SYSTEMATIC STATUS OF THE DEER MOUSE, *PEROMYSCUS MANICULATUS*, ON THE LLANO ESTACADO AND IN ADJACENT AREAS

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ABSTRACT.—Geographic and nongeographic variation of deer mice, *Peromyscus maniculatus*, were statistically analyzed to determine the systematic status of populations of this species on the Llano Estacado and in adjacent areas of Texas. Four external and 12 cranial measurements were analyzed. Museum specimens were classified as juveniles, subadults, young adults, adults, or old adults based on tooth wear and pelage characteristics. Only individuals categorized as adults of one age or another were used in statistical analyses. A MANOVA was used to test for sexual dimorphism, which resulted in a nonsignificant ($P = 0.083$) value, allowing the sexes to be combined. ANOVAs and discriminant function analysis also were used to define taxonomic affinities. From this analysis, it was concluded that *P. m. pallescens* extends from south-central Texas northward and westward, intergrading with *P. m. luteus* in the Lubbock area and perhaps elsewhere in the southeastern part of the Llano. Mice clearly referable to *Peromyscus maniculatus luteus* as currently recognized appear to occupy all other areas of the Llano Estacado. *Key words*: deer mouse; *Peromyscus maniculatus*; distribution; systematics; Llano Estacado, Texas.

The deer mouse, *Peromyscus maniculatus*, with more than 60 recognized subspecies (Hall, 1981), occurs from British Columbia east to Labrador and southward through most of the United States into Mexico as far as Oaxaca. It occupies a wide variety of habitats across this broad range, with some subspecies being more habitat specified than others.

The Llano Estacado is the southernmost extension of the Great Plains. It is an immense plateau lying south of the Canadian River in eastern New Mexico and western Texas (Lotspeich and Coover, 1962). Caprock cliffs delimit its northern and eastern margins and, to a lesser extent, the western edge (Mescalero Ridge). To the south, the Llano merges without sharp contrast with the Monahans Sandhills and adjacent areas. Lacking significant topographic features, the Llano has a relatively uniform climate (Judd, 1970).

The taxonomic status of *Peromyscus maniculatus* on the Llano Estacado has long been the subject of speculation (Blair, 1954b; Judd, 1970); according to Hall (1981), five subspecies occupy the Llano and areas immediately adjacent to it. Several species of *Peromyscus* often live together in a relatively small geographic area (Thompson and Conley, 1983), and identification of specimens sometimes poses problems (Cornely et al., 1981); differentiation at the subspecific level also can be

problematic. The paucity of investigations addressing intergradation between subspecies of *P. maniculatus* that utilize similar habitats contributes to the complexity of the problem (Caire and Zimmerman, 1975). A circuitous pattern of gene exchange may take place between adjacent populations, with little or no direct interbreeding (Blair, 1953), thus adding to the problems surrounding the relationships among, and identity of, subspecies. Blair (1954a) found no evidence of reproductive isolation among *P. m. pallescens*, *P. m. blandus*, and *P. m. rufinus*. Although more is known about population dynamics and geographic variation in *Peromyscus maniculatus* than any other species of small mammal (Blair, 1953), its taxonomic status is still uncertain over parts of its distribution, including the Llano Estacado. The only apparent distinct geographic feature that might provide a barrier to gene flow between or among subspecies in the vicinity of the Llano is the edge of the caprock, which is evident to a greater or lesser degree along all but the southern part of the region.

The deer mouse is generally distributed over the Llano Estacado, but rarely is locally common. It is much less abundant overall, for example, than its relative, *Peromyscus leucopus*. Most often, *P. maniculatus* has been taken in mesquite grassland, in grassy areas having a sandy substrate, such as on the Muleshoe Sandhills, and along overgrown grassy-woody fence rows.

Judd (1970) examined 145 specimens from the Llano and assigned them to the subspecies *P. m. luteus*. The relative scarcity of *P. maniculatus* on the Llano Estacado (Blair, 1954b; Judd, 1970; Jones et al., 1988) has made it difficult to assemble representative groups of specimens to determine their taxonomic status. New collections have been acquired since Judd's work, however, and multivariate statistical techniques have come into general use. The goal of research resulting in this paper was to better define the systematic affinities of *Peromyscus maniculatus* on the Llano and in adjacent areas through use of multivariate morphometeric analysis.

Historical Taxonomy

Osgood (1905) described *Peromyscus luteus*, with type locality at Kennedy, Cherry County, Nebraska. Later, he (1909) relegated *luteus* to subspecific status under *P. maniculatus*, and assigned 10 specimens from Washburn, Armstrong Co., Texas, to *P. m. nebrascensis* [= *luteus*] (see Jones, 1958, for the proper use of the subspecific name *nebrascensis*). Hall (1981) mapped five subspecies converging in the geographic region on or near the Llano Estacado, but the exact borders of the ranges of these races was unclear. They are listed below, based on Hall's distributional scheme.

Peromyscus maniculatus blandus Osgood, 1904, was mapped as

occurring from southern Coahuila and Chihuahua northward to a latitude of approximately 34° north. In the United States, *P. m. blandus* is found in the lower Sonoran life-zone of western Texas, north to southern New Mexico (Osgood, 1909). This race evidently occurs throughout the southern Pecos River drainage, an area directly adjacent to the southwestern and western edges of the Llano Estacado.

Peromyscus maniculatus luteus Osgood, 1905, was shown to range from South Dakota southward to the southern edge of the Llano Estacado. Osgood (1909) associated *luteus* primarily with the sandhill region of western Nebraska and adjacent areas.

Peromyscus maniculatus nebrascensis (Coues, 1877) was reported as extending from southeastern Alberta and southern Saskatchewan, south through the western parts of the Dakotas and Nebraska to the Oklahoma Panhandle, and westward to include the southeastern part of Montana and the eastern parts of Wyoming and Colorado. Hall (1981) even mapped an extension of the distribution of this race into the Texas Panhandle, although no specimens were referenced from that area. Osgood (1909) associated the subspecies now known as *nebrascensis* with the plains and foothill regions of the Rocky Mountains.

Peromyscus maniculatus pallescens J. A. Allen, 1896, occurs throughout central Texas and approaches the Llano from the southeast. It also has been recorded from Hardeman County, Texas, by Hall (1981), but this was an extrapolation of a county record referenced only to species by Davis (1974). Jones et al. (1987), however, listed *P. m. pallescens* as a subspecies that might be present in northwestern Texas.

Peromyscus maniculatus rufinus (Merriam, 1890) is distributed from western Colorado southward through the southeastern corner of Utah into most of eastern Arizona and western New Mexico. Hall (1981) illustrated the eastern extent of the range of this subspecies as entering the extreme northwestern edge of the Texas Panhandle, although no specimen records were cited from there. *P. m. rufinus* inhabits areas of transition and boreal vegetation in the southern Rocky Mountains (Osgood, 1909; Wilson, 1968). Wilson found it to be the dominant small mammal of mixed conifer forests above 8500 feet. Dalquest et al. (1990) reported that *P. m. rufinus* and *P. m. luteus* intergrade in Union County, New Mexico. Judd (1970) opined that habitat limitations prevent *P. m. rufinus* from entering the Llano Estacado. We concur that *P. m. rufinus* is not found on the Llano, and it is included here for comparative purposes only. As an aside having no relationship to the present study, Hoffmeister (1986) regarded *rufinus* as a synonym of *P. m. sonoriensis*.

Methods and Materials

Four external measurements (total length, length of tail vertebrae, length of hind foot, length of ear) were obtained from original specimen labels. Weights of pregnant females

were removed from the data set. No weights were recorded for specimens of *P. m. pallescens* from Hill County, and that subspecies thus could not be compared with the other groups for that parameter. Inconsistency in recording weight and problems associated with missing values prompted removal of that measure from the analysis. Furthermore, because missing values did not allow us to maintain reasonable sample sizes, external measurements were not used in tests involving multivariate techniques.

Judd (1970) noted considerable variation in pelage color within samples taken from the Llano Estacado, and remarked that many deer mice from that region appeared to be intermediate in color between *P. m. pallescens* and *P. m. nebrascensis*, but that some resembled *P. m. luteus*. Although qualitative observations of pelage were made, quantitative pelage characteristics were not assessed in this study.

Twelve cranial measurements were taken (by Cooper) with Fowler digital calipers to the nearest 0.01 mm. These were selected based on other studies of *Peromyscus* (Osgood, 1909; Fox, 1948; Cockrum, 1954; Judd, 1970; Schmidly, 1973; Cornely et al., 1981; Koh and Peterson, 1983). Description of cranial measurements follows:

Greatest length of skull.—Length from anterior margin of nasal bone to posterior projecting margin of occiput.

Breath of braincase.— Greatest width of braincase measured perpendicular to long axis of skull between posterior margins of zygomatic arches.

Zygomatic breadth.—Greatest distance perpendicular to long axis of skull across the zygomatic arches.

Interorbital constriction.—Least width across frontal bones (that is, least constriction in interorbital region).

Length of rostrum.—Distance from anteriormost projection of nasal bone to lateral junction of lacrimal and maxilla.

Occipital depth.—Distance from ventral plane of auditory bullae to dorsalmost projection of parietals.

Breadth of rostrum.—Greatest distance across rostrum anterior to zygomatic arches.

Condylobasal length.—Greatest distance from posteriormost projection of occipital condyle to anteriormost projection of premaxilla.

Breadth of upper molars.—Greatest distance across outer buccal margins of upper molars.

Length of maxillary toothrow.—Greatest length of alveolar space of the upper molar toothrow.

Length of diastama.—Shortest distance between posterior alveolus of incisor and alveolar space at anterior margin of upper molar row.

Length of palate.—Shortest distance from anteriormost point at posterior border of palate to posterior lip of alveolus of incisor.

All statistical tests were made using SPSS/PC + statistical package (SPSS, Inc., 1986) for IBM compatible personal computers. Specified tests are discussed in greater detail in the following sections on nongeographic and geographic variation.

Nongeographic Variation

Subspecies of *Peromyscus maniculatus* have been extensively studied with regard to growth rates and development (see, for example, Svihla, 1934, 1935; Dice, 1936, 1937; Dice and Bradley, 1942). In order to minimize the effects of variation in external and cranial dimensions associated with normal development, we initially excluded juveniles and subadults from our evaluations. Dice (1936) found that mice in laboratory populations of *P. m. gracilis* had demonstrable growth in both

external and cranial dimensions after the second year of life, although individuals rarely live that long in the wild. Fox (1948), however, found no significant age variation in adult specimens that possessed at least slight wear on the last molar. We assigned specimens of *P. maniculatus* to one of five age classes based on criteria developed by Koh and Peterson (1983).

Juvenile.—Specimens with grayish pelage, M3 not reaching the height of M1 and M2.

Subadult.—Specimens with drab brownish subadult pelage or in the process of molting to or from that pelage, with little or no tooth wear evident.

Young adult.—Specimens with new adult pelage, with some wear on cusps of upper molars.

Adult.—Specimens in adult pelage, with noticeable wear on cusps of upper molars.

Old adult.—Specimens in adult pelage, with substantial wear on upper molars (cusps obliterated).

To assess the amount of morphological variation that was attributable to sexual variation, a sample from Lubbock County was analyzed for secondary sexual dimorphism. Comprised of 32 specimens (17 males and 15 females, all young adults and adults), the Lubbock sample represents the largest available from a single locality. A one-way multivariate analysis of variance was performed, using the program MANOVA from SPSS (SPSS, Inc., 1986) with sex as the main factor. The effect of sex was nonsignificant ($P = 0.083$), and the sexes thus were combined for subsequent analyses.

A one-way multivariate analysis of variance was performed on the same Lubbock sample, using the program MANOVA with age as the main factor (entire sample made up of young adults and adults). Nonsignificant ($P = 0.330$) results were obtained for the effect of age, and animals from these two age groups (and old adults) thus were combined in all subsequent analyses.

Geographic Variation

In order to obtain acceptable sample sizes for statistical treatment, mice from some localities were pooled. In forming *a priori* groups, however, caution was taken not to cross biogeographic barriers in pooling specimens (Thorpe, 1976; Hollander, 1990). In one case, however, the grouped sample representing *P. m. blandus* crossed such a barrier in that the Pecos River divided localities from which specimens were selected from Pecos and Winkler counties. Individuals we examined from possible areas of intergradation between subspecies were not grouped, but were treated as "unknowns." The small available sample of *P. m. nebrascensis* precluded it from the statistical analysis. A listing of the resulting eight *a priori* groups follows (see Table 1 for a summary of statistics): group 1—Lubbock County, Texas; group 2—Sherman and Moore counties, Texas; group 3—Lamb and Bailey counties, Texas; group 4—Randall and Castro counties, Texas; group 5—Cherry and

TABLE 1. Summary statistics including sample size (N), mean, standarrd deviation (SD), standard error (SE), and minimum and maximum values.

Group	Mean	SE	SD	Minimum	Maximum	*N*
			Breadth of braincase			
GLOC 1	10.84	.06	.35	9.72	11.56	32
GLOC 2	11.13	.04	.20	10.75	11.54	30
GLOC 2	11.12	.05	.23	10.67	11.58	17
GLOC 4	11.15	.09	.32	10.52	11.70	13
GLOC 5	11.35	.06	.26	10.78	11.83	22
GLOC 6	11.49	.05	.26	10.87	11.91	28
GLOC 7	11.50	.07	.33	10.97	12.20	23
GLOC 8	11.05	.08	.44	10.00	11.51	28
			Breadth across upper molars			
GLOC 1	4.58	.03	.16	4.24	4.94	32
GLOC 2	4.74	.03	.15	4.41	5.09	30
GLOC 3	4.76	.04	.17	4.47	5.09	17
GLOC 4	4.75	.04	.16	4.50	4.98	13
GLOC 5	4.69	.04	.21	4.01	5.13	23
GLOC 6	4.81	.03	.16	4.41	5.03	28
GLOC 7	4.85	.03	.16	4.62	5.24	25
GLOC 8	4.58	.03	.16	4.25	4.89	29
			Condylobasal length			
GLOC 1	21.72	.14	.80	20.04	23.19	32
GLOC 2	22.59	.11	.62	21.12	23.75	30
GLOC 3	22.51	.16	.67	20.96	23.59	17
GLOC 4	22.81	.13	.48	22.08	23.79	13
GLOC 5	22.22	.16	.76	20.49	24.08	22
GLOC 6	23.11	.12	.64	21.68	24.97	28
GLOC 7	23.38	.18	.89	21.47	25.15	25
GLOC 8	21.42	.16	.85	19.26	22.62	27
			Length of diastama			
GLOC 1	6.27	.06	.36	5.52	7.00	32
GLOC 2	6.51	.11	.60	3.57	7.06	30
GLOC 3	6.52	.09	.38	5.83	7.24	17
GLOC 4	6.66	.08	.28	6.34	7.36	13
GLOC 5	6.52	.08	.40	5.51	7.32	23
GLOC 6	6.88	.06	.32	6.37	7.52	28
GLOC 7	6.67	.08	.41	6.00	7.68	25
GLOC 8	5.93	.06	.31	4.94	6.34	29
			Occipital depth			
GLOC 1	8.77	.07	.38	8.02	9.59	31
GLOC 2	9.06	.07	.38	8.29	9.82	30
GLOC 3	9.03	.07	.28	8.61	9.51	17
GLOC 4	9.17	.09	.33	8.61	9.84	13
GLOC 5	9.22	.07	.32	8.44	9.68	22
GLOC 6	9.34	.05	.29	8.70	9.79	28

TABLE 1. Continued

GLOC 7	9.36	.06	.31	8.77	10.04	24
GLOC 8	8.73	.09	.46	7.74	9.50	28
			Greatest length of skull			
GLOC 1	23.73	.14	.77	21.48	24.89	31
GLOC 2	24.69	.10	.56	23.83	25.86	29
GLOC 3	24.47	.13	.52	23.40	25.44	17
GLOC 4	24.86	.15	.53	24.10	25.63	13
GLOC 5	24.57	.17	.80	22.84	26.22	21
GLOC 6	25.53	.16	.79	24.18	27.87	25
GLOC 7	25.72	.22	1.06	23.58	27.82	24
GLOC 8	23.67	.18	.93	21.39	25.03	28
			Length of rostrum			
GLOC 1	8.86	.09	.46	8.05	10.10	28
GLOC 2	9.29	.06	.32	8.79	9.90	29
GLOC 3	9.16	.08	.35	8.48	9.69	17
GLOC 4	9.40	.07	.25	8.89	9.90	13
GLOC 5	9.24	.12	.55	8.27	10.59	22
GLOC 6	9.92	.07	.37	9.23	10.72	25
GLOC 7	9.82	.11	.54	8.83	10.61	25
GLOC 8	8.83	.09	.50	7.79	9.66	28
			Length of maxillary toothrow			
GLOC 1	3.61	.03	.16	3.26	3.98	32
GLOC 2	3.75	.03	.14	3.47	4.04	30
GLOC 3	3.74	.04	.18	3.40	4.0	17
GLOC 4	3.76	.05	.20	3.39	4.0	13
GLOC 5	3.69	.04	.17	3.18	4.04	23
GLOC 6	3.91	.03	.15	3.60	4.28	28
GLOC 7	3.89	.03	.17	3.69	4.44	25
GLOC 8	3.60	.03	.17	3.23	3.96	29
			Length of palate			
GLOC 1	9.84	.07	.41	9.14	10.63	32
GLOC 2	10.05	.06	.30	9.54	10.64	30
GLOC 3	9.97	.09	.37	9.07	10.37	17
GLOC 4	10.37	.09	.33	9.87	10.85	13
GLOC 5	10.01	.11	53	8.75	11.31	23
GLOC 6	10.51	.07	.36	9.78	11.39	28
GLOC 7	10.36	.08	.40	9.63	11.29	25
GLOC 8	9.50	.08	.44	8.44	10.39	29
			Interorbital constriction			
GLOC 1	3.76	.03	.16	3.45	4.13	32
GLOC 2	3.93	.03	.14	3.67	4.26	30
GLOC 3	3.86	.02	.10	3.73	4.05	17
GLOC 4	3.91	.03	.11	3.67	4.08	13
GLOC 5	3.94	.04	.17	3.70	4.35	23

TABLE 1. Continued

GLOC 6	3.94	.05	.27	2.95	4.30	28
GLOC 7	4.01	.03	.14	3.64	4.27	25
GLOC 8	3.88	.04	.23	3.28	4.20	28
			Breadth of rostrum			
GLOC 1	4.34	.05	.27	3.58	4.81	32
GLOC 2	4.49	.03	.18	4.18	5.01	30
GLOC 3	4.58	.05	.21	4.12	4.80	17
GLOC 4	4.58	.06	.22	4.29	4.96	13
GLOC 5	4.54	.05	.23	4.12	5.12	22
GLOC 6	4.46	.03	.17	4.10	4.85	27
GLOC 7	4.59	.06	.30	3.87	5.11	25
GLOC 8	4.40	.04	.22	3.76	4.90	29
			Zygomatic breadth			
GLOC 1	12.34	.10	.53	10.95	13.19	32
GLOC 2	12.84	.07	.37	12.13	13.91	30
GLOC 3	13.01	.07	.29	12.57	13.51	16
GLOC 4	12.99	.07	.25	12.50	13.33	11
GLOC 5	13.03	.09	.44	12.28	13.75	22
GLOC 6	13.00	.08	.41	12.15	13.84	28
GLOC 7	13.40	.09	.42	12.47	14.15	24
GLOC 8	12.43	.10	.47	11.05	13.22	20

Thomas counties, Nebraska; group 6—Lincoln and Otero counties, New Mexico; group 7—Winkler and Pecos counties, Texas; group 8—Hill County, Texas.

Groups 1, 3, and 4 are from the Llano Estacado. Group 2 represents a sample from north of the Canadian River in an area were mice possibly could be assignable to *P. m. nebrascensis* according to Hall (1981). Group 5 represents topotypic material of *P. m. luteus* from the sandhill region of Nebraska. All specimens of group 6 are from mountainous areas of New Mexico and represent *P. m. rufinus*. Animals in group 7 represent *P. m. blandus* from just beyond the southern edge of the Llano. *Peromyscus maniculatus pallescens* was represented by group 8—specimens from Hill County, Texas.

The presence of significant geographic variation among groups was tested using multivariate analysis of variance (program MANOVA, SPSS, Inc., 1986). Significant results were obtained ($P < 0.001$) indicating morphometeric differentiation among at least some groups. The 12 cranial and four external measurements then were tested using one-way ANOVAs with the *a priori* groups as the main effect. If significant differences were detected, the character then was subjected to a Student-Neuman-Keuls multiple range test. All characters displayed significant results ($P < 0.05$), indicating some morphometeric differentiation between

or among some *a priori* groups for every character. All characters, except length of hind foot ($P = 0.0178$) were significant at $P < 0.001$. The Student-Neuman-Keuls test was selected to delineate nonoverlapping subsets among the *a priori* groups. Student-Neuman-Keuls procedure is computationally identical to Welsch's set-up procedure, except that a different table of critical values is associated with each test (Sokal and Rohlf, 1981). The summarized results of the Student-Neuman-Keuls multiple range test appear in Table 2. Grouped locality (Gloc) 8 and Gloc 1 were placed in the same subset for 10 of the 16 parameters. Glocc 1 and 5 formed subsets for only three of 16 characters. Gloc 6 and Gloc 7 were grouped in subsets for 14 of 16 characters.

A discriminant function analysis (DFA—program Discriminant, SPSS, Inc., 1986) then was employed to test how well individuals within grouped localities could be distinguished. Because any missing value would result in removal of the entire specimen from analysis, only cranial characters were included in the DFA (Table 3). The resulting 60.37 percent of grouped cases correctly classified indicated that the *a priori* groups did not particularly well reflect potential biological groupings in the region. If all of the Llano Estacado specimens are grouped with *P. m. luteus* and analyzed by DFA, the percentage of correctly classified specimens increases to a respectable 77.44 percent. However, in this grouping strategy there are only four samples, which somewhat restricts the resolution capability of the test.

Discussion

Results of the multiple range tests lead us to conclude that most *P. maniculatus* on the Llano Estacado clearly should be assigned to *P. m. luteus*. Grouped localities 2, 3, and 4 all formed subsets with Gloc 5, for 15 of the 16 characters tested. The strong affinity with the *luteus* material reaffirms the existing taxonomic status for *P. maniculatus* from the northern and central Llano Estacado.

However, mice from the immediate vicinity of Lubbock are intergrades between *P. m. pallescens*, based on cranial measurements and qualitative pelage characteristics, and some mice with relatively dark pelage occur even farther westward, in Hale and Lamb Counties. Specimens from the Lubbock County sample formed subsets with Gloc 5 for only three of the 16 characters tested, but this group formed subsets with Gloc 8 for 12 of the 16 characters. Seven of the 16 characters formed nonoverlapping subsets, indicating a significant difference between the subsets at ($P < 0.05$). The Lubbock mice also have pelage characteristics that resemble *pallescens* more than *luteus*, exhibiting a distinctive dorsal stripe similar to *pallescens*. Few Lubbock specimens exhibited the pale buffy pelage of topotypic *luteus* material, but many specimens assigned to *luteus* from the northern Llano Estacado generally had a darker brown coat than

TABLE 2. Results of the one-way ANOVAs on 12 cranial and four external characters with the grouped localities (GLOC) as the main effect. Also the results of Student-Newman-Keuls multiple range test (MRT). Asterisks in a column indicate nonsignificant subsets.

Group	MRT			Mean	Range	*N*	P
				Breadth of braincase			
GLOC 1	*			10.84	9.72-11.56	32	<0.001
GLOC 8		*		11.05	10.00-11.51	28	
GLOC 3		*		11.12	10.67-11.58	17	
GLOC 2		*		11.13	10.75-11.54	30	
GLOC 4		*	*	11.15	10.52-11.70	13	
GLOC 5			*	11.35	10.78-11.83	22	
GLOC 6			*	11.49	10.87-11.91	28	
GLOC 7			*	11.50	10.97-12.20	23	
				Breadth across upper molars			
GLOC 8	*			4.58	4.25-4.89	29	<0.001
GLOC 1	*			4.58	4.24-4.94	32	
GLOC 5		*		4.69	4.01-5.13	23	
GLOC 2		*	*	4.74	4.41-5.09	30	
GLOC 4		*	*	4.75	4.50-4.98	13	
GLOC 3		*	*	4.76	4.47-5.09	17	
GLOC 6		*	*	4.81	4.41-5.03	28	
GLOC 7			*	4.85	4.62-5.24	25	
				Condylobasal length			
GLOC 8	*			21.42	19.26-22.62	27	<0.001
GLOC 1	*			21.72	20.04-23.19	32	
GLOC 5		*		22.22	20.49-24.08	22	
GLOC 3		*		22.51	20.96-23.59	17	
GLOC 2		*		22.59	21.12-23.75	30	
GLOC 4		*	*	22.81	22.08-23.79	13	
GLOC 6			*	23.11	21.68-24.97	28	
GLOC 7			*	23.38	21.47-25.15	25	
				Length of diastama			
GLOC 8	*			5.93	4.94-6.34	29	<0.001
GLOC 1		*		6.27	5.52-7.00	32	
GLOC 2			*	6.51	3.57-7.06	30	
GLOC 5			*	6.52	5.51-7.32	23	
GLOC 3			*	6.52	5.83-7.24	17	
GLOC 4			*	6.66	6.34-7.36	13	
GLOC 6			*	6.88	6.37-7.52	28	
GLOC 7			*	6.67	6.00-7.68	25	
				Occipital depth			
GLOC 8	*			8.73	7.74-9.50	28	<0.001
GLOC 1	*			8.77	8.02-9.59	31	
GLOC 3		*		9.03	8.61-9.51	17	
GLOC 2		*		9.06	8.29-9.82	30	
GLOC 4		*	*	9.17	8.61-9.84	13	
GLOC 5		*	*	9.22	8.44-9.68	22	

TABLE 2. Continued

GLOC 6		*	9.34	8.70-9.79	28	
GLOC 7		*	9.36	8.77-0.04	24	
			Greatest length of skull			
GLOC 8	*		23.16	21.39-25.03	28	<0.001
GLOC 1	*		23.73	21.48-24.89	31	
GLOC 3		*	24.47	23.40-25.44	17	
GLOC 5		*	24.57	22.84-26.22	21	
GLOC 2		*	24.69	23.83-25.86	29	
GLOC 4		*	24.86	24.10-25.63	13	
GLOC 6		*	25.53	24.18-27.87	25	
GLOC 7		*	25.72	23.58-27.82	24	
			Length of rostrum			
GLOC 8	*		8.83	7.79-9.66	28	<0.001
GLOC 1	*		8.86	8.05-10.10	28	
GLOC 3		*	9.16	8.48-9.69	17	
GLOC 5		*	9.24	8.27-10.59	22	
GLOC 2		*	9.29	8.79-9.90	29	
GLOC 4		*	9.40	8.89-9.90	13	
GLOC 7		*	9.82	8.53-10.61	25	
GLOC 6		*	9.92	9.23-10.72	25	
			Length of maxillary toothrow			
GLOC 8	*		3.60	3.23-3.96	29	<0.001
GLOC 1	*		3.61	3.26-3.98	32	
GLOC 5	*	*	3.69	3.18-4.04	23	
GLOC 3		*	3.74	3.40-4.10	17	
GLOC 2		*	3.75	3.47-4.04	30	
GLOC 4		*	3.89	3.69-4.10	13	
GLOC 7		*	3.89	3.69-4.44	25	
GLOC 6		*	3.91	3.60-4.28	28	
			Length of palate			
GLOC 8	*		9.50	8.44-10.39	29	<0.001
GLOC 1		*	9.84	9.14-10.63	32	
GLOC 3		*	9.97	9.07-10.37	17	
GLOC 5		*	10.01	8.75-11.31	23	
GLOC 2		*	10.05	9.54-10.64	30	
GLOC 7		*	10.36	9.63-11.29	25	
GLOC 4		*	10.37	9.87-10.85	13	
GLOC 6		*	10.51	9.78-11.39	28	
			Interorbital constriction			
GLOC 1	*		3.76	3.45-4.13	32	<0.001
GLOC 3	*	*	3.86	3.28-4.20	28	
GLOC 8		*	3.88	3.28-4.20	28	
GLOC 4		*	3.91	3.67-4.08	13	
GLOC 2		*	3.93	3.67-4.26	30	
GLOC 6		*	3.94	2.95-4.30	28	

TABLE 2. Continued

GLOC 5		*		3.94	3.70-4.35	23	
GLOC 7		*		4.01	3.64-4.27	25	
				Breadth of rostrum			
GLOC 1	*			4.34	3.58-4.81	32	<0.001
GLOC 8	*	*		4.40	3.76-4.90	29	
GLOC 6	*	*		4.46	4.10-4.85	27	
GLOC 2		*		4.49	4.18-5.01	30	
GLOC 5		*		4.54	4.12-5.12	22	
GLOC 4		*		4.58	4.29-4.96	13	
GLOC 3		*		4.58	4.12-4.80	17	
GLOC 7		*		4.59	3.87-5.11	25	
				Zygomatic breadth			
GLOC 1	*			12.34	10.95-13.19	27	<0.001
GLOC 8	*			12.43	11.05-13.22	20	
GLOC 2		*		12.84	12.13-13.91	30	
GLOC 4		*		12.99	12.50-13.33	11	
GLOC 6		*		13.00	12.15-13.84	28	
GLOC 3		*		13.01	12.57-13.51	16	
GLOC 5		*		13.03	12.28-13.75	22	
GLOC 7		*		13.40	12.47-14.12	24	
				Total length			
GLOC 8	*			132.80	112-147	25	<0.001
GLOC 1	*			137.69	125-160	29	
GLOC 5		*		147.26	133-171	23	
GLOC 3		*		147.29	135-158	14	
GLOC 2		*		150.41	137-179	27	
GLOC 4		*		150.50	141-164	12	
GLOC 6		*	*	154.71	127-189	28	
GLOC 7			*	160.17	144-180	23	
				Length of tail vertebrae			
GLOC 1	*			53.83	41-68	29	<0.001
GLOC 8	*	*		57.04	43-67	25	
GLOC 2	*	*		57.41	50-64	27	
GLOC 4		*		60.55	57-64	11	
GLOC 3		*		60.93	54-68	14	
GLOC 5		*		61.70	34-71	23	
GLOC 6			*	67.39	52-85	28	
GLOC 7			*	68.08	58-82	24	
				Length of hind foot			
GLOC 1	*			17.96	15-20	28	<0.020
GLOC 8	*			18.68	14-21	20	
GLOC 2	*	*		19.04	18-20	27	
GLOC 4	*	*		19.42	19-22	12	
GLOC 3	*	*		19.50	18-21	14	
GLOC 7	*	*		20.08	18-24	24	

TABLE 2. Continued

GLOC 5	*	*		20.22	18-22	23	
GLOC 6		*		21.89	18-70	28	
				Length of ear			
GLOC 8	*			14.39	11-18	20	<0.001
GLOC 1	*			14.50	12-17	28	
GLOC 3	*	*		15.14	13-17	14	
GLOC 2	*	*		15.22	11-18	27	
GLOC 5		*		15.70	14-19	23	
GLOC 7		*		15.71	13-18	24	
GLOC 4		*		15.75	13-17	12	
GLOC 6			*	17.57	14-21	28	

found in those from Nebraska. Based on the results of the multiple range tests and qualitative pelage characteristics, we conclude that mice in the Lubbock area are intergrades, which we tentatively assign to *luteus* at the present time.

Results of DFA indicate that the influence *P. m. pallescens* diminishes in Hale County, from which four individuals fell out with Gloc 3 and only two with Gloc 8. However, the area of intergradation also may include areas along the eastern edge of the Llano, possibly immediately to the north of Lubbock and certainly to the south, once adequate material is at hand for study. Additional specimens also are needed from the extreme southern and southwestern parts of the Llano to confirm certainly that mice from there should be assigned to *luteus*. [It should be noted here that even though more than 30 specimens were examined from Andrews and Ector counties, most had not yet been associated with cleaned skulls at the time of our study.]

Using discriminant function analysis, ungrouped specimens were aligned with those groups that they most closely resembled in terms of measurements. Of eight specimens from Garza County, Texas, for

TABLE 3. Results of discriminant function classification.

Actual groups	Predicted group membership							
	1	2	3	4	5	6	7	8
1	14	5	1	2	0	1	0	1
2	1	15	2	2	4	2	1	2
3	1	5	7	0	1	0	1	1
4	1	4	0	5	0	0	1	0
5	1	1	1	2	11	1	2	0
6	0	1	1	0	0	21	1	0
7	1	1	0	1	1	3	15	0
8	4	1	0	0	2	0	1	11

example, four were distributed through DFA with the Lubbock sample, but two were placed with Gloc 2, and one each with Gloc 3 and 4, all representing areas occupied by *luteus*. Therefore, Garza County, like Lubbock County immediately to the northwest, appears to represent an area of intergradation between *luteus* and *pallescens*, but specimens are here assigned to the former. Of seven unknowns from Hale County, four were placed with Gloc 3, two with Gloc 8, and one with Gloc 7. The individual placed with Gloc 7 is an unusually large specimen, but the others indicate a reduced influence of *pallescens* in Hale County. Of two specimens examined from Collingsworth County, Texas, one aligned with Gloc 5 and the other with Gloc 8. Due to the small sample size no taxonomic judgement concerning relationships should be made, and more material clearly needs to be obtained from this area of the eastern Panhandle.

Peromyscus maniculatus blandus and *P. m. rufinus* formed subsets for 14 of the 16 characters tested under the Student-Neuman-Keuls procedure. Although size may be similar in *P. m. blandus* and *P. m. rufinus*, pelage, habitat, and other distinctions continue to support their status as distinct races. A list of the total number of specimens examined of the several subspecies follows.

Peromyscus maniculatus blandus Osgood, 1904

Specimens examined (41).—TEXAS. *Pecos Co.*: 4 mi. S, 14.5 E Imperial, 16. *Winkler Co.*: Winkler County Airport, 6 mi. S Kermit, 17; 1 mi. S Kermit, 2; 2.5 mi. NE Winkler County Airport, 1; 19 mi. E Kermit, base Concho Bluff, 1; 19 mi. E Kermit, 1; vicinity Wink, 3.

Peromyscus maniculatus luteus Osgood, 1905

Specimens examined (334).—NEBRASKA. *Cherry Co.*: 2.9 mi. N, 1.1 mi. E Valentine, 4; Valentine National Wildlife Refuge, Hackberry Lake, 11; Rice Lake, 10. *Thomas Co.*: Nebraska National Forest, Bessey Division, 13.

TEXAS. *Andrews Co.*: 4 mi. N, 9 mi. W Andrews, 1; 3 mi. N, 11 mi. W Andrews, 6; 18 mi. E Andrews, 1; 7 mi. S, 3 mi. E Andrews, 1. *Bailey Co.*: 2 mi. S, 10 mi. W Muleshoe, 1; 2.2 mi. S Muleshoe, 3; 5.1 mi. S, 2 mi. W Needmore, 7; 1.7 mi. W Needmore, 1; 5.3 mi. S, 0.8 mi. W Needmore, 3. *Briscoe Co.*: Los Lingos Canyon, 1. *Carson Co.*: Pantex Research Farm, 12 mi. E Amarillo, 23. *Castro Co.*: 8 mi. N, 1.5 mi. W Hart, 8; 4 mi. NW Hart, 9; Dimmit, 6. *Collingsworth Co.*: 9 mi. E Lutie, 7; 2 mi. N, 9 mi. E Lutie, 4. *Ector Co.*: 4 mi. W Goldsmith, 1; 9 mi. N Odessa, 5; 4 mi. N Notrees, 3; 1 mi. N Notrees, 1; 3.5 mi. S, 1 mi. E Notrees, 1; 2 mi. N Odessa, 3; 10 mi. E Loop 338, Odessa, 10. *Garza Co.*: 12 mi. S Post, 2; 6 mi. SE Southland, 1; 1 mi. W Post, 3; 8.5 km NE Southland, 9. *Hale Co.*: 4 mi. N, 5.5 mi. W Cotton Center 2; 5 mi. N, 12.5 mi. W Hale Center, 3. *Hemphill Co.*: Howe Wildlife Refuge, 5; Lake Marvin, 12 mi. E Canadian, 3. *Hockley Co.*: 14 mi. NW Levelland, 3; 8.5 mi. NW Levelland, 4. *Lamb Co.*: 7.2 mi. S Olton, FM 168, 4; 4 mi. N Fieldton, 3; 6 mi. S Spring Lake, 6; 8 mi. S Spring Lake, 1; 3.5 mi. S Earth, 1; 5.5 mi. N FM 168, 1.7 mi. W FM 1842, 2 mi. N dirt road near Running Water Draw, 3. *Lipscomb Co.*: 2 mi. N, 8 mi. E Lipscomb, 2. *Lubbock Co.*: 3.5 mi. N Slaton, 5; 8 mi. W Lubbock on 4th St., 1; 3.4 mi NW Lubbock, 4; Lubbock, 10; 10 mi. SW Lubbock, 1; 7.5 mi. N Lubbock, 15; 5 mi. N Lubbock, 4; 11 mi. S Lubbock on U.S. Hwy. 62, 3 mi. S FM 179, 1 mi. E dirt road, 0.5 mi. S, 1; 8 mi. N, 6 mi. NE Lubbock, 2; 5 mi. N Lubbock Lake, 1; 0.5 mi. N Lubbock Lake, 5; 2.8 mi. E Idalou, 4; 1 mi. N, 5 mi. W Lubbock, 4; 1 mi. N, 1.5 mi. W Lubbock, 4; 7 mi. W

FM 1264 and Loop 289, 10; 4 mi. S, 5.7 mi. E Lubbock, 16. *Moore Co.*: 4 mi. N, 1 mi. E Dumas, 8. *Randall Co.*: Palo Duro State Park, 7 mi. S entrance, 1; 9.2 mi. S, 13.7 mi. E Canyon, 1; 1 mi. S Umbarguer, 1; Buffalo Lake Wildlife Refuge, 3. *Roberts Co.*: 6 mi. N Miami, 2. *Sherman Co.*: 8 mi. S, 2 mi. E Stratford, 17; 10 mi. N Stratford, 15.

Peromyscus maniculatus nebrascensis (Coues, 1877)

Specimens examined (18).—WYOMING. *Unita Co.*: 3.6 mi. W, 0.8 mi. N Fort Bridger, 12 (NMSU); 7.1 mi. W, 1.9 mi. S Robertson 6 (NMSU).

Peromyscus maniculatus pallescens J. A. Allen, 1896

Specimens examined (41).—TEXAS. *Hill Co.*: 3 mi. S, 0.5 mi. W Hillsboro, 12 (TCWC); 3.1 mi. S, 6.6 mi. W Hillsboro, 5 (TCWC); 3.1 mi. S, 0.9 mi. W Hillsboro, 6 (TCWC); 3.4 mi. S, 1.6 mi. W Hillsboro, 2 (TCWC); 5.8 mi. S, 3.4 mi. W Hillsboro, 1 (TCWC); 5.8 mi. S, 3.1 mi. W Hillsboro, 7 (TCWC); 6 mi. S, 4.2 mi. W Hillsboro, 3 (TCWC); 6 mi. S, 3.9 mi. W Hillsboro, 1 (TCWC); 3.4 mi. S, 1.6 mi. W Hillsboro, 4 (TCWC).

Peromyscus maniculatus rufinus (Merriam, 1890)

Specimens examined (65).—NEW MEXICO. *Lincoln Co.*: 2.5 mi. W Bonito Lake, 15; 2.5 mi. N Bonito Lake, 5; 4 mi. N, 5 mi. W Bonito Lake, 1; 4.9 mi. E, 1.3 mi. N Sierra Blanca, 4 (NMSU); Oak Grove Camp, Sierra Blanca, 6 (NMSU); 1.7 mi. N, 1.2 mi. E Sierra Blanca, 1 (NMSU). *Otero Co.*: 20 mi. S Cloudcroft, 12; Lightning Lake, 7; Cloudcroft, 14.

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Specimens housed in the collection at Texas Tech University are not identified by an acronym, whereas those examined at Texas A&M University (for access to which we are thankful to George Baumgardner and Michael Forstner) are identified by the acronym TCWC. We also thank Charles Thaler and Karl Wilson for access to the collection at New Mexico State University, specimens from which bear the acronym NMSU.

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