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Sigmodon fulviventer.

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Sigmodon Say and Ord, 1825

Cotton rats

Sigmodon Say and Ord, 1825:352. Type species *Sigmodon hispidus* Say and Ord, 1825, by original designation.

CONTEXT AND CONTENT. Order Rodentia, Suborder Myomorpha, Family Muridae, Subfamily Cricetinae. The genus *Sigmodon* now includes at least seven extant species (see key below) distributed from approximately 41°N latitude in Nebraska and Iowa to 8°S latitude in coastal Perú. Specific status of Central American and northern South American cotton rats, now assigned to *S. hispidus*, is unclear (Dalby and Lillevik, 1969). Measurements are in millimeters and are of adults.

1 Tail sparsely haired and scaly in appearance, individual scales broad, 0.75 wide; skull generally long and narrow, basioccipital long and broad, palatal pits shallow ---------- *Sigmodon hispidus* group, 2

Tail heavily haired and not scaly in appearance, individual scales narrow, 0.50 wide; skull generally short and broad, basioccipital either long and narrow or short and broad, palatal pits deeply marked ---- *Sigmodon fulviventer* group, 4

2(1) Length of hind foot ≥ 34; distance between temporal and occipital crests > 3.6, averaging 4.0; crest on posterior of palate present or absent ---------- 3

Length of hind foot < 34, averaging 32; distance between temporal and occipital crests < 3.6, averaging 3.2; diameter of foramen ovale < three-fourths the diameter of M3; well-developed crest on posterior of palate ---------- *Sigmodon hispidus*

3(2) Length of hind foot ≥ 36; size of foramen ovale ≤ diameter of M3; greatest length of skull usually > 37; well-developed crest on posterior of palate ------ *Sigmodon arizonae*

Length of hind foot < 36; size of foramen ovale averaging ≤ three-fourths diameter M3; greatest length of skull < 37; crest on posterior of palate only slightly developed or absent ---------- *Sigmodon mascotensis*

4(1) Ears (inside of pinnae) whitish, in marked contrast to color of dorsum; interparietal generally < 2 in length at midline; upper part of each premaxillary with pronounced rostral depression; mesopterygoid fossa generally parallel-sided at anterior end; lingual root of first lower molar reduced in size and sometimes absent ---------- *Sigmodon leucotis*

Ears (inside of pinnae) not colored conspicuously different from dorsum; interparietal ≤ 2 in length at midline; upper part of premaxillary with slight or no rostral depression; mesopterygoid fossa generally not parallel-sided anteriorly; lingual root of first lower molar not reduced in size ---------- 5

5(4) Buff coloring on nose and around eye conspicuous; adult size small, length of head and body averaging 143 and condylopremaxillary length averaging 32; auditory bullae small and elongate; median keel on basioccipital developed; lateral bulge of capsular projections of upper incisors pronounced; interparietal with slight to marked median posterior notch; paraoccipital process curved (when viewed from below) and notched on the anterior base ---------- *Sigmodon ochrognathus*

Buff coloring on nose and around eye usually not in marked contrast with rest of dorsum; adult size large, length of head and body averaging at least 168 and condylopremaxillary length averaging at least 34.5; auditory bullae large and broad (relative to length of skull); lateral bulge of capsular projections of upper incisors slight to moderate; interparietal usually lacking any indication of median posterior notch; paraoccipital process (when viewed from below) generally straight or slightly hooked -- 6

6(5) Dorsum always brownish, underparts washed with whitish or pale buff; adult size medium, length of head and body averaging 168 and condylopremaxillary length averaging 34.5; skull flattened in appearance, long and narrow; incisive foramina not extending to line drawn between anterior ends of first upper molars; basioccipital short and wide; mesopterygoid fossa broad anteriorly; median keel on palate slightly developed; palatal pits moderately deep; incisors usually markedly recurved opisthodont) ---------- *Sigmodon alleni*

Dorsum "pepper and salt" in color, underparts washed with buff; adult size large, length of head and body averaging 179 and condylopremaxillary length averaging 36.5; skull arched, short and broad; incisive foramina extending to or beyond a line drawn between anterior surfaces of the first upper molars; foramen ovale large, at least ¾ diameter of M3; basioccipital long and narrow; mesopterygoid fossa narrow anteriorly; median keel on palate well developed; palatal pits markedly deep; incisors not highly recurved ---------- *Sigmodon fulviventer*

Sigmodon fulviventer Allen, 1889

Tawny-bellied Cotton Rat

Sigmodon fulviventer Allen, 1889:180. Type locality Zacatecas, Zacatecas.

Sigmodon minima Mearns, 1894:130. Type locality west bank of Rio Grande, 1500 m, Hidalgo Co., New Mexico, on the Mexican boundary line.

Sigmodon melanotis Bailey, 1902:114. Type locality Patzcuáro, 2135 m, Michoacán.

Four subspecies of *Sigmodon fulviventer* are recognized (Baker, 1969) as follows:

S. f. fulviventer Allen, 1889:180, see above.
S. f. minimus Mearns, 1894:130, see above.
S. f. melanotis Bailey, 1902:114, see above.
S. f. goldmani Bailey, 1913:132. Type locality 7 mi. N Las Palomas, Sierra Co., New Mexico.

DIAGNOSIS. The tawny venter and the "pepper and salt" colored dorsum coupled with large size (for captive animals, maximum weights are 206 g for nonpregnant females and 222 g for males; maximum lengths of head and body are 200 mm and 197 mm, respectively) separate *S. fulviventer* from other members of the *S. fulviventer* group. Distinctive cranial characters include: anterior end of mesopterygoid fossa narrow; foramen ovale large (≥ three-fourths width M3); palatal pits markedly deep; and median keel on palate well developed.

Sigmodon fulviventer differs from the *S. hispidus* group in possessing small tail scales (0.50 mm wide rather than 0.75 mm wide) and a tail heavily haired instead of sparsely haired (Baker, 1969; Zimmerman, 1970).

GENERAL CHARACTERS. No sexual dimorphism in size was found in the tawny-bellied cotton rat (Baker, 1969; Jiménez, 1971, 1972), and the following measurements (in mm, N = 9, from Baker, 1969) include examples of both sexes of wild-taken adults from Hacienda Coyotes, Durango. External measurements are: length of head and body, 150 (138 to 164); length of hind foot, 28 (26 to 30); height of ear from notch, 21.6 (20 to 22). Cranial measurements are: condylopremaxillary length, 32.5 (31.2 to 33.7); zygomatic breadth, 10.8 (10.0 to 11.4); depth of cranium, 10.9 (10.7 to 11.1); length of nasals, 12.1 (10.6 to 12.7); alveolar length of maxillary toothrow, 6.8 (6.2 to 6.9).

Dental characters for *Sigmodon* (Hershkovitz, 1955) are: well-developed upper incisors, anterior face smooth or grooved, opisthodont; molar rows parallel-sided or slightly divergent posteriorly; molars large, with high crowns and terraced surfaces; mesoloph rudimentary or absent in first two molars, present or absent in third upper molar; mesostyle never functional (or as-

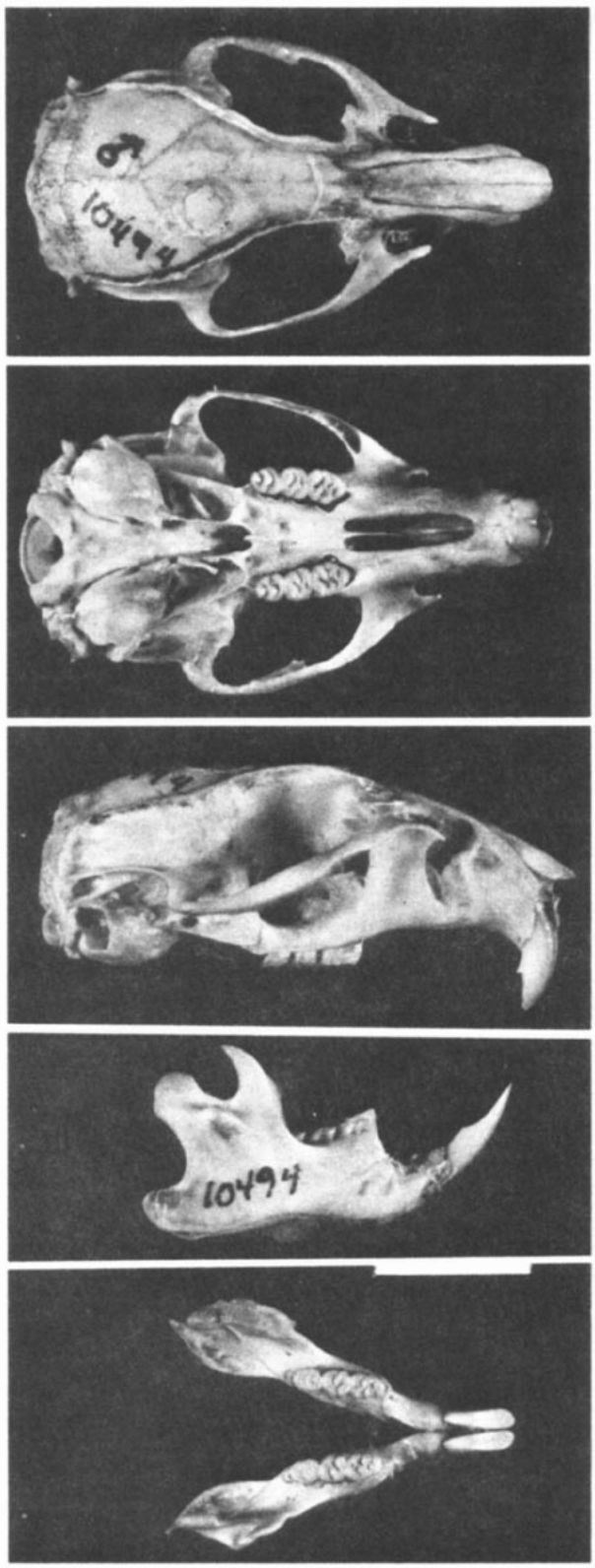

FIGURE 1. Dorsal, ventral, and lateral views of cranium, and lateral and occlusal views of mandible of *Sigmodon fulviventer* (MSU 10494, male from Hacienda Coyotes, 2707 m, Durango). Scale shown is 10 mm.

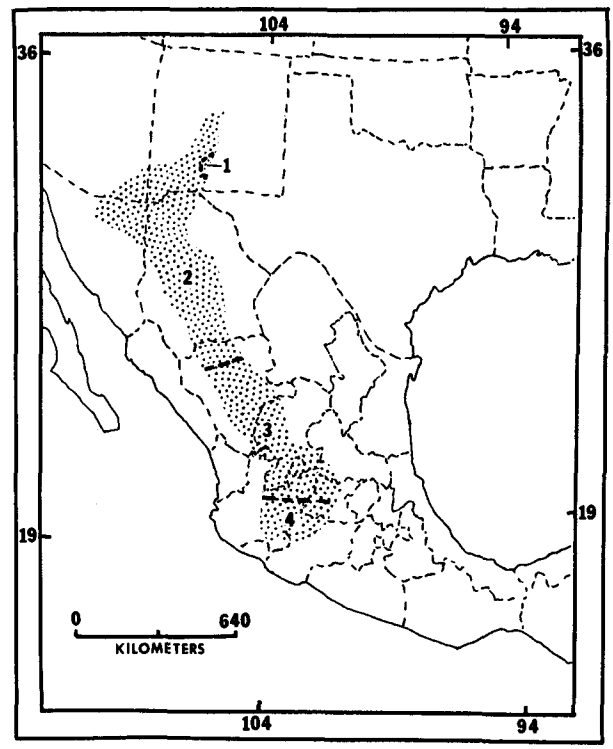

FIGURE 2. Distribution of tawny-bellied cotton rats: 1) *S. f. goldmani*; 2) *S. f. minimus*; 3) *S. f. fulviventer*; and 4) *S. f. melanotis*.

sociated with mesoloph), but small or absent; occlusal surface of M3 with S-shaped enamel pattern; primary folds deeply penetrating, the first primary or lower (secondary primary of upper) molars always extending medially beyond midline of tooth and apex of major fold; greatest length of first primary fold of upper molars $\geq$ half length of second primary fold; major and first primary folds of M3 confluent and forming a lamina; second secondary fold (posterior cingulum) of M1 and M2 absent in adults and reduced (or absent) in juvenals; internal folds absent; first minor folds of M2 and M3 absent in adults but sometimes present in juvenals. The skull of *S. fulviventer* is shown in Figure 1.

DISTRIBUTION. The tawny-bellied cotton rat inhabits mesquite-grassland (Leopold, 1959) in a north-northwest to south-southeast direction along the eastern side of the Sierra Madre Occidental (see Figure 2). This range extends southward from central New Mexico and southeastern Arizona to the northwestern base of the Transverse Volcanic Belt in Jalisco and northern Michoacán (Hall and Kelson, 1959; Cockrum, 1960; Baker and Greer, 1962; Baker, 1969; Anderson, 1972; Findley *et al.*, 1975). Today, habitats suitable for these cotton rats consist of scattered plots, which have been protected from heavy grazing by domestic ungulates.

FOSSIL RECORD. While the fossil record is sparse, the information available for the genus *Sigmodon*, especially that pertinent to the *S. fulviventer* group, is presented below. Cotton rats, *Sigmodon*, presumed to be tropical American in origin (Hooper, 1949), evolved in either a South American (Hershkovitz, 1966) or Middle American pastoral habitat (Baker, 1969) from a yet unknown, grass-eating cricetine ancestor. This ancestor may have developed as a progressive offshoot from the main line of phyllotine rodent origin (Hershkovitz, 1962).

The earliest known specimen of the genus is from the Blancan of the late Pliocene (Hibbard, 1960; Hibbard *et al.*, 1965; Downs and White, 1968; Martin, 1974). A modern species, *Sigmodon hispidus*, occurred as early as Sangamon times in the Pleistocene of Texas (Slaughter, 1966). The geological record shows that *Sigmodon* reached Kansas in the late Pliocene and early Pleistocene (Hibbard, 1960). During the Wisconsin glaciation representatives of this genus were presumably displaced southward into two refugia, peninsular Florida and the American Southwest (Blair, 1958). After the melt of glaciation, the southern plains sector of what is now the United States again became suitable for cotton rat occupancy, and *S. hispidus* moved northward reaching southern Nebraska and southwestern Iowa within the past century (Cockrum, 1948; Jones, 1964; Genoways and Schlitter, 1966; Bowles, 1975; Farney, 1976). It may have been as late as Wisconsin times, in what is now northwestern México, that conditions occurred allowing for the evolution (although no fossil evidence exists) of the *S. fulviventer* group, perhaps from a *S. hispidus* ancestor (Baker, 1969).

FORM. In *Sigmodon fulviventer* and its near relatives, the pelage consists of three basic hair types, excluding vibrissae. The guard-awl and auchene types (sometimes simply referred to as guard hairs) are longer and somewhat stiffer than underhairs. The auchene type is intermediate in height between guard-awl and underhairs and has a zig-zag shape (Searle, 1968). The dorsum possesses hairs (McWhirter *et al.*, 1974) that are: 1) black, or black with a tawny tip (guard-awl); 2) black to tawny base, ivory band, and black tip (auchene); and 3) black, or black with tawny tip (underhair). The ventral hairs are dark gray with tan tips for guard-awl and auchene types and medium gray for underhairs. The feet are similar in color to the venter. The tail is dark and possesses just enough hairs to hide its scaly appearance (Bailey, 1902, 1913). The tail, feet, and ears are moderately long (Anderson, 1972); however, the ears are partially hidden by fur.

Species of *Sigmodon* are members of a mammalian fauna adapted for a grass-eating diet in open country of the New World (Baker, 1971). The flat-surfaced, high-crowned molars (Hershkovitz, 1955) are suitable for withstanding the rigorous mastication of harsh grasses and associated grit (Vorontsov, 1960).

FUNCTION. The basal metabolism of *S. fulviventer* from three localities in México with different climates was measured by Bowers (1971). He did not find any intraspecific metabolic adaptation to diverse climates. The mean value of oxygen consumption for this species was approximately 1510 mm^3 O_2/g/hr.

ONTOGENY AND REPRODUCTION. Growth curves for *Sigmodon fulviventer* and three related species (Baker, 1969) are represented in Figures 3 and 4 (see also Chipman, 1965; Hoffmeister, 1963; Jiménez, 1971, 1972). Inasmuch as no sexual dimorphism was found, the curves are for combined sexes. In laboratory-raised animals, female *S. fulviventer* produced offspring at 77 days and would have mated approximately 35 days earlier (Baker, 1969).

Different age groups of laboratory-raised animals compared to wild-caught individuals have shown that, in general, cotton rats of various species less than 75 days old are juveniles, between 75 and 200 days old are young adults, between 200 and 300 days of age are adults, and more than 300 days old are old adults (Baker, 1969).

ECOLOGY. *Sigmodon fulviventer* has been found in a variety of grass and grass-shrub habitats (Hooper, 1955; Mohlhenrich, 1961; Baker and Greer, 1962; Baker, 1969; Petersen, 1973). Some major grasses associated with this species are: *Muhlenbergia* sp., *Aristida* sp., *Cynodon dactylon*, and *Sporoblus wrightii*. Tawny-bellied cotton rats follow their runway systems, which may be only partly exposed because the associated grassy cover is usually dense. This species is known to construct nests woven out of grasses in which the rats reside and care for their young (Baker, 1969).

Sigmodon fulviventer has been collected in association with, or adjacent to, *S. hispidus*, *S. leucotis*, and *S. ochrognathus*. The tawny-bellied cotton rat is apt to live in association with *S. hispidus*, especially in eastern parts of the range of *S. fulviventer* (Baker, 1969). Interactions between these two species were investigated by Petersen (1973) in Durango. *Sigmodon fulviventer* was found to depress and replace *S. hispidus* populations. This may mean that *S. fulviventer* is somewhat of a specialist, which is capable of out-competing the more ubiquitous generalist, *S. hispidus* (Colwell and Fuentes, 1975).

Along the eastern base of the Sierra Madre Occidental where grasslands occur on deep alluvial soil, *S. fulviventer* also presumably excludes or dominates other cotton rat species (Baker and Greer, 1962). When either *S. leucotis* or *S. ochrognathus* occur sympatrically with *S. fulviventer*, the latter species inhabits level, open areas leaving the peripheral, sparsely vegetated slopes to the former two species. However, where *S. fulviventer* is absent, *S. leucotis* and *S. ochrognathus* may occupy all available grassy habitat. *Sigmodon fulviventer* and *S. alleni* are not known to coexist probably due to their different ecological preferences (Baker, 1969).

Sigmodon fulviventer is parasitized by fleas, *Polygenis martinez-baezi* Vargas, 1951, and *Archopeas leucopus* from near Boquilla, and *Pleochaetis* sp. from near Hacienda Coyotes (Baker, 1969). The nematode, *Litomosoides carinii* (Travassos, 1919), has been found in the tawny-bellied cotton rat (Doran, 1955).

GENETICS. Sex determination is XX/XY with both X and Y chromosomes being acrocentric. *Sigmodon fulviventer* possesses a diploid number of chromosomes of 28, 29, or 30 (*FN*, 34) depending on the sex and locality of capture (Lee and Zimmerman, 1969; Zimmerman, 1970).

McWhirter *et al.* (1974) described for this species a mutant gene affecting pelage color, garnet (p^{ga}). Variations in the pigment granule characteristics of the hair were similar to those reported in the pink-eyed house mice (Russell, 1946). This mutant strain possesses a pale-tan coat color in which melanin is reduced. Hair lengths from the mutant proved to be significantly longer than those of normal individuals. The mutant gene also appeared to reduce litter size.

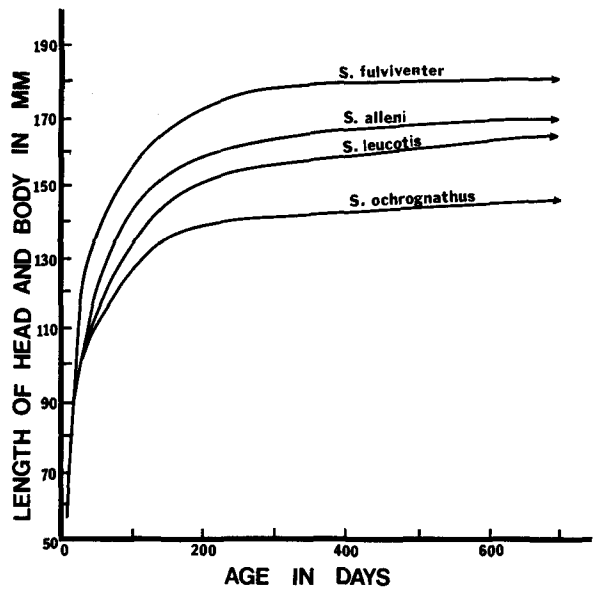

FIGURE 3. Growth of the head and body length in four species of *Sigmodon*. Data from laboratory-raised animals, the ages of which were known at death. Adapted from Baker, 1969.

REMARKS. The exact phylogenetic relationship of *S. fulviventer* to other *Sigmodon* species is still nebulous. Serological evidence (Dalby and Lillevik, 1969) agrees with morphological considerations (Baker, 1969) indicating two distinct *Sigmodon* groups (as presented in the previous key). Karyology studies (Zimmerman, 1970) showed that *S. fulviventer* is in a separate group from *S. hispidus* as previously suggested (Baker, 1969; Dalby and Lillevik, 1969) but that *S. alleni*, *S. ochrognathus*, and *S. leucotis* are most closely related to *S. hispidus*. Although the exact partitioning is somewhat speculative, a division of the genus into two groups seems justified.

Sigmodon fulviventer may be useful as an experimental animal in studying dietary problems. The protein content and utilization of various foods are important to underdeveloped countries,

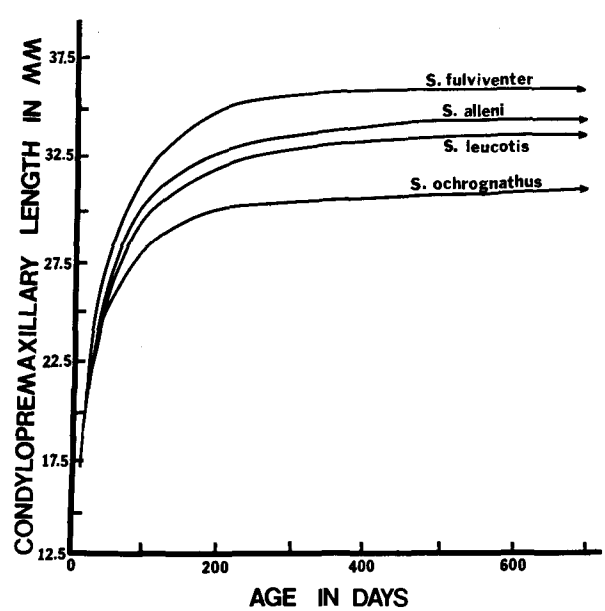

FIGURE 4. Cranial growth as judged by condylopremaxillary length in four species of *Sigmodon*. Data from laboratory-raised animals, the ages of which were known at death. Adapted from Baker, 1969.

and this species, along with *S. hispidus*, make excellent bioassay test organisms for protein efficiency studies (Underhill, 1973). A laboratory colony maintained in the Division of Living Vertebrates of The Museum at Michigan State University was docile, thrived, and produced litters with great regularity. This species has considerable potential as an experimental animal in biomedical studies.

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