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Chaetodipus goldmani.

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Chaetodipus goldmani (Osgood, 1900)

Goldman's Pocket Mouse

Perognathus goldmani Osgood, 1900:54. Type locality "Sinaloa, Sinaloa, Mexico."

C[*haetodipus*]. *goldmani*: Hafner and Hafner, 1983:24. Elevation of subgenus to generic status.

CONTEXT AND CONTENT. Order Rodentia, Family Heteromyidae, Subfamily Perognathinae. The genus *Chaetodipus* contains 14 species. *C. goldmani* is monotypic (Hall, 1981), but six chromosomal races have been described (Patton, 1969).

DIAGNOSIS. Compared with *C. artus*, apparently a close relative (Patton, 1969), *C. goldmani* is slightly larger in external measurements, has a more hairy tail, and a narrower dorsal tail stripe. The skull of *C. goldmani* (Fig. 1) has a narrower supraoccipital (least width 5.7 mm in an adult *C. goldmani*, but 6.0 and 6.4 mm in two adult *C. artus*), is larger, has less rugose and less prominently ridged mastoids, and has shorter extensions of the premaxillae beyond the posterior borders of the nasals (<1 mm in *C. goldmani*, >1 mm in *C. artus*—Burt and Hooper, 1941). Anderson (1964) suggested using the following characteristics of *C. goldmani* to distinguish it from *C. artus*: well-developed rump bristles; skull larger (based on occipitonasal length); skull wider, based on mastoid breadth; mastoid larger in area anterior to transverse ridge; transverse ridge on mastoid less strongly marked; audital (tympanic) bullae larger, in ventral aspect; ascending processes of premaxillae extend posterior to nasals a distance less than the least breadth of one nasal bone; greater total length; tail more hairy, especially in distal one-third, scalation less evident in basal part; dorsal tail stripe narrower, in dorsal view white visible along sides; supraoccipital narrower, based on least supraoccipital breadth; mastoid less rugose, fewer pits; interparietal relatively narrow; pelage paler; pigmentation of ears paler; dorsal pelage less uniform, more grizzled; baculum longer, less curved, thinner in proportion to length, and base not deflected ventrally; lacrimal suture with maxilla and frontal, as viewed in dorsal aspect, shorter than the length of the lacrimal from the suture to tip; maxillofrontal suture not extending as far posteriorly, relative to position of lacrimal; jugal in dorsal view thicker; temporal ridge more curved, and has an angular tuberosity on the anterior part of the squamosal; skull deeper; palatal pits shallower; exoccipital not forming a distinct flange at the edge that meets the mastoid; stylomastoid foramen smaller, less conspicuous.

Compared with *C. penicillatus*, *C. goldmani* has rump spines (Caire, 1978), lesser premaxillonasal length, interorbital width, and nasal length, and greater length of ears. Compared with *C. intermedius*, *C. goldmani* has greater occipitonasal length, breadth of the zygomatic arch, and interparietal dimensions (Anderson, 1972). Compared with *C. pernix*, *C. goldmani* is larger (>200 mm—Caire, 1978). Compared with *C. baileyi*, *C. goldmani* possesses rump spines or bristles (Caire, 1978).

GENERAL CHARACTERS. *Chaetodipus goldmani* is medium-sized for the genus (Best, in press). The skull (Fig. 1) is large and heavy. The tail is moderately long and heavily crested. The ears are relatively large and the antitragal lobe is prominent and wider at the base than at the apex. The pelage is somewhat hispid and the rump has a few short bristles (Osgood, 1900).

The general color across the shoulders and anterior portion of the upper parts is broccoli brown. The posterior one-half of the dorsum is much darkened by an admixture of black. The lateral line is pinkish buff. The ears are blackish with hoary margins, and externally are whitish for the distal one-half; a subauricular spot is present. The tail is sharply bicolored, blackish above and white below (Osgood, 1900). A population with black pelage occurs on a lava field south of Moctezuma, Sonora (Findley, 1967).

The length of the hind foot is 31% of the length of head and body, the length of tail is 124% of the length of head and body, and the tip of the tail is pencillate (Hatt, 1932). Mean measurements (in mm) of 20 adult males and 20 adult females, respectively, from throughout the range of the species are: total length, 197.9, 189.4; length of body, 81.4, 83.7; length of tail, 107.5, 105.8; length of hind foot, 24.2, 23.4; length of ear, 11.3, 10.4; basal length of cranium, 16.7, 16.1; greatest length of cranium, 27.0, 26.0; maxillary arch spread, 12.5, 11.8; interorbital width, 6.2, 6.1; nasal length, 10.6, 10.0; intermaxillary width, 4.6, 4.5; alveolar length,

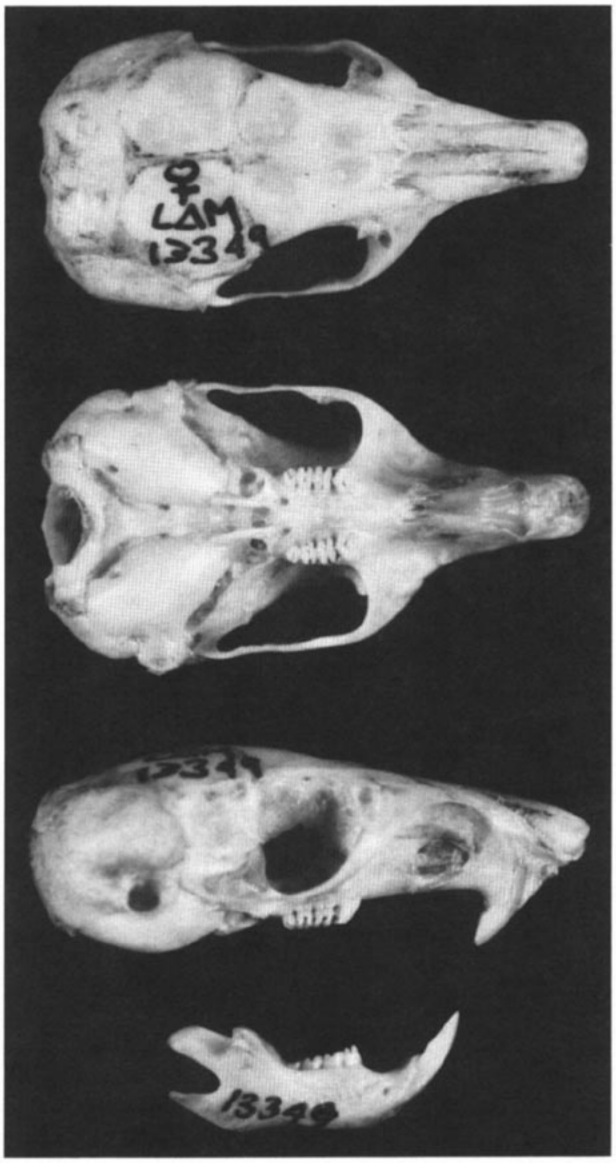

FIG. 1. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of *Chaetodipus goldmani* from La Aduana, Sonora, Mexico (female, Natural History Museum of Los Angeles County 13349). Greatest length of cranium is 26.2 mm. Photographs by T. H. Henry.

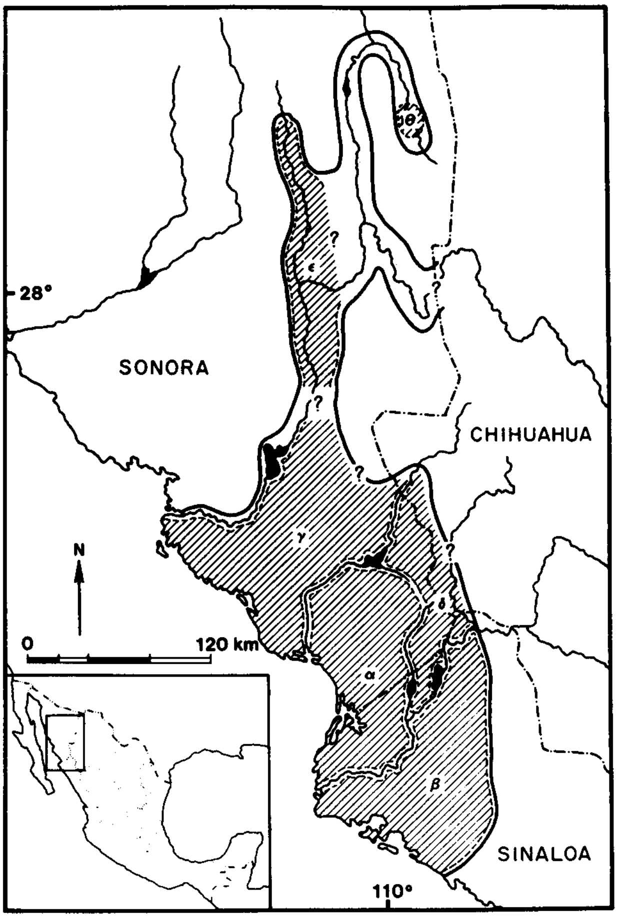

FIG. 2. Distribution of *Chaetodipus goldmani* in western Mexico, with known range of chromosomal races indicated by hatching (modified from Patton, 1969).

3.9, 3.7; lacrimal length, 2.0, 1.8; maxillary arch width, 1.4, 1.4; basioccipital length, 4.3, 4.1; greatest depth of cranium, 8.6, 8.5; greatest width of cranium, 13.6, 13.2; zygomatic width, 13.0, 12.6; nasal width, 3.3, 3.1. In this sample, males are significantly larger than females in basal length of cranium, greatest length of cranium, maxillary arch spread, interorbital width, nasal length, intermaxillary width, alveolar length, greatest width of cranium, and zygomatic width (Best, in press). For measurements of 15 characters (4 external, 11 cranial) of specimens from 20 localities, sexual dimorphism in morphological characters was examined with a three-level nested analysis of variance. When expressed as a proportion of the total variance and averaged over 15 characters, the residual variance was 0.62. The variance due to sexual dimorphism averaged 0.22 between chromosomal races, and averaged 0.09 within localities; the latter variance was similar to that found between localities within chromosome races (Straney and Patton, 1980).

Northern and extreme southern chromosomal races are larger than centrally located races in 10 of 15 measures of size (Straney and Patton, 1980). This size trend is correlated with the chromosomal evolution that led to the six chromosomal races (Patton, 1969). Phylogenetic position (lineage effect) accounted for 36% of interlocality morphological variation, whereas five ecogeographic predictors, such as temperature, rainfall, and a measure of length of growing season, together accounted for only 29% of the variation, leaving 35% of the variation unexplained (Straney and Patton, 1980).

DISTRIBUTION. *Chaetodipus goldmani* occurs (Fig. 2) from northeastern Sonora in the Río Yaqui drainage southward through the coastal plains of Sonora and northwestern Sinaloa, in northwestern Mexico (Patton, 1969). No fossils of *C. goldmani* are known.

FORM AND FUNCTION. The baculum of *C. goldmani* is large and sigmoid, has a slightly enlarged basal end, and an upturned distal end forming approximately a right angle with the shaft. Height of the base is slightly greater than the width. Measurements (in mm) of five specimens are: length, 13.2–14.1 (average, 13.5); height of base, 0.9–1.1 (average, 0.96—Burt, 1960). Nothing is known regarding ontogeny and reproduction of *C. goldmani.*

ECOLOGY. *Chaetodipus goldmani* occurs in brushy arroyos in southern Sonora, along the second bottom of the Río Mayo at Tésia (near Navajoa) and along the edges of cultivated fields at Chinobampo (Burt, 1938). It occurs in sandy areas among mesquite (*Prosopis*) along the Río Mayo near Carimechi, Sonora (Burt and Hooper, 1941). This species is common near rocks and in dry arroyos at Aduana and Alamos in southern Sonora (Ingles, 1958).

The habitat of *C. goldmani* in extreme northeastern Sonora and along the coastal plain of southern Sonora and northern Sinaloa is thornscrub and short-tree forests with alluvial soils. In that region, this species is absent or uncommon in riparian communities, along river terraces, or on rocky slopes (Patton, 1969). In contrast, in northcentral Sonora this species occurs on the talus slopes of a lava flow (malpais) near Moctezuma. The lava flow has a rich vegetative cover of shrubs, primarily *Prosopis* and other legumes (Findley, 1967). In the northern part of the range of *C. goldmani,* occupation of rock-free alluvial soils by *C. penicillatus* may have been responsible for *C. goldmani* shifting to an uncharacteristic rock-slope habitat (Patton, 1969). On the lava flow south of Moctezuma, in northern Sonora, *C. goldmani* primarily inhabits a region of dense rocks on steep slopes, whereas the sympatric *C. baileyi* occupies a region of finer soils on the upper terrace. In the lower Río Yaqui Valley north of Ciudad Obregon, *C. goldmani* is found in a habitat of rocky slopes dominated by columnar cactus and tree ocotillo, whereas the sympatric *C. pernix rostratus* occurs in the fine soils of the river terrace. *C. goldmani* also is common on rocky hillsides in southern Sonora. Some of these shifts in habitat occupation by *C. goldmani* in various parts of its geographic range may represent segregation of the species according to soil types in regions where this species is sympatric with other species of *Chaetodipus* (J. L. Patton, in litt.). The southern part of the range of *C. goldmani* overlaps that of *C. artus,* a sibling species of *C. goldmani.* In that region, *C. artus* occupies habitats such as river terraces and immediately adjacent mesic short-tree forests to the near-exclusion of *C. goldmani,* whereas *C. goldmani* is more abundant away from rivers in xeric forest and shrub communities, except for a population in the upper Río Bavispe drainage in northeastern Sonora where this species occurs in lower montane woodland and riparian habitats. The occupation of river terraces and adjacent short-tree forests by *C. artus* apparently creates many barriers to the movements of *C. goldmani* and may have contributed to the establishment of six chromosomal races. If the absence of *C. goldmani* in mesic forest habitats near rivers is due in part to competition with *C. artus,* habitats occupied by *C. goldmani* in other parts of its range where it is allopatric to *C. artus* may differ from those in southern Sonora and northern Sinaloa where the two species are sympatric (Patton, 1969). There is a paucity of information regarding diet, however, in Sonora *C. goldmani* eats grass seeds (Burt, 1938).

Mammals associated with *C. goldmani* include *C. baileyi, C. pernix* (Patton and Jones, 1972), *C. artus, Lepus alleni, Onychomys torridus, Neotoma albigula* (Lucas and Loomis, 1968), and *Peromyscus eremicus* (Findley, 1967). Ectoparasites include the chiggers *Euschoengastoides annectens, E. arizonae, E. expansellus, E. tumidus* (Loomis, 1971), *Hexidionis allredi* (Lucas and Loomis, 1968), *Hyponeocula deserticola, H. rugosa* (Tanigoshi and Loomis, 1974), and *Otorhinophila intrasola* (Loomis and Wrenn, 1973; Wrenn and Loomis, 1967). No other parasites are known (Whitaker, in press).

GENETICS. There are six allopatric chromosomal races of *C. goldmani* (Figs. 2 and 3). Race alpha inhabits the coastal region of southern Sonora and northern Sinaloa and has a diploid number (2n) of 52 chromosomes, a fundamental number (FN) of 54, and a karyotype consisting of 2 pair of medium submetacentrics, 1 pair of "rabbit-ear" acrocentrics, 22 pair of acrocentrics, a large acrocentric X, and a small acrocentric Y. This race occupies the central range of the species. Race beta is found in northern Sinaloa, adjacent to and south of races alpha and delta, and has a 2n of 56, a FN of 56, and a karyotype consisting of 1 pair of small metacentrics, 1 pair of "rabbit-ear" acrocentrics, 25 pair of acrocentrics, a large submetacentric X, and a small acrocentric Y. Race gamma inhabits

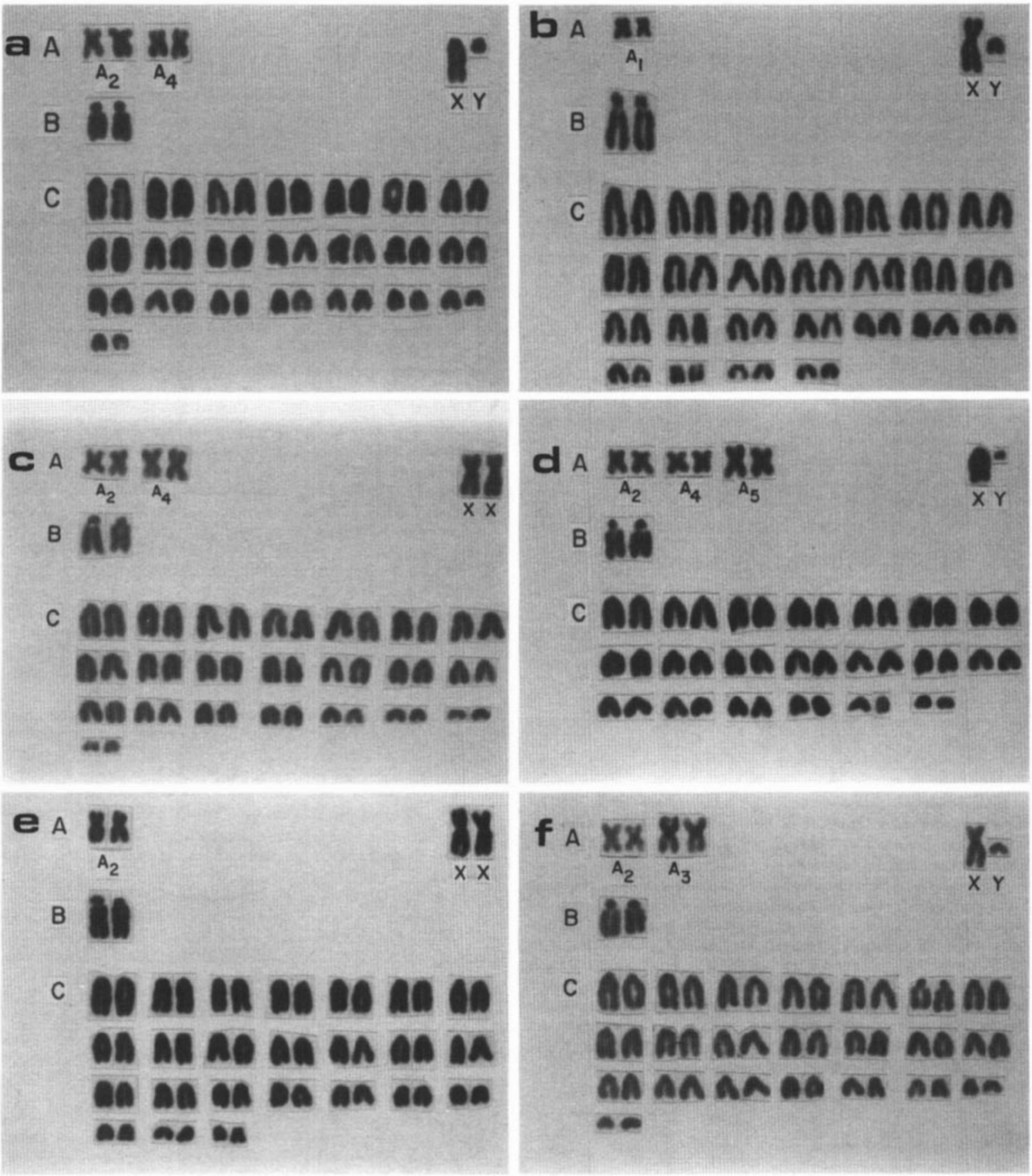

FIG. 3. Karyotypes of the six chromosomal races of *Chaetodipus goldmani*: a, alpha, 17.5 miles south of Alamos, Sonora (Museum of Vertebrate Zoology 137404); b, beta, south bank of Río Fuerte, ca. 1 mile west of El Fuerte, Sinaloa (MVZ 137863); c, gamma, 16 miles north of Navajoa, Sonora (University of Arizona 15901); d, delta, south bank of Río Mayo at Las Penelas, Sonora (MVZ 137456); e, epsilon, ca. 1 mile south of Tonichi (by road), Sonora (UA 15632); f, theta, 1 mile north of Huachinera (by road), Sonora (UA 15907). Submetacentric and metacentric chromosomes are indicated by "A," rabbit-ear acrocentrics by "B," and acrocentrics by "C." Figures and data were provided by J. L. Patton (from Patton, 1969).

a region adjacent to and northwest of races alpha and delta, and has a 2n of 52, a FN of 54, and a karyotype consisting of 2 pair of medium submetacentrics, 1 pair of "rabbit-ear" acrocentrics, 22 pair of acrocentrics, a large submetacentric X, and a small acrocentric Y. Race delta occupies a narrow zone adjacent to and east of races alpha and gamma, and adjacent to and north of race beta, and has a 2n of 50, a FN of 54, and a karyotype consisting of 2 pair of medium submetacentrics, 1 pair of large submetacentrics, 1 pair of "rabbit-ear" acrocentrics, 20 pair of acrocentrics, a large acrocentric X, and a small acrocentric Y. Race epsilon occurs adjacent to and north of race gamma, and has a 2n of 54, a FN of 54, and a karyotype consisting of 1 pair of medium submetacentrics, 1 pair of "rabbit-ear" acrocentrics, 24 pair of acrocentrics, a large submetacentric X, and a small acrocentric Y. Race theta occupies a river valley upstream (northeast) from race epsilon, and has a 2n of 52, a FN of 54, and a karyotype consisting of 1 pair of medium submetacentrics, 1 pair of large metacentrics, 1 pair of "rabbit-ear" acrocentrics, 22 pair of acrocentrics, a large submetacentric X, and a small acrocentric Y (Patton, 1969).

It is postulated that two lines of karyotypic evolution, climatic and subsequent habitat shifts during late and post-Pleistocene times, and possibly interspecific competition, collectively led to the six extant chromosomal races of *C. goldmani.* A widespread ancestral population inhabited the general region now occupied by *C. goldmani.* During a pluvial period in late Pleistocene time, the region became more mesic and, and as a result, supported a tropical deciduous forest, the habitat of the sibling species *C. artus.* In response, *C. artus* expanded its range westward from the base of the Sierra Madre Occidental to the coast, thereby dividing the range of *C. goldmani* into northern and southern populations that continued to exist in restricted arid habitats near the coast. The southern population of *C. goldmani* subsequently evolved into one of the six extant chromosomal races (beta) through a pericentric inversion in a small autosome. The northern population evolved into a new chromosomal race (epsilon), from which evolved another chromosomal race (theta), presently inhabiting the upper Río Bavispe drainage to the north of race epsilon. As post-Pleistocene climates in southern Sonora and northern Sinaloa became increasingly arid, the tropical deciduous forest retreated eastward toward the Sierra Madre Occidental, and into river bottoms. In response, *C. artus* followed its retreating habitat and *C. goldmani* moved into those regions vacated by *C. artus.* During this period, chromosomal race epsilon gave rise to a new race (gamma) to the south; race gamma in turn gave rise to another new race (alpha) and, lastly, race alpha gave rise to race delta to the east. The evolution of the five northern chromosomal races included four autosomal centric fusions and a pericentric inversion in the X chromosome. There presently is little gene flow among chromosomal races; only three karyotypic hybrids are known, and morphologic analyses provide additional support. The barrier to gene flow appears to include lack of suitable habitat for *C. goldmani* along river systems; transects of traplines across a river bottom and adjacent regions revealed a near-absence of *C. goldmani* in the riparian and mesic forest habitats bordering the river. Those habitats instead were occupied by *C. artus,* whereas *C. goldmani* was found on higher, more arid environments farther from the river. *C. artus* itself might presently inhibit gene flow among the chromosomal races of *C. goldmani* through competition. Rivers and associated mesic habitats (and possibly *C. artus*) may not only have been instrumental in the formation of the chromosomal races by impeding gene flow intermittently during the reinvasion by *C. goldmani,* but apparently continue to keep gene flow among contiguous races so low the races maintain monomorphic chromosomal arrangements. There is no association between the various chromosomal arrangements and environmental adaptations (Patton, 1969; Straney and Patton, 1980).

The mean number of alleles per locus was 1.418 in 26 loci of 256 individuals of *C. goldmani* from 19 populations. The mean proportion of polymorphic loci per population was 0.276 and the mean proportion of loci heterozygous per individual was 0.027 (range, 0.000–0.045). There was virtually no geographic differentiation in genic characters. Average similarity between populations of the same chromosome race did not differ significantly from the average between chromosome races. Coastal populations of chromosome race gamma are fixed for an allele at the albumin locus, which is rare or absent in other populations of *C. goldmani* (Patton et al., 1981).

REMARKS. On the basis of morphological analyses, *C. artus* and *C. goldmani* have been considered conspecific (Hall and Ogilvie, 1960). Anderson (1964), however, concluded on the basis of morphology and sympatry that they represent separate, but closely related species. Morphology of the X chromosome and size and centromere position of the bi-armed chromosome pairs support that conclusion (Patton, 1967). That the two species are phyletically close and can be termed sibling species is evidenced by the presence in both species of one pair of "rabbit-ear" chromosomes, unique to these two species in the genera *Perognathus* and *Chaetodipus* (Patton, 1967). Phenetic analyses of morphologic characters separated *C. goldmani* from other species of *Chaetodipus* (Caire, 1976), or near *C. artus* and *C. pernix* (Best, in press). Analyses of allozyme variation in species of *Chaetodipus* do not permit a firm statement on the phylogenetic relationship of *C. goldmani* to its congeners with the exception of *C. hispidus,* which clearly is a divergent form within *Chaetodipus* on this basis (Patton et al., 1981).

Chaetodipus is derived from the Greek *chaeta* referring to bristle-like hairs, *di* meaning two, and *podos* alluding to feet (Jaeger, 1955). The specific epithet *goldmani* honors E. A. Goldman.

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LITERATURE CITED

ANDERSON, S. 1964. The systematic status of *Perognathus artus* and *Perognathus goldmani* (Rodentia). American Museum Novitates, 2184:1–27.

———. 1972. Mammals of Chihuahua: taxonomy and distribution. Bulletin of the American Museum of Natural History, 148:149–410.

BEST, T. L. In press. Patterns of morphologic and morphometric variation in heteromyid rodents. *In* Biology of the Heteromyidae (H. H. Genoways and J. H. Brown, eds.). Special Publication, The American Society of Mammalogists, 10.

BURT, W. H. 1938. Faunal relationships and geographic distribution of mammals in Sonora, Mexico. Miscellaneous Publications, Museum of Zoology, University of Michigan, 39:1–77.

———. 1960. Bacula of North American mammals. Miscellaneous Publications, Museum of Zoology, University of Michigan, 113:1–76.

BURT, W. H., AND E. T. HOOPER. 1941. Notes on mammals from Sonora and Chihuahua, Mexico. Occasional Papers of the Museum of Zoology, University of Michigan, 430:1–7.

CAIRE, W. 1976. Phenetic relationships of pocket mice in the subgenus *Chaetodipus* (Rodentia: Heteromyidae). Journal of Mammalogy, 57:375–378.

———. 1978. The distribution and zoogeography of the mammals of Sonora, Mexico. Ph.D. dissert., The University of New Mexico, Albuquerque, 613 pp.

FINDLEY, J. S. 1967. A black population of the Goldman pocket mouse. The Southwestern Naturalist, 12:191–192.

HAFNER, J. C., AND M. S. HAFNER. 1983. Evolutionary relationships of heteromyid rodents. Great Basin Naturalist Memoirs, 7:3–29.

HALL, E. R. 1981. The mammals of North America. Second ed. John Wiley & Sons, New York, 1:1–600 + *90.*

HALL, E. R., AND M. B. OGILVIE. 1960. Conspecificity of two pocket mice, Perognathus goldmani and P. artus. University of Kansas Publications, Museum of Natural History, 9:513–518.

HATT, R. T. 1932. The vertebral columns of ricochetal rodents. Bulletin of the American Museum of Natural History, 63:599–738.

INGLES, L. G. 1958. Notas acerca de los mamiferos mexicanos. Anales del Instituto de Biologia, Universidad Nacional Autonoma de Mexico, 29:379–408.

JAEGER, E. C. 1955. A source-book of biological names and terms. Charles C Thomas Publisher, Springfield, Illinois, 323 pp.

LOOMIS, R. B. 1971. The genus *Euschoengastoides* (Acarina: Trombiculidae) from North America. The Journal of Parasitology, 57:689–707.

LOOMIS, R. B., AND W. J. WRENN. 1973. The North American genus *Otorhinophila* Wrenn and Loomis (Acarina: Trombiculidae), with the descriptions of three new species. The Journal of Parasitology, 59:175–182.

LUCAS, J. L., AND R. B. LOOMIS. 1968. The genus *Hexidionis* (Acarina, Trombiculidae) with the description of a new species from western Mexico. Bulletin of the Southern California Academy of Sciences, 67:233–239.

OSGOOD, W. H. 1900. Revision of the pocket mice of the genus Perognathus. North American Fauna, 18:1–73.

PATTON, J. L. 1967. Chromosome studies of certain pocket mice, genus *Perognathus* (Rodentia: Heteromyidae). Journal of Mammalogy, 48:27–37.

———. 1969. Chromosome evolution in the pocket mouse, *Perognathus goldmani* Osgood. Evolution, 23:645–662.

PATTON, J. L., AND J. K. JONES, JR. 1972. First records of *Perognathus baileyi* from Sinaloa, Mexico. Journal of Mammalogy, 53:371–372.

PATTON, J. L., S. W. SHERWOOD, AND S. Y. YANG. 1981. Biochemical systematics of chaetodipine pocket mice, genus *Perognathus.* Journal of Mammalogy, 62:477–492.

STRANEY, D. O., AND J. L. PATTON. 1980. Phylogenetic and environmental determinants of geographic variation of the pocket mouse *Perognathus goldmani* Osgood. Evolution, 34:888–903.

TANIGOSHI, L. K., AND R. B. LOOMIS. 1974. The genus *Hyponeocula* (Acarina, Trombiculidae) of western North America. Melanderia, 17:1–27.

WHITAKER, J. O., JR. In press. Parasites of heteromyids. *In* Biology of the Heteromyidae (H. H. Genoways and J. H. Brown, eds.). Special Publication, The American Society of Mammalogists, 10.

WRENN, W. J., AND R. B. LOOMIS. 1967. *Otorhinophila*, a new genus of chiggers (Acarina, Trombiculidae) from western North America. Acarologia, 9:152–178.

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