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Sorex arcticus.

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Sorex arcticus Kerr, 1792

Arctic Shrew

Sorex arcticus Kerr, 1792:206. Type locality "settlement on Severn River, Hudson Bay" (= Fort Severn at mouth of Severn River, Ontario, Canada—Jackson, 1928).
Sorex richardsonii Bachman, 1837:383. Type locality "probably plains of Saskatchewan."
Sorex sphagnicola Coues, 1877:650. Type locality "Fort Liard, Mackenzie, Northwest Territories, Canada."
Sorex belli Merriam, 1892:25. *Nomen nudum.*

CONTENT AND CONTEXT. Order Insectivora, Superfamily Soricoidea, Family Soricidae, Subfamily Soricinae, Tribe Soricini (Repenning, 1967). Genus *Sorex*, Subgenus *Sorex* (Junge and Hoffmann, 1981). The genus *Sorex*, which contains 70 species (Hutterer, 1993), is found throughout the Holarctic. *Sorex arcticus* belongs to the *araneus-arcticus* species group, which includes eight species (Volobouev and Dutrillaux, 1991).

Three subspecies of *S. arcticus* are recognized (van Zyll de Jong, 1983*a*). Craniometric analysis by van Zyll de Jong (1983*b*) and subsequent karyotypic analysis by Volobouev and van Zyll de Jong (1988) suggest that *maritimensis* may represent a separate species; however, Hutterer (1993) retained *maritimensis* as a subspecies of *S. arcticus.*

S. a. arcticus Kerr 1792: 206, see above.
S. a. laricorum Jackson 1925: 127. Type locality "Elk River, Sherburne Co., Minnesota."
S. a. maritimensis Smith 1939: 244. Type locality "Wolfeville, Kings Co., Nova Scotia, Canada."

DIAGNOSIS. Throughout its range, *Sorex arcticus* is the only member of the subgenus *Sorex* and thus is distinguished by its well-developed postmandibular canals and lack of pigmented ridges on the unicuspids (Junge and Hoffmann, 1981). The third unicuspid is larger than the fourth, and there is no accessory tine on the anterior facet of the first upper incisor (Junge et al., 1983). The tricolored pelage of adults (Fig. 1) also distinguishes this shrew from other sympatric North American soricids. In *S. arcticus*, the light sides contrast strongly with the dark dorsum, especially in winter pelage. Young of the year in summer pelage are lighter in color and bicolored (Junge and Hoffmann, 1981). In northern Canada and Alaska, masked shrews (*Sorex cinereus*) may have distinctly lighter sides, but they are much smaller and do not possess postmandibular canals.

The range of *S. arcticus* overlaps that of the smoky shrew (*S. fumeus*) in Ontario and Quebec, and in portions of the Canadian maritime provinces of Nova Scotia and New Brunswick (Hall, 1981; van Zyll de Jong, 1983*a*). Pigmentation of the unicuspid ridges is weakly developed in *S. fumeus*, and a postmandibular foramen is sometimes present, at least on one side. However, *S. fumeus* lacks the lighter sides of *S. arcticus* and has a smaller skull (e.g., maxillary toothrow <6.6 mm, compared to >6.7 mm in *S. arcticus*–Junge and Hoffmann, 1981). Although the dimensions of the skull of *S. arcticus* average larger than those of *S. fumeus*, these two species are approximately the same size and overlap considerably in external measurements and weight.

GENERAL CHARACTERS. The arctic shrew is a medium-sized shrew. Adults possess a distinctive tri-colored pelage (Clough, 1963). The dorsum is very dark brown to black, sides are lighter brown, and underparts are grayish-brown. The tail is indistinctly bicolored, brown to brownish-black above and lighter below (van Zyll de Jong, 1983*a*).

Sexes are similar in size (Clough, 1963). The respective means (measurements in mm or g, ranges and sample sizes in parentheses) for males and females from Wisconsin were as follows: total length, 113.6 (100–121, n = 31) and 116.2 (105–124, n = 22); length of tail, 41.6 mm (37–45, n = 31) and 41.9 (36–45, n = 22); length of hind foot, 13.9 (12–15, n = 30) and 13.8 (13–15, n = 23); and body mass, 8.0 (6.0–12.3, n = 30) and 8.3 (5.3–13.5, n = 24). Adults of both sexes weighed more and had greater body length than younger individuals (Clough, 1963).

The skull of *S. arcticus* (Fig. 2) is typical of the genus. The dental formula for the genus *Sorex* is i 3/1, c 1/1, p 3/1, m 3/3, total 32 (Burt, 1957). The medial tine on the anterior face of I1 lies within the pigmented region, the palate is not unusually broad, and the third unicuspid (U3) usually is larger than the fourth (U4—Junge and Hoffmann, 1981). Cranial measurements of a sample from Wisconsin did not differ between the sexes (Clough, 1963). The respective means (measurements in mm, ranges and sample sizes in parentheses) for males and females from Wisconsin for six cranial measurements were as follows: condylobasal length, 19.4 (19.1–20.0, n = 17) and 19.4 (19.0–20.0, n = 16); cranial breadth, 9.3 (9.0–9.4, n = 17) and 9.2 (9.0–9.5, n = 16); cranial height, 6.0 (5.6–6.4, n = 18) and 6.0 (5.5–6.4, n = 17); interorbital breadth, 3.5 (3.0–3.7, n = 25) and 3.4 (3.2–3.7, n = 20); length of maxillary tooth row, 6.9 (6.7–7.9, n = 24) and 7.0 (6.7–7.5, n = 21); and palatal length, 8.4 (8.2–8.7, n = 24) and 8.4 (8.1–8.6, n = 20).

DISTRIBUTION. *Sorex arcticus* is largely limited in distribution to the region of boreal coniferous forests in North America (Fig. 3). The arctic shrew occupies an extensive area of Canada from the southern Yukon and MacKenzie valleys eastward to eastern Quebec and the Atlantic Maritime provinces, with a southern extension into the northern United States in eastern North and South Dakota, Wisconsin, Michigan, and Minnesota (Hall, 1981; Jannett and Huber, 1994; van Zyll de Jong, 1983*a*). Populations in the Maritimes are disjunct and subspecifically distinct (*S. a. maritimensis*). Within its distribution, *S. arcticus* occurs in a variety of habitats; however, populations generally are highest in non-forested areas such as marshes or grassy clearings in forests (Baird et al., 1983).

FOSSIL RECORD. *Sorex arcticus* is well known from Pleistocene deposits of the central and southern Appalachian Mountains, and from the Great Plains region (Fig. 3). The earliest records for *S. arcticus* are those at Hansen Bluff, Alamosa Co., Colorado, and Trout Cave, Pendleton Co., Virginia, which are Late Irvingtonian in age (690,000–900,000 years). Others are Late Wisconsinan (latest Rancholabrean—E. Anderson, in litt.). With the exception of late Pleistocene remains from Caverne de Saint-Elzéar de Bonaventure (LaSalle and Guilday, 1980), which is located on the south shore of the Gaspé Peninsula, Quebec, all known fossils of *S. arcticus*

FIG. 1. Illustration of an arctic shrew based on a museum specimen (SUVM 6871, adult female from Anoka Co., Minnesota. Collected 17 October 1976) and color plates of *S. arcticus* in Banford (1974) and van Zyll de Jong (1983*a*). Original by P. Kim Van Fleet.

FIG. 2. Dorsal, ventral, and lateral views of the cranium and lateral view of left ramus of *S. arcticus laricorum* (USNM 186844, adult female from Elk River, Minnesota. Collected 22 February 1886 by Vernon Bailey. Greatest length of skull = 19.60 mm). Photographs by DFS.

have been found well south of the maximum extent of the Wisconsinan glaciation. Sites in the United States yielding fossilized remains of *S. arcticus* include: Arkansas—Newton Co., Peccary Cave (Kurtén and Anderson, 1980); Colorado—Alamosa Co., Hansen Bluff (Rogers et al., 1985); Kansas—Meade Co., Mt. Scott (Hibbard, 1963); Missouri—Jefferson Co., Crankshaft (Pit) Cave (Parmalee et al., 1969); Oklahoma—Harper Co., Doby Springs (Stephens, 1960); Pennsylvania—Bedford Co., New Paris No. 4 (Guilday et al., 1964); York Co., Bootlegger Sink (Guilday et al., 1966); Tennessee—Overton Co., Robinson Cave (Guilday et al., 1969); Sullivan Co., Baker Bluff Cave (Guilday et al., 1978), Carrier Quarry (Kurtén and Anderson, 1980); Virginia—Bath Co., Clark's Cave (Guilday et al., 1977); Augusta Co., Natural Chimneys (Guilday, 1962); and West Virginia—Pendleton Co., Eagle (Eagle Rock) Cave (Guilday and Hamilton, 1973), Trout Cave (Kurtén and Anderson, 1980). These fossil remains indicate that during the Pleistocene, the range of *S. arcticus* extended considerably south of its present southern limits. With the possible exception of areas in Wisconsin, the current range of *S. arcticus* lies entirely within areas covered by continental ice sheets in the late Pleistocene.

FORM AND FUNCTION. The metabolism of *S. arcticus*

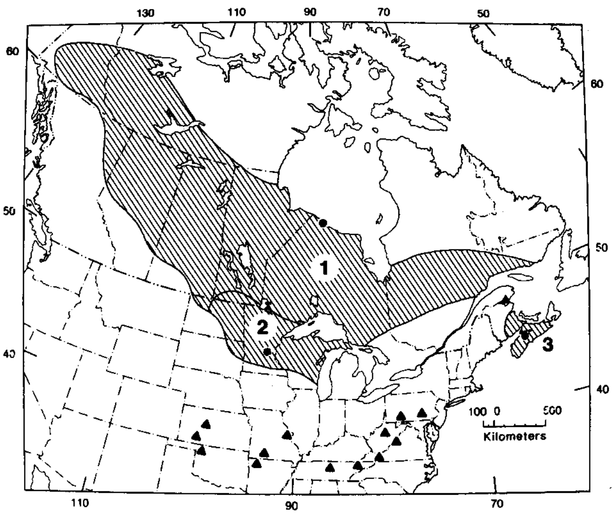

FIG. 3. Current distribution of *Sorex arcticus*: 1, *S. a. arcticus*; 2, *S. a. laricorum*; 3, *S. a. maritimensis*. Dots indicate the type localities for the three subspecies. Triangles indicate approximate locations of Pleistocene records of *S. arcticus*. Map by DFS.

appears to be intermediate between that of the smaller *S. cinereus* and the larger northern short-tailed shrew (*Blarina brevicauda*). Oxygen consumption of *S. arcticus* (n = 33, mean body mass = 5.4 g) averaged 10.9 ml g^{-1} h^{-1} (range = 7.5–19.7 ml g^{-1} h^{-1}—Buckner, 1964). This was lower than oxygen consumption of *S. cinereus* (n = 15, $\bar{x}$ body mass = 3.6 g, $\bar{x}$ oxygen consumption = 15.4 ml g^{-1} h^{-1}; range = 7.9–28.9 ml g^{-1} h^{-1}), but was higher than the rate for *B. brevicauda* (n = 11, $\bar{x}$ body mass = 20.1 g, $\bar{x}$ oxygen consumption = 4.6 ml g^{-1} h^{-1}; range = 4.2–5.4 ml g^{-1} h^{-1}). Average CO_2 production in *S. arcticus* was 8.8 ml g^{-1} h^{-1}, compared to 13.6 ml g^{-1} h^{-1} in *S. cinereus* and 3.6 ml g^{-1} h^{-1} in *B. brevicauda* (Buckner, 1964). Urinary nitrogen production in *S. arcticus* averaged 1.08 mg g^{-1} h^{-1}, compared to 0.87 mg g^{-1} h^{-1} in *S. cinereus* and 0.27 mg g^{-1} h^{-1} in *B. brevicauda* (Buckner, 1964). Estimated minimal daily metabolic rate in *S. arcticus* was 4.7 kcal per day, compared to 3.1 kcal per day in *S. cinereus* and 8.8 kcal per day in *B. brevicauda* (Buckner, 1964).

In feeding trials on larch sawflies (*Pristiphora erichsonii*), *S. arcticus* had an average assimilation efficiency of 88% (Buckner, 1964). Mean caloric value of stomach contents was 0.44 kcal (17 mg protein, 6 mg carbohydrate, and 12 mg fat). This represented 9.5% of the estimated total daily metabolic requirements, and meant that individuals would need to feed to near stomach capacity 11 times per day (Buckner, 1964).

ONTOGENY AND REPRODUCTION. The reproductive season in *S. arcticus* at the southern limits of its distribution in Wisconsin extends from February to August (Clough, 1963). All males collected from February through June had active testes (Clough, 1963). Further north (Minnesota) the season appears to be shorter, with the first reproductively active individuals being captured in April (Baird et al., 1983). Clough (1963) suggested that gestation and lactation periods in *S. arcticus* should be similar to those in the closely related European common shrew (*S. araneus*), which has a gestation between 13 and 21 days and a lactation period between 20 and 24 days.

Litter size in *S. arcticus* averaged 6.7 embryos (range = 4–9) in 35 pregnant females collected from throughout the range, as follows: Manitoba ($\bar{x}$ = 6.0, range = 5–8, n = 12—Buckner, 1966), Wisconsin ($\bar{x}$ = 6.6, range = 4–9, n = 9—Clough, 1963; Jackson, 1961), Minnesota ($\bar{x}$ = 7.7, range = 5–9, n = 12—Bailey, 1929; Baird et al., 1983), and Nova Scotia ($\bar{x}$ = 6.0, range = 5–7, n = 2—Smith, 1940). Corpora lutea counts for a sample of 15 nonpregnant females from Minnesota averaged 7.3 (range = 5–9), which approximated the mean number of embryos in 10 pregnant *S. arcticus* from that state (Baird et al., 1983).

Breeding by arctic shrews in southern Wisconsin occurs principally in individuals older than one year (Clough, 1963). Among 20 female *S. arcticus* that were marked and recaptured in southeastern Manitoba, nine bred once, four bred twice, and seven bred three times. Three (15%) bred in consecutive years (Buckner, 1966). This frequency of breeding in consecutive years by *S. arcticus* compared to 21% (13 of 61) in the masked shrew and 25% (1 of 4) in the northern short-tailed shrew from the same region (Buckner, 1966).

The conventional view that in *Sorex arcticus* tri-colored pelage represents winter pelage and dull brown pelage constitutes summer pelage is not supported by Clough (1963). In Wisconsin, he found that pelage coloration was influenced by age and season. Overwintered adults always exhibited the tri-colored pelage. Young of the year were dull brown in July, but between July and November, they had either dull brown pelage or the tri-colored pattern typical of adults. By November, all young had molted and exhibited tri-colored pelage. Clough (1963) concluded that young of the year molt from bicolor to tricolor adult pelage in the first autumn and maintain the adult pelage for the remainder of their lives.

ECOLOGY. *Sorex arcticus* is most abundant in moist, nonforested habitats. In Nova Scotia, preferred habitat is the edges of freshwater swamps and marshes, which are overgrown with tangles of grasses and rushes (Smith, 1940). In Minnesota, Bailey (1929) found *S. arcticus* to be fairly common in marshes surrounding rice lakes. Wrigley et al. (1979) noted that in Manitoba *S. arcticus* appeared to prefer the early terrestrial stages of the hydrosere. Of 167 specimens collected throughout that province, 78 were taken in grass-sedge marshes, 37 in willow-alder fens, and 23 in mesic-shrub habitats. Eighty percent of the sample was taken in hydric habitats, 19% in mesic, and only 1% in xeric habitats. However, Buckner (1966) reported that in Manitoba there was an inverse relationship between the abundance of arctic shrews and the depth of the water table, such that they were most abundant in sites with a deep water table (dry sites) and least abundant at sites with shallow water tables (wet sites).

In a study of small mammal communities in Quetico Provincial Park, Ontario, Nagorsen and Peterson (1981) failed to capture *S. arcticus* in four different forest habitats (upland conifer, upland mixed, lowland conifer, and lowland mixed) but did take them in wet meadows characterized by meadow-sweet (*Spirea alba*), speckled alder (*Alnus rugosa*), willow (*Salix* sp.), common cat-tail (*Typha latifolia*), water-dock (*Rumex orbiculatus*), and various graminoids. Other small mammals taken in association with *S. arcticus* included four other soricids (*Blarina brevicauda*; *Sorex cinereus*; water shrew, *S. palustris*; and pygmy shrew, *S. hoyi*) and six species of small rodents (deer mouse, *Peromyscus maniculatus*; southern red-backed vole, *Clethrionomys gapperi*; meadow vole, *Microtus pennsylvanicus*; heather vole, *Phenacomys intermedius*; southern bog lemming, *Synaptomys cooperi*; and meadow jumping mouse, *Zapus hudsonius*). With the exception of *Phenacomys* and *S. hoyi*, these same species, plus the ermine (*Mustela erminea*), eastern chipmunk (*Tamias striatus*), least chipmunk (*T. minimus*), and red squirrel (*Tamiasciurus hudsonicus*), were reported by Buckner (1964) as being taken in association with *S. arcticus* in tamarack bogs in southern Manitoba. In a long-term study conducted in a grass-sedge marsh in southern Wisconsin, Clough (1963) found *S. arcticus* associated with six other species of small mammals: *Sorex cinereus*, *Blarina brevicauda*, *S. hoyi*, *Microtus pennsylvanicus*, *Zapus hudsonius*, and house mouse (*Mus musculus*). In general, *Sorex cinereus*, *Microtus pennsylvanicus*, and *Blarina brevicauda* tend to be the most frequent ecological associates of *S. arcticus* throughout its range.

In a study of intraspecific spacing patterns in *S. cinereus* and *S. arcticus*, *S. arcticus* appeared to tolerate considerable home range overlap, whereas *S. cinereus* exhibited apparent intolerance of home range overlap. In the same study, increases in one species were usually accompanied by decreases in the other (Buckner, 1966). However, Clough (1963) found no indications of either positive or negative associations between *S. arcticus* and *S. cinereus* at trapping stations. Fluctuations in numbers of *S. arcticus* over 28 months appeared to be independent of and generally were of lower amplitude than those of *S. cinereus*.

The diet of 62 *S. arcticus* from southern Manitoba consisted almost exclusively of insects (Buckner, 1964). Towards the end of August, the proportion of larch sawfly in the diet increased rapidly to nearly 70% and remained at this level into November.

Nestling arctic shrews experience high mortality, estimated at 50% by Buckner (1966), during the first month of life. Approximately one-seventh of total generational mortality occurs during the first month after shrews leave the nest, and approximately 80% of the mortality of a cohort occurs before sexual maturity is reached. Nevertheless, individuals may live as long as 18 months (Buckner, 1966). The survivorship curve for *S. arcticus* in southern Manitoba mirrored that of *S. cinereus* in the same region (Buckner, 1966).

In southern Wisconsin, young of the year first appear in traps in July, and overwintered adults are not captured after July (Clough (1963). Thus, consecutive generations overlap by only one month each year. Clough (1963) noted that this contrasts with data from other *Sorex* in which adults have been taken much later in the year, and he suggested that *S. arcticus* may have a shorter life span than other members of the genus.

An estimated October density of 8.6/ha was reported by Clough (1960) for *S. arcticus* in marsh habitat near Madison, Wisconsin. This compares to estimates (depending upon method of calculation) of 4.1–5.1/ha in July and 7.3–7.8/ha in September for tamarack bogs in southeastern Manitoba (Buckner, 1957).

The following external parasites were reported by Whitaker and Pascal (1971) from *S. arcticus* (n = 18) from Pine Co., Minnesota: hypopial mite (*Labidophorus soricis*), larval tick (*Ixodes muris*), myobiid mites (*Protomyobia brevisetosus*, *Amorphacarus elongatus*), and laelapid mite (*Androlaelops fahrenholzi*). *Labidophorus soricis* was the most abundant ectoparasite, being too numerous to count on some shrews. *Ixodes murinus* was the second most abundant of the ectoparasites recovered. No ticks or lice were found on any shrews, and two shrews (11%) did not yield any ectoparasites (Whitaker and Pascal, 1971). Ectoparasites recovered from arctic shrews in northern Michigan included ixodid ticks (*Haemaphysalis leporispalustris* and *Ixodes murinus*), two ticks of the superfamily Parasitoidea (*Euhaemogamasus liponyssoides* and *Monyssus jamesoni*), two trombiculid mites (*Trombicula harperi* and *T.* [*Miyatrombicula*] sp.), a myobid mite (*Amorphacarus henegerorum*), a pyemotid mite (*Resinacaris* sp.), and a flea (*Corrodopsylla curvata*—Lawrence et al., 1965).

BEHAVIOR. *Sorex arcticus* is active throughout the 24-h day, but Clough (1963) found that it was least active between 0600 h and 1000 h. This concurs with the observations of Buckner (1964), who noted that daily activity in *S. arcticus* is characterized by alternating short bouts of activity and rest throughout the 24-h day. There were approximately 14 activity bouts daily, with activity greater at night (Buckner, 1964). Average daily activity in a sample of nine *S. arcticus* was 115 minutes (Buckner, 1964).

Sorex arcticus in Manitoba has been observed capturing the grasshopper *Melanoplus ferumrubrum* (Buckner, 1970). Grasshoppers were resting on stems and grasses early in the morning when two subadult arctic shrews attacked them by climbing slowly to a height of about 31 cm on adjacent stems (ca. 25 cm away). They then launched themselves at the grasshoppers, grasping the prey with their jaws and feet. Thirty-seven such attacks were observed in a 15-minute period, of which 33 (89%) were successful. This success was in part due to the low activity level of the grasshoppers at an air temperature of 6° C. The attacks diminished as the air temperature rose and the grasshoppers more actively avoided capture by jumping away upon approach. Legs and wings were not eaten. This hunting behavior indicated that arctic shrews apparently use vision during diurnal foraging.

GENETICS. *Sorex arcticus* has, like other members of *Sorex araneus-arcticus* species group, trivalent sex chromosomes (Volobouev and Dutrillaux, 1993). The three sex chromosomes in males are X, Y1, Y2. Females are XX. The presence of this unusual chromosomal arrangement supports the monophyletic origin of the *S. araneus-arcticus* species group (Volobouev and van Zyll de Jong, 1988). The diploid karyotype of the nominate subspecies includes 29 chromosomes in males and 28 in females; the fundamental number (FN) is 38 (Meylan, 1968; Meylan and Hausser, 1973). The karyotype of *S. a. maritimensis* has the same diploid complement as *S. a. arcticus*, but FN = 34 (Volobouev and van Zyll de Jong, 1988). This difference, coupled with craniometric differences between *S. a. arcticus* and *S. a. maritimensis* (van Zyll de Jong, 1983*b*), suggests the possibility of separate specific status for the latter.

REMARKS. *Sorex* is from the Latin *soric* meaning "shrewmouse," and *arcticus* is from the Greek arktikos, referring to north or "land of the bear" (Jaeger, 1955). Although arctic shrew is the accepted common name for *S. arcticus* (Jones et al., 1992), two additional common names that describe the appearance of this species are saddle-backed and black-backed shrew.

Sorex arcticus formerly included *S. tundrensis* (Junge et al., 1983), whose range lies to the north and west of *S. arcticus*, and may extend westward into the eastern Palearctic (Hutterer, 1993; Rausch and Rausch, 1993; Volobouev and Dutrillaux, 1991; Youngman, 1975). Palearctic populations formerly assigned to *S. arcticus* have been transferred to *S. tundrensis* (Junge et al., 1983).

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