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Spermophilus annulatus.

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Spermophilus annulatus Audubon and Bachman, 1842

Ring-tailed Ground Squirrel

Spermophilus annulatus Audubon and Bachman, 1842:319. Type locality unknown, subsequently designated as "Manzanillo, Colima, Mexico" (Howell, 1938:163).

CONTEXT AND CONTENT. Order Rodentia, Suborder Sciurognathi, Family Sciuridae, Subfamily Sciurinae, Genus *Spermophilus*, Subgenus *Otospermophilus*. The genus *Spermophilus* contains 38 species (Wilson and Reeder, 1993). Two subspecies of *S. annulatus* are recognized (Hall, 1981):

S. a. annulatus Audubon and Bachman, 1842:319, see above.
S. a. goldmani Merriam, 1902:69. Type locality "Santiago, Tepic [=Nayarit—Miller, 1924:180], Mexico."

DIAGNOSIS. Congeners that may be sympatric with *S. annulatus* (Fig. 1) are *S. adocetus*, *S. mexicanus*, and *S. variegatus*. *S. annulatus* (total length, 383–470 mm) resembles *S. adocetus* (total length, 315–353 mm), but *S. annulatus* is larger, darker (more reddish), the tail has annulations, the rostrum is longer and narrower, and the interorbital region averages 45% instead of 49% of the zygomatic breadth (Hall, 1981). Compared with the skull of *S. annulatus* (Fig. 2), the skull of *S. adocetus* is only ca. 75% as large, the jugal is broader, and the coronoid and angular processes of the jaw are longer (Merriam, 1903). Compared with *S. mexicanus* (total length, 280–380 mm), which usually has nearly square white spots arranged in about nine longitudinal rows on the dorsum, *S. annulatus* is larger and has no dorsal stripes. Compared with *S. variegatus* (total length, 430–525 mm), *S. annulatus* has a closed supraorbital foramen and the sides of the head are tawny or buffy (Hall, 1981).

Compared with the closely related and allopatric *S. beecheyi*, *S. annulatus* is slenderer, the ears are broader and less pointed, the feet and legs are slenderer, and the claws on the front feet are sharper and more curved. *S. annulatus* is slightly smaller than *S. beecheyi*, and the skull of *S. annulatus* is relatively narrower across the zygomata, which are less widely expanded at the posterior end, the interorbital breadth is relatively greater, and the upper incisors are shorter and thicker (Howell, 1938).

GENERAL CHARACTERS. The upperparts of the ring-tailed ground squirrel are nearly uniform mixed fuscous-black and cinnamon-buff or pale pinkish-buff; the blackish color often predominates on the head and in some individuals on the back. The chin, throat, and sides of the nose and face are ochraceous buff. The sides of the neck, shoulders, and forelimbs are hazel. The ears and hind legs are hazel or tawny. The underparts are warm buff or pinkish buff. The tail is mixed pinkish buff and black above, hazel beneath (Hall, 1981). Coloration varies seasonally; *S. annulatus* is more brightly colored during the breeding season (December to June—G. Ceballos, in litt.). The tail is about the same length as the head and body, narrow, not bushy, and has ca. 15 blackish annulations. The interorbital breadth is >42% of the zygomatic breadth (Hall, 1981). There are three pair of mammae (Moore, 1961).

Skulls of females average larger than those of males. Means and ranges of external and cranial measurements (in mm) of males (n = 8) and females (n = 9), respectively, of *S. a. annulatus* from Colima and females (n = 6) of *S. a. goldmani* from Nayarit, respectively, are: total length, 439 (410–470), 434 (390–470), 415 (383–430); length of tail, 213 (187–228), 216 (193–238), 204 (186–216); length of hind foot, 58 (54–64), 57 (54–60), 52 (50–54); length of ear (dry), 15 (14–16), 15 (14–18), 15 (15–16); greatest length of cranium, 53.6 (51.6–55.8), 55.4 (54.0–57.0), 53.5 (51.9–55.4); palatilar length, 25.2 (24.0–26.4), 25.5 (25.0–26.2), 25.0 (24.0–26.0); zygomatic breadth, 30.5 (28.5–32.2), 31.2 (30.4–32.6), 30.4 (29.0–32.1); cranial breadth, 21.8 (21.2–22.8), 22.1 (21.1–23.0), 22.2 (21.6–23.1); interorbital breadth, 13.7 (13.3–15.2), 14.5 (13.6–15.3), 13.5 (13.0–14.1); postorbital constriction, 14.4 (13.9–14.9), 14.3 (13.3–14.8), 15.2 (14.5–15.8); length of nasals, 17.8 (15.9–19.3), 18.3 (18.0–18.8), 17.5 (16.8–18.5); length of maxillary toothrow, 10.0 (9.6–10.3), 9.9 (9.5–10.2), 9.7 (9.3–10.1—Howell, 1938).

Compared with *S. a. annulatus*, *S. a. goldmani* has shorter hind feet (averaging 52.5 mm instead of 56.5 mm as in *S. a. annulatus*). In *S. a. goldmani*, the white of the eyelids is clearer and more distinct, the ferruginous of the face, neck, thighs, and tail is less extensive and usually less intense (Merriam, 1902), the upperparts are darker (more blackish) and the underparts are paler, the tawny color on the sides of the head and neck is paler and less extensive, and the hind legs are less tawny and more mixed with black than in *S. a. annulatus* (Howell, 1938).

DISTRIBUTION. The ring-tailed ground squirrel is endemic to the lowlands of western Mexico, and occurs at elevations from sea level to ≥1,200 m (G. Ceballos, in litt.; Hall, 1981). It inhabits the Nayarit-Guerrero biotic province (Goldman, 1951) along the Pacific coast of western Mexico from southern Nayarit into northwestern Guerrero (Fig. 3; Hall, 1981). The range of *S. annulatus* is entirely tropical (Howell, 1938). The genus *Spermophilus* evolved by the early Pleistocene (Black, 1972). No fossils of *S. annulatus* are known.

FORM AND FUNCTION. The hair on the dorsum is short and smooth. The short pelage, which lies beneath this coarser hair, is sparsely distributed. On the undersurface, the hairs are longer and thinly scattered (Audubon and Bachman, 1842).

The forelegs of *S. annulatus* are long and slender. On the forefeet, there are four toes covered to the extremities of the nails with short pelage. The first and fourth toe are of equal length. The second and third, which are longer, also are uniform in length. The nails are short, crooked, and sharp. The hind feet are thickly covered with short pelage and have five toes. The soles and palms are naked (Audubon and Bachman, 1842).

The highest point of the moderately convex dorsal profile of the skull of *S. annulatus* is situated slightly posterior to the plane of the postorbital processes. From this point to the rostrum, the skull is nearly flat. The downward inclination of the rostrum is about the

FIG. 1. *Spermophilus a. annulatus* near El Jabali, Colima, Mexico. Photograph courtesy of G. Ceballos.

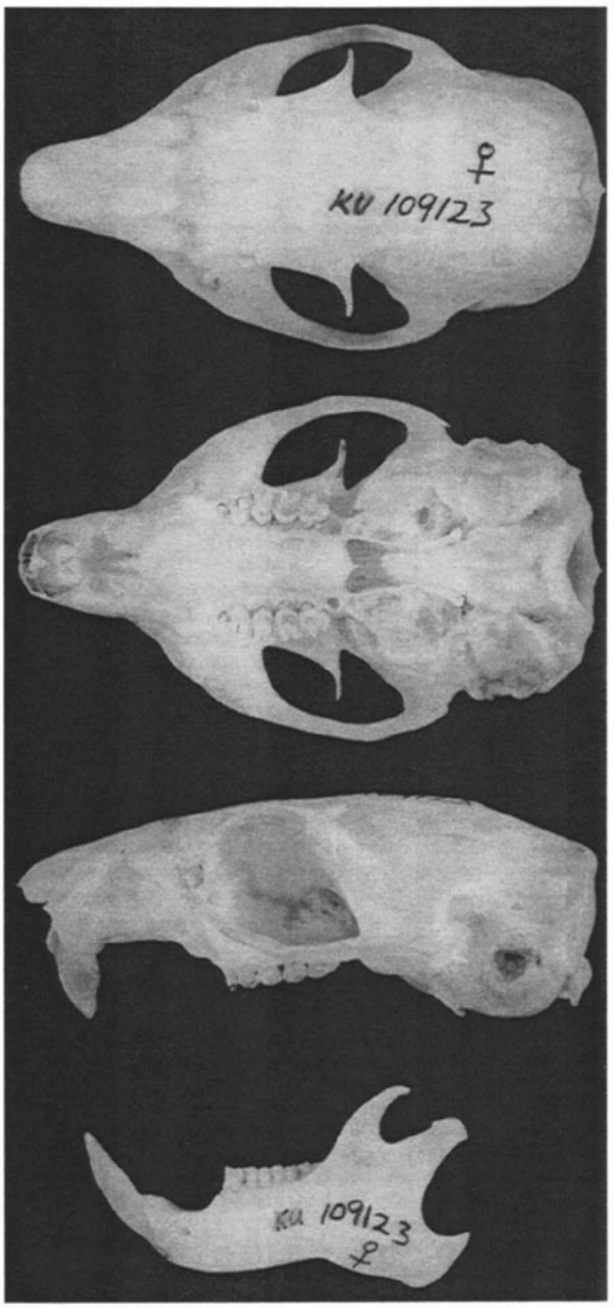

FIG. 2. Dorsal, ventral, and lateral views of cranium and lateral view of mandible of *Spermophilus a. annulatus* from Tolimán, 660 m elevation, Jalisco, Mexico (female, University of Kansas Museum of Natural History 109123). Greatest length of cranium is 55.5 mm.

same as that of the cranium posterior to the highest point. The rostrum is short in comparison with length of skull. From the dorsal view, the cranium is ovate. The parietal ridges are prominent and meet at an acute angle shortly anterior to the crest. The dorsal margins of the optic foramina are moderately concave medially, the anterior end of the sphenoid between the foramina is moderately constricted, and the optic groove is trapezoidal in outline (Bryant, 1945).

The cheekpouches are large and open inside the mouth immediately anterior to the premolars (Audubon and Bachman, 1842). The dental formula of *S. annulatus* is i 1/1, c 0/0, p 2/1, m 3/3, total 22 (Hall, 1981). As in other sciurids, the upper toothrows are farther apart than the lower toothrows. Thus, it is impossible for the two series of teeth to be in perfect occlusion at the same time. Nevertheless, the arrangement of the cusps is such that an excellent

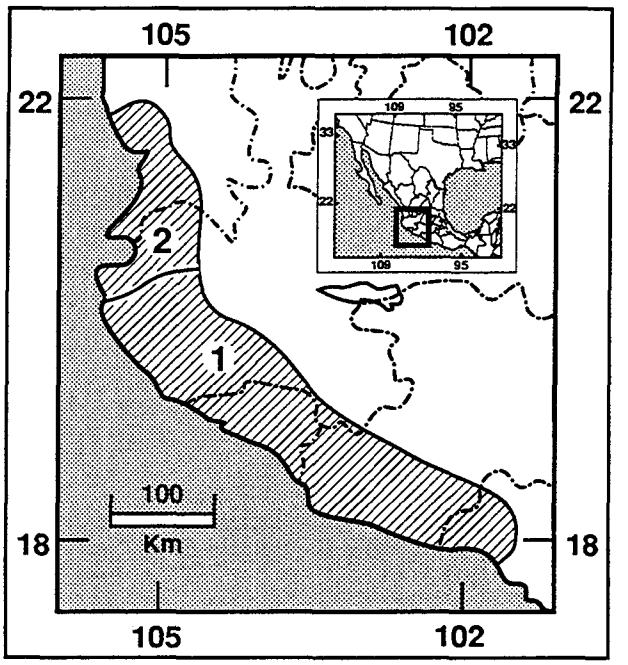

FIG. 3. Distribution of *Spermophilus annulatus* in western Mexico (Hall, 1981): 1, *S. a. annulatus*; 2, *S. a. goldmani*.

lateral grinding movement is assured. When the teeth are meshed, the transverse ridges prevent a fore-and-aft movement of the mandible. When gnawing is desired, this mechanical condition is overcome by lowering the mandible and pushing the lower incisors forward to make contact with the upper incisors. These relationships account for the fore-and-aft gnawing movements and the transverse grinding movements (Bryant, 1945).

The incisors are deep orange (Audubon and Bachman, 1842). The alveoli of the upper incisors open cranioventrally in the anterior ends of the premaxillae. The incisors pass through the lateral parts of the premaxillae and maxillae and terminate medial to the infraorbital foramina. The upper incisors are shorter, stouter, and more curved than the lower ones. The anterior surfaces usually are more rounded than the lateral surfaces, and the medial surfaces are flat. The lower incisors are longer, slenderer, and less curved than the upper incisors. Each incisor extends posteriad through the ventral part of the body of the mandible and terminates at the base of the condyloid process. A small tubercle on the lateral surface of the ramus marks the point of termination (Bryant, 1945).

The diastemal part of the mandible is slender, rounded laterally, concave above and below, and flattened medially. The alveolar border is level with or below the level of the anterior tip of the mandible. The anterior margin of the alveolar surface passes ventrad to join the diastemal part in a gradual curve (Bryant, 1945).

The hyoid apparatus consists of a single basihyal and paired thyrohyals, ceratohyals, and stylohyals. The basihyal is round in cross-section and fuses with the long thyrohyals at an early age (Hoffmeister and Hoffmeister, 1991).

The basal end of the baculum (Fig. 4) is distinctly oval in cross section and is wider than high. The bone tapers rapidly into the slightly curved shaft, which expands abruptly into the broad distal end. The distal spoon-like portion is bordered by a continuous row of tooth-like projections (24 in one and 25 in the other of two specimens from Colima and Jalisco). The pointed projections curve inward at the sides, but around the front of the disc they curve outward, except for one projection near the middle that curves inward. This situation is not seen in any other *Spermophilus*. Further, the anterior disc is the broadest of any *Spermophilus*. There is no ventral projection on the distal end. The forward-curving tooth-like projections and smooth ventral surface of the distal end, without a median projection, are found in no other bacula. Measurements (in mm) of two bacula are: length, 5.2, 5.2; width of base, 2.0, 2.1; width of distal end, 2.8, 2.7 (Burt, 1960).

ONTOGENY AND REPRODUCTION. Breeding occurs during the dry season (December to June—G. Ceballos, in litt.). In

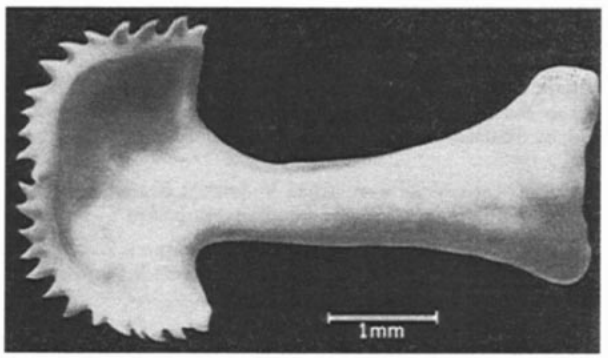

FIG. 4. Baculum of *Spermophilus annulatus* from Tenacatita Bay, Jalisco, Mexico (modified from Burt, 1960).

Colima on 10–17 February, one of two females examined had four embryos that were 10–15 mm in length (Hooper, 1955).

ECOLOGY. The ring-tailed ground squirrel frequents large trees, and was observed only around the dense mass of vines and tangled brush that climb around the larger trees (Allen, 1889). In Colima and Jalisco, *S. annulatus* inhabits dense, tropical, deciduous forests (G. Ceballos, in litt.; Hooper, 1955), and is common on the plains of Colima. The ring-tailed ground squirrel is not shy, although it may rush into its burrow at the first glimpse of an intruder. Its burrows are on hillsides among rocks, and in sandy flats along walls and hedges bordering cultivated fields. *S. annulatus* also occurs in the shade of the densest groves of oil palms (Arecaceae), with burrows under masses of fallen palm fronds or sheltered by the thorny growth of mesquite (*Prosopis*) and catclaw (*Acacia*). One burrow was found under a cactus whose spreading branches gave shelter on more open ground (Howell, 1938). The ring-tailed ground squirrel also lives in holes in large trees (Allen, 1889), in sides of dikes, in stone walls, and in walls of barns (Allen, 1890).

In Jalisco, most *S. annulatus* were observed in rocky situations, such as rock fences and rock outcroppings along arroyos. In the vicinity of La Cuesta, vegetation consisted of tropical-deciduous trees including wild figs (*Ficus*); brush had been cleared away under the tall trees for coffee and rubber plantings. The area southeast of Tecomate is humid; tall tropical-deciduous trees line the streams in the numerous steep-walled valleys that lead away from the first range of mountains inland from the coast. There were many large boulders, especially along the streams. Stands of oaks grew on the adjacent mountainsides, slightly above the place where this species was observed. At Tolimán, which is situated in a hot valley near the Río Armería, there was little natural vegetation remaining. Most of the fields were planted to agave, but some were in corn. Around the edge of town, orchards of bananas, citrus, mango, chico, and guayavo were grown. Sympatric species include *Hodomys alleni, Xenomys nelsoni, Sciurus aureogaster* (G. Ceballos, in litt.), *S. colliaei, Pappogeomys bulleri, Liomys pictus, Oryzomys melanotis, O. palustris, Osgoodomys banderanus, Peromyscus boylii, Reithrodontomys fulvescens, Baiomys musculus, Spilogale putorius*, and *Conepatus mesoleucus* (Genoways and Jones, 1973).

The ring-tailed ground squirrel eats fruits and nuts (Allen, 1889). The nuts of the oil palm, mesquite beans, cactus seeds, fleshy fronds of pear-leafed cactus (*Opuntia*), wild figs, and a variety of other seeds and fruits make up its varied diet (Howell, 1938); it also may feed on insects (G. Ceballos, in litt.). In Colima, foods also include corn and seeds of other plants (Allen, 1890).

In Colima, a male was heavily infested with botfly larvae (*Cuterebra*—Hooper, 1955). No other parasites are known.

BEHAVIOR. In dense palm groves and thickets of other trees, the ring-tailed ground squirrel may be seen gliding silently from log to log or from one brush pile or similar shelter to another, occasionally stopping a moment to dig for a seed or sitting up on its haunches to eat, then moving on again. It often is observed 3–4 m up on the trunks of small trees, sometimes climbing out on the ends of the branches to obtain mesquite beans, cactus leaves, or other fruit. When startled, it frequently runs about 1 m up a tree, takes a hasty look at the intruder, moves around the tree, down the other side, and away in a direct line to a hole many meters away. Often *S. annulatus* will crouch close to the ground and lie still in the bushes, while other individuals will slip away to some sheltering hole and then utter short, shrill, whistling or chirping notes at short intervals. These are the only types of vocalizations known. The ring-tailed ground squirrel also may stop and stand up on the hind feet, sometimes stretching the body so that the tail is used to help support the body as on a tripod. When alarmed, it scurries away into the first shelter. *S. annulatus* carries its tail in a curve like a tree squirrel (*Sciurus*), and its motions are more light and agile than those of most spermophiles (Howell, 1938). Nothing is known concerning the genetics of *S. annulatus*.

REMARKS. The type specimen of *S. annulatus* described by Audubon and Bachman (1842) was not accompanied by data regarding the collecting locality. As a result, there was considerable confusion for many years as to whether the species was found in North America or Africa (Allen, 1877).

Spermophilus is derived from the Greek *sperma* and *philos* meaning seed-loving. The specific epithet *annulatus* is derived from the Latin *annulus* meaning ornamented with a ring (Jaeger, 1955), which refers to its tail. *S. annulatus* also has been referred to as the annulated marmot-squirrel (Audubon and Bachman, 1842), annulated-tailed spermophile (Allen, 1877), ring-tailed spermophile, Goldman's spermophile (Elliot, 1905), and Goldman's ground squirrel. In Colima and Jalisco, the Spanish name for *S. annulatus* is tezmo or tesmo (Allen, 1890; G. Ceballos, in litt.).

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