GEOGRAPHIC VARIATION IN THE DEERMOUSE,
PEROMYSCUS MANICULATUS, ON THE
LLANO ESTACADO

by
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TABLE OF CONTENTS

ACKNOWLEDGEMENTS	ii
LIST OF TABLES	iv
LIST OF ILLUSTRATIONS	v
I. INTRODUCTION	1
II. METHODS AND MATERIALS	6
III. RESULTS AND DISCUSSION	31
IV. CONCLUSIONS	97
LITERATURE CITED	101

LIST OF TABLES

Table	Page
1. CLIMATOLOGICAL DATA	9
2. SEXUAL VARIATION	21
3. VARIABILITY OF BODY MEASUREMENTS	25
4. VARIABILITY OF MEASUREMENTS	26
5. T-VALUES	32
6. COMPARISON OF <u>P. m. pallescens</u> WITH <u>P. m. luteus</u> AND <u>nebrascensis</u>	81
7. COMPARISON OF <u>P. m. luteus</u> AND <u>nebrascensis</u>	82
8. COMPARISON OF SUBSPECIES AND SELECTED SAMPLES	86
9. COMPARISON OF <u>P. m. luteus</u> WITH SAMPLES	91
10. COMPARISON OF <u>P. m. nebrascensis</u> WITH SAMPLES	92

LIST OF ILLUSTRATIONS

Figure		Page
1a.	OUTLINE MAP OF THE LLANO ESTACADO	8
1b.	SOIL TEXTURAL PATTERN	8
2.	LOCALITIES OF SPECIMENS EXAMINED	11
3.	SAMPLE LOCALITIES	12
4.	PELAGE COLOR IN SAMPLES	19
5.	OVERALL LENGTH	35
6a.	TAIL LENGTH	36
6b.	OVERALL LENGTH	36
7.	TAIL VERTEBRAE LENGTH	38
8.	EAR LENGTH	39
9a.	BODY LENGTH	40
9b.	EAR LENGTH	40
10.	BODY LENGTH	42
11.	CONDYLO-BASILAR LENGTH	43
12a.	CONDYLO-BASILAR LENGTH	44
12b.	CONDYLO-ZYGOMATIC LENGTH	44
13.	CONDYLO-ZYGOMATIC LENGTH	46
14.	ZYGOMATIC BREADTH	47
15a.	ZYGOMATIC BREADTH	48
15b.	LENGTH OF MANDIBLE	48
16.	NASAL LENGTH	50
17.	ROSTRAL BREADTH	51

18a.	NASAL LENGTH	52
18b.	ROSTRAL BREADTH	52
19.	LENGTH OF INCISIVE FORAMEN	54
20a.	LENGTH OF INCISIVE FORAMEN	55
20b.	LENGTH OF PALATE	55
21.	LENGTH OF PALATE	56
22.	LEAST INTERORBITAL CONSTRICTION	58
23.	DEPTH OF CRANIUM	59
24a.	LEAST INTERORBITAL CONSTRICTION	60
24b.	DEPTH OF CRANIUM	60
25.	LENGTH OF MAXILLARY MOLAR SERIES	62
26.	MANDIBULAR HEIGHT	63
27a.	LENGTH OF MAXILLARY MOLAR SERIES	64
27b.	HEIGHT OF MANDIBLE	64
28.	MANDIBULAR LENGTH	66
29.	OUTLINE MAP OF LLANO ESTACADO	73
30.	DISTRIBUTION OF SUBSPECIES OF <u>Peromyscus maniculatus</u> SURROUNDING THE LLANO ESTACADO	76

CHAPTER I

INTRODUCTION

The deer mouse, Peromyscus maniculatus, ranges from the Atlantic to the Pacific coast and from the Arctic Circle to the Isthmus of Tehuantepec. Thus, it is the most widely distributed rodent in North America. Deer mice are extremely ubiquitous occurring from sea level to 10,000 feet in mexic and xeric regions. Degree of geographic differentiation is considerable and twenty six continental and forty insular subspecies are recognized.

More is known about population dynamics and geographic variation of deer mice than any other small mammal. Studies of variation in populations of deer mice have been chiefly recorded by Sumner, Dice, and Blair. Sumner (1918, 1929a, 1929b, 1930, and 1932) pioneered in hybridization experiments and in the analysis of intraspecific geographic variation. Dice (numerous papers) compared populations of many subspecies throughout much of the range of the species.

Blair (1953) divided the geographic range of deer mice in the United States into nine major regions on the basis of ecologic preference: northeastern forests, cleared deciduous forest, central prairies and plains, Nebraska sand hills, Black Hills, Rocky Mountains, Columbia Basin,

Pacific Coast forest, basin and range. Five subspecies characterized partly by short tails are recognized in the central prairies and plains. Blair (1953) reported these extending southward into the tall grass prairies of eastern Texas. Dice (1932, 1937, 1940, 1941) analyzed variation in northern portions of the central prairies and plains where mice were small, short-tailed and dark in color with a gradual increase in size and length of tail from east to west. However, in the Nebraska sand hills, deer mice were predominately paler than mice from surrounding darker soils. Deer mice from the sand hills were mostly yellowish or orange (Blair, 1953) and genetically dominant to the darker, duller colored prairie deer mice to the east (see Clark, 1938). Dice (1941) noted the population of the interior of the sand hills was quite variable, with both color types represented. The predominately pale-colored population of deer mice on the sand hills may have resulted because intensity of selection was sufficient to retard but not prevent infiltration of genes for dark pelage from populations on surrounding dark brown chernozem soils. Deer mice inhabiting the short grass prairie to the west of the sand hills were relatively larger, longer tailed, and pale grayish brown.

Concerning the western populations Blair (1953) stated " . . . over much of the western United States,

corresponding roughly to the Basin and Range Physiographic province, the deer mouse occupies grassland or brush habitats in the desert basins and forest habitats on the mountain slopes." Deer mice reach their greatest abundance in open yellow pine forests in New Mexico, but were often taken in dense spruce and fir (Bailey, 1932:143). In the basins, deer mice were generally found in riparian situations in open valley bottoms (1932:147). Dice (1930 and 1942) indicated deer mice are rare on the lower slopes of the Sacramento Mountains. Little or no interbreeding occurred between populations of the dense, montane forests and populations of the desert basins.

Osgood (1909) first reported dichromatism (gray and buff phases) in the desert populations. Dice (1933) and Blair (1947a) showed that gray pelage acted as a dominant allele to buff pelage. Blair (1947a) also called attention to the presence of modifiers at the same loci. The two pelage colors have different survival values on differently colored soils and under various conditions of ecological isolation (1947b). The gray phase apparently occurs only rarely in populations other than those of the deserts. Blair (1947c) found recessive gray mice in populations from Troy, Idaho; Isle Royale, Michigan; and, from Mountain Lake, Virginia. He (1947c) also reported grays in the montane populations of the Sacramento Mountains

and suggested (1953) that the desert populations may breed more with mice of the montane forests than was suggested by Dice (1930 and 1942).

Until recently P. maniculatus was known from the Llano Estacado on the basis of ten specimens from Washburn, Armstrong County, Texas (Bailey, 1905). Deer mice were thought rare or absent from the grasslands of much of western Texas (Blair, 1950 and 1953). This led Blair (1954) to propose a circular route of gene exchange from the population inhabiting the desert basins in Trans-Pecos Texas through the montane forest adapted form in New Mexico to the population inhabiting the tall grass prairie of eastern Texas. Subsequently, Blair (1954), Davis (1960) and Packard and Garner (1964) reported specimens from widely scattered localities on or closely adjacent to the Llano Estacado. Blair (1954) reported a recessive gray specimen from ten miles E Hermleigh, Fisher County, Texas.

Theoretically, deer mice inhabiting the Llano Estacado provide a link between Trans-Pecos populations and grassland forms to the north and east. Thus, geographic analysis of variation of deer mice from Llano Estacado was important to obtain a more thorough understanding of variation in the species

The purposes of this investigation were to: (1) study variation in twenty-two morphological characters of eleven

selected samples from the Llano Estacado; (2) re-evaluate certain characters upon which three subspecies of Peromyscus maniculatus are based; (3) where possible correlate observed variations with the external environment; (4) discuss trends of variation in deer mice on the Llano Estacado and their biological importance; (5) derive, as a result, a better understanding of the variation of a wide ranging species.

CHAPTER II

METHODS AND MATERIALS

Description of the Area

Llano Estacado is a Spanish term for that portion of the Great Plains physiographic province (see Fig. 1a) south of the Canadian River that lies in eastern New Mexico and western Texas. It is a plateau of approximately 20,000 square miles, bounded on three sides by near vertical escarpments from 500 to 1,000 feet in height (Wendorf et al., 1961: 14). These caprock cliffs are prominent along the western, northern and eastern margins. Toward the south the Llano Estacado merges gradually with the Edwards Plateau (Lotspeich and Coover, 1962). Throughout this large area the surface is remarkably flat; however, there is a gentle slope downward of approximately ten feet per mile to the east and southeast (Wendorf et al., 1961: 14). The surface is little eroded by water except along the escarpment where short canyons extend several miles into the plain. The interior of the plain is essentially lacking in prominent topographic features.

The surface of the Llano Estacado is marked by a large number of playas. These depressions are believed to be the result of alternating periods of leaching and wind

deflation. Playas range in size from a few feet to several miles in diameter and from a few inches to over a hundred feet in depth (Wendorf et al., 1961: 14).

The textural pattern of the soil (see Fig. 1b) suggests that the dominant source of sediment was from the west and southwest. Soil color varies from reds along the western edge, where sands dominate, to dark grayish-brown on the northeastern part where silty clay loam soils occur (Lotspeich and Coover, 1962). Hues of the surface soils vary from 7.5 YR in the south to 10 YR in the north and northeast. A sand dune area extends from the western escarpment eastward between Clovis and Portales, New Mexico, to northeast of Littlefield, Texas, (see Fig. 1b) and another dune area lies north of Plains, Texas.

Because of the absence of topographic variety, the climate of the entire Llano Estacado is remarkably similar (Wendorf et al., 1961: 16). It is semi-arid and continental climate with low and irregularly distributed precipitation. Table 1 lists the mean annual temperature, mean January temperature, mean July temperature days above 32^oF, and mean total annual precipitation for a period from January 1956 through January 1966 for eleven selected localities.

Blair (1950) placed the Llano Estacado in the Short-grass Plains Biotic District of the Kansan Province. Most of the native vegetation of the Llano Estacado was a mixed

Fig. 1a.--Outline Map of the Llano Estacado

Fig. 1b.--Soil Textural Pattern

TABLE 1

CLIMATOLOGICAL DATA

1956-1965

(temperature in degrees F, precipitation in inches)

Station	Temperature			Precipitation	
	Jan. Avg.	July Avg.	Annual Avg.	Days above 32°F	Annual Total
Miami	33.8	79.9	57.3	197	22.06
Amarillo	34.8	78.4	57.2	204	22.15
Canyon	37.2	78.0	58.2	203	21.04
Plainview	35.7	78.1	58.3	204	20.57
Lubbock	37.9	79.8	59.7	216	17.18
Brownfield	37.9	79.4	59.7	215	15.93
Hobbs	41.8	80.6	62.0	221	13.49
Midland	42.8	82.2	63.7	238	14.59
Crosbyton	37.8	79.6	59.5	210	20.29
Lubbock	37.9	79.8	59.7	216	17.18
Muleshoe	35.5	78.2	57.3	201	17.58
Portales	35.6	77.4	57.2	176	15.95

prairie of buffalo-grass (Buchloe dactyloides) and grama grass (Bouteloa, ssp.) (Wendorf et al., 1961). Today much of the Llano Estacado is under cultivation. In the sand dune section, shin-oak (Quercus havardii), sand and hop sage (Artemisia spp.), broom sedge (Andropogon spp.), and yucca (Yucca glauca) are common. In the southern sections, mesquite (Prosopis spp.) is common.

Sample Localities

Figure 2 shows localities from which specimens were examined. From these, I have selected eleven sample localities for analysis (see Fig. 3). It was necessary to lump localities of close geographic proximity for each sample. A north-south transect consists of samples from Miami, Roberts County, Texas; Washburn, Armstrong County, Texas; Randall County, Texas; Hart, Castro County, Texas; Plainview, Hale County, Texas; Lubbock, Lubbock County, Texas; Terry County, Texas; Hobbs, Lea County, New Mexico; and Odessa, Ector County, Texas. An east-west transect employs samples from Crosbyton, Crosby County, Texas; Lubbock, Lubbock County, Texas; and Roosevelt County, New Mexico--Bailey County, Texas.

Fig. 2.--Localities of Specimens Examined

Fig. 3.--Sample Localities

Materials

In this study, 238 specimens of P. maniculatus from the Llano Estacado have been examined. Most were conventional study skins accompanied by cleaned skulls and external measurements. A few specimens were preserved in alcohol or formalin or as complete skeletons. Additionally, a total of 105 specimens of Peromyscus maniculatus blandus, luteus, nebrascensis, ozarkiarum, pallesens, and rufinus were examined for comparative purposes.

The source of specimens examined and abbreviations for same are as follows:

American Museum of Natural History--AMNH

Eastern New Mexico University Natural History
Collection--ENMU

University of Kansas Museum of Natural History--KU

Midwestern University Collection of Recent Mammals--MU

Texas Technological College Collection of Recent
Mammals--TTC

United States National Museum--USNM

University of Texas Natural History Collection--TU

Wayland Baptist College Natural History Collection--WBC

Measurements

Measurements of total length, length of tail, hind-foot, and ear are those usually recorded by the collector.

Body length (or head and body length) has been calculated. Skulls were measured using calipers graduated to five hundredths of a mm. Thus, the limit of error in determining each cranial measurement is ± 0.05 mm. Cranial measurements employed have been selected from those used by Dice (1933), Hooper (1952) and Cockrum (1962). They are: (1) Condylar-basilar length--From the posterior margin of the occipital condyle to the angle at the most anterior part of the zygomatic process of the maxilla; (2) Condylar-zygomatic length--From the posterior margin of the occipital condyle to the angle at the most anterior part of the zygomatic process of the maxilla; (3) Zygomatic breadth--The greatest distance across the zygomatic arches of the cranium perpendicular to the long axis of the skull; (4) Greatest breadth across bullae--The greatest distance across the widest portion of the bullae; (5) Nasal length--From the most anterior part of either nasal to the most posterior extension of that nasal in the median line of the skull; (6) Rostral breadth--The greatest transverse breadth of the rostrum; (7) Length of incisive foramen--The greatest length of one of the incisive foramina; (8) Length of palate--The greatest length of the hard palate between the mesopterygoid fossa and the incisive foramina; (9) Least interorbital constriction--The least diameter of the frontal bones between the orbital fossae; (10) Depth of cranium--

The distance from the dorsal limits of the brain case to a horizontal plane passing through the incisor tips and the ventral borders of the auditory bullae (see Hooper, 1952); (11) Length of maxillary molar series--The distance from the anterior border of the anterior molar to the posterior border of the posterior molar; (12) Length of mandibular molar series--Same as (11); (13) Mandibular height--Greatest horizontal distance from the ventral border of the ramus of the mandible to the dorsalmost point of the first molar; (14) Mandibular length--The greatest length of either ramus, from the posteriormost projection of the mandibular condyle of that ramus to the anteriormost point of the ramus.

Pelages and Pelage Color

Osgood (1909) and Collins (1918) have discussed the sequential molts during growth to maturity in Peromyscus. Three distinct pelages are recognized: juvenile, subadult, and adult. Apparently breeding is continuous throughout the year (Hamilton, 1943), so that specimens of various ages may be taken at almost all seasons. After the adult pelage is assumed there is one annual molt; however, the exact time is extremely variable, so that season is usually of little value for determining the pelage of a given individual (Osgood, 1909: 19). Collins (1918) has discussed

the origin, sequence, and directions of growth in the assumption and regeneration of pelage of P. m. gambeli, P. m. rubidus, and P. m. sonoriensis. Osgood (1909, 19-21) discussed the effect of wear on the dorsal pelage. This is indicated by a general brightening of color owing to wear of the black or dusky tips of certain hairs, thus exposing various shades of buff. If one considers the various factors that affect pelage such as wear, secondary renewal, and age phases it is virtually impossible, except in large collections, to find two series of specimens that are comparable as to condition of pelage.

The nature and extent of variation in color must be recognized before conclusions are made concerning differences in color between populations. Munsell Soil Color Charts (1942) were used as color standards in this study. R. S. Miller (1958) and Bowers (1956) have discussed the advantages of this system of color notation. The Munsell System is the official standard used by the U.S. Soil Conservation Service for classifying the colors of various types of soils. Numerous authors have emphasized the selective advantage of concealing coloration in mice. Dice (1947) conducted experiments designed to test the ability of owls to discriminate between concealing and non-concealing colors of pelage. He found barn owls (Tyto alba pratincola) and long-eared owls (Asio wilsonianus), under simulated night-time illuminations, captured significantly more mice that were

conspicuous on their background than those that resembled the background. I used soil charts to determine color of surface soil at each sample locality in this study; it seemed advisable, therefore, to use the same color notations for pelage color.

Color readings were taken for adults and subadults (see Fig. 4). Color determinations were made for three areas on each specimen. A dorsal reading was made on the median line of the back approximately 10 mm posterior to a point between the shoulders. An area on the side was read just lateral to the area for the dorsal reading. Care was taken to place this side area midway between the edge of the dorsal stripe and the border of the white underparts. A reading was also taken on the tail stripe midway between the rump and the tip of the tail. A graph of the color notations for each sample is illustrated in Fig. 4.

Age Classes

In this study each specimen was assigned to one of three age levels: juvenile, subadult, or adult. Specimens classified as juveniles were seemingly sexually immature, whereas adults were apparently sexually mature. The subadults had approached or recently attained sexual maturity. These age groups were based upon the following criteria:

- (1) juveniles--in juvenile pelage or assuming subadult coat, skull fragile, sutures between bones incompletely closed

Fig. 4.--Comparison of pelage color in samples of Peromyscus maniculatus from the Llano Estacado. Number of specimens in each sample is indicated below sample name. Graphs are arranged from left to right as follows: color of dorsum, color of side, color of tail stripe. Vertical lines separate hue notations. Value/chroma notations are listed below corresponding bars. Percent of sample exhibiting a given color notation is indicated by a bar. Percent of color notation exhibited by subadults is indicated by black blocks. Percent of color notation exhibited by adults is indicated by open blocks. Soil color at the sample locality is indicated to the right of graphs.

MIAMI
N:18

WASHBURN
N:10

RANDALL CO.
N:8

HART
N:18

PLAINVIEW
N:35

LUBBOCK
N:41

BROWNFIELD
N:9

HOBBS
N:17

ODESSA
N:4

CROSBYTON
N:6

ROOSEVELT CO.
BAILEY CO.
N:14

and molar teeth, if completely emerged, unworn; (2) subadults--in subadult pelage or molting into adult pelage, skull resembles adult, but bones less completely fused and brain case relatively higher, molar teeth completely emerged (M3 shows slight wear); (3) adults--bright adult pelage acquired, cranial bones well ossified and ankylosed, molar teeth well worn with dentine of all primary cusps occlusally confluent. Only those specimens classified as adults were used for comparative purposes and in statistical analysis.

Sexual Variation

The measurements for each character in the Lubbock and Plainview samples were graphed using the Hubbs and Hubbs method (1953). When inspection indicated a possible difference (see Simpson, Roe and Lewontin, 1960: 353) a Student's t-test was employed. The mean, standard deviation, standard error and sample size for all linear measurements are given in Table 2. In the Plainview sample there are no apparent differences between the sexes in any of the characters examined on the basis of the graphs, thus t-tests were not employed. In the Lubbock sample, males were significantly larger than females in length of hindfoot, greatest breadth across bullae, and length of mandibular molar series. Dice (1932) found that male P. m. bairdii tend to exceed females in hindfoot length, weight, length of tail vertebrae and bullar width. Males of P. m. rufinus

TABLE 2
SEXUAL VARIATION
(Measurements in Millimeters)

Sex and Character	Plainview				Lubbock				Significant + Values
	N	$\bar{X}$	SD	SE	N	$\bar{X}$	SD	SE	
M. Total Length	19	139.37	12.72	2.92	17	130.65	10.00	2.50	2.161 .05
F. Total Length	12	139.50	15.36	4.44	12	130.92	8.68	2.51	
M. Tail Length	19	57.37	8.55	1.96	18	51.50	5.87	1.42	
F. Tail Length	13	55.92	4.58	1.27	12	50.00	3.61	1.04	
M. Hindfoot Length	18	18.33	2.36	.56	18	17.72	1.11	.26	
F. Hindfoot Length	12	18.91	1.00	.29	12	16.67	1.45	.42	
M. Ear Length	16	14.44	1.34	.34	18	13.72	.84	.20	
F. Ear Length	13	14.00	1.29	.36	12	13.83	1.09	.32	
M. Body Length	19	82.00	5.47	1.25	17	79.41	7.70	1.87	
F. Body Length	12	84.50	10.86	3.14	12	81.58	6.19	1.79	
M. Condylar-Basilar Length	14	21.67	1.16	.31	15	21.39	.95	.24	2.345 .05
F. Condylar-Basilar Length	10	22.00	.68	.22	11	21.11	.43	.13	
M. Condylar Zygomatic Length	14	16.58	.96	.25	15	16.48	.70	.18	
F. Condylar Zygomatic Length	10	16.75	.36	.11	11	16.32	.29	.09	
M. Zygomatic breadth	14	12.36	.92	.25	15	12.26	.38	.10	
F. Zygomatic breadth	14	12.44	.40	.13	12	12.23	.29	.08	
M. Bullar width	14	10.61	.44	.12	15	10.58	.32	.08	
F. Bullar width	10	10.50	.31	.10	11	10.31	.25	.08	
M. Nasal length	13	9.08	.64	.18	15	8.91	.55	.14	
F. Nasal length	10	9.18	.59	.19	12	8.85	.59	.18	
M. Rostral breadth	14	4.51	.32	.09	15	4.40	.24	.06	3.710 .005
F. Rostral breadth	10	4.54	.26	.08	12	4.32	.19	.06	
M. Length of incisive foramina	13	4.72	.34	.09	15	4.65	.26	.07	
F. Length of incisive foramina	10	4.83	.32	.10	12	4.74	.23	.07	
M. Palate length	13	3.65	.24	.07	15	3.52	.32	.08	
F. Palate length	10	3.60	.18	.06	12	3.51	.17	.05	
M. Least interorbital constriction	14	3.55	.16	.04	15	3.48	.13	.04	
F. Least interorbital constriction	10	3.47	.16	.04	12	3.50	.13	.04	
M. Cranial depth	14	8.72	.36	.10	15	8.57	.23	.06	
F. Cranial depth	10	8.85	.46	.15	11	8.53	.12	.04	
M. Length of maxillary molar series	14	3.35	.15	.04	15	3.39	.14	.04	3.710 .005
F. Length of maxillary molar series	10	3.38	.10	.03	12	3.30	.15	.04	
M. Length of mandibular molar series	14	3.45	.15	.04	15	3.53	.15	.04	
F. Length of mandibular molar series	10	3.45	.10	.03	12	3.33	.14	.04	
M. Mandibular height	14	3.94	.35	.09	15	3.78	.21	.05	
F. Mandibular height	10	3.89	.20	.06	12	3.83	.16	.05	
M. Mandibular length	14	13.25	.96	.26	15	12.78	.61	.16	
F. Mandibular length	10	13.29	.45	.14	12	12.85	.31	.09	

also (Dice, 1933) had larger hindfeet and were heavier than females. Fox (1948) found females significantly larger in body length than males in two of seventeen samples. Fox (1948) states " . . . The samples used by Dice were large enough to determine that there are sexual differences in size in the genus *Peromyscus*, but for the most part, the differences are slight and appear not to be significant." Both authors (Dice, 1932, 1933, and Fox, 1948) included males and females in the same population sample. I have included males and females in the same sample, but have not considered hindfoot length, bullar width or length of the mandibular molar series in the comparisons of samples.

Statistical Treatment

The following statistical treatments were employed:

- (1) mean, $\bar{X}$; (2) standard error of the mean, SE;
- (3) standard deviation, SD; (4) coefficient of variation, V;
- and (5) value of t , t . (See Simpson et al., 1960, for explanation.) The .05 per cent level was selected as significant for t -values.

Both desk calculator and the Texas Technological College Computer Center facilities were used in this study. Means, standard deviations, and standard errors, were computed using a program written by the Health Science Computing Facility of the University of California at

Los Angeles. T-tests were computed using a standard program in the statistical library of the Computer Center at Texas Technological College.

Graphic presentation of data follows the method of Hubbs and Hubbs (1953). The 95 per cent confidence interval was employed instead of two standard errors on either side of the mean because two standard errors on either side of the mean encompasses the 95 per cent confidence interval only in very large samples (Simpson et al., 1960: 352). The 95 per cent confidence interval was constructed using the t distribution for $N-1$ in order to compensate for small sample size. The vertical line represents the mean. The number of specimens (N) is indicated to the left of each graph.

Simpson et al. (Wendorf et al., 1960: 352) point out that the correspondence between overlap and significance depends upon the relative sample sizes and standard errors of the two samples; intervals may overlap markedly despite a significant difference between the mean at the 0.05 per cent level, and, conversely, means which are not significantly different may have non-overlapping intervals. Therefore, I employed a t-test for each characteristic for all possible pairs of samples. T-tests are not needed if the confidence interval for one sample includes the observed mean for another sample (Simpson et al., 1960: 353), thus

t-values are listed only in those cases that are significant at the .05 level.

Sample Variation

Owing to small sample size, specimens of near geographic proximity have been lumped. Coefficients of variation of cranial measurements in my samples compared favorably with the c. v.'s of those measurements reported by Clark (1941) for highly selected and standardized samples of laboratory raised stocks of deer mice. However, the c. v.'s of external measurements in my samples did not compare favorably with those reported by Clark (1941) and Dice (1933). Differences probably resulted from measurements being recorded by several collectors. Coefficients of variation of a sample from Hobbs, New Mexico, wherein all measurements were made by me (see Table 3) have been compared to figures taken from Dice (1933). His samples (P. m. rufinus) from Cloudcroft, New Mexico, were composed of wild-killed and first year age class cage-reared animals. Table 4 lists the c. v.'s for all characters for samples consisting of five or more specimens.

Texas Samples

Miami.--6 mi. N Miami, Roberts County, 15 (14-MU, 1-TTC); 9 mi. NNE Miami, in Hemphill County, 3 (MU). Red

TABLE 3

VARIABILITY OF BODY MEASUREMENTS

Coefficients of Variation				
Cloudcroft, New Mexico				
Hobbs, New Mexico				
Wild-killed (sexes combined)				
1-year age class				
Wild-killed				
Wild-killed (sexes combined)				
Body length	M.	4.90	4.09	
	F.	4.75	4.50	3.95
Tail length	M.	7.53	8.47	
	F.	6.34	6.70	9.57
Hindfoot length	M.	4.16	3.95	
	F.	3.19	1.72	6.25
Ear length	M.	4.16	4.51	
	F.	4.32	2.97	6.96

TABLE 4
VARIABILITY OF MEASUREMENTS
(N in parenthesis)

Coefficients of Variation									
Character	Miami	Wash- burn	Randall Co.	Hart	Plain- view	Lubbock	Brown- field	Hobbs	Roosevelt Co.--- Bailey Co.
Total length	(14) 6.63	(8) 4.37	(7) 4.56	(14) 7.59	(31) 9.56	(31) 7.30	(5) 5.69	(11) 3.22	(12) 5.36
Tail length	(14) 7.05	(8) 7.28	(7) 10.86	(14) 9.07	(31) 12.53	(31) 10.08	(5) 5.61	(11) 9.57	(12) 10.17
Hindfoot length	(14) 6.67	(8) 2.32	(7) 2.81	(14) 5.79	(30) 9.27	(31) 6.88	(4) 5.32	(12) 6.25	(10) 7.77
Ear length	(13) 10.94		(7) 9.20	(14) 9.22	(29) 9.09	(31) 5.88	(5) 15.15	(12) 6.96	(9) 10.75
Body length	(14) 9.82	(8) 3.67	(7) 10.77	(14) 5.13	(31) 8.52	(30) 8.79	(5) 6.37	(12) 3.95	(12) 8.32
Condyllo-basilar length	(11) 1.75	(5) 2.18	(7) 2.83	(14) 3.55	(24) 5.01	(28) 3.70	(5) 2.98	(12) 3.40	(6) 4.09
Condyllo-zygomatic length	(11) 1.78	(5) 2.84	(7) 3.47	(13) 3.72	(24) 4.66	(28) 3.34	(5) 3.18	(12) 3.21	(6) 3.79
Zygomatic breadth	(12) 3.69	(5) 2.59	(7) 3.45	(13) 3.71	(24) 5.98	(27) 2.77	(5) 1.21	(12) 3.80	(6) 2.96
Bullar width	(13) 2.15	(5) 3.31	(7) 2.00	(12) 3.65	(23) 2.96	(28) 2.14	(5) 3.00	(11) 4.09	(5) 4.09
Nasal length	(13) 4.82	(5) 3.88	(7) 7.38	(14) 5.80	(24) 6.50	(29) 6.17	(5) 3.69	(12) 5.88	(6) 6.93
Rostral breadth	(13) 5.64	(6) 6.54	(6) 4.96	(14) 6.37	(23) 6.19	(29) 5.04	(5) 6.14	(12) 4.17	(6) 7.44
Length of incisive foramen	(13) 4.36	(6) 3.62	(6) 4.14	(14) 6.16	(23) 6.74	(29) 5.09	(5) 4.13	(12) 6.00	(6) 3.55
Length of palate	(11) 5.48	(5) 7.00	(7) 7.10	(14) 6.32	(24) 5.60	(29) 7.10	(5) 5.32	(12) 5.55	(6) 6.43
Least intevorbital constriction	(12) 5.86	(5) 4.01	(7) 5.96	(13) 5.77	(24) 4.66	(28) 4.01	(5) 6.34	(12) 4.59	(6) 3.31
Depth of Cranium	(13) 3.07	(6) 2.69	(7) 2.90	(14) 2.17	(24) 4.54	(29) 2.45	(5) 2.52	(12) 2.77	(6) 2.84
Length of maxillary molar series	(13) 4.31	(6) 4.86	(7) 6.35	(14) 3.52	(24) 3.85	(29) 4.17	(5) 9.72	(12) 3.60	(6) 5.21
Length of mandibular molar series	(13) 3.52	(6) 4.38	(7) 4.18	(14) 3.50	(24) 3.77	(29) 4.94	(5) 3.86	(12) 4.40	(6) 6.09
Height of mandible	(12) 5.50	(5) 5.12	(7) 5.71	(14) 5.43	(24) 7.81	(29) 4.72	(5) 4.12	(12) 5.27	(6) 5.87
Length of mandible	(12) 3.48	(5) 2.45	(7) 3.72	(14) 3.39	(24) 5.81	(29) 4.28	(5) 2.96	(12) 4.20	(6) 3.72

Deer Creek flows northeastward into the Canadian River through a deeply incised canyon on the northeastern part of the Llano Estacado. Cottonwood trees (Populus deltoides) are abundant along the flood plain of this creek. The canyon slopes and adjacent plains are dominated by blue grama (Bouteloua gracilis) and hairy grama (Bouteloua hirsuta). Indiangrass (Sorghastrum nutans) is abundant in gulleys. P. maniculatus was taken only along the upper canyon slopes. P. leucopus was abundant in the cottonwood association along the stream, and less commonly on the slopes.

Washburn.--Washburn, Armstrong County, 10 (USNM); Bailey (1905) referred this series to P. sonoriensis. He reported that one specimen was captured on the short-grass plains " . . . miles from any cover that would conceal even a mouse" and that others were captured on the prairie at the edges of fields.

Randall County.--Palo Duro State Park 6 (3-TTC, 2-WBC, 1-TU); vic. Buffalo Lake National Wildlife Refuge, 3 (TTC); 27 mi. S Amarillo, 1 (TU). I collected the specimens from the Buffalo Lake locality in Indiangrass which is common in gulleys in the buffalograss-grama-yucca association at this locality.

Hart.--4 mi. NW Hart, Castro County, 9 (TTC); 4 mi. NW, 1 mi. E Hart, 9 (WBC); 1 1/2 mi. W Hart, 1 (WBC). I

collected the specimens from 4 mi. NW Hart along a railroad right-of-way in blue grama.

Plainview.--35 (WBC) specimens from localities within an eight mile radius of Plainview, Hale County; 1 mi. W Finney, Hale County, 1 (WBC); 5 mi. N Abernathy, Hale County, 1 (TTC). Most of the land in Hale County is cultivated. Mr. Hoyt Bowers, Assistant Professor of Biology at Wayland Baptist College, informs me (pers. comm.) that most of the specimens were taken along railroad right-of-ways and along the margins of playas.

Lubbock.--31 (TTC) specimens from within a 14 mile radius of Lubbock, Lubbock County; 10 (TTC) from within a 6 mile radius of Slaton, Lubbock County. Specimens from near Slaton were taken near the margin of Yellow House Canyon in Johnsongrass along road right-of-ways and around rock piles. Rock piles are seemingly preferred as den sites by deer mice on the Llano Estacado. Heavily grazed areas along the canyon seem not to offer adequate cover for deer mice. Deer mice from near Lubbock were taken along railroad right-of-ways and around the margins of playas.

Terry County.--9 1/2 mi. NW Brownfield, 3 (WBC); Meadow, 3 (TTC); 10 mi. S Brownfield, 2 (TTC); 1 mi. S Wellman, 1 (TTC). Specimens from Meadow were taken along a railroad right-of-way. Specimens from 10 mi. S Brownfield were collected in an abandoned field that supported a

dense growth of scrub oak. The specimen from 1 mi. S Wellman was collected in an abandoned field that supported sparse grasses and yucca.

Odessa.--9 mi. N Odessa, Ector County, 5 (TTC).

Specimens were taken in a mesquite-grama-buffalograss association where Sigmodon hispidus and Neotoma micropus were extremely abundant.

Crosbyton.--6 (5-TTC, 1- MU). Specimens from within a 10 mi. radius of Crosbyton, Crosby County. Specimens were taken along the slopes of the canyon cut by the White River. Two were taken from traps set near a rock pile, the rest in buffalo grass and blue grama.

New Mexico Sample

Hobbs.--15 mi. W Hobbs, Lea County, 14 (TTC); 17 1/2 mi. W Hobbs, 1 (TTC); 2 1/2 mi. E Maljamar, Lea County, 1 (TTC); 19 mi. E Maljamar, 1 (TTC). Specimens from 15 mi. W Hobbs were captured in a buffalograss-blue grama association along a terrace of bladed-up asphalt road. Specimens from 2 1/2 mi. E Maljamar and from 19 mi. E Maljamar were taken along a low terrace of caliche rocks, that were bladed-up in forming the shoulder of roads. The specimen from 17 1/2 mi. W Hobbs was taken in 6 ft. high Indiangrass growing in a low swale.

New Mexico--Texas SampleRoosevelt County New Mexico--Bailey County, Texas.--

Pep, Roosevelt Co., 6 (TTC); Portales, Roosevelt Co., 4 (ENMU); 22 mi. S Muleshoe, Bailey Co., 2 (TTC); 20 mi. S Muleshoe, 2 (TTC). Most of the land from Hobbs to Portales is used for grazing cattle. Buffalograss and blue grama are dominant. Specimens from near Pep were taken near trash piles. Specimens from Bailey County, were taken along the margin of Muleshoe National Wildlife Refuge.

CHAPTER III

RESULTS AND DISCUSSION

Comparison of Samples

Total Length

Total length was the least variable external measurement (see Table 4). Coefficients of variability conformed to average (5 to 6) values set forth by Simpson et al. (1960:91) in all but the two largest samples (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 5) showed no distinct differences. Significant t-values for non-adjacent pairs of samples are listed in Table 5. Total length decreased gradually to the Lubbock sample. From Lubbock there was a gradual increase again to the south. If it were not for the intermediate samples one might conclude that the difference between the Washburn and Lubbock samples was significant. Comparison of samples in an east-west transect (see Fig. 6b) indicated a possible difference between the Lubbock and Roosevelt Co.-Bailey Co. samples; however a t-test was not significant. The number of samples in the east-west transect was too few to illustrate trends clearly, however seemingly there was an increase in total length from east to west.

TABLE 5

T-VALUES
(significant at .05 level or above)

Measurement	Miami- Washburn	Miami- Lubbock	Washburn- Lubbock	Washburn- Brownfield	Washburn- Plainview	Washburn- Hobbs	Washburn- Odessa
Total Length			5.680 36df	6.980 11df	2.490 36df	5.840 17df	3.780 9df
Tail Length		4.593 43df	6.500 37df	5.43 11df			
Ear Length		3.991 42df					
Body Length			2.820 36df	3.447 11df		5.870 18df	
Condyllo-basilar Length	2.268 14df		3.050 31df				
Condyllo-Zygomatic Length			2.981 31df				
Zygomatic Breadth		4.252 38df	2.917 32df				
Nasal Length			6.000 29df				
Length of Incisive Foramen	3.579 17df		2.522 33df				
Depth of Cranium		4.565 37df	3.429 31df				
Length of Palate							
Least Interorbital Constriction							

TABLE 5--Continued

Measurement	Randall Co.- Lubbock	Hart- Lubbock	Hobbs- Lubbock	Hart- Hobbs	Hart- Odessa	Brownfield- Odessa	Roosevelt Co.- Bailey Co.- Lubbock
Total Length		5.136 42df					
Tail Length	5.106 36df						
Ear Length	3.938 36df	4.669 43df	4.154 41df				
Body Length		4.094 42df		6.192 24df			
Condyllo-Basilar Length							
Condyllo-Zygomatic Length					5.487 12df	11.329 4df	3.927 33df
Zygomatic Breadth							
Nasal Length							
Length of Incisive Foramen							
Depth of Cranium		4.673 39df	4.302 38df				
Length of Palate					5.043 13df		
Least Interorbital Constriction	3.930 34df						

Fig. 5.--Variation in overall length. The horizontal line represents the range; the vertical midline the arithmetic mean. The black part of each bar represents 95% confidence interval of the mean on either side of the mean. One half of each black bar plus the white bar at either end outline 1 SD on either side of the mean. Samples localities are indicated by first two letters of name. Distance on the graph between samples is proportional to the actual distance between localities. Number of specimens for each locality is shown to the right of sample name. Direction of transect is indicated by arrow and appropriate letter symbol.

TAIL LENGTH

Fig. 6a

OVERALL LENGTH

Fig. 6b

Fig. 6a and 6b.--Variation in length of tail and overall length. See Fig. 5 for explanation of symbols.

Tail Length

Tail length was one of the most variable measurements (see Table 4). Comparison of adjacent samples in a north-south transect (see Fig. 7) revealed a difference only between the Plainview and Lubbock samples; however, a t-test showed that the difference was not significant. There were significant differences between non-adjacent pairs of samples (see Table 5). The trend was essentially the same as for total length. Figure 6a shows no distinct differences between samples in an east-west transect.

Ear Length

Ear length was extremely variable in samples wherein specimens were measured by several collectors (see Tables 3 and 4). Ear length was not recorded by the collectors of the Washburn sample. Comparison of adjacent samples in a north-south transect (see Fig. 8) showed a possible difference between the Hobbs and Odessa samples; however a t-test was not significant. Significant differences between pairs of non-adjacent samples are listed in Table 5. The trend was similar to that for total length and tail length. Comparison of samples in an east-west transect (see Figure 9b) showed no significant differences between samples. A trend toward longer ears to the west was suggested.

TAIL VERTEBRAE

Fig. 7.--Variation in length of tail.
See Fig. 5 for explanation of symbols.

Fig. 8.--Variation in length of ear.
See Fig. 5 for explanation of symbols.

BODY LENGTH

Fig. 9a

EAR LENGTH

Fig. 9b

Figs. 9a and 9b.--Variation in length of body and length of ear. See Fig. 5 for explanation of symbols.

Body Length

Coefficients of variation only slightly exceeded average values (5 to 6) in most samples. Comparison of adjacent samples in a north-south transect (see Fig. 10) revealed distinct differences between the Hart and Plainview samples and between the Hobbs and Odessa samples; however, t-tests indicated neither was significant. Significant t-values for pairs of non-adjacent samples are listed in Table 5. The trend was similar to that for other external measurements. Figure 9a compares samples in an east-west transect. There were no significant differences between the samples. A gradual increase in body length from east to west was apparent.

Condylar-basilar Length

Condylar-basilar length was one of the least variable cranial measurements (see Table 4). Figure 11 compares samples in the north-south transect. Comparison of adjacent samples showed a distinct difference between the Miami and Washburn samples; a t-test is significant (see Table 5). There was, also, a significant difference between the Washburn and Lubbock samples. The trend was essentially the same as that exhibited by external measurements. Figure 12a compares samples in an east-west transect. There were no significant differences between samples.

BODY LENGTH

Fig. 10.--Variation in length of body.
See Fig. 5 for explanations of symbols.

Fig. 11.--Variation in condylo-basilar length of skull. See Fig. 5 for explanation of symbols.

CONDYLO—BASILAR LENGTH

Fig. 12a

CONDYLO—ZYGOMATIC LENGTH

Fig. 12b

Figs. 12a and 12b.--Variation in condylo-basilar and condylo-zygomatic length of skull. See Fig. 5 for explanation of symbols.

Condyllo-zygomatic Length

This measurement is a function of condylo-basilar length and shows little variability (see Table 4). Comparison of samples in the north-south transect (see Fig. 13) showed no distinct differences between adjacent samples. The trend was similar to that exhibited by condylo-basilar length. A t-test revealed a significant difference between the Washburn and Lubbock samples (see Table 5). Comparison of adjacent samples in an east-west transect (see Fig. 12b) revealed no significant differences between samples. There was a suggestion of a trend toward larger dimensions to the west.

Zygomatic Breadth

This measurement is a function of cranial breadth and shows little variability (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 14) indicated a difference between the Hobbs and Odessa samples; however, a t-test was not significant. Significant differences between pairs of non-adjacent samples are listed in Table 5. The trend is similar to that exhibited by condylo-basilar length and condylo-zygomatic length. Comparison of samples in an east-west transect (see Fig. 15a) showed a significant difference (see Table 5) between the Lubbock and Roosevelt Co.-Bailey Co. sample. A trend to larger zygoma to the west was suggested.

Fig. 13.--Variation in condylo-zygomatic length of skull. See Fig. 5 for explanation of symbols.

Fig. 14.--Variation in zygomatic breadth of skull. See Fig. 5 for explanation of symbols.

ZYGOMATIC BREADTH

Fig. 15a

LENGTH OF MANDIBLE

Fig. 15b

Figs. 15a and 15b.--Variation in zygomatic breadth of skull and length of mandible. See Fig. 5 for explanation of symbols.

Nasal Length

Coefficients of variability were average in all samples except Randall Co. (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 16) indicated a possible difference between the Hobbs and Odessa samples; however, a t -test was not significant. Comparison of non-adjacent samples revealed a significant difference between the Washburn and Odessa samples (see Table 5). The trend was similar to that for other cranial measurements. Figure 18a shows the comparison of samples in the east-west transect. No significant differences were detected.

Rostral Breadth

Coefficients of variation were close to average (5 to 6) values in all samples except Roosevelt Co.-Bailey Co. which was slightly higher (see Table 4). No differences were apparent in adjacent samples of the north-south transect (see Fig. 17). T -tests between adjacent and non-adjacent samples revealed no significant differences. Washburn mice averaged smaller in rostral breadth than those from Miami or Randall Co. Plainview mice averaged slightly larger in rostral breadth than mice from Hart. These exceptions modified the general trend for the cranial measurements, thus no trend was evident for this measurement in the north-south transect. Figure 18b compares rostral

Fig. 16.--Variation in length of nasal bones. See Fig. 5 for explanation of symbols.

Fig. 17.--Variation in breadth of rostrum. See Fig. 5 for explanation of symbols.

NASAL LENGTH

Fig. 18a

ROSTRAL BREADTH

Fig. 18b

Figs. 18a and 18b.--Variation in length of nasal bones and breadth of rostrum. See Fig. 5 for explanation of symbols.

breadth in samples in an east-west transect. There were no significant differences.

9

Length of Incisive Foramen

Coefficients of variation were average (5 to 6) or below (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 19) indicated a difference between the Miami and Washburn samples and a t -test revealed a significant difference (see Table 5). Significant t -values for tests between non-adjacent samples are listed in Table 5. The trend was similar to that for most cranial measurements. Figure 20a compares length of incisive foramen in an east-west transect. There were no significant differences.

Length of Palate

Coefficients of variation slightly exceeded average values in the Washburn, Randall Co. and Lubbock samples (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 21) revealed a difference between the Plainview and Lubbock samples; however, a t -test indicated the difference was not significant. T -tests between pairs of non-adjacent samples showed a significant difference between the Hart and Odessa samples (see Table 5). Mice of the Washburn sample averaged smaller than mice of

Fig. 19.--Variation in length of incisive foramen. See Fig. 5 for explanation of symbols.

LENGTH OF INCISIVE FORAMEN

Fig. 20a

LENGTH OF PALATE

Fig. 20b

Figs. 20a and 20b.--Variation in length of incisive foramina and length of palate. See Fig. 5 for explanation of symbols.

Fig. 21.--Variation in length of palate. See Fig. 5 for explanation of symbols.

the Miami or Randall Co. samples. Also, mice of the Hobbs and Odessa samples averaged smaller than mice of the Lubbock sample. Figure 20b compares samples in an east-west transect; no differences were indicated and a trend was not evident.

Least Interorbital Constriction

Coefficients of variation (see Table 4) were average or below. Comparison of adjacent samples in the north-south transect (see Fig. 22) revealed a difference between the Hobbs and Odessa samples; however, a t -test was not significant. Significant differences between pairs of non-adjacent samples are indicated by t -values listed in Table 5. Figure 24a compares adjacent samples in an east-west transect. There were no significant differences between samples.

Depth of Cranium

Coefficients of variation were low in all samples (see Table 4). Comparison of adjacent samples in the north-south transect (see Fig. 23) showed decided differences between the Plainview and Lubbock samples and the Hobbs and Odessa samples; however, t -tests were not significant. Significant t -values for pairs of non-adjacent samples are listed in Table 5. The trend was similar to

LEAST INTERORBITAL CONSTRICTION

Fig. 22.--Variation in least interorbital constriction of cranium. See Fig. 5 for explanation of symbols.

Fig. 23.--Variation in depth of cranium.
See Fig. 5 for explanation of symbols.

LEAST INTERORBITAL CONSTRICTION

Fig. 24a

DEPTH OF CRANIUM

Fig. 24b

Figs. 24a and 24b.--Variation in least interorbital constriction and depth of cranium. See Fig. 5 for explanation of symbols.

that for zygomatic breadth. Figure 24b compares samples in an east-west transect. A slight difference exists between the Lubbock and Roosevelt Co.-Bailey Co. samples; however, a t -test is not significant.

Length of Maxillary Molar Series

Coefficients of variation were average or below (see Table 4). A comparison of adjacent samples in the north-south transect (see Fig. 25) showed a difference between the Plainview and Lubbock samples that was not significant. A t -test revealed a significant difference between the Washburn and Lubbock samples (see Table 5). Lubbock mice averaged larger than those of all samples except Randall Co. This was the only cranial measurement to exhibit such a trend. Generally, Lubbock mice averaged smallest in linear dimensions. Comparison of samples in an east-west transect (see Fig. 27a) revealed no distinct differences. There was a suggestion of a trend to larger dimensions to the west.

Height of Mandible

Coefficients of variation were average or below (see Table 4) except in the Plainview sample. Comparison of adjacent samples in the north-south transect (see Fig. 26) showed no distinct differences. T -tests confirmed this

LENGTH OF MAXILLARY MOLAR SERIES

Fig. 25.--Variation in length of maxillary molar series. See Fig. 5 for explanation of symbols.

MANDIBULAR HEIGHT

Fig. 26.--Variation in height of mandible. See Fig. 5 for explanation of symbols.

LENGTH OF MAXILLARY MOLAR SERIES

Fig. 27a

HEIGHT OF MANDIBLE

Fig. 27b

Figs. 27a and 27b.--Variation of length of maxillary molar series and height of mandible. See Fig. 5 for explanation of symbols.

observation. Figure 27b compares samples in an east-west transect. There were no significant differences. A trend to larger dimension westward was suggested.

Length of Mandible

Coefficients of variation were below average values in all samples except Plainview. Comparison of adjacent samples in the north-south transect (see Fig. 28) showed no distinct differences and t-tests confirmed this observation. The trend was similar to that for length of palate. Figure 15b compares samples in the east-west transect. No distinct differences were evident and t-tests were not significant.

Pelage Color

Considerable variation in pelage color was found in each sample (see Fig. 4). Subadults often exhibited the same pelage color as adults of the modal class. Therefore, pelage color was not as good for separation of adults from subadults as cranial characteristics. Disregarding pelage color of subadults, the typical (= modal) color was quite uniform in each sample and between samples. Typical side color (Munsell, 1942) ranges from 7.5 YR 5/6 (strong brown) to 7.5 YR 6/6 (reddish yellow). There was a single visual step difference between the two colors; the difference was

Fig. 28.--Variation in length of mandible.
See Fig. 5 for explanation of symbols.

in the value notation that indicates the degree of lightness or darkness of a color in relation to a neutral gray scale. Hence 7.5 YR 6/6 was slightly lighter than 7.5 YR 5/6. Typical color of dorsal pelage ranges from 7.5 YR 3/2 (dark brown) to 7.5 YR 4/4 (brown to dark brown) in all samples except mice from Miami. Thus, typical dorsal pelage varies slightly in darkness and saturation of color. The marked difference in dorsal pelage from side pelage results from the presence of dark brown to blackish dorsal guard hairs giving the effect of a dorsal stripe. A dorsal stripe is typical of many subspecies of Peromyscus maniculatus. The slight color difference between dorsal and side pelage in the Miami sample tends to eliminate or dilute the effect of a dorsal stripe. Typical color of the tail stripe ranges from 7.5 YR 2/0 (black) to 7.5 YR 3/2 (dark brown) in all samples save mice from Washburn. Their typical tail stripe color 7.5 YR 4/4 (brown to dark brown) was the same as typical dorsal pelage color. There was a distinct difference between color of the dorsum and color of the tail stripe in the Miami, Hart, Brownfield, Hobbs and Crosbyton samples.

Correlation between pelage color and soil color was not obvious. Furthermore, soil samples did not support trends for hues of surface soils reported by Lotspeich and Coover (1962). This may be owing to the fact that I

took only a single soil sample at each sample locality. Regardless of the presence or absence of a trend, one would expect darker colored mice on darker soils. I did not find this. For example, deer mice from Miami are brighter in general color pattern than other samples, yet Miami mice were obtained from grayish brown soils. Deer mice on the Llano Estacado were similar in color regardless of the color of the surface soil.

Dice (1947) demonstrated the selective advantage of correlation of pelage color with background color. However, the background effect need not be substrate. In areas where vegetation is dense (i.e., forms a thick mat or consists of tall closely spaced grasses) vegetation may indeed provide the background. Deer mice on the Llano Estacado are often found in dense vegetation, therefore, ecological preference may account for lack of correlation of pelage color with soil color.

Correlation of Morphological Characters and Environment

Hoffmeister (1951) suggested that character gradients (clines) in most species of Peromyscus in western North America proceed from north to south and east to west, often transecting each other. Generally, a decrease occurred in size of body and skull from north to south and similar changes in the same features were noted from the continental

interior toward the Pacific coast, (Hoffmeister, ibid.). Dice (1940, 1941) found deer mice larger from western North Dakota and western portions of the Nebraska sandhills compared to samples to the eastern parts of these areas respectively. He concluded (1941) " . . . this geographical size gradient seems to be characteristic of the deer mice of all the northern part of the Great Plains."

In an effort to correlate temperature and its relation to body size, I used linear dimensions of the body, condylo-basilar length, zygomatic breadth and cranial depth. Principal reliance has been on cranial measurements because these measurements are statistically more reliable than body length. Because of slight and gradual changes in elevation on the Llano Estacado from NW to SE (see Wendorf et al. 1961:14), elevation was disregarded as a factor influencing temperature.

Temperature data were collected from U.S. Weather Bureau stations at or nearby the collecting localities, except for Hart; thus, temperature is closely correlated to each sample of deer mice. In Table 1, stations were arranged from north (top) to south (bottom). The east-west temperature records were arranged to read from east (top) to west (bottom). A gradual increase in temperature from north to south and a gradual decrease from east to west was detected (see Table 1). Disregarding the Odessa

sample, which consists of only two specimens, (see Fig. 10) there was an apparent decrease in body length from north to south (Bergmann's Rule). Regarding condylo-basilar length (see Fig. 11), deer mice from Lubbock averaged smallest of all samples. The means of the Miami and Hobbs samples did not differ significantly. The trend for zygomatic breadth (see Fig. 14) was essentially the same as that for condylo-basilar length. The sample with the least mean size (Lubbock) was located about midway along the north-south transect and samples with larger dimensions were found in both directions away from Lubbock. Disregarding the specimen from Odessa, cranial depth (see Fig. 23) was similar to condylo-basilar length and zygomatic breadth. North of Lubbock, however, sample means were closely similar and there was a distinct difference (not significant) between the Plainview and Lubbock samples.

Body length increased gradually from east to west across the Llano Estacado. Crosbyton and Roosevelt Co.-Bailey Co. samples were too small for the means of cranial characters to be reliable. Thus, the east-west trend is not clear. However, zygomatic breadth (see Fig. 15a) and cranial depth (see Fig. 24a) suggest an increase in dimensions from east to west. Two clines for body size seemingly are present across the Llano Estacado. This would explain, for example, the similarity of the Miami

and Hobbs samples; especially if the slope of the east-west cline was greater than the slope of the north-south cline. This pattern of variation does not explain the small dimensions in the Lubbock sample. Deer mice from the Lubbock area may be small because of intergradation with the small subspecies (P.m. pallescens) to the east of the Llano Estacado and as a result of partial isolation (see p. 74 in discussion).

An attempt to correlate patterns of variation of external features to temperature gradients on the Llano Estacado revealed some applicability of Allen's Rule. Figure 7 and Table 1 compare tail length and temperatures in samples from north to south. The trend to become smaller is similar to that for condylo-basilar length and body length. Figure 6b, Fig. 9a and Table 1 compare length of tail and length of ear with temperature in samples from east to west. A trend to larger dimensions westward was suggested. Figure 8 and Table 1 compare ear length and temperatures in samples from north to south. No trend was apparent. There was no relationship to Allen's Rule from east to west or from north to south. In fact, the reverse was suggested. Hoffmeister (1951) obtained similar results in P. truei and suggested that this trend is followed by most species of Peromyscus in western North America.

Perhaps there is no significant difference between northernmost and southernmost deer mice or between eastern and western deer mice in any measurements because mean temperatures at the extremes do not vary significantly from each other. However, Table 1 reveals a difference of 41 days of above freezing temperature between northern and southern extremes and a difference of 34 days of above freezing temperatures between eastern and western extremes. The number of days above freezing may be a better criterion for indicating relative coolness of an area than is mean annual temperature.

Microgeographic Variation

In this study distinct variation was apparent between two closely situated localities. Figure 29 shows areas of extensive cultivation and areas in more or less continuous vegetation on the Llano Estacado. There is a crescent-shaped area along the northern, western and southern margins where continuous or intermittent vegetation remains. Samples collected from areas of extensive cultivation were Hart, Plainview, Lubbock and Brownfield. In these areas native vegetation still grows around playas and along railroad right-of-ways. Dispersal from playa to playa seems possible, but such may be slight, for playas are as much as 3 miles apart with little or no cover in intervening areas. Therefore, populations in these playa

Fig. 29.--Outline map of the Llano Estacado showing areas of cultivation (open) and areas of continuous vegetation (black).

areas are partially isolated from other such populations. Railroad right-of-ways offer avenues of dispersal.

Lubbock mice were smaller than Plainview mice in all measurements except length of maxillary tooth row. Most mice were taken in February, March, April and May in both samples. It seems unlikely that seasonal variation was a factor in producing any observed differences between samples. Mice of both samples were in most instances collected from similar habitats.

Small size of Lubbock mice may be owing to isolation and the results of random fixation (Wright, 1948). If small size was the result of isolation and a selective factor, such as limited food supply, one also would expect the Hart, Plainview and Brownfield samples to exhibit consistently small size. Yellow House Canyon in Lubbock County may offer an avenue of dispersal and thus gene exchange with the small subspecies (P. m. pallescens) to the east of the Llano Estacado. A clue may be provided by the length of maxillary tooth row in which Lubbock mice exceed all samples except Randall Co. Young mice have larger teeth than old adults (teeth are worn considerably as the animal grows older). The Lubbock sample was composed principally of young adult mice, possibly explaining longer maxillary tooth row. Length of the alveolar space seems a more reliable measurement as a function of size of teeth,

because this measurement is not subject to wear once the molar teeth are fully erupted.

Lubbock mice were smaller because of the age composition of the sample and secondarily as a result of intergradation with P. m. pallescens to the east.

Taxonomic Relationships

Distribution of subspecies of Peromyscus maniculatus surrounding the Llano Estacado (where heretofore except for the extreme northern portion, they were presumed absent) are shown in Figure 30. The distribution of P. m. bairdii is also illustrated. P. m. ozarkiarum is a grassland inhabitant whose occurrence in Texas is based on three specimens from Cooke County (Russell, 1953). Osgood (1909:84) referred a single specimen from Gainesville, Cooke County, to P. m. pallescens. Mc Carley (1952) referred eight specimens from the vicinity of Colbert, Bryan County, Oklahoma (a county bordering northeastern Texas) to pallescens. It seems likely to me that specimens reported by Russell could be intergrades between ozarkiarum and pallescens, although I have not examined any of these. A north-south transect through the ranges of bairdii, ozarkiarum and pallescens should reveal morphological information permitting better understanding of the relationships of these forms. Because of the questionable (to me)

Fig. 30.--Distribution of subspecies of Peromyscus maniculatus surrounding the Llano Estacado and the distribution of P. m. bairdii. (Taken from Hall and Kelson, 1959:615-616).

evidence of the presence of ozarkiarum in Texas, I have not compared mice from the Llano Estacado to this subspecies.

Osgood (1909:77) referred specimens from Washburn, Armstrong County, Texas, to the subspecies P. m. nebrascensis; and it extends finger-like onto the Llano Estacado. P. m. luteus (see Jones, 1958, for proper use of nebrascensis and luteus) was thought present in the northeastern part of the Llano Estacado (see Blair, 1939, and Hall and Kelson 1959).

Mice of the subspecies P. m. rufinus are long-tailed, large-footed, large-eared, dark-colored inhabitants of coniferous, montane forests (Blair, 1954). Because of the obvious size and ecological differences, mice from the Llano Estacado have been only cursorily compared to this subspecies. P. m. blandus, however, is a robust, relatively pale, moderate-sized inhabitant of intermontane basins and semi-desert habitats of the Chihuahuan Desert (Blair, 1954). Osgood (1909) first reported dicromatism in this subspecies, noting a gray phase and a buff phase. Dice (1933) showed that buff (dominant) and gray (recessive) are alleles. This was later confirmed by Blair (1947) who called attention to modifiers of buff and gray. Blair (1947) found what appeared to be grays in a population of P. m. nubiterrae from the vicinity of Mountain Lake, Virginia. Breeding tests, gray blandus x gray nubiterrae, produced an F1

generation of all gray mice. Some of the mice were browner than blandus (gray mice) and resembled buff mice. Blair attributed these results to the presence of modifiers of gray. The nearest records for P. m. blandus to the Llano Estacado are Carlsbad, Eddy County, New Mexico (V. Bailey, 1932:148) and Toyahvale, Reeves County, Texas (Osgood, 1909:86). I have taken two specimens (one gray, one buff) from the Winkler County Airport, Winkler County, Texas, that extend the known range of blandus 75 miles south-eastward from Carlsbad and 70 miles north-eastward from Toyahvale. Deer mice inhabiting the Llano Estacado are possibly complex intergrades between blandus and nebrascensis and luteus. An examination of 238 specimens of P. maniculatus from the Llano Estacado failed to reveal a single recessive gray. If blandus interbreeds with deer mice on the Llano Estacado an occasional gray should occur, unless gray were masked by modifiers. If the gray allele were present in the population at a frequency of 10 percent at least one, and not more than 19 grays in one hundred specimens should occur. If interbreeding between blandus and deer mice from the Llano Estacado occurs, the gray allele is either masked by modifiers or is present at frequencies so low that detection would be difficult in an examination of 238 specimens. Two specimens from 19 miles E Kermit (at the base of Concho Bluff) Winkler County, Texas, and two

specimens from 4 miles N Notrees, Ector County, Texas, are indistinguishable from mice of the Hobbs and Odessa samples and markedly distinct from P. m. blandus from the Winkler County Airport. It seems likely that the two subspecies come into contact. Breeding tests will be necessary to determine whether or not gene exchange takes place.

Based on the evidence at hand, it appears unlikely that blandus interbreeds with palleszens. Dice (1930,1942) reported limited gene exchange between rufinus and blandus due to occupation of different ecological niches and avoidance of intermediate habitats. A possible avenue of gene exchange for blandus with other populations of the species is to the west with the subspecies sonoriensis. Hall and Kelson (1959:616) show the ranges of blandus and sonoriensis separated by a narrow zone in the Chiricahua Mountains of Arizona. Here P. m. rufinus occurs. Seemingly blandus is almost totally isolated by ecological factors from all other populations of the species.

Blair (1954) tested for discrimination in pair matings between blandus and ozarkiarum, palleszens and rufinus. His results showed no evidence of reproductive isolation between these subspecies of deer mice, however only one test was made for blandus with rufinus. Discrimination tests between blandus and deer mice from the Llano Estacado, rufinus, and sonoriensis are needed to better understand

possible isolating mechanisms involved between blandus and these subspecies.

P. m. pallescens is a small, dark-colored, short-tailed, small-eared prairie inhabitant. I have compared luteus and nebrascensis to pallescens for selected measurements (see Table 6). P. m. pallescens is significantly smaller in all measurements tested.

Blair (1954) reported P. maniculatus from west-central Texas at: 3 mi. N Slaton, Lubbock County; 10 mi. E Hermleigh, Fisher County; 9 mi. E Stinnett, Hutchinson County; 27 mi. S Amarillo, (Palo Duro Canyon) in Randall County; and Palo Duro State Park, Randall County. Blair (1954) referred these specimens to the subspecies osgoodi (= nebrascensis). He reported a mummified specimen of the gray color phase from a woodrat nest at the Hermleigh station. Davis (1960) records specimens from Hutchinson, Hemphill, Randall, Armstrong, Briscoe and Lubbock Counties. Packard and Garner (1964) reported specimens from the following localities on the Llano Estacado: 22 mi. S Muleshoe, Bailey County, 5 mi. NE Abernathy, Hale County and 5 mi. S, 4 mi. W Tahoka, Lynn County.

Comparisons were made between topotypes of nebrascensis and topotypes of luteus for each external and cranial measurement listed in the materials and methods section. Table 7 lists sample, size, range, mean, standard deviation,

TABLE 6
COMPARISON OF P. m. pallescens WITH P. m. luteus AND nebrascensis

<u>pallescens</u>					<u>luteus</u>					<u>nebrascensis</u>				
Character	N	$\bar{X}$	SD	N	$\bar{X}$	SD	t-value	Confidence level	N	$\bar{X}$	SD	t-value	Confidence level	
Total Length	10	129.5	7.62	21	146	8.00	5.972	.001	22	156	7.08	9.590	.001	
Tail Length	10	52.9	3.38	21	59	4.84	4.047	.001	22	64	3.47	8.429	.001	
Body Length	10	76.8	5.22	21	87	4.18	5.867	.001	22	92	5.98	7.717	.001	
Condyllo-basilar Length	10	20.1	.84	16	22.0	1.01	5.0425	.001	22	22.9	.57	11.151	.001	
Zygomatic Breadth	10	11.2	.66	16	12.7	.73	10.157	.001	22	13.0	.59	8.541	.001	
Depth of Cranium	9	8.3	.27	16	8.8	.32	3.900	.001	22	9.0	.37	5.000	.001	

TABLE 7

COMPARISON OF P. m. luteus AND nebrascensis

Character	<u>luteus</u>					<u>nebrascensis</u>					T-values significant at .05 level or above
	N	Range	$\bar{X}$	SD	SE	N	Range	$\bar{X}$	SD	SE	
Total Length	21	131-164	146	8.00	1.20	22	143-172	156	7.08	1.54	4.346
Tail Length	21	51-72	59	4.84	1.05	22	57-70	64	3.47	.81	3.907
Hindfoot Length	21	19-20	19	.49	.11	22	18-22	20	1.02	.22	4.127
Ear Length	21	14-15	14.5	.51	.11	22	16-20	18	1.00	.23	14.553
Body Length	21	77-95	87	4.18	.91	22	80-103	92	5.98	1.30	
Condyllo-basilar Length	16	19.5-23.1	22.0	1.01	.25	22	22.0-24.4	22.9	.57	.14	
Condyllo-zygomatic Length	16	14.7-17.8	16.8	.85	.21	22	16.4-18.5	17.3	.56	.12	
Zygomatic Breadth	16	11.3-13.9	12.7	.73	.18	22	12.0-14.3	13.0	.59	.13	
Greatest Bullar Breadth	13	9.7-11.0	10.4	.34	.09	22	10.0-11.5	10.7	.38	.08	
Nasal Length	20	7.5-10.1	9.2	.71	.16	21	9.3-10.9	10.0	.43	.46	4.388
Rostral Breadth	21	3.5-4.8	4.2	.28	.06	21	4.2-5.1	4.5	.21	.05	3.928
Length of Incisive Foramen	22	4.2-5.4	4.9	.33	.07	22	4.8-5.6	5.2	.26	.06	
Length of Palate	22	3.3-4.0	3.7	.19	.04	22	3.4-4.1	3.8	.21	.05	
Least Interorbital Constriction	21	3.2-3.9	3.5	.17	.04	22	3.6-4.0	3.8	.13	.03	6.519
Depth of Cranium	16	8.2-9.3	8.8	.32	.08	22	8.5-9.9	9.0	.37	.08	
Length of Maxillary Molar Series	18	3.0-3.6	3.3	.16	.04	21	3.1-3.7	3.5	.15	.04	4.026
Length of Mandibular Molar Series	20	3.2-3.8	4.5	.14	.03	22	3.0-3.9	3.6	.21	.04	
Height of Mandible	22	3.6-4.5	4.0	.23	.05	22	3.7-4.8	4.1	.28	.06	
Length of Mandible	22	12.0-14.0	13.2	.62	.13	22	12.8-14.6	13.6	.49	.11	

standard error and significant t-values (.05 level or above). Topotypes of nebrascensis were significantly larger in nine of the 19 measurements than topotypes of luteus. In color, nebrascensis ranged from 7.5 YR 4/2 to 10 YR 5/6 on the dorsum, or from a dark brown to a yellowish brown, with a mode of 7.5 YR 5/6 (strong brown). Side color ranged from 7.5 YR 5/6 (strong brown) to 10 YR 6/4 (light yellowish brown) with a mode of 7.5 YR 6/6 (reddish yellow). Tail-stripe ranged from 7.5 YR 3/2 (dark brown) to 10 YR 5/3 (brown) with a mode of 7.5 YR 3/2 (dark brown). Dorsal color of P. m. luteus ranged from 5 YR 4/6 (yellowish red) to 10 YR 3/2 (very dark grayish brown) with a mode of 7.5 YR 5/6 (strong brown). Color of side pelage ranged from 5 YR 6/8 (reddish yellow) to 10 YR 6/4 (light yellowish brown) with a mode of 7.5 YR 7/6 (reddish yellow). Color of tail-stripe ranged from 5 YR 3/3 (dark reddish brown) to 10 YR 3/4 (dark yellowish brown) with a mode of 7.5 YR 4/2 (brown). Thus, in color P. m. nebrascensis and P. m. luteus differ in that many individuals of luteus are redder than nebrascensis. A dorsal stripe is slightly more prominent in luteus as a result of more contrast between dorsal and side pelage than in nebrascensis. P. m. nebrascensis typically possessed a darker tail-stripe. Jones (1964) in commenting on differences between the two subspecies in Nebraska pointed out the following: luteus

was smaller in cranial and external features; the most reliable characteristic was length of ear (15 mm or less in luteus, 16 mm or more in nebrascensis).

The dorsum of P. m. pallescens ranged from 7.5 YR 3/0 (very dark gray) to 10 YR 3/4 (dark yellowish brown) with a mode of 7.5 YR 3/2 (dark brown). Color of side pelage ranged from 7.5 YR 4/4 (brown to dark brown) to 10 YR 6/2 (light brownish gray) with a mode of 7.5 YR 5/6 (strong brown). Color of tail-stripe ranged from 7.5 YR 2/0 (black) to 10 YR 4/2 (dark grayish brown) with a mode of 7.5 YR 3/2 (dark brown). Thus, pallescens samples were decidedly browner than nebrascensis or luteus as well as being significantly smaller.

I have compared topotypes of pallescens, luteus, nebrascensis and samples from Washburn, Miami and Lubbock for total length, tail length, body length, ear length, condylo-basilar length, zygomatic breadth and depth of cranium. Hindfoot length was omitted in the comparisons of external measurements because of considerable secondary sexual dimorphism. Ear length was not recorded by the collector of the Washburn sample and topotypes of pallescens. Cranial dimensions were selected based on low coefficients of variation (see Table 4). Samples were chosen for the following reasons: (1) Washburn because it had previously been referred to nebrascensis, (2) Miami because it falls

within the presumed range of luteus; (3) Lubbock because mice of this sample exhibited the smallest means for all samples from the Llano Estacado for most of the measurements studied. T-tests were employed in cases where degree of difference between two samples was in question. Significant difference was interpreted when there was non-overlap of the 95 percent confidence intervals. Means of samples were considered similar if the interval for one sample included the observed mean for another sample. Sample size, range, mean, standard deviation and standard error for each measurement in each sample are listed in Table 8.

In total length, P. m. nebrascensis is largest and palleszens is smallest. The mean of the Washburn sample was between those for luteus and nebrascensis. The Washburn mean seems closer to that of nebrascensis, however it is skewed toward the larger measurements. A larger sample might exhibit a mean similar to that of luteus. The mean of the Miami sample is clearly similar to luteus. The mean of the Lubbock sample was notably similar to that of palleszens and significantly different from means of other samples.

The three subspecies are distinctly different from one another in tail length with nebrascensis largest and palleszens smallest. The mean of Washburn mice was

TABLE 8

COMPARISON OF SUBSPECIES AND SELECTED SAMPLES

Character	<u>pallascens</u>					<u>luteus</u>					<u>nebrascensis</u>				
	N	Range	$\bar{X}$	SD	SE	N	Range	$\bar{X}$	SD	SE	N	Range	$\bar{X}$	SD	SE
Total Length	10	120 to 143	129.5	7.62	2.41	21	131 to 164	146	8.00	1.20	22	143 to 172	156	7.08	1.54
Tail Length	10	50 to 59	53	3.38	1.07	21	51 to 72	59	4.84	1.05	22	57 to 70	64	3.47	.81
Ear Length						21	14 to 15	14.50	.51	.11	22	16 to 20	18.00	1.00	.23
Body Length	10	69 to 85	76.8	5.22	1.65	21	77 to 95	87	4.18	.91	22	80 to 103	92	5.98	1.30
Condyllo-basilar Length	10	19.38 to 21.85	20.09	.84	.27	16	19.50 to 23.10	22.00	1.01	.25	22	22.00 to 24.40	22.90	.57	.14
Zygomatic Breadth	10	10.35 to 12.60	11.12	.66	.21	16	11.30 to 13.90	12.70	.73	.18	22	12.00 to 14.30	13.00	.59	.13
Cranial Depth	9	8.00 to 8.75	8.31	.27	.09	16	8.20 to 9.30	8.80	.32	.08	22	8.50 to 9.90	9.00	.37	.08

TABLE 8--Continued

Character	Washburn				Miami				Lubbock						
	N	Range	$\bar{X}$	SD	SE	N	Range	$\bar{X}$	SD	SE	N	Range	$\bar{X}$	SD	SE
Total Length	8	137 to 156	152	6.66	2.36	14	129 to 163	143	9.48	2.54	30	117 to 155	131.5	9.60	1.75
Tail Length	8	55 to 69	64	4.68	1.66	14	52 to 66	58	4.08	1.09	31	41 to 68	51	5.16	.93
Ear Length						13	13 to 19	15.23	1.64	.46	31	12 to 15	13.77	.80	.14
Body Length	8	82 to 93	88	3.23	1.14	14	67 to 97	85	8.34	2.23	30	63 to 93	81	7.09	1.29
Condyllo-basilar Length	5	21.65 to 23.00	22.45	.49	.22	11	21.45 to 22.40	21.95	.38	.12	28	20.10 to 23.20	21.34	.79	.15
Zygomatic Breadth	5	12.35 to 13.15	12.73	.33	.15	11	11.80 to 13.50	12.82	.47	.14	29	11.65 to 12.90	12.25	.34	.06
Cranial Depth	.5	8.60 to 9.25	8.91	.24	.11	11	8.45 to 9.35	8.93	.27	.08	28	7.85 to 8.90	8.56	.21	.04

identical to that of nebrascensis. Miami mice are similar to luteus and different from nebrascensis and pallesens. Lubbock mice had shorter tails than all other samples but most resembled pallesens.

P. m. luteus and P. m. nebrascensis were larger than P. m. pallescens in body length. P. m. nebrascensis was slightly larger than luteus. Washburn mice were intermediate between luteus and nebrascensis (but closer to luteus). The mean of Miami mice was between luteus and pallesens, but closer to luteus. Lubbock mice were similar to pallesens, and significantly smaller than luteus and nebrascensis.

Jones (1964) reported ear length longer in nebrascensis than luteus. In samples of topotypes I examined the ranges do not overlap. The Miami sample was similar to luteus and significantly smaller than nebrascensis. Lubbock mice had shorter ears than luteus.

A t-test showed luteus and nebrascensis not significantly different in condylo-basilar length. However, both are significantly larger than pallesens. Sample size was too small in the Washburn sample to permit reliable comparisons, but it appears that these mice most resemble nebrascensis. The Miami and Lubbock samples were most similar to luteus.

P. m. luteus and P. m. nebrascensis were larger than P. m. pallescens in zygomatic breadth, but similar to each other. The Washburn mice exhibited a mean value identical to topotypes of luteus, whereas the mean value of Miami mice was similar to those for luteus and nebrascensis. Lubbock mice were significantly larger in this measurement than pallescens and smaller than both luteus and nebrascensis. The difference between the means of the Lubbock sample and topotypes of luteus was not significant at the .05 level.

Cranial depth in luteus and nebrascensis was similar, both being larger than pallescens. Washburn and Miami were intermediate between luteus and nebrascensis in this measurement. Lubbock mice resembled luteus.

Washburn mice resembled nebrascensis in total length, tail length and condylo-basilar length, and luteus in body length, and zygomatic breadth. Miami mice resembled luteus in all external measurements and in condylo-basilar length and zygomatic breadth. Lubbock mice had affinities with pallescens in total length, tail length, body length (a comparison of ear length was not possible). However, Lubbock mice were similar to luteus in the three cranial measurements examined.

The data indicate that the Washburn sample was closer to nebrascensis in external measurements, but intermediate

between luteus and nebrascensis in cranial measurements. Miami mice distinctly resemble luteus. Lubbock mice are similar to pallesens in external measurements, but have affinities with luteus in cranial measurements.

I interpret these results to suggest populations of deer mice inhabiting the Llano Estacado represent a zone of intergradation between luteus, nebrascensis and pallesens.

In color deer mice on the Llano Estacado appear intermediate between nebrascensis and pallesens; however, the Miami and Plainview samples (see Fig. 4) exhibit the hue 5 YR that is common in luteus. This further substantiates the assumption that the Llano Estacado represents a zone of intergradation among the three subspecies.

I compared each sample (except Washburn) separately to luteus and nebrascensis in 16 selected measurements (see Tables 9 and 10). I did not compare the Llano Estacado samples to pallesens because, except for external measurements of the Lubbock sample, measurements of samples are not similar to that subspecies. Significant differences were noted between luteus and Lubbock in four external measurements, between luteus and Plainview in rostral breadth, between luteus and Hobbs in body length (see Table 9). P. m. nebrascensis differs significantly in at least one characteristic from each of the samples compared (see Fig. 10). A total of 58 significant differences were

noted. Deer mice on the Llano Estacado are best referred to P. m. luteus, although these populations seem to represent a broad zone of intergradation.

TABLE 9

COMPARISON OF P. m. luteus WITH SAMPLES
(t-values significant at .05 level or above)

Character	Lubbock	Plainview	Hobbs
Total Length	5.640 49df		
Tail Length	5.510 50df		
Ear Length	3.700 50df		
Body Length	4.060 49df		5.460 31df
Rostral Breadth		3.820 43df	

TABLE 10

COMPARISON OF P. m. nebrascensis WITH SAMPLES
(t-values significant at .05 level or above)

Character	Miami	Randall Co.	Hart	Plainview	Lubbock
Total Length	4.702 34df		4.128 34df	5.204 51df	10.080 50df
Tail Length	4.443 34df		4.775 34df	4.935 52df	10.143 51df
Ear Length	6.232 33df	5.699 27df	6.833 34df	11.445 49df	17.091 51df
Body Length				4.876 51df	6.127 50df
Condyllo-basilar Length	4.982 31df		4.192 44df		7.797 48df
Condyllo-zygomatic Length					5.5081 48df
Zygomatic Breadth					5.718 49df
Nasal Length			5.197 31df	5.672 42df	7.515 47df
Rostral Breadth					
Length of Incisive Foramen	6.910 33df		4.345 34df	4.934 43	6.967 49df
Length of Palate					4.238 49df
Least Interorbital Constriction				6.709 44df	8.074 49df
Depth of Cranium					5.307 48df
Length of Maxillary Molar Series					
Height of Mandible					4.4931 49df
Length of Mandible					5.119 49df

TABLE 10--Continued

Character	Brownfield	Hobbs	Odessa	Crosbyton	Roosevelt Co.- Bailey Co.
Total Length	6.773 25df	7.958 31df		6.195 24df	5.701 32df
Tail Length	7.149 25df	3.896 31df		4.469 24df	5.641 32df
Ear Length	6.466 25df	8.245 25df	6.9179 22df	7.247 24df	7.080 29df
Body Length	4.123 25df	6.772 32df		4.469 24df	
Condyllo-basilar Length		5.102 32df			
Condyllo-zygomatic Length					
Zygomatic Breadth					
Nasal Length					
Rostral Breadth					
Length of Incisive Foramen		4.788 31df	4.143 21df		
Length of Palate		5.217 32df			
Least Interorbital Constriction		4.659 32df			
Depth of Cranium		5.137 32df			
Length of Maxillary Molar Series			5.2315 22df	4.421 24df	4.9139 26df
Height of Mandible					
Length of Mandible					

Specimens Examined

Unless otherwise noted specimens examined are in the Texas Technological College Collection of Recent Mammals.

Peromyscus maniculatus blandus Osgood

1909. Peromyscus maniculatus blandus Osgood, N. Amer. Fauna 28:84, April 17.

Type.--From Escalon, Chihuahua, Mexico.

Specimens examined.--Total number, 15, from: CHIHUAHUA. Escalon, 8 (USNM). TEXAS. 7 mi. NW Toyahvale, Reeves Co., in Jeff Davis Co., 5 (MU); Winkler Co. Airport, Winkler Co., 2.

Peromyscus maniculatus luteus Osgood

1909. Peromyscus maniculatus luteus Osgood, N. Amer. Fauna, 28:77, April 17.

Type.--From Kennedy, Cherry Co., Nebraska.

Specimens examined.--Total number, 238, from: NEBRASKA. Cherry Co. : 2 mi. E Kennedy, 1 (KU); 4 mi. E Kennedy, 24 (KU). TEXAS. Armstrong Co.: Washburn, 10 (USNM); 17 mi. S Claude, 2. Hutchinson Co.: 9 mi. E Stinnett, 2 (TU); 13 mi. S, 6 1/2 mi. E Stinnett, 1; 6 mi. N, 6 mi. W Stinnett, 1. Roberts Co.: 6 mi. N Miami, 1, 14 (MU). Hemphill Co.: 9 mi. NNE Miami, 3 (MU); Canadian, 1. Randall Co.: Vicinity Buffalo Lake National Wildlife Refuge, 3; Palo Duro State Park, 1 (TU); 27 mi. S Amarillo, 1 (TU); 5 mi. SE Gate to Palo Duro State Park, 1; 7 1/2 mi. SE Gate to Palo Duro State Park, 1; 13 mi. E Canyon, 1; 10 mi. E. 1/2 mi. S Canyon, 2 (WBC). Castro Co.: 1 1/2 mi. NW Hart, 1 (WBC); 4 mi. NW, 1 mi. E Hart, 9 (WBC); 4 mi. NW Hart, 9. Hale Co.: 5 mi. NE Abernathy, 1; 1 mi. W Finney, 1 (WBC); Plainview, 1 (WBC); 8 mi. W Plainview, 2 (WBC); 8 1/2 mi. W Plainview, 1 (WBC); 8 mi. N Plainview, 1 (WBC); 8 mi. NW Plainview, 5 (WBC); 8 mi. NE Plainview, 1 (WBC); 2.3 mi. N, 2.3 mi. W Plainview, 3 (WBC); 2.3 mi. N, 2 1/2 mi. W Plainview, 1 (WBC); 2.1 mi. E Plainview, 1 (WBC); 2 1/2 mi. N, 2.3 mi. W Plainview, 2 (WBC); 2 mi. SE Plainview, 1 (WBC); 2 mi. S, 2 mi. E Plainview, 2 (WBC); 1 1/2 mi. S, 4 mi. W Plainview, 2 (WBC); 1 1/2 mi. E Plainview, 1 (WBC);

3 mi. N Plainview, 1 (WBC); 3 mi. N, 2 mi. W Plainview, 3 (WBC); 4 mi. W Plainview, 4 (WBC); 5 3/4 mi. NW Plainview, 1 (WBC); 5 mi. S Plainview, 2 (WBC); 5 mi. N, 3 mi. W Plainview, 1 (WBC). Lubbock Co.: 5 mi. N, 2 mi. E Slaton, 2; 1 mi. NW Slaton, 1; 6 mi. N Slaton, 2; 3 1/2 mi. N Slaton, 3; 3 mi. N Slaton, 1 (TU); Lubbock, 8; 3.4 mi. NW Lubbock, 3; 10 mi. N Lubbock, 1; 10.1 mi. SW Lubbock, 1; 8 mi. W Lubbock, 1; 5 mi. N Lubbock, 11; 14 mi. S, 1 mi. E Lubbock, 3; 8 mi. N, 6 mi. NE Lubbock, 1; 7 1/2 mi. N Lubbock, 1; 10 mi. W Lubbock, 2; 6.7 mi. N Lubbock, 1; 4 mi. NW Lubbock, 2. Terry Co.: 9 1/2 mi. NW Brownfield, 3; 10 mi. S Brownfield, 2; Meadow, 3; 1 mi. S Wellman, 1. Ector Co.: 9 mi. N Odessa, 5; 4 mi. N Notrees, 2. Crosby Co.: 10 mi. N Crosbyton, 1 (MU); 3 mi. E Crosbyton, 2; 6 mi. N Crosbyton, 1; 7 mi. N Crosbyton, 1; 7 1/2 mi. E Crosbyton, 1. Swisher Co.: 3 mi. E Kress, 2 (WBC); 15 mi. NE Tulia, 1 (WBC). Floyd Co.: 4 mi. N Floydada, 2 (WBC). Borden Co.: Tom Good Ranch, 1 (TU). Hockley Co.: 2 mi. S Levelland, 1; Lynn Co.: 5 mi. S, 4 mi. W Tahoka, 1; 2 mi. S Tahoka, 1. Winkler Co.: 19 mi. E Kermit, 2. Bailey Co.: 20 mi. S Muleshoe, 2; 22 mi. S Muleshoe, 2. NEW MEXICO. Roosevelt Co.: Pep, 6; Portales, 3 (ENMU); 2 mi. S, 1 1/2 mi. E Portales, 1 (ENMU). Chaves Co.: 3 mi. W, 1 mi. S Caprock, 2. Lea Co.: 2 1/2 mi. E Maljamar, 1; 19 mi. E Maljamar, 1; 17 1/2 mi. W Hobbs, 1; 15 mi. W Hobbs, 14.

Peromyscus maniculatus nebrascensis (Coues)

1909. Peromyscus maniculatus nebrascensis Osgood, N. Amer. Fauna, 28:75, April 17.

Type.--Restricted to Deer Creek, approximately five miles from its mouth, Converse Co., Wyoming, by Jones, Proc. Biol. Soc. Washington, 71: 108, July 16, 1958, and others.

Specimens examined.--Total number, 25, from: WYOMING. Converse Co.: 22 mi. S, 24 1/2 mi. W Douglas, 9 (KU); 3 mi. N, 5 mi. E Orin, 6 (KU); 12 mi. N, 6 mi. W Bill, 10 (KU).

Peromyscus maniculatus ozarkiarum Black

1935. Peromyscus maniculatus ozarkiarum Black, Jour. Mamm., 16:144, May 15.

Type.--From 3 mi. S Winslow, Washington Co., Arkansas.

Specimens examined.--Total number, 23, from: ARKANSAS. Washington Co.: 1 mi. N Winslow, 8 (KU); 1 mi. E Winslow, 4 (KU); 2 mi. SW Winslow, 8 (KU); 3 mi. S Winslow, 1 (KU). Madison Co.: 4 mi. E Huntsville, 2 (KU).

Peromyscus maniculatus pallescens J. A. Allen

1909. Peromyscus maniculatus pallescens Osgood, N. Amer. Fauna, 28:83, April 17.

Type.--From San Antonio, Bexar Co., Texas.

Specimens examined.--Total number, 16, from: TEXAS. Bexar Co.: San Antonio, 6 (USNM), 7 (AMNH); 4 1/2 mi. E Sayrs, 1 (KU). Williamson Co.: 2 mi. S Taylor, 2 (TU).

Peromyscus maniculatus rufinus (Merriam)

1909. Peromyscus maniculatus rufinus, Osgood, N. Amer. Fauna, 28:72, April 17.

Type.--From San Francisco Mountain, 9000 ft., Coconino Co., Arizona.

Specimens examined.--Total number, 39, from: NEW MEXICO. Torrance Co.: Red Canyon, 39.

CHAPTER IV

CONCLUSIONS

1. Secondary sexual dimorphism was present in one of two samples of P. maniculatus on the Llano Estacado. Males were larger than females in length of hindfoot, greatest breadth across bullae and length of mandibular molar series. Length of hindfoot and bullar width are sexually dimorphic in two subspecies of P. maniculatus (see Dice, 1932 and 1933). These characters seem unreliable in comparisons of samples unless sexes are considered separately.

2. External measurements were more variable than cranial measurements. External measurements may be reliable taxonomically when taken by the same investigator.

3. Most cranial and mandibular characters are functions of one of three linear dimensions: skull length, skull width, skull depth.

4. The least variable and hence most suitable characters for geographic comparisons are: (1) condylo-basilar length, (2) condylo-zygomatic length, (3) zygomatic breadth, (4) least interorbital constriction, (5) depth of cranium, and (6) mandibular length.

5. All samples examined exhibited similar modal values for pelage color; however, pelage color was variable within each sample.

6. Pelage color was not as reliable a criterion for separating subadults and adults as were cranial characters.

7. Pelage color in deer mice on the Llano Estacado seems not closely correlated with soil color.

8. Deer mice from the Llano Estacado appear intermediate in color between P. m. nebrascensis and P. m. pallescens. Two samples studied contained mice that were a pelage color common in P. m. luteus.

9. Size decreases from north to south and from west to east, thus having some correlation with temperature clines. The two clines affect the same characters and apparently intersect each other.

10. Small size of mice in the Lubbock sample is apparently due primarily to age classes in the sample, and secondarily from intergradation with the small subspecies pallescens (occurring to the east).

11. Peromyscus maniculatus is currently scarce on the Llano Estacado. In 5,903 trap nights I have taken 93 specimens. Countless trap nights by others have produced another 145 specimens. The scarcity of this species on the Llano Estacado may be a result of cultivation. In

many sections it is difficult to find remnants of the original ecological communities. Even in areas where native vegetation remains, grazing has reduced the ground cover to a height insufficient to offer protection to deer mice.

12. Deer mice in extensively cultivated areas on the Llano Estacado are subdivided into small local populations where suitable habitat is found around playas and along railroad right-of-ways. Gene flow is no doubt reduced between these local populations. Population size is small. Railroad right-of-ways are the principal avenues of dispersal between local populations.

13. Due to the interaction of isolation, selection and genetic drift, rapid diversification may take place in these local populations. Adequate samples from such local populations are not available at present to determine extent of variation in and between local populations.

14. Deer mice on the Llano Estacado apparently do not interbreed with P. m. blandus to the south and southwest.

15. Populations of deer mice on the Llano Estacado appear to represent a zone of intergradation between P. m. luteus, nebrascensis, and pallesens, but most nearly resemble luteus in linear dimensions, and are referred to P. m. luteus.

16. A study of geographic variation in P. m. bairdii, ozarkiarum and palleszens is needed in order to determine the taxonomic status of these forms.

17. P. m. blandus may be isolated by ecological and behavior-isolating mechanisms from those subspecies with which it might intergrade. Breeding tests, compatibility tests and extensive collection along zones of contact are needed in order to determine the biological and taxonomic status of P. m. blandus.

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