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Blarina hylophaga (Soricomorpha: Soricidae)

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Abstract: *Blarina hylophaga* (Elliot, 1899) is a soricid commonly called Elliot's short-tailed shrew. A short-legged, robust shrew with a long, pointed snout and a short tail; it is 1 of 4 species in the genus *Blarina*. It occurs throughout most of the Great Plains of the United States, where it inhabits moist, well-drained grassland and riparian areas with deep leaf litter. It is listed as a species of greatest conservation need in Iowa and at possible risk in Texas, which might be due to the limited knowledge of the species throughout its geographic range.

Key words: Elliot's short-tailed shrew, insectivore, North America, shrew, venomous mammal

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Blarina hylophaga (Elliot, 1899)
Elliot's Short-tailed Shrew

Blarina brevicauda hulophaga Elliot, 1899:287. Type locality "Dougherty, Indian Territory." (= Dougherty, Murray Co., Oklahoma, USA).
Blarina [(*Blarina*)] *brevicauda hylophaga* Elliot, 1905:461. Justified emendation of *Blarina brevicauda hulophaga* Elliot, 1899:287.
Blarina brevicauda carolinensis: Blair, 1939:99. Not *Sorex carolinensis* Bachman, 1837.
Blarina carolinensis carolinensis: Genoways and Choate, 1972:114. Name combination; not *Sorex carolinensis* Bachman, 1837.
Blarina hylophaga: George, Choate, and Genoways, 1981:503. First use of current name combination.
Blarina hylophaga hylophaga: George, Choate, and Genoways, 1981:504. First use of current name combination.
Blarina hylophaga plumbea: George, Choate, and Genoways, 1981:510. First use of current name combination.

CONTEXT AND CONTENT. Order Soricomorpha, family Soricidae, subfamily Soricinae, tribe Blarinini (Hutterer 2005; Repenning 1967). The genus *Blarina* includes 4 species found only in North America: *B. brevicauda*, *B. carolinensis*, *B. hylophaga*, and *B. shermani* (Benedict et al. 2006). The following 2 subspecies of *B. hylophaga* are recognized (George et al. 1981; Jones et al. 1984):

B. h. hylophaga (Elliot, 1899:287). See above.
B. h. plumbea (Davis, 1941:317). Type locality "one-half mile west of Mariano Mill, Arnasas National Wildlife Refuge, Aransas County, Texas."

NOMENCLATURAL NOTES. Until recently, *B. hylophaga* was listed as a subspecies of *B. brevicauda* and subsequently *B. carolinensis* (Blair 1939; Elliot 1899, 1905; Genoways and Choate 1972; George et al. 1981; Schmidly and Brown 1979). Therefore, an extensive literature search was conducted to find current citations of the name *B. hylophaga* and the

Fig. 1.—An adult male *Blarina hylophaga* from Kansas: Ellis Co.; 9¼ mi. N, 3¼ mi. W Hays, T12S, R19W, E center sec. 14; 39.01055°N, 99.39038°W. Photographed by C. W. Thompson.

*Deceased

previous synonyms in the localities set by George et al. (1981). All literature that is known currently for *B. hylophaga* is thought to have been included in this monograph.

The origin of the scientific name, *B. hylophaga*, is not known fully. The origin of *Blarina* is unknown. However, the specific epithet, *hylophaga*, means wood-eater, which has been correlated to its habitat (Schwartz and Schwartz 2001).

DIAGNOSIS

Blarina hylophaga (Elliot's short-tailed shrew [Fig. 1]) is a medium-sized species of the genus *Blarina* (Choate et al. 1994; Jones et al. 1985; Jones and Birney 1988; Jones and Glass 1960). *B. hylophaga* typically is smaller in size than *B. brevicauda* (northern short-tailed shrew—Davis 1941; Genoways and Choate 1972; Kays and Wilson 2002; Schwartz and Schwartz 2001) and *B. shermani* (Sherman's short-tailed shrew—Benedict et al. 2006), and larger than *B. carolinensis* (southern short-tailed shrew—Jones et al. 1985; Jones and Birney 1988; Jones and Glass 1960; Schmidly and Brown 1979). Several authors have presented the external measurements of the 4 species, but the measurements of *B. hylophaga* overlap with those of the other 3 species to some extent (Benedict 1999a, 1999b; Bowles 1975; Davis and Schmidly 1994; Ellis et al. 1978; Genoways and Choate 1972; Jones et al. 1985; Kays and Wilson 2002; Schmidly 2004); therefore, external measurements are not reliable in defining each species. Cranial measurements of *B. hylophaga* also overlap those of other species in the genus (Benedict 1999a, 1999b; Benedict et al. 2006; Ellis et al. 1978; Genoways and Choate 1972; George et al. 1981; Jones and Findley 1954; Moncrief et al. 1982; Stangl and Carr 1997) and are not a particularly useful tool to distinguish among the 4 species. However, the dentaries might be a useful exception. Generally, *B. hylophaga* and *B. carolinensis* have smaller dentaries (height of coronoid process $\leq$ 6.0 mm; length of c1–m3 $\leq$ 6.5 mm; length of coronoid–condyloid process $<$ 5.0 mm) than *B. brevicauda* (height of coronoid process $\geq$ 6.0 mm; length of c1–m3 $\geq$ 6.5 mm; length of coronoid–condyloid process $\geq$ 5.2 mm). To differentiate between *B. hylophaga* and *B. carolinensis*, the angle of the 1st lower incisor from the horizontal ramus is greater in *B. hylophaga* ($\geq$18°) than *B. carolinensis* ($\leq$ 17°—Carraway 1995; Fig. 2).

The distinction in geographic ranges offers some assurance as to differentiating the species (Benedict 1999a, 1999b; Genoways and Choate 1972; George et al. 1981, 1982; Moncrief et al. 1982). The geographic range of *B. hylophaga* generally lies south and west of *B. brevicauda* and *B. carolinensis* (Fig. 3), respectively (Jones et al. 1984; Schmidly 1983). However, a parapatric contact zone occurs in areas of southwestern Iowa (Benedict 1999a, 1999b; Bowles 1975; Thompson 2008), northeastern Kansas (Thompson 2008), southern Nebraska (Benedict 1999a, 1999b; Genoways and Choate 1972; Jones 1960; Jones and Findley 1954; Jones and Glass 1960), and northwestern Missouri (Thompson 2008) with *B. brevicauda* and in northwestern Arkansas (Garland and Heidt 1989; Sealander 1979; Sealander and Heidt 1990), northeastern Louisiana (George et al. 1981), southeastern Missouri (Schwartz and Schwartz 2001), and Texas (Baumgardner et al. 1992; Schmidly and Brown 1979) with *B. carolinensis*. In these areas, geographic range should not be used as an identification tool.

Fig. 2.—Dorsal, ventral, and lateral views of skull and lateral view of mandible of an adult female *Blarina hylophaga* (TTU [Natural Science Research Laboratory, Museum of Texas Tech University] 26163) from Kansas: Ellis Co.; 15 mi. N, 7 mi. W Hays, T11S, R19W, SW ¼ sec. 16. Greatest length of skull is 22.75 mm.

The best identification tool for species of *Blarina* is karyotypic analysis (Caire et al. 1989; Choate et al. 1994; George et al. 1982; Kays and Wilson 2002; Moncrief et al.

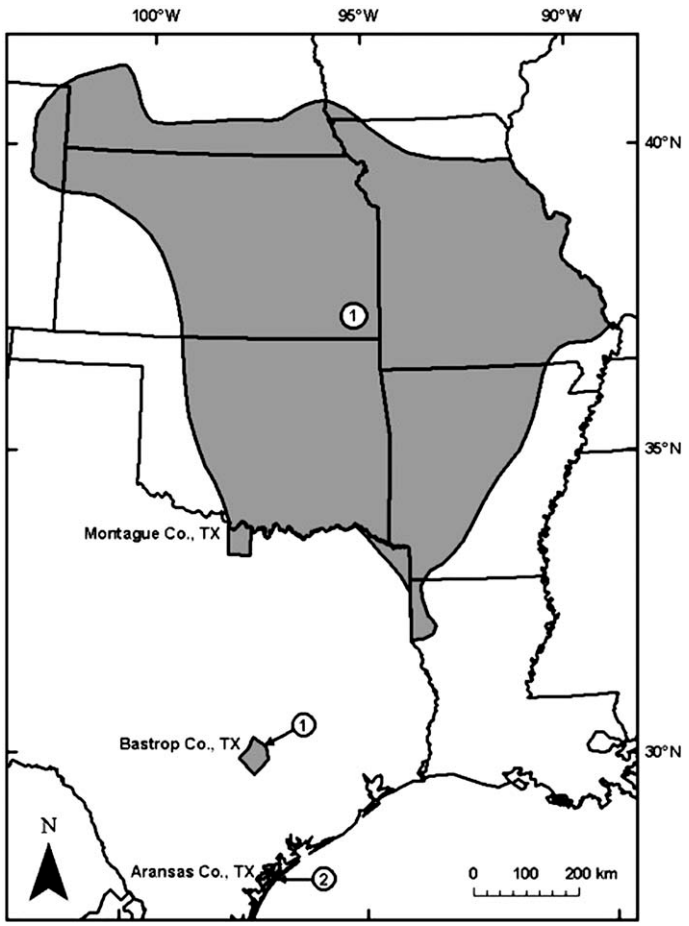

Fig. 3.—Geographic distribution of *Blarina hylophaga*. Subspecies are: 1, *B. h. hylophaga* and 2, *B. h. plumbea*. Map redrawn from Armstrong (1972), Benedict (1999a, 1999b), Bowles (1975), Choate et al. (1994), Genoways and Choate (1972), George (1981), Moncrief et al. (1982), Reilly et al. (2005), and Sealander (1979) with modifications.

1982; Schmidly 2004) and through molecular genetic analysis (Benedict 1999a; Brant and Ortí 2002; Reilly et al. 2005). *B. hylophaga* has a diploid number (2n) of 52 chromosomes and a fundamental number (FN) of 62, 61, or 60 (Davis and Schmidly 1994; Genoways et al. 1977; George et al. 1981, 1982). In comparison, *B. carolinensis* has a karyotype of 2n = 46 and FN = 44 across most of its range (George et al. 1982). However, 2 subspecies of *B. carolinensis* have a different karyology: *B. c. minima* in Tennessee (2n = 40, 39, 38, 37, 36, 35, or 34 and FN = 45, 44, 43, 42, or 41—Beck et al. 1991; Elrod 1992; Elrod et al. 1996; George et al. 1982; Qumsiyeh et al. 1997) and *B. c. peninsulae* in Florida (2n = 52, 51, or 50 and FN = 52—George et al. 1982). *B. brevicauda* has a karyotype of 2n = 48, 49, or 50 and FN = 48 (Genoways et al. 1977; George et al. 1982; Thompson and Hoffman 2009). No karyological data exist for *B. shermani* (Benedict et al. 2006). In comparisons of the mitochondrial cytochrome-*b* gene (*Cytb*), *B. hylophaga* and *B. brevicauda* had 9.4% in differences of base pairs, whereas *B. hylophaga* and *B. carolinensis* had 7.1% in differences of base pairs (Brant and Ortí 2002).

GENERAL CHARACTERS

Blarina hylophaga is described as being short-legged, robust, and having a long, pointed snout (Caire et al. 1989; Dalquest and Horner 1984; Davis 1974; Fitzgerald et al. 1994). *B. hylophaga* also has a short tail (20.65–22.31% of total length), which forms the basis of the common name of the genus (Dalquest and Horner 1984). The species decreases in size from north to south (Cockrum 1952; Genoways and Choate 1972; George et al. 1981; Jones and Glass 1960; Schmidly and Brown 1979). Vibrissae on the snout are conspicuous, ears are inconspicuous, and eyes are tiny (Davis and Schmidly 1994; Fitzgerald et al. 1994; Schmidly 2004). In some cases, the eyes lack developed or functional eyelids (Jones et al. 2007). The fur is described as being soft and velvety (Caire et al. 1989; Dalquest and Horner 1984), ranging from plumbeous to brown in color (Blair 1939; Fitzgerald et al. 1994; Jones and Glass 1960; Schmidly and Brown 1979). The teeth are red-pigmented (Caire et al. 1989; Dalquest and Horner 1984; Fitzgerald et al. 1994).

Ranges of external measurements (mm or g) of *B. hylophaga* are: total length, 92–121 mm; length of tail, 19–27 mm; length of hind foot, 11–19 mm; and body mass, 13–16 g (Kays and Wilson 2002; Schlitter and Bowles 1967; Schwartz and Schwartz 2001). Ranges (mm) of selected skull measurements (Fig. 2; Benedict 1999a; Bowles 1975; Davis 1941; Jones and Glass 1960; Schmidly and Brown 1979) are cranial breadth, 10.32–13.80; interorbital breadth, 5.18–6.20; length of p4–m3, 5.4–5.9; maxillary breadth, 6.79–7.80; condylobasal length, 12.9–21.8; and mandibular length, 6.03–6.17. Secondary sexual dimorphism does not contribute to any morphological variation within the genus (Bee et al. 1981; Graham and Semken 1976).

Comparing the subspecies, George et al. (1981) noted that *B. h. plumbea* was identical morphologically to southern populations of *B. h. hylophaga*. However, Davis (1941) and Schmidly and Brown (1979) previously noted that a few cranial characteristics differ between the 2 subspecies. Davis (1941:318) found the posterior border of palate to arch higher anterodorsally in *B. h. plumbea* (in *B. h. hylophaga* it is straight or slightly arched) and to have "posterior projections of maxillae terminating on a plane with, or anterior to, the posterior edges of m^2." Schmidly and Brown (1979) noted that cranial breadth and height of the mandible are larger in *B. h. plumbea* than in *B. h. hylophaga*. However, cranial measurements of *B. h. hylophaga* and *B. h. plumbea* overlap (Davis 1941; Schmidly and Brown 1979). Davis (1941) and Schmidly and Brown (1979) also observed that *B. h. plumbea* was paler (plumbeous, rather than brownish) than *B. h. hylophaga*.

DISTRIBUTION

Blarina hylophaga (Fig. 3) occurs throughout most of the Great Plains of the United States (Dalquest and Horner 1984; George et al. 1981, 1982; Jones et al. 1985; Jones and Birney 1988). *B. hylophaga* forms a contact zone with *B. brevicauda* in the northern expanse of the distribution of *B. hylophaga* in southern Nebraska (Benedict 1999a, 1999b; Genoways and Choate 1972; Jones 1960; Jones and Findley 1954; Jones and Glass 1960). The contact zone with *B. brevicauda* extends into southern Iowa, northeastern Kansas, and in northern Missouri (Moncrief et al. 1982). Other researchers limit the extent of the species to extreme southwestern Iowa (Benedict 1999b; Bowles 1975; Findley et al. 1954; Schlitter and Bowles 1967; Thompson 2008). The northern end of the range extends west across southern Nebraska to extreme northeastern Colorado, where the species is rare (Armstrong 1972; Fitzgerald et al. 1994; Jones and Loomis 1954).

The geographic range extends south to the northern and central part of eastern Texas, with isolated populations of *B. h. hylophaga* and *B. h. plumbea* occurring within Bastrop and Montague counties (Baumgardner et al. 1992; Dalquest and Horner 1984; Reilly et al. 2005; Schmidly 2004) and on the Aransas National Wildlife Refuge in Aransas County, respectively (Davis 1974; George et al. 1981; Hall 1981; Halloran 1966; Hice and Schmidly 2002; Schmidly and Brown 1979; Stangl and Carr 1997). The southeastern extent of the geographic range occurs into northwestern Louisiana (Choate et al. 1994; George et al. 1981). Between the latitudinal extremes of *B. hylophaga*, the subspecies is noted as occurring in most of Oklahoma (Blair 1939; Caire et al. 1989; Glass and Halloran 1961; Haner et al. 1999; Hays 1958; Jones and Glass 1960; Stangl and Carr 1997; Stangl et al. 1992), Kansas (Anderson and Fleharty 1967; Cockrum 1952; Finck et al. 1986; Fleharty and Hulett 1988; Hall 1955; Jones and Findley 1954; Pitts et al. 1987), most of Missouri (George et al. 1981), and northwestern Arkansas (Garland and Heidt 1989; Sealander 1979; Sealander and Heidt 1990). The southern and most eastern expanses of *B. hylophaga* come into contact with the range of *B. carolinensis* (Baumgardner et al. 1992; George et al. 1981; Schmidly and Brown 1979; Sealander and Heidt 1990).

FOSSIL RECORD

The origin of *Blarina hylophaga* possibly stems from recent speciation events. The fossil record suggests that an ancestral *Blarina* species arose in the middle or late Pliocene (Jones et al. 1984). *B. brevicauda* was separated 1st in the early Pleistocene during the Irvingtonian, creating a northern population that became *B. brevicauda* and a southern population (Genoways and Choate 1972; Graham and Semken 1976; Jones et al. 1984). The southern population was then separated shortly after the Wisconsinan glaciation to form an eastern population, known today as *B. carolinensis*, and a western population, currently known as *B. hylophaga*, which appeared 1st in the fossil record (late Wisconsinan–early Holocene) in Missouri and Texas (Jones et al. 1984). No fossil evidence for *B. shermani* exists (Benedict et al. 2006).

The separation of *B. hylophaga* into its subspecies could be attributed to climate warming and retreat of *Blarina* eastward in southern Texas during the late Pleistocene. The increased continentality of the climate in recent times led to the current distribution of extant *Blarina* species (Graham and Semken 1976). Therefore, the relict population of *B. h. plumbea* could have remained intact due to favorable conditions on the central Texas Gulf Coast (Reilly et al. 2005; Schmidly and Brown 1979). However, a population of *B. hylophaga* might have moved southwestward recently to find the conditions of the present day Aransas National Wildlife Refuge to be favorable enough to persist (Schmidly and Brown 1979). Regardless of the means of separation, Schmidly and Brown (1979) suggest that the isolation of the population of *B. h. plumbea* to have occurred only 1,000 years ago.

Fossil evidence of *B. hylophaga* is found in a number of local faunas. Fossils of *Blarina* were found in the Blancan, Irvingtonian, and Rancholabrean faunas (Jones et al. 1984), corresponding to high vole diversity (Graham and Semken 1976). The Rancholabrean yielded most of the local faunas that included *B. hylophaga*. Those Rancholabrean local faunas included Ben Franklin (Delta County, Texas), Crankshaft Cave (Jefferson County, Missouri), Klein Cave (Kerr County, Texas), Miller's Cave (Llano County, Texas), Red Rodgers Site (Briscoe County, Texas), and Schulze Cave (Edwards County, Texas). The Irvingtonian included only the Kentuck (McPherson County, Kansas) local fauna as a possible site of fossils of *B. hylophaga* (Jones et al. 1984).

FORM AND FUNCTION

The dental formula for *Blarina* is i 3/1, c 1/1, p 3/1, m 3/3, total 32 (Choate 1968; Sealander and Heidt 1990). Dental abnormalities that are attributed to subnumerary complements of unicuspids, displaced unicuspids, or diminutive unicuspids are found in 9.9% of *B. hylophaga*. Musculature of the jaw is not correlated significantly to decreasing age, which might be due to a diet of softer foods or a change to a softer diet with increasing age not seen in its congener *B. brevicauda* (Choate 1968). Ritzi et al. (2005) found contradicting evidence, with beetles being the primary food source (50.3%) of *B. hylophaga* in Kansas. The same was found for mass of the masticatory musculature (Verts et al. 1999). *B. hylophaga* also was noted to be slightly venomous, enabling it to subdue larger prey (Bee et al. 1981; Dalquest and Horner 1984; Davis and Schmidly 1994; Schmidly 2004);

however, the certainty of this claim is unknown (Verts et al. 1999).

Findley and Jones (1956) reported on the molt of the genus *Blarina*. Newborns were found to be hairless. Juvenile pelage was described as being fuzzy and retained until adult size was reached. Upon reaching adult size, young short-tailed shrews go through a postjuvenile molt that begins anteriorly and moves posteriorly. Timing of birth determines what type of adult pelage individuals will develop. Spring molt into the summer pelage varies among the sexes of adult *Blarina*, with females following a continuous pattern from the head to the posterior end and 2nd-year males having an irregular pattern that arises from anywhere on the body. Spring molt was found to begin in specimens collected in February, March, April, May, and July. Autumn molt, which creates winter pelage, differs from the spring molt because it begins from the posterior end and moves toward the head. Autumn molt was noted to have occurred in specimens that were taken in October and November. In all molting patterns, molting was completed from the dorsal side to the ventral side (Findley and Jones 1956).

ONTOGENY AND REPRODUCTION

The life span of *Blarina hylophaga* in the southern tip of the distribution (Texas) averaged 8 months (Schmidly 2004) to 2 years (Dalquest and Horner 1984; Davis and Schmidly 1994). Two-year life spans also were found to occur in Kansas (Bee et al. 1981). The sexes remain solitary until breeding season, which occurs during the early spring and late summer. Gestation periods last about 21–22 days (Bee et al. 1981). Examination of placental scar data indicates that reproductive tract activity was balanced only 58% of the time (Baird and Birney 1985). In Kansas, a nest contained a litter of 6 half-grown young (Cockrum 1952). In Texas, litter sizes ranged from 4 to 6 young (Dalquest and Horner 1984; Davis and Schmidly 1994), but Schmidly (2004) found 6 or 7 young per litter. *B. hylophaga* also is noted to produce 2 or 3 litters in a year in Texas (Davis and Schmidly 1994), but 1 or 2 litters is probably the average (Schmidly 2004). Cockrum (1952) also made observations in Kansas showing the possibility of multiple litters by finding a nest of *B. hylophaga* in April and by capturing a lactating female in August of the same year. Anderson and Fleharty (1967) confirmed these results by finding lactating females from June to September. Young are hairless at birth (Bee et al. 1981; Findley and Jones 1956) and at approximately 1 month are weaned (Schmidly 2004) and fully haired (Findley and Jones 1956).

ECOLOGY

Population characteristics.—Density of *Blarina hylophaga* varies annually (Clark et al. 1995) and seasonally (D. W. Kaufman et al. 1990). In some Kansas sites, *B. hylophaga* was the most common small mammal (Brillhart et al. 1995; Clark et al. 1989; D. W. Kaufman et al. 1990); however, abundance seems to be seasonal, with higher abundance occurring in autumn and lower abundances in spring (Matlack et al. 2002). Sex ratios have been found to not differ significantly (Clark et al. 1995; Swihart and Slade 1990). *B. hylophaga* also is found to increase in abundance with an increase in precipitation, soil moisture, and litter depth, and decrease in abundance with an increase in temperature (Cable and Cook 1999; G. A. Kaufman and Kaufman 1997; Matlack et al. 2002). However, G. A. Kaufman and Kaufman (1997) did not find vegetation height to affect spring abundances. A correlation between increasing temperatures in the summer and decreasing abundances was found. After a flooding event in Missouri along the Missouri River, *B. hylophaga* decreased significantly in abundance (Williams et al. 2001). G. A. Kaufman and Kaufman (1997) suggested that changes in abundance and distribution could occur with global warming. *B. hylophaga* also was in low abundance at the Tar Creek Superfund Site in Ottawa County in northeastern Oklahoma (Phelps and McBee 2009).

In general, *B. hylophaga* is a fire-negative species (D. W. Kaufman et al. 1990). Controlled burns in autumn produce long-term decreases in abundance of *B. hylophaga* (D. W. Kaufman et al. 1990; Matlack et al. 2002; McMillan et al. 1995); whereas, spring burns produce short-term decreases in abundance of *B. hylophaga* (Clark and Kaufman 1990b; Matlack et al. 2001). However, populations of *B. hylophaga* are unexpectedly higher in the autumn after spring controlled burns in Kansas (D. W. Kaufman et al. 1989; Matlack et al. 2001). Controlled burns that were maintained to create a patchy framework of annual burned and nonburned habitat did not influence activity of *B. hylophaga* (Brillhart et al. 1995), and in fact, movements increased into unburned areas (Clark et al. 1989; D. W. Kaufman et al. 1990; G. A. Kaufman and Kaufman 1997). Grazed and burned habitats are avoided, whereas abundances of *B. hylophaga* are high in ungrazed and unburned areas (Clark et al. 1989, 1995; G. A. Kaufman and Kaufman 1997, 2008; Matlack et al. 2001). The abundance of *B. hylophaga* also seems to respond negatively to agricultural disturbance (i.e., haying and plowing) when compared to unhayed native prairie (G. A. Kaufman and Kaufman 2008; Sietman et al. 1994).

Blarina hylophaga has been reported to travel 270 m in 6 days and 280 m in 8 weeks (Choate and Fleharty 1973). Benedict (1999a, 1999b) indicated that *B. hylophaga* did not cross highways, streets, or streams. Home ranges of 3 individuals of *B. hylophaga* were established by multiple trappings, and the individual home ranges were found to be 0.55 ha, 0.46 ha, and 0.06 ha (Choate and Fleharty 1973). Differences in home ranges occur between the sexes, with males (0.26 ha) having a significantly larger home range than females (0.14 ha—Clark et al. 1995). Movement peaks during

crepuscular times, regardless of season (Anderson and Fleharty 1967).

Space use.—*Blarina hylophaga* is described as being a habitat generalist, occurring mostly in moist, well-drained areas and moist stream valleys (Bee et al. 1981; Finck et al. 1986; Hibbard 1963; D. W. Kaufman et al. 1983, 2000; Matlack et al. 2002). Finck et al. (1986) noted cultivated lands as being poor habitat for *B. hylophaga*. *B. hylophaga* also is found in several habitats with dense vegetation, including road ditches, riparian communities, windbreaks, nongrazed grasslands, old fields, native prairies, and hayfields (Anderson and Fleharty 1967; Cable and Cook 1999; Choate and Fleharty 1975; Fleharty and Channell 1997; Hopton and Choate 2002; D. W. Kaufman et al. 1993, 2000; G. A. Kaufman and Kaufman 2006; Laakkonen and Brant 2005; Sietman et al. 1994).

However, in Colorado, *B. hylophaga* was collected in dry, sandy substrates with dense vegetation (Fleharty and Channell 1997; Jones and Loomis 1954). In Kansas, *B. hylophaga* has been observed to extensively use fencerows (D. W. Kaufman and Kaufman 1989). *B. hylophaga* also is known to occur in woodland habitats (Blair 1939; Choate and Fleharty 1975; Finck et al. 1986; Haner et al. 1999; Hays 1958; D. W. Kaufman et al. 1993; Matlack et al. 2008) with extensive amounts of ground litter (Anderson and Fleharty 1967; Bee et al. 1981; Choate and Fleharty 1973; Clark et al. 1989; Matlack et al. 2002), considerable soil depth (Glass and Halloran 1961), and under log piles (Pitts et al. 1987). Overall, *B. hylophaga* shows a preference for lowland habitat over upland habitat in Kansas (Choate and Fleharty 1975; Clark et al. 1995; G. A. Kaufman and Kaufman 1997; G. A. Kaufman et al. 1995).

In Texas, *B. hylophaga* is found generally in grassy areas with pines and in grassy areas with oak trees (Baumgardner et al. 1992; Davis and Schmidly 1994; Schmidly 2004). Baumgardner et al. (1992) also noted that *B. hylophaga* occurred in sandy areas with little ground litter. Similarly, *B. h. plumbea* is found to inhabit sandy areas of live-oak shinnery and a live-oak grove with little or no ground cover in the Aransas National Wildlife Refuge in Aransas County, Texas (Davis 1941, 1974; Davis and Schmidly 1994; Hice and Schmidly 2002). Other captures in the refuge were made in dense ground litter and grass along with red bay (*Persea borbonia*), dwarf live oak (*Quercus virginiana*), and seacoast bluestem (*Schizachyrium littorale*—Halloran 1966).

Diet.—The diet of *Blarina hylophaga* consists primarily of insects but also snails, millipedes, earthworms, and grubs (Anderson and Fleharty 1967; Bee et al. 1981; Davis and Schmidly 1994), and also includes some plant material (Caire et al. 1989) and mice (Davis and Schmidly 1994). An examination of 25 stomachs of a Kansas population found that the diet of *B. hylophaga* consisted of 61.6% insects, with 50.3% of this volume consisting of beetles. Slugs and spiders constituted 21.2% and 7.3% of the diet, respectively. Other materials consisted of small percentages of the North American deermouse (*Peromyscus maniculatus*), plants, and fungi. Percentages of the diet of other *Blarina* species were noted as being similar, with the exception of higher percentages of earthworms in *B. brevicauda* and fungi in *B. carolinensis*. Beetles also appear to be found more often in the diet of *B. hylophaga* (Ritzi et al. 2005). Within a 24-h period, *B. hylophaga* generally eats half of its body mass (Bee et al. 1981).

Diseases and parasites.—A total of 24 species of ectoparasites have been associated with *Blarina hylophaga* of which 16 are shared with *B. carolinensis*, 21 with *B. brevicauda*, and 15 are shared among all 3 *Blarina* species (Poorbaugh and Gier 1961; Ritzi et al. 2005). Those species found exclusively on *B. hylophaga* include: *Geomylichus texana*, *Neotrombicula fitchi*, and *Mycoptes musculinus*. *B. hylophaga* also tends to be infested more often than other species of *Blarina* with the flea *Corrodopsylla curvata* (Poorbaugh and Gier 1961; Ritzi et al. 2005), glycyphagid mites (*Glycypagus hypudaei* and *Orycteroxenus soricis*), laelapid mites (*Androlaelaps fahrenholzi*, *Echinonyssus blarinae*, and *Haemogamasus liponyssoides*), listrophorid mites (*G. texana* and *Olistrophorus blarina*), myobiid mites (*Blarinobia simplex* and *Protomyobia blarinae*), a myocoptid mite (*Mycoptes musculinus*), and a pygmephorid mite (*Pygmephorus whitakeri*—Ritzi et al. 2005; Whitaker et al. 2007). Other flea species found on *B. hylophaga* include *Ctenophthalmus pseudagyrtes*, *Rhadinopsylla* (*Rectofrontia*) *fraterna*, and *Stenoponia americana* (Poorbaugh and Gier 1961).

Endoparasites, trematodes (Barger and Hnida 2008), and nematodes (Brant 2005; Laakkonen and Brant 2005) have been associated with *B. hylophaga*. Two species of trematodes, *Brachylaima thompsoni* and *Panopistus pricei*, occur in the posterior half of the small intestine of *B. hylophaga*. Both species occur within the gastropod species *Neohelix albolabris* and *Webbhelix multilineata*, which probably are prey species of *B. hylophaga* in southeastern Nebraska (Barger and Hnida 2008). The parasitic nematode *Longistriata* (Trichostrongyloidea: Heligmosomidae) occurs across soricid shrews (Brant 2005). *Longistriata caudabullata* was found in 60% of individual *B. hylophaga* sampled in southern Nebraska (Brant and Ortí 2003). In addition, *L. blarinae* occurs in *B. hylophaga* (Brant 2005). Lung nematodes (Metastrongyloidea) also occur readily in *B. hylophaga* (Laakkonen and Brant 2005).

Brant and Ortí (2003) and Brant (2005) analyzed the coevolutionary relationship among parasitic nematodes (*Longistriata*) and their *Blarina* hosts. *L. caudabullata* occurred with no morphological variation or phylogeographic differences across the contact zone between *B. brevicauda* and *B. hylophaga*, possibly as a result of secondary contact or host-switching (Brant 2005; Brant and Ortí 2003). In addition, *Longistriata blarinae* was found in all species of *Blarina*. *B. hylophaga* did not have a unique

nematode, unlike the other *Blarina* species analyzed (Brant 2005).

Interspecific interactions.—In Kansas (Cockrum 1952), Nebraska (Gubanyi et al. 1992), Oklahoma (Glass and Halloran 1961), and Texas (Baker 1991), barn owl (*Tyto alba*) pellets have revealed remains of *Blarina hylophaga*, as have the pellets of unknown owls (Strigiformes) in Nebraska (Huebschman et al. 2000). Hawks (Falconiformes—Bee et al. 1981), snakes (Serpentes—Bee et al. 1981; Dalquest and Horner 1984), and swift fox (*Vulpes velox*—Sovada et al. 2001) also are predators of *B. hylophaga*. The domestic cat (*Felis catus*), however, only kills but apparently does not eat *B. hylophaga* (Bee et al. 1981; Caire et al. 1989), which is likely due to the odors produced by skin glands (Bee et al. 1981).

Miscellaneous.—*Blarina hylophaga* has been collected by use of Museum Special mousetraps (Woodstream Corp., Lititz, Pennsylvania—Anderson and Fleharty 1967; Cable and Cook 1999; Hays 1958; Jones and Loomis 1954) and Sherman live traps (H. B. Sherman Traps, Inc., Tallahassee, Florida—Baumgardner et al. 1992; Clark and Kaufman 1990a; George et al. 1982; Hopton and Choate 2002; McMillan et al. 1995; Sietman et al. 1994). The mortality rate of *B. hylophaga* collected in Sherman live traps was 29.8% (Clark et al. 1995). *B. hylophaga* also has been captured by using pitfall traps (Baumgardner et al. 1992; Dalquest and Horner 1984; Davis and Schmidly 1994; Garland and Heidt 1989; Matlack et al. 2008; Schmidly 2004), as well as reptile and amphibian traps (G. A. Kaufman and Kaufman 2006).

BEHAVIOR

Blarina hylophaga generally lives alone. *B. hylophaga* is active year-around with no period of hibernation. Activity is highest at night (Bee et al. 1981; Pitts et al. 1987), with animals only resting between feeding periods (Bee et al. 1981). *B. hylophaga* makes its own runways but also has been documented to use runways of moles and microtine rodents (Anderson and Fleharty 1967; Bee et al. 1981; Cockrum 1952; Dalquest and Horner 1984) and commonly is associated with the prairie vole (*Microtus ochrogaster*), woodland vole (*M. pinetorum*—Dalquest and Horner 1984; Stangl et al. 1992), and hispid cotton rat (*Sigmodon hispidus*). In addition, *B. hylophaga* also digs burrows under leaf litter and soil (Dalquest and Horner 1984). In Texas, *B. hylophaga* digs burrows deep into the soil under leaf litter and logs and does not necessarily need ground cover to dig burrows. Burrows of *B. h. plumbea* always occurred in the soft, damp sandy soils of Aransas National Wildlife Refuge in Texas, with little or no ground cover (Davis and Schmidly 1994; Schmidly 2004). *B. hylophaga* uses these runways to locate prey by means of echolocation (Bee et al. 1981). Nests also have been found in burrows and include materials such as grass and plant fibers (Bee et al. 1981). A nest of *B. hylophaga* under a log in Kansas was described as composed of dry leaves of elm (*Ulmus*) and honey locust (*Gleditsia triacanthos*), located on the surface of the ground, and about 20 cm in diameter (Cockrum 1952).

GENETICS

Cytogenetics.—Chromosomal polymorphism is found readily in members of the family Soricidae (Zima et al. 1998). Within *Blarina*, chromosomal variation probably is linked to chromosomal fusions and autosomal arm changes (Zima et al. 1998). Diploid number (2n) of *B. hylophaga* is 52 chromosomes (Genoways et al. 1977; George et al. 1982). A fundamental number (FN) of 62 was reported for *B. hylophaga* from Kansas and Nebraska (Genoways et al. 1977), whereas 60, 61, or 62 were reported for specimens from Iowa, Kansas, and Missouri (George et al. 1982). There are 4 pairs of large to medium-sized subtelocentric autosomes and 2 pairs of small submetacentric autosomes (Genoways et al. 1977). The other 19 pairs are acrocentric. The X and Y chromosomes are a large metacentric and a small acrocentric, respectively.

Molecular genetics.—The mitochondrial *Cytb*, 16S, and control region differed among individuals of *Blarina hylophaga* an average of 1.6%, 0.35%, and 1.8%, respectively (Brant and Ortí 2002, 2003). *B. hylophaga* differed in DNA sequences from *B. carolinensis* in an analysis of mitochondrial *Cytb* and 16S on average 7.1% and 1.9%, respectively (Brant and Ortí 2002). Between *B. hylophaga* and *B. brevicauda*, the mitochondrial *Cytb*, 16S, and control region DNA sequences differed on average 9.4%, 1.7%, and 9.4%, respectively (Brant and Ortí 2002, 2003). These differences support a basal relationship of *B. hylophaga* to a *brevicauda–carolinensis* sister group (Brant and Ortí 2002).

In contrast, Reilly et al. (2005) found *B. hylophaga* to be sister to *B. carolinensis* with *B. brevicauda* being basal to the clade through analysis of the mitochondrial *Cytb*. Evaluation of *B. hylophaga* in Texas showed unique haplotypes and that divergence ranged from 0.09% to 0.97%. These populations grouped sister to midwestern *B. hylophaga*. Divergence between populations of *B. hylophaga* across its range was 1.3–2.6% (Reilly et al. 2005).

CONSERVATION

In Iowa, *Blarina hylophaga* is listed as a species of greatest conservation need (Zohrer et al. 2006), and as a result, it has been designated as a target species for the Multiple Species Inventory and Monitoring Program by the Iowa Department of Natural Resources (Kinkead 2006). However, populations have been reported to be in good condition in the state but limited in distribution to southwestern Iowa (Bowles 1975; Thompson 2008). In Texas, *B. h. plumbea* may be at risk due

to its rare status and the limited knowledge of the effects of management practices at Aransas National Wildlife Refuge (Schmidly 2004). *B. hylophaga* is not listed in any other state.

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