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GORDON L. KIRKLAND, JR.[1] AND HOBART M. VAN DEUSEN[2]

ABSTRACT

The systematics and biology of the two shrews of the *Sorex dispar* group are described on the basis of a review of the literature and an examination of 247 museum specimens (224 *Sorex dispar* and 23 *S. gaspensis*). *Sorex gaspensis* is retained as a full species, and the subspecies boundary between *S.d. dispar* and *S.d. blitchi* is shifted northward to the region of the Pennsylvania/Maryland/West Virginia borders. Information is also presented on the distribution, clinal variation, habitat preference, ecological niche, food habits, and reproduction of the two species.

INTRODUCTION

The rock shrew, *Sorex dispar* Batchelder, and the Gaspé shrew, *Sorex gaspensis* Anthony and Goodwin, are two geographically limited and ecologically specialized North American soricids. The two shrews are restricted in distribution to the mountains of the Appalachian Mountains region and to the Gaspé Peninsula and Maritime Provinces of Canada (fig. 1). Within their geographic ranges, these shrews exhibit pronounced stenotopy with captures confined to a narrow spectrum of habitats, generally either talus slopes and other rocky sites or adjacent to cold mountain streams. As a result of their limited geographic and ecological distributions, relatively little is known of the systematics and biology of the two shrews of the *Sorex dispar* group.

This study of *Sorex dispar* and *S. gaspensis* is based on a thorough review of the literature and the examination of most specimens housed in North American mammal collections. The large number of specimens examined has permitted us to assess the taxonomic status of the Gaspé shrew and to re-evaluate the location of the subspecific boundary between *S.d. dispar* and *S.d. blitchi*. We also present information on the morphology, distribution, and ecology of the two species.

MEASUREMENTS

External measurements and localities of specimens examined were recorded from specimen labels. External measurements are in millimeters (mm.) and weight is in grams (gm.). Body length is equal to total length minus tail length. Skulls were measured by the first author with dial micrometers (calibration 0.05 mm.)

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under a dissecting microscope. Sixteen cranial measurements were taken for unbroken skulls and as many of these measurements as possible for broken skulls and rami. The 16 skull measurements are defined below and illustrated in figure 2.

Canine Width, distance between the lateral edges of the canines measured at the alveolar border.
Cheek Tooth Row, from posterior margin of M^3 to anterior margin of P^2 at alveolar border.
Condylobasal Length, from anterior edge of premaxillae to posteriormost projection of the occipital condyles.
Cranial Breadth, greatest lateral diameter of braincase.
Greatest Length, from anterior surface of incisors to posteriormost point on skull.
Incisor Width, distance between lateral edges of I^2 measured at alveolar border.
Interorbital Breadth, least distance between the orbits.
Mandible Height, vertical distance from base of mandible to tip of coronoid process.
Mandible Length I, distance from anterior tip of I_1 to posterior tip of condyle.
Mandible Length II, distance from anterior tip of I_1 to posterior tip of angular process.
Molar Width, distance between lateral edges of M^2 at posterior lateral margin of tooth.
Molariform Tooth Row, from posterior margin of M^3 to anterior margin of P^4 at alveolar border.
Nasal Length, from anteriormost point to posterior margin of nasal.
Palatal Length, greatest anterio-posterior measurement of the palate in the median line.
Post-palatal Length, distance from posterior margin of the palate to anterior border of the foramen magnum.
Total Tooth Row, from posterior margin of M^3 at alveolar border to anteriormost margin of I^1.

ABBREVIATIONS

Specimens of *S. dispar* and *S. gaspensis* from 22 institutions were examined in this study. Abbreviations preceding names of institutions are used in the accounts beyond to identify the source of specimens.

AMNH, American Museum of Natural History
ANSP, Academy of Natural Sciences of Philadelphia
CM, Carnegie Museum of Natural History
CU, Cornell University
JTW, J. Thomas Wampler (private collection)
KU, Museum of Natural History, University of Kansas
MCZ, Museum of Comparative Zoology, Harvard University
MM, Mohonk Museum
MVZ, Museum of Vertebrate Zoology, University of California, Berkeley
NCSU, North Carolina State University
NMC, National Museum of Natural Sciences, Ottawa
NSM, Nova Scotia Museum
NYSM, New York State Museum and Science Service
ROM, Royal Ontario Museum
RPMAG, Reading Public Museum and Art Gallery
SSC, Vertebrate Museum, Shippensburg State College
UCONN, Museum of Natural History, University of Connecticut
UMMZ, Museum of Zoology, University of Michigan
USNM, National Museum of Natural History, Smithsonian Institution, Washington, D.C.
WGFC, W.G. Frum (private collection)
WVMSC, West Virginia Mammal Society Collection, Marshall University
YPM, Peabody Museum, Yale University

STATISTICAL ANALYSES

To facilitate certain statistical analyses of morphological data, an *a priori* division of specimens into five groups was made. These groupings of specimens were based on one or more of the following criteria: (1) prior published taxon boundaries; (2) range disjunction; and (3) presence of a major geographic feature that might serve as an impediment to gene flow. The last criterion is consistent with the methodology in Whitaker's (1970) biological subspecies concept. The five groups are as follows: (1) *Sorex gaspensis*; (2) New England *Sorex dispar*; (3) Middle Atlantic states *S. dispar*; (4) *S. dispar* from West Virginia and Virginia; and (5) *S. d. blitchi* from Tennessee and North Carolina.

LITERATURE

The literature of *Sorex dispar* is characterized by scattered records of its occurrences and new state records (e.g., Mearns, 1898; Howell, 1911; Copeland, 1912; Kirk, 1916;

Harper, 1929; Green, 1930; Mohr, 1931; Poole, 1932; Mather, 1933; Lincoln, 1935; Osgood, 1935, 1938; Tate, 1935; Preble, 1937; Wilson and Friedel, 1942; Richmond and Roslund, 1949; Gardner, 1950; Grimm and Roberts, 1950; Gifford and Whitebread, 1951; Mc Keever, 1951; Roslund, 1951; Conaway and Pfitzer, 1952; Grimm and Whitebread, 1952; Mansueti and Flyger, 1952; Roberts and Early, 1952; Conaway and Howell, 1953; Starrett, 1954; Davis, 1956; Handley, 1956; Holloway, 1957; Paradiso, 1960; Linzey and Linzey, 1971; Lowman, 1975). Taxonomic assessments have been limited to those of Jackson (1928) and Schwartz (1956), and these were based on the examination of a small number of specimens. The only major ecological study of *S. dispar* is that of Richmond and Grimm (1950) based on data collected as part of the Mammal Survey of Pennsylvania.

Following its description by Anthony and Goodwin (1924), little has been published on *Sorex gaspensis*. Distributional and habitat records are presented by Goodwin (1924, 1929), Peterson and Symansky (1963) and Roscoe and Majka (1976). Food habits are described by Hamilton and Hamilton (1954).

The literature of *Sorex dispar* and *Sorex gaspensis* contains references to several localities for which we did not examine specimens. These published localities are as follows:

Sorex gaspensis

NEW BRUNSWICK: near Mount Carleton, 1 (Peterson and Symansky, 1963).

Sorex dispar

QUEBEC: Armstrong, 10 mi. SE, near Lac du Portage and near Maine border, 1 (Peterson, 1966); south of Cartierville, a few yards north of New Hampshire border, 3 (Peterson, 1966).

MARYLAND: GARRETT CO., Swallow Falls State Park, Muddy Creek Falls, 3 (Mansueti and Flyger, 1952).

NORTH CAROLINA: SWAIN CO., talus slope above Highway 107, 4400′, 1 (Schwartz, 1956).

TENNESSEE: SEVIER CO., Walker Prong, Great Smoky Mountains National Park, 4400-4500′, 2 (Schwartz, 1956); between Highway 71 and West Prong, Little Pigeon River, 3400′, 2 (*Ibid.*).

VERMONT: RUTLAND CO., East Wallingford, 1800′, 1 (Osgood, 1935).

TAXONOMIC RESOURCES

In the first 32 years following its description, *Sorex dispar* was considered a rare species, and fewer than 30 specimens existed in museum collections when Jackson (1928) reviewed the American long-tailed shrews. Although still not abundant, the number in North American mammal collections has increased dramatically in the past half-century and presently exceeds 220 specimens. The largest series of specimens are housed at four museums: the National Museum of Natural History, Smithsonian Institution, Washington, D.C. (44); Carnegie Museum of Natural History (37); the American Museum of Natural History (33); and the Vertebrate Museum, Shippensburg State College (31). Few specimens of *S. gaspensis* exist in museum collections; the largest series are at the American Museum of Natural History (14) and the National Museum of Natural History, Ottawa (8).

The increase in the number of *S. dispar* collected since 1928 is partly attributable to the greater efforts of mammalogists to capture this species, particularly at the periphery of its range. However, a more important factor has been the altering of trapping strategies following the discovery of the tendency of *S. dispar* to confine its activity below the surface of the rocky habitats it prefers. In appropriate habitat, *S. dispar* may be caught with regularity in traps set from one to three feet below the surface of the rocks.

SPECIMENS EXAMINED

The localities, numbers of specimens, and abbreviations for the museums housing the 23 *S. gaspensis* and 224 *S. dispar* examined in this study are presented below.

Sorex gaspensis

NOVA SCOTIA: Cape Breton Highlands National Park, South Mountain, 2 (NMC);

Grande Anse Valley, 1 (NMC); Cheticamp River Valley, 3 (NMC). VICTORIA CO., Summit Kelly's Mountain, near Englishtown, 1 (NSM).

QUEBEC: Gaspesian Provincial Park, 2 (NMC); near Chutes, 3 (AMNH); Mount Albert, 3 (AMNH); Cascapedia River, 7 (AMNH); and New Dureen, 1 (AMNH).

Sorex dispar

MAINE: PISCATAQUIS CO., Baxter State Park, South Branch Pond, 1000′, 1 (UMMZ); Mount Katahdin, 1 (UCONN). SOMERSET CO., Enchanted Pond, 1 (AMNH).

MASSACHUSETTS: BERKSHIRE CO., Adams, Mount Greylock, 4 (MCZ).

NEW HAMPSHIRE: COOS CO., Mount Washington, 3560′, 1 (CU); 3850′, 1 (AMNH); Hermit Lake, 3750′, 16 (AMNH), 11 (UCONN), 1 (CU), 1 (RPMAG); Tuckerman's Ravine, 5 (AMNH), 1 (MCZ), 1 (NCSU); Kinsman Notch, Lost River, 1900′, 1 (MCZ). GRAFTON CO., Franconia Ridge, Liberty Spring, 3900′, 1 (UMMZ), 1 (MVZ); Mount Moosilauke, 1 (CU).

NEW JERSEY: SUSSEX CO., Stillwater Township, near Lake Kathryn, 3 (AMNH).

NEW YORK: ESSEX CO., Beede's (sometimes called Keene Heights), 1 (MCZ); Beede, 1½ mi SSE Beede Brook, 1540′, 2 (NYSM); Beede Brook, 1700′, 2 (AMNH); Chapel Pond, 1600′, 2 (AMNH); ½ mi N, Beede Brook, 1 (NYSM); Keene, ice caves near Chapel Pond, 1540′, 1 (CU), 1 (MCZ); Mount Marcy, summit, 1 (MCZ); Newcomb, Huntington Experimental Forest, 1 (SSC); Ray Brook, 1630′, 2 (CU); Saint Hubert's, 1.7 mi SE, 1500′, 3 (SSC); 1.9 mi SE, Giant's Washbowl, 1 (SSC); Tahawus, 2 (SSC); 0.2 mi NE, Lake Sally, 1 (SSC); 2.3 mi NNW, 1 (SSC); Tahawus P.O., 1.1 mi N, 0.6 mi W, 1 (SSC); Wallface Mountain, 0.5 mi SW, 1 (SSC); Whiteface Mountain, 1 (CU), 1 (SSC); 3300′, 1 (CU); 3900′, 3 (CU); 4400′, 1 (CU); 4700′, 1 (CU); Willsboro, 4.4 mi N, 2.4 mi W, 1 (SSC); Wilmington, 4 mi WSW, Whiteface Mountain, 1 (NYSM). GREENE CO., Catskill Mountains, 3 (USNM); Hunter Mountain, 1 (CU), 1 (ROM), 3 (USNM); Hunter, 3.5 mi SSE, Notch Lake, 2000′, 1 (NYSM). SCHOHARIE CO., Gilboa, 1½ mi N, W slope of Reed Hill, 1300′, 9 (NYSM). SULLIVAN CO., DeBruce Fish Hatchery, 1½ mi above, 1 (YPM). ULSTER CO., 1 (MM); Awasting Falls, Lake Minnewaska Region, 1 (AMNH); New Paltz, 1½ mi N, 3½ mi W, 2 (SSC).

NORTH CAROLINA: HAYWOOD CO., Wagon Road Gap, 2 mi NE, 1 (USNM). SWAIN CO., Clingman's Dome, 3 (USNM).

PENNSYLVANIA: BERKS CO., Northkill, 900-1000′, 1 (RPMAG). CARBON CO., Lake Harmony, 1 mi W, Split Rock, 2 (CM); 1¼ mi SE, 1 (CM). CLEARFIELD CO., McGee's Mills, 1300′, 1 (CM). CUMBERLAND CO., South Mountain, 1 (JTW). HUNTINGTON CO., Spruce Creek, 2 mi N, 2 (CM). JEFFERSON CO., Siegel, 5.5 mi NE, 6 (CM). LUZERNE CO., Mountain Springs, 1 (MVZ); Sweet Valley, 7½ mi WNW, 1 (CM); 8 mi NW, 3 (CM); 9 mi NW, 1 (CM). LYCOMING CO., Williamsport, 3½ mi S, 3 (CM). NORTHAMPTON CO., Danielsville, 1 mi N, 1 (CM); Wind Gap, ½ mi NW, 1300′, 2 (CM). PERRY CO., New Bloomfield, 5 mi SSW, 1 (CM). SOMERSET CO., Bakersville, ½ mi NW, 2300′, 1 (CM). SULLIVAN CO., Lake Leigh, North Mountain, 1 (ANSP). UNION CO., Glen Iron, 1 mi S, 1 (CM). VENANGO CO., Franklin, 4 mi S, 3 (CM); Oil City, 6 mi E, 1 (CM). WAYNE CO., Sterling, 2½ mi SW, Gas Hollow, 1800′, 1 (RPMAG). WESTMORELAND CO., Latrobe, 4 mi SE, 4 (CM); Laughlintown, ½ mi ESE, 2 (CM); Rector, 2 mi SSE, 3 (CM); 4 mi SSE, 3 (CM).

TENNESSEE: CARTER CO., Roan Mountain, N slope, 4800′, 5 (USNM); Carver's Gap, 2.6 mi by road below, 4800′, 11 (KU), 2 (AMNH); 2 mi by road below, 2 (KU). SEVIER CO., W Fork Little Pigeon River, 1 (USNM).

VERMONT: RUTLAND CO., Mendon, 900′, 1 (MCZ); 1400′, 2 (MCZ), 1 (UCONN); Bald Mountain, 900′, 1 (UCONN); Killington Peak, 4000′, 1 (UCONN).

VIRGINIA: BATH CO., near Highland Co. line, 3 mi S Paddy's Knob, 1 (USNM). GILES CO., Mountain Lake, 0.35 mi S, 4363′, 1

(USNM); 0.75 mi SSW, 1 (USNM); 1.4 mi ENE, 3 (USNM); 1.5 mi ENE, Bear Cliffs, 3 (USNM); 4.2 mi ENE, 1 (USNM); 4.3 mi NNE, Castle Rock Cliffs, 4000-4100′, 5 (USNM); 4.7 mi NNE, 4100′, 1 (USNM). RUSSELL CO., Mutter's Gap, Chuck Mountain, 3 (USNM). SMYTH CO., Whitetop Mountain, 5300′, 1 (USNM).

WEST VIRGINIA: MONONGALIA CO., Dellslow, ½ mi SE, 1200′, 1 (WGFC). RALEIGH CO., Winding Gulf, SW Pemberton, 1 (USNM). RANDOLPH CO., Cheat Bridge, 1.5 mi E, 3 (SSC); 4.8 mi SW, 1 (SSC); 5.0 mi SW, 6 (SSC); Durbin, 4.6 mi NNW, 3650′, 1 (NCSU); 5 mi NNW, 4350′, 1 (WVMSC). TUCKER CO., Parsons, 2.6 mi SE, 1 (SSC).

DISTRIBUTION

The two species of the *Sorex dispar* group are limited to the Appalachian Mountain System in eastern North America. *Sorex dispar* is confined to a narrow belt extending from Maine to North Carolina and including the Adirondack Mountains of northern New York (fig. 1). Within its range, it is restricted to upland areas and is not recorded from any of the major valleys. The known range of *Sorex gaspensis* has been greatly expanded recently. For nearly 40 years, *S. gaspensis* was known only on the Gaspé Peninsula of eastern Quebec. Then, in 1961, a single specimen was captured near Mount Carleton in central New Brunswick (Peterson and Symansky, 1963) and, in 1974, seven specimens were collected on Cape Breton Island, Nova Scotia (Roscoe and Majka, 1976). At present, no specimens are known from the mainland of Nova Scotia. However, since *S. gaspensis* is found in major mountain areas in other parts of its range, it is likely that it occurs in the Cobequid and North Mountains of Nova Scotia (fig. 1).

At the height of the Wisconsin Glaciation, the Laurentide Ice Sheet extended over the northern half of the present range of *S. dispar* and all of that of *S. gaspensis*. Fossil remains of *S. dispar* from late Pleistocene cave deposits in Pennsylvania (Guilday, 1971) and Virginia (Guilday et al., 1977) suggest that the southern Appalachians served as a refugium for *S. dispar* during the Wisconsin Glaciation and a possible source for the recolonization of the New York/New England region following the glacial retreat. In contrast, there are no fossil records for *S. gaspensis*. Until recently, it would have been appropriate to consider *S. gaspensis* as a northern isolate of *S. dispar* because of its presumed restriction to the Gaspé Peninsula and its proximity to the northern limits of *S. dispar* in Maine. However, the capture of *S. gaspensis* in New Brunswick and Cape Breton Island focuses attention eastward and raises the possibility that this shrew is derived from populations that survived the Wisconsin Glaciation on continental shelf refugia or on nunataks in the Maritime Provinces (see Charlesworth, 1957).

As Guilday et al. (1977) noted, following the glacial retreat, *S. dispar* (and also *S. gaspensis*) were unable to cross the St. Lawrence/Great Lakes water barrier to colonize east-central Canada as did so many other boreal mammals whose ranges were pushed southward during the Wisconsin Glaciation. Thus, these two shrews are the only boreal mammals whose ranges lie completely south of the St. Lawrence, and *S. gaspensis* is the only mammal species restricted to the Canadian Biotic Province (Dice, 1938).

MORPHOLOGY AND TAXONOMY

EXTERNAL AND SKULL MORPHOLOGY: The two shrews of the *Sorex dispar* group are morphologically very similar and presumably closely related. They are distinguished from other North American *Sorex* by the location of the infraorbital foramen whose posterior border lies caudad of the plane of the space between M^1 and M^2. The skull of each species is delicately constructed with a narrow rostrum (fig. 3). In *S. gaspensis*, condylobasal length is $<$ 16.4 mm., whereas it is $>$ 16.4 mm. in *S. dispar*. In both species, the tail is long and not distinctly bicolored. A 6-8 mm. pencil of hairs at the tip of the tail is present in younger specimens, but in older specimens, the tail is naked and frequently scarred. Both species are

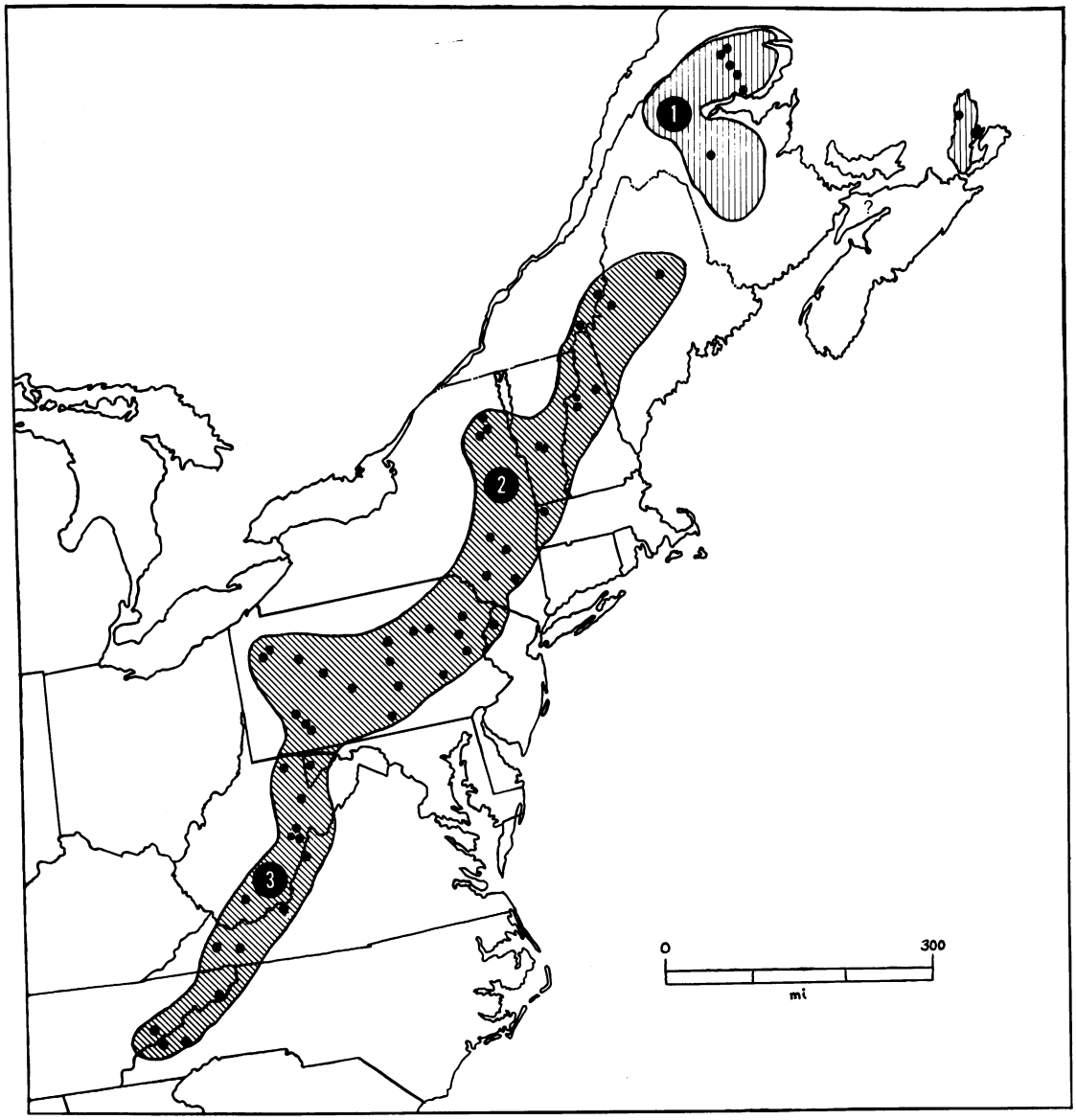

FIG. 1. Distribution for the shrews of the *Sorex dispar* group: (1) *Sorex gaspensis*; (2) *S. d. dispar*; and (3) *S. d. blitchi*, based on the localities of specimens examined plus additional literature records. One dot may represent more than one locality if several specimens have been collected from different localities in the same region.

slate gray in color dorsally with venters only slightly paler. Previous workers (Anthony and Goodwin, 1924; Jackson, 1928; and Peterson, 1966) have indicated that *S. gaspensis* is paler dorsally than *S. dispar*; however, our examination of specimens indicates that these differences are not sufficiently conspicuous or consistent to be diagnostic. Detailed diagnoses

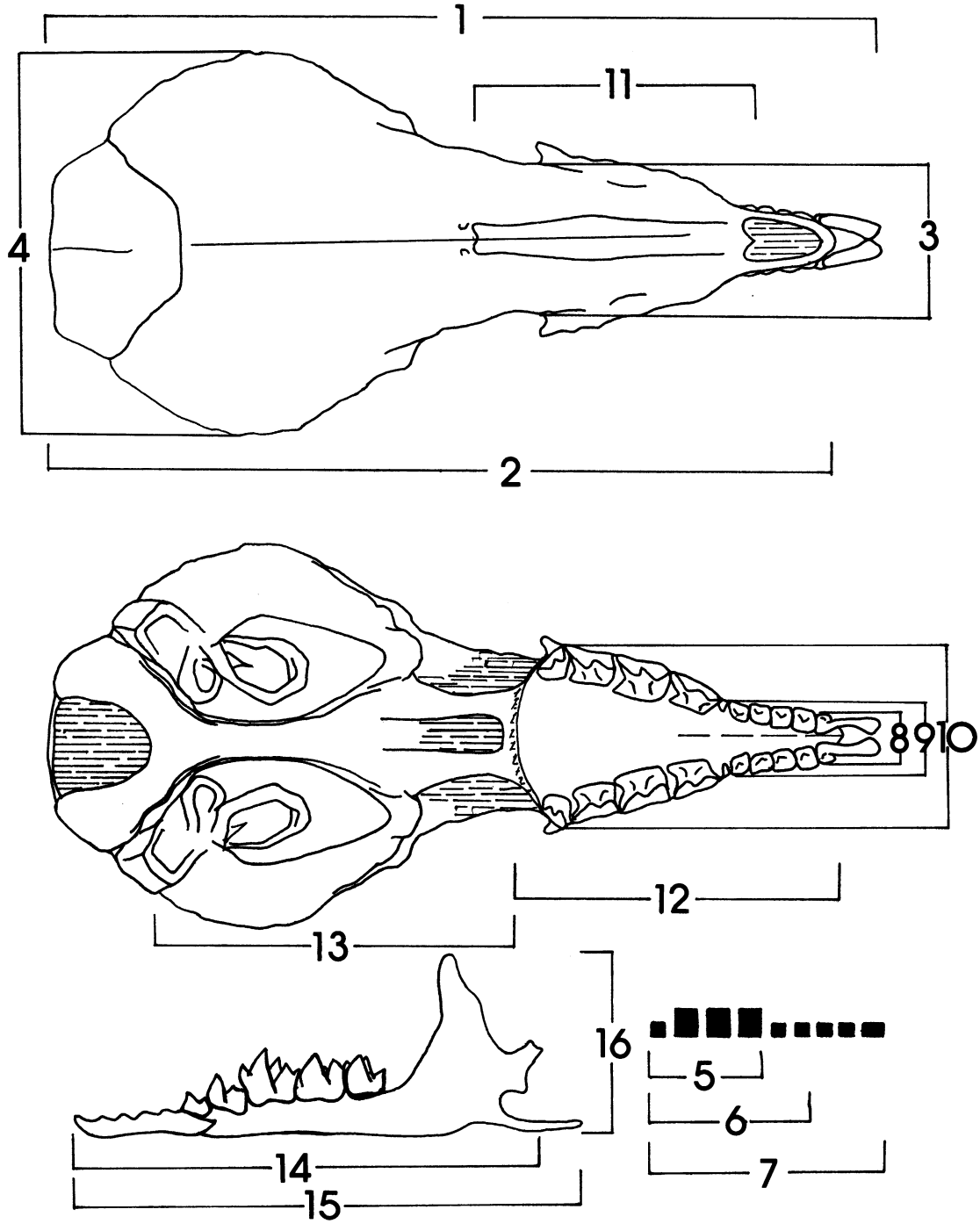

FIG. 2. Diagrammatic views of the skull, mandible and upper tooth row of *Sorex dispar/gaspensis* showing measurements employed. The measurements as defined in the text are as follows: (1) greatest length; (2) condylobasal length; (3) interorbital breadth; (4) cranial breadth; (5) molariform tooth row; (6) cheek tooth row; (7) total tooth row; (8) incisor width; (9) canine width; (10) molar width; (11) nasal length; (12) palatal length; (13) post-palatal length; (14) mandible length I; (15) mandible length II; (16) mandible height.

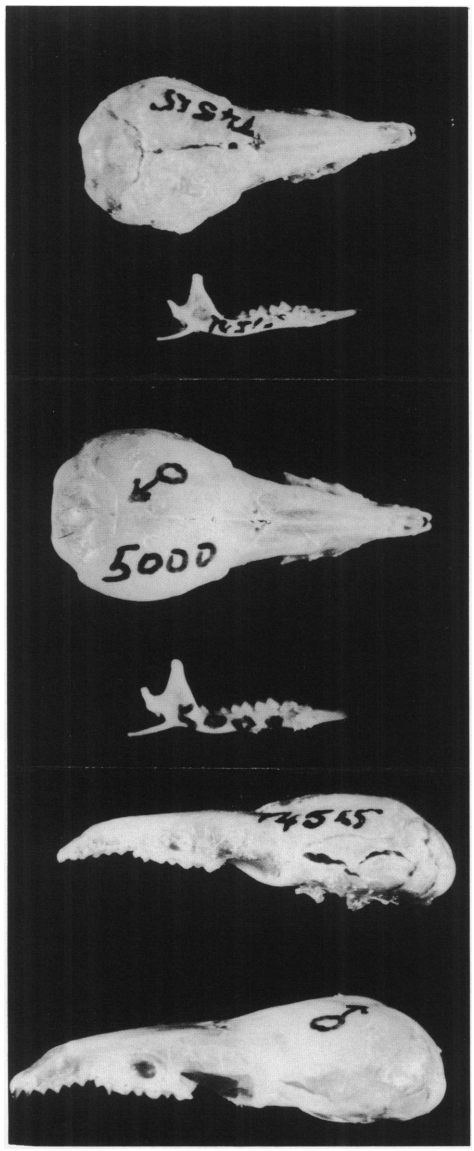

FIG. 3. Skulls with right mandibles of *Sorex gaspensis* (AMNH 74515), a female from Cascapedia River, Gaspé Peninsula, Quebec (top) and *Sorex dispar* (SSC 5000), a male from Ulster Co., New York. Lateral views of 74515 and 5000 at bottom.

of these taxa have previously been published, as follows: *S. dispar* (Batchelder, 1898; Jackson, 1928), *S.d. blitchi* (Schwartz, 1956), and *S. gaspensis* (Anthony and Goodwin, 1924; Jackson, 1928). Table 1 presents skin and skull measurements of these three taxa.

SUBGENERIC AFFINITY: Findley (1955) considered *S. dispar* and *S. gaspensis* to be members of the subgenus *Sorex*, and this taxonomic designation was followed by Hall and Kelson (1959). We have evaluated the subgeneric affinities of *S. dispar* and *S. gaspensis* on the basis of the three diagnostic characters employed by Findley (1955). Both species are characterized by the presence of an uninterrupted pigmented ridge extending from the apices of the unicuspids medially to the cingula and the absence of a post-mandibular foramen. In each, the third and fourth unicuspids are subequal in size with the fourth slightly larger than the third in some specimens. On the basis of these characteristics, we conclude that *S. dispar* and *S. gaspensis* should be placed in the subgenus *Otisorex* rather than the subgenus *Sorex*.

SUBSPECIES OF *Sorex dispar*: *Sorex dispar* was considered to be a monotypic species until Schwartz (1956) described a southern Appalachian subspecies, *S.d. blitchi*, from specimens collected in Haywood Co., North Carolina. Schwartz assigned specimens from North Carolina, Tennessee and southwestern Virginia to *S.d. blitchi* but considered five specimens from West Virginia and Virginia to be intergrades between *S.d. blitchi* and *S.d. dispar*. His range map for the species indicated that the subspecies boundary could be drawn either along the Pennsylvania/Maryland or southern West Virginia/Virginia borders (*op. cit.*, p. 25). Hall and Kelson (1959) chose the latter, thus limiting the range of *S.d. blitchi* to the southernmost Appalachians.

The substantially larger number of southern Appalachian *S. dispar* currently available for study has permitted us to conduct a more detailed analysis of the distributional limits of the two subspecies of *S. dispar* than was possible in the mid-1950s. Eighty-two specimens with unbroken skulls were examined, as follows: 48 from the mid-Atlantic States (NY, NJ, PA), 19 from Schwartz's region of intergradation (WV, VA), and 15 from the range of *S.d. blitchi* (NC, TN). Univariate comparisons of these samples were conducted to assess the size relationships of the WV/VA specimens to those

TABLE 1

Metric Measurements of 22 Skin and Skull Characters of Three Taxa in the *Sorex dispar* Group: *Sorex gaspensis*, *Sorex dispar dispar* and *Sorex dispar blitchi*[a]

	S. gaspensis	*S.d. dispar*	*S.d. blitchi*
Total Length	105.00 ± 8.78 95.0 – 127.0 n = 21	118.05 ± 6.30 103.0 – 136.5 n = 153	123.02 ± 5.84 108.0 – 135.0 n = 65
Tail Length	49.72 ± 2.65 45.0 – 55.0 n = 23	55.70 ± 2.62 46.0 – 65.0 n = 154	57.79 ± 3.45 49.0 – 67.0 n = 65
Hind Foot Length	11.98 ± 0.57 10.5 – 12.5 n = 23	13.78 ± 0.93 12.0 – 15.5 n = 151	14.75 ± 0.66 13.5 – 18.0 n = 65
Ear	8.17 ± 1.60 5.0 – 9.0 n = 6	7.75 ± 1.49 3.5 – 9.9 n = 96	8.00 ± 1.66 4.0 – 9.9 n = 38
Body	55.25 ± 7.73 45.0 – 77.0 n = 20	62.29 ± 5.51 48.0 – 79.0 n = 152	64.85 ± 5.22 50.0 – 76.0 n = 64
Weight	2.89 ± 0.63 2.2 – 4.3 n = 9	4.70 ± 0.83 3.1 – 8.3 n = 80	5.30 ± 0.79 4.0 – 7.6 n = 47
Greatest Length	16.62 ± 0.52 15.70 – 17.50 n = 18	18.11 ± 0.37 17.30 – 19.10 n = 84	18.47 ± 0.37 17.80 – 19.20 n = 37
Condylobasal Length	15.88 ± 0.37 15.35 – 16.35 n = 18	17.38 ± 0.40 16.45 – 18.40 n = 85	17.90 ± 0.41 17.20 – 18.70 n = 37
Interorbital Breadth	3.13 ± 0.19 2.80 – 3.50 n = 19	3.42 ± 0.16 3.10 – 3.85 n = 107	3.75 ± 0.20 3.25 – 4.15 n = 43
Cranial Breadth	7.48 ± 0.32 7.10 – 8.20 n = 18	8.02 ± 0.23 7.50 – 8.65 n = 84	8.08 ± 0.30 7.20 – 8.65 n = 40
Molariform Row	3.56 ± 0.07 3.40 – 3.65 n = 18	3.98 ± 0.12 3.75 – 4.30 n = 110	4.09 ± 0.09 3.85 – 4.25 n = 44
Cheek Tooth Row	4.23 ± 0.11 4.05 – 4.40 n = 18	4.70 ± 0.14 4.10 – 5.00 n = 109	4.84 ± 0.10 4.60 – 5.05 n = 44
Total Tooth Row	6.68 ± 0.20 6.35 – 7.25 n = 18	7.35 ± 0.15 6.80 – 7.65 n = 106	7.46 ± 0.18 7.15 – 7.75 n = 42
Incisor Width	1.11 ± 0.07 1.00 – 1.30 n = 19	1.24 ± 0.07 1.10 – 1.45 n = 106	1.31 ± 0.84 1.15 – 1.50 n = 43

TABLE 1 — (*Continued*)

	S. gaspensis	*S.d. dispar*	*S.d. blitchi*
Canine Width	1.42 ± 0.06 1.30 – 1.55 n = 19	1.66 ± 0.10 1.40 – 1.90 n = 109	1.74 ± 0.08 1.50 – 1.85 n = 46
Molar Width	3.48 ± 0.16 3.20 – 3.80 n = 18	3.95 ± 0.17 3.65 – 4.60 n = 109	4.07 ± 0.13 3.70 – 4.30 n = 44
Nasal Length	5.84 ± 0.22 5.40 – 6.30 n = 18	6.39 ± 0.32 5.60 – 7.25 n = 108	6.48 ± 0.23 6.10 – 7.10 n = 44
Palatal Length	6.37 ± 0.16 6.00 – 6.75 n = 19	7.06 ± 0.21 6.60 – 7.70 n = 107	7.37 ± 0.15 7.10 – 7.75 n = 44
Post-palatal Length	7.35 ± 0.21 6.90 – 7.60 n = 18	8.12 ± 0.29 7.30 – 8.70 n = 87	8.31 ± 0.19 8.00 – 8.65 n = 39
Mandible Length I	9.44 ± 0.22 9.70 – 9.90 n = 19	10.33 ± 0.23 9.75 – 10.95 n = 109	10.52 ± 0.19 10.10 – 10.90 n = 46
Mandible Length II	10.17 ± 0.29 9.70 – 10.80 n = 15	11.04 ± 0.28 10.10 – 11.70 n = 93	11.27 ± 0.23 10.85 – 11.65 n = 38
Mandible Height	3.15 ± 0.21 2.95 – 3.95 n = 19	3.51 ± 0.19 3.05 – 4.00 n = 108	3.61 ± 0.20 3.20 – 4.10 n = 46

[a]Measurements are explained in text. Mean, standard deviation, minimum, maximum, and sample size are given.

from regions immediately to the north and south (table 2). In general, the means for the WV/VA specimens were intermediate, being closer to the means of the NY/NJ/PA sample for 10 characters with five differences significant and closer to those of the NC/TN sample for eight characters with four differences significant. Thus, these size relationships are consistent with Schwartz's (1956) observations.

These 82 specimens plus 25 *S.d. dispar* from New England and 14 *S. gaspensis* were also compared using a step-wise discriminant analysis BMD 07M (Dixon, 1967). The results of this analysis revealed that the WV/VA specimens grouped with the *S.d. blitchi* from NC/TN rather than with the NY/NJ/PA *S.d. dispar* (fig. 4). Two additional BMD 07M analyses were made using only the 82 specimens from the mid-Atlantic States southward. When the 19 specimens from West Virginia and Virginia were assigned *a priori* to the mid-Atlantic specimens (*S.d. dispar*), the BMD 07M analysis reassigned seven of 19 (37 percent) to *S.d. blitchi*; however, when the 19 were assigned *a priori* to *S.d. blitchi*, only 2 of 19 (11 percent) were reassigned to *S.d. dispar*. On the basis of the results of these discriminant analyses, we propose that specimens from West Virginia and Virginia should be designated as *S.d. blitchi*, and that the subspecies boundary between *S.d. dispar* and *S.d. blitchi* should be established in the region of the Pennsylvania/Maryland/West Virginia borders (fig. 1). This change would bring the boundary of the subspecies ranges of *S. dispar* into closer conformity with those of six other species of boreal small mammals:

Sorex palustris, Tamiasciurus hudsonicus, Glaucomys sabrinus, Clethrionomys gapperi, Microtus chrotorrhinus, and *Synaptomys cooperi* (Hall and Kelson, 1959). The symmetry of the revised range of *S.d. blitchi* and those of *S. palustris punctulatus* and *M. chrotorrhinus carolinensis* is significant because of the frequent ecological association of *S. dispar* with those two species (see Habitat Preferences and Ecological Associates sections).

LATITUDINAL CLINE: Morphological data for specimens from four different regions of the geographic range of *S. dispar* suggest the presence of a N-S cline for size with progressive decreases in size with increasing latitude (table 3). To confirm the presence of a relationship between size in *S. dispar* and latitude, each of 22 morphological variables was analyzed individually with latitude using an SPSS Pearson Correlation Program (Nie et al., 1975). Latitudes of specimen localities, measured to the nearest 0.1°, were employed as the independent variable. The analyses revealed significant negative correlations between size and latitude for 21 of the 22 variables (table 4). These results coincide with those of Mezhzherin (1964) who observed that in Eurasian *Sorex*, the smallest representatives were from the most northern regions with the lowest winter temperatures.

TAXONOMIC STATUS OF *Sorex gaspensis*: *Sorex gaspensis* is morphologically very similar to *Sorex dispar* and is differentiated from the latter primarily on the basis of its smaller size, since color differences are slight (Anthony and Goodwin, 1924; Jackson, 1928). Both non-statistical and statistical comparisons of specimens of these two taxa demonstrate the substantial size differences between them. In comparing skulls of *S. dispar* and *S. gaspensis*, nearly all

TABLE 2

Univariate Comparisons of *Sorex dispar dispar* from New York, New Jersey, Pennsylvania; *Sorex dispar blitchi* from North Carolina and Tennessee; *Sorex dispar* ssp. from West Virginia and Virginia

(Measurements are explained in text. Mean and standard deviation are given.)

	1	2	3		
Sample States	NY, NJ, PA	WVA, VA	NC, TENN	Student's t-tests	
Sample Size	48	19	15	1 vs 2	2 vs 3
Total Length	119.15 ± 5.42	123.03 ± 6.00	124.63 ± 5.56	2.56[a]	0.80
Tail Length	56.16 ± 2.94	57.42 ± 4.15	59.47 ± 3.44	1.41	1.54
Hind Foot Length	14.37 ± 0.67	14.53 ± 0.49	15.10 ± 0.39	0.91	3.73[b]
Body	62.57 ± 4.58	65.08 ± 5.49	64.89 ± 2.91	1.91	0.12
Greatest Length	18.29 ± 0.33	18.36 ± 0.38	18.66 ± 0.30	0.81	2.52[a]
Condylobasal L.	17.55 ± 0.36	17.86 ± 0.38	18.04 ± 0.41	3.12[b]	1.37
Interorbital Breadth	3.50 ± 0.15	3.78 ± 0.20	3.75 ± 0.16	6.34[c]	0.44
Cranial Breadth	8.09 ± 0.21	8.07 ± 0.25	8.18 ± 0.25	0.19	1.26
Molariform Row	4.04 ± 0.09	4.08 ± 0.06	4.10 ± 0.11	1.58	0.80
Cheek Tooth Row	4.77 ± 0.11	4.84 ± 0.09	4.84 ± 0.09	2.59[a]	0.02
Total Tooth Row	7.39 ± 0.15	7.45 ± 0.20	7.52 ± 0.14	1.40	1.14
Incisor Width	1.27 ± 0.07	1.28 ± 0.09	1.34 ± 0.05	0.71	2.45[a]
Canine Width	1.71 ± 0.10	1.73 ± 0.10	1.77 ± 0.07	0.68	1.51
Molar Width	4.05 ± 0.14	4.05 ± 0.12	4.11 ± 0.12	0.08	1.45
Palatal Length	7.07 ± 0.23	7.34 ± 0.15	7.43 ± 0.15	4.69[c]	1.71
Post-palatal Length	8.22 ± 0.25	8.26 ± 0.18	8.43 ± 0.14	0.67	2.99[b]
Mandible Length I	10.43 ± 0.22	10.48 ± 0.19	10.59 ± 0.14	0.98	1.69
Mandible Height	3.57 ± 0.18	3.62 ± 0.24	3.64 ± 0.16	1.03	0.18

[a] $p < .05$
[b] $p < .01$
[c] $p < .001$

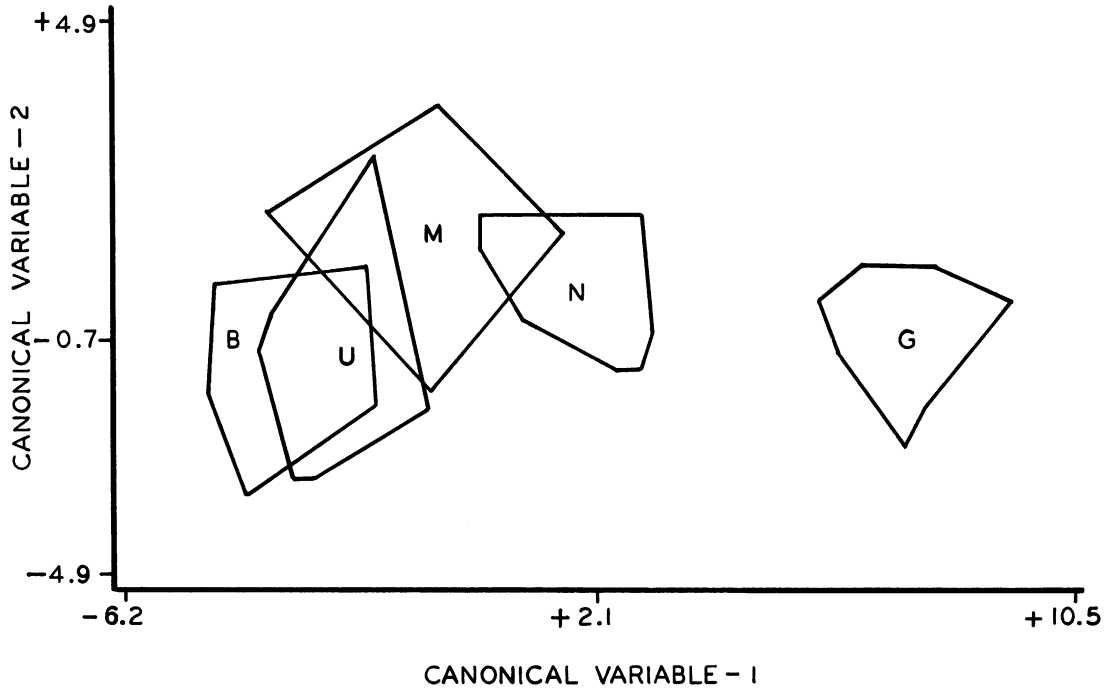

FIG. 4. Relationships of 121 shrews in five groups as plotted by discriminant analysis (BMD 07M). Groups with means (+ signs) are as follows: G = *Sorex gaspensis* (Quebec, N.S.) X = 7.478, Y = −0.660; N = *S. dispar* from New England (Maine, N.H., Vt., Mass.) X = 1.838, Y = 0.261; M = *S. dispar* from Mid-Atlantic States (N.Y., N.J., Pa.) X = −1.146, Y = 0.839; *S. dispar* from W. Va. and Va. X = −2.479, Y = −1.272; B = *S. dispar* from Tenn. and N.C. X = −3.238, Y = −0.892.

specimens can be correctly identified on the basis of size alone (See skull measurements, table 1). The size differences between *S. dispar* and *S. gaspensis* are comparable to those between *S. f. fumeus* and *S. c. cinereus* from New York/New England.

In Student's t comparisons of 53 *S. dispar* from New England and 23 *S. gaspensis*, the former were significantly larger for 21 of the 22 variables examined (table 5). A step-wise discriminant analysis (BMD 07M) was performed on 122 specimens from throughout the ranges of both taxa using morphological data from 18 skin and skull characters. The 14 *S. gaspensis* were distinctly differentiated from the four groups of *S. dispar* specimens examined (fig. 4). The results of these analyses indicate that *S. gaspensis* differs from *S. dispar* to such a degree that it warrants retention as a separate species.

HABITAT PREFERENCES

Sorex dispar is a stenotopic species, occupying a narrow spectrum of habitats. The literature and museum specimen data reveal that *S. dispar* is captured primarily in two types of sites, under and among rocks, especially in talus slopes, and adjacent to cool mountain streams. The type specimen was captured in a cool, moist, shaded area "among large angular rocks at the head of a wooded talus" (Batchelder, 1896). Subsequent habitat descriptions have emphasized the importance of rocks as a prime habitat component, thus giving rise to the common name rock shrew (e.g., Jackson, 1928; Green, 1930; Richmond and Grimm, 1950; Starrett, 1954; Davis, 1956; Handley, 1956; and Holloway, 1957). These sites have usually been wooded with the rocks cool, moist, and moss covered. In the Great Smoky

TABLE 3

Comparison of 22 Morphological Variables in Specimens of *Sorex dispar* and *Sorex gaspensis* from Five Regions of the Ranges of the Two Species

(Measurements are described in text. Means, standard deviations, and sample sizes are presented.)

	S. gaspensis	*S. dispar*			
	QUE/NS	NEW ENGLAND	NY/NJ/PA	WV/VA	NC/TN
Total Length	105.00 ± 8.78 n = 21	115.81 ± 7.55 n = 53	119.24 ± 5.19 n = 100	122.65 ± 5.75 n = 41	123.65 ± 6.06 n = 24
Tail Length	49.72 ± 2.62 n = 23	55.23 ± 2.97 n = 53	55.94 ± 2.40 n = 101	56.84 ± 2.40 n = 41	59.42 ± 2.96 n = 24
Hind Foot Length	11.98 ± 0.57 n = 23	13.13 ± 0.88 n = 53	14.14 ± 0.74 n = 98	14.63 ± 0.73 n = 41	14.94 ± 0.47 n = 24
Ear	8.17 ± 1.60 n = 6	7.03 ± 1.30 n = 29	8.07 ± 1.47 n = 67	8.26 ± 1.52 n = 34	5.75 ± 0.96 n = 4
Body	55.25 ± 7.73 n = 20	60.75 ± 6.76 n = 52	63.09 ± 4.57 n = 100	65.32 ± 5.51 n = 41	64.02 ± 4.67 n = 23
Weight	2.89 ± 0.63 n = 9	4.40 ± 0.39 n = 4	4.71 ± 0.85 n = 76	5.45 ± 0.94 n = 28	5.07 ± 0.43 n = 19
Greatest Length	16.62 ± 0.52 n = 18	17.84 ± 0.25 n = 32	18.28 ± 0.33 n = 52	18.36 ± 0.37 n = 20	18.60 ± 0.34 n = 17
Condylobasal Length	15.88 ± 0.37 n = 18	17.12 ± 0.33 n = 33	17.55 ± 0.36 n = 52	17.84 ± 0.37 n = 20	17.97 ± 0.44 n = 17
Interorbital Breadth	3.13 ± 0.19 n = 19	3.31 ± 0.12 n = 48	3.50 ± 0.14 n = 59	3.77 ± 0.23 n = 24	3.73 ± 0.17 n = 19
Cranial Breadth	7.48 ± 0.32 n = 18	7.90 ± 0.21 n = 31	8.09 ± 0.22 n = 53	8.02 ± 0.33 n = 22	8.15 ± 0.25 n = 18
Molariform Row	3.56 ± 0.07 n = 18	3.92 ± 0.12 n = 49	4.02 ± 0.10 n = 61	4.07 ± 0.09 n = 25	4.10 ± 0.10 n = 19
Cheek Tooth Row	4.23 ± 0.11 n = 18	4.64 ± 0.15 n = 49	4.75 ± 0.11 n = 60	4.84 ± 0.11 n = 25	4.84 ± 0.09 n = 19
Total Tooth Row	6.68 ± 0.20 n = 18	7.30 ± 0.15 n = 47	7.39 ± 0.15 n = 59	7.45 ± 0.19 n = 23	7.48 ± 0.16 n = 19
Incisor Width	1.11 ± 0.07 n = 19	1.21 ± 0.07 n = 49	1.26 ± 0.07 n = 57	1.29 ± 0.10 n = 24	1.32 ± 0.06 n = 19
Canine Width	1.42 ± 0.06 n = 19	1.60 ± 0.07 n = 49	1.70 ± 0.09 n = 60	1.72 ± 0.09 n = 26	1.77 ± 0.06 n = 20
Molar Width	3.48 ± 0.16 n = 18	3.85 ± 0.13 n = 49	4.04 ± 0.14 n = 60	4.04 ± 0.13 n = 25	4.11 ± 0.11 n = 19
Nasal Length	5.84 ± 0.22 n = 18	6.47 ± 0.32 n = 49	6.32 ± 0.30 n = 59	6.47 ± 0.20 n = 25	6.49 ± 0.26 n = 19
Palatal Length	6.37 ± 0.16 n = 19	7.04 ± 0.17 n = 47	7.03 ± 0.23 n = 60	7.35 ± 0.15 n = 25	7.39 ± 0.16 n = 19
Post-palatal Length	7.35 ± 0.21 n = 18	7.96 ± 0.26 n = 34	8.21 ± 0.28 n = 53	8.25 ± 0.18 n = 22	8.39 ± 0.16 n = 17

TABLE 3 — (*Continued*)

Mandible Length I	9.44 ± 0.22 n = 19	10.23 ± 0.20 n = 48	10.41 ± 0.22 n = 60	10.47 ± 0.21 n = 27	10.59 ± 0.14 n = 19
Mandible Length II	10.17 ± 0.29 n = 15	10.94 ± 0.27 n = 37	11.10 ± 0.27 n = 56	11.19 ± 0.25 n = 20	11.35 ± 0.19 n = 18
Mandible Height	3.15 ± 0.21 n = 19	3.45 ± 0.19 n = 48	3.56 ± 0.19 n = 60	3.60 ± 0.23 n = 27	3.63 ± 0.15 n = 19

TABLE 4

Pearson Correlation Coefficients of Latitude (measured to nearest 0.1°) vs. each of 22 Morphological Characters in 224 Specimens of *Sorex dispar*

(Measurements are explained in text. Coefficient (r), number of cases, and significance level (S) are given.)

Total Length r = −0.36 n = 218 S = 0.001	Tail Length r = −0.35 n = 219 S = 0.001	Hind Foot Length r = −0.58 n = 216 S = 0.001	Ear Length r = −0.18 n = 134 S = 0.019
Body Length r = −0.21 n = 216 S = 0.001	Weight r = −0.30 n = 127 S = 0.001	Greatest Length r = −0.53 n = 121 S = 0.001	Condylobasal Length r = −0.61 n = 122 S = 0.001
Interorbital r = −0.69 n = 150 S = 0.001	Cranial Breadth r = −0.20 n = 124 S = 0.012	Molariform Tooth Row r = −0.56 n = 154 S = 0.001	Cheek Tooth Row r = −0.52 n = 153 S = 0.001
Incisor Width r = −0.49 n = 149 S = 0.001	Total Tooth Row r = −0.34 n = 148 S = 0.001	Canine Width r = −0.53 n = 155 S = 0.001	Molar Width r = −0.55 n = 153 S = 0.001
Nasal Length r = −0.05 n = 152 S = 0.253	Palatal Length r = −0.51 n = 151 S = 0.001	Post-Palatal Length r = −0.52 n = 126 S = 0.001	Mandible Length I r = −0.45 n = 154 S = 0.001
Mandible Length II r = −0.42 n = 131 S = 0.001	Mandible Height r = −0.31 n = 154 S = 0.001		

Mountains, *S. dispar* has been captured in artificial talus slopes created by road building (Conaway and Pfitzer, 1952).

The first author and his students also have captured *S. dispar* at the edge of small streams in traps set to catch *Sorex palustris* (New York, Essex Co.; West Virginia, Randolph and Tucker Cos.). Osgood (1935) and Conaway and Pfitzer (1952) have likewise captured both *S. dispar* and *S. palustris* in the same traplines. Additional records of *S. dispar* captured adjacent to small streams include those of Mather

TABLE 5

Univariate Comparison of 53 *Sorex dispar* from New England and 23 *Sorex gaspensis*

(Measurements are explained in text. Mean and standard deviation are given.)

	Sorex dispar NEW ENGLAND	*Sorex gaspensis* QUEBEC/NOVA SCOTIA	Student's t-test
Total Length	115.81 ± 7.55 n = 53	105.00 ± 8.78 n = 21	5.30[a]
Tail Length	55.23 ± 2.97 n = 53	49.72 ± 2.65 n = 23	7.67[a]
Hind Foot Length	13.13 ± 0.88 n = 53	11.98 ± 0.57 n = 23	5.78[a]
Ear Length	7.03 ± 1.30 n = 29	8.17 ± 1.60 n = 6	1.62
Body Length	60.75 ± 6.76 n = 52	55.25 ± 7.73 n = 20	2.97[b]
Weight	4.40 ± 0.39 n = 4	2.89 ± 0.63 n = 9	4.37[b]
Greatest Length	17.84 ± 0.25 n = 32	16.62 ± 0.52 n = 18	11.13[a]
Condylobasal Length	17.12 ± 0.33 n = 33	15.88 ± 0.37 n = 18	12.34[a]
Interorbital Breadth	3.31 ± 0.12 n = 48	3.13 ± 0.19 n = 19	4.60[a]
Cranial Breadth	7.90 ± 0.21 n = 31	7.48 ± 0.32 n = 18	5.56[a]
Molariform Tooth Row	3.92 ± 0.12 n = 49	3.56 ± 0.07 n = 18	12.18[a]
Cheek Tooth Row	4.64 ± 0.15 n = 49	4.23 ± 0.11 n = 18	10.35[a]
Total Tooth Row	7.30 ± 0.15 n = 47	6.68 ± 0.20 n = 18	13.53[a]
Incisor Width	1.21 ± 0.07 n = 49	1.11 ± 0.07 n = 19	5.58[a]
Canine Width	1.60 ± 0.07 n = 49	1.42 ± 0.06 n = 19	9.16[a]
Molar Width	3.85 ± 0.13 n = 49	3.48 ± 0.16 n = 18	9.99[a]
Nasal Length	6.47 ± 0.32 n = 49	5.84 ± 0.22 n = 18	7.72[a]
Palatal Length	7.04 ± 0.17 n = 47	6.37 ± 0.16 n = 19	14.46[a]
Post-palatal Length	7.96 ± 0.26 n = 34	7.35 ± 0.21 n = 18	8.73[a]

TABLE 5 — (*Continued*)

Mandible Length I	10.23 ± 0.20 n = 48	9.44 ± 0.22 n = 19	14.12[a]
Mandible Length II	10.94 ± 0.27 n = 37	10.17 ± 0.29 n = 15	9.01[a]
Mandible Height	3.45 ± 0.19 n = 48	3.15 ± 0.21 n = 19	5.47[a]

[a] $p < .001$
[b] $p < .01$

(1933) and Lincoln (1935) in New Hampshire and Mansueti and Flyger (1952) in Maryland.

Two capture records for *S. dispar* suggest that it may possess greater ecological amplitude than previously supposed. In July 1974, five specimens were captured on a one-year-old clearcut in a red spruce (*Picea rubens*) stand, located 5.0 mi SW Cheat Bridge, Randolph Co., West Virginia (Kirkland et al., in press). The 3 ha. clearcut was characterized by abundant logging residue, exposed dry soil, and scattered sandstone boulders. Subsequent snap-trapping at the site in October 1974 failed to produce any additional *S. dispar*. Stormer (1968) reported capturing a *S. dispar* in talus rocks on a recent mixed oak clearcut in Centre Co., Pennsylvania.

Literature records and habitat descriptions for *S. gaspensis* are much fewer than for *S. dispar*. Banfield (1974) described *S. gaspensis* as living beneath boulders along swift-flowing streams in spruce forests. Anthony and Goodwin (1924) noted that all three specimens in the type series were trapped at the edge of small streams, and that one specimen was captured in a trap set for *S. palustris*. Another was caught along a stream in a trapline that yielded three *S. palustris*. These habitat records suggest that *S. gaspensis* may be more restricted in its habitat preferences and more closely tied to stream-side habitats than *S. dispar*. However, specimens of *S. gaspensis* recently reported from Cape Breton Island, Nova Scotia (Roscoe and Majka, 1976) were captured in rocky, mixed deciduous forest habitats, similar to those described for *S. dispar*.

FOOD HABITS

Three studies have described the food habits of *Sorex dispar*. In Pennsylvania, Richmond and Grimm (1950) found that centipedes were the primary constituent in three stomachs examined. Insects and spiders were present in lesser amounts. The stomachs of six specimens collected in the Great Smoky Mountains contained chiefly insect material with Coleoptera identified in five stomachs and Arachnida in two (Conaway and Pfitzer, 1952). Connor (1960) found that adult Diptera were the primary component of the stomach contents of nine New York *S. dispar*. Other major food items were Orthoptera and spiders. Hamilton and Hamilton (1954) reported beetles and spiders as the principal components of the stomachs of two *S. gaspensis*.

ECOLOGICAL ASSOCIATES, NICHES, AND COMPETITION

The literature and field notes accompanying museum specimens reveal that throughout its range, *Sorex dispar* is consistently captured in association with several species of small mammals having boreal affinities. These are *Sorex cinereus, S. fumeus, Peromyscus maniculatus* (long-tailed races) and *Clethrionomys gapperi*. Two other boreal species trapped less frequently in conjunction with *S. dispar* are *Sorex palustris* and *Microtus chrotorrhinus*. The only consistent non-boreal associate throughout the range of *S. dispar* is *Blarina brevicauda*. In the southern portion of its range, *S. dispar* has been captured with *Neotoma floridana* in New

Jersey (Davis, 1956) and Virginia (Handley, 1956; Holloway, 1957), an association that undoubtedly reflects independent selection of rocky habitats by these species.

Sorex dispar has also been recorded from late Pleistocene cave deposits in Pennsylvania (Guilday, 1970) and Virginia (Guilday et al., 1977). At these sites, ecological associates include, in addition to those previously mentioned, several other boreal species whose ranges are currently disjunct from that of *S. dispar* (e.g., *Sorex arcticus, Phenacomys intermedius, Microtus xanthognathus,* and *Dicrostonyx hudsonius*).

Sorex dispar has been trapped with or found in cave deposits with six other soricids, including four members of the genus *Sorex* (*S. cinereus, S. fumeus, S. arcticus, S. palustris, B. brevicauda,* and *Microsorex thompsoni*). The co-existence of so many ecologically similar species, particularly congeners, raises the question of how these species reduce interspecific competition (MacArthur, 1958). In organisms with high metabolic rates, such as shrews, the successful reduction or avoidance of both interference and exploitative competition for food should bestow considerable selective advantage. Food habit studies of the soricids in question reveal broad similarities in terms of the dietary components of the species but differences in the proportion of food items consumed (Hamilton, 1930, 1941). This suggests that these soricids reduce competition by concentrating their feeding on different portions of the available food spectrum, either a result of behavioral specializations, size, or other anatomical differences.

In assessing the potential for severe interspecific competition between *S. dispar* and the five soricids currently sympatric, four species may be considered relatively unimportant because of substantial size differences. *Blarina brevicauda* and *Sorex palustris* are considerably larger than *S. dispar* in critical measurements of head-body length, condylobasal length, and weight (table 6). Likewise, *S. cinereus* and *M. thompsoni* are considerably smaller and have correspondingly little morphological overlap (table 6). Only *S. fumeus* approximates *S. dispar* in size and general morphology; this to such an extent that in its gray winter pelage, *S. fumeus* may be easily confused with *S. dispar*. Not only is *S. fumeus* morphologically similar to *S. dispar*, but it also occupies the same subterranean cavities and is frequently captured in traps set specifically for *S. dispar*. Thus, on the basis of morphological and ecological similarities, *S. fumeus* appears to be the most important potential interspecific competitor of *S. dispar*.

A comparison of the morphology of these two species reveals that *S. dispar* differs from

TABLE 6
Selected External and Skull Measurements of *Sorex dispar*, *Sorex gaspensis*, and Recent and Pleistocene Sympatric Soricids

	Body Length[a]	Skull Length[b]	Weight[b]
Sorex dispar[c]	48-79 mm.	17.3-19.2 mm.	3.1-8.3 gm.
Sorex gaspensis[c]	45-77 mm.	15.7-17.5 mm.	2.2-4.3 gm.
Sorex arcticus	70-78 mm.	19.2-20.6 mm.	7-11 gm.
Sorex fumeus	66-81 mm.	18.0-18.6 mm.	6-11 gm.
Sorex palustris	74-88 mm.	21.4-22.2 mm.	10-15.5 gm.
Blarina brevicauda	74-100 mm.	20.8-24.8 mm.	12-23 gm.
Microsorex thompsoni	50-67 mm.	15.0-16.5 mm.	2.3-4.0 gm.
Sorex cinereus	55-61 mm.	16.0-17.4 mm.	3.5-5.5 gm.

[a]From Blair et al. (1968).
[b]From Burt (1957).
[c]From present study.

S. fumeus in ways which provide clues to its method of reducing competition for food. *Sorex dispar* is more slender and has a considerably longer tail. The skull of *S. dispar* is more delicately constructed and has a narrower rostrum with slightly more procumbent incisors, particularly in the lower jaw (fig. 5). We believe that these differences permit *S. dispar* to exploit food resources in the narrower and more remote crevices of their subterranean habitats which are not accessible to the more robust *S. fumeus*. These same anatomical specializations would also reduce competition between *S. dispar* and *B. brevicauda* and *S. palustris*, as well as *S. arcticus* during the Pleistocene.

REPRODUCTION

Little is known of the reproductive biology of *Sorex dispar* and *S. gaspensis*. Based on the capture of reproductively active males, the breeding season appears to extend from late April to August. In sexually active male *S. d. dispar*, testes average 5 by 3 mm., whereas those of *S. d. blitchi* are slightly larger and *S. gaspensis* slightly smaller. Pregnant or lactating *S. dispar* have been captured from May through August. Embryo counts are known from only four females. Tate (1935) reported finding two embryos in a specimen from Essex County, New York. Another specimen from Essex Co. collected by Kirkland also carried two embryos. In Pennsylvania, two Jefferson Co. specimens yielded five embryos each (Richmond and Grimm, 1950). No pregnant *S. gaspensis* have been recorded.

Males may be more abundant or more readily trapped than females in both species. Of 211 *S. dispar* of known sex, 124 (58.8%) were males. Likewise, 10 of 17 (58.8%) *S. gaspensis* of known sex were males. Although the differ-

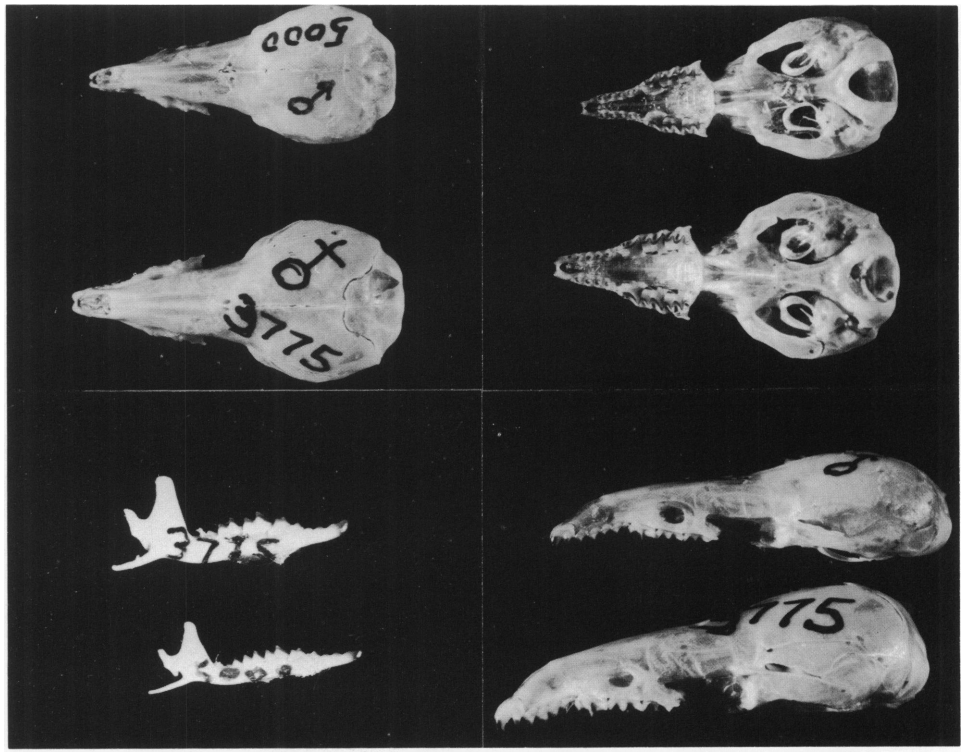

FIG. 5. Skulls of *Sorex dispar* (SSC 5000), a male from Ulster Co., New York and *Sorex fumeus* (SSC 3775), a female from Tucker Co., West Virginia. Clockwise from upper left are dorsal, ventral (*S. dispar* upper skull), lateral views of crania and lateral views of right mandibles.

ence is statistically significant for *S. dispar* ($\chi^2 = 6.48$, $p < .025$), the biological significance cannot be assessed. Too little is known of the behavior of *S. dispar* to preclude the possibility that an unknown factor may bias sampling in favor of males.

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LITERATURE CITED

Anthony, H.E., and G.G. Goodwin
1924. A new species of shrew from the Gaspé peninsula. Amer. Mus. Novitates, no. 109, pp. 1-2.

Banfield, A.W.F.
1974. The mammals of Canada. Toronto, Univ. Toronto Press, 438 pp.

Batchelder, C.F.
1896. An undescribed shrew of the genus *Sorex*. Proc. Biol. Soc. Wash., vol. 10, pp. 133-134.

Blair, W.F., A.P. Blair, P. Brodkorb, F.R. Cagle, and G.A. Moore
1968. Vertebrates of the United States. 2nd ed. New York, McGraw-Hill Book Company, 616 pp.

Burt, W.H.
1957. Mammals of the Great Lakes region. Ann Arbor, Univ. Michigan Press, 246 pp.

Charlesworth, J.K.
1957. The Quaternary Era with special reference to its glaciation. London, Edward Arnold Publishers, Ltd. 2 vol., 1700 pp.

Conaway, C.H., and D.W. Pfitzer
1952. *Sorex palustris* and *Sorex dispar* from the Great Smoky Mountains National Park. Jour. Mammal., vol. 33, pp. 106-108.

Conaway, C.H., and J.C. Howell
1953. Observations on the mammals of Johnson and Carter Counties, Tennessee and Avery County, North Carolina. Jour. Tennessee Acad. Sci., vol. 28, pp. 53-61.

Connor, P.F.
1960. The small mammals of Otsego and Schoharie Counties, New York. N.Y. State Museum and Science Serv. Bull., no. 382, pp. 1-84.

Copeland, M.
1912. Notes on the mammals of Mt. Greylock, Mass. Proc. Biol. Soc. Wash., vol. 25, pp. 157-162.

Davis, J.A.
1956. A first record for *Sorex dispar* in New Jersey, Jour. Mammal., vol. 37, p. 110.

Dice, L.R.
1938. The Canadian biotic province with special reference to mammals. Ecology, vol. 19, pp. 503-514.

Dixon, W.J.
1967. BMD Biomedical Computer Programs. Berkeley, Univ. California Press, Univ. California Publ. in Automatic Computation, no. 2. 600 pp.

Findley, J.S.
1955. Speciation of the wandering shrew. Univ. Kansas Publ., Mus. Nat. Hist., no. 9, pp. 1-18.

Gardner, M.C.
1950. A list of Maryland mammals (Pt. 1, Marsupials and Insectivores). Proc. Biol. Soc. Wash., vol. 3, pp. 65-68.

Gifford, C.L., and R. Whitebread
1951. Mammal survey of Southcentral Pennsylvania. Pittman-Robertson Project 38-R. p. 50.

Goodwin, G.G.
1924. Mammals of the Gaspé Peninsula, Quebec. Jour. Mammal., vol. 5, pp. 246-257.
1929. Mammals of the Cascapedia Valley, Quebec. Ibid., vol. 10, pp. 239-246.

Green, M.M.
1930. A contribution to the mammalogy of the North Mountain region of Pennsylvania. Ardmore, Pa. pp. 1-11.

Grimm, W.C., and H.A. Roberts
1950. Mammal survey of Southwestern Pennsylvania. Pittman-Robertson Project 24-R. pp. 43-44.

Grimm, W.C., and R. Whitebread
1952. Mammal survey of Northeastern Pennsylvania. Pittman-Robertson Project 42-R. pp. 55-56

Guilday, J.E.
1971. The Pleistocene History of the Appalachian Mammal Fauna. pp. 233-262. *In* P.C. Holt (ed.), The distributional history of the biota of the southern Ap-

palachians. Part III. Blacksburg, Virginia Polytechnic Inst. and State Univ., Research Division Monograph, no. 4.

Guilday, J.E., P.W. Parmalee, and H.W. Hamilton
1977. The Clark's Cave bone deposit and the late Pleistocene paleoecology of the central Appalachian Mountains of Virginia. Bull. Carnegie Mus. Nat. Hist., no. 2, pp. 1-87.

Hall, E.R., and K.R. Kelson
1959. The mammals of North America. New York, Ronald Press. 2 Vol. 1083 pp.

Hamilton, W.J., Jr.
1930. The food of Soricidae, Jour. Mammal., vol. 11, pp. 26-39.
1941. The food of small forest mammals in Eastern United States. *Ibid.*, vol. 22, pp. 250-263.

Hamilton, W.J. Jr., and W.J. Hamilton III
1955. The food of some of the small mammals from the Gaspé Peninsula, P.Q. Canadian Field Nat., vol. 68, pp. 108-109.

Handley, C.O.
1956. The shrew, *Sorex dispar*, in Virginia. Jour. Mammal., vol. 37, p. 435.

Harper, F.
1929. Notes on the mammals of the Adirondacks. New York State Museum Handbook, no. 8, pp. 51-118.

Holloway, H.L.
1957. *Sorex dispar* at Mountain Lake, Virginia. Jour. Mammal., vol. 38, p. 406.

Howell, A.H.
1911. Capture of *Sorex dispar* in West Virginia. Proc. Biol. Soc. Wash., vol. 24, pp. 98-99.

Jackson, H.H.T.
1928. A taxonomic review of the American long-tailed shrews (genera *Sorex* and *Microsorex*). North Amer. Fauna, no. 51. 238 pp.

Kirk, G.L.
1916. The mammals of Vermont. Joint Bull., no. 2. Vermont Botanical and Bird Clubs. pp. 28-34.

Kirkland, G.L. Jr., C.R. Schloyer, and D.K. Hull
[In press]. A novel habitat record for the long-tailed shrew, *Sorex dispar*. Proc. West Virginia Acad. Sci., vol. 48.

Lincoln, A. Jr.
1935. *Sorex dispar* in New Hampshire. Jour. Mammal., vol. 16, p. 223.

Linzey, A.V., and D.W. Linzey
1971. Mammals of the Great Smoky Mountains National Park. Knoxville, Univ. Tennessee Press. 114 pp.

Lowman, G.E.
1975. A survey of endangered, threatened, rare, status undetermined, peripheral and unique mammals of the Southeastern National Forest and Grasslands. Dept. Agric., Forest Service. pp. 22-24.

MacArthur, R.H.
1958. Population ecology of some warblers of the northeastern coniferous forests. Ecology, vol. 19, pp. 599-619.

Mansueti, R., and V.F. Flyger
1952. Long-tailed shrew (*Sorex dispar*) in Maryland. Jour. Mammal., vol. 33, p. 250.

Mather, D.W.
1933. Gray long-tailed shrew from New Hampshire. Jour. Mammal., vol. 14, p. 70.

McKeever, S.
1951. A survey of West Virginia mammals. Conserv. Comm. West Virginia. 126 pp.

Mearns, E.A.
1898. Notes on the mammals of the Catskill Mountains, New York, with general remarks on the fauna and flora of the region. Proc. U.S. Natl. Mus., vol. 21, pp. 341-360.

Mezhzherin, V.A.
1964. Dehnel's phenomenon and its possible explanation. (In Russian with English summary). Acta Theriologica, vol. 8, pp. 95-114.

Mohr, C.E.
1931. Preliminary report on the mammals of Pennsylvania. Proc. Pennsylvania Acad. Sci., vol. 5, pp. 17-27.

Nie, N.H., C.H. Hull, J.G. Jenkins, K. Steinbrenner and D.H. Bent
1975. Statistical Package for the Social Sciences, 2nd ed. New York, McGraw-Hill Book Co. 675 pp.

Osgood, F.L.
1935. Four Vermont records of the big-tailed shrew. Jour. Mammal., vol. 16, p. 146.
1938. The mammals of Vermont. *Ibid.*, vol. 19, pp. 435-441.

Paradiso, J.L.
1960. Maryland shrews. Maryland Nat., vol. 29, pp. 9-11.

Peterson, R.S., and A. Symansky
1963. First record of the Gaspé shrew from New Brunswick. Jour. Mammal., vol. 44, pp. 278-279.

Peterson, R.L.
1966. The mammals of eastern Canada. Cambridge, Oxford Univ. Press. 465 pp.
Poole, E.L.
1932. A survey of the mammals of Berks County, Pennsylvania. Reading Publ. Mus. and Art Gallery Bull., no. 13, pp. 1-74.
Preble, N.A.
1937. *Sorex dispar* in New Hampshire. Jour. Mammal., vol. 18, p. 95.
Richmond, N.D. and H.R. Roslund
1949. Mammal survey of Northwestern Pennsylvania. Pittman-Robertson Project 20-R. p. 38.
Richmond, N.D., and W.C. Grimm
1950. Ecology and distribution of the shrew *Sorex dispar* in Pennsylvania. Ecology, vol. 31, pp. 279-282.
Roberts, A.A., and R.C. Early
1952. Mammal survey of Southeastern Pennsylvania. Pittman-Robertson Project 43-R. pp. 44-45.
Roscoe, B., and C. Majka
1976. First records for the rock vole (*Microtus chrotorrhinus*) and the Gaspé shrew (*Sorex gaspensis*) from Nova Scotia and second record of the Thompson's pygmy shrew (*Microsorex thompsoni*) from Cape Breton Island. Canadian Field Nat., vol. 90, pp. 497-498.
Roslund, H.R.
1951. Big-tailed shrew, *Sorex dispar*. Mammal survey of Northcentral Pennsylvania. Pittman-Robertson Project 37-R. p. 39.
Schwartz, A.
1956. A new subspecies of the longtailed shrew (*Sorex dispar dispar* Batchelder) from the Southern Appalachian Mountains. J. Elisha Mitchell Sci. Soc., vol. 72, pp. 24-30.
Siegel, S.
1956. Non-parametric statistics for the behavioral sciences. New York, McGraw-Hill Book Co. 312 pp.
Sokal, R.R., and F.J. Rolf
1969. Biometry. The principles and practice of statistics in biological research. San Francisco, W.H. Freeman and Co. 776 pp.
Starrett, A.
1954. Longtail shrew, *Sorex dispar*, in Maine. Jour. Mammal., vol. 35, pp. 583-584.
Stormer, F.A.
1968. Factors affecting the distribution and abundance of *Peromyscus leucopus* and *Clethrionomys gapperi* in mixed oak forests of central Pennsylvania. Ms. thesis, Pennsylvania State Univ. 83 pp.
Tate, G.H.H.
1935. Observations on the big-tailed shrew (*Sorex dispar* Batchelder). Jour. Mammal., vol. 16, pp. 213-215.
Whitaker, J.O., Jr.
1970. The biological subspecies: an adjunct of the biological species. The Biologist, vol. 52, pp. 12-15.
Wilson, L.W., and J.E. Friedel
1942. A list of mammals collected in West Virginia. Proc. West Virginia Acad. Sci., vol. 15, pp. 85-92.