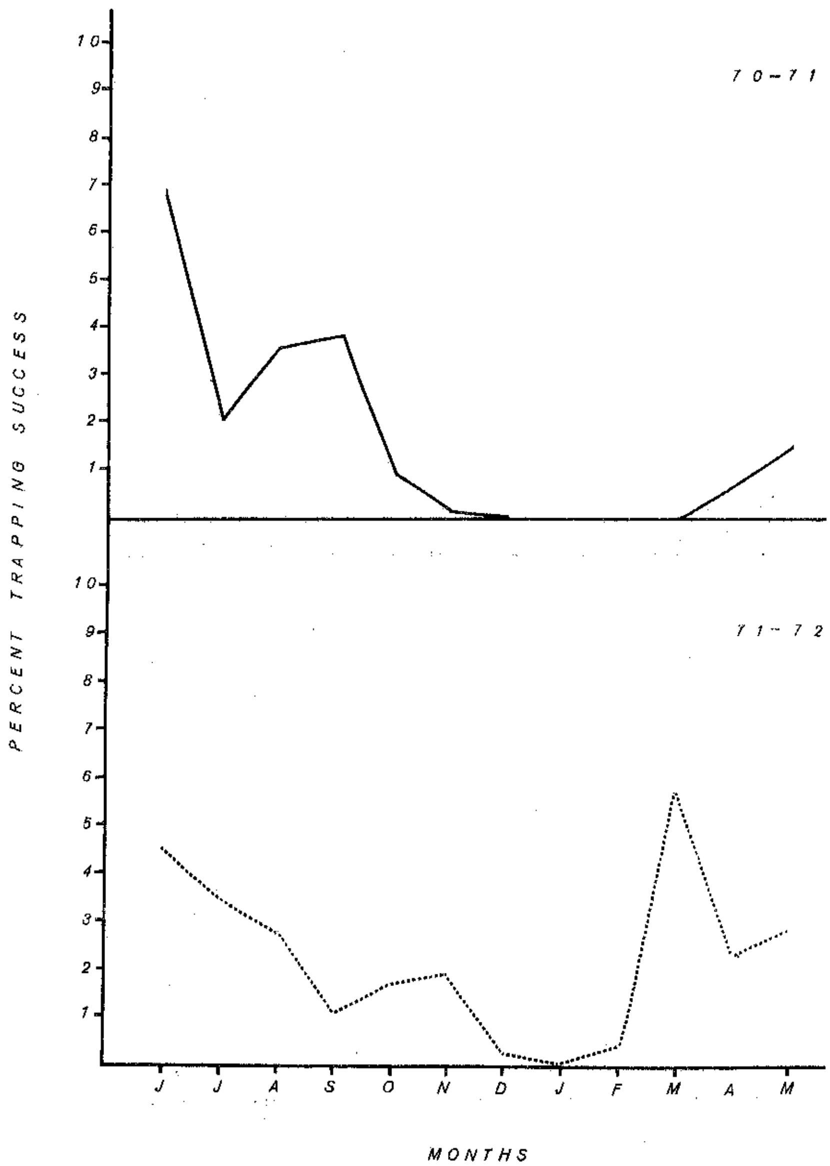

Figure 7. Percent trapping success of *Perognathus amplus*. (DSCODES A3UBE21,BE22)

SIZE, SEX, AND AGE RATIOS (DSCODES A3UBE21, BE22)

Dipodomys merriami

Dipodomys merriami has a rapid early development (Butterworth 1961), being weaned at 17-22 days postpartum. Allometric ontogenic growth in foetal kangaroo rats partially contributes to rapid postnatal development (Van De Graaff, 1973). Young kangaroo rats rapidly gain weight and are between 20.5 and 26.5 g within three to six weeks (Chew and Butterworth, 1964). *Dipodomys merriami* attains 82% of its adult size within 15 days after birth and achieves its average adult weight within 150 to 180 days (Butterworth, 1961). Chew and Butterworth (1959), under laboratory conditions, reported estrus in *D. merriami* at 24 to 33 days of age. Trapping percentages of young kangaroo rats are low because juveniles mature rapidly (Chew and Butterworth, 1964).

A very small number of kangaroo rats (.83%) were juvenile (Table 30) and, likewise, few (7.1%) were subadult. Five of the 13 juveniles were trapped during the first half of June, 1970. The sex ratio for both juveniles and subadults was near 50:50 (Table 30).

Adult kangaroo rats accounted for 91.6% of the total animals trapped over the two-year period. Of the adult animals, 53.6% were males (Table 30), showing little departure from a 50:50 ratio. The slightly higher percentage of males may be indicative of their more aggressive behavior or larger home ranges. Blair (1943) found that *D. merriami* males occupied 4.07±0.24 acres and females 3.88±0.51 acres. York (1949) likewise found males to have larger home ranges (2.58 ha) than females (1.37 ha).

Table 30. Total semimonthly, and monthly sex and age ratio of 1,572 *Dipodomys merriami*—DSCODE A3UBE21,22

	Adults			Young			
Month	Males	Females	%Males	Males	Females	%Males	% Young
1970							
Jun 10	54	46	54.0	20	11	64.5	23.7
Jun 20	5	9	35.7	0	0	--	0
Jul 10	11	8	57.9	3	2	60.0	20.8
Jul 20	16	17	48.5	3	5	37.5	19.5
Aug 10	18	12	60.0	1	2	33.3	9.1
Aug 20	5	10	33.3	1	0	100.0	6.3
Sep	25	22	53.2	0	2	0	4.1
Oct	46	46	50.0	3	2	60.0	5.2
Nov	45	32	58.4	3	1	75.0	4.9
Dec	41	30	57.7	3	2	60.0	6.6

Continued

Table 30. Continued

Month	Adults Males	Females	%Males	Young Males	Females	%Males	% Young
1971							
Jan	36	29	55.4	0	0	--	0
Feb	33	44	42.9	1	1	50.0	2.5
Mar	24	17	58.5	0	0	--	0
Apr	31	30	50.8	0	0	--	0
May	41	48	46.1	1	4	20.0	5.3
Jun 10	18	15	54.5	0	0	--	0
Jun 20	28	27	50.9	1	4	20.0	8.3
Jul 10	27	19	58.7	0	1	0	2.1
Jul 20	34	26	56.7	4	2	66.6	9.1
Aug 10	16	11	59.3	0	0	--	0
Aug 20	34	28	54.9	1	1	50.0	3.1
Sep	16	13	55.2	1	0	100.0	3.3
Oct	10	3	77.0	0	1	0	7.1
Nov	15	11	57.7	1	2	33.3	10.3
Dec	24	18	57.1	4	3	57.1	14.3
1972							
Jan	28	17	62.2	4	3	57.1	13.5
Feb	33	28	54.1	6	1	85.7	10.3
Mar	30	26	53.6	3	4	42.9	11.1
Apr	6	4	60.0	1	1	50.0	16.7
May	24	23	51.1	6	3	66.6	16.1
Total	774	669	53.6	71	58	55.0	8.2

Adult males were approximately 3 g heavier than adult females (Table 31) and approximately 4 mm longer. Males that were considered reproductively active were likewise heavier (up to 6 g heavier) than non-reproductive adult males. There was a direct correlation between the amount of spermatozoa present in the caudal epididymis and the weight of the animal. Those adult animals with no sperm present (N=90) had an average weight of 38.95 g; those having moderate amounts (N=137) had a mean weight of 41.79 g; those having large amounts (N=356) had a mean weight of 43.28 g (Table 32).

Three-hundred adult females in breeding condition (mean weight 41.54 g) were appreciably heavier than 80 non-breeding adult females (mean weight 34.26 g). Pregnant females (N=193), having a mean weight of 42.36 g, were heavier than any other category of females. The condition of lactating apparently did not pose severe metabolic strains on females. Weights of 87 lactating females diminished an average of 1.68 g from their fecund weight and remained heavier than those in estrus or those with placental scars (Table 33).

Table 31. Body measurement statistics of 1,572 *Dipodomys merriami**

Measurement	Males Adult	Subadult	Juvenile
Total length	245.8±8.7(770)215-268	224.1±14.8(63)184-253	193.8±12.2(8)175-212
Tail length	140.4±7.1(770)117-177	130.3±12.2(63)99-155	113.9±9.7(8)105-133
Hind foot	36.0±1.1(774)28-39	35.3±1.6(63)25-38	34.6±1.1(8)33-36
Ear	12.0±0.8(774)8-15	11.0±0.7(63)9-12	10.5±1.2(8)9-12
Weights	41.4±4.3(774)27.8-55.2	29.4±4.6(63)20.9-36.2	17.4±2.5(8)13.5-20.0
Bacula length	11.3±0.9(774)7.4-13.1	8.5±1.0(63)5.7-10.8	6.8±0.7(8)5.7-7.8
	Females		
Total length	241.2±9.1(668)211-263	223.3±15.6(53)180-260	195.4±28.0(5)157-223
Tail length	137.6±7.2(668)116-160	129.8±12.8(53)96-147	115.0±17.7(5)92-130
Hind foot	35.5±1.0(669)32-39	35.0±0.8(53)32-36	34.4±0.6(5)34-35
Ear	11.8±0.8(669)8-15	11.1±0.8(53)9-13	9.8±1.1(5)8-11
Weights	39.9±4.6(669)27.6-57.8	27.9±4.1(53)18.2-35.6	18.6±4.8(5)12.0-24.7

*The mean number is given, followed by the standard deviation, the size of the sample (in parentheses), and the range. Lengths are expressed in mm, weights in g. DSCODE A3UBE21, 22.

Table 32. Mean body weights (g) and bacula measurements (mm) of various ages and reproductive categories of 845 *Dipodomys merriami**

	N	Body Weight Mean	Body Weight Range	Baculum Mean	Baculum Range
Juvenile	8	17.36	13.50-20.00	6.79	5.65-7.75
Subadult	63	29.43	20.90-46.30	8.49	5.70-10.80
Adult					
No spermatozoa	90	37.20	27.80-48.90	9.95	7.40-12.15
Small amounts	137	38.95	30.50-47.70	10.88	8.60-12.55
Moderate amounts	191	41.79	32.20-51.00	11.50	9.10-12.90
Large amounts	356	43.28	35.10-55.20	11.70	10.00-13.10

*i.e., spermatazoa content in caudal epididymes.

Table 33. Breeding characteristics of adult female *Dipodomys merriami*—DSCODE A3UBE22

Month	Sample Size No.	Gravid No.	Gravid %	Gravid Weight Mean±S.D.	Embryos Mean±S.D.	Postpartum No.	Postpartum %	Postpartum Weight Mean±S.D.	Placental Scars Mean±S.D.
1970									
Jun 10	46	31	67	39.5±4.2	2.0±0.2	6	13	35.7±1.9	1.8±0.4
Jun 20	9	5	56	38.7±2.9	2.0	3	33	36.9±3.8	2.0
Jul 10	8	4	50	43.8±6.6	2.0	2	25	34.4±0.7	2.0
Jul 20	17	2	12	38.6±4.2	2.0	9	53	36.8±2.2	2.0
Aug 10	12	2	17	39.9±8.3	1.5±0.7	8	67	36.9±4.0	2.0±0.5
Aug 20	10	2	20	36.6±2.6	2.0	6	60	40.0±4.7	2.0
Sep	22	9	41	42.5±4.5	2.3±0.5	4	18	42.0±1.7	2.0
Oct	46	2	4	40.6±3.5	2.0	27	59	38.6±2.5	2.0
Nov	32	0	0			27	84	37.3±2.7	2.0
Dec	30	0	0			23	77	38.1±3.5	2.0
1971									
Jan	29	0	0			24	83	37.2±3.1	2.0
Feb	44	8	18	43.1±5.0	2.0	26	59	37.6±2.6	2.0
Mar	17	0	0			13	76	35.3±2.8	2.0
Apr	30	4	13	39.4±2.4	2.0	18	60	36.9±2.4	2.0
May	48	9	19	38.2±2.2	1.9±0.3	25	52	33.0±1.1	2.0
Jun 10	15	1	7	39.2	1.0	8	53	35.8±3.8	2.0
Jun 20	27	1	4	38.7	1.0	16	59	36.4±2.5	2.0±0.4
Jul 10	19	2	11	39.1±0.5	2.0	13	68	36.4±2.2	2.0±0.4
Jul 20	26	7	27	42.6±3.7	2.0	14	54	38.2±2.4	1.9±0.4
Aug 10	11	5	45	39.7±3.7	2.0	1	9	42.3	2.0
Aug 20	28	23	82	44.2±3.6	2.2±0.5	0	0		
Sep	13	6	46	43.4±3.3	2.2±0.4	2	15	41.2±0.1	2.5±0.7
Oct	3	2	67	42.2±0.3	2.0	0	0		
Nov	11	6	55	46.9±3.1	2.3±0.5	0	0		
Dec	18	2	11	40.1±6.2	2.0	4	22	39.6±2.4	2.0
1972									
Jan	17	10	59	43.2±5.4	2.0	1	6	40.7	2.0
Feb	28	16	57	44.1±5.3	1.9±0.4	4	14	41.4±2.6	2.0
Mar	26	22	85	45.1±5.4	2.1±0.3	0	0		
Apr	4	2	50	38.9±7.2	2.0	1	25	38.0	3.0
May	23	10	43	44.6±3.5	1.9±0.3	4	17	40.0±3.8	2.0
Total	669	193	29	42.4±4.9	2.0±0.4	289	43	37.4±3.0	2.0±0.2

Body weights of adult kangaroo rats sometimes fluctuated markedly (Figs. 8 and 9) throughout the study period and could be correlated to climatic conditions and reproductive phases. Chew and Butterworth (1964) reported a seasonal trend (in years of adequate food supply) of mean body weight of adult animals that indicated that conditions in winter and early spring were most conducive to general vigor of kangaroo rats. Figure 8 shows a similar pattern of body weight increase during the cooler months of this study period.

Males reached their lowest weights in early August, 1970, then increased through the last half of August after the summer rains, and reached their peak weight in late September. During the first year, both the adult males and adult females were strikingly lighter in weight (Fig. 8) than in the second year. Correspondingly, the amount of rainfall (Table 1), phenology of plants and available seeds were also drastically different in the two years. Indications of decline in body weights indicate that the hottest times of the year are stressful to kangaroo rats (Fig 9).

Perognathus amplus

No studies have been done to determine growth rates and development in *Perognathus amplus;* therefore, body weights and measurements at a given age are not known. Hayden and Gambino (1966) have measured growth and development of another small pocket mouse (8.5 g), *Perognathus longimembris,* therefore data are available for a species closely related to *P. amplus* and of comparable size.

Juveniles had an average weight of 6.30 g and accounted for 3.1% of the *P. amplus* trapped. Thirty-seven of the total juveniles (36%) were taken during the first half of June 1970. Fifteen juveniles were males (35%) and were slightly heavier (6.7 g) than the females (5.9 g).

Subadults accounted for 20% of the total *P. amplus* trapped (mean weight 7.57 g). Sixty-eight percent of the subadults were taken during the first half of June, 1970 (Table 34)

Table 34. Total semimonthly and monthly sex and age ratio of 1,410 *Peromyscus amplus*——DSCODE A3UBE21,22

	Adult			Young			
Month	Males	Females	% Males	Males	Females	% Males	% Young
1970							
Jun 10	60	66	47.6	111	119	48.3	64.6
Jun 20	14	12	53.9	7	9	43.8	38.1
Jul 10	24	26	48.0	4	10	28.6	21.9
Jul 20	24	15	61.5	2	6	25.0	17.0
Aug 10	54	62	46.6	2	6	25.0	6.5
Aug 20	21	14	60.0	1	4	20.0	12.5
Sep	42	36	53.8	1	4	20.0	6.0
Oct	11	7	61.1	0	0	--	0
Nov	1	1	50.0	0	0	--	0
Dec	0	0	--	0	0	--	--

Continued

Table 34. Continued

Month	Adult Males	Adult Females	Adult % Males	Young Males	Young Females	Young % Males	% Young
1971							
Jan	0	0	--	0	0	--	--
Feb	0	0	--	0	0	--	--
Mar	0	0	--	0	0	--	--
Apr	7	9	43.8	0	0	--	0
May	27	7	79.4	1	2	33.3	8.1
Jun 10	33	45	42.3	2	3	40.0	6.0
Jun 20	40	40	50.0	0	1	0	1.2
Jul 10	26	38	40.6	0	2	0	3.0
Jul 20	23	42	35.4	2	3	40.0	7.1
Aug 10	22	23	48.9	0	0	--	0
Aug 20	37	29	66.1	11	3	78.6	20.0
Sep	12	7	63.2	0	0	--	0
Oct	13	8	62.0	8	4	66.6	36.4
Nov	10	7	58.8	0	2	0	10.5
Dec	1	1	50.0	0	0	--	0
1972							
Jan	0	0	--	0	0	--	--
Feb	2	1	66.6	0	0	--	0
Mar	31	20	60.8	0	0	--	0
Apr	12	10	54.5	0	0	--	0
May	8	4	66.6	3	2	60.0	29.4
Total	555	530	51.2	145	180	44.6	23.0

Over the two-year period, adult *P. amplus* had an average body weight of 10.92 g. The males were slightly heavier (11.35 g) than the females (10.49 g). Males were, likewise, consistently heavier throughout the two-year study, even though there were seasonal weight fluctuations (Figs 10 and 11, Table 35)

There was a striking contrast in the body weights of adult animals between the two years of study. During June 1970, immediately following a reproductive period, adult *P. amplus* were heavier than at any other time of the first year. Their body weights were the lowest immediately preceding and immediately following winter dormancy (Fig 10).

In contrast to the previous June (1970), the average body weights of the adults were at their lowest level during June, 1971. The summer rains started and germination of plants occurred in August, 1971 and concurrently the average body weights of *P. amplus* greatly increased. Heavier animals (those weighing over 10 g) did not go into winter inactivity for so long as in the previous year. The increased body weights of *P. amplus* during the second year indicate that high availability of food is probably conducive to increased surface activity in pocket mice. Trapping during four months of the first winter yielded no *P. amplus*, whereas in the second winter only during January were no *P. amplus* taken.

Increased body weight in *P. amplus* appears to be a prerequisite for successful reproduction. Adult males with large amounts of spermatozoa present (N=192) had an average body weight of 12.76 g, whereas adult males with no spermatozoa had a mean body weight of 10.27 g. Likewise, 66 females that were determined to be reproductively active had an average body weight of 12.57 g; in contrast, 302 non-reproductive females averaged 9.55 g in body weight. (Table 36).

Pregnant females (N=32) had the heaviest average body weight (13.14 g) of all other categories of *P. amplus*. The average body weight of lactating females (12.41 g) was not significantly lighter than that of pregnant individuals.

Perognathus baileyi (DSCODE A3UBE21,22)

Perognathus baileyi of different ages exhibited a wide range in body weights and lengths (Table 37). Five juveniles had an average body weight of 12.85 g. Although the average body length of these five juveniles was considerably less (164.1 mm) than that of 164 adults (210.8 mm), the hind foot length of the juveniles (25.45 mm) was nearly comparable to that of the adults (26.22 mm). This same allometric growth ratio of the hind foot to other parts of the body has been examined in other heteromyids and is probably of significant adaptive value (Van De Graaff, 1973).

Subadults accounted for 12.7% of the *P. baileyi* sampled. They had an average body weight of 18.27 g, an average body length of 186.7 mm, and an average hind foot length of 25.27 mm. The body length and weight increased greatly over that of juveniles, but the length of the hind food remained virtually unchanged. During the first year, young animals occurred from June through September and constituted a significant portion of the sample (Table 38). In the second year, young animals were trapped from July through September and then not again until April 1972.

Cumulative data for the two years showed 211 adult females to have a mean body weight of 24.51 g and 165 adult males to have a mean body weight of 28.14 g. The interesting aspect of adult body weights in *P. baileyi* is the wide range (Table 39) within the adult categories. Analysis of this information, plus other data, implies that *P. baileyi* does not mature as rapidly as the other heteromyids and perhaps has a longer life expectancy.

Table 35. Body measurement statistics of 1,410 *Perognathus amplus**—DSCODE A3UBE21, 22

Measurement	Males: Adult	Subadult	Juvenile
Total length	146.5±8.3(544)118-178	136.4±7.2(130)119-156	125.1±6.2(15)117-137
Tail length	74.4±5.3(544)58-93	71.5±5.5(130)55-85	65.3±4.1(15)61-73
Hind foot	19.6±0.9(555)17-26	19.2±1.0(130)17-26	19.1±0.6(15)18-20
Ear	6.8±0.6(555)2-8	6.4±0.6(130)5-7	6.0±0.7(15)5-7
Weights	11.4±2.1(555)5.6-18.5	8.5±1.3(130)4.9-10.9	6.7±1.1(15)4.7-8.6
Bacula length	6.6±1.0(555)4.4-9.2	5.2±0.4(130)3.4-6.6	4.9±0.4(15)4.5-5.6
	Females		
Total length	144.9±9.0(515)120-256	135.0±7.4(151)115-154	121.1±9.2(28)100-136
Tail length	74.0±4.8(515)58-90	71.1±5.6(151)53-85	62.8±7.3(28)44-73
Hind foot	19.4±0.9(530)13-24	19.0±0.8(152)17-21	18.0±1.1(28)14-19
Ear	6.7±0.6(530)5-9	6.3±0.5(152)5-7	5.9±0.6(28)5-7
Weights	10.5±1.9(530)6.8-19.3	8.3±1.1(152)5.9-11.2	5.9±0.6(28)4.9-7.2

*The mean number is given, followed by the standard deviation, the size of the sample (in parentheses), and the range. Lengths are expressed in mm, weights in g.

Table 36. Mean body weights (g) and bacula measurements (mm) of various ages and reproductive categories of 700 *Perognathus amplus**

	N	Body Weight: Mean	Body Weight: Range	Baculum: Mean	Baculum: Range
Juvenile	15	6.68	4.70- 8.60	4.85	4.45-5.60
Subadult	130	8.45	6.90-10.90	5.24	3.40-6.44
Adult					
No spermatozoa	209	10.27	7.40-14.30	5.74	4.35-7.90
Small amounts	70	10.62	5.60-17.40	6.53	5.00-8.35
Moderate amounts	84	11.39	8.30-18.30	6.88	4.70-8.50
Large amounts	192	12.76	8.70-18.50	7.52	6.00-9.20

*i.e., spermatozoa content in caudal epididymes

Table 37. Body measurement statistics of 438 *Perognathus baileyi**—DSCODE A3UBE21,22

Measurement	Males: Adult	Subadult	Juvenile
Total length	210.8±14.0(164)106-240	184.1±14.0(29)143-205	164.3±16.7(4)148-181
Tail length	114.0±8.0(164)76-140	102.3±9.8(29)70-114	86.8±12.6(4)75-100
Hind foot	26.6±1.4(165)24-38	25.4±1.4(30)22-29	25.5±1.3(4)24-27
Ear	9.5±1.1(165)7-19	8.5±1.0(30)7-10	8.3±0.5(4)8-9
Weight	28.1±5.1(165)18.6-44.0	17.9±2.8(30)12.0-24.3	12.5±1.9(4)10.6-15.1
Bacula length	10.2±1.1(165)6.8-12.8	8.7±0.8(30)7.3-10.8	8.1±0.4(4)7.7-8.6
	Females		
Total length	201.4±12.9(209)176-228	189.4±8.9(27)170-205	163±0(1)163
Tail length	109.2±6.5(209)86-125	105.7±6.3(27)95-119	95±0(1)95
Hind foot	25.8±1.0(211)21-29	25.1±1.9(27)20-29	25±0(1)25
Ear	9.2±0.8(211)7-11	9.1±0.7(27)8-11	7±0(1)7
Weight	24.5±3.4(211)16.6-38.4	18.6±2.8(27)13.7-23.7	14.4±0(1)14.4

*The mean number is given, followed by the standard deviation, the size of the sample (in parentheses) and the range. Lengths are expressed in mm, weights in g.

Table 38. Total semimonthly and monthly sex and age ratio of 438 *Perognathus baileyi* DSCODE A3UBE21,22

Month	Adult: Males	Adult: Females	Adult: % Males	Young: Males	Young: Females	Young: % Males	% Young
1970							
Jun 10	1	8	11.1	5	3	62.5	47.1
Jun 20	6	17	26.1	6	5	54.5	32.4
Jul 10	2	1	66.6	1	1	50.0	40.0
Jul 20	11	14	44.0	1	5	16.7	19.4
Aug 10	4	10	28.6	4	5	44.4	39.1
Aug 20	5	4	55.6	0	2	0	18.2
Sep	23	37	38.3	3	3	50.0	9.1
Oct	24	29	45.3	0	0	--	0
Nov	12	15	44.4	2	1	66.6	10.0
Dec	6	8	42.9	0	0	--	0
1971							
Jan	1	1	50.0	0	0	--	0
Feb	3	1	75.0	0	0	--	0
Mar	3	0	100.0	0	0	--	0
Apr	3	2	60.0	0	0	--	0
May	7	5	58.3	1	0	100.0	7.7

Continued

Table 38. Continued

Month	Adult Males	Adult Females	Adult % Males	Young Males	Young Females	Young % Males	% Young
Jun 10	6	6	50.0	0	0	--	0
Jun 20	0	0	--	0	0	--	--
Jul 10	15	9	62.5	4	1	80.0	17.2
Jul 20	3	4	42.9	0	0	--	0
Aug 10	3	6	33.3	1	1	50.0	18.2
Aug 20	1	3	25.0	1	0	100.0	20.0
Sep	5	5	50.0	2	0	100.0	16.7
Oct	2	6	25.0	0	0	--	0
Nov	0	0	--	0	0	--	--
Dec	6	4	60.0	0	0	--	0
1972							
Jan	0	0	--	0	0	--	--
Feb	4	8	33.3	0	0	--	0
Mar	6	6	50.0	0	0	--	0
Apr	1	0	100.0	1	0	100.0	50.0
May	2	2	50.0	2	1	66.6	42.9
Total	165	211	43.9	34	28	54.8	14.2

Table 39. Mean body weights (g) and bacula measurements (mm) of various ages and reproductive categories of 199 *Perognathus baileyi**

	N	Body Weight Mean	Body Weight Range	Baculum Mean	Baculum Range
Juvenile	4	12.47	10.60-15.10	8.10	7.70- 8.60
Subadult	30	17.91	12.00-24.30	8.66	7.25-10.80
Adult					
No spermatozoa	70	25.01	18.60-34.90	9.26	6.75-10.90
Small amounts	30	29.91	22.40-40.10	10.29	8.30-11.70
Moderate amounts	20	31.31	21.60-41.80	11.05	9.90-12.50
Large amounts	45	30.44	21.20-44.00	11.11	8.85-12.80

*i.e., spermatozoa content in caudal epididymes.

Males were consistently heavier than females (Fig. 12), but both males and females had seasonal weight fluctuations. Adults were heaviest prior to and during reproductive periods and weighed less during the colder months of the year. (Fig. 13).

Ninety-five adult male *P. baileyi* were found to be fertile. These fecund males had a mean body weight of 30.45 g, which was 5.44 g heavier than 70 adult non-fecund males. Readiness to mate apparently involves an increase in body weight (Table 39).

Only four females in estrus were taken; these had a mean body weight of 23.42 g, which is not significantly higher than the mean weight of 86 non-breeding females (22.55 g). Pregnant and lactating females were significantly heavier, averaging 28.43 g and 27.42 g respectively.

Perognathus intermedius DSCODE A3UBE21,22

Of those *P. intermedius* examined, 46.1% were males. Although this percentage reflects an even ratio of males to females, there were times of the year when males were distinctly more active than females (Table 40). Seemingly, during the cooler months of the winter, males had greater surface activity than females; in contrast, females were trapped in greater numbers during the summers. Adult males were slightly heavier (13.1 g) than adult females (12.7 g), Table 41, and perhaps were more sensitive to high temperatures than females, but could better tolerate colder temperatures.

Table 40. Total semimonthly and monthly sex and age ratio of 1,212 *Perognathus intermedius*—DSCODE A3UBE21, 22

	Adults			Young			
Month	Males	Females	% Males	Males	Females	% Males	% Young
1970							
Jun 10	19	49	27.9	9	12	42.9	23.6
Jun 20	27	38	41.5	14	19	42.4	33.7
Jul 10	11	17	39.3	13	13	50.0	48.1
Jul 20	11	29	27.5	11	5	68.8	28.6
Aug 10	18	29	38.3	16	7	69.6	32.9
Aug 20	29	34	46.0	1	2	33.3	4.5
Sep	25	30	45.5	1	2	33.3	5.2
Oct	20	12	62.5	0	0	--	0
Nov	4	2	66.6	0	0	--	0
Dec	0	0	--	0	0	--	--
1971							
Jan	0	0	--	0	0	--	--
Feb	0	0	--	0	0	--	--
Mar	8	3	72.7	0	0	--	0
Apr	6	7	46.2	0	0	--	0
May	26	11	70.3	0	0	--	0
Jun 10	20	18	52.6	0	0	--	0

Continued

Table 40. Continued

Month	Adults Males	Adults Females	Adults % Males	Young Males	Young Females	Young % Males	% Young
Jun 20	22	42	34.4	0	0	--	0
Jul 10	19	31	38.0	9	11	45.0	28.6
Jul 20	29	40	42.0	6	2	75.0	10.4
Aug 10	4	8	33.3	3	0	100.0	20.0
Aug 20	16	22	42.1	1	3	25.0	9.5
Sep	18	23	43.9	0	1	0	2.4
Oct	2	14	12.5	2	2	50.0	20.0
Nov	13	16	44.8	1	1	50.0	6.5
Dec	17	10	63.0	0	0	--	0
1972							
Jan	52	11	82.5	0	2	0	3.1
Feb	18	7	72.0	0	0	--	0
Mar	20	15	57.1	1	0	100.0	2.8
Apr	23	31	65.7	1	0	100.0	1.9
May	2	11	15.4	2	0	100.0	13.3
Total	479	560	46.1	91	82	52.6	14.3

Young animals comprised 14.1% of the *P. intermedius* trapped (1.7% juvenile and 12.4% subadult). The mean weight of the juveniles was 7.35 g and the mean weight of the subadults was 9.70 g. During the first year, young animals were trapped only throughout the summer months (Table 40), with a peak of 48.1% of the total sample of *P. intermedius* being young in the first portion of July 1970. Young animals were trapped in every month of the second year after June except during December and February.

Adult *P. intermedius* had a mean weight of 12.9 g. Body weights of adult males averaged 13.1 g (Table 41) which was only slightly heavier than adult females with a mean body weight of 12.7 g. Males were generally heavier than females (Fig. 15) throughout the non-reproductive periods, but females increased their weights and were often heavier than males during reproductive peaks.

Comparisons of body weights of *P. intermedius* during different seasons in two years indicated that the only time the weights of the animals approached the lower limits of their range was immediately prior to winter dormancy (November, 1970) and immediately after emergence (March, 1971). Perhaps decreased body weight due to paucity of food is a factor contributing to reduced surface activity.

As in the other heteromyids, there is a correlation in adult males between reproductive condition and body weight (i.e., spermatozoa present). Adult males with large amounts of spermatozoa in the caudal epididymis (N=174) had a mean body weight of 13.99 g and 64 adult males with moderate amounts of spermatozoa had a mean body weight of 13.39 g. Adult *P. intermedius* with no spermatozoa observed in the caudal epididymis (N=172) weighed an average of 12.15 g (Table 42).

Table 41. Body measurement statistics of 1,212 *Perognathus intermedius**

Measurement	Adult	Subadult	Juvenile
	Males		
Total length	169.0±8.0(461)142-188	160.6±10.5(81)130-184	142.4±6.4(9)134-156
Tail length	91.3±6.5(461)67-110	91.0±7.8(81)67-104	80.7±3.3(9)75-87
Hind foot	20.4±0.8(479)18-23	19.9±0.7(82)18-22	20.0±1.0(9)19-22
Ear	7.2±0.5(479)6-9	6.6±0.6(82)5-9	6.3±0.5(9)6-7
Weight	13.1±1.8(479)9.2-20.6	9.9±1.4(82)6.7-14.0	7.5±1.5(9)6.0-9.9
Bacula length	11.3±1.2(479)7.9-13.6	8.8±0.7(82)6.0-10.3	7.8±0.6(9)6.9-8.9
	Females		
Total length	167.4±8.0(533)122-188	158.0±9.3(69)139-177	142.0±12.8(13)116-159
Tail length	90.8±6.2(533)69-105	89.6±6.8(69)73-102	79.4±9.9(13)62-91
Hind foot	20.2±0.9(560)18-23	20.0±0.9(69)18-22	19.1±0.8(13)18-20
Ear	7.1±0.5(560)6-9	6.7±1.3(69)6-9	6.2±0.6(13)5-7
Weight	12.7±1.9(560)7.1-20.0	9.5±1.5(69)6.7-12.8	7.2±1.3(13)5.2-10.0

*The mean number is given, followed by the standard deviation, the size of the sample (in parentheses) and the range. Lengths are expressed in mm, weights in g (DSCODE A3UBE21,22)

Table 42. Mean body weights (g) and Bacula measurements (mm) of various ages and reproductive categories of 570 *Perognathus intermedius**

		Body Weight		Baculum	
	N	Mean	Range	Mean	Range
Juvenile	9	7.54	6.00- 9.90	7.79	6.90- 8.90
Subadult	82	9.93	6.70-14.00	8.80	6.00-10.30
Adult					
No spermatozoa	172	12.15	9.20-16.50	10.04	7.90-13.40
Small amounts	69	12.84	10.40-16.20	11.59	9.85-12.85
Moderate amounts	64	13.39	10.40-20.30	11.91	9.70-12.80
Large amounts	174	13.99	10.50-20.60	12.18	8.50-13.55

*i.e., spermatozoa content in caudal epididymes.

Eighty-two pregnant females had a mean body weight of 14.82 g; this mean is higher than that for any other category of *P. intermedius*. Lactating females, likewise, were heavy (13.54 g, N=45), but the average body weights of 16 females in estrus (12.27 g) was not significantly heavier than 159 non-reproductive females (11.59 g).

Peromyscus eremicus (DSCODE A3UBE21,22)

The sex ratio in *P. eremicus* was close to 1:1 (Table 43). Davis and Davis (1947) reported sex ratios from large laboratory colonies of *P. eremicus* to be 53% males and Lewis (1972) reported a predominance of 66% males, ascribing the uneven ratio to a more aggressive behavior of males.

Brand and Ryckman (1968) in studying the postnatal development in *P. eremicus*, found that weaning begins on the 20th to 22nd day postpartum and is completed by the 25th day. They further observed post-juvenile molt beginning on the 34th to 37th day. Apparently there is only an approximate 10-day foraging period as juveniles which explains why such a low percentage of juveniles were sampled (2.1% from a sample of 534).

There were sexual differences in the body length and weights of the juveniles. The mean weight of juveniles was 10.06 g and the mean length was 148.58 mm. Eight juvenile females averaged exactly 1 g heavier than nine juvenile males. The females also averaged 2.19 mm longer than the males and had a slightly longer hind foot (Table 44).

The greatest number of subadults were taken during June and July of the first year, indicating a spring reproductive peak. Some young animals were taken in all but four months of the study (Table 43) and in two of those months (September, 1970, and May, 1972) there were no *P. eremicus* trapped. The uniform occurrence of young animals indicates continuous breeding in cactus mice. The combined mean subadult male and female body weight was 13.96 g and the combined mean body length was 164.75 mm. Although the body length and body weight significantly increased over juveniles, the mean hind foot length remained nearly the same.

Adults were represented by 419 specimens (78.5% of the population) that had an average body weight of 20.09 g. Of the six species studied, only in *P. eremicus* was the mean female weight heavier than that in the male, 20.76 g to 19.42 g respectively. There did not appear to be any pattern of body weight changes that could be correlated with environmental conditions (Figs. 16 and 17). Not only were the females heavier than the males, they also averaged 3.42 mm longer (males were 181.96 mm, females were 185.38 mm), while the mean hind foot lengths were essentially the same (19.53 mm).

Table 43. Total, semimonthly and monthly sex and age ratio of 534 *Peromyscus eremicus*——DSCODE A3UBE21,22

Month	Adult Males	Adult Females	Adult % Males	Young Males	Young Females	Young % Males	% Young
1970							
Jun 10	13	12	52.0	10	3	77.0	34.2
Jun 20	5	8	38.5	13	5	72.2	58.1
Jul 10	1	3	25.0	3	1	75.0	50.0
Jul 20	9	8	52.9	4	4	50.0	32.0
Aug 10	8	5	61.5	5	4	55.6	40.9
Aug 20	3	1	75.0	0	1	0	20.0
Sep	0	0	--	0	0	--	--
Oct	8	10	44.5	3	2	60.0	21.7
Nov	7	11	38.9	1	2	33.3	14.3
Dec	1	2	33.3	0	1	0	25.0
1971							
Jan	3	2	60.0	0	1	0	16.7
Feb	12	7	63.2	0	1	0	5.0
Mar	6	5	54.5	1	1	50.0	15.4
Apr	3	2	60.0	0	0	--	0
May	5	2	71.4	1	0	100.0	12.5
Jun 10	0	1	0	0	0	--	0
Jun 20	0	2	0	0	0	--	0
Jul 10	2	4	33.3	1	1	50.0	25.0
Jul 20	9	6	60.0	1	1	50.0	11.8
Aug 10	3	2	60.0	1	1	50.0	28.6
Aug 20	2	1	66.6	0	0	--	0
Sep	0	0	--	1	0	100.0	100.0
Oct	0	1	0	1	1	50.0	66.0
Nov	11	14	73.3	2	2	50.0	13.8
Dec	16	13	55.2	1	5	16.6	17.1
1972							
Jan	22	24	47.8	3	5	37.5	14.8
Feb	33	26	56.0	1	4	20.0	7.8
Mar	27	23	54.0	7	2	77.8	15.3
Apr	7	8	46.7	3	4	42.9	31.8
May	0	0	--	0	0	--	--
Total	216	203	51.6	63	52	54.8	21.5

Table 44. Body measurement statistics of 534 *Peromyscus eremicus**——DSCODE A3UBE21,22

Measurement	Male Adult	Male Subadult	Male Juvenile
Total length	182.0±9.3(213)159-205	166.3±9.8(54)143-188	147.4±12.3(9)123-161
Tail length	93.1±7.4(213)71-117	86.2±8.1(54)64-103	75.9±7.5(9)62-85
Hind foot	19.5±0.7(216)17-21	19.1±0.8(54)17-20	18.8±1.4(9)17-20
Ear	17.8±1.1(216)15-21	17.1±1.1(54)12-19	16.4±1.9(9)14-20
Weight	19.4±2.3(216)11.7-28.0	14.2±1.7(54)10.0-17.8	9.6±2.2(9)6.3-12.2
Bacula length	8.9±0.8(216)5.8-10.4	7.0±0.9(54)5.5-8.8	5.5±0.5(9)4.8-6.3

Continued

Table 44. Continued

Measurement	Female Adult	Female Subadult	Female Juvenile
Total length	185.0±11.5(202)143-220	163.2±10.8(43)136-183	149.6±11.1(8)135-165
Tail length	95.8±8.7(202)64-135	84.4±9.3(43)62-101	77.0±7.9(8)67-89
Hind foot	19.6±0.8(202)17-22	19.0±0.7(44)18-20	19.1±0.8(8)18-20
Ear	17.8±1.2(203)17-20	17.0±1.4(44)14-22	16.1±0.8(8)15-17
Weight	20.8±3.9(203)12.6-35.2	13.7±1.7(44)9.6-19.2	10.6±1.8(8)8.1-12.7

*The mean number is given, followed by the standard deviation, the size of the sample (in parentheses), and the range. Lengths are expressed in mm, weights in g.

As in the other rodents of the study, increased body weight accompanied breeding in *P. eremicus*. A very high percentage of adult males (49.07 %) were found to have large quantities of spermatozoa present in the caudal epididymis. These males had an average body weight of 20.44 g, 1.13 g more than that of 50 males with moderate amounts of spermatozoa (Table 45). Fertile adult males were heavier than non-fecund adult males (Table 45). Breeding females, likewise, were on the average heavier than were non-breeding females (19.15 g vs. 16.50 g). Pregnant females averaged slightly heavier than lactating females (Table 46). It was perhaps because of the high number of reproductive females (Table 47) in the population from month to month that the females weighed more than the males.

Table 45. Mean body weights (g) and bacula measurements (mm) of various ages and reproductive categories of 279 *Peromyscus eremicus* *

	N	Body Weight Mean	Body Weight Range	Baculum Mean	Baculum Range
Juvenile	9	9.56	6.30-12.20	5.49	4.80- 6.30
Subadult	54	14.23	10.00-17.80	6.98	5.50- 8.80
Adult					
No spermatozoa	13	16.22	14.10-19.50	7.36	5.75- 9.60
Small amounts	43	18.01	14.90-21.70	8.51	6.25- 9.70
Moderate amounts	54	19.31	11.70-28.00	8.89	7.40-10.20
Large amounts	106	20.44	16.80-25.30	9.15	7.85-10.40

*i.e., spermatozoa content in caudal epididymes.

Table 46. Breeding characteristics of adult female *Peromyscus eremicus*---DSCODE A3UBE22

Month	Sample Size No.	Gravid No.	Gravid %	Gravid Weight Mean±S.D.	Gravid Embryos Mean±S.D.	Postpartum No.	Postpartum %.	Postpartum Weight Mean±S.D.	Placental Scars Mean±S.D.
1970									
Jun 10	12	8	67	24.3±3.3	2.6±0.5	3	25	21.5±1.9	3.3±0.6
Jun 20	8	2	25	19.4±4.5	2.0	2	25	21.7±2.3	3.0
Jul 10	3	3	100	21.3±1.6	2.0	0	0		
Jul 20	8	2	25	21.3±5.0	3.0	5	63	17.6±2.5	2.6±0.6
Aug 10	5	3	60	19.9±3.4	2.7±0.6	2	40	16.1±2.8	2.0
Aug 20	1	1	100	30.6	4.0	0	0		
Sep									
Oct	10	2	20	20.8±3.4	3.0±1.4	2	20	20.5±3.5	3.0
Nov	11	1	9	17.9	2.0	5	45	20.1±2.1	2.2±1.1
Dec	2	1	50	19.4	3.0	1	50	20.9	4.0
1971									
Jan	2	0	0			1	50	19.5	3.0
Feb	7	0	0			3	43	19.0±1.6	2.0±1.0
Mar	5	0	0			4	80	18.8±1.8	2.3±1.0
Apr	2	0	0			0	0		
May	2	0	0			0	0		
Jun 10	1	0	0			1	100	16.4	2.0
Jun 20	2	0	0			2	100	19.0±1.3	3.5±0.7
Jul 10	4	2	50	22.3±1.3	3.5±0.7	0	0		
Jul 20	6	1	17	22.0		3	50	20.0±1.2	3.0
Aug 10	2	2	100	22.5±2.1	2.5±0.7	0	0		
Aug 20	1	1	100	29.2	3.0	0	0		
Sep									
Oct	1	0	0			0	0		
Nov	14	8	57	24.3±2.9	2.8±0.7	3	21	20.8±1.4	2.3±0.6
Dec	13	7	54	23.5±5.6	3.0±0.6	0	0		
1972									
Jan	24	9	38	21.1±1.5	2.4±0.5	4	17	24.3±1.1	3.0
Feb	26	5	19	25.7±4.7	2.8±1.1	11	42	22.9±4.5	2.6±0.7
Mar	23	10	43	22.6±3.6	2.2±0.4	8	35	21.1±1.9	2.4±0.5
Apr	8	4	50	23.5±2.5	2.8±0.5	1	13	22.0	3.0
May									
Total	203	72	35	22.9±3.8	2.6±0.7	61	30	20.6±3.1	2.6±0.7

Table 47. Summary of the reproductive cycles of *Peromyscus eremicus* based on 225 females (203 adults, 52 young) from June 1970 through May 1972—DSCODE A3UBE22

Month	Estrus	% Reproductive Pregnant	% Reproductive Lactating	% Non-reproductive Adult	% Non-reproductive Young
1970					
Jun 10	0	53.33	6.67	20.00	20.00
Jun 20	0	15.38	30.77	15.39	38.46
Jul 10	0	75.00	0	0	25.00
Jul 20	0	16.67	8.33	41.67	33.33
Aug 10	0	33.33	0	22.22	44.44
Aug 20	0	50.00	0	0	50.00
Sep	-	--	--	--	--
Oct	0	16.67	8.33	49.00	16.66
Nov	0	7.69	7.69	69.24	15.38
Dec	0	33.34	0	33.33	33.33
1971					
Jan	0	0	0	66.67	33.33
Feb	0	0	0	87.50	12.50
Mar	0	0	0	83.33	16.67
Apr	0	0	0	100.00	0
May	0	0	50.00	50.00	0
Jun 10	0	0	0	100.00	0
Jun 20	0	0	0	100.00	0
Jul 10	0	40.00	40.00	0	20.00
Jul 20	0	14.29	28.57	42.85	14.29
Aug 10	0	66.67	0	0	33.33
Aug 20	0	100.00	0	0	0
Sep	--	--	--	--	--
Oct	0	0	50.00	0	50.00
Nov	0	50.00	18.75	18.75	12.50
Dec	5.56	38.89	11.11	16.67	27.78
1972					
Jan	0	31.03	0	51.73	17.24
Feb	0	16.67	0	70.00	13.33
Mar	0	40.00	20.00	32.00	8.00
Apr	8.33	33.33	8.33	16.68	33.33
May	--	--	--	--	--

Perognathus penicillatus (DSCODE A3UBE21, 22)

Of those specimens of *P. pennicillatus* examined, 57.2% were males. This is not a significant departure from a 1:1 ratio, especially considering the small sample size (Table 48).

Four juveniles accounted for 2.1% of the total sample of *P. penicillatus* and had a mean weight of 8.85 g and a mean total length of 143.50 mm (Table 49).

Table 48. Total semimonthly and monthly sex and age ratio of 187 *Perognathus penicillatus*—DSCODE A3UBE21,22

Month	Adult Males	Adult Females	Adult % Males	Young Males	Young Females	Young % Males	% Young
1970							
Jun 10	18	7	72.0	5	0	100.0	16.7
Jun 20	2	0	100.0	0	1	0	33.3
Jul 10	1	0	100.0	0	0	--	0
Jul 20	3	2	60.0	0	1	0	16.7
Aug 10	4	3	57.1	0	0	--	0
Aug 20	0	1	0	1	0	100.0	50.0
Sep	7	10	41.1	0	1	0	5.6
Oct	2	3	40.0	0	0	--	0
Nov	0	0	--	0	0	--	--
Dec	0	0	--	0	0	--	--
1971							
Jan	0	1	0	0	0	--	0
Feb	1	0	100.0	0	0	--	0
Mar	1	0	100.0	0	0	--	0
Apr	1	0	100.0	0	0	--	0
May	9	1	90.0	1	0	100.0	9.1
Jun 10	2	3	40.0	1	0	100.0	16.7
Jun 20	12	9	57.1	0	0	--	0
Jul 10	4	4	50.0	0	0	--	0
Jul 20	4	4	50.0	3	0	100.0	27.3
Aug 10	1	2	33.3	1	2	33.3	50.0
Aug 20	2	1	66.6	1	2	33.3	50.0
Sep	4	7	36.4	2	2	50.0	26.7
Oct	5	5	50.0	2	1	66.6	23.1
Nov	2	0	100.0	0	0	--	0
Dec	1	0	100.0	0	1	0	50.0
1972							
Jan	0	0	--	0	0	--	--
Feb	1	0	100.0	0	0	--	0
Mar	0	0	--	0	0	--	--
Apr	0	0	--	0	0	--	--
May	3	4	42.9	0	2	0	22.2
Total	90	67	57.3	17	13	56.7	16.0

Table 49. Body measurement statistics of 187 *Perognathus penicillatus** DSCODE A3UBE21,22

Measurement	Male: Adult	Subadult	Juvenile
Total length	178.5±9.3(87)124-202	164.2±8.7(14)149-181	143.0±10.6(3)131-151
Tail length	95.2±5.4(87)82-105	90.6±7.1(14)80-104	78.0±12.5(3)65-90
Hind foot	23.0±1.3(90)20-26	22.3±1.6(14)19-24	22.0±2.0(3)20-24
Ear	7.9±0.7(90)7-10	7.3±0.7(14)6-8	6.7±1.2(3)6-8
Weight	16.8±2.7(90)10.0-25.0	12.5±2.4(14)9.4-16.5	8.4±0.3(3)8.1-8.6
Bacula	11.7±1.2(90)6.8-13.4	9.0±1.0(14)7.0-11.4	7.7±0.4(3)7.2-7.9
	Female		
Total length	179.5±8.2(66)161-203	165.3±6.2(12)153-173	145.0±0(1)145
Tail length	96.8±5.3(66)84-112	90.5±5.5(12)82-98	79.0±0(1)79
Hind foot	23.7±1.4(67)22-29	22.4±0.7(12)21-23	23.0±0(1)23
Ear	8.2±0.8(67)6-11	7.8±0.6(12)7-9	7.0±0(1)7
Weight	17.0±2.2(67)13.0-23.3	13.7±3.1(12)10.0-20.0	10.2±0(1)10.2

*The mean number is given, followed by the standard deviation, the size of sample (in parentheses) and the range. Lengths are expressed in mm, weights in g.

One of the diagnostic characteristics of *P. penicillatus* is the large hind foot (Hall and Kelson, 1959). Juveniles had a mean hind foot length of 22.25 mm as compared to a mean hind foot length in 157 adults of 23.34 mm. The mean weight of juveniles was 52.4% that of adults. The mean total body length was 80.2% that of adults and the mean hind foot length was 95.3% that of adults. The disproportionately long hind limb in juveniles is of apparent adaptive value for locomotion.

Twenty-six subadults had a mean body length of 164.73 mm, a mean body weight of 13.05 g, and accounted for 13.9% of the total *P. penicillatus* trapped.

Young animals were trapped from June through September of the first year (Table 48). During the second year, however, young animals were trapped throughout the summer except in July, 1971. One young animal was trapped in October, 1971 and another in December 1971. No further young were taken until May, 1972.

Over the two-year period, 157 adult *P. penicillatus* had a mean weight of 16.89 g. The mean body weight of 67 females (17.04 g) was slightly higher than that of 90 males (16.75 g). In contrast, the average body length of females (x=179.45 mm) and males (x=178.47 mm) were essentially the same (Fig. 18).

Fertile males of *P. penicillatus* were approximately the same weight as non-fertile males. The reproductive males had a mean body weight of 16.88 g while non-fecund males had a mean body weight of 16.23 g (Table 50).

Adult female *P. penicillatus* did show increased body weight with fecundity. Eight lactating females had a mean body weight of 18.12 g which is heavier than any other category of male or female. Pregnant females (N=8) had a mean body weight (x=17.85 g) slightly less than lactating females, but their mean body weight was still 1.94 g heavier than that of 17 non-reproductive females.

Table 50. Mean body weights (g) and bacula measurements (mm) of various ages and reproductive categories of 107 *Perognathus penicillatus**

		Body Weight		Baculum	
	N	Mean	Range	Mean	Range
Juvenile	3	8.40	8.10- 8.60	7.65	7.15- 7.90
Subadult	14	12.45	9.40-16.50	9.01	7.00-11.40
Adult					
No spermatozoa	19	16.23	10.00-21.10	10.03	6.80-12.70
Small amounts	13	17.58	12.10-25.00	11.46	10.10-12.80
Moderate amounts	17	16.19	12.90-20.70	12.11	11.00-12.90
Large amounts	41	16.95	13.50-24.80	12.47	11.20-13.40

*i.e., spermatozoa content in caudal epididymes.

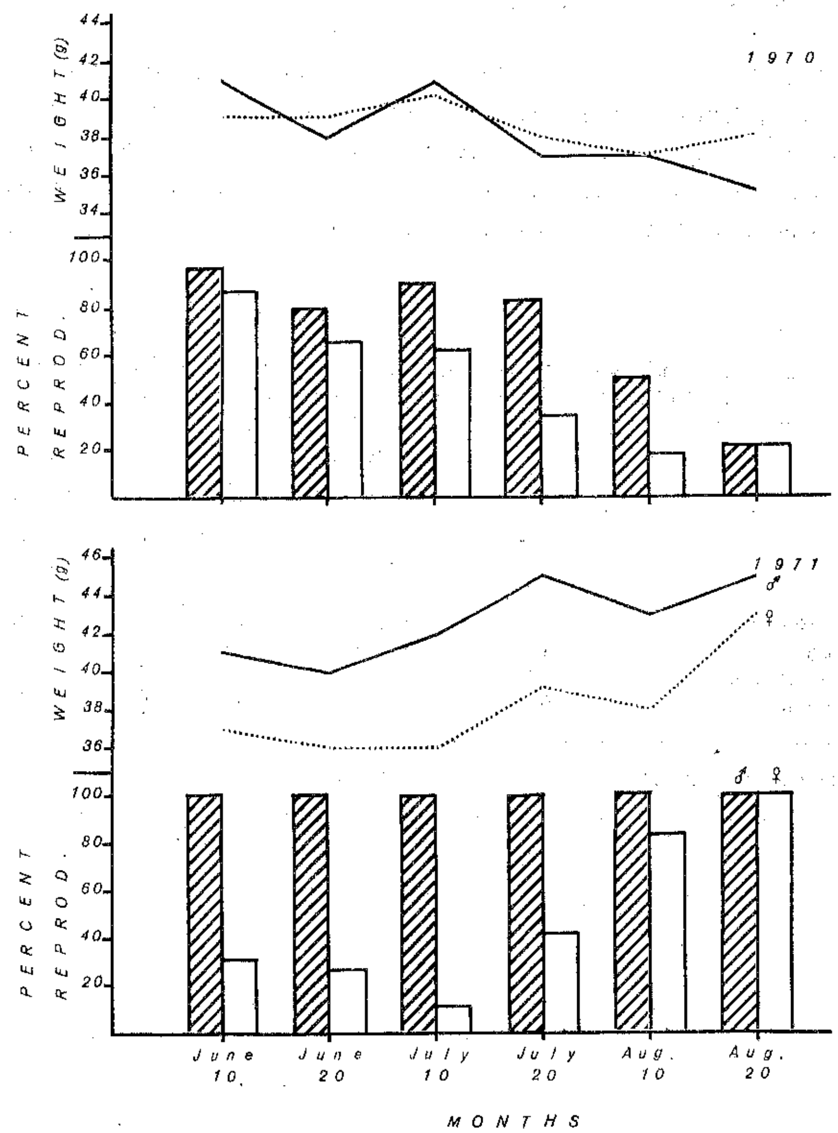

Figure 8. Summary of comparative weight fluctuations and fecundity of adult male and female *Dipodomys merriami*. Graph represents the six summer trapping periods of both years. (DSCODES A3UBE21, BE22)

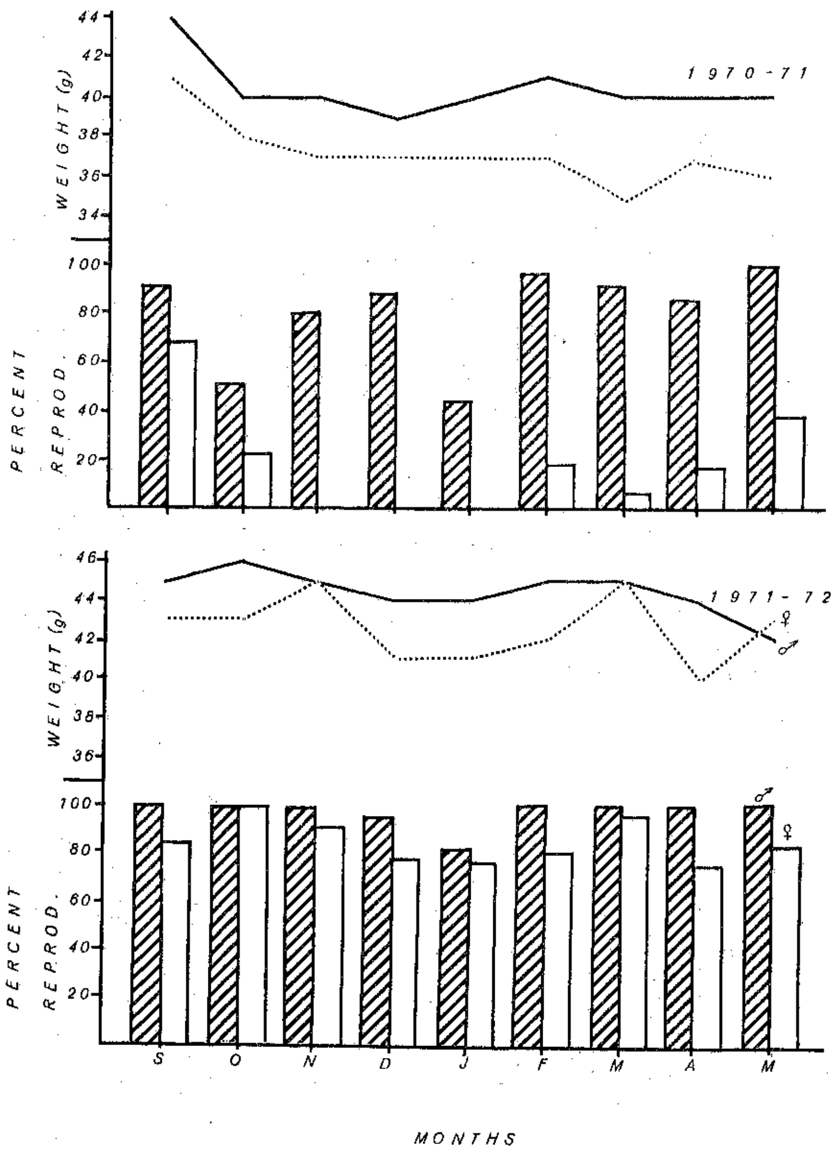

Figure 9. Summary of comparative weight fluctuations and monthly fecundity of adult male and female *Dipodomys merriami*. Graph represents months of September through May of both years. (DSCODES A3UBE21, BE22)

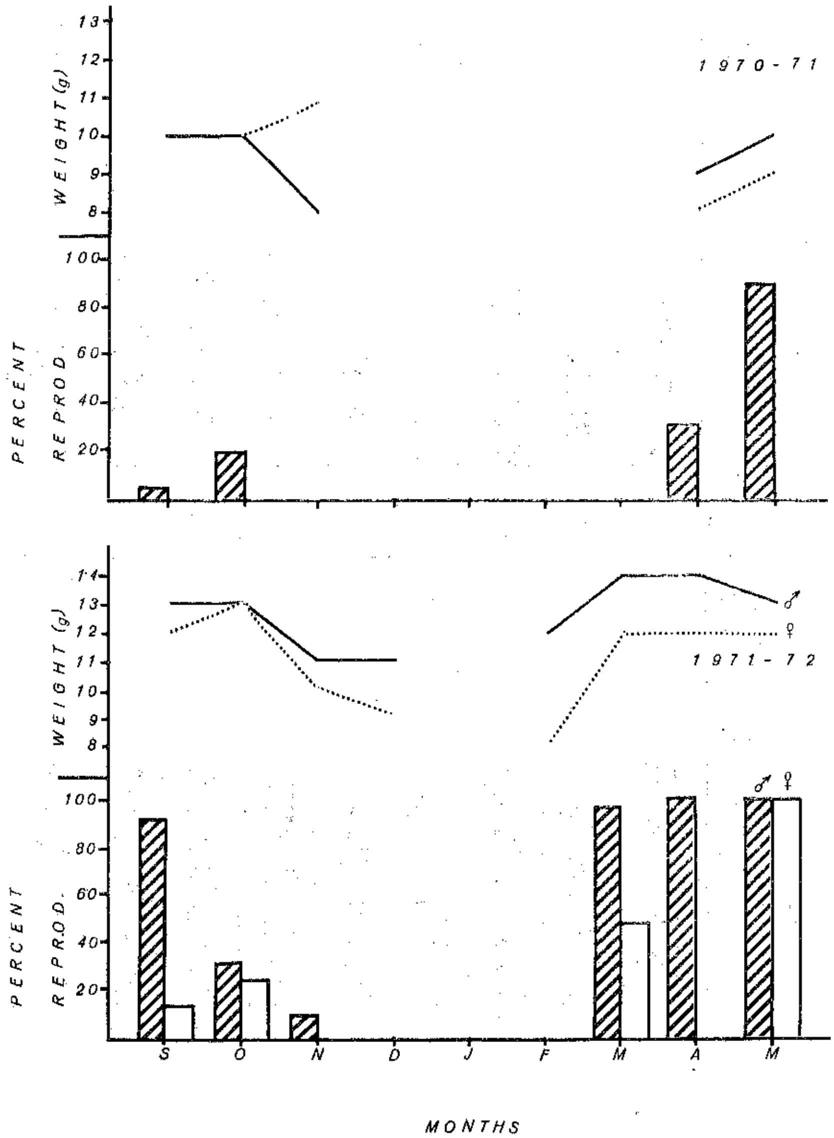

Figure 10. Summary of comparative weight fluctuations and monthly fecundity of adult male and female *Perognathus amplus*. Graph represents months of September through May of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

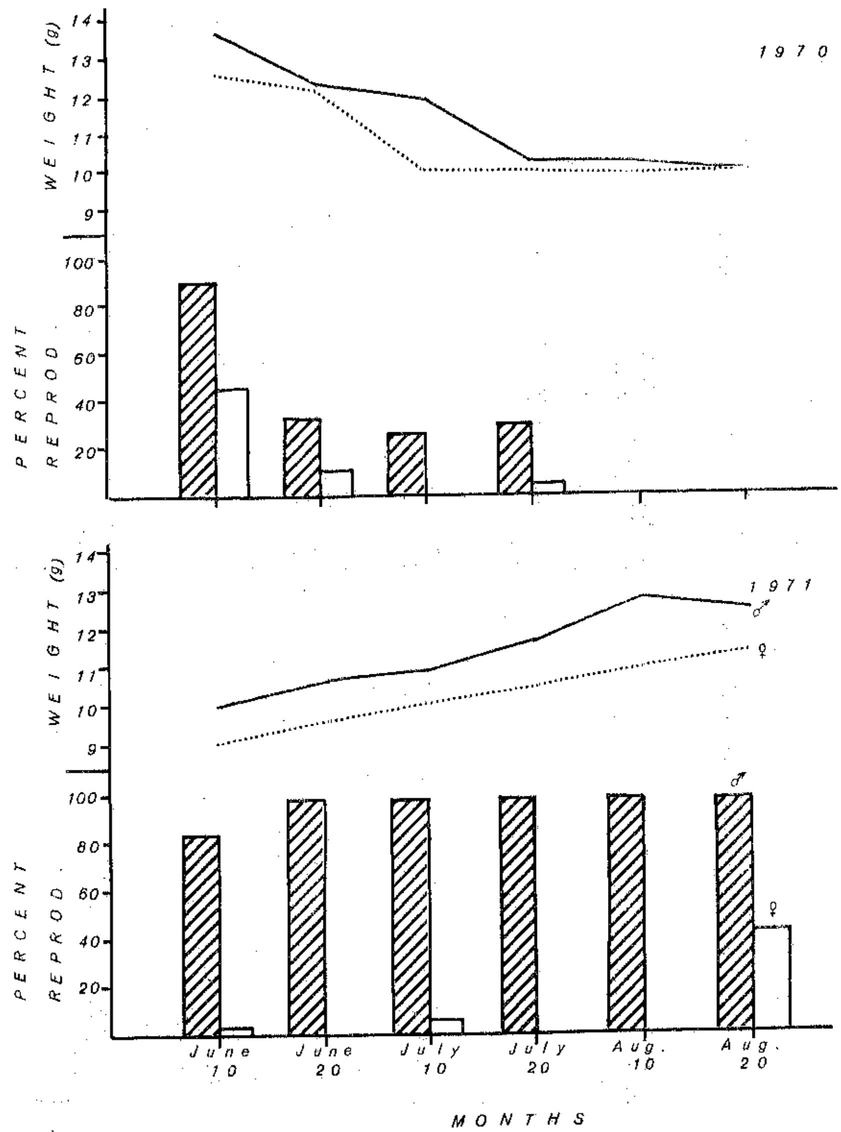

Figure 11. Summary of comparative weight fluctuations and fecundity of adult male and female *Perognathus amplus*. Graph represents the six summer trapping periods of both years (DSCODES A3UBE21, BE22)

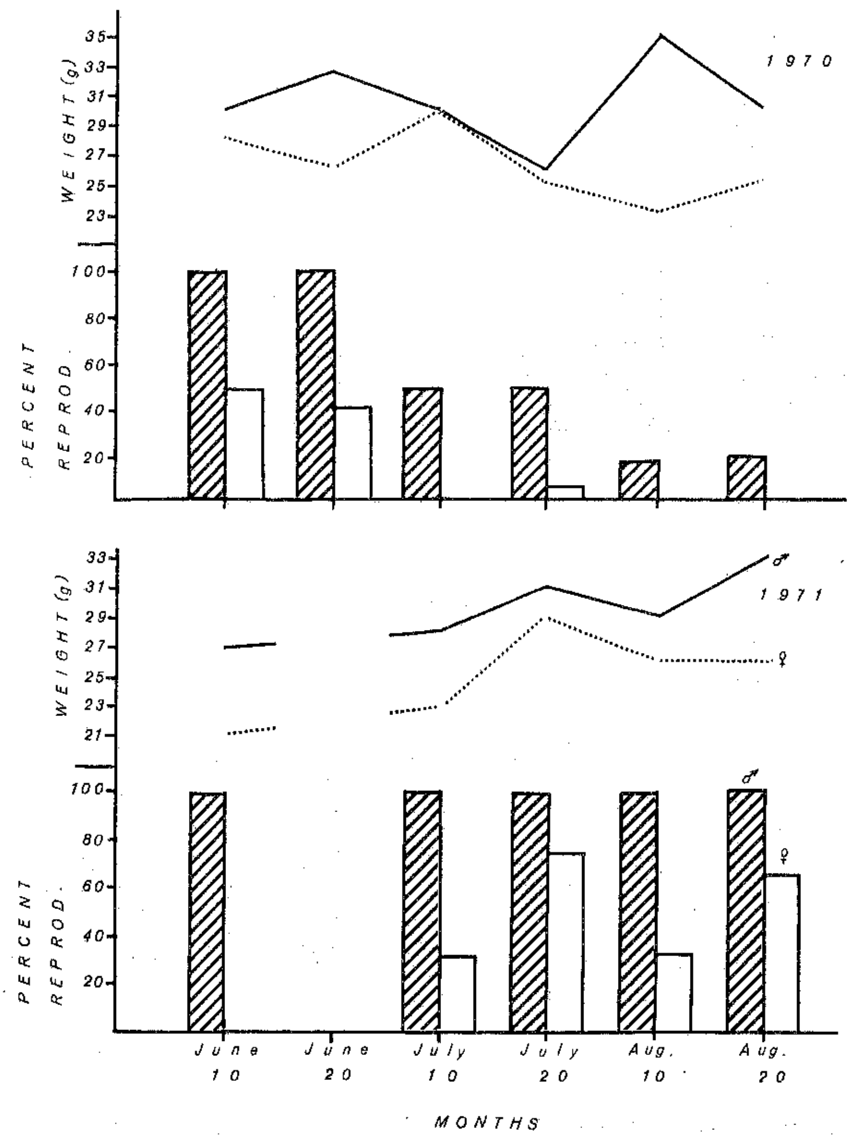

Figure 12. Summary of comparative weight fluctuations and fecundity of adult male and female *Perognathus baileyi*. Graph represents the six summer trapping periods of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

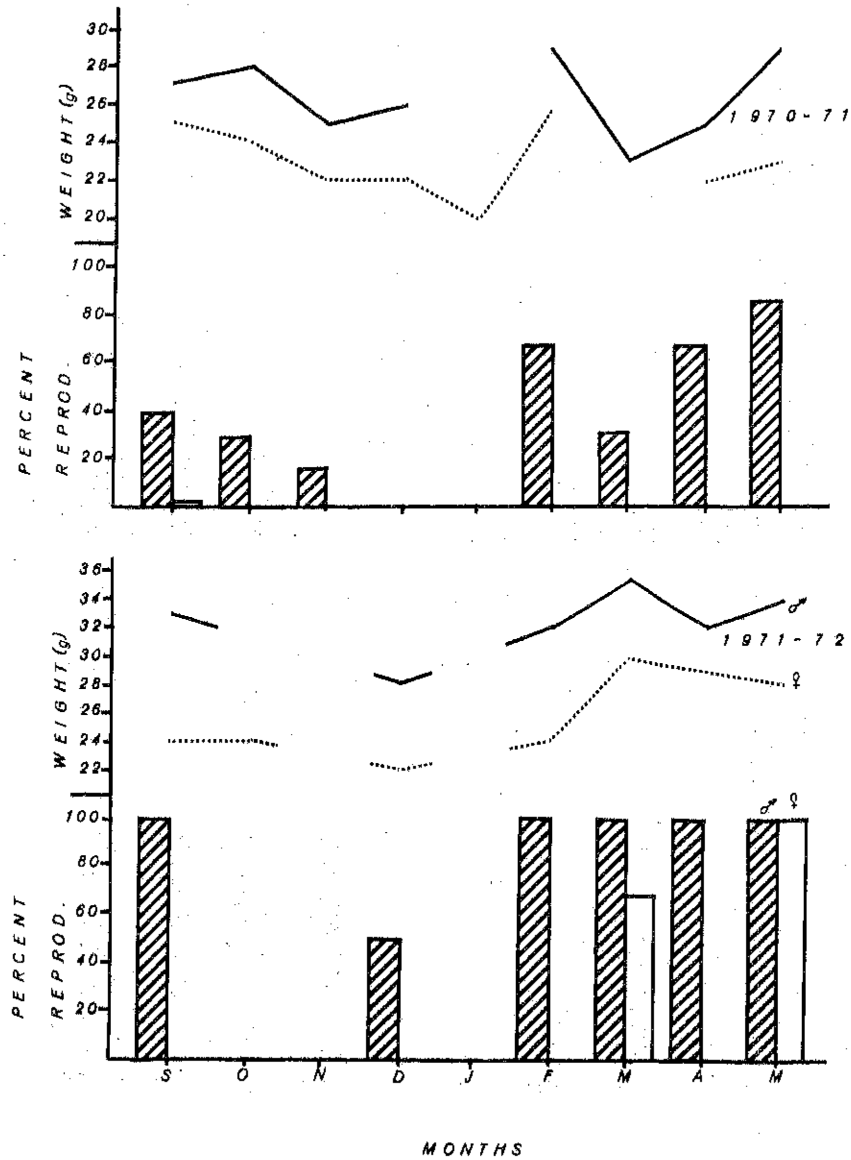

Figure 13. Summary of comparative weight fluctuations and monthly fecundity of adult male and female *Perognathus baileyi*. Graph represents months of September through May of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

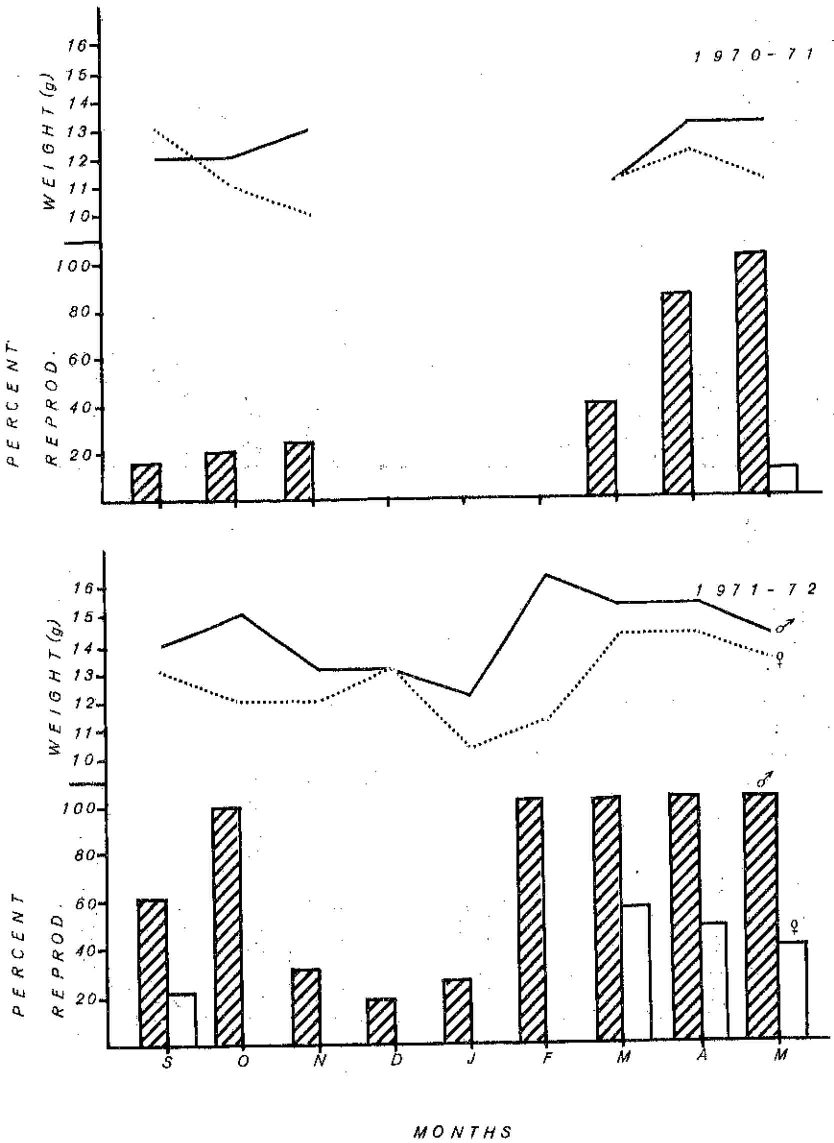

Figure 14. Summary of comparative weight fluctuations and monthly fecundity of adult male and female *Perognathus intermedius*. Graph represents months of September through May of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

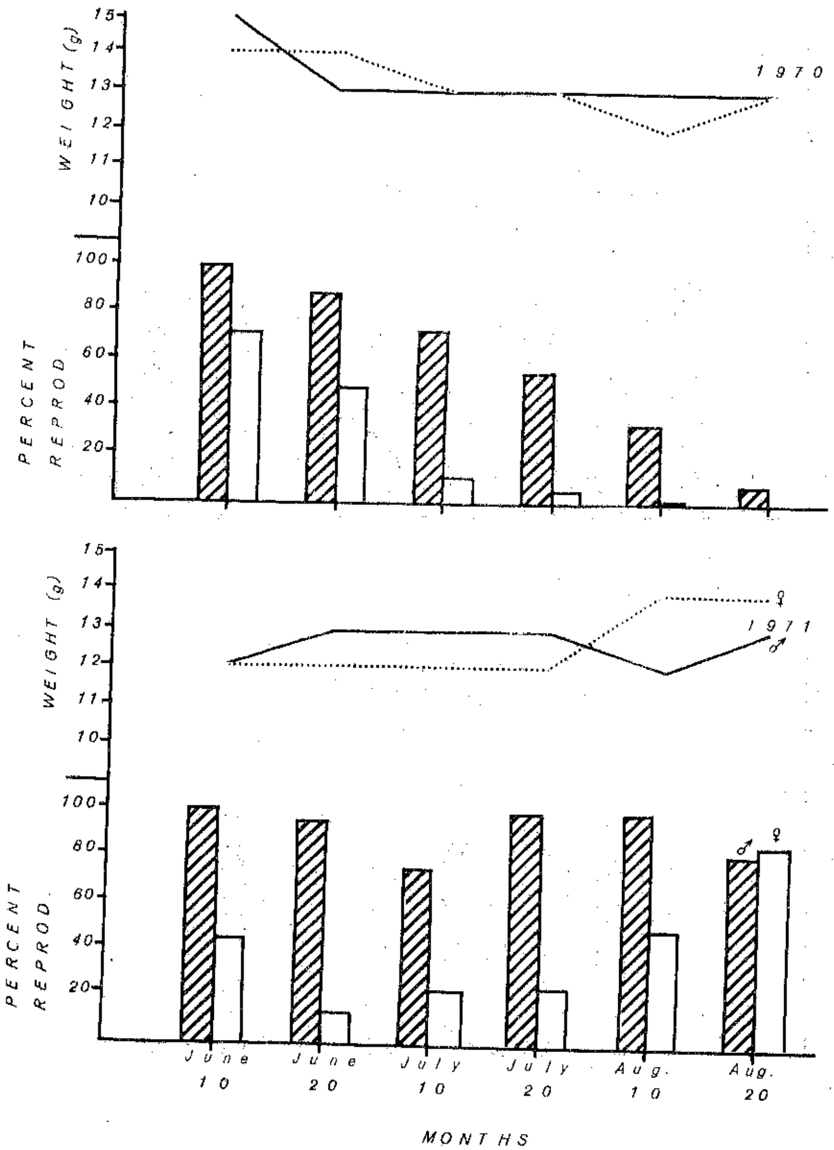

Figure 15. Summary of comparative weight fluctuations and fecundity of adult male and female *Perognathus intermedius*. Graph represents the six summer trapping periods of both years. (DSCODES A3UBE21, BE22)

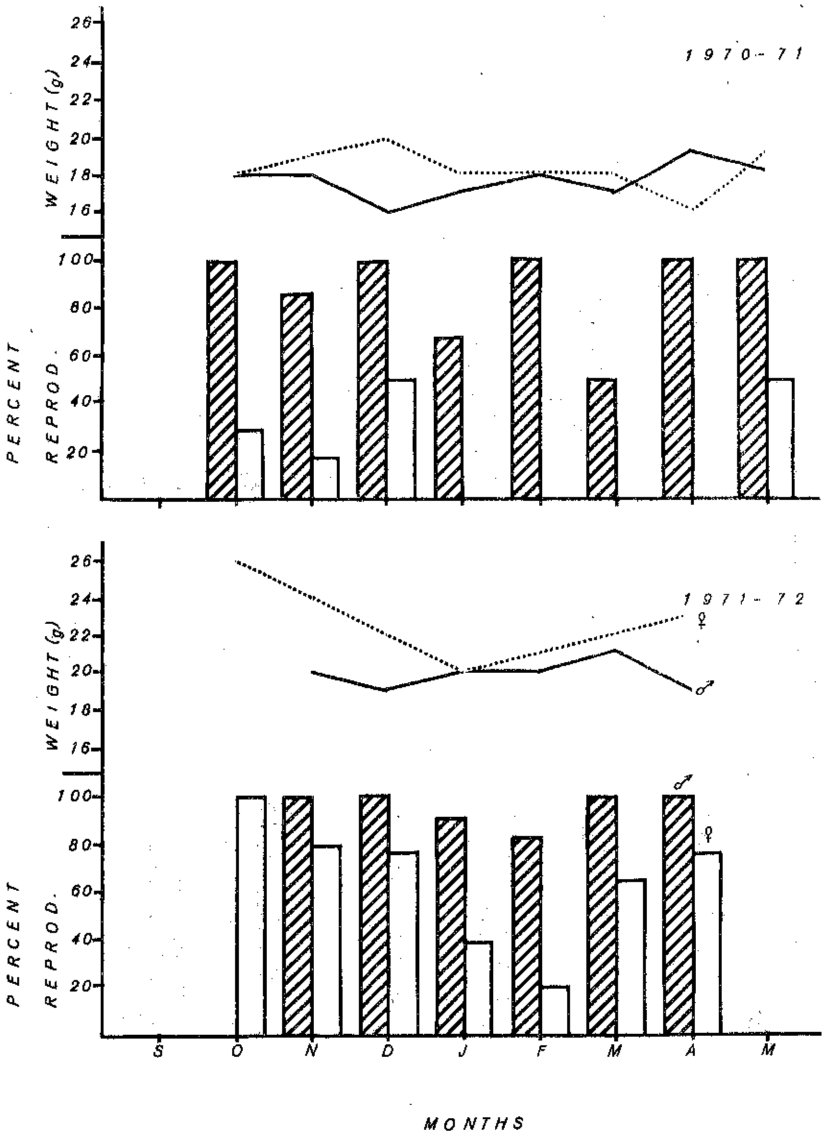

Figure 16. Summary of comparative weight fluctuations and monthly fecundity of adult male and female *Peromyscus eremicus*. Graph represents months of September through May of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

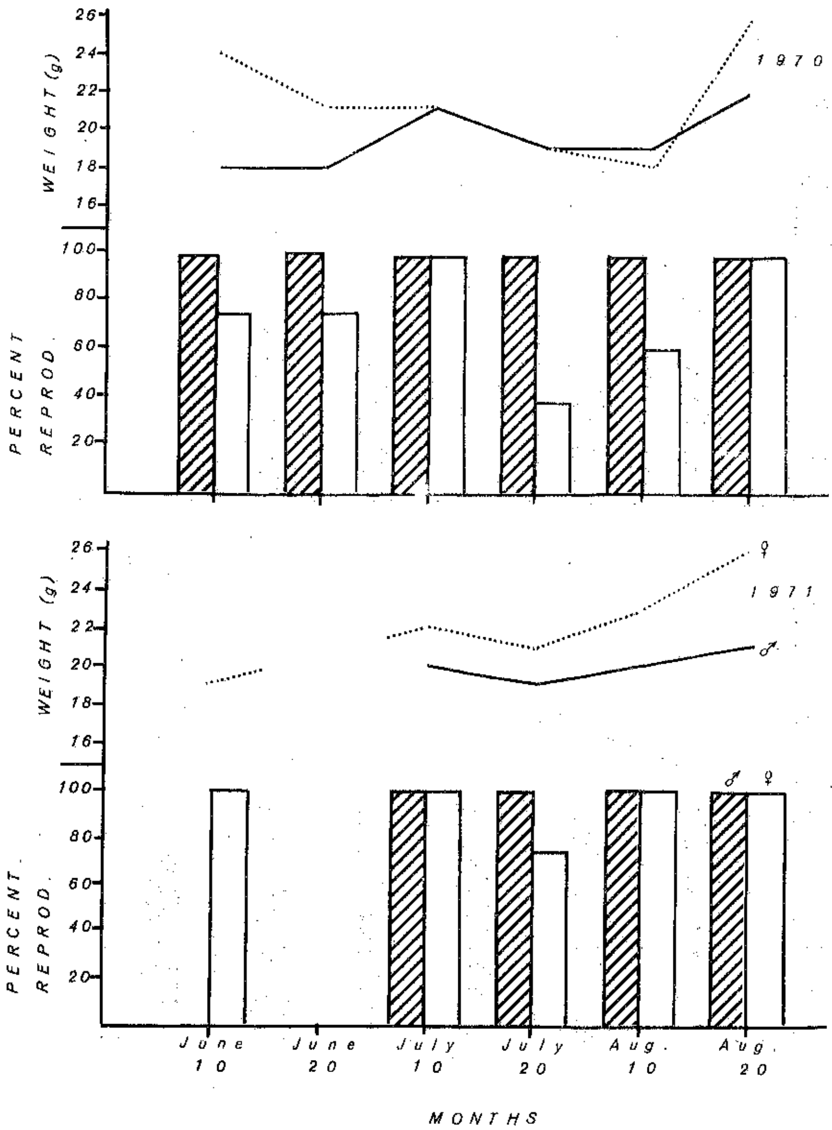

Figure 17. Summary of comparative weight fluctuations and fecundity of adult male and female *Peromyscus eremicus*. Graph represents the six summer trapping periods of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

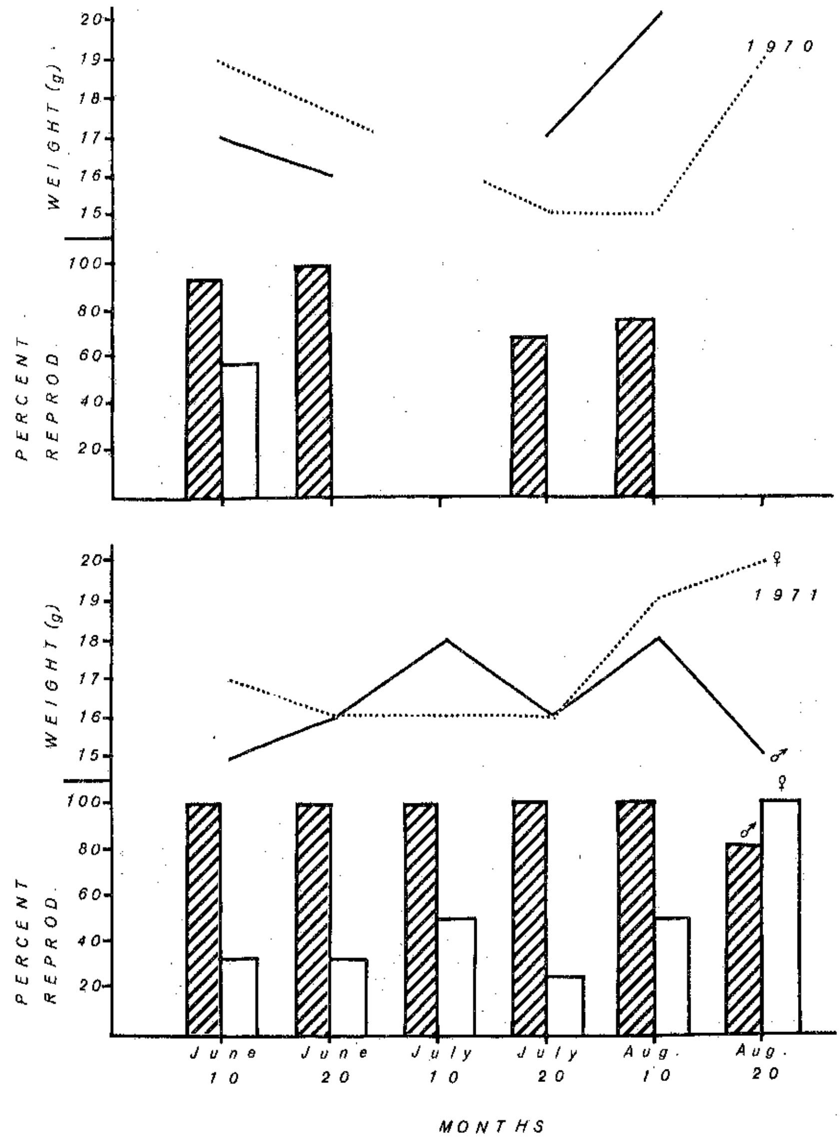

Figure 18. Summary of comparative weight fluctuations and fecundity of adult male and female *Perognathus penicillatus*. Graph represents the six summer trapping periods of both years. Gaps in weight lines indicate lack of specimens. (DSCODES A3UBE21, BE22)

REPRODUCTIVE CYCLES
(DSCODE BE21 BE22)

Dipodomys merriami

Male reproductive cycle: Males had a longer reproductive season than did females and a higher, or equal, percentage of individuals reproductively active in any given trapping period (Table 51 and Fig. 8). Butterworth (1960) found active spermatozoa in *D. merriami* when the testes were longer than 5 mm, regardless of the testes position. Bradley and Mauer (1971), using the 5 mm testes dimensions as a criteria, did not examine for active spermatozoa. Care should be used in determining reproductively active animals, especially from small sample sizes. In this study many males were found to have testes longer than 5 mm with no spermatozoa. Some testes, however, were less than 5 mm in length and contained small-to-moderate amounts of spermatozoa. The last trapping period of August 1970 revealed the lowest percentage of *D. merriami* having spermatozoa (Fig. 9). Following the summer rains in September, 1970, there was a striking increase in reproductive activity. Ninety-two percent of the adult kangaroo rats were reproductively active, an increase of 72% over the previous trapping period.

Lengths and shapes of the bacula varied according to age classification and reproductive condition (Fig. 19). Bacula of juvenile kangaroo rats (N=8) averaged 6.79 mm in length. The bacula of juveniles appeared thicker proximally in proportion to length and had greater flexion than those of other age categories. Subadults (N=63) had bacula averaging 8.49 mm and a less prominent curvature than juveniles. The bacula of 774 adults averaged 11.30 mm in length. The shaft of the adult bacula was relatively straight with a slight distal hook. The proximal end was rounded and more massive. Often when adult animals were in breeding condition, a hardened cartilagenous-like extension attached to and protruded from the distal tip. The function of this penial extension is not known but is assumed to facilitate copulation. The presence of this extension appeared to be correlated with those adult animals having large amounts of spermatozoa. Bacula from animals with large amounts of spermatozoa (N=356) averaged .20 mm longer than bacula from males with moderate amounts of spermatozoa and averaged 1.75 mm longer than adult males with no spermatozoa present (Table 32).

Measurements of various reproductive organs (Figs. 19 and 21) demonstrated size fluctuations that correlated with amounts of spermatozoa observed. Testicular dimensions (Fig. 20), caudal epididymides lengths (Fig. 21) and seminal vesicle lengths (Fig. 22) diminished as spermatozoa content declined. Males were considered reproductively active if spermatozoa were observed in the caudal epididymides. It was only during the autumn and winter of the second year, however, that the majority of males had copious amounts of spermatozoa.

Table 51. Summary of the reproductive cycles of *Dipodomys merriami* based on 727 females (669 adults, 58 young) from June 1970 through May 1972—— DSCODE A3UBE22

		% Reproductive		% Non-reproductive	
Month	Estrus	Pregnant	Lactating	Adult	Young
1970					
Jun 10	1.75	54.39	14.04	10.53	19.30
Jun 20	0	55.56	11.11	33.33	0
Jul 10	0	40.00	10.00	30.00	20.00
Jul 20	0	9.09	18.18	50.00	22.73
Aug 10	0	14.29	0	71.42	14.29
Aug 20	0	20.00	0	80.00	0
Sep	4.17	37.50	20.83	29.17	8.33
Oct	0	4.17	16.67	74.99	4.17
Nov	0	0	0	96.97	3.03
Dec	0	0	0	93.75	6.25
1971					
Jan	0	0	0	100.00	0
Feb	0	17.78	0	80.00	2.22
Mar	5.88	0	0	94.12	0
Apr	0	13.33	3.33	83.34	0
May	5.77	17.31	11.54	57.69	7.69
Jun 10	0	6.67	26.67	66.66	0
Jun 20	3.23	3.23	16.13	64.50	12.91
Jul 10	0	10.00	0	85.00	5.00
Jul 20	3.57	25.00	10.71	53.58	7.14
Aug 10	34.36	45.45	0	20.19	0
Aug 20	10.34	79.31	6.90	0	3.45
Sep	0	46.15	38.46	15.39	0
Oct	0	50.00	25.00	0	25.00
Nov	0	46.15	30.77	7.70	15.38
Dec	4.76	9.52	52.38	19.05	14.29
1972					
Jan	10.00	50.00	5.00	20.00	15.00
Feb	0	55.17	20.69	20.69	3.45
Mar	0	73.33	10.00	3.33	13.33
Apr	0	40.00	20.00	20.00	20.00
May	7.69	38.47	26.92	15.39	11.54

Male fecundity in the second year contrasted with that of the first year. Virtually every trapping period of the second year yielded almost 100% of the adult male kangaroo rats in reproductive prime. Only during December, 1971 and January, 1972 were a small portion of the adult male kangaroo rats non-fecund.

Female reproductive cycle: During the first year there were two distinct peaks of reproduction for *D. merriami* (Fig. 23) which apparently is typical for kangaroo rats from southern Arizona (Reynolds, 1960) (Table 52). These two reproductive periods correspond to the bimodal rainfall patterns typical of the lower Sonoran desert. Only during three months, November, December and January of the first year, were no females in reproductive condition recorded.

The second year was remarkably different from the first. There was a lull in reproduction in *D. merriami* during the early summer months (Fig. 23) when reproductive activity of females dropped to 20%. Following this decline, however, reproduction accelerated with 100% of the adult population reproducing during August and October of 1971. Throughout August, 1971 and June, 1972 reproductive activity in *D. merriami* did not fall below the 50% level.

Table 52. Reported reproductive periods for *Dipodomys merriami*

Peaks	Months	Author
Two seasonal peaks	May and September	Reynolds (1960)
Generally two peaks	Early spring and Autumn	Van De Graaff
One peak	March, April and May	Chew and Butterworth (1964)
One peak	March and April	Bradley and Mauer (1971)
One peak	Early spring	Butterworth (1960)
One peak	Late spring	Hall (1946)
One peak	March, April and May	Alcorn (1941)

The duration of estrus condition in *D. merriami* is not known, but for *D. ordii* it is five to six days (Day et al., 1956). When a female is in estrus, the horns and body of the uterus are highly vascularized. Females in estrus had a body weight of 37.30 g; an average of 3.04 g heavier than non-fecund adult females. Increased body weight has an apparent bearing on readiness to mate (Chew, 1958). Females apparently develop a vaginal plug shortly after copulation that is shaped similar to those described for *Dipodomys deserti* by Butterworth (1961).

The body of the developing foetus could not be measured by rump-crown lengths until it was approximately 11.90 mm. Embryos near partuation had rump-crown lengths of approximately 20.30 mm. Gestation in *D. merriami* ranges between 17 to 23 days (Chew, 1958).

As in voles (Fitch, 1957) and other rodents, *D. merriami* has three pair of mammae -- one pair pectoral and the other two abdominal. Of the female kangaroo rats observed lactating, few showed evidence of utilizing the pectoral mammae. This same situation was mentioned in prairie voles by Jameson (1947) and Fitch (1957). In females that had not yet produced young, the teats were small and obscured in the fur. During lactation the teats became prominent, averaging 2.68 mm in length (range 2.20 mm to 2.95 mm). The fur around the teats was often matted down, further exposing the mammae. Subcutaneous mammary tissue was often difficult to detect even in those kangaroo rats that were obviously lactating. This inconspicuous mammary tissue might be correlated to the milk with low-water content of kangaroo rats by Kooyman (1963).

Ovarian dimensions in *D. merriami* are a reliable and sensitive indicator of reproductive activity (Table 53). The smooth, pinkish, turgid ovaries of juveniles had the smallest dimensions. Subadults had larger ovaries with a darker coloration. Ovaries of females in estrus averaged 0.40 mm longer and 0.5 mm wider than those of non-reproductive adults. The ovarian dimensions remained consistent from estrus through pregnancy, regressing slightly during lactation. Average ovary length and average ovary width of postpartum females with placental scars was 2.2±0.3 and 1.4±0.4 respectively. Although corpora lutea of pregnancy were observed, no data concerning their appearance or duration were recorded.

The horns of the uteri of juvenile kangaroo rats were pale pink, translucent, and slightly thicker than in subadults. Uteri of females in estrus were swollen and often a deep red color from the presence of increased vascularization (Table 54). Implantation generally occurred midway down the horn of the uterus from the ovary. Generally an embryo developed in either horn with one or three implantations occasionally occurring. In multiple foetal development the embryos were never in only one horn.

There were only five instances of embryo resorption out of 193 pregnancies. All five resorptions occurred in multiple pregnancies, involved one embryo, and occurred in summer.

Placental scars are large and black immediately postpartum and are located on the medial side of the horn of the uterus. The duration of the scar is not known in *D. merriami* but is assumed to be approximately one year following parturation. The older the placental scar, the more difficult it is to detect as it becomes both lighter and smaller with age. Each trapping period had a high percentage of adults with placental scars; the fewest occurring in the last half of July, 1970 when 12% had scars. The high incidence of placental scars suggests a good carry-over of individuals each year, concurring with the findings of Chew and Butterworth (1964).

Table 53. Ovarian dimensions (mm) of 2,240 adult females representing the six species of desert rodents studied at the Silverbell Biome site *

Species		Non-reproductive	Estrus	Pregnant	Lactating
Dipodomys merriami	length	2.1±2.1(80)1.2-3.0	2.5±0.4(20)1.9-3.2	2.5±0.4(193)1.3-4.0	2.4±0.3(87)1.5-3.3
	width	1.3±0.3(80)0.7-1.9	1.8±0.5(20)1.1-2.5	1.8±0.3(193)0.9-2.5	1.6±0.3(87)1.0-2.7
Perognathus amplus	length	1.5±0.3(302)0.8-2.6	1.9±0.2(17)1.6-2.2	1.7±0.3(32)1.3-2.7	1.7±0.4(17)1.2-2.5
	width	1.0±0.3(302)0.6-1.8	1.4±0.2(17)1.2-1.9	1.3±0.3(32)0.8-2.0	1.2±0.4(17)0.7-2.2
Perognathus baileyi	length	1.9±0.4(86)1.0-2.9	2.5±0.3(4)2.2-2.8	2.6±0.4(16)1.7-3.2	2.2±0.4(9)1.6-2.7
	width	1.2±0.4(86)0.4-2.3	1.7±0.2(4)1.6-2.0	2.0±0.4(16)1.3-2.8	1.5±0.3(9)1.0-1.9
Peromyscus eremicus	length	1.9±0.5(43)1.0-3.1	2.2±0.2(2)2.0-2.3	2.3±0.7(72)1.0-4.0	2.2±0.6(25)1.5-3.9
	width	1.3±0.5(43)0.7-2.7	1.6±0.2(2)1.5-1.7	1.8±0.5(72)1.0-2.7	1.7±0.4(25)1.0-2.6
Perognathus intermedius	length	1.6±0.3(159)1.0-2.6	1.9±0.2(16)1.6-2.3	2.0±0.4(82)1.1-3.0	1.8±0.3(45)1.2-2.5
	width	1.1±0.2(159)0.6-1.9	1.3±0.2(16)1.0-1.6	1.5±0.3(82)0.8-2.2	1.3±0.4(45)0.6-2.8
Perognathus penicillatus	length	1.8±0.3(17)1.2-2.4		2.1±0.3(8)1.6-2.5	2.2±0.4(8)1.8-2.9
	width	1.2±0.3(17)0.7-1.6		1.6±0.4(8)1.1-2.4	1.6±0.4(8)1.1-2.5

* The mean number is given, followed by the standard deviation, the size of the sample (in parentheses), and the range (DSCODE A3UBE22).

Table 54. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Dipodomys merriami*—DSCODE A3UBE22

	Ovary						Uterus		
	Length			Width					
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	46	2.2	0.2	46	1.5	0.2	46	2.3	0.6
Jun 20	9	2.4	0.2	9	1.4	0.2	9	2.1	1.0
Jul 10	8	2.4	0.3	8	1.6	0.2	8	2.2	0.5
Jul 20	17	2.3	0.3	17	1.6	0.2	17	2.2	0.4
Aug 10	12	2.2	0.4	12	1.5	0.3	12	2.0	0.4
Aug 20	10	2.4	0.3	10	1.8	0.3	10	2.4	0.5
Sep	22	2.2	0.3	22	1.4	0.4	22	1.7	0.4
Oct	46	2.1	0.3	46	1.2	0.2	46	1.6	0.3
Nov	32	1.9	0.3	32	1.1	0.2	32	1.8	0.4
Dec	30	1.9	0.3	20	1.1	0.3	30	1.7	0.3
1971									
Jan	29	2.0	0.3	29	1.0	0.2	29	1.5	0.4
Feb	44	2.2	0.3	44	1.4	0.3	44	2.1	0.7
Mar	17	2.1	0.3	17	1.3	0.2	17	1.8	0.3
Apr	30	2.0	0.2	30	1.3	0.3	30	1.9	0.5
May	48	2.4	0.3	48	1.7	0.3	48	2.3	0.7
Jun 10	15	2.5	0.3	15	1.7	0.2	15	1.7	0.2
Jun 20	27	2.4	0.2	27	1.7	0.2	27	2.1	0.4
Jul 10	19	2.5	0.3	19	1.8	0.2	19	2.1	0.3
Jul 20	26	2.5	0.3	26	1.8	0.3	26	2.6	0.7
Aug 10	11	2.7	0.3	11	2.1	0.3	11	2.6	0.3
Aug 20	28	2.8	0.3	28	2.1	0.2	28	3.0	0.8
Sep	13	2.6	0.3	13	1.9	0.3	13	2.6	0.4
Oct	3	2.9	0.2	3	2.0	0.3	3	2.3	0.1
Nov	11	2.4	0.3	11	1.7	0.2	11	2.4	0.7
Dec	18	2.3	0.4	18	1.7	0.2	18	2.5	0.6
1972									
Jan	17	2.4	0.3	17	1.6	0.2	17	2.6	0.3
Feb	28	2.2	0.3	28	1.6	0.3	28	2.5	0.6
Mar	26	2.7	0.4	26	1.9	0.4	26	3.1	0.7
Apr	4	2.6	0.1	4	2.1	0.1	4	3.4	0.6
May	23	2.6	0.3	23	1.8	0.2	23	2.8	0.6
Total	669	2.3	0.4	669	1.5	0.4	669	2.2	0.7

D. merriami kangaroo rats may breed before reaching adult weight, especially if optimum environmental conditions prevail. Reynolds (1960) found several pregnant females in the fall which were about 70% of their mature weight. In this study, immature females were also found breeding, especially in autumn and when ideal conditions existed (i.e., presence of green annuals and continued rainfall). Young animals clearly breed within the year of their birth.

In southern Arizona, *D. merriami* is seasonally polyestrus. There were many instances of postpartum estrus in lactating females or females that were pregnant and also lactating. Reynolds (1960), Lidicker (1960), Chew and Butterworth (1964), and Bradley and Mauer (1971) have all found indications that female *D. merriami* are polyestrus throughout their range.

Litter sizes in *D. merriami* vary in different areas of its geographic range (Table 55). Seemingly, litter sizes are largest in localities where there are shortened breeding seasons. Litter sizes from pregnant females in the Silverbell study area averaged 2.03 (Table 55). Placental scars from females gave evidence of litter sizes of 2.00.

Table 55. Reported litter size in *Dipodomys merriami*

Litter size	Sample	Author	Location
2.02	133	Reynolds (1960)	Santa Rita Experimental Station, Pima Co., Arizona
2.03	193	Van De Graaff	Silverbell Biome Site, Pima Co., Arizona
2.10	9	Doran (1952)	San Bernardino Co., California
2.30	4	Eisenberg (1963)	Kern Co., California
2.60	163	Bradley and Mauer(1971)	Las Vegas, Nevada
2.67	127	Lidicker (1960)	Southwest Deserts (over entire range)
3.00	72	Hall (1946)	Nevada
3.10	32	Alcorn (1941)	Churchill Co., Nevada

Compared to other heteromyids, *D. merriami* seems to have lengthened their reproductive period with repeated litters and reduced their litter size (Eisenberg, 1963).

The reproductive performance of *D. merriami* in the first year contrasted with that of the second in the following ways: 1) There were two distinct peaks in the reproductive pattern; 2) activity intensities were lower as indicated by trapping percentages and 3) average body weights were lower. During the first year less greenery was available and was ingested and there was less rainfall.

Perognathus amplus

Male reproductive cycle: Males had a longer reproductive season than did females and a higher percentage of reproductive males were recorded. In *P. amplus* distinctive reproductive peaks were observed; the first year differing from that of the second.

Reproduction in the first year for *P. amplus* terminated by August, 1970. During the first half of June 1970, 87% of the adult males were reproductively active (Fig. 11). There was a rapid decline in fertile males from mid-June through July and by August no reproductive adult males were trapped. Following the late summer rains, a few of the adult males (5% in September and 18% in October) became reproductive although no females were found to be reproductive. Those male *P. amplus* trapped immediately prior to winter (November) inactivity had once again become reproductively dormant. Upon emergence from inactivity (April), the number of males that were fertile rapidly increased to 89% by May. Females did not show a corresponding increase in percent reproduction (Fig. 10), so apparently conditions necessary for reproduction did not occur.

The reproduction in the second year was strikingly different from that of the first. Whereas the males showed limited signs of reproduction during the summer months of the first year (Fig. 11) 100% of the adult males trapped from mid-June through August of the second year were reproductively active. The second summer was cooler and moister than the summer of the first year. With the onset of autumn and winter, the adult males repsonded as they did the first year with a gradual tapering off of reproductive activity prior to their winter's inactivity. *Perognathus amplus* did not remain dormant so long the second year, however, and virtually all of the adult males captured on the surface from January through May, 1972 were fertile.

Lengths of the various reproductive organs in adult male *P. amplus* were good indicators of reproductive activity (Figs. 24 and 25). Testicular dimensions, lengths of the caudal epididymis and seminal vesicles reflected the presence of spermatozoa and hence seasonal fertility.

In *P. amplus* a distinct correlation occurs between the size and shape of the bacula and age and presence of spermatozoa in the caudal epididymides (Fig. 19 and Table 36). The bacula of 15 juveniles averaged 4.85 mm in length; the bacula of 130 subadult males averaged 5.24 mm; those of 555 adult males averaged 6.63 mm. The shaft of the bacula of juveniles was straight with a sharp, terminal distal hook. The bacula of subadults also were characterized by straight shafts, but the distal hooks were not so prominent. The bacula of adults were more robust proximally and the shaft had more curvature. The distal portion, however, was similar to that of subadults. Bacula from 192 animals with large amounts of spermatozoa averaged 7.52 mm in length. This was 164 mm longer than bacula from 34 males with small amounts of spermatozoa present. Non-reproductive adult males had bacula that averaged only 5.74 mm which was 1.78 mm shorter than animals with large amounts of spermatozoa.

Female reproductive cycle: During the spring of the first year there was only one peak in reproduction in *P. amplus* (Fig. 26 and Table 56). One pregnant female was trapped during the last half of July, 1970, however, after the culmination of the main reproductive period. Rainfall was low the winter and spring of the first year and although some males became fertile in the spring, no reproductive females were trapped until the last half of August 1971.

Table 56. Summary of the reproductive cycles of *Perognathus amplus* based on 710 females (530 adults, 180 young) from June, 1970 through May 1972 DSCODE A3UBE22

	% Reproductive			% Non-reproductive	
Month	Estrus	Pregnant	Lactating	Adult	Young
1970					
Jun 10	0	12.43	4.32	18.92	64.33
Jun 20	4.76	0	4.76	47.62	42.86
Jul 10	0	0	0	72.22	27.78
Jul 20	0	4.76	0	66.97	28.57
Aug 10	0	0	0	91.18	8.82
Aug 20	0	0	0	77.78	22.22
Sep	0	0	0	90.00	10.00
Oct	0	0	0	100.00	0
Nov	0	0	0	100.00	0
Dec	--	--	--	--	--
1971					
Jan	--	--	--	--	--
Feb	--	--	--	--	--
Mar	--	--	--	--	--
Apr	0	0	0	100.00	0
May	0	0	0	77.78	22.22
Jun 10	0	0	2.08	91.67	6.25
Jun 20	0	0	0	97.56	2.44
Jul 10	0	0	2.50	92.50	5.00
Jul 20	0	0	0	93.33	6.67
Aug 10	0	0	0	100.00	0
Aug 20	15.63	18.75	6.25	49.99	9.38
Sep	0	0	14.29	85.70	0
Oct	0	0	16.67	50.00	33.33
Nov	0	0	0	77.78	22.22
Dec	0	0	0	100.00	0
1972					
Jan	--	--	--	--	--
Feb	0	0	0	100.00	0
Mar	45.00	5.00	0	50.00	0
Apr	0	0	0	100.00	0
May	33.33	16.67	16.67	0	33.33

Reproduction patterns in the second year differed from those of the first year; whereas a spring peak in reproduction was apparent during 1970, reproduction in 1971 came only after ample summer rains and the appearance of large amounts of green vegetation. Reproduction continued from the last half of August 1971 through September and October and then abruptly terminated with the onset of cold weather. In the spring of the second year reproduction again resumed in *P. amplus* following an abundant production of winter annuals.

Of 710 females examined, only 17 were in estrus. The low number of females trapped that were in estrus may be due to the relatively brief time of reproductive activity (Fig. 26). The duration of estrus for *P. amplus* has not been established but is probably not more than a few days; nor is the gestation period known for *P. amplus*.

Females in estrus had a significantly higher body weight (11.64 g) over adult, non-reproductive females (9.55 g). Conditions conducive for increased body weights (i.e., green vegetation) may also be a prerequisite for initiating estrus in females. Although vaginal plugs were not observed in *P. amplus*, presumably they do occur as they have been observed in other species of *Perognathus*.

Unlike *D. merriami*, the ovarian measurements of *P. amplus* could not be used as an indicator of reproductive activity because they did not seasonally change in size (Table 57). The condition of the ovaries did change with the production of ova, but no observations of these data were tabulated. The width of the uterus and the condition of placental scars were reliable indicators of reproductive activity in *P. amplus*.

The horns of the uteri in juvenile *P. amplus* resembled translucent threads and had a mean width of 0.52 mm. The uterine horns of subadults had a mean width of 0.63 mm and were no longer translucent but rather had a pale pinkish-white coloration. The uterine horns of non-fecund adult females were more pinkish in coloration and averaged 0.82 mm in width. Uterine horns of females in estrus became highly vascularized, had a deep red coloration, and were enlarged to a width of 1.67 mm.

The mean widths of the uterine horns of 126 pregnant females (1.26 mm) and of 17 lactating females (1.40 mm) were not as great as those females in estrus.

No cases of reabsorption of embryos in *P. amplus* were observed, suggesting that reproduction only occurred in prime females during optimal environmental conditions.

Table 57. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Perognathus amplus*—DSCODE A3UBE22

	Ovary						Uterus		
		Length			Width				
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	66	1.5	0.3	66	1.0	0.2	66	1.9	0.4
Jun 20	12	1.7	0.4	12	1.2	0.3	12	1.4	0.3
Jul 10	26	1.4	0.2	26	1.0	0.2	26	1.1	0.3
Jul 20	15	1.5	0.2	15	1.0	0.1	15	1.3	0.3
Aug 10	62	1.4	0.2	62	0.9	0.1	62	1.1	0.2
Aug 20	14	1.4	0.2	14	0.9	0.1	14	1.2	0.1
Sep	36	1.3	0.2	36	0.8	0.1	36	0.8	0.2
Oct	7	1.4	0.2	7	0.9	0.2	7	0.9	0.2
Nov	1	0.9	0	1	0.9	0	1	1.0	0
Dec	0	--	--	0	--	--	0	--	--
1971									
Jan	0	--	--	0	--	--	0	--	--
Feb	0	--	--	0	--	--	0	--	--
Mar	0	--	--	0	--	--	0	--	--
Apr	9	1.5	0.2	9	1.0	0.2	9	1.1	0.2
May	7	1.7	0.1	7	1.3	0.1	7	1.2	0.2
Jun 10	45	1.8	0.2	45	1.3	0.1	45	1.3	0.1
Jun 20	40	1.7	0.2	40	1.3	0.2	40	1.3	0.2
Jul 10	38	1.7	0.2	38	1.2	0.2	38	1.3	0.3
Jul 20	42	1.3	0.2	42	0.9	0.2	42	0.9	0.2
Aug 10	23	1.9	0.2	23	1.5	0.1	23	1.4	0.3
Aug 20	29	1.9	0.3	29	1.5	0.2	29	1.5	0.3
Sep	7	1.6	0.1	7	1.1	0.1	7	1.5	0.3
Oct	8	1.7	0.2	8	1.4	0.3	8	1.5	0.2
Nov	7	1.5	0.2	7	1.1	0.2	7	1.0	0.1
Dec	1	1.2	0	1	0.8	0	1	1.1	0
1972									
Jan	0	--	--	0	--	--	0	--	--
Feb	1	1.9	0	1	1.3	0	1	1.0	0
Mar	20	1.9	0.8	20	1.4	0.2	20	1.7	0.3
Apr	10	2.0	0.3	10	1.5	0.3	10	1.7	0.3
May	4	1.9	0.3	4	1.6	0.2	4	1.6	0.3
Total	530	1.6	0.3	530	1.1	0.3	530	1.3	0.4

Placental scars were recorded in 195 females and averaged 4.15 per female (Table 58). There were only two instances of pregnant females having recent placental scars, both occurring in September 1971. *Perognathus amplus* usually has one litter per season, but some individuals were observed to be polyestrus.

Table 58. Breeding Characteristics of adult female *Perognathus amplus*—DSCODE A3UBE22

		Gravid				Postpartum			
Month	Sample Size No.	No.	%	Weight Mean±S.D.	Embryos Mean±S.D.	No.	%	Weight Mean±S.D.	Placental Scars Mean±S.D.
1970									
Jun 10	66	23	35	13.4±1.3	4.3±0.5	22	33	12.7±1.4	4.2±0.5
Jun 20	12	0	0			5	42	13.5±1.3	4.2±0.5
Jul 10	26	0	0			4	15	11.0±1.6	4.3±0.5
Jul 20	15	1	7	10.6	3.0	4	27	10.6±1.3	4.0±0.8
Aug 10	62	0	0			12	19	10.8±0.8	4.1±0.5
Aug 20	14	0	0			4	29	11.3±2.1	4.0
Sep	36	0	0			9	25	11.6±1.6	4.9±1.1
Oct	7	0	0			2	29	9.4±1.4	5.0
Nov	1	0	0			1	100	10.9	4.0
Dec									
1971									
Jan									
Feb									
Mar									
Apr	9	0	0			2	22	8.9±1.1	4.5±0.7
May	7	0	0			3	43	9.3±0.8	4.3±0.6
Jun 10	45	0	0			12	27	9.7±1.1	4.2±0.6
Jun 20	40	0	0			17	43	9.9±1.1	3.9±0.9
Jul 10	38	0	0			17	45	10.8±1.2	3.9±0.8
Jul 20	42	0	0			14	33	11.5±1.3	4.3±0.9
Aug 10	23	0	0			9	39	12.6±2.1	4.2±0.7
Aug 20	29	6	21	12.7±1.9	4.0±0.6	8	28	11.5±1.3	4.0±0.5
Sep	7	0	0			4	57	13.1±2.2	4.3±0.5
Oct	8	0	0			3	38	15.3±3.5	4.3±0.6
Nov	7	0	0			0	0		
Dec	1	0	0			0	0		
1972									
Jan									
Feb	1	0	0			0	0		
Mar	20	1	5	13.2	5.0	5	25	12.0±1.6	3.8±0.5
Apr	10	0	0			5	50	12.4±1.5	3.8±0.5
May	4	1	25	11.2	3.0	0	0		
Total	530	32	6	13.1±1.5	4.2±0.6	162	31	11.4±1.8	4.2±0.7

Perognathus baileyi

Male reproductive cycle: Males had a longer breeding period than the females and a larger percentage of males than females were reproductive during the reproductive period. These periods of greatest sexual activity were concurrent with new vegetative growth; Reynolds and Haskel (1949) found a similar pattern in southern Arizona.

Data gathered during the first year indicated a breeding period in late spring (as shown by young animals and postpartum females). All of the adult males trapped in June 1970 were fertile. During the continued aridity and hot weather in July, fertility in males rapidly declined. A second breeding peak occurred in August, following summer rains. From this reproductive peak, percentages of fecund males gradually declined through the remainder of the autumn (Fig. 13). Most males were fecund from February through May even though no reproductive females were observed during that same period.

In the second year, in contrast to the first, nearly all of the adult males examined were fertile. Only during December of 1971 were some adult males taken that were not reproductively active.

Bacula from *P. baileyi* were examined for changes associated with age and with reproductive status (Fig. 19). Bacula of four juveniles averaged 8.10 mm in length; they were poorly ossified, and had a straight shaft with only a slight distal hook. Bacula from 30 subadults averaged 8.66 mm in length. Although they were only slightly longer than those of juveniles, they were thicker and had a distinct angle on the tip. The bacula of adults were characterized by their long, thin shape with only a slight hook at the end. Bacula of *P. baileyi* differ markedly from the bacula of the other heteromyids studied.

As in the other heteromyids examined, males with large numbers of spermatozoa had long bacula. The bacula of non-breeding adults averaged 9.26 mm in length as compared to 10.29 mm in individuals with small amounts of spermatozoa, 11.05 mm in adults with moderate amounts, and 11.11 mm in individuals with large amounts. Certainly there is not a regression in the size of the bacula after culmination of breeding, but apparently selective forces favor longer bacula in males that are sexually mature.

Other male reproductive organs also show a linear size increase with age and fecundity. The mean length of testes in juveniles was 4.23 mm; in subadults it was 4.27 mm; in reproductive adults with small amounts of spermatozoa, the length of testes averaged 5.30 mm; and in males having large amounts of spermatozoa, the length of testes averaged 7.08 mm.

There was a definite seasonal pattern of change in testicular size (Fig. 27). The testes in *P. baileyi* decreased in size during late summer and early autumn of both years, but in the second year the testes of adult males were consistently larger than they were in the first year. A similar pattern was apparent with the seminal vesicles and caudal epididymis (Fig. 28).

Female reproductive cycle: Reproduction in *P. baileyi* from southern Arizona varies with weather patterns. Reynolds and Haskell (1949) reported a peak in reproductive activity in the late spring for *P. baileyi*, with reproduction diminishing through June and July, but gaining impetus again in August following summer rains. Reproduction in the first year of our study showed a similar trend, with reproduction being most intense in the late spring, diminishing during the hottest and driest portion of the summer, and then a few females becoming active again following summer rains (Fig. 29).

Reproduction in the second year was delayed until late summer (July and August), presumably due to scarcity of rain and the resulting delay in the germination of annual vegetation. By spring of the second year (March, April and May, 1972), females were again reproductive. Considering the normal pattern of rainfall, reproduction in late spring for *P. baileyi* is probably the usual pattern.

The samples included few females in reproductive condition; of those examined, only four were in estrus, 16 were pregnant, and nine were lactating (Table 59). These 29 breeding females represented 12.13% of the female population and 13.74% of the adult female population. The small percentage of *P. baileyi* females in reproductive condition suggests low population turnovers and long individual life spans.

Although few reproductive females were examined, changes in the sizes of reproductive organs were noted. One juvenile was found to have a width of the uterine horn of 0.95 mm with other features of the reproductive tract typical of heteromyids (as described for *P. intermedius*). The uterine horn of 27 subadults averaged 0.87 mm in width. Females in estrus had an average uterine horn width of 1.96 mm. This is over a full mm wider than non-reproductive adults. Sixteen pregnant females had a mean uterine horn width of 2.45 mm and nine lactating females, 1.83 mm. Changes in the dimensions of the ovaries for various stages of reproductive females were not so drastic as changes in the uterine horns (Table 60).

The mean number of placental scars in females was only slightly higher than the mean number of embryos in pregnant females (3.57 vs. 3.50) (Table 61). One subadult female was observed with two recent placental scars, indicating breeding in some subadults. There was no evidence that *P. baileyi* was seasonally polyestrus.

Table 59. Summary of the reproductive cycles of *Perognathus baileyi* based on 239 females (211 adults, 28 young) from June 1970 through May, 1972 DSCODE A3UBE22

Month	Estrus	% Reproductive Pregnant	Lactating	% Non-reproductive Adult	Young
1970					
Jun 10	0	36.37	0	36.36	27.27
Jun 20	0	9.09	22.73	45.45	22.73
Jul 10	0	0	0	50.00	50.00
Jul 20	0	0	5.26	68.42	26.32
Aug 10	0	0	0	66.67	33.33
Aug 20	0	0	0	66.67	33.33
Sep	2.50	0	0	90.00	7.50
Oct	0	0	0	100.00	0
Nov	0	0	0	93.75	6.25
Dec	0	0	0	100.00	0
1971					
Jan	0	0	0	100.00	0
Feb	0	0	0	100.00	0
Mar	--	--	--	--	--
Apr	0	0	0	100.00	0
May	0	0	0	100.00	0
Jun 10	0	0	0	100.00	0
Jun 20	--	--	--	--	--
Jul 10	20.00	10.00	0	60.00	10.00
Jul 20	0	25.00	50.00	25.00	0
Aug 10	0	28.00	0	57.71	14.29
Aug 20	33.33	33.33	0	33.34	0
Sep	0	0	0	100.00	0
Oct	0	0	0	100.00	0
Nov	0	0	0	77.78	22.22
Dec		0	0	100.00	0
1972					
Jan	--	--	--	--	--
Feb	0	0	0	100.00	0
Mar	0	66.67	0	33.33	0
Apr	--	--	--	--	--
May	0	33.33	33.33	0	33.34

Table 60. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Perognathus baileyi*—DSCODE A3UBE22

	Ovary						Uterus		
		Length			Width				
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	8	2.1	0.5	8	1.5	0.4	8	2.0	0.9
Jun 20	17	2.1	0.3	17	1.5	0.2	17	2.1	0.5
Jul 10	1	2.2	0	1	1.6	0	1	1.6	0
Jul 20	14	1.9	0.4	14	1.4	0.3	14	1.8	0.3
Aug 10	10	2.1	0.2	10	1.3	0.2	10	1.4	0.4
Aug 20	4	2.0	0.3	4	1.2	0.1	4	1.4	0.3
Sep	37	1.8	0.3	37	1.1	0.3	37	1.2	0.3
Oct	29	1.8	0.3	29	1.0	0.2	29	1.3	0.3
Nov	15	1.8	0.2	15	1.0	0.2	15	1.3	0.4
Dec	8	1.7	0.1	8	0.9	0.2	8	1.0	0.3
1971									
Jan	1	1.7	0	1	1.0	0	1	1.3	0
Feb	1	2.0	0	1	1.4	0	1	2.7	0
Mar	0	--	--	0	--	--	0	--	--
Apr	2	2.0	0.2	2	1.1	0.1	2	1.6	0.1
May	5	2.3	0.3	5	1.8	0.3	5	1.7	0.4
Jun 10	6	2.1	0.1	6	1.6	0.1	6	1.5	0.3
Jun 20	0	--	--	0	--	--	0	--	--
Jul 10	9	2.4	0.2	9	1.8	0.2	9	1.9	0.4
Jul 20	4	2.3	0.5	4	1.6	0.4	4	2.0	0.3
Aug 10	6	2.6	0.3	6	2.3	0.3	6	2.4	0.9
Aug 20	3	2.7	0.5	3	1.9	0.2	3	2.4	0.4
Sep	5	2.2	0.2	5	1.6	0.2	5	2.1	0.7
Oct	6	2.3	0.2	6	1.6	0.2	6	1.6	0.2
Nov	0	--	--	0	--	--	0	--	--
Dec	4	1.8	0.4	4	1.4	0.3	4	1.5	0.5
1972									
Jan	0	--	--	0	--	--	0	--	--
Feb	8	2.2	0.5	8	1.6	0.4	8	1.7	0.4
Mar	6	2.6	0.4	6	1.9	0.4	6	2.6	0.9
Apr	0	--	--	0	--	--	0	--	--
May	2	2.8	0.1	2	2.1	0.3	2	2.3	0.1
Total	211	2.0	0.4	211	1.3	0.4	211	1.6	0.6

Table 61. Breeding characteristics of adult female *Perognathus baileyi*---DSCODE A3UBE22

Month	Sample Size No.	Gravid No.	Gravid %	Gravid Weight Mean S.D.	Gravid Embryos Mean S.D.	Postpartum No.	Postpartum %	Postpartum Weight Mean S.D.	Postpartum Placental Scars Mean S.D.
1970									
Jun 10	8	4	50	28.8±2.5	3.8±0.5	4	50	27.5±1.6	3.8±0.5
Jun 20	17	2	12	24.9±5.5	2.5±0.7	9	53	26.4±3.1	3.3±0.7
Jul 10	1	0	0			1	100	30.0	2.0
Jul 20	14	0	0			10	71	25.9±2.9	3.3±0.8
Aug 10	10	0	0			5	50	23.8±4.0	2.8±0.8
Aug 20	4	0	0			1	25	29.0	3.0
Sep	37	0	0			15	41	27.5±3.5	4.2±0.7
Oct	29	0	0			17	59	24.6±2.5	4.2±1.4
Nov	15	0	0			6	40	23.2±2.5	3.5±0.6
Dec	8	0	0			2	25	25.5±3.5	3.0
1971									
Jan	1	0	0			1	100	20.4	4.0
Feb	1	0	0			0	0		
Mar									
Apr	2	0	0			2	100	22.2±0.6	4.0
May	5	0	0			2	40	26.5±0.7	3.5±0.7
Jun 10	6	0	0			3	50	21.9±3.3	2.3±1.2
Jun 20									
Jul 10	9	1	11	22.4	3.0	3	33	22.9±2.0	3.0±1.0
Jul 20	4	1	25	28.8	3.0	1	25	28.2	4.0
Aug 10	6	2	33	29.1±2.2	4.0	3	50	24.2±1.7	4.0±1.0
Aug 20	3	1	33	30.5	5.0	0	0		
Sep	5	0	0			5	100	24.4±4.4	2.8±0.5
Oct	6	0	0			2	33	26.7±3.0	3.0
Nov									
Dec	4	0	0			0	0		
1972									
Jan									
Feb	8	0	0			2	25	23.9±1.8	3.5±0.7
Mar	6	4	67	30.0±4.0	3.0	2	33	27.9±5.4	3.0
Apr									
May	2	1	50	25.9	5.0	0	0		
Total	211	16	8	28.4±3.5	3.5±0.8	96	46	25.4±3.3	3.6±1.0

Perognathus intermedius

Male reproductive cycle: As in the other heteromyids, *P. intermedius* males had a greater percentage that were fertile and a larger period of reproduction than did the females (Figs. 14 and 15).

All of the adult males taken in June, 1970 were reproductive but throughout the remainder of this summer there was a gradual decline in the percentage of males with spermatozoa in the caudal epididymis and only 10% of the males taken in August were reproductively active. With the occurrence of late summer rains (Fig. 15), however, more males became reproductively active. By November, 1970, immediately prior to the dormant period of *P. intermedius*, one of four animals taken was reproductive. *Perognathus intermedius* was not trapped during the coldest winter months (December, January and February), but upon emergence in March, 1971, 38% of eight adult males taken had spermatozoa in their caudal epididymis. The percentage of males considered reproductively active increased each month throughout the spring and by May, 1971, all of the adult males were potentially reproductive.

Reproduction in the second year was unlike that of the first; whereas during the first year the number of reproductive males had a linear decline during the summer, during the second summer there was a sharp rebound in the number of fertile males following intense summer rains. The majority of adult males in the population were fertile from June, 1971 through October, 1971 (Fig. 15). Although *P. intermedius* did not completely suspend surface activity during the second year, the number of fertile males during the coldest winter months (November, December and January) markedly declined. With the warmer spring weather from February through May, 1972, all of the adult males were in reproductive condition. This was also in contrast to the spring of the first year and was perhaps in response to the increased rainfall and available food during the second year.

Changes in the length and shape of the bacula occurred in male *P. intermedius* as animals matured (Table 41). The bacula of juvenile animals averaged 7.79 mm in length, with shafts having a gradual curvature, terminating distally in sharp hooks. The bacula of subadults had a mean length of 8.80 mm with the shaft generally straight and the distal hook not so prominent as in the juveniles (Fig. 19).

The bacula of adults were more robust proximally than those of subadults and the shaft had more flexure with a more pronounced hook on the distal tip. The overall contour was similar regardless of the breeding condition of the male, but the lengths were considerably different. There was positive correlation between the length of the bacula and the amount of spermatozoa observed in the caudal epididymis. A cartilaginous-like penial extension, as described for *Dipodomys merriami*, was also present in some of the male *P. intermedius* that had large amounts of spermatozoa in their reproductive organs. Bacula from animals with large amounts of spermatozoa averaged 12.18 mm, whereas those with moderate amounts of spermatozoa averaged 11.91 mm. Likewise, adult males with small amounts of spermatozoa had an average bacula length of 11.59 mm as compared to adult males with no spermatozoa that had bacula lengths of 10.04 mm.

The mean lengths of the fleshy reproductive organs (testes, seminal vesicles and caudal epididymes) increased in size during periods of reproduction; measurements of these organs are useful indicators of reproductive peaks. These organs were small during the winter months and larger from February through July (Figs. 30 and 31). It is interesting to note that the period in which the males were fertile exceeded by several months the fertile period in the females. This presumably insures fertilization of the recipient female.

Female reproductive cycle: Reproduction during the first year was confined to a succinct late spring and early summer period. During the first trapping period (June 10, 1970), 71% of the females were fertile, indicating a peak of reproduction in late spring (Fig. 32). Reproduction gradually tapered off during the remainder of the summer and had ended by the last half of August. No fertile females were taken again until May, 1971, at which time only 9% of the females trapped were reproductive.

The temporal pattern of reproduction in the second year for *P. intermedius*, as in the other heteromyids studied, was very different than that of the first year (Table 62 and Fig. 32). There was not a clear peak in reproduction in late spring as there was the previous year. Following heavy summer rains, however, reproductive activity increased, with the peak of 86% of the adult female population being reproductive the last half of August, 1971. By this same period in 1970 reproduction had ended for the year. The entire population of *P. intermedius* did not suspend surface activity during the second winter as it had the first, but even while maintaining surface activity, no fertile females were taken from October through February. Apparently conditions were once again favorable for reproduction in spring 1972, as in March over half of the females were in reproductive condition.

Sixteen females (2.49%) from a total of 642 examined were determined to be in estrus (Table 63). The duration of estrus is not known for *P. intermedius*. Females in estrus had an increase in body weight to a mean of 12.27 g over 159 non-reproductive adult females whose mean body weight was 11.59 g. Vaginal plugs were not observed in *P. intermedius* but were presumed to occur as they are present in other heteromyid species (Wilken and Ostwald, 1968).

Because of their underdeveloped state, embryos were measured *in vitro* until they obtained a rump-crown length of approximately 12.05 mm. Embryos near parturition had rump-crown lengths of approximately 14.00 mm and apparently were born in a more precocial state than were fetuses of *Dipodomys merriami* (Van De Graaff, 1973). The gestation period in *P. intermedius* was determined by Svihla (1932) to be approximately 21 days.

Table 62 Breeding characteristics of adult female *Perognathus intermedius* DSCODE A3UBE22

Month	Sample Size No.	Gravid No.	Gravid %	Gravid Weight Mean±S.D.	Gravid Embryos Mean±S.D.	Postpartum No.	Postpartum %	Postpartum Weight Mean±S.D.	Placental Scars Mean±S.D.
1970									
Jun 10	49	19	39	14.6±2.1	3.5±0.6	13	27	13.9±2.5	3.7±0.8
Jun 20	38	13	34	14.7±2.5	3.5±0.7	19	50	12.8±1.0	3.5±0.9
Jul 10	17	2	12	15.5±4.9	3.0	13	76	12.5±1.2	3.6±0.7
Jul 20	29	2	7	18.3±0.4	4.0	23	79	12.7±1.4	3.7±0.7
Aug 10	29	1	3	15.4	2.0	19	66	12.3±1.2	3.4±0.7
Aug 20	34	0	0			19	56	12.2±1.1	3.3±0.8
Sep	30	0	0			13	43	14.1±1.8	4.2±0.8
Oct	12	0	0			6	50	11.9±0.8	3.3±1.2
Nov	2	0	0			0	0		
Dec									
1971									
Jan									
Feb									
Mar	3	0	0			2	67	10.0	3.0±1.4
Apr	7	0	0			1	14	10.0	4.0
May	11	0	0			6	55	11.2±0.7	3.0±1.3
Jun 10	18	6	33	12.6±1.3	2.3±0.5	6	33	12.0±1.0	3.5±0.6
Jun 20	42	1	2	14.3	2.0	20	48	11.9±1.1	3.4±0.7
Jul 10	31	3	10	14.7±2.2	2.7±0.6	15	48	11.4±1.3	3.3±0.8
Jul 20	40	1	3	13.6	3.0	18	45	12.3±1.1	3.3±0.8
Aug 10	8	4	50	16.7±2.7	4.0±1.4	2	25	11.2	3.0±1.4
Aug 20	22	14	64	14.2±1.6	3.6±0.7	2	9	12.9±0.9	3.0
Sep	23	1	4	16.8	4.0	14	61	13.0±0.9	3.2±0.7
Oct	14	0	0			8	57	12.6±0.9	3.6±0.9
Nov	16	0	0			8	50	11.9±0.7	3.5±0.5
Dec	10	0	0			3	30	13.8±1.1	3.7±0.6
1972									
Jan	11	0	0			2	18	9.7±1.7	3.0±1.4
Feb	7	0	0			0	0		
Mar	15	5	33	14.9±1.6	3.4±0.6	2	13	14.0±1.7	4.0
Apr	31	8	26	15.7±2.1	2.9±0.8	17	55	13.6±1.3	3.1±0.7
May	11	2	18	15.1±1.9	3.0	7	64	12.5±1.3	2.9±0.9
Total	560	82	15	14.8±2.2	3.3±0.8	258	46	12.7±1.6	3.4±0.8

A slight trend in size fluctuation of the ovary occurred as the females went through a breeding cycle (Table 64). An analysis of the females of various reproductive categories (i.e., estrus, pregnant, lactating, etc.) and age groups (i.e., juvenile, subadult, adult) yields some revealing comparisons (Tables 63 and 64). Young females had smaller ovaries of light pink coloration. Sixteen females in estrus had ovaries that averaged .26 mm longer and .13 mm wider than non-reproductive adults. The ovarian dimension increased slightly in pregnant females but then the ovarian size stabilized in postpartum females.

Table 63. Summary of the reproductive cycles of *Perognathus intermedius* based on 632 females (560 adults, 72 young) from June 1970 through May, 1972 DSCODE——A3UBE22

	% Reproductive			% Non-reproductive	
Month	Estrus	Pregnant	Lactating	Adult	Young
1970					
Jun 10	0	31.15	26.23	22.94	19.68
Jun 20	0	22.81	8.77	35.09	33.33
Jul 10	0	6.67	0	49.99	43.34
Jul 20	0	5.88	0	79.41	14.71
Aug 10	0	2.78	0	77.77	19.45
Aug 20	0	0	0	94.44	5.56
Sep	0	0	0	93.75	6.25
Oct	0	0	0	100.00	0
Nov	0	0	0	100.00	0
Dec	--	--	--	--	--
1971					
Jan	--	--	--	--	--
Feb	--	--	--	--	--
Mar	0	0	0	100.00	0
Apr	0	0	0	100.00	0
May	9.09	0	0	90.91	0
Jun 10	0	33.33	11.11	55.56	0
Jun 20	4.76	2.38	4.76	88.10	0
Jul 10	0	7.14	9.52	57.15	26.19
Jul 20	14.29	2.38	7.14	71.43	4.76
Aug 10	0	50.00	0	50.00	0
Aug 20	8.00	56.00	12.00	12.00	12.00
Sep	0	4.17	16.67	74.99	4.17
Oct	0	0	0	87.50	12.50
Nov	0	0	0	94.12	5.88
Dec	0	0	0	100.00	0
1972					
Jan	0	0	0	84.62	15.38
Feb	0	0	0	100.00	0
Mar	20.00	33.33	0	46.67	0
Apr	6.45	25.81	12.90	54.84	0
May	0	18.18	18.18	63.64	0

Table 64. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Perognathus intermedius*—DSCODE A3UBE22

	Ovary						Uterus		
	Length			Width					
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	49	1.6	0.3	49	1.1	0.2	49	1.8	0.5
Jun 20	38	1.7	0.4	38	1.1	0.3	38	1.8	0.5
Jul 10	17	1.7	0.3	17	1.2	0.2	17	1.5	0.3
Jul 20	29	1.6	0.2	29	1.1	0.2	29	1.6	0.5
Aug 10	29	1.5	0.2	29	1.0	0.2	29	1.4	0.4
Aug 20	34	1.5	0.2	34	1.0	0.2	34	1.3	0.3
Sep	30	1.5	0.2	30	0.9	0.2	30	1.0	0.3
Oct	12	1.4	0.2	12	0.9	0.1	12	1.1	0.3
Nov	2	1.2	0.3	2	0.9	0.1	2	0.9	0.1
Dec	0	--	--	0	--	--	0	--	--
1971									
Jan	0	--	--	0	--	--	0	--	--
Feb	0	--	--	0	--	--	0	--	--
Mar	3	1.7	0.4	3	1.0	0	3	1.2	0.3
Apr	7	1.6	0.2	7	1.1	0.1	7	1.3	0.4
May	11	2.0	0.3	11	1.6	0.2	11	1.4	0.2
Jun 10	18	2.0	0.3	18	1.5	0.2	18	1.9	0.5
Jun 20	42	1.8	0.2	42	1.4	0.2	42	1.6	0.4
Jul 10	31	1.9	0.3	31	1.5	0.2	31	1.7	0.5
Jul 20	40	1.6	0.3	40	1.1	0.2	40	1.5	0.4
Aug 10	8	2.2	0.5	8	1.7	0.3	8	2.2	0.6
Aug 20	22	2.3	0.2	22	1.8	0.3	22	2.2	0.4
Sep	23	1.9	0.2	23	1.4	0.2	23	1.8	0.4
Oct	14	1.8	0.2	14	1.3	0.1	14	1.6	0.2
Nov	16	1.6	0.2	16	1.0	0.2	16	1.2	0.3
Dec	10	1.9	0.2	10	1.3	0.2	10	1.4	0.2
1972									
Jan	11	1.6	0.2	11	1.2	0.2	11	1.0	0.2
Feb	7	1.7	0.1	7	1.3	0.1	7	1.1	0.1
Mar	15	2.0	0.3	15	1.4	0.2	15	1.8	0.4
Apr	31	2.0	0.2	31	1.6	0.2	31	2.4	0.6
May	11	2.1	0.2	11	1.5	0.2	11	2.0	0.5
Total	560	1.7	0.3	560	1.2	0.3	560	1.0	0.5

The horns of the uteri are good indicators of reproductive activity. As in other species of *Perognathus* the uterine horns of juveniles were thin ($\bar{X}$=0.78 mm), translucent and a pinkish-white color. Uterine horns of subadults were thicker ($\bar{X}$=0.88 mm) and not so translucent. The uterine horns of non-fecund females averaged 0.95 mm in width and were a definite pinkish color. Females that were in estrus hadreddish-colored, vascularized uterine horns that were enlarged to an average of 1.78 mm. Pregnant females had the widest uterine horns ($\bar{X}$=1.87 mm). The uterine horns of postpartum females in a lactating condition were greatly distended and darkened with no centralized placental scar yet visible.

Perognathus penicillatus

Male reproductive cycle: Fertile males were trapped in each of the summer months from June through September during the first year. The peak in male fecundity during the first summer appeared to be in June, 1970 when over 95% of the males examined were reproductive. From September, 1970 until April, 1971, there were no fertile males trapped.

There was a higher percentage of fertile males in the second year than the first (Fig. 33). During each of the six trapping periods of the second summer (except August, 20), all of the males were found to be fertile. Percentage of fertile males decreased towards the end of August and continued to decline through October, 1971. From November, 1971 through April, 1972, no fertile males were sampled. The increased fertility during the second year was presumably associated with increased rainfall and subsequent vegetation.

Burt (1936) examined the bacula of three specimens of the subspecies of *P. penicillatus* with which we were working. He found the mean length to be 12.58 mm and described the bacula as having a roughly sigmoid curvature when viewed laterally. Bacula of both juveniles and subadults examined in this study lacked the sigmoid appearance that is characteristic of adult males. The bacula of young animals had extensive dorsal curvature, giving it an inverted J-shaped appearance. Three bacula from juveniles averaged 7.65 mm in length and bacula from 14 subadults averaged 9.01 mm.

Of the six species studied, adult *P. penicillatus* had the longest baculum and as in the other heteromyids there was a correlation between fertility and the length of the baculum. Measurements were made on bacula of 90 adult males. Bacula from animals with large amounts of spermatozoa had a mean length of 12.47 mm. This was only a slight increase in length over 17 specimens with moderate amounts of spermatozoa present ($\bar{X}$=12.11 mm). There was an increase, however, in the mean bacula lengths over 13 individuals with small amounts of spermatozoa present ($\bar{X}$=11.46 mm) and over 19 non-fecund adult males ($\bar{X}$=10.03 mm).

Testicular dimensions of *P. penicillatus* differed seasonally. In the first year, the average length of the testes was 6.60 mm during the first trapping period. From this length (6.60 mm), the mean testicular length gradually decreased and just before the animals went into dormancy, the mean testes length was 3.93 mm. By the time specimens were trapped again following emergence in spring, the mean testicular length was already 6.15 mm. The length of the testes remained high through the second summer and did not appear to atrophy until November, 1971.

Female reproductive cycle: The data showed female *P. penicillatus* to have two reproductive peaks during the first year; there was a late spring and early summer peak that terminated by mid-June and a less intensive peak in September following summer rains (Fig. 18). No reproductive females were trapped from October through May of the first year, even though reproductive males were trapped during the same period. Burt and Grossenheider (1964) listed the breeding season for *P. pennicillatus* as April through September.

The breeding season of the second year was longer than that of the first and a greater percentage of the females were reproductive (Fig. 18). Reproductive females were continuously trapped from June through October, 1971. Apparently conditions of the second year were very favorable for reproduction in rodents (Table 65).

Vaginal plugs which were obtained from three metestral females (Fig. 19) averaged 10.55 mm in length. They were thickest distally and tapered proximally to a bulb-like enlargement that presumably blocked the cervix. Extending into the uterus from the bulb-like enlargement were several short strands of cartilage-like material.

Wilken and Ostwald (1968) have described copulation and associated events in *P. penicillatus*, and state that estrus lasts only a few hours and that the period of gestation is 23 days.

The lengths of the ovary in various age and reproductive categories of females did not reveal any significant changes as the animals matured or the seasons changed. The coloration and texture of the reproductive organs at various ages are similar to those previously described for other *Perognathus* species (Tables 65 and 66).

The mean litter size of eight pregnant females was 3.38 and evidences from placental scars from 34 females indicated mean litter sizes of 3.53. Ten litters from laboratory animals had a mean litter size of 4.9, with a range of three to seven (Wilden and Ostwald, 1968). The greatest number of placental scars or embryos from 42 female *P. penicillatus* in this study was five, suggesting that litters from laboratory animals may be abnormally large due to atypical environmental conditions.

Table 65. Summary of the reproductive cycles of *Perognathus penicillatus* based on 80 females (67 adults, 13 young) from June 1970 through May 1972 DSCODE——A3UBE22

Month	% Reproductive			% Non-reproductive	
	Estrus	Pregnant	Lactating	Adult	Young
1970					
Jun 10	0	28.57	28.57	42.86	0
Jun 20	0	0	0	0	100.00*
Jul 10	--	--	--	--	--
Jul 20	0	0	0	66.67	33.33
Aug 10	0	0	0	100.00	0
Aug 20	0	0	0	100.00	0
Sep	0	9.09	0	81.82	9.09
Oct	0	0	0	100.00	0
Nov	--	--	--	--	--
Dec	--	--	--	--	--
1971					
Jan	0	0	0	100.00	0
Feb	--	--	--	--	--
Mar	--	--	--	--	--
Apr	--	--	--	--	--
May	0	0	0	100.00	0
Jun 10	0	33.33	0	66.67	0
Jun 20	0	11.11	22.22	66.67	0
Jul 10	0	50.00	0	50.00	0
Jul 20	0	0	25.00	75.00	0
Aug 10	0	0	25.00	25.00	50.00
Aug 20	0	0	33.33	0	66.67
Sep	0	11.11	0	66.67	22.22
Oct	0	0	16.67	66.66	16.67
Nov	--	--	--	--	--
Dec	0	0	0	0	100.00*
1972					
Jan	--	--	--	--	--
Feb	--	--	--	--	--
Mar	--	--	--	--	--
Apr	--	--	--	--	--
May	0	0	0	66.67	33.33

*Small sample size

Table 66. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Perognathus penicillatus*—DSCODE A3UBE22

		Ovary					Uterus		
		Length			Width				
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	7	1.8	0.3	7	1.3	0.3	7	2.3	0.9
Jun 20	0	--	--	0	--	--	0	--	--
Jul 10	0	--	--	0	--	--	0	--	--
Jul 20	2	1.8	0.3	2	1.3	0.1	2	1.5	0.6
Aug 10	3	2.0	0.2	3	1.4	0.1	3	1.8	0.7
Aug 20	1	1.6	0	1	1.0	0	1	1.5	0
Sep	10	1.7	0.3	10	1.1	0.3	10	1.2	0.4
Oct	3	1.8	0.2	3	1.0	0.1	3	1.1	0.1
Nov	0	--	--	0	--	--	0	--	--
Dec	0	--	--	0	--	--	0	--	--
1971									
Jan	1	2.0	0	1	1.1	0	1	1.0	0
Feb	0	--	--	0	--	--	0	--	--
Mar	0	--	--	0	--	--	0	--	--
Apr	0	--	--	0	--	--	0	--	--
May	1	2.1	0	1	1.4	0	1	1.9	0
Jun 10	3	2.0	0.3	3	1.5	0.1	3	2.1	0.4
Jun 20	9	2.0	0.4	9	1.6	0.2	9	2.0	0.2
Jul 10	4	2.1	0.3	4	1.7	0.6	4	2.0	1.0
Jul 20	4	1.5	0.2	4	1.2	0.1	4	1.7	0.4
Aug 10	2	2.1	0	2	1.8	0	2	1.9	0.4
Aug 20	1	2.3	0	1	2.5	0	1	2.3	0
Sep	7	2.0	0.3	7	1.6	0.3	7	2.0	0.4
Oct	5	2.0	0.3	5	1.4	0.2	5	1.7	0.4
Nov	0	--	--	0	--	--	0	--	--
Dec	0	--	--	0	--	--	0	--	--
1972									
Jan	0	--	--	0	--	--	0	--	--
Feb	0	--	--	0	--	--	0	--	--
Mar	0	--	--	0	--	--	0	--	--
Apr	0	--	--	0	--	--	0	--	--
May	4	2.3	0.2	4	1.6	0.2	4	1.9	0.5
Total	67	1.9	0.3	67	1.4	0.4	67	1.8	0.6

Peromyscus eremicus

Male reproductive cycle: In every month in which cactus mice were trapped, the majority of the adult males were fertile (Figs. 16 and 17). During both summers, 100% of all adult males were fertile. Not all of these had scrotal testes; however, they did have small-to-moderate and, in some cases, large amounts of spermatozoa in their caudal epididymes. There were periods during the winter of both years in which there was decreased fecundity in male *P. eremicus* (Fig.16). A larger percentage of males were, however, non-fecund during the first year than in the second.

Magidson and Hoffmeister (1965) did a comprehensive study in age variation in the bacula of 182 *P. eremicus* but did not present data correlating bacula measurements with reproductive condition of the male. The above authors divided the bacula into five groups based on tooth development in the specimens from which the bacula were taken. The smallest groups of bacula averaged 6.46 mm in length and the largest group of bacula had a mean length of 9.07 mm.

In this study 279 bacula were examined and categorized into three major divisions; juveniles, subadults and adults. In addition, the adults were further subdivided, based upon the amount of spermatozoa observed or relative fertility. Bacula from juveniles averaged 5.49 mm in length, had a laterally thickened proximal base and a straight, tapering shaft. The mean bacula length of 54 subadults averaged 6.98 mm and was further thickened at the base. The shaft had a slight dorsal curve.

The overall bacula length of 216 males averaged 8.85 mm. The shaft of the bacula had increased flexure (Fig. 19) from that of subadults and had a thicker, more rounded proximal base. There was often a cartilage tip on the terminal knob that occurred more often in fertile males. Thirteen non-fecund adult males had bacula lengths averaging 7.36 mm. As the amount of spermatozoa content increased in the caudal epididymis, so did the length of the bacula. The mean bacula length of 43 animals with small amounts was 8.51 mm, 54 males with moderate amounts averaged 8.89 mm, and 106 males with large amounts had an average bacula length of 9.15 mm.

Just as the bacula increased in length as sexual maturity of the males improved, so did the testes (Fig. 34), seminal vesicles, and caudal epididymis, and measurements of these organs were equally useful guides to reproductive status. The size of the seminal vesicles differ from season to season and are indicative of periods of reproduction (Figure 35). The seminal vesicles atrophied in size during the winter months even though spermatozoa was still found in the caudal epididymis. The caudal epididymis remained fairly consistent in size throughout the two-year study (Fig. 35). Perhaps *P. eremicus* is potentially active during the winter months but they are not actively inseminating. This explanation would agree with the findings of MacMillen (1964).

Female reproductive cycle: A remarkably high (48.77) percentage of all the adult females throughout the two-year study were in breeding condition. There were only four months during the study (January through April, 1972) in which all of the females were non-reproductive (Fig. 16). Females during these same months in the second year were reproductive; the disparity was presumably due to better environmental conditions. *Peromyscus eremicus* eats large quantities of insects and greenery (Reichman, 1973) and these items were more abundant during the second year. An increase in reproduction occurred during the summer of both years (Fig. 17) and a larger percentage of females were breeding in the second summer than in the summer of the first year.

As compared to some of the pocket mice, the cyclic events associated with reproduction is fairly well known for *P. eremicus*. Svihla (1932) reported the gestation period of *P. eremicus* to be 21 days, whereas Davis and Davis (1947) reported individual females had multiple litters at intervals of 28 to 30 days. Postpartum estrus occurs within 24 hr after parturition (Brand and Ryckman, 1968) and lactation is known to extend gestation by two to seven days (Svihla, 1932). Our data, as well as MacMillen's (1964), indicates seasonal polyestrus females are common occurrences in natural populations. On numerous occasions pregnant females were trapped that had recent placental scars and on several occasions some were lactating. Only two of the females trapped were in estrus, indicating that the period of estrus is not so long in *Peromyscus* species as it is in heteromyids.

Because of the continuous breeding patterns in *P. eremicus*, comparing monthly ovarian or uterine measurements were non-revealing as no patterns were established. The size of the ovaries and uterus did increase from juvenile to adult and from non-breeding to breeding. The length of the pinkish-colored ovary for juveniles averaged 1.69 mm and the uterine width averaged 0.81 mm. Forty-four subadults had a mean ovary length of 1.83 mm and a mean uterine width of 1.36 mm. Of the adults, 72 pregnant females had an average ovary length of 2.34 mm and an average uterine width of 2.43 mm. Lactating females had slightly smaller ovary and uterine dimensions, 2.22 mm and 2.26 mm respectively. The ovaries and uterine horns of females in estrus were likewise larger than those of non-reproductive females (Table 67).

Studies by several workers have shown *P. eremicus* to have similar litter sizes. Brand and Ryckman (1968) reported a mean litter size of 2.22 young from 14 females. Svihla (1932) lists a mean litter size of 2.60 based on five litters. Davis and Davis (1947) found the mean number of young in 404 litters to be 2.42 and Lewis (1972) recorded an average of 2.53 per litter in 13 pregnant females examined. In this study, 72 pregnant females and an additional 61 postpartum females with placental scars were examined; both groups showed exactly the same mean data (2.60±0.7) in the number of young per litter.

Table 67. Measurements (mm) of the length and width of the ovaries and the uteri of adult female *Peromyscus eremicus*—DSCODE A3UBE22

	Ovary						Uterus		
		Length			Width				
Month	No.	Mean	S.D.	No.	Mean	S.D.	No.	Mean	S.D.
1970									
Jun 10	12	2.5	0.6	12	1.9	0.6	12	2.8	0.9
Jun 20	8	2.2	0.8	8	1.4	0.4	8	3.0	1.0
Jul 10	3	1.6	0.5	3	1.4	0.3	3	3.9	1.9
Jul 20	8	2.7	0.8	8	1.8	0.4	8	3.1	1.5
Aug 10	5	1.6	0.2	5	1.2	0.1	5	2.5	1.1
Aug 20	1	1.7	0	1	1.4	0	1	5.4	0
Sep	0	--	--	0	--	--	0	--	--
Oct	10	2.7	0.5	10	1.5	0.4	10	1.3	0.3
Nov	11	2.1	0.5	11	1.3	0.4	11	1.4	0.3
Dec	3	1.3	0.4	3	0.9	0.2	3	1.7	0.5
1971									
Jan	2	1.9	1.0	2	1.2	0.3	2	1.7	0.8
Feb	7	2.0	0.3	7	1.2	0.3	7	1.6	0.2
Mar	5	2.0	0.3	5	1.3	0.1	5	1.6	0.4
Apr	2	1.5	0	2	0.9	0	2	1.4	0.4
May	2	2.4	0.1	2	1.9	0.2	2	2.5	0
Jun 10	1	1.8	0	1	1.3	0	1	2.8	0
Jun 20	2	2.2	0.3	2	1.9	0.1	2	3.1	0.2
Jul 10	4	2.9	0.2	4	2.0	0.4	4	3.8	0.3
Jul 20	6	1.9	0.4	6	1.4	0.3	6	2.6	0.8
Aug 10	2	2.1	0.1	2	1.8	0	2	2.6	0.1
Aug 20	1	2.5	0	1	2.1	0	1	4.5	0
Sep	0	--	--	0	--	--	0	--	--
Oct	1	2.1	0	1	1.9	0	1	2.4	0
Nov	14	2.1	0.7	14	1.6	0.5	14	2.5	0.8
Dec	13	2.5	0.4	13	2.1	0.4	13	3.4	1.0
1972									
Jan	24	1.7	0.3	24	1.2	0.3	24	1.8	0.4
Feb	26	1.9	0.4	26	1.5	0.4	26	2.2	0.7
Mar	23	2.3	0.3	23	1.9	0.3	23	2.9	0.8
Apr	8	2.5	0.5	8	2.1	0.4	8	3.1	0.8
May	0	--	--	0	--	--	0	--	--
Total	203	2.1	0.6	203	1.6	0.5	203	2.5	1.0

Subadults becoming reproductive occurs more frequently in *P. eremicus* than in the heteromyids studied. There was only one subadult female observed to have placental scars, but several subadults were found to be pregnant. Likewise, many subadult males were considered fertile.

Peromyscus eremicus is polyestrus, has a continuous breeding season year around, and many of the subadults are fertile. It is surprising, therefore, that the population density was not greater. The high breeding ratio and the low population numbers suggest a short life span and fast population turnover. Indeed, not many pregnant females were observed that had old placental scars. A study to determine longevity and population dynamics in the cactus mouse would be worthwhile.

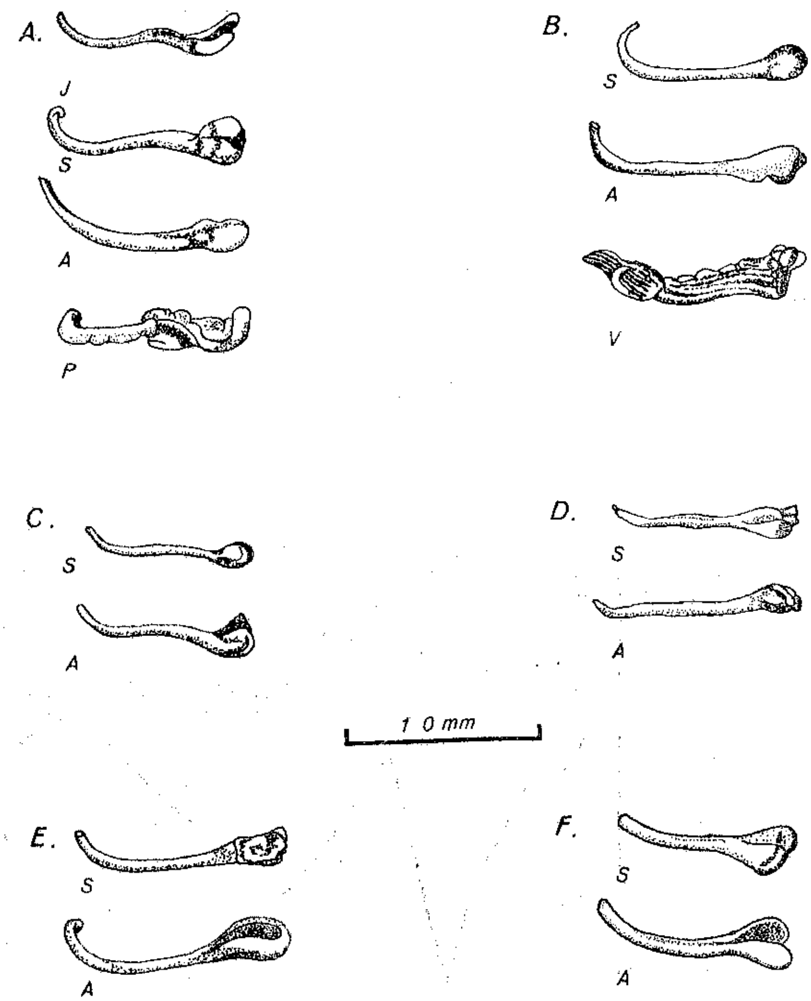

Figure 19. Diagrams of bacula of six species of desert rodents, vaginal plug of *Perognathus penicillatus* (V), and a penial extension of the baculum of *Dipodomys merriami* (P). A. *Dipodomys merriami;* B. *Perognathus penicillatus;* C. *Perognathus amplus;* D. *Perognathus baileyi;* E. *Perognathus intermedius;* F. *Peromyscus eremicus.* Juvenile (J), Subadult (S), and Adult (A). (DSCODES A3UBE21, BE22)

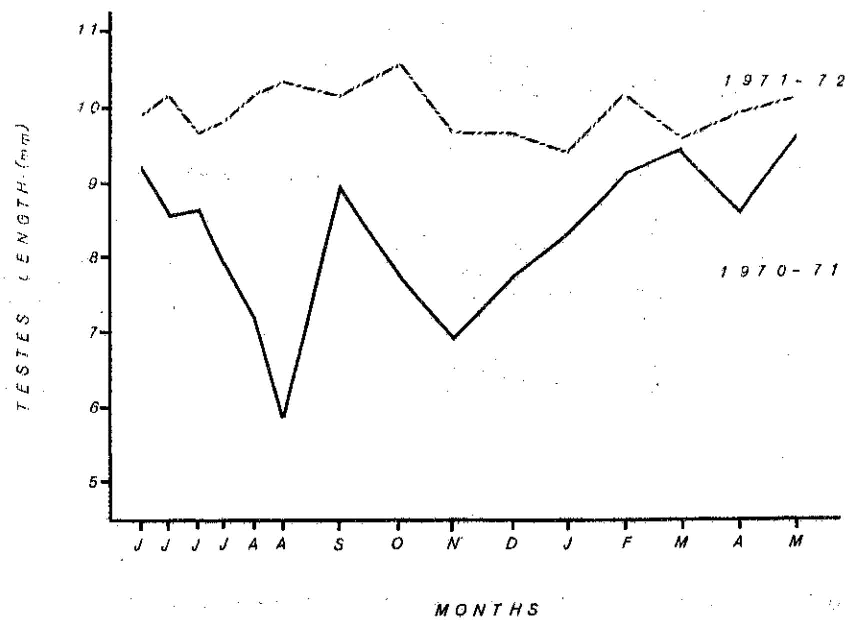

Figure 20. Monthly mean lengths of the testes of 774 *Dipodomys merriami*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

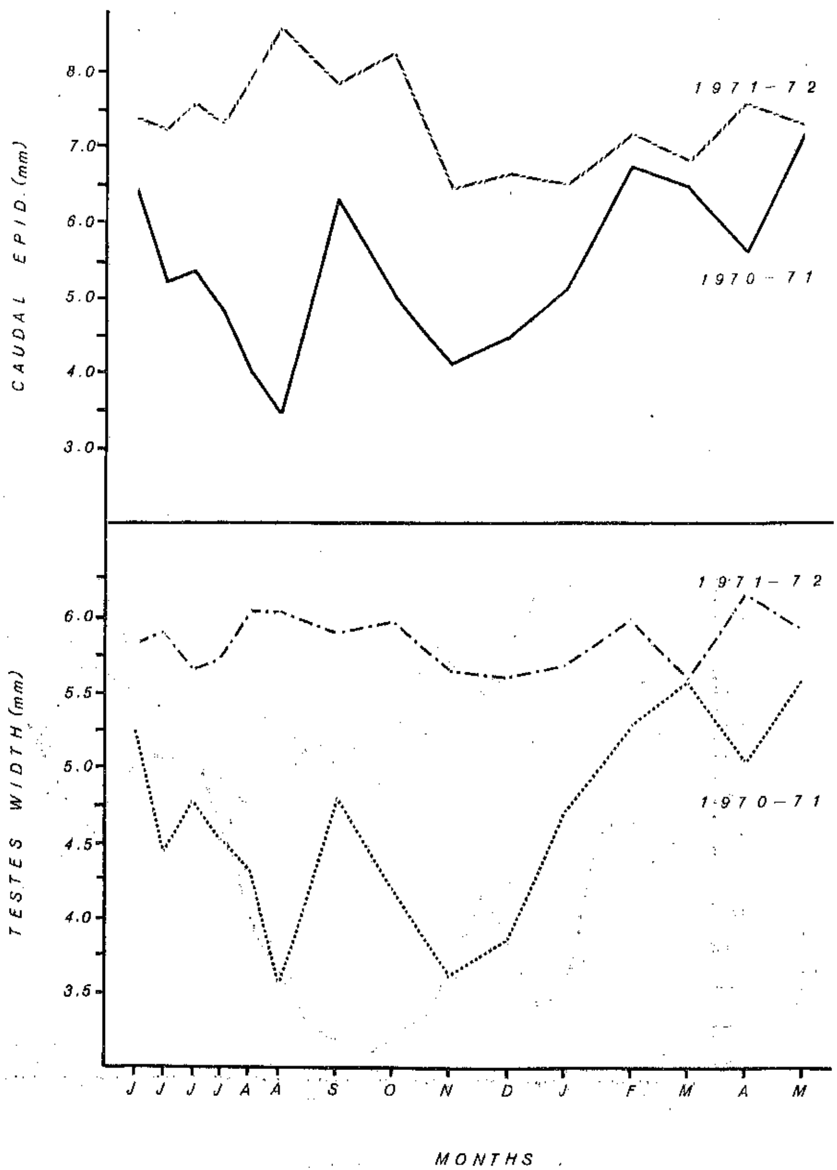

Figure 21. Monthly mean lengths of the caudal epididymides and widths of the testes of 774 adult *Dipodomys merriami*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

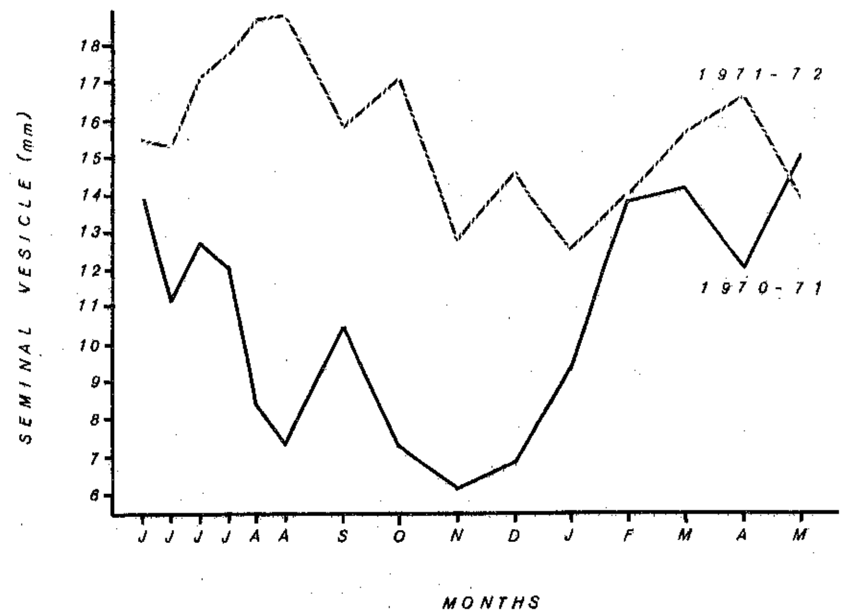

Figure 22. Monthly mean lengths of the seminal vesicles of 774 adult *Dipodomys merriami*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

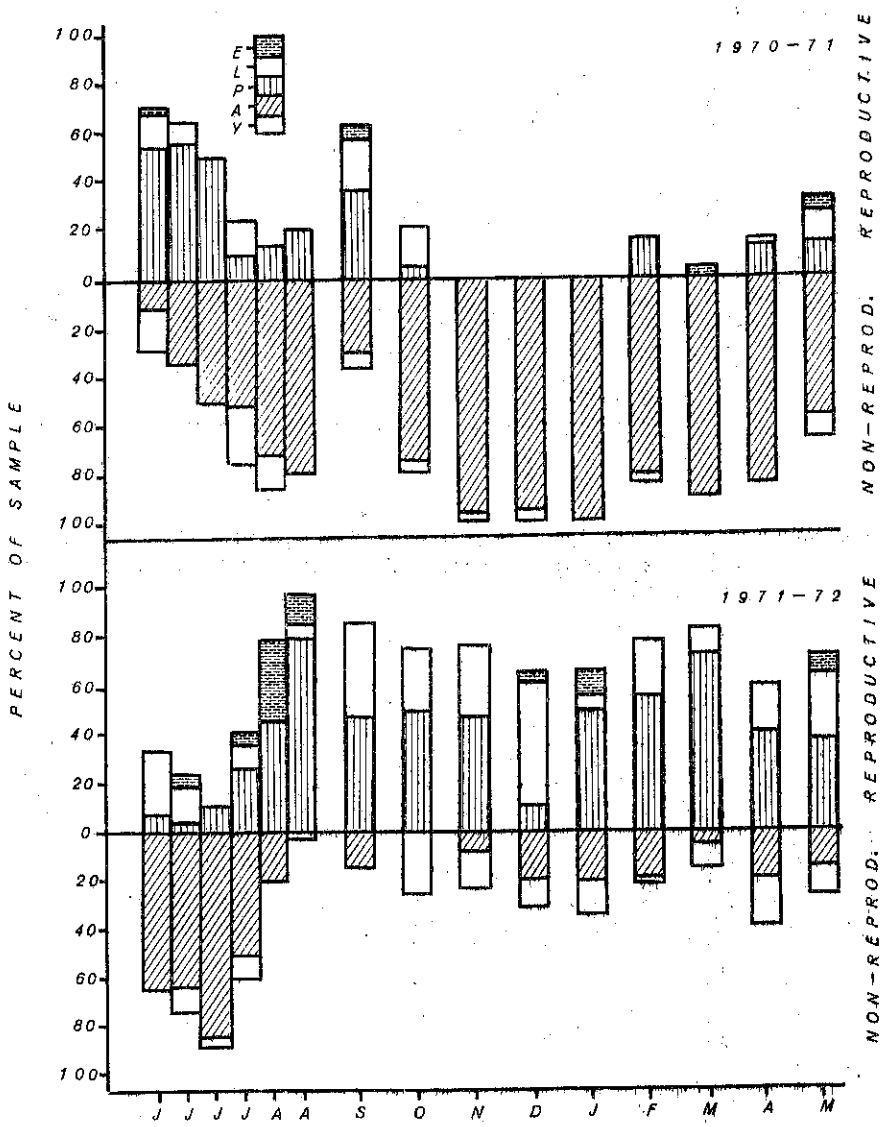

Figure 23. Summary of the reproductive cycles of *Dipodomys merriami* based on 727 females (669 adults, 58 young) trapped from June,1970 to June, 1972. Reproductive females categorized as estrus (E), lactating (L), or pregnant (P) and non-reproductive females categorized as adults (A) or young (Y). DSCODE A3UBE22)

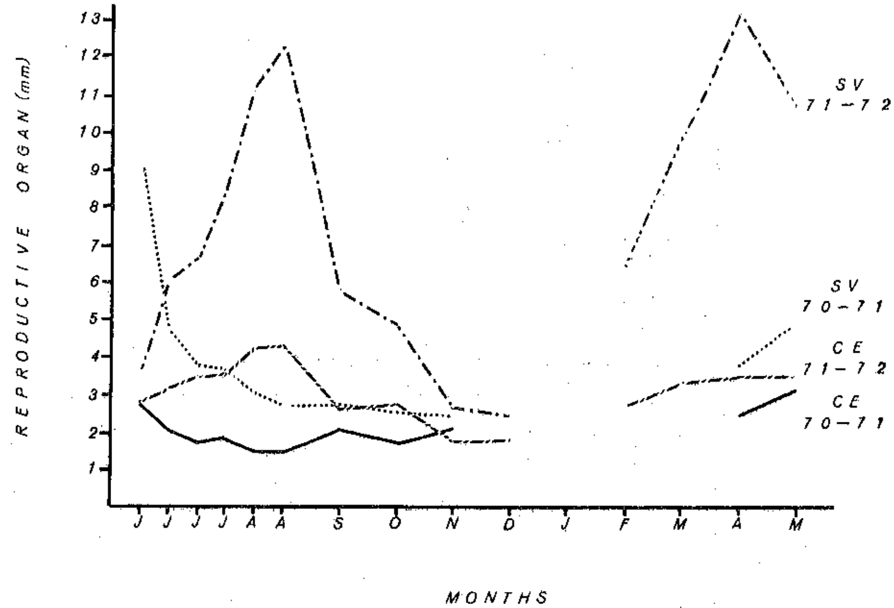

Figure 24. Monthly mean lengths of the caudal epididymides (CE) and seminal vesicles (SV) of 555 adult *Perognathus amplus*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

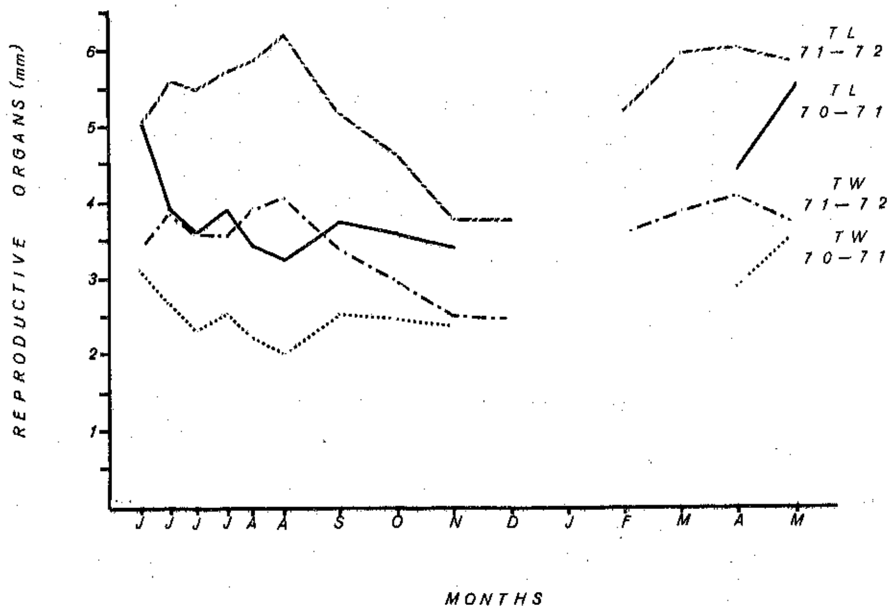

Figure 25. Monthly mean measurements of the testes length (TL) and testes width (TW) of 555 adult *Perognathus amplus*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

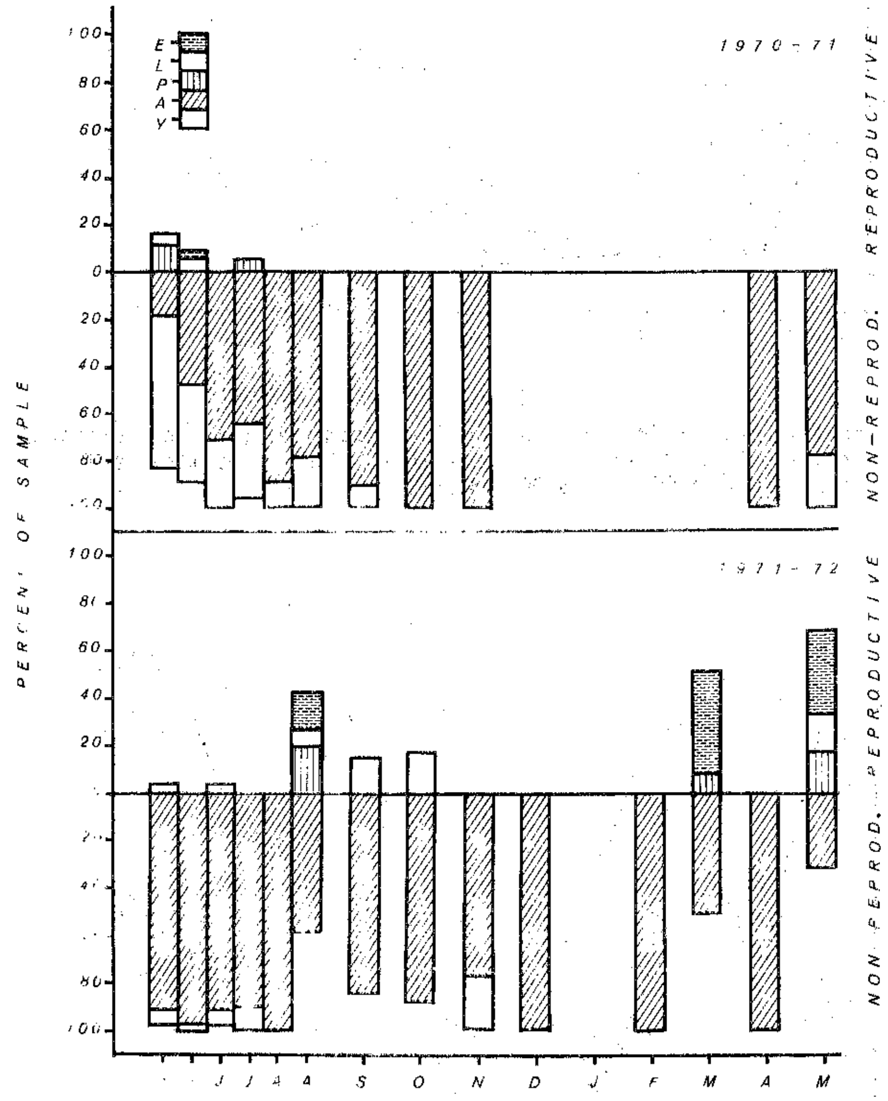

Figure 26. Summary of the reproductive cycles of *Perognathus amplus* based on 710 females (530 adults, 180 young) trapped from June, 1970 to June, 1972. Reproductive females categorized as estrus (E), lactating (L), or pregnant (P) and non-reproductive females categorized asadults (A) or young (Y). (DSCODE A3UBE22)

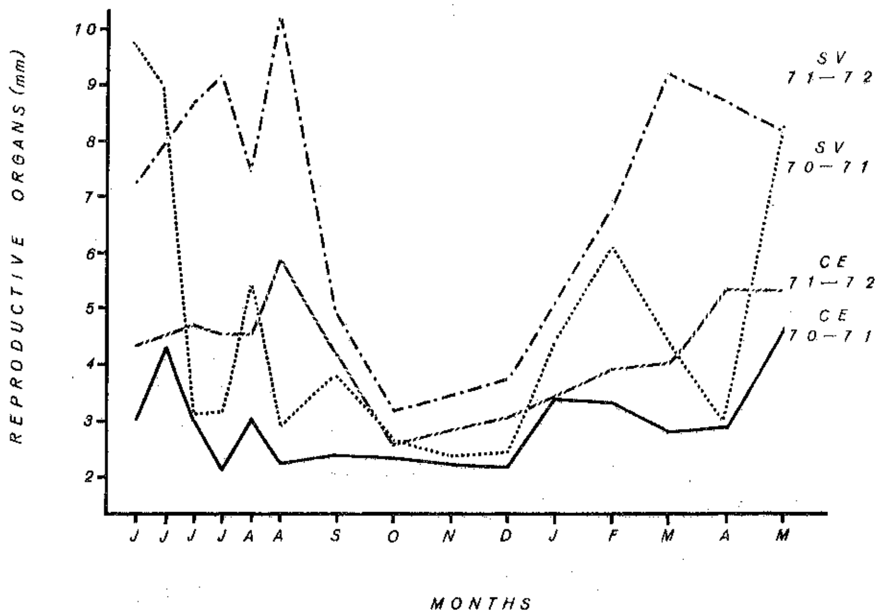

Figure 27. Monthly mean lengths of the caudal epididymides (CE) and seminal vesicles (SV) of 165 adult *Perognathus baileyi*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

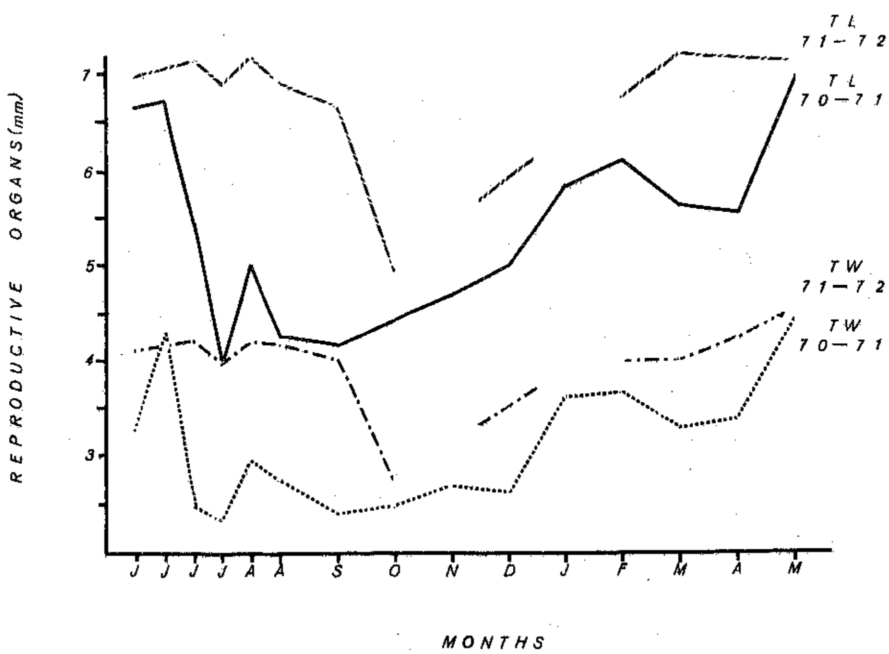

Figure 28. Monthly mean measurements of the testes length (TL) and testes width (TW) of 165 adult *Perognathus baileyi*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

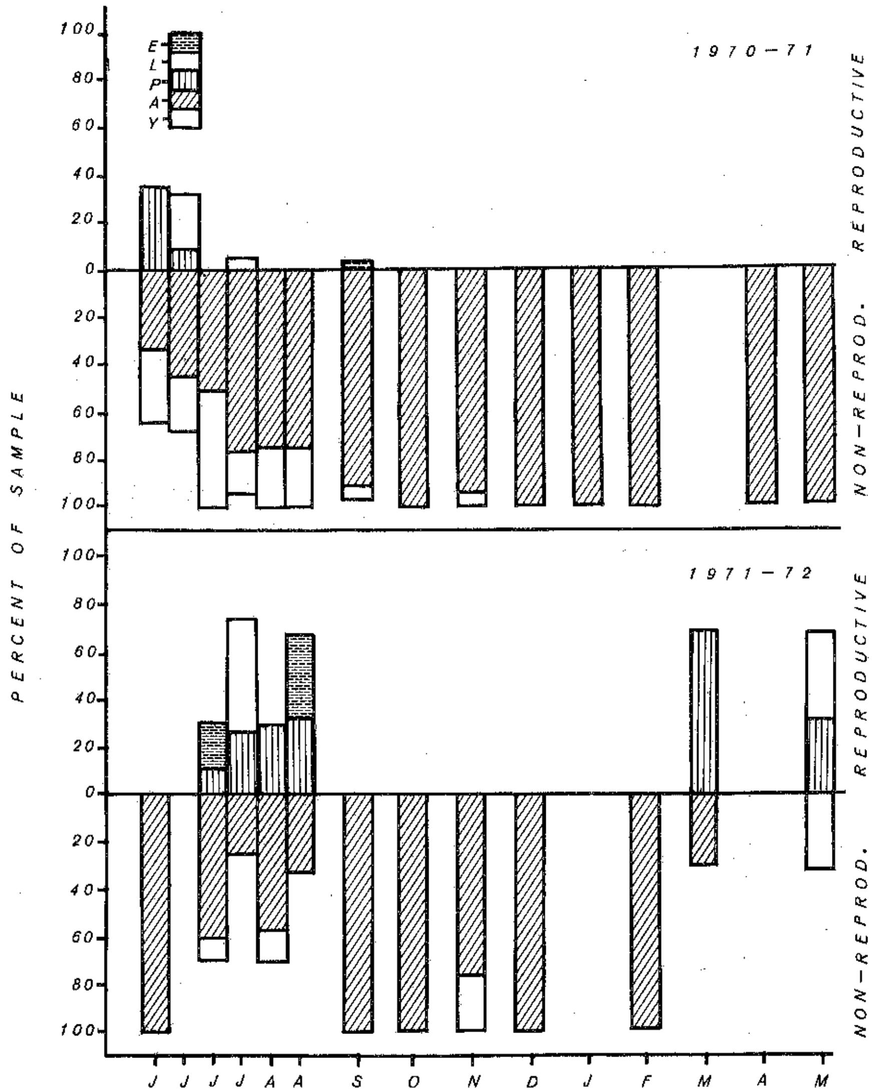

Figure 29. Summary of the reproductive cycles of *Perognathus baileyi* based on 239 females (211 adults, 28 young) trapped from June, 1970 to June, 1972. Reproductive females categorized as estrus (E), lactating (L), or pregnant (P) and non-reproductive females categorized as adults (A) or young (Y). (DSCODE A3UBE22)

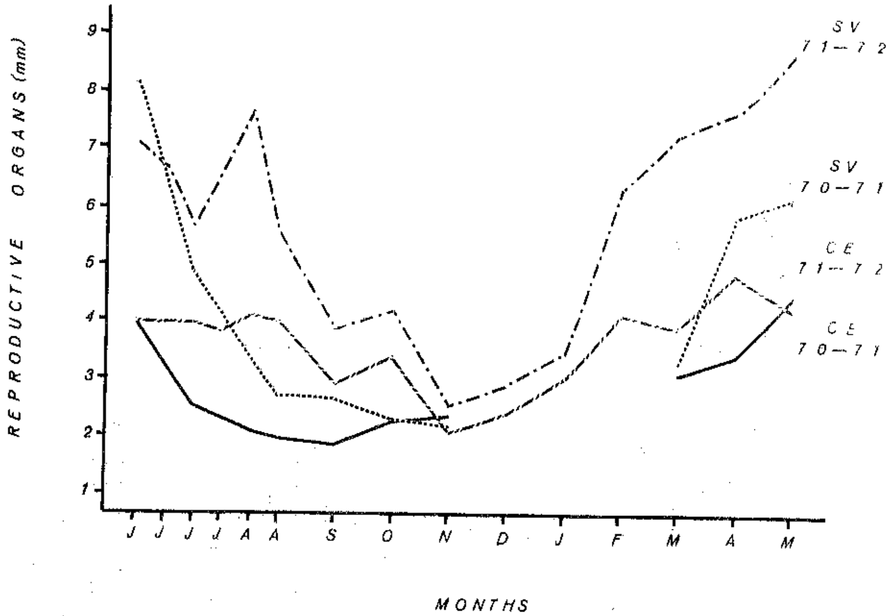

Figure 30. Monthly mean lengths of the caudal epididymides (CE) and seminal vesicles (SV) of 479 adult *Perognathus intermedius*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

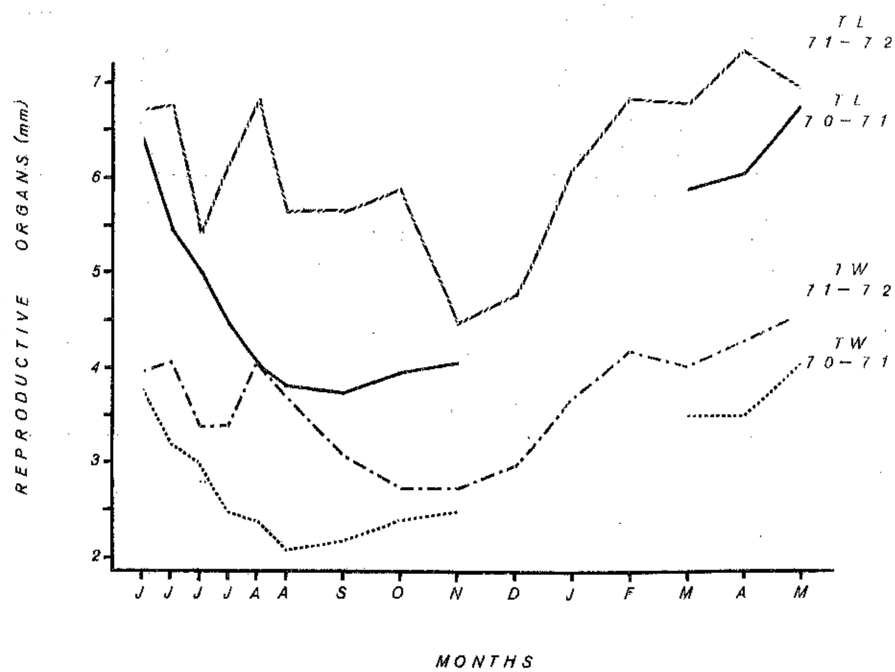

Figure 31. Monthly mean measurements of the testes length (TL) and testes width(TW) of 479 adult *Perognathus intermedius*. Summers were sampled bi-monthly (DSCODE A3UBE21)

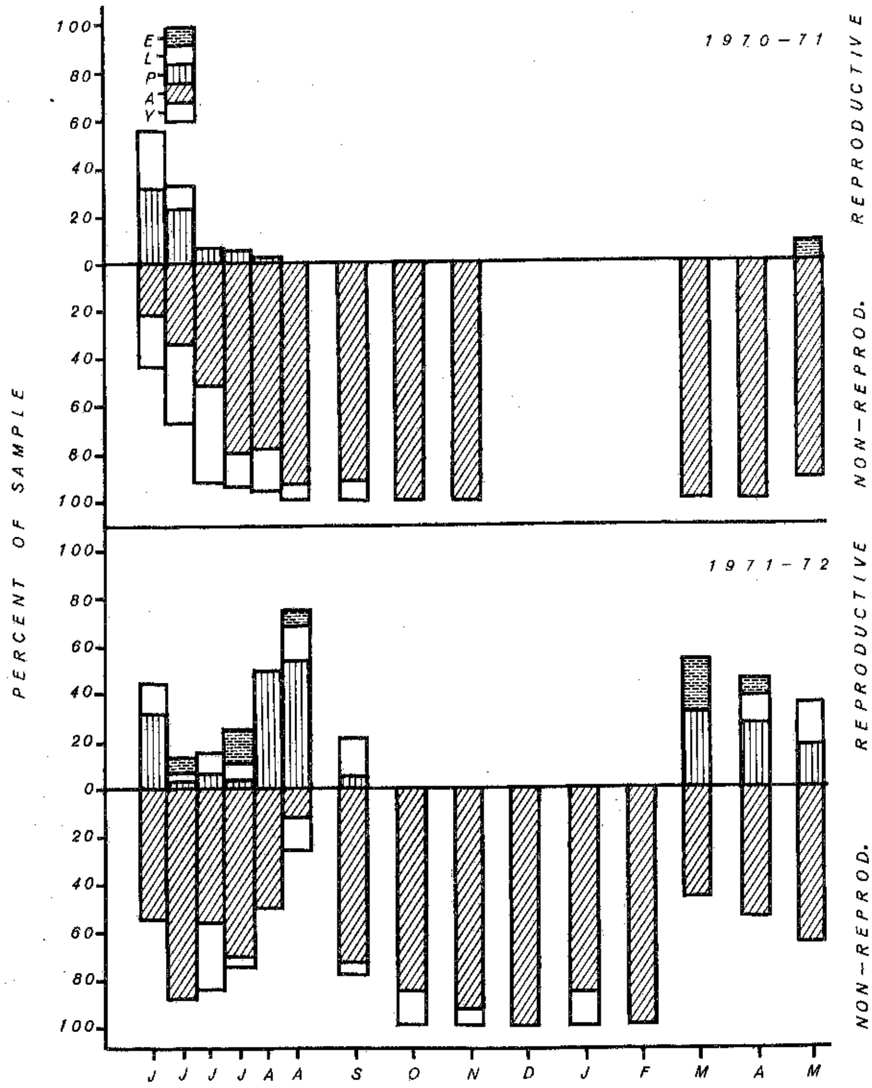

Figure 32. Summary of the reproductive cycles of *Perognathus intermedius* based on 642 females (560 adults, 82 young) trapped from June, 1970 to June, 1972. Reproductive females categorized as estrus (E), lactating (L), or pregnant (P) and non-reproductive females categorized as adults (A) or young (Y). (DSCODE A3UBE22)

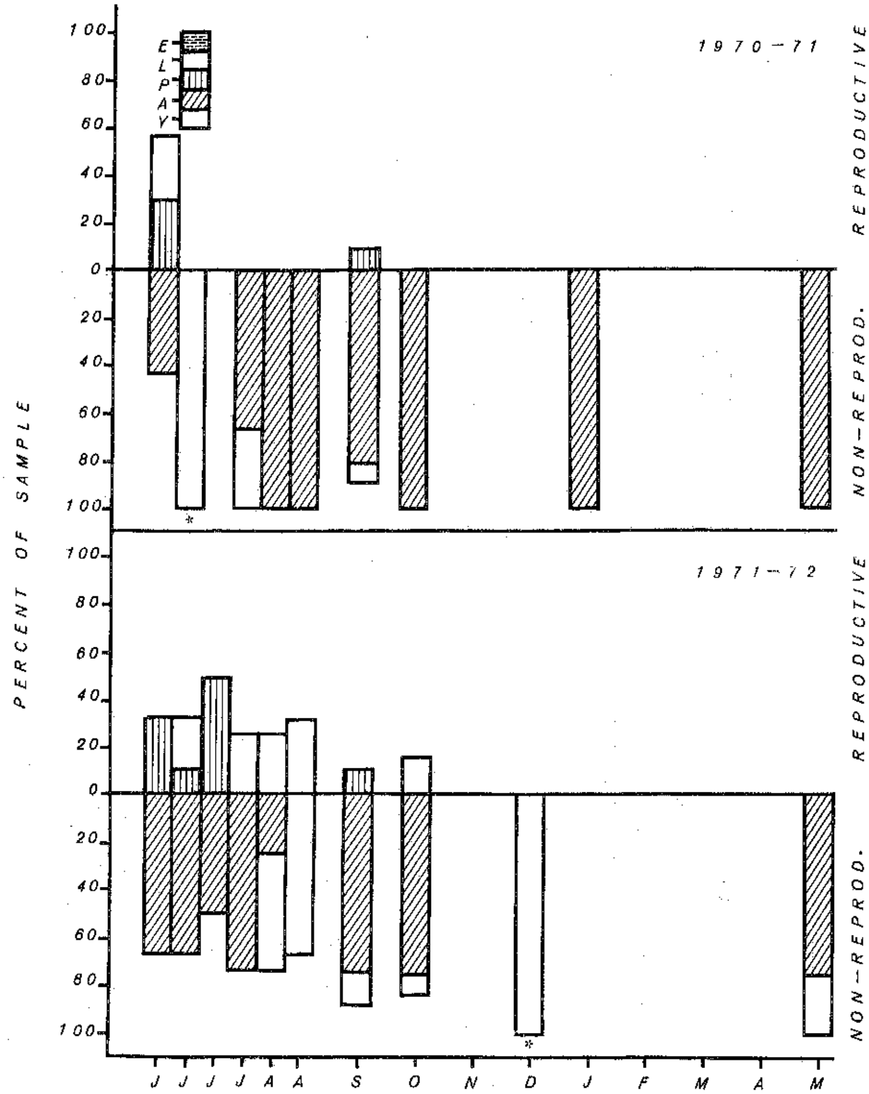

Figure 33. Summary of the reproductive cycles of *Perognathus penicillatus* based on 80 females (67 adults, 13 young) trapped from June, 1970 to June, 1972. Reproductive females categorized as estrus (E), lactating (L), or pregnant (P) and non-reproductive females categorized as adults (A) or young (Y). (DSCODE A3UBE22)
*Small sample size

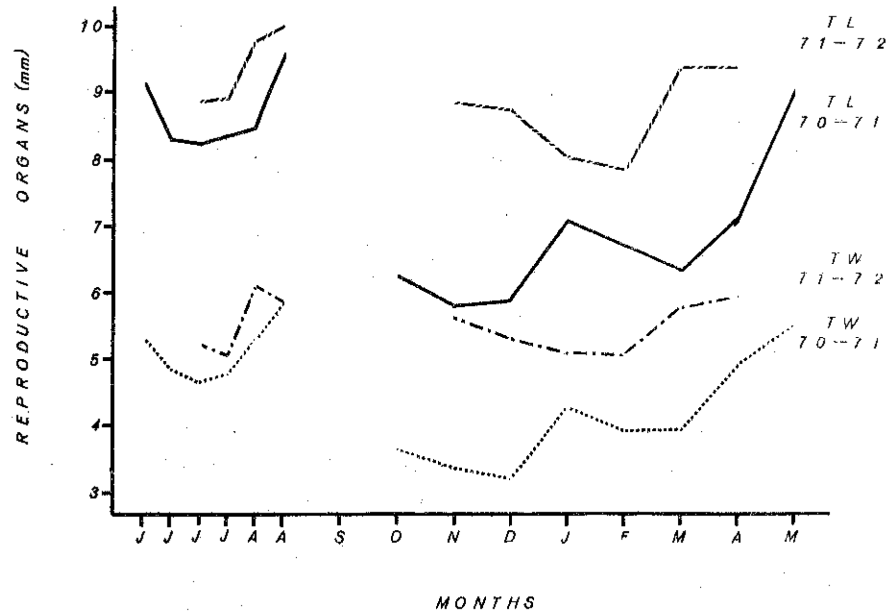

Figure 34. Monthly mean measurements of the testes length (TL) and testes width (TW) of 216 adult *Peromyscus eremicus*. Summers were sampled bi-monthly. (DSCODE A3UBE21)

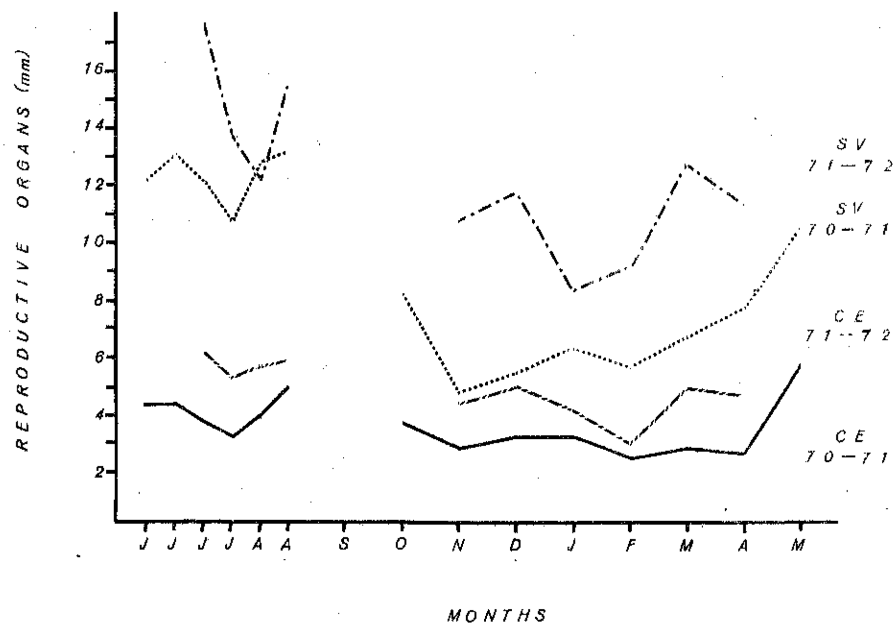

Figure 35. Monthly mean lengths of the caudal epididymides (CE) and seminal vesicles (SV) of 216 adult *Peromyscus eremicus*. Summers were sampled bi-monthly (DSCODE A3UBE21)

Vegetation (DSCODE A3UBE01 A3UBE02, A3UBE03)

The unique geographic position of the Sonoran Desert is demonstrated by two distinct groups of annuals responding to a bi-seasonal rainfall pattern (Shreve, 1951). Bracketed by the Chihuahuan Desert to the east and the Mohave and Great Basin Deserts to the west and north, the Sonoran Desert receives precipitation both winter and summer. In Went's classic desert of Joshua Tree National Monument, two major groups of desert annuals were identified (Juhren et al., 1956). Using both field and lab techniques, Went grouped plants into winter annuals, which included *Festuca octoflora, Pectocaryon* spp. and *Plantago insularis,* and summer annuals, which included *Bouteloua aristidoides, Boerhaavia intermedia* and *Euphorbia micromera.*

The observations compare favorably with our study area south and east of the monument. Both the kinds of plants and the time that they germinated were reasonably similar. About the only major difference was the observation of *Boerhaavia* by Went. *Boerhaavia* occurred in our study area only in rocky habitats. *Allionia incarnata,* which is in the same family as *Boerhaavia* (Nyctaginaceae) was also observed in the area. These plants are extremely difficult to tell apart in the seedling stage, as is noted by Schiffler (1968) in his phenology study of the Chihuahuan Desert. Mature plants of these species can easily be separated by their distinct seed differences.

Euphorbia spp. and *Allionia-Boerhaavia* were flowering between July and September in the Chihuahuan Desert (Schiffler, 1968). These species apparently flowered earlier and set seed earlier than comparable species in the Sonoran Desert. Approximately 95% of the *Euphorbia* in the Chihuahuan Desert were dead by the middle of September. At our site, maximum density of *Euphorbia* was observed in December of 1970 and in November of 1971. Perhaps a combination of altitude, timing of precipitation, and temperatures accompanying a rainfall could account for distinct differences in growth periods. Went found these factors were extremely critical in the germination of desert annuals in the Mohave Desert (Juren et al., 1956).

Phenological data, considering only one aspect (ripe and dispersing seeds), clearly show a seasonal response. Observations over the entire study area demonstrate that approximately 20% of the herbs were dispersing seeds in June of 1970. Previous winter rains in 1969-1970 must have been substantial because in June of 1971, no herbs were observed with ripe and dispersing seeds. Comparison of observations for the same phenological data after the summer rains was approximately the same. Maximum dispersal occurred in October and November and gradually tapered off during the following months to zero values.

Phenological data is of considerable value in monitoring individual plant species. For example, *Plantago insularis* maintained fairly high densities through the winter months of both 1971 and 1972. This species remained in the vegetative stage throughout the spring of 1971 without producing any flowers or seeds. In contrast, *Plantago* did flower during the spring of 1972 and produced ripe and dispersing seeds in April and May of 1972. Thus, observation of density alone for both years could lead to some misleading interpretations of plant responses.

It is apparent from this study that the annual plants in the Sonoran Desert have the potential for providing green matter during a large segment of the desert year. During this interval, the plants may remain vegetative (e.g., *Plantago*) or reproduce quickly and put out seeds (e.g., *Bouteloua*). In contrast, seed production for these plants is confined to the period after the summer rains in the Chihuahuan Desert (Schiffler, 1968), or after the winter rains in the Mohave Desert (Beatley, 1969). This distinct "lag" response of annual plants in the Sonoran Desert may be of critical importance to animals depending directly or indirectly on these plants for food.

Unfortunately, the data on the seeds in the soil is not valid for comparing the fluctuating presence of seeds, as the samples were taken in different areas of Avra Valley over the two years of the study. They are, however, most appropriate for comparisons with the diets of the rodents, as they were taken at or near the actual capture sites.

Through the first year of the study, soil samples were secured from random locations on the creosote flats and therefore are comparable only to *Dipodomys merriami* and *Perognathus amplus*. We realized after the first year how important seeds were and began taking samples at the individual rodent capture sites. Table 16 indicates that the seeds available to the sympatric rodents on the flats were very similar. These sympatric rodents are therefore obtaining their seeds from the same basic resource. However, Table 17 indicates that *Perognathus intermedius* and *P. baileyi* on the hills occur in somewhat different habitats in terms of seeds available.

The data presented on the average number of seeds per square meter (Tables 9-14) appear to be much lower than some determinations from other areas. Tevis (1958) presents data on 4.5 billion seeds per hectare.

Diets of rodents (DSCODE A3UVC01)

Because of the predominance of seeds in the diets of the rodents, compared to greenery, the discussion on diets in this section will pertain to seeds. Greenery will be discussed in relation to reproduction in another section. Diet comparisons will be made between *Dipodomys merriami* and *Perognathus amplus* which are sympatric on the flats, and *Peroganthus baileyi* and *P. intermedius*, which are sympatric on the hills. *Peromyscus eremicus* will be discussed separately, as it is not a heteromyid rodent.

Dipodomys merriami: Table 18. Two of the most abundant seed species, *Pectocarya* and *Plantago*, make up a total of 36% of the kangaroo rats diet. Significantly, another major dietary item is insects. For a two year period insects made up 17% of the diets and 62% of the stomach contents contained insects. Comparisons of the two years indicate that the kangaroo rat ate more *Euphorbia* and less *Pectocarya* the second year. Those 13 species making up 1% or more of the diet totaled over 90% of the items ingested.

Dipodomys merriami collected in its cheek pouches more than twice as much *Larrea* and *Plantago* as was in its stomach, perhaps indicating that these seeds are eaten in the burrow. Conversely, insects rarely occurred in the cheek pouches, even though they are an important dietary item.

Perognathus amplus: Table 19. This pocket mouse feeds on two of the most abundant seeds in the soil, *Pectocarya* and *Larrea*. *Erodium* also appears to be an important dietary item. The diet of *P. amplus* was consistent between the two years. Those 10 seed species making up more than 1% of the dietary items totaled over 90%. *Erodium* is found much more frequently in the stomach than in the cheek pouches, as is *Pectocarya*. *Plantago* occurs in the pouches more frequently than in the stomach, and *Larrea* is ingested at the same frequency as it is collected.

D. merriami -- P. amplus comparisons: These sympatric rodents ingested many of the same items at similar frequencies. The major trade off of diets appears to be with the kangaroo rat eating many more insects than the pocket mouse, and the pocket mouse eating much more *Larrea*. Perhaps the kangaroo rat is more adept at catching insects than the pocket mouse, and the insects supply the kangaroo rat what *Larrea* provides the pocket mouse.

By comparing frequency figures with usage figures it appears that almost one half of the kangaroo rats used *Larrea* but in no great quantity. By contrast, more kangaroo rats had insects in their diets than any other item. The same is true of *Larrea* in the diet of *P. amplus*.

Perognathus intermedius: Table 20. Several dietary items were of particular importance to *P. intermedius*, including insects, *Larrea*, *Pectocarya*, and various *Opuntia* species. This pocket mouse is the only rodent in the study which uses grass seeds to any extent (*Tridens*, *Festuca*, and *Eriochloa*).

Several of the species in the diet were utilized differently between the two years of the study. *Boerhaavia* increased in consumption considerably the second year, while *Larrea, Pectocarya,* and *Festuca* decreased.

As with the other heteromyid species, insects rarely occurred in the cheek pouches, and *Opuntia* was noticably absent from the pouches while making up a major portion of the diet.

Perognathus baileyi: Table 21. The major dietary items for *P. baileyi* were *Pectocarya* and *Opuntia*. As with its sympatric congener, *Boerhaavia* became important the second year of the study, as did *Opuntia*. The seeds of the grass *Eriochloa* occurred in much greater abundance in the cheek pouches than it did in the diet, as did *Plantago*. Again, insects were only occasionally found in the pouches.

Peroganthus intermedius -- *Perognathus baileyi* comparisons: *P. intermedius* utilized almost six times as much grass and twice as many insects as did *P. baileyi*. Conversely, *P. baileyi* used much more *Plantago* and *Pectocarya*. Even though the quantity of these items varies, the usage figures are similar between the two species for the same species of seed. This might indicate that the rodents sample almost all seeds available, but select for major dietary items.

Peromyscus eremicus: Table 22. By far the most important item in the diet of *P. eremicus* is insects. Over 58% of the diet was made up of insects, and almost 95% of the stomachs had insects in them. The important seeds in the diet of *P. eremicus* were *Boerhaavia* and *Opuntia*.

A major point that needs to be made about the diet determinations is that the cheek pouch contents are poor indicators of when an item is eaten and how much is eaten. This is probably responsible for the relatively low figures given in the literature for the occurrence of insects in the diets of heteromyids. It was also found that green vegetation is rarely found in the cheek pouches, even when it is abundant in the stomachs at certain times of the year.

Another point is that there seem to be seeds, such as *Larrea* and *Pectocarya*, which are generally available and used by all rodents in all habitats. Then there are seeds which are abundant and heavily used only in the flats (e.g., *Plantago* and the crucifer), and on the hills (e.g., *Boerhaavia* and *Opuntia*). These items, along with insects, make up the major portions of the diets, with other seeds being less widespread and only seasonally important to the rodents.

The figures for the number of seeds ingested by the species of rodents are probably conservative, even though they intuitively seem high (Table 23). The calculations for the impact do not include those seeds taken and cached, but not ingested. Therefore, impact here means only those seeds ingested, and says nothing about the impact of the rodents which bury caches of seeds and then "forget" them, perhaps lending to the seed's germination.

It is difficult to imagine a kangaroo rat hopping about, gathering 4000 individual seeds in the amount of time available for foraging. This would seem to indicate that the seeds are clumped in distribution so that the rodents can gather several hundred at one stop. Indeed, when there are as many as several hundred seeds in the cheek pouches of an animal, the seeds are primarily (90%) of one species, indicating that the rodents got them from a clumped source. If seeds are dispersed according to some physical parameter such as size or weight, there is every reason to suppose that they are sorted into clumps by wind and/or rain. Another possibility is that the rodents harvest the seeds during those few weeks when the seeds are available on the plants.

It is pertinent to note that *P. intermedius*, which weighs 13 g, eats fewer seeds than *P. amplus*, which weighs 11 g. This can be explained by the fact that *P. intermedius* eats larger seeds than *P. amplus*, and therefore does not have to eat as many.

Diet and reproduction conclusions (DSCODES A3UVC01,A3UBE21, A3UBE22)

From data now analyzed concerning diets and reproduction in desert rodents, certain tentative conclusions seem justified:

1. *Dipodomys merriami* and *Perognathus amplus* share a common seed resource on the flats while *P. baileyi* and *P. intermedius* use somewhat different seed resources on the hills.
2. In most cases, 4 or 5 dietary items make up 60% to 80% of the diets of the rodents.
3. There are some dietary items important to all rodents (*Pectocarya*), some only to those on the flats (*Euphorbia*) or on the hills (*Opuntia*), and some to just one rodent species (*Larrea* to *P. amplus*).
4. Cheek pouch contents are poor indicators of the kind and quantity of items eaten.
5. The population of rodents at the Silverbell site ingest over 15 million seeds a year per hectare.
6. In the five species of heteromyids, the male is, on average, heavier than the female; with *P. eremicus* the reverse is true.
7. The body weight fluctuates seasonally, probably in response to the quality and quantity of food available and environmental stress factors. The animals are heaviest prior to and during a reproductive period.

8. There is a positive correlation within adult males between increased body weight and amount of spermatozoa present in the reproductive organs.
9. There was a correlation between average body weight and surface inactivity for the winter months of the six species studied. *Dipodomys merriami* increased its activity during the winter months whereas the other hereromyids had varying lengths of surface inactivity during winter months.
10. Each of the species were more active during the second year as compared to the first.
11. The males of each species had a longer reproductive season than did females and a higher percentage of reproductive males were recorded.
12. There was a positive correlation between bacula length and both spermatozoa content and age categories. Measurements of testes, caudal epididymes and seminal vesicles demonstrated size fluctuations that correlated with amounts of spermatozoa observed.
13. Both male and female fecundity, for all six species, in the second year greatly contrasted that of the first year.
14. The smaller species have shorter breeding periods and larger litters.

LITERATURE CITED

Alcorn, J.R. 1941. Counts of embryos in Nevadan kangaroo rats (genus *Dipodomys*). J. Mamm., 22:88-89.

Arnold, L.W. 1942. Notes on the life history of the sand pocket mouse. J. Mamm., 23:331-341.

Bartholomew, G.A. and T.J. Cade. 1957. Temperature regulation, hibernation, and aestivation in the little pocket mouse, *Perognathus longimembris*. J. Mamm., 38:60-72.

Baumgartner, L.L., and A.C. Martin. 1939. Plant histology as an aid in squirrel foodhabit studies. J. Wildl. Manag., 3:266-268.

Beatley, J.C. 1969. Dependence of desert rodents on winter annuals and precipitation. Ecology, 50:721-724.

Blair, F.W. 1943. Populations of the deer mouse and associated small mammals in the mesquite areas of southern New Mexico, Contr. Lab. Vertebr. Biol. Univ. Michigan, No. 21:1-41.

Bradley, W.G. and R.A. Mauer. 1971. Reproduction and food habits of Merriam's kangaroo rat, *Dipodomys merriami*. J. Mamm. 52:479-507.

Brand, L.R. and R.E. Ryckman. 1968. Laboratory life histories of *Peromyscus eremicus* and *Peromyscus interparietalis*. J. Mamm. 49:495-501.

Burt, W.H. 1936. A study of the baculum in the genera *Perognathus* and *Dipodomys*. J. Mamm., 17:145-156.

Burt. W.H., and R.P. Grossenheider. 1964. A field guide to mammals. Boston. Houghton Mifflin Co. 143 pp.

Butterworth, B.B. 1960. A comparative study of sexual behavior and reproduction in the kangaroo rats, *Dipodomys deserti* Stephens and *Dipodomys merriami* Mearns. Unpublished Ph.D. Dissertation, Univ. of Southern California, 170 pp.

Butterworth, B.B. 1961. The breeding of *Dipodomys deserti* in the laboratory. J. Mamm., 42:413-414.

Butterworth, B.B. 1961. A comparative study of growth and development of the kangaroo rats, *Dipodomys deserti* Stephens and *Dipodomys merriami* Mearns. Growth. 25:127-139.

Cain, S. 1938. The species-area curve. Amer. Midl. Natur. 19:578-581.

Chew, R.M. 1958. Reproduction by *Dipodomys merriami* in captivity. J. Mamm., 39:597-598.

Chew, R.M., and B.B. Butterworth. 1959. Growth and development of Merriam's kangaroo rat, *Dipodomys merriami*. Growth, 23:75-95.

Chew, R.M., and B.B. Butterworth. 1964. Ecology of rodents in Indian Cove (Mohave Desert) Joshua Tree National Monument, California. J. Mamm., 45:203-225.

Chew, R.M., R.G. Lindberg and P. Hayden. 1965. Circadian rhythm of metabolic rate in pocket mice. J. Mamm., 46:477-494.

Croker, B.H. 1959. A. method of estimating the botanical composition of the diet of sheep. New Zealand J. Agr. Res., 2:72-85.

Davis, D.E., and D.J. Davis. 1947. Notes on reproduction of *Peromyscus eremicus* in a laboratory colony. J. Mamm. 41:305-310.

Davis, I. 1959. The use of epidermal characteristics for the identification of grasses in the leafy stage. Brit. Grassland. Soc. J., 4:7-16.

Day, B.N., H.J. Egoscue, and A.M. Woodbury. 1956. Ord kangaroo rat in captivity. Science., 124:485-486.

Doran, D.J. 1952. Observations on the young of the Merriam kangaroo rat. J. Mamm., 33:494-495.

Eisenberg, J.R. 1963. The behavior of heteromyid rodents. Univ. Calif. Press., 69: 1-114.

Fitch H.S. 1957. Aspects of reproduction and development in the prairie vole (*Microtus ochrogaster*). Univ. Kansas Mus. Nat. Hist. Publ., 10:129-161.

Fraker, S.B., and J.A. Brischle. 1944. Measuring the local distribution of *Ribes*. Ecology, 25:238-303.

French, N.R., B.G. Maza, and A.P. Aschwanden. 1967. Life spans of *Dipodomys* and *Perognathus* in the Mohave Desert. J. Mamm., 48:537-548.

Hall, E.R. 1946. Mammals of Nevada. Univ. of Calif. Press. Berkely, xi + 710 pp.

Hall, E.R., and K.R. Kelson. 1959. The mammals of North America. New York: The Ronald Press Co. 1083 pp.

Hastings, J.R. and R.M. Turner. 1965. The changing mile. Arizona Press, Tucson, 314 pp.

Hayden, P. 1965. Free running period and phase shifts in two species of pocket mouse. In investigation of *Perognathus* as an experimental organism for research in space biology. Northrop Space Laboratories, Hawthorn, California. 87-105.

Hayden, P., and J.J. Gambino. 1966. Growth and development of the little pocket mouse, *Perognathus longimembris*. Growth, 30:187-197.

Hudson. J.W. 1964. Water metabolism in desert mammals. In Thirst, Proceedings of 1st International Symposium on thirst in the regulation of body water. Pergamon Press, Oxford. 221-235.

Jameson, E.W. 1947. Natural history of the prairie vole. Univ. Kansas Mus. Nat. Hist. Publ., 1:125-151.

Juhren, Marcella, F.W. Went, and E. Phillips. 1956. Ecology of desert plants IV. Combined field and laboratory work on germination of annuals in the Joshua Tree National Monument, California. Ecology 37:318-330.

Kooyman, G.L. 1963. Milk analysis of the kangaroo rat, *Dipodomys merriami*. Sci. 142:1467.

Lewis, A.W. 1972. Seasonal population changes in the cactus mouse, *Peromyscus eremicus*. So. Wt. Natur., 17:85-93.

Lidicker, W.Z., Jr. 1960. An analysis of intraspecific variation in the kangaroo rat *Dipodomys merriami*. Univ. California Publ. Zool., 67:125-218.

Lieth, H. 1970. Phenology in productivity studies. In Analysis of Temperate Forest Ecosystems. David E. Reichle, Ed. p. 29-46. Springer-Verlag, New York.

Lindeborg, R.G. 1952. Water requirements of certain rodents from xeric and mesic habitats; Contr. Lab. Vert. Biol. Univ. Michigan, 58:1-32.

Lowe, C.H. 1964. The Vertebrates of Arizona. The University of Arizona Press, Tucson. 270 pp.

MacMillen, R.E. 1964. Population ecology, water relations, and social behavior of a southern California semidesert rodent fauna. Univ. of California Press. Berkely. 1-65.

MacMillen, R.E. 1965. Aestivation in the mouse, *Peromyscus eremicus*. Comp. Biochem. Physiol., 16:227-248.

Magidson, E. and D.F. Hoffmeister. 1965. Age variations in the bacula of the cactus mouse, *Peromyscus eremicus*. Mammalia, 29:614-617.

Reynolds, H.G. 1958. Ecology of the Merriami kangaroo rat (*Dipodomys merriami* Mearns) on the grazing lands of southern Arizona. Ecol. Monogr., 28:111-127.

Reynolds, H.G. 1960. Life history notes on Merriam's kangaroo rat in southern Arizona. J. Mamm. 41:58.

Reynolds, H.G. and H.S. Haskell. 1949. Life history notes on price and bailey pocket mice of southern Arizona. J. Mamm., 30:150-156.

Schiffler, W. 1968. Phenology of desert ephemerals in southern New Mexico. New Mexico State University Master's Thesis. 34 pp.

Schreiber, R.K., and D.R. Johnson. 1972. Ingestion rates, live weight caloric densities and standing crop estimates for Desert Biome rodents. US/IBP Desert Biome Res. Memo RM 72-30.

Shreve, F. 1951. Vegetation of the Sonoran Desert. Carnegie Institute of Washington Publ. #591.

Sparks, D.E., and J.C. Malechek. 1968. Estimating percentage dry weight in diets using a microscopic technique. J. Range Manag., 21:264-265.

Storr, G.M. 1961. Microscopic analysis of faeces, a technique for ascertaining the diet of herbivorous mammals, Austral. J. Biol. Sci., 14:157-164.

Svihla, 1932. Univer. of Mich. Museum of Zool. Misc Publ. #24.

Tevis, L. 1958. Interrelationships between the harvester ant *Veromessor pergandei* and some desert ephemerals. Ecology, 39:695-704.

Thames, J.L. (Coordinator) et al. 1972. Tucson Validation Site Report. US/IBP Desert Biome Res. Memo. RM 72-3.

Van De Graaff, K.M. 1973. Comparative developmental osteology in three species of desert rodents, *Peromyscus eremicus, Perognathus intermedius* and *Dipodomys merriami* J. Mamm, 54:3.

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., 54:2.

Ward, A.L., and J.O. Keith. 1962. Feeding habits of pocket gophers in mountain grasslands, Black Mesa, Colorado. Ecology, 43:744-749.

Wilken, K.K., and R. Ostwald. 1968. Partial contact as a stimulus to laboratory mating in the desert pocket mouse, *Perognathus penicillatus.* J. Mamm., 49:570-572.

York, C.L. 1949. Notes on home range and population density of two species of heteromyid rodents in southwestern Texas. Texas J. Sci., 1:42-51.