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Sorex tenellus and Sorex nanus.

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Sorex tenellus Merriam, 1895
Inyo Shrew, Great Basin Dwarf Shrew

Sorex tenellus Merriam, 1895:81. Type locality, Lone Pine Creek, about 4500 ft., Owens Valley, Inyo Co., California (Howell, 1923).

Sorex tenellus myops Merriam, 1902. Type locality, Pipers Creek (=Cottonwood Creek), east slope of White Mountains, 9550 ft., Mono Co., California. E. W. Nelson's original field notes read, "5850′ above Lone Pine Camp at 3638′ . . . near main peak on Pipers Creek (Cottonwood Creek) . . . E. slope" (Howell 1923). Howell assumed that "Lone Pine Camp" referred to Lone Pine, Inyo Co., the correct elevation of which is 3727 feet, and thus calculated the elevation of the type locality as "about 9550 feet." He further assumed that "Cottonwood Creek" referred to that creek on the east side of the White Mountain Peak. However, Nelson does not state that the "main peak" was White Mountain Peak. If it were, Howell was in error in assigning the type locality to Inyo County; this was corrected by Grinnell (1933).

Sorex nanus (Merriam, 1895)
Dwarf Shrew, Rocky Mountain Dwarf Shrew

Sorex tenellus nanus Merriam, 1895:81. Type locality, Estes Park, Larimer Co., Colorado.

Sorex nanus (Merriam, 1895). First use of name combination (Jackson, 1928).

CONTEXT AND CONTENT. Order Insectivora, Family Soricidae, Subfamily Soricinae, Tribe Soricini, Genus *Sorex*, Subgenus *Otisorex* (Repenning, 1967; Findley, 1955). About 50–60 species are recognized in the genus *Sorex*, which has a Holarctic distribution. The subgenus *Otisorex* lacks a post-mandibular canal, and the pigmented ridge on the unicuspids, extending from apices to cingula, is usually well developed (Findley, 1955; Hoffmann and Peterson, 1967; Diersing and Hoffmeister, 1977). *Sorex tenellus* and *S. nanus* are allospecies belonging to the *S. ornatus* species group; each is monotypic (Jackson, 1928).

DIAGNOSIS. Dental formula is probably i 3/1, c 1/1, p 3/1, m 3/3, total 32 (Vaughan, 1978; see also Kindahl, 1960). Homologies of these teeth are uncertain, and Repenning (1967) advocates referring to them as incisors (i.e. incisor 1), antemolars, including unicuspids and molariform (fourth) premolar, and molars.

Third upper unicuspid teeth smaller than fourth; fifth smaller than third (Fig. 1). Accessory cusp on first upper incisor well developed and heavily pigmented (Fig. 1, inset). Size small, condylobasal length of skull less than 15.2 mm. No characters known to us, or to Diersing (in litt.) will reliably separate the two allospecies, although *S. tenellus* tends to be slightly larger, and with somewhat paler pelage (see also Spencer, 1966).

GENERAL CHARACTERS. Very small shrews (Fig. 2); *S. nanus* weighs 1.8 to 3.2 g, while 3.4 to 4.1 g are recorded for *S. tenellus*. Total length and length of tail of *S. tenellus* average 91.9 mm ± s.d. 1.22 (85 to 103, n = 16) and 39.9 ± 0.45 (36 to 42, n = 17) respectively, while comparable values for *S. nanus* are 89.9 ± 2.14 (82 to 105, n = 10) and 37.9 + 1.46 (27 to 45, n = 10). Differences in these dimensions are statistically insignificant, but *S. tenellus* has a significantly larger skull than *S. nanus*. Condylobasal lengths of skulls are: *S. tenellus*, 14.92 ± 0.060 (14.5 to 15.3, n = 18); and *S. nanus*, 14.36 ± 0.074 (13.8 to 14.8, n = 14). Summer pelage of *S. nanus* is Hair Brown to Olive Brown dorsally, extending far down the sides where it merges rather sharply with the Smoke Gray, somewhat buffy, venter (color terms from Ridgway, 1912). The tail is indistinctly bicolored to the tip, dark above and buff below. Winter pelage is lighter and grayer, especially on the back. *Sorex tenellus* has a summer pelage that is slightly paler than *nanus*, being Drab Gray above, and Smoke Gray tinged with buff below. Winter pelage is noticeably lighter, Pale Drab dorsally and Pale Smoke Gray to whitish ventrally. An adult female collected in mid-July was molting from winter to summer pelage, while an adult male collected one day earlier had not commenced molting (Jackson, 1928). This relatively late molt may be correlated with late reproduction (see below); the fall molt probably occurs in October.

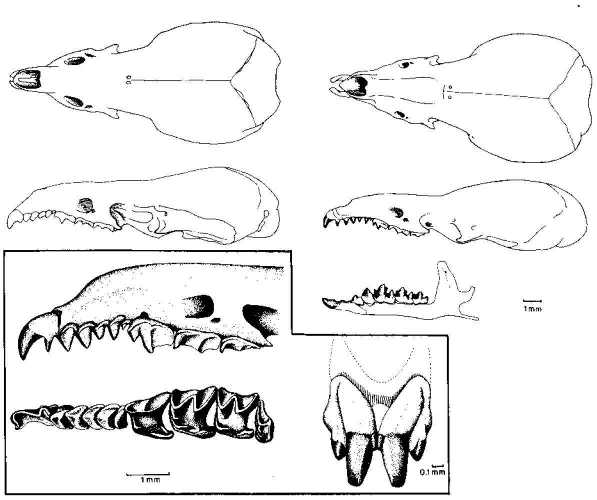

FIGURE 1. Skulls and teeth of *Sorex tenellus* (MVZ 86842, male, from Rainbow Falls, Kyle Canyon, 8200 ft, Charleston Mountains, Clark Co., Nevada) and *Sorex nanus* (KU 91000, female, from North Fork Campground [=W slope, Corner Mt.], T16N, R78W, sec. 28, 8500 ft, Medicine Bow Mountains, Albany Co., Wyoming). Left, dorsal (upper) and lateral (lower) views of *S. tenellus*; right, dorsal and lateral views of *S. nanus* (all except mandible from Hall and Kelson, 1959, by permission of authors). Inset: left upper, lateral view of rostrum and toothrow; left lower, occlusal view of toothrow; right, frontal view of first upper incisors; all of *S. nanus* (KU 91000).

DISTRIBUTION. Both species are primarily montane in distribution, but descend to at least 4500 to 5500 ft (1400 to 1500 m) in the foothills of the Great Basin ranges and the Rocky Moun-

FIGURE 2. Subadult male dwarf shrew (*S. nanus*) immediately after removal from pitfall trap, Beartooth Plateau, Park Co., Wyoming (UMZ 13124; Pattie and Verbeek, 1967). Paper match in foreground provides scale. Photograph courtesy D. L. Pattie.

tains. Adjacent to the Black Hills, *S. nanus* may occur even lower (to 2400 ft). The known ranges of the species are plotted in Fig. 3 (based on Armstrong, 1972; Armstrong et al., 1973; Bradshaw, 1961; Brown, 1967; Burt, 1934; Cinq-mars et al., 1979; Clothier, 1957; Durrant and Lee, 1955; Findley, 1965; Findley and Baker, 1956; Findley and Poorbaugh, 1957; Findley et al., 1975; Hall, 1946; Hemphill, 1942; Hoffmann and Taber, 1960*a*; Hoffmeister, 1955; Jones, 1961; Jorgensen and Hayward, 1963; Koster and Clothier, 1952; Marshall and Weisenberger, 1971; Martin, 1971; Merriam, 1902; Mickey, 1948; Ruffner and Carothers, 1975; Schellbach, 1948; Spencer, 1975; Spencer and Pettus, 1966; Stewart, 1979; Thompson, 1977; Von Bloeker, 1944; V. E. Diersing, in litt.; R. B. Finley, Jr., in litt.). Fort Custer, Montana, 3000 ft, is indicated by a question mark; a specimen of *S. nanus* was reported by Merriam (1895) from there, but cannot be found (Jackson, 1928), and the record may be in error (Hoffmann and Taber, 1960*a*). However, in view of the scarcity of specimens, except where pitfall traps have been employed (see below), it is likely that the species will be found in other parts of the Rocky Mountains, Colorado Plateau, Great Basin and northern Great Plains. Diersing (in litt.) has found that specimens of *S. tenellus* from southern Nevada are much like *S. nanus* from the Kaibab Plateau of northern Arizona, and this latter population is morphologically variable, some specimens clustering with reference samples of *tenellus*, and others with *nanus*. If shrews of this species group are found in southeastern Nevada, and southwestern Utah or northwestern Arizona, it may be possible to determine whether or not intergradation between the two nominal species occurs.

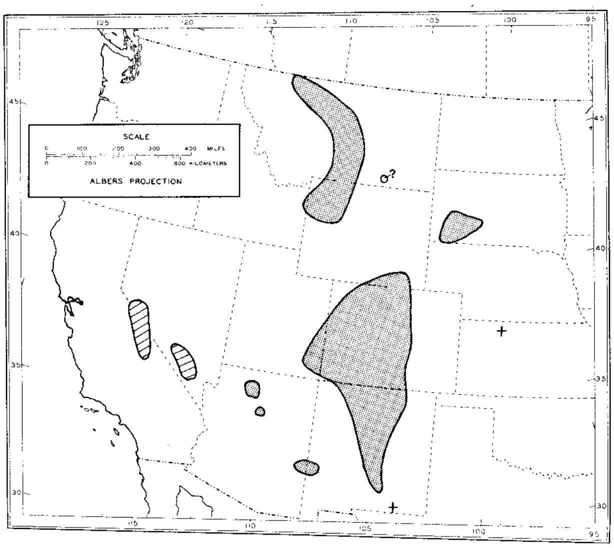

FIGURE 3. Distribution of the allospecies *S. tenellus* (crosshatch) and *S. nanus* (light stipple). Crosses indicate fossil and subfossil localities.

FOSSIL RECORD. The only unequivocal fossils of *S. nanus* are from "pre-Basketmaker levels" in Hermit Cave, Guadalupe Mountains, New Mexico (Fig. 3) and are probably late Pleistocene or early Holocene in age (Findley, 1965). The species is not known to occur in this area at the present time, nor is *S. monticolus* (=*vagrans*; Hennings and Hoffmann, 1977), with which it was associated. Comparison of the fossil *S. nanus* with recent specimens from Montana and New Mexico indicated no significant mensural differences (Findley, 1965). Stewart (1979) also assigned a single femur in the Trapshoot local fauna, western Kansas, to *S. nanus*. This fauna is probably late Pleistocene in age, and contains a number of other Rocky Mountain elements, such as *Clethrionomys gapperi*, *Phenacomys intermedius*, and *Microtus montanus*. No fossils of *S. tenellus* have been reported.

Findley (1955) postulated that during the Illinoian glaciation, shrews ancestral to *S. tenellus* and *S. nanus* dispersed into mountainous regions of California, Nevada, Arizona, New Mexico, and the Black Hills. During the relatively warm and dry Sangamonian interglacial that followed the Illinoian, this ancestral stock became isolated and gave rise to *S. ornatus*, *S. tenellus* and *S. nanus*. Findley (1955) suggested that *S. nanus* ". . . remained in these general areas during the Wisconsin age . . ." and that ". . . its present range is peripheral to the main body of the Rockies and the Colorado Plateau." Hoffmann and Taber (1966*a*) noted that specimens from Montana and Wyoming indicate a Recent distribution of *S. nanus* in areas which were under the Cordilleran ice sheets and pointed out that ". . . the localities of occurrence of *S. nanus* in Arizona and Utah, at Grand Canyon National Park and San Juan County, respectively . . . are well within the Colorado Plateau as it is defined by geologists . . . ."

Thompson (1977) hypothesized that *S. nanus* evolved in areas peripheral to Cordilleran glaciers. Considerable rubble and rocky tundra occurred in the northern Great Plains during the interstadial between the first and second glacial advances of the Wisconsin, and Thompson suggested that ancestral *S. nanus* radiated into this periglacial habitat and became adapted to it. Thompson (1977) noted that as post-Wisconsin climatic changes caused the retreat of coniferous forests from the northern Great Plains, the development of prairie soils rendered most of the northern plains unsuitable for *S. nanus*, except for uplifted areas where rubble slopes and coniferous forests persisted. *S. nanus* now endures as relatively small and disjunct populations where suitable islands of habitat remain.

Sorex tenellus may also have evolved in a periglacial environment of the montane glaciers covering the southern Sierra Nevada during the Wisconsin, and has also apparently adapted to more arid and hotter foothills habitats (Jorgensen and Hayward, 1963) than has *S. nanus*.

FORM AND FUNCTION. The rostrum and dentition of *S. nanus* and the cranium of *S. tenellus* were first described and figured by Merriam (1895). The skull of *S. tenellus* is slightly larger and more robust than that of *S. nanus*, but both species have slender, markedly flattened skulls compared to *S. ornatus*. The postcranial skeleton has not been described. These two shrews are among the smallest members of the genus *Sorex*, which distinction they share with *S. preblei* (condylobasal length of skull, 13.8–14.6 mm; Hoffmann et al., 1969) and the Palearctic *S. minutissimus* (condylobasal length of skull, 12.0–14.3 mm; Yudin, 1971). Some populations of *Microsorex* (Long, 1972, 1974) also approach what is probably a lower limit to the size of mammals (Pearson, 1948; Tracy, 1977).

There appear to be no physiological studies of these two species, and only Spencer and Pettus (1966) have maintained *S. nanus* in captivity. Functional parameters are probably similar to those of other small *Sorex* and *Microsorex* (see Buckner, 1964; Wunder, 1975).

ONTOGENY AND REPRODUCTION. No data on ontogeny have been recorded for either species, and nothing is known of reproduction in *S. tenellus*. Based on limited unpublished data from pitfall-trapped *S. nanus*, breeding probably began in the alpine zone in late June to early July, after snowmelt. First litters were produced in late July to early August, and postpartum estrus appeared common; of five lactating adult females, four were also pregnant. These second litters were then born in late August to early September, about a month before the alpine snowpack begins to accumulate. There is no evidence that juvenile females reproduce in their first summer of life, in contrast to sympatric alpine populations of *S. monticolus* (unpublished data). Embryo counts numbered 6, 6, 6, and 8 (average 6.5) for second litters of adults. This is somewhat less than found in sympatric *S. monticolus* in the Montana alpine (average 8.0), but greater than for *monticolus* in subalpine forest in Colorado (average 5.6) (Vaughan, 1969). Early litters, and those of juvenile females, are likely to differ in size, and breeding phenology may also be modified at lower elevations.

The male breeding season appears to be extended, as adults in breeding condition have been captured throughout July and August on the Beartooth Plateau (unpublished data). How early in the spring adult males come into breeding condition is unknown. Two adult males from low elevation grassland were in breeding condition by 13–16 June (Cinq-Mars et al., 1979). There is also some indication that juvenile males in Colorado may attain reproductive maturity late in the summer of their birth (unpublished data).

ECOLOGY AND BEHAVIOR. Mammalogists have long considered the dwarf shrews to be rare species. From 1895, the year of capture of the holotype, until 1966, *S. nanus* was known from reports of only 18 specimens, and during that same period, only 21 specimens of *S. tenellus* were reported. However, this rarity may be more apparent than real. During a four-year study of the boreal chorus frog, *Pseudacris triseriata*, Spencer and Pettus (1966) collected 23 or 24 *S. nanus* in the mountains of western Larimer County, Colorado. They used sunken one-gallon paint cans, as pitfall traps, with short drift fences extending from the cans. Brown (1967) also employed pitfall traps to capture dwarf shrews in the Medicine Bow Mountains of Wyoming. He collected 25 specimens from a subalpine rockslide, 21 from an alpine rockslide and two from alpine tundra. Brown (1967) compared the relative efficiency of conventional snap traps and pitfall traps in a spruce-fir bog and subalpine rockslide. For 12 days, comprising 300 trap-nights, a snap trap was placed adjacent to a pitfall trap. No *S. nanus* were taken from the spruce-fir bog in either type of trap, but in the subalpine rockslide six dwarf shrews were collected from the pitfall traps and none from the snap traps. Hoffmann and coworkers also captured a considerable number of dwarf shrews in pitfall traps in the alpine tundra of the Beartooth Plateau, on the Montana-Wyoming border (Hoffmann and Taber, 1960*b*; Hoffmann and Pattie, 1968). In his study of *S. nanus* in north-central Montana, Thompson (1977) also set snap traps near pitfall traps; all of the dwarf shrews collected were taken from pitfall traps. By far the largest number of *S. nanus* taken in pitfall traps were reported by Armstrong et al. (1973). A series of pitfalls, set in altitudinal transects ranging from 1630 to 3080 m (5300 to nearly 10,000 ft), captured a total of 81 *S. nanus* in the course of two years. Other shrews taken in the same pitfall traps included *S. cinereus*, *S. monticolus*, *S. merriami*, and *Notiosorex crawfordi*. Dwarf shrews were caught between 1850 and 3015 m. Thus, dwarf shrews seem to escape snap traps, giving the appearance of being absent from habitat in which they may regularly occur. Rates of capture per pitfall trap (Armstrong et al., 1973) indicate that they may sometimes be common.

The ecological distribution of dwarf shrews is poorly known. *Sorex nanus* has been most often reported from rocky habitats in the alpine tundra and subalpine coniferous forest. Other habitats from which it has been reported include sedge marsh, dry brushy slopes where *S. merriami* also was collected (Spencer and Pettus, 1966), grass, and roadside ditch swale (Martin, 1971; Cinq-mars et al., 1979), over an altitudinal range of at least 740 to 3350 m. The species seems to be tolerant of a wide variety of ecological conditions. Some specimens from non-montane areas such as the shrew found dead in a dry stubble field (Findley and Baker, 1956), may be accidental, but the species does occur in arid shortgrass prairie (Cinq-Mars et al. 1979).

Dwarf shrews are often collected in relatively arid habitats. All of those taken by Brown (1967) were in dry situations, while the specimen reported by Clothier (1957) was collected over one-half mile from the nearest water (an enclosed spring). Spencer and Pettus (1966) found that they occurred at a greater mean distance from permanent water than *Microsorex hoyi*, *S. cinereus*, or *S. monticolus*. *S. nanus* thus appears to be more tolerant of dry situations than many of its congeners. *Sorex tenellus* probably shares this tolerance, which may account for its occurrence in the arid mountain ranges of the southern Great Basin (Hemphill, 1942; Jorgensen and Hayward, 1963). However, they are probably most common in rocky habitats in subalpine coniferous forest. Burt (1934) found the species "common along the small streams at altitudes of 8000 feet or above" in the Charleston Mountains. He captured a series of 13 specimens from the three localities with snap traps (in contrast to the usual situation for *S. nanus*), six males and seven females. Of these, seven came from 275 trap-nights in one place, the bottom of Kyle Canyon, at 10,000 ft (3077 m). However, subsequent efforts by others to capture dwarf shrews in the same area were less successful, only one specimen being obtained (Hall, 1946). *Sorex tenellus*, like *S. nanus*, probably also occurs in the alpine zone; Bole (1938) reported evidence of its occurrence on the summit of White Mountain Peak, at 14,240 ft (4380 m).

Spencer and Pettus (1966) noted a yearly cyclic population fluctuation for *S. cinereus* and *S. monticolus*, but nor for either *S. nanus* or *M. hoyi*. Spencer and Pettus also observed that a decline in density of *S. cinereus* and *S. monticolus* did not stimulate an increase in density of either *S. nanus* or *M. hoyi*, and interpreted this as indicating that there was little competitive interaction between the pairs of species.

Spencer and Pettus (1966) cited a number of terrestrial vertebrates present on their study plot and observed that captive dwarf shrews fed on the carcasses of many of them. They refused slugs, however, and seemed to prefer soft-bodied spiders and insects. Spencer and Pettus (1966) also observed that captive dwarf shrews would cache extra prey, piling the unused food up in the corners of their cages.

The only reported instance of predation upon dwarf shrews was a mandible recovered from barn own pellets (Martin, 1971).

REMARKS. Hoffmeister (1967) reported on specimens of *S. nanus* found under unusual circumstances. Five dwarf shrews along with 23 *S. merriami* and three *S. monticolus* were positively identified from remains in a three-gallon pottery jar, buried on the floor of room 71 of Mug House, Wetherill Mesa, Mesa Verde National Park, Colorado. These shrews were identified from skeletal elements of about 100 *Sorex* found in the jar, and it was determined that the shrews were very unlikely to have gotten into the jar by natural means. Hoffmeister, believing the immediate vicinity to be unsuitable for these species, supposed that the shrews were captured in some other area by Indians and placed in the jar. However, Spencer (1975) subsequently obtained *S. nanus* in the area. Dr. Arthur H. Rohn suggested one possible reason for this odd collection; the shrew was a Zuni beast god, believed to protect stored grain from rodents (Hoffmeister, 1967).

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