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Sorex monticolus.

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Sorex monticolus Merriam, 1890

Montane Shrew

Sorex monticolus Merriam, 1890:43. Type locality "San Francisco Mtn., 11,500 ft., Cococino Co., Arizona."

Sorex dobsoni Merriam, 1891:33. Type locality "Alturas Lake, E base Sawtooth Mts., 7200 ft., Blaine Co., Idaho." *Nomen oblitum.*

Sorex vagrans similis Merriam, 1891:34. Type locality "near Timber Creek, 8200 ft., Salmon River Mts. [now Lemhi Mts.], Lemhi Co., Idaho." Name preoccupied by *Sorex similis* Hensel, 1855 = *Neomys similis.*

Sorex obscurus Merriam, 1895:72. New name for *S. vagrans similis* (Merriam, 1891).

Sorex bairdi Merriam, 1895:77. Type locality "Astoria, Oregon."

Sorex glacialis Merriam, 1900:16. Type locality "Point Gustavus, E side of entrance to Glacier Bay, Alaska."

Sorex durangae Jackson, 1928:127. Type locality "El Salto, Durango, Mexico."

Sorex melanogenys Hall, 1932:260. Type locality "Marijilda Canyon, 8600′, Graham Mts., Graham Co., Arizona."

CONTEXT AND CONTENT. Order Insectivora, Family Soricidae, Subfamily Soricinae, Tribe Soricini, Genus *Sorex*, Subgenus *Otisorex* (Findley, 1955; Repenning, 1967). Keys to the species of *Sorex* can be found in Junge and Hoffmann (1981) and Hennings and Hoffmann (1977). Eighteen subspecies are recognized by Hennings and Hoffmann (1977):

S. m. alascensis Merriam, 1895:76. Type locality "Yakutat, Alaska." Includes *glacialis* Merriam, 1900 (see above).

S. m. bairdi Merriam, 1895:77. See above.

S. m. calvertensis Cowan, 1941:103. Type locality "Safety Cove, Calvert Island, British Columbia."

S. m. elassodon Osgood, 1901:35. Type locality "Cumshewa Inlet, Moresby Island, Queen Charlotte Islands, British Columbia."

S. m. insularis Cowan, 1941:103. Type locality "Smythe Island, Bardswell Group, British Columbia."

S. m. isolatus Jackson, 1922:263. Type locality "Millstone Creek, Nanaimo, Vancouver Island, British Columbia."

S. m. longicauda Merriam, 1895:74. Type locality "Wrangell, Alaska."

S. m. malitiosus Jackson, 1919:23. Type locality "E side of Warren Island, Alaska."

S. m. mixtus Hall, 1938:462. Type locality "Vanada, Texada Island, Georgia Strait, British Columbia."

S. m. monticolus Merriam, 1890:43. Includes *melanogenys* Hall, 1932 (see above).

S. m. neomexicanus Bailey, 1913:133. Type locality "Cloudcroft, 9,000 ft., Sacramento Mts., Otero Co., New Mexico."

S. m. obscurus Merriam, 1891:34. See above. Includes *longiquus* Findley, 1955 and *obscuroides* Findley, 1955.

S. m. parvidens Jackson, 1921:161. Type locality "Thurmans Camp, Bluff Lake, about 7,500 ft., San Bernardino Mts., California."

S. m. permiliensis Jackson, 1918:128. Type locality "Permilia Lake, W base Mt. Jefferson, Cascade Range, Marion Co., Oregon."

S. m. prevostensis Osgood, 1901:35. Type locality "N end Prevost Island (Kunghit Island on some maps), off coast of Houston Stewart Channel, Queen Charlotte Islands, British Columbia."

S. m. setosus Elliot, 1899:274. Type locality "Happy Lake, Olympic Mts., Clallam Co., Washington."

S. m. shumaginensis Merriam, 1900:18. Type locality "Popof Island, Shumagin Islands, Alaska."

S. m. soperi Anderson and Rand, 1945:47. Type locality "2 and a half miles NW Lake Audy, Riding Mtn. National Park, Manitoba."

DIAGNOSIS. *Sorex monticolus* traditionally has been included in the *Sorex vagrans–obscurus* group. *Sorex monticolus* is most closely related to *S. pacificus*, and *S. vagrans* forms a sister taxon to these two species (George, 1988). *Sorex pacificus* is larger and generally has no medial tines on the upper incisors. *Sorex monticolus* differs from *S. vagrans* in structure and pigmentation of the upper incisor teeth, cranial dimensions, and by the number of digital callosities on the feet. In *S. monticolus*, the medial tines of the upper incisors typically are large and situated well below the upper limit of the red pigment of the incisors. In *S. vagrans*, typically the tines are small, and located above the upper limit of the pigment (Hennings and Hoffmann, 1977; Junge and Hoffmann, 1981). The teeth of *S. monticolus* are more robust, harder, and more brittle than those of *S. vagrans* (Hawes, 1975).

Trivariate analysis of condylobasal lengths, palatal lengths, and least interorbital breadths of *S. v. vagrans* and *S. m. obscurus* revealed little overlap between the two species in samples from the northern Rocky Mountains and Columbia Plateau regions (Hennings and Hoffmann, 1977). Condylobasal length in *S. m. obscurus* ranged from 16.1 to 17.7 mm, with sample means varying from 16.7 to 17.1 mm. In comparison, condylobasal length in *S. v. vagrans* ranged from 15.5 to 17.5 mm with sample means varying from 16.2 to 16.9 mm. In *S. m. obscurus* palatal length was generally >7.0 mm. Palatal length in *S. v. vagrans* ranged from 6.1 to 7.3 mm, but was <7.0 mm in 80% of the specimens. Interorbital breadth in *S. m. obscurus* was generally >3.2 mm, whereas in *S. v. vagrans*, it was generally <3.2 mm (Hennings and Hoffmann, 1977). Multivariate analysis of 14 cranial measurements from samples of *S. monticolus* and *S. vagrans* collected in an area of sympatry in southwestern British Columbia unequivocally discriminate between the species. Two variables that provide unambiguous separation are widths across U4–U4 and M2–M2 (George and Smith, 1991).

Compared with *S. vagrans*, the toes of *S. monticolus* are relatively longer and possess a greater number of small paired digital callosities or friction pads. In *S. monticolus* there are five or six paired friction pads on the second to fourth digits, whereas there are four or fewer in *S. vagrans*. This character is more evident on the hind feet (van Zyll de Jong, 1982).

Sorex monticolus can be distinguished from other sympatric soricids such as *S. arizonae*, *S. arcticus*, *S. cinereus*, and *S. tundrensis* by the relative size of U3 and U4. The U3 is smaller than U4 in *S. monticolus*, whereas U3 is larger than U4 in the other three species (Junge and Hoffmann, 1981).

GENERAL CHARACTERS. *Sorex monticolus* is a small to medium-sized long-tailed shrew (Fig. 1). In the upper jaw there is one incisor with two cusps, five unicuspidate teeth, and four molariform teeth; the lower jaw possesses one incisor, two unicuspidate teeth, and three molariform teeth. A dark reddish-brown pigmented ridge runs from the apex to the cingulum on the lingual face of the teeth (Junge and Hoffmann, 1981). Medial tines on the upper incisors of *S. monticolus* (and *S. bairdii* and *S. preblei*) are relatively long and acutely pointed compared to *S. pacificus*, *S. bendirii*, *S. palustris*, *S. trowbridgii*, and *S. vagrans*. Angle of the median tine varies from 15–20° in *S. m. alascensis*, and is 15° in *S. m. setosus* (Carraway and Verts, 1994). The U3 usually is distinctly smaller than U4, and unicuspids are appressed posteriorly (Fig. 2). The cranium is relatively inflated compared with *S. ornatus* (Junge and Hoffmann, 1981).

In general, dorsal pelage varies from a dusky brown to gray, ventral pelage is silvery white to gray, and the tail is bicolored

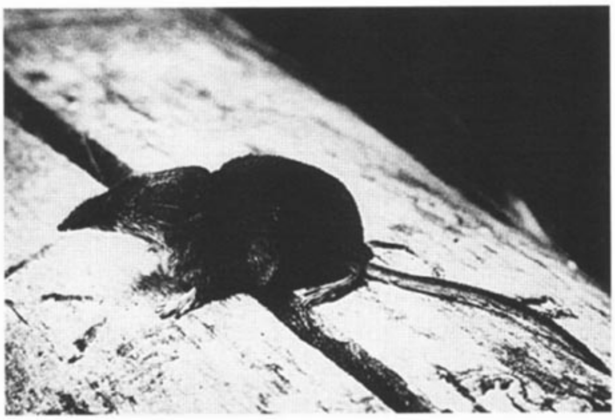

FIG. 1. Adult *Sorex monticolus* photographed near Mt. Timpanogas, 2400 m elevation, Utah Co., Utah. Photograph by M. C. Belk.

without a black tip. Molting occurs twice per year. Juveniles obtain winter pelage during September or October. Timing of molt in spring differs between sexes; females molt from late March to early April, whereas males molt from late May to early August (van Zyll de Jong, 1983). There are clines in body size and intensity of pelage pigmentation, especially among populations in coastal mountain ranges (Findley, 1955). Among eight populations of *S. m. obscurus* from different mountain ranges (*n* ranging from 3 to 66 per population), total length varied from 86 to 128 mm and mean total length varied from 100 to 112 mm (Hennings and Hoffmann, 1977). Among four intermountain populations of *S. m. obscurus* (*n* ranging from 7 to 50), condylobasal length ranged from 16.1 to 17.7 mm, and means varied from 16.7 to 17.1 mm; least interorbital breadth ranged from 3.0 to 3.6 mm, and means varied from 3.3 to 3.4 mm; palatal length ranged from 6.7 to 7.7 mm, and means varied from 7.1 to 7.3 mm (Hennings and Hoffmann, 1977). Mean adult male mass was 7.2 g in riparian habitats ($SE = 0.33$, $n = 100$), and 7.0 g in upland habitats ($SE = 0.27$, $n = 34$) in samples collected near Blue River, Oregon (Doyle, 1990). Mean male mass of 6.9 g ($SE = 0.2$, $n = 3$) and female mass of 5.9 g (from one individual) was reported by Innes (1994). Mean body mass was 5.5 g ($n = 10$) in a sample collected in the Sierra Nevada of California (Churchfield, 1994). Among samples representing 13 subspecies of *S. monticolus* (*n* ranging from 2 to 8 per population), range of mean total length was 103–136 mm (range of individual measurements, 103–142 mm), range of mean length of tail vertebrae was 46–59 mm (range of individual measurements, 40–62 mm), and range of mean hind foot length was 12–15 mm (range of individual measurements, 12–16 mm—Jackson, 1928).

DISTRIBUTION. *Sorex monticolus* is found from northern Alaska to northern Mexico, from the Pacific coast eastward into the boreal taiga and northern Great Plains at least to north-central Manitoba (Wrigley et al., 1979). *S. monticolus* occurs in the coastal ranges of Washington and Oregon, along the Rocky Mountains into the Columbia Plateau, farther south in the mountains of Utah, Nevada, and Colorado, and in isolated mountain ranges in eastern Arizona, south-central and western New Mexico, northwestern Mexico, and southern California (Fig. 3; Hennings and Hoffmann, 1977).

FOSSIL RECORD. The small size of shrew bones and teeth causes them to be easily overlooked; thus their fossil record is relatively incomplete compared to the fossil record of larger mammals. The earliest known shrew from North America, genus *Domnina*, was recovered from late Eocene deposits (Krishtalka and Setoguchi, 1977), and a variety of shrew species have been identified from late Eocene and Oligocene deposits onward (Engesser, 1979). Fossil remains of *S. monticolus* were collected from Moonshiner and Middle Butte Caves in Idaho (Holocene; Mullican and Carraway, 1990), and from False Cougar and Shield Trap Caves in south-central Montana (late Pleistocene and Holocene; Bonnichsen et al., 1986). However, paleontologists generally have not distinguished between *S. monticolus*, *S. pacificus*, and *S. vagrans* when identifying fossil remains (George, 1988); other *S. monticolus* fossil remains may be identified upon closer examination of specimens.

FIG. 2. Dorsal, ventral, and lateral views of the cranium and lateral view of mandible of female *Sorex monticolus obscurus* from San Juan Co., Utah. Occipitonasal length of skull is 17.8 mm. Specimen deposited in the Monte L. Bean Life Science Museum, Brigham Young University, catalog number 11686. Photograph by M. C. Belk.

FORM AND FUNCTION. Shrews of the genus *Sorex* commonly have dermal glands on their sides (Jackson, 1928). Histologically, the glands of *S. monticolus* probably are a mixture of highly vascularized sweat tubules and large sebaceous glands (Hawes, 1976). Sweat glands may be responsible for production of odor, whereas oily secretions of sebaceous tubules may function to trap odor (Dryden and Conaway, 1967). The strong correlation between growth of testes and development of side glands suggests a reproductive role for the odor emitted. Male side glands enlarge considerably at the onset of reproductive maturity, whereas these glands appear not to change in breeding females. Male pheromones may attract females in estrus (Hawes, 1976). The odor of breeding *S. monticolus* is pungent and acrid, whereas that of breeding *S. vagrans* males is musky (Hawes, 1976).

Relative bite force of two subspecies of *S. monticolus* is less than expected based on average condylobasal length, likely a result of a less-than-expected coronoid-condyloid length. The lesser relative bite force correlates with a diet of predominantly soft-bodied prey (Carraway and Verts, 1994).

ONTOGENY AND REPRODUCTION. The life history of *Sorex monticolus* is similar to that of other closely related species (Hawes, 1977; Johnston and Rudd, 1957). Males show signs of reproductive activity by mid-winter corresponding with a 50% increase in body size, whereas females become sexually receptive in March. The precise timing of reproduction varies with locality. Young are born throughout spring and summer and are weaned within three weeks (Hawes, 1977; Hoffmeister, 1986).

Females exhibit postpartum estrus and may have three or four litters. The embryo count for second litters was higher in the Montana alpine forest ($\bar{x} = 8.0$) than in the subalpine forest of Colorado

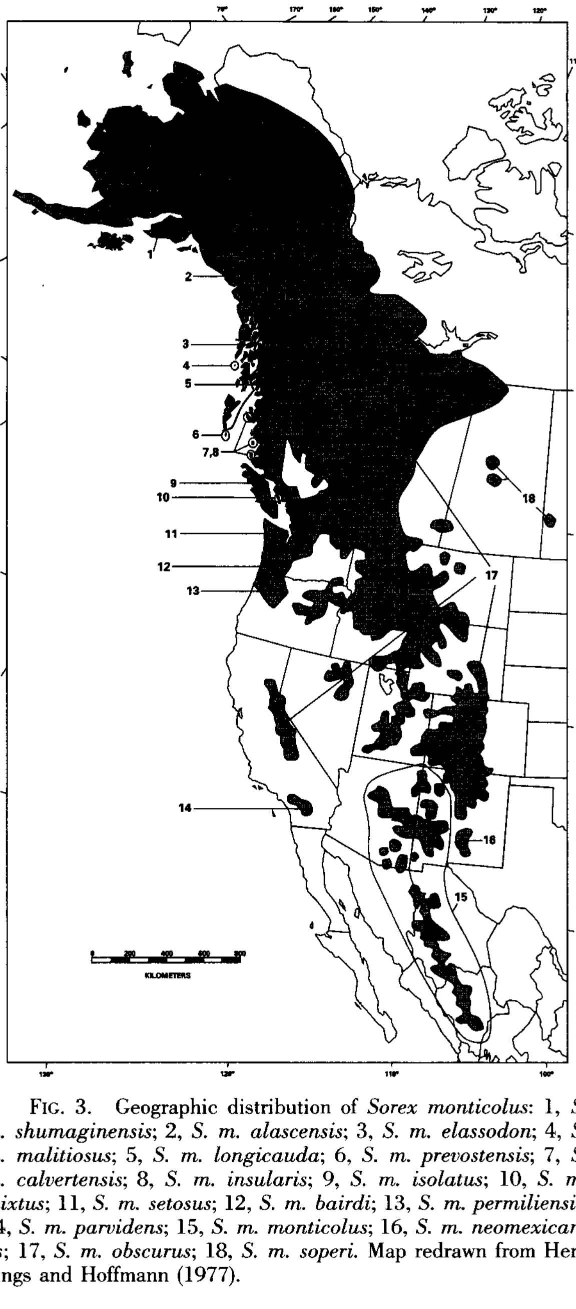

FIG. 3. Geographic distribution of *Sorex monticolus*: 1, *S. m. shumaginensis*; 2, *S. m. alascensis*; 3, *S. m. elassodon*; 4, *S. m. malitiosus*; 5, *S. m. longicauda*; 6, *S. m. prevostensis*; 7, *S. m. calvertensis*; 8, *S. m. insularis*; 9, *S. m. isolatus*; 10, *S. m. mixtus*; 11, *S. m. setosus*; 12, *S. m. bairdi*; 13, *S. m. permiliensis*; 14, *S. m. parvidens*; 15, *S. m. monticolus*; 16, *S. m. neomexicanus*; 17, *S. m. obscurus*; 18, *S. m. soperi*. Map redrawn from Hennings and Hoffmann (1977).

($\bar{x}$ = 5.6—Vaughan, 1969). Three pregnant females collected in April and May in the White Mountains of Arizona had two, six, and seven embryos. Crown–rump lengths of these embryos were 5 mm (24 April), 2 mm (29 April), and 11 mm (19 May), respectively. Four of five females collected on 24 April were not pregnant, and three females taken on 29 and 30 August, and 1 September were lactating. Occurrence of lactation late in summer suggests two breeding periods in this White Mountain population (Hoffmeister, 1986). Litter size is reported as 6.4 ± 1.1 by Innes (1994). Life expectancy of this species is about 16 months. There is a yearly population turnover because the adult, breeding generation virtually disappears by autumn, and young of the year overwinter and reproduce in spring (Hawes, 1977; Hoffman and Owen, 1980).

ECOLOGY AND BEHAVIOR. The montane shrew occurs in a variety of montane and boreal habitats (Hennings and Hoffmann, 1977), with dense understory ground cover being the main component of suitable microhabitat (Belk et al., 1990; Doyle, 1990; Gunther et al., 1983; Hawes, 1977; Ingles, 1965; Reichel, 1986; Terry, 1981). *Sorex monticolus* typically inhabits the surface litter layer and seldom burrows. For this reason it is found more often in deadwood debris areas (Terry, 1981) and in clearcuts that have 85–90% herbaceous ground cover, than in heavily forested areas with less herbaceous cover (Doyle, 1990; Gunther et al., 1983).

In montane areas of central Utah, before herbaceous growth occurs in early summer, montane shrews use habitats with woody ground cover such as fallen logs and shrubs. During mid-summer, herbaceous growth covers the ground and shrews are found in all areas. By early autumn, montane shrews are restricted to patches of herbaceous growth that persist under canopies of aspen (*Populus tremuloides*) and Douglas fir (*Pseudotsuga menziesii*; Belk et al., 1990).

In the Cascade Range near Blue River, Oregon, *S. monticolus* is found in both riparian and upland areas. Dominant vegetation in riparian areas included Oregon oxalis (*Oxalis oregona*), western swordfern (*Polystichum munitum*), starry solomon plume (*Smilacina stellata*), trailing blackberry (*Rubus ursinus*), red huckleberry (*Vaccinium parvifolium*), California hazel (*Corylus cornuta*), bigleaf maple (*Acer macrophyllum*), vine maple (*Acer circinatum*), red alder (*Alnus rubra*), Douglas-fir (*Pseudotsuga menziesii*), and western hemlock (*Tsuga heterophylla*). In upland areas, dominant vegetation included twin flower (*Linnaea borealis*), bracken fern (*Pteridium aquilinum*), starry solomon plume, salal (*Gaultheria shallon*), Pacific rhododendron (*Rhododendron macrophyllum*), trailing blackberry, Oregon grape (*Berberis nervosa*), Douglas-fir, and western hemlock (Doyle, 1990). In central California, *S. monticolus* was the most abundant small mammal collected in an area dominated by red fir (*Abies magnifica*), lodgepole pine (*Pinus contorta*), Jeffrey pine (*Pinus jeffreyi*), and white fir (*Abies concolor*; Williams, 1984). In alpine areas of Washington and Oregon, *S. monticolus* was captured only in wet meadow and krummholz habitats. Wet meadows were characterized by dense herbaceous vegetation or sedges, and krummholz habitats were dominated by dwarfed conifers (Reichel, 1986).

Although the montane shrew has been found in both riparian and upland areas (Doyle, 1990; Egoscue, 1988), it is more commonly found in riparian zones (Doyle, 1990). All specimens collected from taiga forests of Manitoba were found within 100 m of watercourses (Wrigley et al., 1979). In southern British Columbia, *S. monticolus* was found predominantly on acidic soil types, whereas *S. vagrans* was found on more basic soils in the same study area (Hawes, 1977). In the Oregon Cascades, adult males weighed more, and more often were in breeding condition in riparian areas than in upland areas, whereas the number of juveniles and reproductively active females was greater in upland areas (Doyle, 1990).

Home range size of non-breeding *S. monticolus* in southern British Columbia averaged 1,227 m^2 (*SD* = 300 m^2), whereas home range size of breeding individuals was significantly larger, averaging 4,020 m^2 (*SD* = 1,200 m^2). Home range size of breeding individuals differed by sex with males having significantly larger breeding home ranges than females ($\bar{x}$ = 5,978 m^2, *SD* = 1,800 m^2; and $\bar{x}$ = 2,226 m^2, *SD* = 900 m^2; respectively). Females are likely to remain on their original home range during their entire life. After onset of breeding, males tend to abandon their original home range and wander widely. Density in autumn was about 12/ha during a year of relatively high abundance (Hawes, 1977). Slipp (1942) described a nest of a montane shrew as being a sphere of dried grass about the size of a man's fist.

Diet of the montane shrew consists of invertebrates, conifer seeds, fungi, and lichens, with invertebrates and conifer seeds comprising 77–99% based on relative frequency (Gunther et al., 1983). Soft-bodied invertebrates and insect larvae make up 58.8% of the diet by volume (Carraway and Verts, 1994). About 88% of prey consumed by *S. monticolus* are surface-dwelling, and about 65% of prey are 3–5 mm in body length. Maximum size of prey consumed is >30 mm (Churchfield, 1994).

Sorex monticolus has been captured using pitfall traps, Sherman live-traps, and Museum Special snap traps (Belk et al., 1990; West, 1985; Williams and Braun, 1983). There was no significant difference in the number of montane shrews captured in new and old models of Museum Special snap traps (West, 1985).

Use of echolocation has not been investigated in *S. monticolus*. However, a closely related species, *S. vagrans*, uses echolocation to locate suitable cover in unfamiliar areas (Buchler, 1976).

GENETICS. *Sorex monticolus* has a diploid number of 54 chromosomes. In *S. monticolus*, the two largest metacentric pairs of chromosomes are relatively equal in size, whereas they differ considerably in size in *S. vagrans* (Brown, 1974). The number of submetacentric autosomes is 4–5 in *S. m. setosus*, 2–4 in *S. m. bairdi*, and 0–1 in *S. m. permiliensis* (Brown, 1970). *Sorex monticolus* exhibited a mean heterozygosity of 0.03 and 19.23% polymorphism when scored using protein electrophoresis on 25 presumptive loci (n = 13—George, 1988).

REMARKS. The species name *monticolus* is from the Latin *mons* meaning mountain and *colere* meaning to inhabit (van Zyll de Jong, 1983). The montane shrew is named for its distribution in the Rocky Mountains of western North America. It is also known as the dusky shrew. *S. monticolus* and *S. vagrans* were considered conspecifics prior to 1977; thus, much of the information published prior to this date cannot be assigned to either species with certainty. We extend sincere thanks to the Honors and Zoology Departments of Brigham Young University for financial support.

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