

OCCASIONAL PAPERS OF THE MUSEUM OF  
ZOOLOGYUNIVERSITY OF MICHIGAN  
ANN ARBOR, MICHIGANDISTRIBUTION AND RELATIONSHIPS OF SIX SPECIES OF  
*PEROMYSCUS* IN BAJA CALIFORNIA AND SONORA, MEXICO

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## INTRODUCTION

IN MY INVESTIGATIONS of the evolution of *Peromyscus* on northern islands in the Gulf of California, Mexico, I attempted to ascertain the relationships of possibly related forms from mainland and other island areas of Baja California and Sonora. Previous studies of *Peromyscus* from these areas have been superficial, owing partly to a paucity of material, and the affinities of the various populations of the mice are unclear. New evidence indicates that taxonomic relationships of certain peromyscines in northwestern Mexico are more complex than formerly realized.

Specimens for study include those collected during field work on islands and the mainland in the summers of 1967–1969 and others contained in the following institutions: American Museum of Natural History (AMNH); California Academy of Sciences (CAS); San Diego Natural History Museum (SD); U.S. National Museum (USNM); Department of Zoology, University of Arizona (UA); Dickey Collection, University of California at Los Angeles (UCLA); Museum of Natural History, University of Kansas (KU); and Museum of Zoology, University of Michigan (UMMZ).

Measurements, in millimeters, were taken with dial calipers (skulls) or with a craniometer (bacula) (Anderson, 1968). Characters of phalli were derived from adult specimens. Vertebral counts were determined from X-rays or from skeletons. Karyotype analyses were made according to the methods of Patton (1967).

I am grateful to persons from the above institutions for permitting

me to examine specimens in their care, and to W. H. Burt and E. T. Hooper who read the manuscript. I also wish to express my thanks to personnel of the field station of the San Diego Natural History Museum at Bahía de los Angeles, Baja California (Dr. Richard P. Phillips, director), and of the Las Cruces Biological Station, Las Cruces, Baja California (Dr. Rita Schafer, director), for their cooperation. Field work was supported in part by a Sigma Xi research grant, by a grant to N. G. Hairston, University of Michigan, from the National Science Foundation for research in Systematic and Evolutionary Biology (NSF GB-6230), and by travel funds from a U.S. Public Health Service predoctoral fellowship (No. 1-F1-GM-37, 761-01).

### SPECIES ACCOUNTS

*Peromyscus merriami*.—Recent investigators who have clarified some of the relationships of *P. merriami* and *P. eremicus* are Commissaris (1960), who reported chiefly on habitat differences between the two species in southern Arizona, and Hoffmeister and Lee (1963), who examined morphological features which distinguish the species.

Characters that help to distinguish *merriami* from *eremicus* are as follows: larger size; skull more robust as a result of relatively greater zygomatic breadth; zygomatic notch generally deeper in dorsal view (Fig. 1); infraorbital canal larger; glans penis (Fig. 2) similar in configuration but longer; baculum longer, having a narrow, straight shaft (rather than being short, broad, and curved dorsally) and rounded, narrow base (not truncate proximally). A comparison of the relationship of width of base and length of baculum in *merriami* with other species examined is shown in Fig. 3.

Because there is a tendency in *eremicus* and other species of *Peromyscus* for skulls to become more robust with advancing age, I suspected that the characters attributed to *merriami* (see above) may be associated with age, the examples of *merriami* simply representing old individuals of *eremicus*. After examining samples from Sonora, however, I found my suspicion to be unwarranted; the characters described above distinguish young individuals as well as adults of the two species.

An index to relative "robustness" of the skull is provided by comparing greatest length of skull and zygomatic breadth. The values for these dimensions were plotted for individuals of *merriami* and *eremicus* from three localities in Sonora—Puerto Libertad (36), Presa Obregon (42), and Alamos (43)—where large samples of both species were

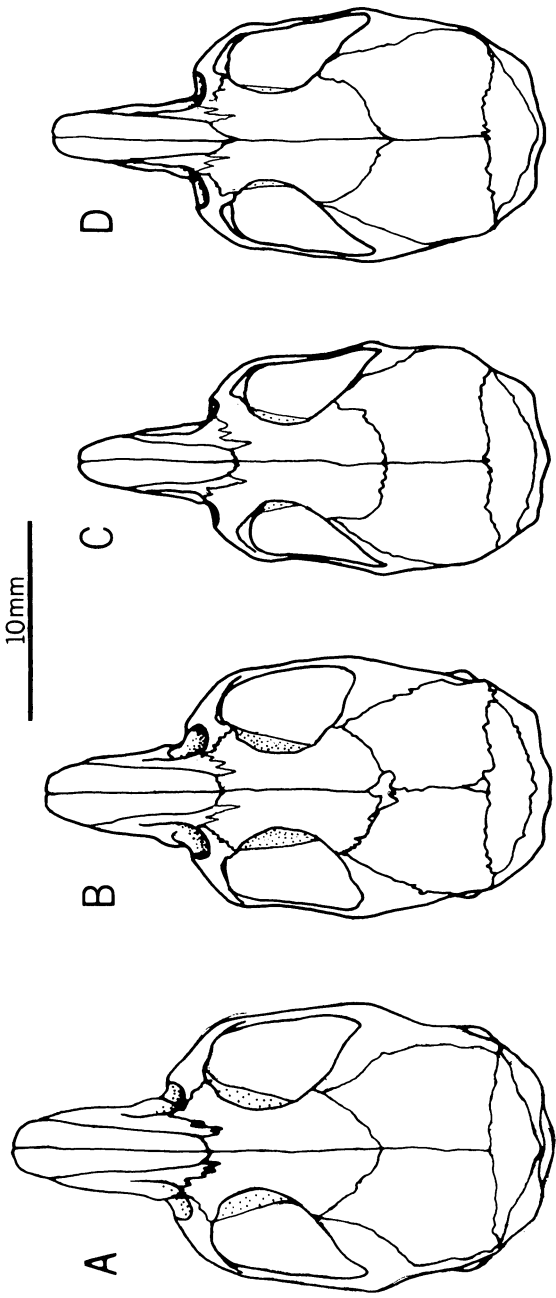


FIG. 1. Dorsal aspect of the skull of (A) *Peromyscus pembertoni*, UCLA 59351; (B) *P. merriami*, KU 90361; (C) *P. eremicus*, KU 95447; and (D) *P. eva*, SD 6850. In order to show the maximum number of differences, the skulls of *merriami* and *eremicus* that are illustrated are representatives of the largest and smallest, respectively, of the two species. All specimens are adults.

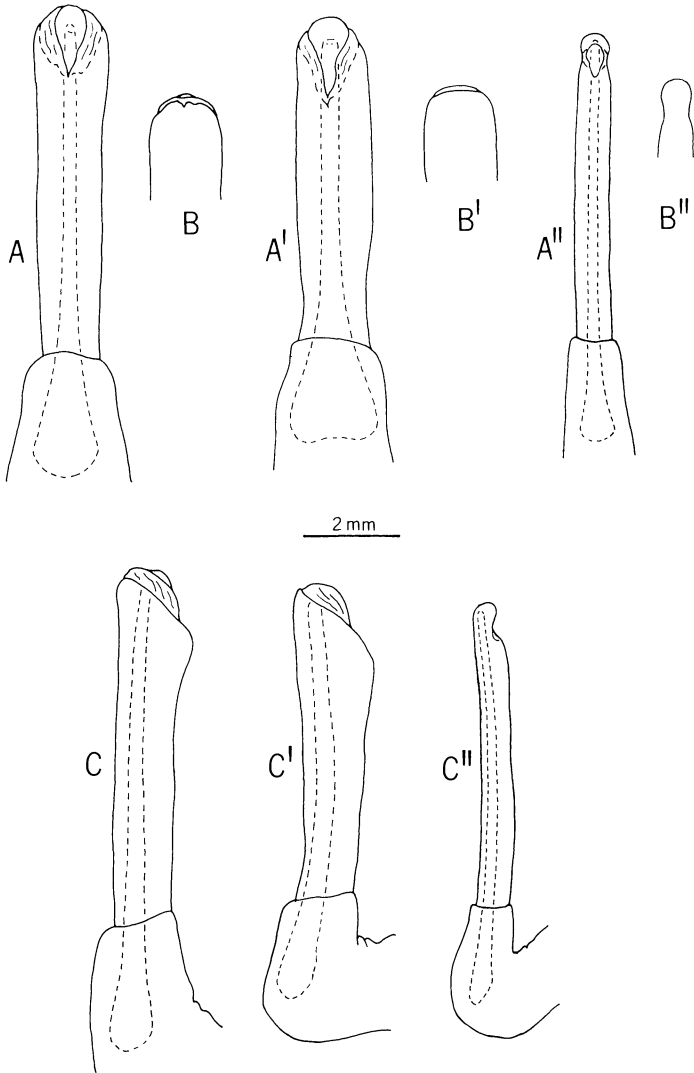


FIG. 2. Views of phalli in *Peromyscus merriami* (A, B, C), UMMZ 116533; *P. eremicus* (A', B', C'), UMMZ 116449; and *P. eva* (A'', B'', C''), CAS 11896.

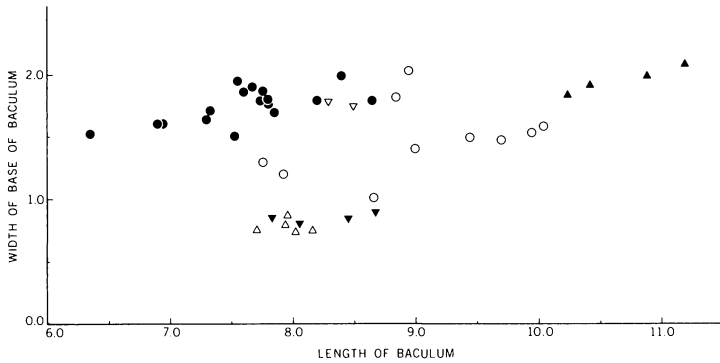


FIG. 3. Relationship of width of base and length of baculum (in mm.) in several species of *Peromyscus*. The symbols are as follows: closed circles—*eremicus*; open circles—*merriami*; closed triangles—*pembertoni*; open triangles—*eva*; closed inverted triangles—*caniceps*; open inverted triangles—*pseudocrinitus*.

examined. A covariance analysis (Snedecor, 1966:394–399) was applied to the samples from each of the localities. Both young and adult animals were used. The data and regressions are plotted in Fig. 4, and the computed values of covariance are presented in Table 1. The species do not differ ( $P > .05$ ) with respect to their residual variances. Also, the variance around the computed common slope is not significantly greater than that around the regression coefficients of the two independently calculated slopes; therefore, the populations at each locality were presumed to have the same regression slopes. The difference between adjusted means, however, is highly significant ( $P < .01$ ) in each instance, indicating that the elevations of the two regression lines in each population may be different. Therefore, the best estimate of the relationship of zygomatic breadth on greatest length at each locality is provided by two separate regressions with common slopes but different elevations. The differences in elevation confirm the impression that *merriami* has a more robust skull than *eremicus*.

Values of  $t$  also were calculated for the above two characters in samples with both species represented, totalling eight localities. Only adults (*sensu* Hoffmeister, 1951), were used in this analysis. *P. merriami* differs significantly ( $P < .05$ ) from *eremicus* for both characters at most

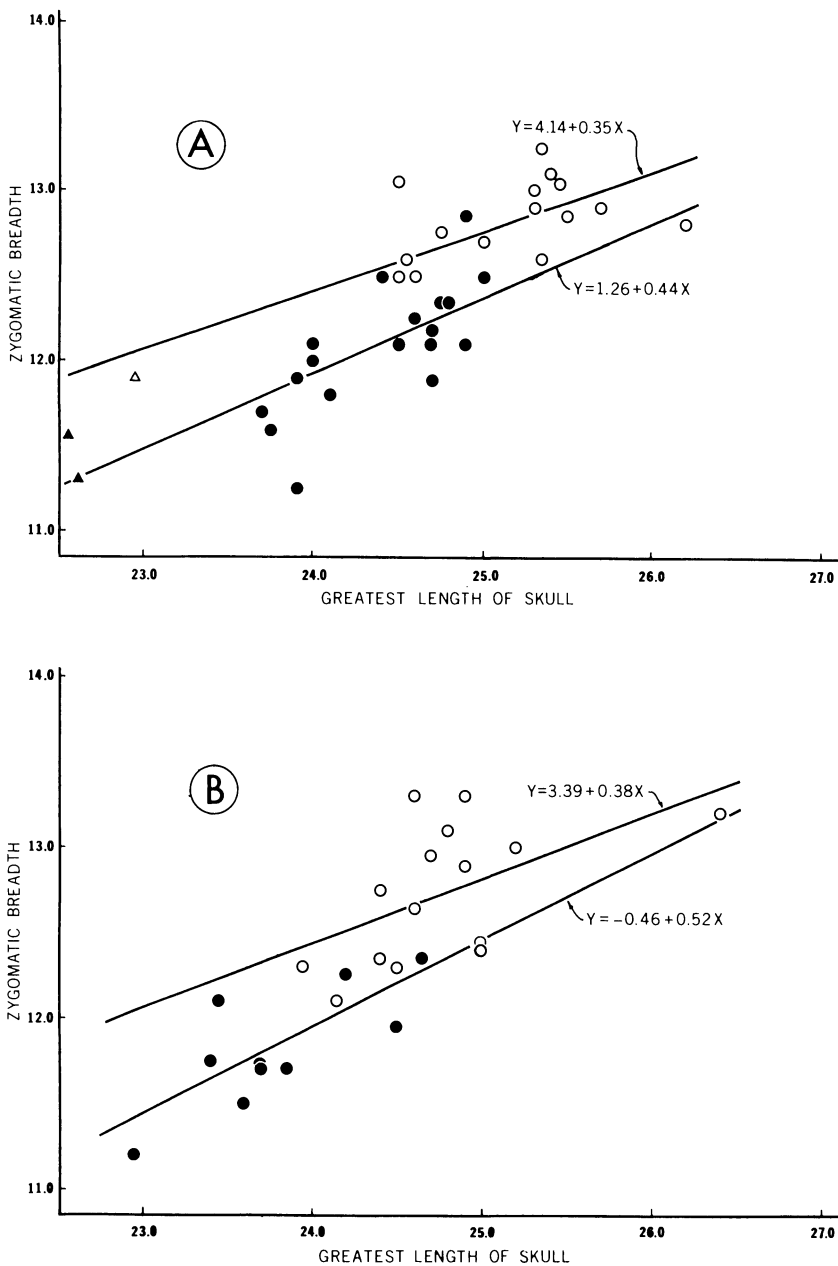


FIG. 4. Relationship of zygomatic breadth to greatest length of skull in three samples of *P. eremicus* and *P. merriami* from Sonora: (A) Puerto Libertad; (B) Presa Obregon; (C) Alamos. Open and closed symbols refer to *merriami* and *eremicus*, respectively. Circles denote adult individuals; triangles represent subadults.

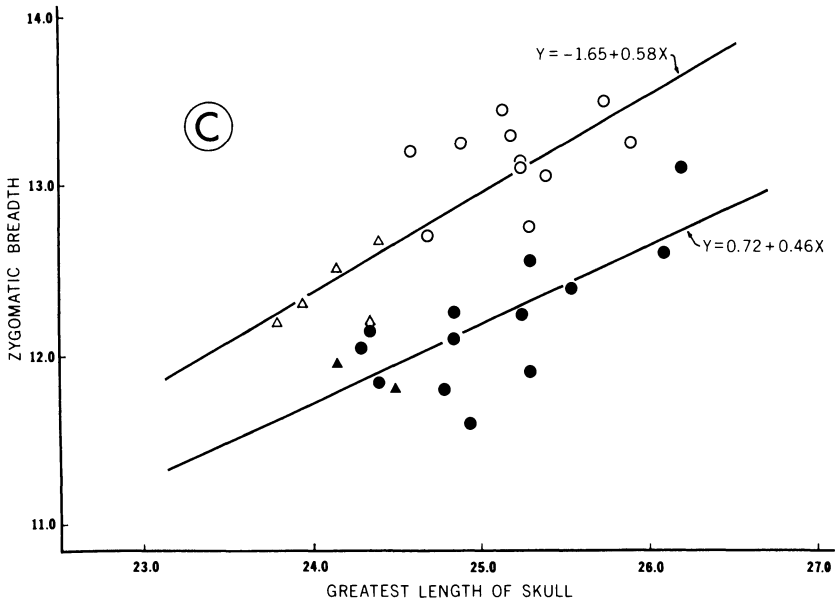


FIG. 4.—Part C

localities. At Sonoyta (34) and Alamos (43), Sonora, the two species are not different ( $P > .05$ ) for greatest length of skull. The same situation obtains for the sample from Guaymas (41), Sonora, but the small sample of *merriami* (two) afforded only one degree of freedom.

The size characters reported as most useful in distinguishing *merriami* and *eremicus* by Commissaris (*op. cit.*) and Hoffmeister and Lee (*op. cit.*) are: total length and lengths of tail, hind foot, ear, skull, palatal bridge, incisive foramina, and interorbital and mastoid breadth. In all cases except tail length, *merriami* averages larger. Certain of these characters (e.g., mastoid breadth; see Fig. 7) are particularly useful, but generally the magnitude of difference between the two species is less, and consequently these measures are not as diagnostic. Other qualitative features (e.g., shape of the posterior margin of the palate, extent of lateral projections of the mastoid processes) also are quite variable. Hoffmeister and Lee also were aware of these variations. Clearly, proper identifications and comparisons of *merriami* and

TABLE 1  
COVARIANCE ANALYSES OF GREATEST LENGTH OF SKULL AND ZYGOMATIC BREADTH IN  
*Peromyscus eremicus* AND *P. merriami* FROM (A) PUERTO LIBERTAD, (B) PRESA OBREGON,  
AND (C) ALAMOS, SONORA.

Source of variation	d.f.	Sum of squares	Mean square	F-tests
A. Error within species	32	1.898	0.059	} $F_s = 0.044/0.059 = 0.738$ (1, 32) n. s.
Regression coefficient	1	0.044	0.044	
Pooled error	33	1.942	0.059	} $F_e = 1.232/0.059 = 20.943$ (1, 33) **
Difference in adjusted means	1	1.232	1.232	
Total error	34	3.174	0.093	
B. Error within species	21	2.024	0.096	} $F_s = 0.030/0.096 = 0.315$ (1, 21) n. s.
Regression coefficient	1	0.030	0.030	
Pooled error	22	2.055	0.093	} $F_e = 2.055/0.093 = 9.022$ (1, 22) **
Difference in adjusted means	1	0.843	0.843	
Total error	23	2.897	0.126	
C. Error within species	27	2.041	0.076	} $F_s = 0.046/0.076 = 0.607$ (1, 27) n. s.
Regression coefficient	1	0.046	0.046	
Pooled error	28	2.087	0.075	} $F_e = 4.821/0.075 = 64.681$ (1, 28) **
Difference in adjusted means	1	4.821	4.821	
Total error	29	6.908	0.238	

Residual variances were homogeneous in the two species at each locality.  $F_s$  and  $F_e$  refer to F values calculated from comparisons of slopes and elevations of regressions, respectively.

*eremicus* can only be made by examining samples of both species on an intralocality basis and by employing a combination of characters (particularly when no male specimens are available). Characters attributable to either *merriami* or *eremicus* at one locality are not necessarily reliable generally.

Contrasts of *merriami* and *eremicus* were explored further by identifying specimens independently according to characters (see above) of the skull and phallus. In all cases where the two structures could be observed in a particular specimen (a total of 43), every individual was consistently categorized as either a *merriami* or *eremicus* on the basis of each character. Differences in pelage, which generally are subtle in the two species, were not always reliable as distinguishing features. Although the pelage of *merriami* usually has a finer texture (there is less admixture of brown or black) and is paler, differences are not always apparent.

I have studied the series of *Peromyscus* from Sonoyta, Sonora, from which Mearns (1896) described *merriami*. It consists of ten specimens



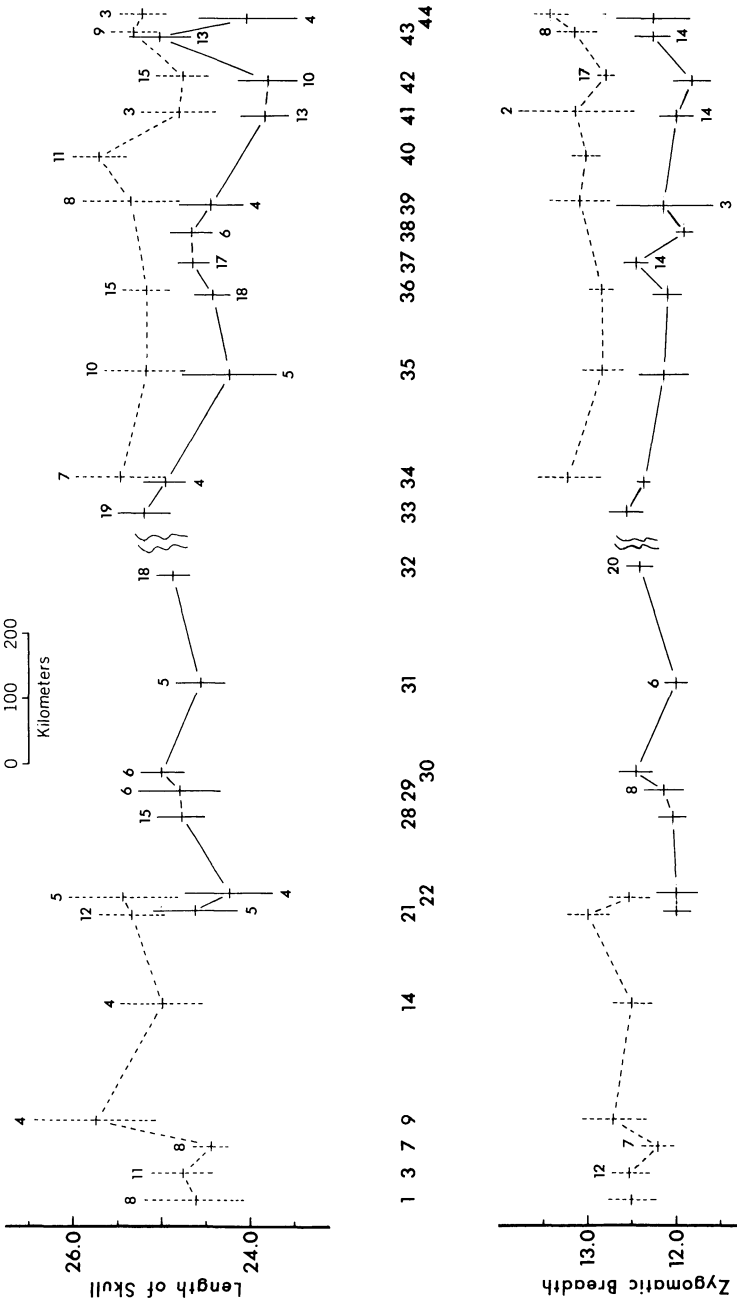


FIG. 5. Geographic variation (mean  $\pm 2$  S.E.) of two cranial measurements (in mm.) in *P. eremicus*, *P. merriami*, and *P. eva*. Distances measure horizontally and are approximate. The small numbers identify sample sizes and are indicated for zygomatic breadth only where they differ from those for length of skull; the large numbers correspond to locality designations given in Fig. 8, in the section "Specimens Examined," and elsewhere in the text. The vertical line refers to the range of variation when the sample size is less than four.

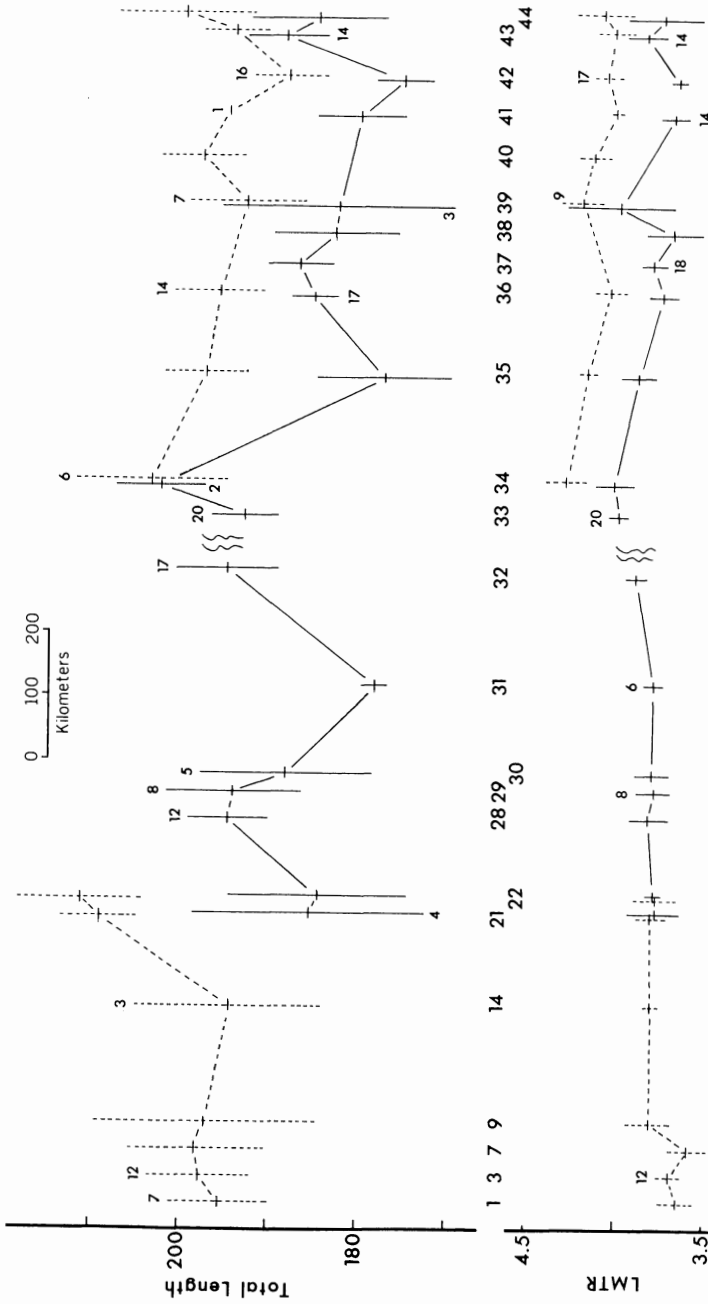


FIG. 6. Geographic variation (mean  $\pm$  2 S.E.) of one external and one cranial measurement in *P. eremicus*, *P. merriami*, and *P. eva*. For explanation of plots, number designations, and distance measurement, see Fig. 5. Sample sizes are indicated only where they differ from those for length of skull (Fig. 5). LMTR = length of maxillary tooththrow.

of *merriami* and six of *eremicus*. Osgood (1909) placed *merriami* in synonymy with *eremicus*, contending that the sample consists of a graded series of individuals from small to large. However, the specimens within the sample form two distinct units that are identifiable on the basis of features previously described for *merriami* and *eremicus*. I agree with Mearns (*loc. cit.*) in considering these forms distinct.

Geographic variation of selected external and cranial measurements for Sonoran samples is presented in Figs. 5-7. There is a general correspondence in the trends of variation in *merriami* and *eremicus*, suggesting that, although the two species occur in different habitats (see below), the environmental influences on size dimensions may be similar in the two species. An exception is length of tail. In this character, *eremicus* usually averages larger (in four of seven cases where the two species are found at the same locality; see Fig. 7). Except at Imuris, Sonora (35), *merriami* and *eremicus* are closely similar in tail length. Aside from local shifts in dimensions, there are no demonstrable geographic changes in size.

I do not appreciate the differences ascribed to the two subspecies of *merriami*—*merriami* and *goldmani*—by Hoffmeister and Lee (1963: 211). In Sonoran material at hand the characters used by those authors to distinguish *goldmani* (greater total length and length of tail, shorter ear, longer skull, greater basilar length and diastemal length, longer nasals, and narrower mastoid breadth) broadly overlap those measurements in *merriami*. In morphometric characters the two subspecies evidently do not differ in any important way. Geographic changes in color seemingly occur with changes in the character of the desert flora so that dark mice (reportedly *goldmani*) occur in the inland scrub forest areas of Sonora, and in Sinaloa, whereas the light-colored form (reportedly *merriami*) is present in the high desert of northern Sonora and southern Arizona, and along the Gulf coast of central and northwestern Sonora. Specimens at hand from Sonora exhibit a gradual shift in color from buffy brown in the north to dark brown in the south. The same clinal shift is reflected by a decrease in bicoloration of the tail and increase in intensity of the ochraceous lateral line. The suffusion of yellow in the underparts (reportedly better developed in *goldmani*) is extremely variable geographically and therefore is not a reliable taxonomic character. My interpretation of available evidence is that *goldmani* and *merriami* represent a single taxonomic unit. Local reversals evident in different characters suggest

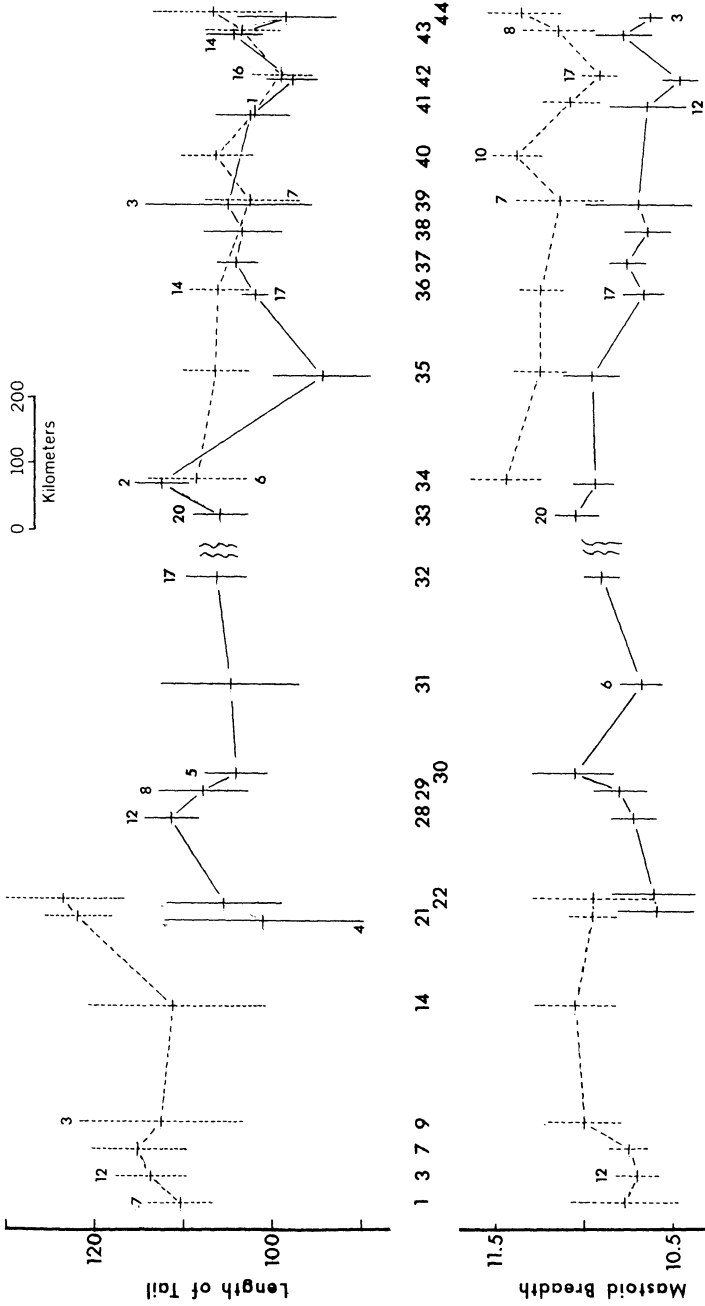


FIG. 7. Geographic variation (mean  $\pm$  2 S.E.) of one external and one cranial measurement in *P. eremicus*, *P. merriami*, and *P. eva*. For explanation of plots, number designations, and distance measurement, see Fig. 5. Sample sizes are indicated only where they differ from those for length of skull (Fig. 5).

that gene flow is incomplete or absent, and geographically variable within the range of the species. Subspecific recognition of *goldmani* as presently known is unwarranted.

From the foregoing account it is evident that *merriami* and *eremicus* are very similar in morphology of the phallus, cranium, and pelage. In addition, karyotypes of the two species are virtually identical (Lawlor, in press). All of the chromosomes in the two species are bi-armed. Moreover, there is a full complement of accessory reproductive glands in males of the two species. These features of the chromosomes and reproductive glands are shared only by species of the subgenus *Haplomylops* (e.g., see Hsu and Arrighi [1968], and Linzey and Layne [1969]). It seems clear that the similarities between *merriami* and *eremicus* are not the result of convergence, but are evidence of close genetic relationship.

*P. merriami* prefers riparian or desert floor habitats consisting of dense thickets or brush. Commissaris (1960) recorded the species in a mesquite bosque along the Santa Cruz River near Tucson, Arizona. I have taken several in the same area. In addition, I trapped several individuals 3 mi. SE Presa Obregon, Sonora, in dense stands of shrubs, trees, and vines underlain with grass and litter on the east bank of the Yaqui River and along a nearby tributary. *P. eremicus* was common on nearby rocky hillsides but not in the habitat of *merriami*.

Apparently *merriami* is more common and more widely distributed than formerly realized (Fig. 8). Nearly every sample I examined from Sonora had both *merriami* and *eremicus* represented. Only samples known to be taken from rocky situations lacked samples of *merriami* (e.g., Bahía Kino [38], and Puerto Peñasco [33]).

*Peromyscus pembertoni*.—This insular species (Isla San Pedro Nolasco) evidently is derived from *merriami*. It agrees with *merriami* in features of the baculum (no entire phalli were available) and skull (for example, see Burt, 1932), except that *pembertoni* is demonstrably larger. Selected average external and cranial measurements ( $\pm 2$  S. E.) of seven adults are as follows: total length, 210.6 ( $\pm 2.0$ ); length of tail, 104.9 ( $\pm .05$ ); length of hind foot, 24.57 ( $\pm 0.20$ ); greatest length of skull, 27.34 ( $\pm 0.18$ ); zygomatic breadth, 14.35 ( $\pm 0.07$ ); mastoid breadth, 12.11 ( $\pm 0.05$ ); length of nasals, 10.16 ( $\pm 0.07$ ); length of maxillary toothrow, 4.44 ( $\pm 0.04$ ). Additional dimensions are given by Burt (*op. cit.*). The skull is very robust; the ratio of zygomatic breadth on length of skull places *pembertoni* on an extension of the

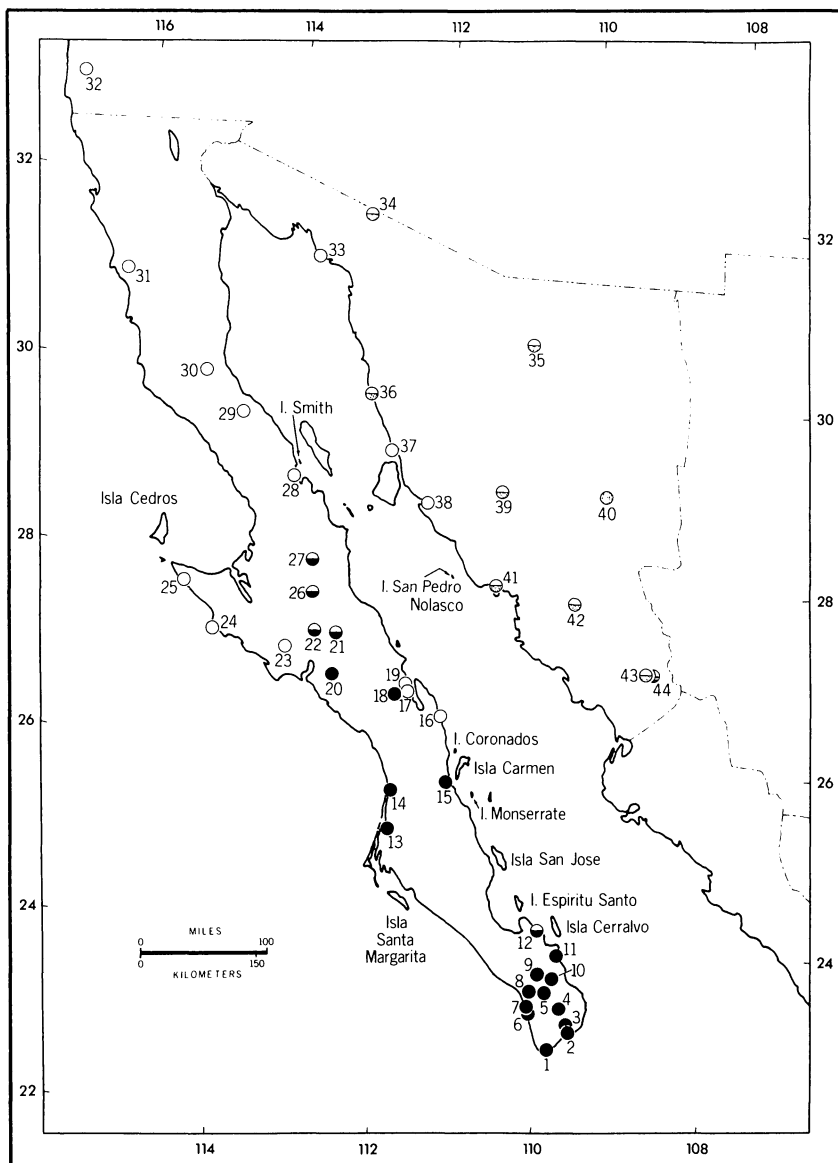


FIG. 8. Distribution of *Peromyscus eremicus*, *P. merriami*, and *P. eva* in northwestern Mexico. Numbers identify localities mentioned in the text, presented in Figs. 5-7, and listed in the section of specimens examined. Circles denote localities as follows: open—*eremicus*; closed—*eva*; stippled—*merriami*.

regression line for *merriami* from Alamos, Sonora (43) (Fig. 4). The ratio is larger (i.e., zygomatic breadth is greater relative to length of skull) in *pembertoni* than in the other two *merriami* samples plotted, and far greater than any of the samples of *eremicus* examined. In all of the above comparisons there is no overlap between *pembertoni* and *merriami* or *eremicus* in either of the two measurements. However, the close similarity of the ratio of the two dimensions in *pembertoni* and *merriami* at Alamos suggests that the skull features of *pembertoni* may have resulted from proportional size increases in a *merriami*-like progenitor.

The baculum of *pembertoni* is actually and relatively larger than in *merriami* (Fig. 3), but in dimensions the species is closer to *merriami* than it is to *eremicus*. Measurements of breadth of base and length of baculum for four specimens are: 1.85 x 10.25; 2.05 x 10.90; 2.20 x 11.20; 1.95 x 10.45.

Other features (e.g., chromosomes and phallus) have not been examined in this species. Nevertheless, the weight of the available evidence indicates a closely affinity of *pembertoni* to *merriami*. It represents the only likely insular derivative of a *merriami*-like ancestor in the Gulf.

The ecologic relationships of this species and the other peromyscine on Isla San Pedro Nolasco, *P. boylei glasselli*, are not known. I have had no success in collecting *pembertoni* on the island, although Burt (1932) reported collecting the two species in about equal numbers. Elsewhere (Lawlor, in press) I have speculated that *boylei* derivatives on islands in the Gulf may be competitively superior to *eremicus*-like forms, and that they may supplant the latter where the two kinds occur together. Perhaps displacement is occurring on Isla San Pedro Nolasco, but conclusive statements to that effect must await further data.

*Peromyscus eva*.—This Baja Californian species has been considered a subspecies of *P. eremicus* since Osgood's (1909) revision of the genus, although Burt (1960:50) alluded to differences between *eva* and *eremicus* on the basis of morphology of the bacula. *P. eva* originally was named and described by Thomas (1898). The following accounts will serve to elucidate features characteristic of the species.

*P. eva* occurs in sympatry with *P. eremicus* at four localities in south-central Baja California: San Ignacio (21), 20 km W San Ignacio (22), Aguaje de Santana (26), and Calmalli (27). The range of *eremicus* extends some distance southward along the east and west coasts (see

below). Measurements of specimens from shared localities reveal the following differences: tail of *eva* actually and relatively much longer; length of skull and zygomatic breadth greater in *eva*, giving the skull a more robust appearance (approaching that in *merriami*); length of nasal bones and length of rostrum greater in *eva*; molar toothrow averages greater in length and width. Several of these measures are presented in Figs. 5-7. Other skeletal features that serve to distinguish *eva* are: zygomatic notch shallow compared with that in *eremicus*; zygoma generally rounded laterally rather than slightly concave; number of tail vertebrae greater (36 in each of five *eva* from Cabo San Lucas [1] and one from San Bartolo [5], and 30-34 in 21 *eremicus* from Sonora and Baja California).

T-tests were made on characters of individuals from two of the localities where both *eva* and *eremicus* were observed (the samples from Aguaje de Santana and Calmalli were too small). The following morphometric characters were analyzed: length of tail, greatest length of skull, mastoid breadth, zygomatic breadth, and length of nasals. The two species differ significantly ( $p < .05$ ) for each character at both localities.

There is considerable geographic change in size in *eva* (Figs. 5-7). The smallest *eva* are found at the southern limit of the range of the species. The largest occur where *eva* is in sympatry with *eremicus*. *P. eremicus* from the latter localities generally are smaller than mice of that species from nearby places. Except for similarities in length of molar toothrow, the trends in variation of *eva* and *eremicus* in the area of overlap suggest the existence of character displacement there. This also is suggested by the small samples from Aguaje de Santana and Calmalli.

The phallus of *eva* is diagnostic (Fig. 2). It is small relative to that of *eremicus* and has the following additional features: shaft of baculum narrow, with a small cartilaginous tip; base small and rounded; glans with a small extended tip. There are no lappets. Comparisons of bacula of *eva* and other species are shown in Fig. 3.

The two species are readily distinguishable on the basis of color and length of pelage. The pelage of *eva* is short and colored with a variable blend of rufous, buffy, and brown, giving it a finely textured appearance. There is no strong admixture of dark brown or black (resulting from a wide dark distal band on the hairs) as in *P. eremicus* from the area. Gray facial color also is better expressed in *eva* than



in *eremicus*. Geographically the dorsum varies from a bright sandy-rufous in the south (e.g., Cape San Lucas [1], and nearby localities) to a darker pelage of ochraceous-brown in the north (e.g., San Ignacio [21]). Specimens from near the southern tip of the peninsula match closely Thomas' (1898) description.

The karyotype of *eva* closely resembles that of *eremicus*. All the chromosomes are bi-armed (based on one male and one female). There also is a full compliment of male accessory reproductive glands.

In overall resemblance *eva* is most like *eremicus*. Judged from available evidence, *eva* was derived from an *eremicus*-like ancestor. When compared with three similar species (Table 2) *eva* most closely resembles *eremicus* and *pectoralis* in external characters, *crinitus* in features of the phallus and certain cranial characters, and *eremicus* in features of the dentition, cranium, accessory reproductive glands, and chromosomes. Moreover, the relatively complex phallus found in *eva* probably is derived from a simple condition as in *eremicus*. Evidently the phallus has evolved in this manner in *P. guardia*, an insular species in the northern part of the Gulf (Lawlor, in press). Derivation of *eva* from an *eremicus*-like progenitor is further supported on zoogeographic grounds. *P. eremicus* is widespread in the Gulf area, while *pectoralis* does not occur there and *crinitus* is distributed in Baja California only as far south as Bahía de los Angeles (28) (see below), where it is uncommon.

Interestingly, the range of *eva* corresponds almost precisely to the Cape Faunal District of Nelson (1921). This region represents one of five such districts that Nelson recognized for Baja California. The districts were based principally on distributions of birds and mammals.

The insular form, *P. eremicus carmeni* (Isla Carmen), closely resembles *P. eva* in cranial and phallic characters. Ratios of width of base and length of baculum of two specimens from Isla Carmen are plotted in Fig. 3; these specimens bear the name *eva* and their dimensions are: 0.75 x 8.00 and 0.75 x 7.70. Note the close resemblance to mainland *eva*. In pelage characters this form is more like nearby mainland *eremicus*. I judge the latter to be convergence, and consider this form to be a derivative of *eva*. It should bear the name *P. eva carmeni*. Morphology and dimensions of the baculum of *P. caniceps* (Isla Monserrate) also suggest a close affinity of this form to *eva* (see Fig. 3). I am presently examining other morphologic features of *caniceps*.

*Peromyscus eremicus*.—The subspecific forms of *eremicus* from main-

TABLE 2  
MORPHOLOGIC COMPARISONS OF FOUR SPECIES OF *Peromyscus*

	<i>eva</i>	<i>eremicus</i>	<i>crinitus</i>	<i>pectoralis</i> <sup>a</sup>
Tail	Nearly unicolored, sparsely haired	Nearly unicolored, sparsely haired	Bicolored well haired	Nearly unicolored, sparsely haired
Pelage	Short, finely textured	Long, with admixture of dark hairs	Long, with admixture of dark hairs	Short, finely textured
Baculum	Minute (7.96 x 0.79), <sup>b</sup> with rounded base; cartilaginous tip small, rounded	Small (7.61 x 1.76), <sup>b</sup> with squarish base; cartilaginous tip very small, diffuse	Small (8.2 x 1.8), <sup>c</sup> with squarish base; cartilaginous tip small, rounded	Large (12.0 x 1.5), <sup>c</sup> with rounded base; cartilaginous tip large conical
Phallus	Small, very slender; no lappets on glans	Small, broad, no lappets on glans	Small, slender two median lappets ventrally and two dorsal lappets separated by a shallow median cleft	Large, slender; glans with a single, ventral lappet and two dorsal lappets separated by a shallow cleft
Premaxillaries	Variable: either subequal to or extending beyond margin of nasals	Extending beyond level of nasals	Extending to posterior margin of nasals	Extending beyond posterior margin of nasals
Breadth of rostrum	Medium	Medium	Narrow	Broad
Zygoma	Robust, rounded, not gradually convergent anteriorly	Usually slight, gradually convergent anteriorly	Slight, gradually convergent anteriorly	Usually slight, anterior convergence variable
Molars <sup>d</sup>	Low frequency of occurrence of styles and lophs	Low frequency of occurrence of styles and lophs	Usually a low frequency of occurrence of styles and lophs	High frequency of occurrence of styles and lophs
Chromosomes (2n = 48 in all species)	Bi-armed	Bi-armed	Four pair bi-armed (usually sex chromosomes)	Seven bi-armed (including sex chromosomes); 17 pairs of acrocentrics
Male accessory reproductive glands <sup>e</sup>	all present	all present	preputial glands absent	preputial glands absent

<sup>a</sup> Based on specimens examined from Nayarit, Mexico. *P. pectoralis* from northern Mexico and Texas, where the species morphologically approaches *boylei* in many respects (Hooper, 1952), does not resemble *eva* as clearly.

<sup>b</sup> Measurements (length x width of base), expressed as means, are from specimens examined in the report.

<sup>c</sup> Measurements from Burt (1960).

<sup>d</sup> In *P. eva* and *P. eremicus* there typically are no accessory lophs (or lophids); mesostyles and endostylids vary in occurrence but ordinarily are present (Hooper, 1957; Lawlor, in press). Mesolophs and mesostyles are typically found on the upper molars in *P. pectoralis*, and at least some accessory lophs and styles are always present on the lowers. *P. crinitus* is intermediate but more closely resembles *P. eremicus* than *P. pectoralis* in occurrence of styles and lophs. See Hooper (1957) and Lawlor (In press) for more details regarding terminology and occurrence of these structures in *P. eremicus*, *P. crinitus*, and other species.

<sup>e</sup> These glands include the preputials, prostates (anterior, dorsal, and ventral), vesicular, ampullary, and bulbo-urethral (Linzey and Layne, 1969).

land Baja California are *P. e. fraterculus* and *P. e. eremicus*. *P. e. fraterculus* occurs along the western and central parts of the peninsula, and *P. e. eremicus* is distributed along the coast east of the central mountains (Huey, 1964). Available specimens indicate that the differences between the two subspecies are slight. Note, for example, the rather uniform pattern of geographic variation among the Baja California samples (Figs. 5-7), including populations of both subspecies, except where the species occurs in sympatry with *eva*. However, the pelage of the highland subspecies (*fraterculus*) is darker in color owing to a greater admixture of brown and black pigment in the hairs.

From evidence at hand *P. eremicus* occurs on the peninsula south at least to Turtle Bay on the west coast and to Punta Pulpito on the east coast (Fig. 8). In addition, I discovered what appears to be a relict population of *eremicus* at Las Cruces (12), a coastal hamlet located about 23 miles (by road) east of La Paz. I collected six *eremicus* and five *eva* within two miles of the village. I could not detect any habitat differences between the two species. The Sonoran forms remain as *P. e. anthonyi* and *P. e. eremicus*. There also is little variation, except in tail length, among populations of these forms examined (Figs. 5-7).

Comparisons of variation in *eremicus* with that in *eva* and *merriami* (see Figs. 5-7 and accounts of *eva* and *merriami*) reveal contrasting patterns. Character displacement is suggested by the variation in *eva* and *eremicus* in the area of overlap, while in *merriami* and *eremicus* the trends are similar where the two species are in sympatry. Degree of habitat separation may account for these differences. *P. merriami* and *eremicus* occupy different habitats, but there are no apparent habitat differences in *eva* and *eremicus* (see above). If there is competition, selection presumably would promote character displacement only in the latter case.

The insular races *cedrosensis* (Isla Cedros), *polypolius* (Isla Santa Margarita), *avius* (Isla Cerralvo), and *cinereus* (Isla San Jose), are, in my opinion, derivatives of *P. eremicus*. Specimens of these forms closely resemble *eremicus* in external, cranial, and phallic features (the latter not observed in *polypolius*). Although the subspecies *insulicola* (Isla Espiritu Santo) tends toward *eva* externally, it is tentatively retained as an *eremicus* on the basis of characters of the skull and phallus.

A series of five small mainland samples from Sierra de la Giganta

in southern Baja California comprises a heterogeneous group with uncertain relationships to *eremicus* or *eva*. Generally there is a lack of correspondence of external and cranial features. The samples as a whole comprise a graded series both externally and cranially. No information regarding phallic characters is available. Further investigation of peromyscines from this area is required.

On the basis of dimensions of the baculum (Fig. 3), *P. pseudocrinitus* (Isla Coronados) also closely resembles *eremicus*. In addition, the glans is *eremicus*-like in every respect. I am now investigating other morphologic features.

*Peromyscus crinitus*.—One specimen was taken at Bahía de los Angeles, Baja California (28), on June 8, 1968. The specimen was taken on sparsely vegetated, rocky alluvium where *P. eremicus* was common. This record extends the southern range of this species approximately 175 miles.

*Peromyscus maniculatus*.—Four examples of this species were obtained on Isla Smith (locally called Isla Coronados) adjacent to Bahía de los Angeles, Baja California. Apparently this represents the first record of any peromyscine from this predominantly volcanic island. The habitat consisted chiefly of lava and slate-like talus; vegetation (predominantly cholla or cardon cactus) was extremely sparse. *Perognathus baileyi* also was taken there.

#### SPECIMENS EXAMINED

The following localities are listed geographically according to the numbered designation (shown below in parentheses preceding each locality) on the distribution map (Fig. 8). Localities from which *P. eremicus* were examined but not actually cited in text are not included.

*Peromyscus merriami*.—SONORA: (34) Sonoyta, 10 (USNM); (35) 9 mi. NNE Imuris, 15 (KU); (36) Puerto Libertad, 16 (6 KU, 10 SD); (39) Hermosillo, 9 (USNM); (40) Matape, 11 (KU); (41) vicinity Guaymas, 4 (2 UA, 2 KU); (42) Presa Obregon, 17 (KU); (43) Alamos, 18 (15 KU, 3 USNM); (44) Vado Cuchijaqui, 3 (KU).

*Peromyscus pembertoni*.—SONORA: Isla San Pedro Nolasco, 9 (UCLA).

*Peromyscus eva*.—BAJA CALIFORNIA: (1) Cabo San Lucas, 13 (3 AMNH, 10 UMMZ); (2) San Jose del Cabo, 3 (1 AMNH, 2 USNM); (3) Santa Anita, 15 (USNM); (4) Miraflores, 3 (1 AMNH, 2 KU); (5) 12.1 mi. NW San Bartolo, 1 (CAS); (6) Pescadero, 1 (USNM); (7)

Todos Santos, 14 (KU); (8) Tres Pachitas, 3 (USNM); (9) La Laguna, 4 (SD); (10) San Antonio, 1 (KU); (11) Bahía de los Muertos, 1 (UCLA); (12) Las Cruces, 5 (UMMZ); (13) Matancita, 2 (USNM); (14) San Jorge, 6 (USNM); (15) Puerta Escondida, 1 (UCLA); (18) El Potrero, 3 (USNM); (20) El Patrocinio, 1 (CAS); (21) San Ignacio, 16 (12 SD, 4 USNM); (22) 20 km. W San Ignacio, 5 (USNM); (26) Aguaje de Santana, 4 (USNM); (27) Calmalli, 1 (USNM); Isla Carmen, 6 (1 SD, 3 USNM, 2 UCLA).

*Peromyscus eremicus*.—BAJA CALIFORNIA: (12) Las Cruces, 6 (UMMZ); (16) Punta Pulpito, 2 (SD); (17) Coyote Cove, 4 (UCLA); Concepcion Bay, 3 (2 AMNH, 1 USNM); (19) Mulege, 5 (4 AMNH, 1 USNM); (not mapped) vicinity Sierra de la Giganta, 11 (USNM); (23) Sierra de Santa Clara, 2 (USNM); (24) San Pablo Point, 3 (AMNH); (25) Turtle Bay, 13 (3 AMNH, 3 SD, 3 USNM, 4 UMMZ); (26) Aguaje de Santana, 2 (USNM); (27) Calmalli, 1 (USNM); (28) Bahía de los Angeles, 23 (2 SD, 1 UCLA, 20 UMMZ); (29) San Francisquito, 16 (USNM); (30) El Marmol, 14 (CAS); (31) San Telmo, 7 (UMMZ); Isla Cedros, 6 (3 SD, 3 USNM); Isla Santa Margarita, 7 (UMMZ); Isla Cerralvo, 14 (2 UMMZ, 12 USNM); Isla Espiritu Santo, 5 (3 UMMZ, 2 USNM); Isla San Jose, 5 (2 UCLA, 3 UMMZ). CALIFORNIA: (32) Escondido, 21 (KU). SONORA: (33) Puerto Peñasco, 20 (17 SD, 3 UA); (34) Sonoyta, 6 (USNM); (35) 9 mi. NNE Imuris, 9 (KU); (36) Puerto Libertad, 20 (2 KU, 18 SD); (37) Punta Sargento, 24 (UCLA); (38) vicinity Bahía Kino, 14 (2 UA, 6 KU, 6 UMMZ); (39) Hermosillo, 4 (USNM); (41) vicinity Guaymas, 26 (6 KU, 20 UA); (42) Presa Obregon, 10 (KU); (43) Alamos, 17 (10 KU, 7 USNM); (44) Vado Cuchijaqui, 4 (KU).

*Additional records*.—Osgood (1909) also recorded *P. eva* from Paso Hondu, Comondu, and La Paz, Baja California. There is an additional specimen of *eva* from the "San Bernardo Mountains" in the collection of the American Museum of Natural History. This locality is not known to me, but it may refer to the mountains surrounding a small milk farm in the Sierra Victoria called San Bernardo (near Miraflores [4]) that was mentioned by Nelson (1921:46). For additional records of *P. merriami* see Hoffmeister and Lee (1963), Cockrum (1960), and Cockrum and Bradshaw (1963).

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