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Notiosorex crawfordi.

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Notiosorex Coues, 1877

Notiosorex Coues, 1877:646. Type species *Sorex (Notiosorex) crawfordi* Coues, 1877.

CONTEXT AND CONTENT. Order Insectivora, Family Soricidae, Subfamily Soricinae, Tribe Neomyini. The genus *Notiosorex* includes a single Recent species, *Notiosorex crawfordi.*

Notiosorex crawfordi (Coues, 1877)

Desert Shrew

Sorex (Notiosorex) crawfordi Coues, 1877:651. Type locality near Old Fort Bliss, approximately 2 miles above El Paso, El Paso Co., Texas.

Notiosorex crawfordi: Merriam, 1895:32.

CONTEXT AND CONTENT. See generic summary above. *Notiosorex crawfordi,* as currently understood, is comprised of two subspecies as follows:

N. c. crawfordi (Coues, 1877:651), see above.

N. c. evotis (Coues, 1877:652). Type locality Mazatlán, Sinaloa.

DIAGNOSIS. Inasmuch as the genus is monotypic, the diagnosis applies to both genus and species. Overall size is small; tail short, less than one-third total length, well-haired, indistinctly bicolored to unicolored; pinnae conspicuous; color of dorsum silver-gray to brownish gray; color of venter paler, silver-gray lightly washed with drab. Cranium is flattened, the braincase rising only slightly above the plane of the rostrum (see figure 1); dental formula, i 3/1, c 1/1, p 1/1, m 3/3, total 28; anterior teeth (to P4) lightly pigmented; unicuspids three, narrow at base, subequal (first largest, third smallest); posterior emargination of P4 strong, junction of labial blade and posterior cingulum rounded; mental foramen below middle of ml.

For more detailed description and illustrations of dentition and mandible, see Repenning (1967:55).

GENERAL CHARACTERS. External and cranial measurements in millimeters of two males and mean and extreme measurements of four females of *N. c. crawfordi,* all from the Huachuca Mountains, Arizona (after Hoffmeister and Goodpaster, 1954:51), are: total length, 77, 85, 85.5 (81 to 90); length of tail, 29, 25, 25.0 (24 to 26); length of hind foot, 11, 10, 10.0 (9 to 11); length of ear from notch, 8, 9, 8.0 (8 only, based on three individuals); condylobasal length, 16.5, 15.7, 16.0 (15.8 to 16.2); palatal length, 7.2, 6.5, 6.5 (6.3 to 6.6); cranial breadth, 8.5, 8.2, 8.3 (7.8 to 8.4); interorbital breadth, 3.6, 3.8, 3.7 (3.6 to 3.8); maxillary breadth, 5.1, 5.1, 5.1 (4.9 to 5.2); length of maxillary toothrow, 6.2, 5.8, 5.9 (5.8 to 6.0). Mean and extreme external measurements of 17 adults from southwestern Oklahoma (Preston and Martin, 1963) are: total length, 88 (77 to 93); length of tail, 29 (27 to 32); length of hind foot, 11 (10 to 11); length of ear from notch, 7 (5 to 9); weight, 4.0 (2.9 to 5.0) g.

External measurements of three males and three females of *N. c. evotis* from northern Sinaloa (Armstrong and Jones, 1971:751–752) are: total length, 88, 87, 87, 84, 85, 85; length of tail, 28, 25, 27, 24, 28, 25; length of hind foot, 12, 12, 12, 12, 11, 11; length of ear from notch, 8, 9, 8, 8, 9, 8; weight, 5.1, 6.2, 5.5, 5.0, 4.5, 4.8. Cranial measurements of three males and mean (and extremes) of four females are: condylobasal length, 17.2, 17.6, 16.8, 16.78 (16.3–16.9); cranial breadth, 8.8, 8.4, 8.6, 8.12 (7.8–8.4); palatal length, 7.2, 7.4, 7.1, 7.22 (7.0 to 7.4); interorbital constriction, 4.0, 4.1, 4.0, 3.76 (3.6 to 4.0); maxillary breadth, 5.3, 5.4, 5.3, 5.12 (4.7 to 5.4); length of maxillary toothrow, 6.3, 6.4, 6.0, 6.12 (6.0 to 6.2). Measurements of a female and mean (and extremes) of four males from southern Sinaloa (Armstrong and Jones, *loc. cit.*) are: total length, 92, 93.2 (90 to 98); length of tail, 22, 25.5 (23 to 27); length of hind foot, 11, 11.9 (11 to 13); length of ear from notch, 8, 7.7 (7 to 8); weight in grams, —, 5.42 (4.4 to 6.3); condylobasal length, 17.1, 17.68 (17.4 to 17.9); cranial breadth, 8.5, 8.68 (8.5 to 8.8); palatal length, 7.4, 7.60 (7.5 to 7.7); interorbital constriction, 4.0, 4.05 (4.0 to 4.1); maxillary breadth, 5.5, 5.37 (5.3 to 5.4); length of maxillary toothrow, 6.3, 6.58 (6.5 to 6.7).

For additional measurements of the species, see Durham (1955) and R. H. Baker (1962). Illustrations of external features were presented by Dixon (1924) and Hoffmeister and Goodpaster (1962).

DISTRIBUTION. The desert shrew has a broad distribution in the southwestern and south-central United States and in northern and central México. Figure 2 indicates all published localities of occurrence that have come to our attention (nearby localities have been combined in some instances to prevent undue crowding of symbols). Altitudinal range of records of occurrence is from near sea level in California (Huey, 1936:143, *inter alia*) to more than 6900 feet (2100 m) in Colorado (Douglas, 1967), Arizona (Lange, 1959:102), and Chihuahua (Anderson and Long, 1961:1).

Insular records of the species are from Isla San Martín, about 6.4 km off the Pacific coast of Baja California (Schulz *et al.*, 1970), and Isla Palmito del Verde, Sinaloa (Armstrong and Jones, 1971:750).

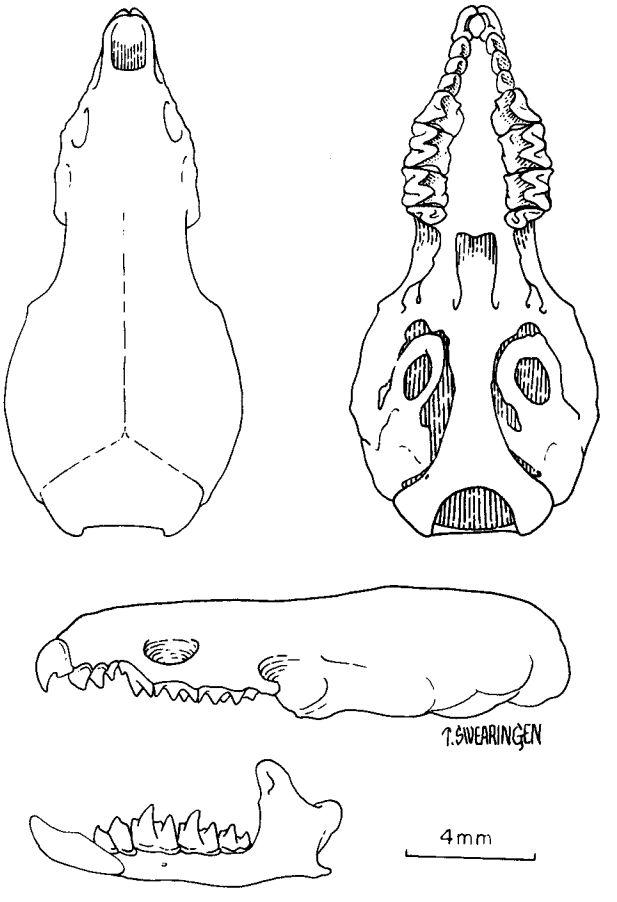

FIGURE 1. Dorsal, ventral, and lateral views of skull, and lateral view of lower jaw of *Notiosorex crawfordi evotis,* KU 105109, female, from Sinaloa, México.

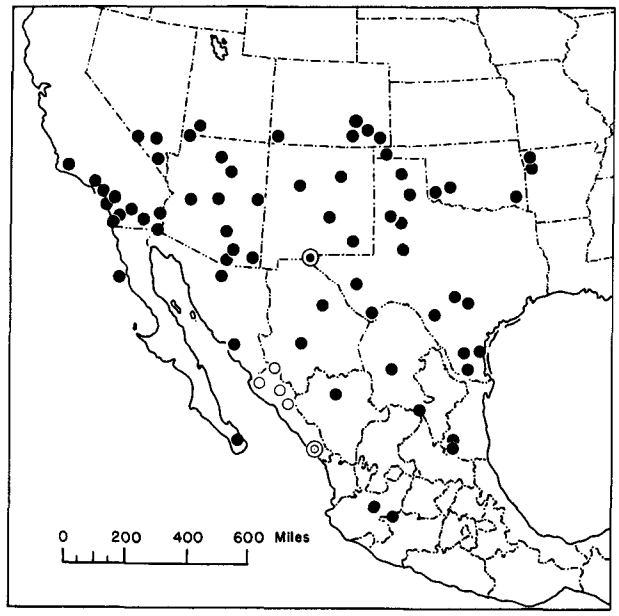

FIGURE 2. Geographic distribution of *Notiosorex crawfordi* in the southwestern United States and México. Solid symbols represent the subspecies *N. c. crawfordi*; open symbols represent *N. c. evotis*. The type localities of the two subspecies are encircled.

The geographic range (figure 2) may, in fact, include disjunct relict populations in eastern Oklahoma (Clark, 1953) and adjacent Arkansas (Sealander, 1952). For comments on this possibility, see Hibbard and Taylor (1960:159). Literature utilized in the preparation of Figure 2, but not cited elsewhere in this review includes: Armstrong (1972), Bailey (1905, 1935), Cahalane (1939), Cockrum (1960), Davis (1966), Dice and Blossom (1937), Findley (1955), Grinnell (1933), Handley (1956), Hoffmeister and Carothers (1969), Jones (1959), Judd and Schmidly (1969), von Bloeker (1944).

FOSSIL RECORD. The earliest known representative of the genus *Notiosorex* is *N. jacksoni*, described by Hibbard (1950:129) from the early Blancan Rexroad fauna (late Pliocene Rexroad formation), of Meade County, Kansas. *N. jacksoni* was larger than the Recent species *N. crawfordi*, but smaller than *Megasorex gigas*. The teeth of *jacksoni* were more generalized than those of *crawfordi*. According to Hibbard (*op. cit.*:133). "no characters, with the exception of size, have been observed. . .which would exclude *N. jacksoni* from the ancestral stock of *N. crawfordi*." A possible record of *N. jacksoni* from the Irvingtonian (mid-Pleistocene) of California was mentioned by Repenning (1967:55). Lammers (1969:524) reported the genus *Notiosorex* from the Benson fauna (St. David formation, late Pliocene–early Pleistocene) of Cochise County, Arizona.

Apparently, the earliest record of *Notiosorex crawfordi* is from the Sangamon of Meade County, Kansas (Cragin Quarry local fauna), as reported by Hibbard and Taylor (1960:158). *N. crawfordi* is known also from the Pleistocene deposit (locality 2051) at Rancho la Brea, California (Compton, 1937: 85). The relatively abundant material there included one skull, five palates, six partial maxillaries, and 22 right and 18 left mandibles.

Dalquest *et al.* (1969) reported abundant remains of the desert shrew from three levels of fill in Schulze Cave, Edwards County, Texas. Estimated age of the deposits, based on radiocarbon determinations and rates of sedimentation, ranges from 11,000 to 8000 years BP.

A subfossil occurrence of *N. crawfordi* was reported from pre-Basketmaker levels in Hermit Cave, Eddy County, New Mexico, by Findley (1965). Preston and Sealander (1969: 641) noted finding skeletal remains of a desert shrew in the rib cage of an Indian mummy from western Arkansas that was 500 to 1000 years old. The length of time that the shrew had been associated with the burial was not determined.

FORM AND FUNCTION. The post-cranial skeleton of *N. crawfordi* has not been studied in detail. The vertebral formula is as follows: 7 cervical, 13 thoracic, 16 lumbar, 5 sacral, 11 to 13 caudal. There is a single pair of floating ribs (Hoffmeister and Goodpaster, 1954:50).

Lateral skin glands are prominent in the desert shrew, especially in mature males, where the gland appears as an elliptical patch of bare, glandular, thickened skin about 5 mm long. In four males captured at Mazatlán, Sinaloa, in mid-December and early February, the glands are 2 to 5 mm long on museum skins. In mature females, the presence of the gland is indicated by a pattern caused by a conspicuous thinning of the hairs. A pregnant female captured on 27 July at Rosario, Sinaloa, had glands 7 mm long. For illustration of the gross aspect of the gland, see Hoffmeister and Goodpaster (1962:249).

Dorsal hairs of adults are about 3 mm long, those of the venter 1.5 to 2 mm. Hairs of subadult pelage are shorter and seemingly sparser than those of mature individuals and are somewhat paler in color basally. Following maturational molts, a single (prevernal) molt is thought to occur each year, from April through June (Dixon, 1924:6; Hoffmeister and Goodpaster, 1962:247), although pertinent data are meager. Some individual variation exists in color of animals in comparable pelage (see Hoffmeister and Goodpaster, 1962:248, for a commentary on the literature).

Available data on sensory acuity are anecdotal. Hoffmeister and Goodpaster (1962:242) thought olfaction to be not remarkably acute. Vision was interpreted to be effective, but not particularly keen. The vibrissae are prominent and the snout twitches continually while the animal forages. The tail also may serve a tactile function. Noises startle these shrews while foraging, but noise does not awaken individuals from deep sleep.

Hoffmeister and Goodpaster (1954:50) reported that the desert shrew has an especially deep sleep Arousal was difficult. Those authors suggested that "an animal that sleeps so soundly, oblivious to numerous noises and movements, must be accustomed to a retreat of considerable security." Coulombe and Banta (1964:291) suggested that the sleep pattern might reflect a metabolic "down-shifting" to minimize respiratory water loss. Such a mechanism—coupled with strict micro-habitat selection—would be highly adaptive in so small a mammal, particularly if these shrews are nocturnal, as suggested by Dixon (1924:2). However, Hoffmeister and Goodpaster (1962:240) found captive individuals to be active both by day and by night.

BEHAVIOR. Unlike many soricids, individual desert shrews are of rather even temperament and can be caged together, when food is in excess, with little antagonism (see Hoffmeister and Goodpaster, 1962:243). Known vocalization is a high-pitched squeak, which is emitted during rough handling, during occasional bouts of fighting (Hoffmeister and Goodpaster, 1962:242), or when food is taken from an individual (Dixon, 1924:2).

In common with some other soricids, desert shrews deposit feces conspicuously and in a stereotyped fashion, frequently on an elevated object, such as a leaf or a piece of rubbish. Regular defecation stations are utilized (Huey, 1936:145; Brach, 1969:120). Fecal pellets of desert shrews in the wild are from 2 to 4 mm in diameter and 5 to 9 mm long (Hoffmeister and Goodpaster, 1962:241). Cunningham (1956:109) reported coprophagy in a captive shrew, but Hoffmeister and Goodpaster (1962:241) suggested that the behavior may have been aberrant.

Based on observation of captives, Hoffmeister and Goodpaster (1962:243) concluded that desert shrews are not fossorial. Crevices in the soil flooring a cage were not utilized, and the earth was not worked for earthworms. However, Pokropus and Banta (1966:78—see remarks) reported that fissures in sod were utilized for cover. Dixon (1924:4) noted some digging in sand, but thought it incidental to food-search activity and not the construction of a burrow. Brach (1969: 120) noted the rapid growth of claws of a captive animal, and suggested that burrowing in the wild might compensate for such growth.

Movements are rapid and nervous. Brach (1969:119) described a captive running in a zig-zag course in spurts of about 250 mm each. When running, the tail is carried in a stiff curve (Dixon, 1924:3; Brach, 1969:119), or more limply (Cunningham, 1956:108; Hoffmeister and Goodpaster, 1962: 242). Runways are not developed about the nest-site, but paths of other small animals are utilized to some extent.

Nests are built by both sexes. Dixon (1924:4) reported on the construction of nests in California. A platform, 2 inches (50 mm) wide with a central depression, built of

web-silk of the bee moth was found to be occupied by a desert shrew in an abandoned bee-hive. In another instance, an oval nest 1½ inches (40 mm) in diameter was built of cornsilk, fine grass, and feathers beneath cornstalks in a field. Each of these nests housed a single individual. Brach (1969: 119) reported a nest in the storage area of a den of *Neotoma albigula*, about 0.3 m below the surface. Grass nests 150 mm in diameter were found by Preston and Martin (1963: 269) amid cactus joints and mesquite branches near the top of dens of *Neotoma micropus*. Hoffmeister and Goodpaster (1962:238) found nests in Arizona to be variable in size, generally constructed of the fibrous inner bark of the cottonwood, or of leaves of that tree. The nests, built beneath piles of building materials, commonly had two side-openings. These shrews apparently do not shred nesting materials, as do many rodents, but rather utilize accessible materials.

REPRODUCTION AND DEVELOPMENT. The reproductive season of the desert shrew apparently extends throughout the warmer months of the year. Turkowski and Brown (1969:128) reported nestling young from Maricopa County, Arizona, in mid-April, and Stephens (1906:255) recorded a pregnant female in southern California captured in early April. Baker and Spencer (1965:330) reported pregnant females taken in mid-November in Harmon County, Oklahoma. Other records of reproductive activity are available from the months of May, July, August, and September. The length of the gestation period is not known, and it has not been established whether females are monestrous or polyestrous. Available data indicate that three to five young comprise a typical litter. There are three pairs of inguinal mammae.

No detailed information is available on embryologic development of desert shrews. Hoffmeister and Goodpaster (1954:50) thought five embryos to be nearly full-term that were 9 mm in crown-rump length. Removed from the amnion, an embryo 9 mm long (crown-rump) measured 22.3 mm in total length. The pinnae were not evident, but the pigmentation of the eye was apparent beneath the skin. Baker and Spencer (1965:330) reported one female with five embryos that were 12 to 13 mm in crown-rump length. Weight of the pregnant female was 5.9; with extra-embryonic membranes removed, the embryos together weighed 1.4 g.

Most available data on post-natal development were published by Hoffmeister and Goodpaster (1962:244). Neonates are highly altricial, being blind and naked. The pinnae are undeveloped and the digits are rudimentary and without claws. At three days of age, short, fine hairs are sparsely present over the body; the toes are clawed, the eyes are about to open, and the pinnae are evident. At day 11, young are still nidicolous, but the skin is less wrinkled, has lost its pink color, and the hair is thicker over the body. At day 40, the young have left the nest, are completely clothed with short, pale pelage, forage for themselves, and have attained about 90% of adult size and weight. After about day 90, wear shows on the posterior cusp of the upper incisor, the mesostyle of M1, and the protoconid of m1. Protocones of M1 and M2 wear with age to form a "lake." After about day 90, molt from subadult to adult pelage occurs, weight increases slightly, and complete fusion of cranial sutures takes place.

Three naked, nestling young captured in Oklahoma in July had the following measurements: total length, 44, 43, 47; length of tail, 9, 9, 9; weight, 1.6, 1.7, 2.0 g. (Preston and Martin, 1963).

ECOLOGY. Available data indicate that *N. crawfordi* occupies a wide variety of ecological situations. The community most commonly occupied is a semidesert scrub association, characterized by such plants as mesquite, agave, and scrub oaks (see, for example, Hoffmeister, 1959; Hooper, 1961; Ryan, 1968:41; Wauer, 1965). Permanent water is not a requisite of suitable habitat, but protected microhabitats usually are selected. The animals do drink when water is available (Dixon, 1924:6). Ecological conditions under which the desert shrew has been captured include: saltbush-saltcedar-reedgrass slough in Nevada (Bradley and Moor, 1958); riparian woodland of oak, sycamore, cottonwood, walnut, and juniper in Arizona (Carothers, 1968); mesic ravine in Arkansas (Clark, 1953); tropical forest of *Tabebuia, Ipomea,* and *Bombax* in Tamaulipas (Alvarez, 1963); pine-oak woodland in Tamaulipas (Alvarez, 1963); ponderosa-pinyon pine woodland in New Mexico (Lindeborg, 1960); grassy desert wash in New Mexico (Blair, 1947:219); cultivated fields (Blossom, 1933, among others); pinyon-juniper woodland (Glass, 1953, among others); desert gravel in California (Fisher, 1941); dry, rocky areas (Borell and Bryant, 1942; Jorgensen and Hayward, 1963). Desert shrews have been taken in and near buildings (Davis, 1941; Douglas, 1967; Packard and Garner, 1964). Coulombe and Banta (1964) provided a thorough review of ecological distribution of *N. crawfordi* and listed vertebrate associates.

Kinds of cover utilized by the desert shrew apparently vary with availability. Frequently, the animals are found beneath piles of brush (Baker, 1966; Vaughan, 1954), rubbish (Thomas, 1888; Turkowski and Brown, 1969), or construction materials (Hoffmeister and Goodpaster, 1954:49). Blair (1954:241) captured a desert shrew beneath cottonwood logs on a floodplain in the Texas Panhandle. Jones *et al.* (1962: 148–149) reported the capture of three individuals at Mazatlán, Sinaloa, in the wake of a bulldozer that was clearing land of a cover of dry, dense weeds and low, thorny scrub; another individual was trapped there in low weeds near thorny scrub. Baker (1962) reported capturing desert shrews beneath a pile of dried palm fronds in a pasture and beneath a large boulder in rank roadside weeds. The animals have been captured in bee-hives on several occasions (see Willett, 1939: 102). A common association is between *N. crawfordi* and woodrats, genus *Neotoma*. On the Southern Great Plains, the desert shrew has been taken frequently in dens of *Neotoma micropus* (Preston and Martin, 1963; Davis, 1941; Baker and Hsu, 1970). In Arizona, this shrew has been captured in houses of *Neotoma albigula* (Baker and Hsu, 1970; Brach, 1969). Gander (1928) reported the species from the den of *Neotoma fuscipes* in California. Shrews were found in both active and abandoned dens of *N. micropus* by Preston and Martin (1963); ten to 30 houses were examined by them before finding a shrew, but then two or three shrews were captured in clusters of adjacent houses.

The wide variety of food acceptable to individual desert shrews was reviewed by Hoffmeister and Goodpaster (1962: 248) and included: mealworms, cut-worms, crickets, cockroaches, house flies, grasshoppers, moths, beetles, earwigs, centipedes, carcasses of skinned birds and mammals, and a dead alligator lizard. Live rodents, salamanders, scorpions, and earthworms were refused. Huey (1936:144) found a captive to prefer (in order): moths, beetles, earwigs, crickets, cockroaches, and sowbugs. Limbs were removed from roaches and crickets to immobilize them, and then the heads were crushed. Dixon (1924:5) reported a shrew to immobilize several mealworms in succession by crushing their heads prior to beginning to eat any of them. The forefeet were used to hold the mealworm as it was bitten through the head, but the feet were not used to manipulate the food. Keasey (1969) maintained two desert shrews for more than a year on a diet of one or two crickets daily and mealworms *ad libitum*.

Great-horned owls and barn owls are the only documented predators on the desert shrew. Owl pellets have been one of the best sources of cranial material of this species (see, for example, Anderson and Ogilvie, 1957; Anderson and Long, 1961; Baker, 1953; Baker and Alcorn, 1953; Bradshaw and Hayward, 1960; Cunningham, 1960; Glass and Halloran, 1961; Twente and Baker, 1951).

Parasitism was reported by Fisher (1941:268). Scolices and proglottids of a cestode, *Raillietina*, and a spiruroid nematode were found in the gut of a male from Nevada.

GENETICS. Baker and Hsu (1970) reported chromosomal polymorphism within the nominal species *N. crawfordi*. A specimen from Pima County, Arizona, showed a diploid number of 62 and a fundamental number of 94. Three specimens from Garza County, Texas, had a diploid number of 68 and a fundamental number of 102. The individual from Arizona had 34 biarmed and 26 acrocentric autosomes, whereas the karyotypes of specimens from Texas contained 36 biarmed and 30 acrocentric autosomes.

REMARKS. Pokropus and Banta (1966) made brief observations on behavior of a captive shrew indentified as *Cryptotis parva*. The observations pertain, in fact, to *Notiosorex crawfordi* (see Armstrong, 1972:53).

Schaldach (1966:289) named a new subgenus and species, *Notiosorex (Xenosorex) phillipsii*, on the basis of specimens from southern Oaxaca. Choate (1969:474) considered the animals to represent *Cryptotis mexicana*, relegating the name *phillipsii* to synonymy under *Cryptotis mexicana peregrina* (Merriam).

For comments on the taxonomy of *Notiosorex crawfordi*, see Merriam (1895), Jones *et al.* (1962), and Armstrong and Jones (1971).

ETYMOLOGY. The generic name *Notiosorex* is compounded of the Greek root, *notios*, "southern," and *sorex*, the classical Latin name for shrew. The specific epithet *crawfordi* honors the collector of the holotype, S. W. Crawford. The name *evotis* is derived from Greek roots meaning "good ear."

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