5-6-1982

Morphometric and Geographic Relationships of Short-Tailed Shrews (Genus *Blarina*) in Kansas, Iowa, and Missouri

Nancy D. Moncrief
Louisiana State University

Jerry R. Choate
Fort Hays State University

Hugh H. Genoways
University of Nebraska - Lincoln, h.h.genoways@gmail.com

ANNALS
of CARNEGIE MUSEUM

MORPHOMETRIC AND GEOGRAPHIC RELATIONSHIPS OF SHORT-TAILED SHREWS (GENUS *BLARINA*) IN KANSAS, IOWA, AND MISSOURI

NANCY D. MONCRIEF[1,2]

JERRY R. CHOATE[1]

HUGH H. GENOWAYS
Curator, Section of Mammals

ABSTRACT

Shrews of the genus *Blarina* from Iowa, Kansas, and Missouri were studied morphometrically and karyologically. The ranges of two species, *B. brevicauda* and *B. hylophaga*, overlap in a broad zone across southern Iowa and northern Missouri. Morphometric analyses revealed an unexpectedly large amount of cranial variation in *B. brevicauda*, and confirmed the presence of that species in the Kansas River Valley of northeastern Kansas. Considerable mensural overlap was found in geographic areas in which *B. hylophaga* and *B. brevicauda* are sympatric, evincing the need for further karyotypic and morphometric studies in those areas. No formal taxonomic changes are proposed herein pending further study of these species.

INTRODUCTION AND TAXONOMIC HISTORY

Short-tailed shrews (genus *Blarina*) in Iowa, Kansas, Missouri, and surrounding states historically were assigned to subspecies of the species *Blarina brevicauda* (Say). Cockrum (1952:43), for example, recognized two subspecies of *B. brevicauda* in Kansas—*B. b. brevi-*

[1] Address: Museum of the High Plains, Fort Hays State University, Hays, KS 67601.
[2] Present Address: Museum of Natural Science, Louisiana State University, Baton Rouge, LA 70893.
Submitted 7 October 1981.

cauda and *B. b. carolinensis* (Bachman). He stated that "Specimens of *B. b. brevicauda* from northeastern Kansas are measurably larger than specimens of *B. b. carolinensis* from southeastern Kansas. Specimens from intermediate geographic localities show a gradual gradation from one to the other—a cline in which no great step exists." Jones and Findley (1954) assigned all specimens they examined from Kansas to *B. b. carolinensis* and determined that the line of contact between *B. b. brevicauda* and *B. b. carolinensis* was in southern Nebraska rather than in Kansas. Jones and Glass (1960:137) studied additional western populations of short-tailed shrews and surmised that "A significant break does occur between shrews in southern Nebraska and those in central Nebraska and it is at this break that *B. b. brevicauda* is distinguished from specimens to the south. Shrews from southern Oklahoma to southern Nebraska seem to form a more or less natural grouping within the cline and in our judgement the same subspecific name [*B. b. carolinensis*] should be applied to all of them." This north-south cline in size was illustrated by Jones and Glass (1960:138) in their Fig. 1.

Referring to that figure, Jones (1964:30) noted that "shrews from Douglas County [in northeastern Kansas] and surrounding areas [sample E in Fig. 1, Jones and Glass, 1960:138] average appreciably larger cranially than shrews either to the north or south of them, and fit nearly perfectly as the missing middle segment into the otherwise sharply stepped north-south cline . . . ." Jones (1964:30) postulated that shrews from the Kansas River Valley of northeastern Kansas represented a remnant of "isolated populations of *B. brevicauda* that must have been left scattered in favorable places in the eastern part of the grasslands in the Xerothermic Period . . . ." In addition, Jones (1964:70) noted that the "external and cranial measurements of Nebraskan *carolinensis* do not differ appreciably . . . from the measurements of the type specimen of *Blarina brevicauda kirtlandi* Bole and Moulthrop . . . ."

Hoffmann and Jones (1970:389–390) detailed the apparent relationships among populations of *Blarina* on the Great Plains. They cited unpublished karyologic differences between northern and southern populations, which later were confirmed by Genoways et al. (1977), as support for the notion that two species of short-tailed shrews might be present on the Great Plains. Genoways and Choate (1972) subsequently published a multivariate analysis of populations of *Blarina* in Nebraska, and elevated *B. b. carolinensis* to the level of a species (*B. carolinensis*). In that study (Genoways and Choate, 1972:113), one specimen was identified as a possible hybrid whose "discriminant score . . . was nearer the upper limit for *carolinensis* than the lower limit for *brevicauda* . . . ."

Bowles (1975) assigned populations of short-tailed shrews in southwestern Iowa to the subspecies *B. b. carolinensis* even though Genoways and Choate (1972:114) had stated that "*brevicauda* and *carolinensis* behave as good biological species where their ranges are contiguous in [adjacent] southern Nebraska. Unpublished data (John B. Bowles, personal communication) indicate that a similar relationship between large and small phena of *Blarina* probably exists across southern Iowa." Bowles (1975:34) did admit that the two taxa "seem to act more or less as distinct species where their ranges meet in southwestern Iowa." Later, Ellis et al. (1978) published a study of *Blarina* in Illinois. Their analyses indicated that *B. brevicauda* occurred nearly statewide, whereas *B. carolinensis* was present only in southernmost Illinois.

Despite morphometric (Jones and Glass, 1960; Jones, 1964; Genoways and Choate, 1972; Ellis et al., 1978) and karyologic (Genoways et al., 1977) evidence to the contrary, Hall (1981:54) recognized only one species of short-tailed shrew in central North America (*Blarina brevicauda,* consisting of the subspecies *B. b. brevicauda* and *B. b. carolinensis*) because Genoways and Choate (1972) had identified one of 66 specimens, from near the zone of contact of the two nominal taxa in Nebraska, as a probable hybrid or intergrade.

The genus *Blarina* long has been in need of taxonomic revision (Jones and Glass, 1960:140; Jones, 1964:69), and such a revision was begun by Genoways and Choate in 1965 when field studies to determine the status of *B. b. carolinensis* were conducted in southeastern Nebraska. Subsequently (in 1978), Genoways and Choate initiated extensive biochemical and morphometric investigations of all taxa of short-tailed shrews.

One of the problems to be resolved pertained to the relationships between eastern and western populations of *B. carolinensis*. Karyologic and morphometric analyses (George et al., 1981) resulted in resurrection of the name *Blarina hylophaga* Elliot (as predicted by Jones and Glass, 1960:140) for certain populations in Nebraska, Kansas, Iowa, Oklahoma, Arkansas, Missouri, Louisiana, and Texas previously known as *carolinensis*. In addition, those studies (George et al., 1982) confirmed the presence of *B. brevicauda* in Douglas County, Kansas (see Graham and Semken, 1976:439–440).

Another of the problems to be resolved pertained to the taxonomic and geographic relationships between *B. brevicauda* and *B. hylophaga* where the ranges of those species abut. In order to better understand those relationships, specimens were collected in 1979 and 1980 in southern Iowa (near the line of contact between the two taxa as described by Bowles, 1975) and in northern and central Missouri. Confirmation of the presence of *B. brevicauda* in the Kansas River Valley

(George et al., 1982), and the subsequent karyotyping (by NDM) of a specimen of *B. brevicauda* in Platte County, Missouri (across the Missouri River from the mouth of the Kansas River), led to incorporation of eastern Kansas into the geographic coverage of this study.

The objectives of this investigation, therefore, were to determine the geographic distributions of *B. brevicauda* and *B. hylophaga* in eastern Kansas, southern Iowa, and Missouri, and to elucidate their morphometric relationships. Because samples of *B. brevicauda* from those areas might pertain to either of two nominal subspecies (*B. b. brevicauda* or *B. b. kirtlandi*), comparisons are made with reference samples of both taxa. Herein, the three taxa are referred to as *hylophaga*, *brevicauda*, and *kirtlandi*. Another species, *B. carolinensis*, is known from the "bootheel" region of Missouri and the Mississippi floodplain near St. Louis, Missouri (George et al., 1981), but is not considered in this study.

MATERIALS AND METHODS

A total of 851 specimens from Illinois, Iowa, Kansas, Missouri, Nebraska, Ohio, and Oklahoma was examined. These specimens are deposited in the following collections: Carnegie Museum of Natural History (CM); Cleveland Museum of Natural History (CMNH); Central College, Iowa (CUI); Pittsburg State University, Kansas (KSCP); Museum of Natural History, University of Kansas (KU); Museum of the High Plains, Fort Hays State University (MHP); Minnesota Museum of Natural History, University of Minnesota (MMNH); University of Missouri (MOU); Museum of Natural and Cultural History, Oklahoma State University (OSU); Stovall Museum of Science and History, University of Oklahoma (OU); Royal Ontario Museum (ROM); Sherman Hoslett Memorial Museum of Natural History, Luther College, Iowa (SHMC); University of Colorado Museum (UCM); University of Michigan Museum of Zoology (UMMZ); National Fish and Wildlife Laboratory, National Museum of Natural History (USNM); Museum of Natural History, University of Wisconsin–Stevens Point (UWSP).

The following cranial and mandibular measurements (Choate, 1972) were taken with dial calipers to the nearest 0.1 mm and recorded for each specimen: occipito-premaxillary length (OPLEN); P^4–M^3 length (PMLEN); cranial breadth (CRNBR); breadth of zygomatic plate (ZYPBR); maxillary breadth (MAXBR); interorbital breadth (INOBR); length of mandible (LENMA); height of mandible (HEMAN); and articular breadth (ARTBR). Specimens were assigned to age classes on the basis of wear to teeth and condition of pelage (Choate, 1972; see also Choate, 1968). Only those specimens with complete sets of cranial and mandibular measurements were used in statistical analyses, which were performed via remote hookup with the ITEL AS/5 at Kansas State University.

Tests for non-geographic variation revealed no consistent pattern of significant differences among age classes and no statistically significant differences among sex classes. Choate (1972) carefully assessed secondary sexual and age variation within populations of *Blarina* in Connecticut and combined age and sex classes for further analyses. Because of Choate's (1972) findings and the lack of a consistent pattern of significant differences in these tests, all age and sex classes were pooled for subsequent statistical analyses.

Assignment of unknowns to reference samples of *brevicauda*, *hylophaga*, and *kirtlandi* was necessary before conducting further statistical analyses. The cluster analysis

(UPGMA) of the Numerical Taxonomic System (NT-SYS, Rohlf et al., 1974) was found to be unsuitable for this task because initial runs (using individuals as OTUs) clustered reference samples of *kirtlandi* from Ohio with *hylophaga* from western Kansas. S. B. George (personal communication) obtained similar results using the DISCRIMINANT procedure of the Statistical Package for the Social Sciences (SPSS, Nie et al., 1975); that procedure was unable to discriminate between samples of *hylophaga* from eastern Kansas and *kirtlandi* from Ohio. A second run of the UPGMA procedure clustered a reference sample of *kirtlandi* from Illinois with *hylophaga* from western Kansas.

At this point, the DISCRIMINANT procedure of the Statistical Analysis System (SAS) 79.3A (Helwig and Council, 1979) was employed because of its greater discriminating capability. Four hundred seventy-nine unknowns from Iowa, Kansas, and Missouri were assigned to reference samples of *B. brevicauda* from Nebraska and *B. hylophaga* from Kansas using this procedure. Preliminary examination of skulls had revealed extensive cranial variation in unknowns from Iowa and Missouri assigned to *B. brevicauda*; specimens as large as topotypical *brevicauda* and as small as topotypical *kirtlandi*, with all gradations between, were present. Because of this variation and the results of analysis by NT-SYS, reference samples of *kirtlandi* were omitted to increase the discriminating power of this procedure (reference samples of *kirtlandi* were used in all subsequent analyses). Additionally, topotypical specimens of *hylophaga* were not used in reference samples because *hylophaga* varies geographically (as described by George et al., 1981) and specimens from near the type locality in southern Oklahoma are considerably smaller than specimens from Iowa, Kansas, and Missouri.

In order to represent geographic variation within *B. brevicauda* and *B. hylophaga* in subsequent analyses, three additional reference samples were selected. This resulted in a total of five reference samples of three taxa of *Blarina* from the following counties (sample sizes are indicated in parentheses): *B. b. brevicauda,* Nebraska—Boyd, Burt, Butler, Cedar, Cherry, Holt, Knox, Washington, and Wayne (25); *B. brevicauda,* Iowa—Chickasaw, Howard, and Winneshiek (28); *B. b. kirtlandi,* Ohio—Geauga and Lake (23); *B. hylophaga,* Kansas—Ellis, Osborne, Phillips, Rooks, Rush, Russell, and Trego (26); *B. hylophaga,* Oklahoma—Cleveland, Garvin, McClain, Murray, and Payne (28). Herein, these samples are identified by the numbers 23, 24, 25, 26, and 27, respectively.

Standard statistics (mean, standard error, range, and coefficient of variation) were computed for each mensural character by sample, and a Duncan's multiple range test was performed for each character. The MANOVA option of the GLM procedure of SAS was used to compute characteristic roots and vectors that were used later in a canonical (discriminant) analysis of variation within and among samples (methodology described by Yates and Schmidly, 1977:5).

Because species of *Blarina* previously have been characterized by their karyotypes (George et al., 1982), karyotypes were prepared to confirm identification based on morphometric analyses. Eight specimens (MHP numbers in parentheses) from the following localities were karyotyped as described by Baker (1970): Kansas—Douglas County: 2½ mi. N, ½ mi. E Lawrence, T.12S, R.20E, W ½ sec. 20 (18806, 18807); Douglas County: 2 mi. N, 1⅔ mi. E Lawrence, T.12S, R.20E, SE ¼ sec. 20 (17702, 17879); Osage County: 1 mi. S, 4 mi. E Scranton, T.15S, R.16E, NE ¼ sec. 7 (18809, 18810, 18811); and Missouri—Platte County: ¼ mi. N, 1 mi. W Weston, T.53N, R.36W, NW ¼ sec. 10 (18808).

RESULTS

The DISCRIMINANT procedure of SAS assigned 183 unknowns to *B. brevicauda* and 296 unknowns to *B. hylophaga*. After assignment to reference samples, specimens from proximal trapping localities were
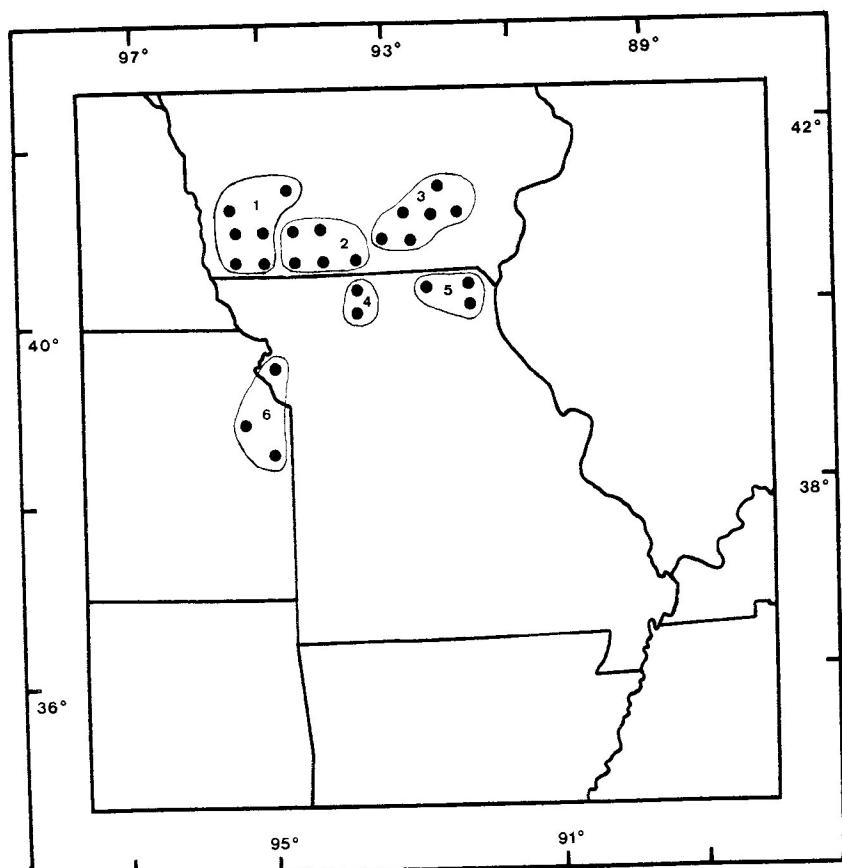
Fig. 1.—Geographic distribution of pooled samples assigned to *Blarina brevicauda*. Numbers refer to samples in Appendix 1.

pooled to increase sample sizes and the discriminating power of univariate and multivariate analyses. A total of 22 samples resulted from this pooling. Samples 1–6 (Fig. 1) include specimens assigned to *B. brevicauda*; samples 7–22 (Fig. 2) consist of specimens assigned to *B. hylophaga* (see Appendix 1 for a listing of sample sizes and counties included within each sample). Eleven specimens were assigned to *B. brevicauda* with less than 0.95 posterior probability of correct assignment; eight specimens were assigned to *B. hylophaga* with a posterior probability of correct assignment of less than 0.95. Trapping localities
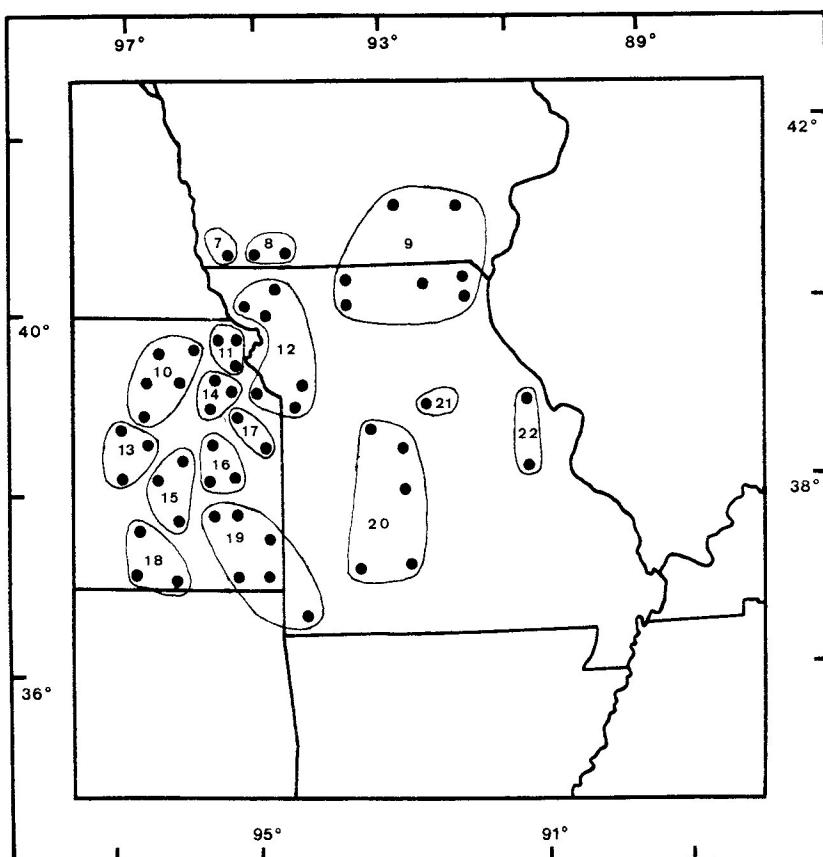
Fig. 2.—Geographic distribution of pooled samples assigned to *Blarina hylophaga*. Numbers refer to samples in Appendix 1.

that contained specimens assigned to both species were located in the following counties (see Fig. 3); samples numbers are identified in parentheses: Iowa—Fremont (1, 7), Keokuk (3, 9), Marion (3, 9), Page (1, 8), Taylor (2, 8); Kansas—Douglas (6, 17), Miami (6, 17); Missouri—Adair (5, 9), Clark (5, 9), Grundy (4, 9), Lewis (5, 9), Mercer (4, 9).

Four routines of MANOVA were used to test the hypothesis that there are no significant morphometric differences among samples. Each of the four tests had results which were significant at $P < 0.0001$:
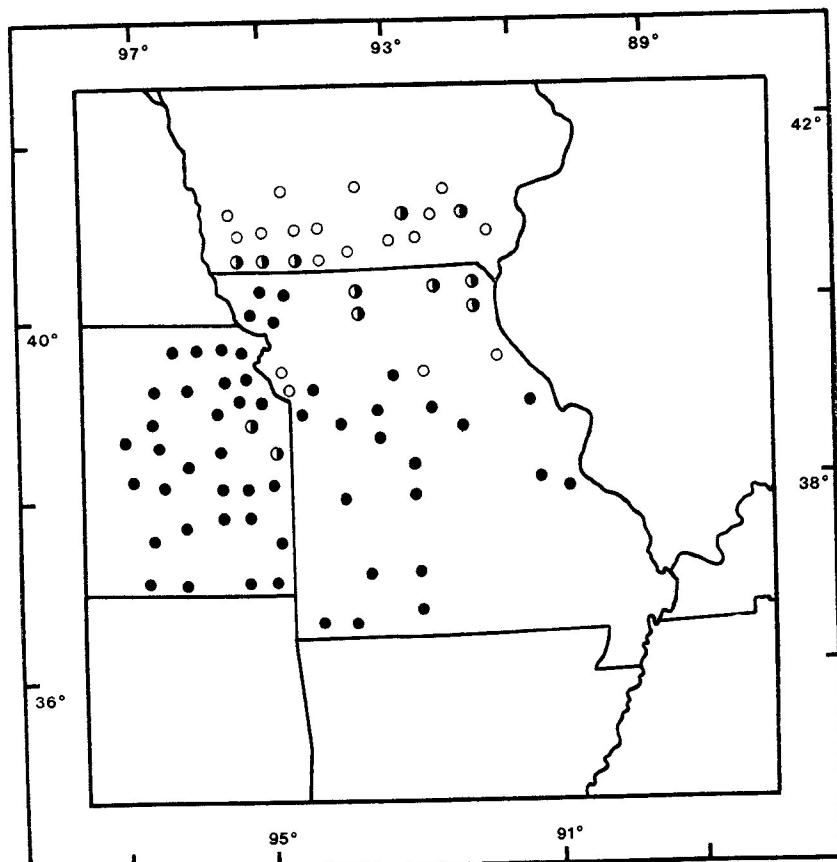
Fig. 3.—Partial geographic distribution of *Blarina brevicauda* and *B. hylophaga* in Kansas, Iowa, and Missouri. Open circles represent counties from which all specimens were assigned to *B. brevicauda*; solid circles represent counties from which all specimens were assigned to *B. hylophaga*; half-solid circles represent counties from which specimens assigned to both species were collected at the same trapping locality. See specimens examined for exact localities.

Hotelling-Lawley's Trace (F = 21.39); Pillai's Trace (F = 5.34); Wilk's Criterion (F = 9.22); Roy's Maximum Root Criterion (F = 172.28).

Table 1 lists standard statistics for all characters and illustrates the results of the Duncan's multiple range tests. For each character, analysis of variance revealed highly significant differences (*P* < 0.001) among samples.

Table 1.—*Univariate statistics for all samples by mensural character. Reference samples mentioned in text are indicated with an asterisk. Samples are identified in Appendix 1. Vertical lines represent nonsignificant subsets as determined by Duncan's multiple range tests; each line represents a separate subset and vertical positioning of lines is insignificant. F value for each character is indicated in parentheses.*

Sample	Mean	2 SE	Range	CV	N
Occipito-premaxillary length (F = 119.56)					
23*	24.00	0.22	23.1–25.2	2.26	25
3	23.58	0.13	22.6–24.8	2.21	62
1	23.51	0.22	21.8–24.6	2.58	30
2	23.41	0.18	20.6–24.9	2.98	56
24*	23.32	0.31	21.7–24.6	3.57	28
5	22.97	0.32	22.3–23.7	2.22	10
4	22.97	0.27	22.0–24.5	2.67	20
6	22.36	0.20	22.0–22.6	1.03	5
9	22.30	0.24	21.6–22.9	1.82	11
17	21.87	0.12	20.3–22.7	2.07	54
25*	21.50	0.23	20.8–23.0	2.66	23
21	21.29	0.18	20.6–22.1	2.05	23
22	21.23	0.46	20.4–22.0	2.64	6
12	21.23	0.28	19.9–22.1	2.89	19
8	21.01	0.26	20.2–22.3	2.84	21
11	20.98	0.29	19.7–21.5	2.47	13
7	20.94	0.15	19.6–22.3	2.55	47
26*	20.90	0.16	20.2–21.7	1.93	26
20	20.90	0.31	20.1–21.2	1.95	7
16	20.87	0.32	20.0–21.7	2.55	11
10	20.85	0.17	20.2–20.5	1.85	20
15	20.71	0.17	19.7–21.6	2.16	27
18	20.69	0.36	20.1–21.7	2.51	8
14	20.65	0.43	19.4–21.5	3.28	10
19	20.63	0.24	19.9–21.4	2.04	12
13	20.54	0.21	20.1–20.8	1.40	7
27*	20.01	0.18	18.8–21.0	2.42	28

The variance-covariance matrix yielded nine canonical variates among the nine mensural characters for all 27 samples. The first canonical variate expressed 88.00% of the morphometric variation, the second 4.52%, and the third 3.20%. Two-dimensional plots of the first two canonical variates (Fig. 4; an ellipse encloses the mean and one standard deviation on each side of the mean for each sample) yielded results similar to those of the Duncan's multiple range tests: sample 23 (reference for *brevicauda* from Nebraska) was placed at the top of the plot and sample 27 (reference for *hylophaga* from Oklahoma) was placed at the bottom of the plot along vector 1, which primarily reflects size variation; sample 6 (*brevicauda*) clustered with samples 1–5 (*brev-*

Table 1.—*Continued.*

Sample		Mean	2 SE	Range	CV	N
		P^4–M^3 length ($F = 73.54$)				
23*		6.59	0.06	6.3–6.8	2.33	25
1		6.46	0.08	5.8–6.8	3.65	30
3		6.45	0.04	6.1–6.8	2.79	62
2		6.43	0.04	6.0–6.8	2.66	56
24*		6.40	0.08	5.8–6.9	3.55	28
5		6.26	0.14	5.9–6.6	3.47	10
6		6.24	0.10	6.1–6.4	1.83	5
4		6.20	0.08	5.9–6.5	2.79	20
9		6.15	0.13	5.7–6.5	3.51	11
17		6.14	0.04	5.6–6.4	2.71	54
22		5.88	0.12	5.7–6.1	2.50	6
21		5.86	0.07	5.6–6.2	2.76	23
25*		5.86	0.05	5.6–6.0	2.40	23
11		5.84	0.10	5.4–6.1	3.01	13
12		5.80	0.12	5.1–6.2	4.46	19
10		5.79	0.04	5.6–6.0	1.72	20
16		5.79	0.06	5.7–6.0	1.80	11
20		5.79	0.18	5.4–6.0	4.17	7
7		5.79	0.05	5.5–6.3	3.26	47
8		5.77	0.08	5.5–6.3	3.25	21
14		5.76	0.10	5.5–6.0	2.74	10
26*		5.74	0.07	5.3–6.2	3.31	26
18		5.72	0.15	5.4–6.0	3.70	8
15		5.71	0.06	5.4–6.0	2.97	27
13		5.69	0.10	5.5–5.9	2.37	7
19		5.64	0.10	5.3–5.9	3.07	12
27*		5.55	0.06	5.2–5.9	3.04	28

icauda) and 24 (reference for *B. brevicauda* from Iowa), and was placed below those samples along vector 1; samples 9 and 17 (*hylophaga*) overlapped each other slightly at the upper end of the lower cluster and were positioned between samples 24 (reference for *B. brevicauda* from Iowa) and 25 (reference for *kirtlandi* from Ohio) along vector 1; sample 25 did not cluster with other samples of *B. brevicauda* (1–6, 23, and 24); reference samples were arranged along vector 1 from highest to lowest in the order 23, 24, 25, 26, and 27; samples 7, 8, 10, 11, 13–16, 18, 19, and 26 (*hylophaga*) clustered together and overlapped so greatly that individual ellipses were essentially indistinguishable; sample 27 (reference for *hylophaga* from Oklahoma) clustered with other samples of *hylophaga* but did not overlap appreciably with any of them.

Karyotypes of specimens from Douglas County, Kansas, and Platte

Table 1.—*Continued.*

Sample		Mean	2 SE	Range	CV	N
		Cranial breadth (F = 99.63)				
23*		13.51	0.14	12.6–14.0	2.57	25
1		13.22	0.18	11.7–13.9	3.75	30
2		13.19	0.12	12.2–14.1	3.48	56
3		13.17	0.10	12.0–14.0	2.99	62
24*		13.13	0.22	12.0–14.2	4.38	28
4		12.88	0.21	12.0–14.0	3.67	20
5		12.78	0.13	12.5–13.2	1.64	10
6		12.58	0.28	12.2–13.0	2.54	5
9		12.51	0.20	12.0–13.0	2.69	11
17		12.23	0.09	11.2–12.8	2.86	54
25*		12.04	0.10	11.5–12.6	2.24	23
21		12.01	0.15	11.4–12.8	3.09	23
22		11.98	0.25	11.6–12.4	2.55	6
20		11.80	0.21	11.3–12.2	2.35	7
12		11.78	0.20	11.0–12.5	3.68	19
8		11.63	0.18	10.9–12.6	3.69	21
7		11.52	0.10	10.8–12.3	2.92	47
11		11.45	0.19	10.9–12.0	3.08	13
26*		11.45	0.12	10.8–11.9	2.66	26
10		11.40	0.15	10.6–11.8	3.00	20
16		11.37	0.17	10.9–12.0	2.46	11
13		11.34	0.19	10.9–11.7	2.21	7
14		11.34	0.36	10.3–12.2	5.01	10
18		11.31	0.21	10.9–11.9	2.65	8
19		11.31	0.26	10.8–12.2	4.05	12
15		11.24	0.14	10.6–12.3	3.36	27
27*		10.96	0.11	10.3–11.6	2.70	28

County, Missouri, evinced that those specimens pertained to *B. brevicauda* (2N = 48, 49, or 50; FN = 48). Examination of skulls of those individuals indicated that they were near the upper mensural extreme for *hylophaga* (and, therefore, near the lower limit of cranial variation for *kirtlandi*), but certain cranial characteristics (for example, shape of the braincase) were more like those of *kirtlandi* than of *hylophaga*. Those specimens thus were assigned to the species *B. brevicauda* on the basis of both morphometric and karyologic evidence. Karyotypes of specimens from Osage County, Kansas, confirmed that those specimens pertained to *B. hylophaga* (2N = 52; FN = 60, 61, or 62).

DISCUSSION

Specimens of the genus *Blarina* traditionally have been assigned taxonomically on the basis of external and cranial measurements (Bole

Table 1.—*Continued.*

Sample		Mean	2 SE	Range	CV	N
		Breadth of the zygomatic plate (F = 26.15)				
23*		2.71	0.09	2.3–3.1	7.97	25
5		2.68	0.09	2.4–2.9	5.22	10
2		2.65	0.06	2.1–3.2	7.89	56
9		2.64	0.11	2.4–3.0	7.24	11
1		2.63	0.06	2.4–2.9	5.83	30
24*		2.61	0.06	2.2–2.9	5.84	28
3		2.60	0.06	2.0–2.9	8.09	62
4		2.60	0.12	2.1–3.2	10.14	20
17		2.51	0.05	2.0–3.0	7.27	54
21		2.45	0.07	2.2–2.7	6.73	23
6		2.44	0.16	2.2–2.6	7.44	5
20		2.39	0.08	2.2–2.5	4.48	7
12		2.33	0.08	2.1–2.6	7.14	19
25*		2.33	0.06	2.0–2.6	5.97	23
22		2.32	0.18	2.0–2.6	9.62	6
13		2.31	0.12	2.2–2.6	5.81	7
7		2.29	0.05	1.8–2.6	7.01	47
11		2.25	0.10	2.0–2.5	7.81	13
19		2.24	0.09	2.0–2.5	6.71	12
26*		2.24	0.05	2.0–2.5	5.52	26
8		2.24	0.08	1.8–2.5	8.17	21
18		2.22	0.10	2.0–2.5	6.69	8
15		2.21	0.06	1.8–2.5	6.64	27
10		2.20	0.05	2.0–2.4	5.40	20
14		2.18	0.11	2.0–2.5	8.03	10
16		2.16	0.10	1.9–2.4	7.53	11
27*		2.13	0.06	1.8–2.4	7.34	28

and Moulthrop, 1942; Cockrum, 1952; Jones and Glass, 1960; Jones, 1964; Genoways and Choate, 1972; Bowles, 1975; Ellis et al., 1978; George et al., 1981). Jones and Glass (1960:137) asserted that "Size . . . [in *Blarina*] definitely varies geographically and seems to be a . . . useful criterion in taxonomic studies."

The mensural relationship between *B. brevicauda brevicauda* and *B. hylophaga* is distinctive: "*Blarina brevicauda brevicauda* can be distinguished from *B. b. carolinensis* [=*B. hylophaga*] . . . by its markedly greater external and cranial size" (Bowles, 1975:34); "*B. b. brevicauda* . . . differs [from *B. hylophaga*] in being significantly larger externally and especially cranially . . . ." (Jones, 1964:67); "external and cranial dimensions in *B. b. brevicauda* are substantially greater than (and seldom overlap) those in *B. b. carolinensis* [=*B. hylophaga*] . . . ." (Genoways and Choate, 1972:106–107). However, the mensural

Table 1.—*Continued.*

Sample			Mean	2 SE	Range	CV	N
Maxillary breadth (F = 84.02)							
23*			8.66	0.10	8.0–9.1	2.79	25
1			8.56	0.10	8.0–9.0	3.22	30
2			8.49	0.07	7.7–9.2	3.23	56
3			8.47	0.06	8.0–9.0	2.83	62
24*			8.32	0.12	7.7–8.9	3.94	28
4			8.28	0.17	7.6–9.2	4.53	20
5			8.20	0.18	7.8–8.7	3.50	10
6			8.08	0.40	7.6–8.6	5.49	5
9			7.93	0.13	7.5–8.3	2.83	11
17			7.75	0.06	7.3–8.3	2.69	54
8			7.61	0.16	7.1–8.4	4.88	21
26*			7.58	0.08	7.1–7.9	2.65	26
12			7.58	0.10	7.1–8.0	3.08	19
22			7.58	0.21	7.3–8.0	3.48	6
25*			7.55	0.10	7.1–7.8	3.29	23
21			7.51	0.09	7.2–7.9	2.81	23
11			7.50	0.07	7.2–7.7	1.63	13
7			7.48	0.08	6.9–8.3	3.87	47
10			7.45	0.10	7.1–7.8	2.90	20
16			7.45	0.14	7.2–7.9	3.14	11
13			7.43	0.12	7.2–7.7	2.16	7
20			7.43	0.17	7.0–7.7	3.08	7
19			7.35	0.10	7.1–7.6	2.28	12
14			7.33	0.15	7.0–7.8	3.28	10
15			7.31	0.09	6.6–7.7	3.36	27
18			7.22	0.12	6.8–7.4	2.64	8
27*			7.15	0.09	6.7–7.8	3.28	28

distinction between *B. brevicauda kirtlandi* (which Bole and Moulthrop, 1942:100, described as being "intermediate between other forms . . . .") and *B. hylophaga* is slight, and the extremes of variation in these taxa overlap broadly, as do the extremes of variation between *B. b. brevicauda* and *B. b. kirtlandi* (see Graham and Semken, 1976). As depicted by Hall (1981:55), the range of *B. b. carolinensis* west of the Mississippi River [=*B. hylophaga*] is separated geographically from that of *B. b. kirtlandi* so that the lack of mensural distinction between the two taxa is of little consequence. However, Ellis et al. (1978:310) examined specimens of *B. brevicauda* from Illinois and central Iowa and concluded "there is a step within this cline [between *brevicauda* and *kirtlandi*] somewhere along the Mississippi River, between northwestern Illinois and central Iowa . . . ." They did not examine specimens between northwestern Illinois and central Iowa, but

Table 1.—*Continued.*

Sample	Mean	2 SE	Range	CV	N
Interorbital breadth (F = 40.96)					
23*	6.18	0.09	5.9–6.7	3.51	25
1	6.14	0.08	5.7–6.8	3.86	30
2	6.12	0.06	5.7–6.5	3.31	56
3	6.11	0.05	5.6–6.5	3.10	62
24*	6.05	0.09	5.6–6.5	4.06	28
4	5.99	0.10	5.6–6.6	3.86	20
5	5.98	0.11	5.8–6.3	2.93	10
9	5.91	0.09	5.6–6.2	2.67	11
17	5.85	0.05	5.5–6.2	3.06	54
6	5.84	0.12	5.7–6.0	2.30	5
21	5.75	0.08	5.5–6.3	3.27	23
8	5.73	0.08	5.4–6.0	3.32	21
12	5.72	0.08	5.4–6.1	3.22	19
7	5.66	0.06	5.2–6.0	3.48	47
22	5.62	0.17	5.3–5.9	3.80	6
26*	5.61	0.05	5.4–5.9	2.33	26
16	5.59	0.09	5.4–5.8	2.82	11
20	5.59	0.18	5.2–5.9	4.31	7
10	5.57	0.08	5.1–5.8	3.44	20
14	5.56	0.08	5.4–5.8	2.43	10
13	5.56	0.07	5.5–5.7	1.76	7
11	5.55	0.08	5.2–5.8	2.72	13
19	5.53	0.10	5.3–5.8	3.11	12
15	5.52	0.04	5.4–5.7	1.74	27
25*	5.52	0.05	5.3–5.8	2.30	23
18	5.51	0.11	5.3–5.8	2.82	8
27*	5.41	0.06	5.1–5.9	3.18	28

their conclusion allowed for the possibility that two very similar taxa (*B. b. kirtlandi* and *B. hylophaga*) occur together in Iowa and, perhaps, Missouri. Data presented herein are inadequate to judge the taxonomic status of the two subspecies of *B. brevicauda,* but they indicate that mensural variation in samples of *B. brevicauda* from Missouri and southern Iowa is not merely a function of geography. Specimens from the same trapping localities often exhibit variation ranging from that of large *brevicauda* to that of small *kirtlandi,* including intermediate-sized shrews. In fact, *kirtlandi*-sized specimens of *B. brevicauda* exist as far west as eastern Nebraska. This might explain the specimen described by Genoways and Choate (1972:113) as a possible hybrid; that specimen was slightly smaller than topotypical *brevicauda* but slightly larger than specimens of *hylophaga* from southeastern Nebraska, as are specimens of *kirtlandi.* On the other hand, specimens

Table 1.—*Continued*.

Sample		Mean	2 SE	Range	CV	N
Length of the mandible (F = 108.92)						
23*		13.79	0.12	13.3–14.4	2.10	25
3		13.58	0.09	13.0–14.2	2.56	62
2		13.53	0.11	12.6–14.3	3.12	56
1		13.48	0.14	12.6–14.3	3.04	30
24*		13.35	0.19	12.3–14.2	3.79	28
4		13.10	0.21	12.2–14.1	3.57	20
5		13.06	0.21	12.6–13.6	2.61	10
6		12.78	0.12	12.7–13.0	1.02	5
9		12.71	0.16	12.3–13.0	2.15	11
17		12.66	0.08	11.8–13.1	2.30	54
21		12.13	0.12	11.6–12.5	2.31	23
25*		12.10	0.16	11.6–13.0	3.16	23
12		12.08	0.20	11.3–12.8	3.70	19
22		12.07	0.28	11.6–12.5	2.90	6
20		12.06	0.32	11.3–12.6	3.55	7
8		12.04	0.18	11.5–13.0	3.52	21
7		11.97	0.10	11.3–12.9	2.93	47
26*		11.93	0.12	11.4–12.6	2.65	26
11		11.91	0.16	11.2–12.3	2.39	13
10		11.86	0.11	11.3–12.2	2.18	20
16		11.83	0.19	11.2–12.5	2.73	11
15		11.79	0.13	11.0–12.5	2.86	27
18		11.74	0.15	11.5–12.1	1.87	8
13		11.73	0.19	11.3–12.1	2.13	7
14		11.68	0.26	11.0–12.5	3.49	10
19		11.67	0.14	11.2–12.1	2.11	12
27*		11.30	0.11	10.7–12.0	2.70	28

of *hylophaga* from southeastern Nebraska examined by Jones (1964:70) actually were individuals of that species that merely had cranial measurements near the upper extreme for *hylophaga*. Jones' (1964:70) statement about the mensural relationships between those specimens and the holotype of *kirtlandi* concur with observations, made by Graham and Semken (1976), about the overlapping mensural extremes of these taxa.

Results of the Duncan's multiple range tests (Table 1) and the canonical analysis (Fig. 4) illustrate cranial variation within test samples of *B. brevicauda* from Iowa and Missouri: samples 1–5 had larger means than sample 25 (reference for *kirtlandi* from Ohio) but had smaller means than sample 23 (reference for *brevicauda* from Nebraska) and clustered with the reference for *B. brevicauda* from Iowa (sample 24). Examination of Table 1 reveals that, for all characters except

Table 1.—*Continued.*

Sample			Mean	2 SE	Range	CV	N
			Height of the mandible (F = 134.02)				
23*			7.86	0.09	7.4–8.2	2.91	25
2			7.66	0.08	6.8–8.3	4.33	56
1			7.63	0.10	7.2–8.1	3.56	30
3			7.61	0.06	7.2–8.2	3.01	62
24*			7.51	0.16	6.2–8.4	5.80	28
4			7.45	0.15	6.9–8.2	4.49	20
5			7.33	0.16	7.0–7.8	3.52	10
6			7.10	0.18	6.9–7.4	2.82	5
9			7.04	0.06	6.9–7.2	1.46	11
17			6.81	0.06	6.1–7.2	3.34	54
22			6.65	0.25	6.3–7.1	4.63	6
25*			6.64	0.09	6.3–7.1	3.17	23
12			6.55	0.15	5.9–7.0	5.04	19
21			6.55	0.10	6.2–7.1	3.82	23
20			6.47	0.20	5.9–6.7	4.16	7
8			6.36	0.16	5.9–7.2	5.91	21
11			6.28	0.09	5.9–6.5	2.53	13
26*			6.26	0.07	5.8–6.5	2.99	26
7			6.25	0.08	5.8–7.1	4.18	47
16			6.19	0.11	5.9–6.5	3.10	11
15			6.16	0.10	5.7–6.7	4.22	27
14			6.15	0.24	5.7–6.9	6.14	10
19			6.14	0.09	5.9–6.4	2.64	12
10			6.13	0.08	5.8–6.5	3.00	20
13			6.11	0.19	5.8–6.4	4.27	7
18			6.04	0.18	5.8–6.6	4.24	8
27*			5.90	0.08	5.5–6.4	3.49	28

two (ZYPBR and ARTBR), sample 24 (*B. brevicauda* from Iowa) had the highest coefficient of variation of any of the reference samples. These observations, together with the placement of samples 1–5 and 24 in the canonical analysis between sample 23 (*brevicauda* from Nebraska) and sample 25 (*kirtlandi* from Ohio) along vector 1 (Fig. 4), indicate that samples 1–5 and 24 contained *brevicauda-* and *kirtlandi-* sized shrews as well as intermediate-sized individuals. The fact that this variation is non-geographic, and the fact that no indication of secondary intergradation (for example, a step) between *brevicauda* and *kirtlandi* has been found either east or west of areas included in this study, preclude assigning specimens of *B. brevicauda* from Iowa, Kansas, and Missouri to either *B. b. brevicauda* or *B. b. kirtlandi* until completion of an ongoing investigation of geographic variation within the overall range of the species. Nevertheless, sample 6, from Kansas

Table 1.—*Continued.*

Sample		Mean	2 SE	Range	CV	N
		Articular breadth (F = 90.60)				
23*		2.98	0.04	2.8–3.2	3.40	25
1		2.87	0.06	2.6–3.2	5.50	30
2		2.84	0.04	2.3–3.5	6.29	56
5		2.76	0.07	2.6–3.0	3.89	10
3		2.75	0.03	2.5–3.0	4.95	62
24*		2.75	0.05	2.5–3.0	4.80	28
4		2.75	0.07	2.5–3.2	5.60	20
6		2.62	0.07	2.5–2.7	3.19	5
9		2.54	0.07	2.4–2.7	4.75	11
17		2.46	0.03	2.2–2.7	4.55	54
25*		2.43	0.04	2.3–2.7	4.40	23
22		2.43	0.10	2.3–2.6	4.98	6
20		2.41	0.07	2.3–2.5	3.73	7
21		2.41	0.05	2.2–2.6	4.56	23
12		2.38	0.06	2.1–2.6	5.16	19
8		2.33	0.08	2.1–2.7	7.71	21
7		2.29	0.04	2.0–2.7	5.99	47
15		2.27	0.05	2.0–2.5	5.87	27
26*		2.26	0.04	2.1–2.4	4.69	26
11		2.25	0.06	2.0–2.4	4.66	13
10		2.24	0.05	2.0–2.4	5.10	20
18		2.24	0.05	2.1–2.3	3.32	8
13		2.21	0.10	2.1–2.4	6.07	7
14		2.21	0.09	2.1–2.5	6.56	10
19		2.21	0.07	2.0–2.4	5.27	12
16		2.18	0.04	2.1–2.3	3.44	11
27*		2.10	0.04	1.9–2.4	5.73	28

and Missouri, was placed nearer sample 25 (reference for *kirtlandi* from Ohio) than sample 23 (reference for *brevicauda* from Nebraska) in the canonical analysis (Fig. 4), and had the smallest mean of any of the samples of *B. brevicauda* (other than sample 25) in eight of nine range tests (Table 1). These analyses, together with karyotypic data and cranial appearance as determined by examination of skulls, indicate that populations of *B. brevicauda* are present in Douglas and Miami counties, Kansas, and Buchanan and Platte counties, Missouri, and that they are more similar to *kirtlandi* than to *brevicauda* (as pointed out previously by Graham and Semken, 1976).

Statistical analyses and examination of skulls of specimens of *hylophaga* revealed considerable geographic variation in size within that species, as reported by George et al., (1981); specimens of *hylophaga* from Oklahoma (sample 27) were near *B. carolinensis* in size and were
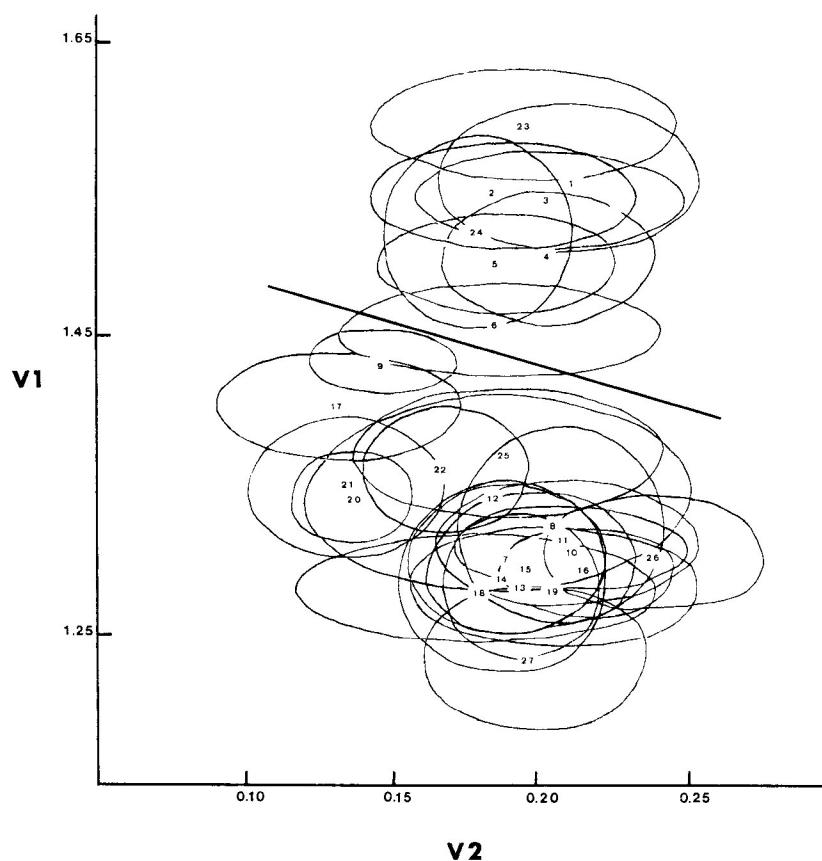
Fig. 4.—Canonical analysis of all samples. Samples 1–6 were assigned to *Blarina brevicauda*; samples 7–22 were assigned to *B. hylophaga*. Samples 23–25 were used as references for *B. brevicauda*; samples 26 and 27 were used as references for *B. hylophaga*.

smaller than test specimens of *hylophaga* from Iowa, Kansas, and Missouri. Certain test samples of *hylophaga* (9, 12, 17, and 20–22) were placed nearer topotypical specimens of *kirtlandi* (sample 25) than the references for *hylophaga* (samples 26 and 27) by the canonical analysis (Fig. 4), thus reiterating the mensural similarities between topotypical *kirtlandi* and western populations of *hylophaga* as revealed in this study by the NT-SYS cluster analysis and as noted by Jones (1964:70).

Because of these mensural similarities, karyotypes remain the only reliable, diagnostic criterion for identification of individuals in areas of Kansas, Iowa, and Missouri where *hylophaga* and *kirtlandi*-sized *brevicauda* occur in sympatry. Comparison of skulls of karyotyped individuals from Douglas County, Kansas, and Platte County, Missouri, with those of *hylophaga* from western Kansas and topotypical *kirtlandi* substantiated the situation described by Graham and Semken (1976)—individuals at the extremes of mensural variation of the two taxa are exceedingly difficult to identify. Additional karyologic and morphometric studies of short-tailed shrews from areas of sympatry are needed to resolve problems in identification of specimens of *B. brevicauda* and *B. hylophaga* in those regions.

In marked contrast to the geographic relationships found between *brevicauda* and *carolinensis* [=*hylophaga*] in Nebraska by Jones (1964) and Genoways and Choate (1972), there is no sharply-defined line of contact between those taxa in Iowa and Missouri. Data presented herein support the contention by Bowles (1975:34) that "Specimens easily referable to one or the other [taxon] have been taken at sites varying from 25 to 50 miles apart along the zone of contact . . . ."

The known distribution of *Blarina hylophaga* in Missouri and Iowa extends northward to Fremont, Page, Taylor, Marion, and Keokuk counties, Iowa, whereas the known distribution of *B. brevicauda* includes all of Iowa and extends southward in Missouri to Platte, Randolph, and Ralls counties (Fig. 3). The two species occur sympatrically in a broad zone across southern Iowa and northern Missouri. In Kansas, *kirtlandi*-sized shrews assigned to *brevicauda* occur in at least Douglas and Miami counties, whereas *hylophaga* occurs throughout the state. Another species of short-tailed shrew, *B. carolinensis*, occurs in the "bootheel" region of Missouri and might be sympatric with *B. hylophaga* on the floodplain of the Mississippi River (George et al., 1981).

SPECIMENS EXAMINED

Asterisks denote localities at which specimens assigned to both *Blarina brevicauda* and *B. hylophaga* were collected.

Blarina brevicauda

ILLINOIS. *Champaign Co.:* 2½ mi. NE Urbana, 4 (1 KU, 3 UCM); 1 mi. N, 2 mi. E Urbana, 1 (KU). *McLean Co.:* Bloomington, 6 (UMMZ).

IOWA. *Adams Co.:* 4 mi. N, ¾ mi. W Nodaway, 1 (KU). *Chickasaw Co.:* 1 mi. S, 1 mi. W North Washington, 10 (KU). *Decatur Co.:* 1 mi. (by road) N Davis City, 1 (CM); 4½ mi. (by road) NW Pleasanton, 6 (3 CM, 3 MHP); 3 mi. (by road) NW Pleasanton, 2 (1 CM, 1 MHP); 3¼ mi. N, ¼ mi. E Woodland, 1 (KU). *Fremont Co.:* 2 mi. S, 3 mi.

E Tabor*, 3 (1 CM, 2 MHP); 2 mi. S, 4 mi. E Tabor, 4 (3 CM, 1 MHP). *Guthrie Co.:* Springbrook State Park, 2 (ROM). *Henry Co.:* Hillsboro, 2 (USNM). *Howard Co.:* T.98N, R.11W, sec. 1, 2 (CUI); T.98N, R.11W, sec. 2, 5 (CUI). *Keokuk Co.:* Sigourney, 3 (KU); 6½ mi. S, 1 mi. W Sigourney*, 1 (KU). *Lucas Co.:* 2½ mi. S, 2½ mi. E Chariton, 1 (CUI); 2½ mi. N, 2½ mi. E Russell, 1 (KU); 1 mi. N, 2½ mi. E Russell, 1 (KU). *Mahaska Co.:* 5½ mi. N Oskaloosa, 2 (KU); 5 mi. N Oskaloosa, 1 (KU); 2 mi. N, 2½ mi. E Oskaloosa, 1 (KU); 2 mi. N, 3 mi. E Oskaloosa, 1 (KU); 1 mi. W Oskaloosa, 1 (KU); Oskaloosa, 2 (KU); 5 mi. E Oskaloosa, 1 (KU); 2 mi. S, 10 mi. W Oskaloosa, 1 (KU); 2½ mi. S, 4 mi. W Oskaloosa, 2 (KU); 3 mi. S, 9 mi. W Oskaloosa, 1 (KU); 3½ mi. SW Oskaloosa, 2 (KU); 5 mi. E Penn College, 1 (KU). *Marion Co.:* 1¼ mi. N, 2¼ mi. W Bussey, 2 (KU); 5¾ mi. N Knoxville, 1 (KU); 4½ mi. N Knoxville, 4 (KU); Knoxville, 2 (USNM); 5½ mi. N, 3 mi. W Pella, 3 (CUI); 1 mi. S, 3 mi. W Pella, 2 (CUI); 1 mi. S Pella, 1 (CUI); 1½ mi. S, ¼ mi. W Pella*, 50 (CUI); 1½ mi. S Pella, 1 (CUI); 2½ mi. S, 2½ mi. W Pella, 1 (CUI); 2½ mi. S, 1½ mi. E Pella, 1 (CUI); ½ mi. W Tracy, 1 (KU). *Mills Co.:* ½ mi. S, 3 mi. W Henderson, 7 (KU); 3 mi. S, 2½ mi. W Hillsdale, 1 (CUI); 3½ mi. N, 2 mi. E Tabor (*in* Fremont Co.), 7 (3 CM, 4 MHP); 2 mi. N, ½ mi. E Tabor (*in* Fremont Co.), 1 (CM); 2 mi. N, 1½ mi. E Tabor (*in* Fremont Co.), 1 (CM). *Monroe Co.:* 5½ mi. N, 3½ mi. E Albia, 1 (KU); 1 mi. N, 2 mi. E Albia, 1 (CUI); 5 mi. S Albia, 3 (CUI); 1½ mi. N Melrose, 2 (KU). *Montgomery Co.:* 1½ mi. S, 2 mi. E Wales, 4 (KU). *Page Co.:* 1 mi. W Bethesda, 1 (MHP); 1 mi. N, 2 mi. E Imogene (*in* Fremont Co.)*, 1 (MHP); 1 mi. N, 6 mi. E Imogene (*in* Fremont Co.)*, 1 (CM). *Polk Co.:* Des Moines, 1 (USNM). *Pottawattamie Co.:* Council Bluffs, 7 (USNM). *Poweshiek Co.:* 1 mi. S, 2 mi. W Grinnell, 1 (KU). *Ringgold Co.:* 2 mi. N Blockton (*in* Taylor Co.), 3 (1 CM, 2 MHP); 1 mi. S Blockton (*in* Taylor Co.), 3 (1 CM, 2 MHP); 3 mi. S Blockton (*in* Taylor Co.), 1 (CM); ½ mi. N, 2 mi. E Mt. Ayr, 3 (KU). *Taylor Co.:* ½ mi. S, 1 mi. E Lenox, 3 (2 CM, 1 MHP); 2 mi. S, 1 mi. E Lenox, 1 (CM); 4½ mi. S, 1 mi. E Lenox, 2 (1 CM, 1 MHP); 5 mi. S, 1 mi. E Lenox, 1 (CM); 6 mi. S, 1 mi. E Lenox, 4 (2 CM, 2 MHP); 10 mi. S Lenox*, 2 (1 CM, 1 MHP); 12 mi. S Lenox, 16 (8 CM, 8 MHP); 14 mi. S Lenox, 2 (1 CM, 1 MHP); 17 mi. S, 1 mi. E Lenox*, 2 (1 CM, 1 MHP); 19 mi. S, 1 mi. E Lenox, 3 (1 CM, 2 MHP). *Union Co.:* 1¾ mi. N, ½ mi. E Thayer, 4 (KU). *Winnesheik Co.:* Conover, 3 (UMMZ); Decorah, 7 (3 SHMC, 4 UMMZ); Ridgeway, 1 (UMMZ).

KANSAS. *Douglas Co.:* 2½ mi. N, ½ mi. E Lawrence (T.12S, R.20E, W ½ sec. 20), 2 (MHP); 2 mi. N, 1⅔ mi. E Lawrence, (T.12S, R.20E, SE ¼ sec. 20), 2 (MHP); 1½ mi. N, 1¹/₅ mi. E Lawrence*, 1 (KU); Lawrence*, 1 (KU); 7½ mi. SW Lawrence*, 1 (KU). *Miami Co.:* 11 mi. SSE Paola*, 1 (KU).

MISSOURI. *Adair Co.:* ½ mi. (by road) W Brashear*, 5 (2 CM, 3 MHP); 3 mi. N Connelsville, 1 (CM). *Buchanan Co.:* St. Joseph, 1 (MOU). *Clark Co.:* 1½ mi. N, 3 mi. W Antioch (T.64N, R.8W, NW ¼ sec. 14)*, 1 (MHP). *Grundy Co.:* 3½ mi. (by road) S Modena (*in* Mercer Co.)*, 1 (CM); 6½ mi. (by road) S Modena (*in* Mercer Co.)*, 7 (2 CM, 5 MHP); 2½ mi. S Tindall*, 5 (2 CM, 3 MHP). *Lewis Co.:* 1½ mi. N Canton (T.62N, R.5W, SE ¼ sec. 23), 1 (CM); ½ mi. S, 2½ mi. E Deer Ridge (T.62N, R.9W, E ½ sec. 2)*, 1 (CM); ½ mi. S, 3 mi. E Deer Ridge (T.62N, R.9W, E ½ sec. 1), 1 (MHP); 2 mi. S, 2 mi. E Deer Ridge (T.62N, R.9W, SE ¼ sec. 11), 1 (CM); 2½ mi. S, 2 mi. E Deer Ridge (T.62N, R.9W, E ½ sec. 14), 1 (MHP). *Mercer Co.:* 14½ mi. (by road) N Goshen, 4 (2 CM, 2 MHP); 11 mi. (by road) N Goshen, 1 (MHP); 9 mi. (by road) N Goshen, 1 (MHP); 3 mi. (by road) N Goshen, 1 (CM); 1 mi. (by road) N Goshen*, 4 (2 CM, 2 MHP); 1½ mi. (by road) S Goshen, 1 (MHP); 5½ mi. (by road) S Goshen, 1 (MHP). *Platte Co.:* ¼ mi. N, 1 mi. W Weston (T.53N, R.36W, NW ¼ sec. 10), 1 (MHP). *Ralls Co.:* Hannibal, 1 (MOU). *Randolph Co.:* Moberly, 1 (MOU).

NEBRASKA. *Boyd Co.:* 5 mi. WNW Spencer, 1 (KU). *Burt Co.:* 1 mi. E Tekamah, 1 (KU). *Butler Co.:* 4 mi. E Rising City, 1 (KU). *Cedar Co.:* 4 mi. SE Laurel, 6 (KU). *Cherry Co.:* 3 mi. SSE Valentine, 1 (KU). *Holt Co.:* 1 mi. S Atkinson, 1 (KU); 6 mi.

N Midway, 1 (KU). *Knox Co.:* 3 mi. W Niobrara, 1 (KU). *Washington Co.:* 6 mi. SE Blair, 4 (KU). *Wayne Co.:* ½ mi. W Wayne, 3 (KU); Wayne, 5 (KU).

OHIO. *Ashtabula Co.:* Farnham, 2 (CMNH); Mechanicsville, 7 (KU). *Geauga Co.:* Chesterland Caves, 19 (CMNH); Holden Arboretum, 1 (KU). *Lake Co.:* Holden Arboretum, 3 (KU).

Blarina hylophaga

IOWA. *Fremont Co.:* 6 mi. N, 3 mi. W Hamburg, 2 (KU); 4 mi. E Hamburg, 9 (KU); 13 mi. E Hamburg, 18 (KU); 1 mi. S Hamburg, 3 (KU); 3 mi. S, 1 mi. E Imogene, 1 (CUI); ½ mi. N, 1 mi. W Riverton, 4 (CUI); 3½ mi. S Sidney, 5 (KU); 4 mi. S, 9 mi. W Sidney, 2 (KU); 5 mi. S, 2 mi. W Sidney, 7 (KU); 2 mi. S, 3 mi. E Tabor*, 2 (1 CM, 1 MHP); 2½ mi. S, 6. mi. E Tabor, 4 (2 CM, 2 MHP); 2½ mi. S, 11 mi. E Tabor, 1 (MHP). *Keokuk Co.:* 6½ mi. S, 1 mi. W Sigourney*, 1 (KU). *Marion Co.:* 1½ mi. S, ¼ mi. W Pella*, 1 (CUI). *Page Co.:* 7 mi. W Bethesda, 1 (CM); 3½ mi. W Bethesda, 2 (1 CM, 1 MHP); $^7/_{10}$ mi. S Coin, 3 (KU); 1 mi. N, 2 mi. E Imogene (*in* Fremont Co.)*, 4 (3 CM, 1 MHP); 1 mi. N, 4½ mi. E Imogene (*in* Fremont Co.), 1 (MHP); 1 mi. N, 6 mi. E Imogene (*in* Fremont Co.)*, 2 (MHP); 1 mi. N, 7½ mi. E Imogene (*in* Fremont Co.), 2 (1 CM, 1 MHP); 1 mi. S, 3 mi. E Northboro, 4 (KU); 2 mi. S, ½ mi. W Shambaugh, 1 (KU). *Taylor Co.:* 2 mi. S, ¾ mi. W Bedford, 1 (KU); 1 mi. S, 1 mi. E Lenox, 1 (MHP); 10 mi. S Lenox*, 1 (CM); 17 mi. S, 1 mi. E Lenox*, 1 (CM).

KANSAS. *Allen Co.:* Moran, 3 (KU); no locality specified, 1 (KU). *Anderson Co.:* 7 mi. S Garnett, 1 (KU); 1 mi. N Welda, 1 (KU). *Atchison Co.:* $1^8/_{10}$ mi. N Atchison, 1 (KU); 1½ mi. S Muscotah, 7 (KU). *Brown Co.:* Brown County State Lake, 1 (MHP); 7 mi. N, ½ mi. E Hiawatha, 1 (KU); 3 mi. N Hiawatha, 1 (KU); 1 mi. S, 7 mi. E Hiawatha, 1 (MHP); 5 mi. S Hiawatha, 1 (KU); 1 mi. N Horton, 1 (KU). *Butler Co.:* 2 mi. N, $^3/_{10}$ mi. W El Dorado, 1 (MHP). *Chase Co.:* 9 mi. E Lincolnville, 1 (KU); ¼ mi. N Matfield Green, 1 (KU). *Chautauqua Co.:* 1 mi. W Wauneta, 1 (KU). *Cherokee Co.:* 1½ mi. S Galena, 1 (KU); 1 mi. N Tri-State Monument, 1 (KU); no locality specified, 1 (KU). *Coffey Co.:* 2½ mi. S Burlington, 2 (KU). *Cowley Co.:* 6 mi. N, 12 mi. E Arkansas City, 1 (KU); $8^1/_{10}$ mi. E Arkansas City, 2 (KU); 3 mi. SE Arkansas City, 4 (KU); 2 mi. N, 3 mi. E Cameron City (T.34S, R.6E, S ½ sec. 8), 1 (MHP); 2 mi. S, ½ mi. W Udall, 1 (KU). *Crawford Co.:* 2 mi. N, 1 mi. E Arma, 1 (KSCP); 1 mi. N, 2 mi. E Cherokee, 1 (KSCP); 1¼ mi. E Crawford County State Lake, 1 (KSCP); Pittsburg, 5 (4 KSCP, 1 UWSP); 2½ mi. E Pittsburg, 1 (KSCP); 2½ mi. SW Pittsburg, 1 (KSCP); 5 mi. S, 1 mi. W Pittsburg, 1 (KSCP). *Dickinson Co.:* ½ mi. S Chapman (T.12S, R.4E, sec. 32), 1 (MHP); 2 mi. W Herington, 6 (MHP). *Doniphan Co.:* Geary, 1 (KU); ½ mi. N, ¼ mi. W Severance, 1 (KU). *Douglas Co.:* 1¼ mi. N Baldwin City, 1 (KU); ½ mi. S, $5^2/_{10}$ mi. W Clinton, 1 (KU); ½ mi. W Eudora, 2 (KU); 7 mi. NNE Lawrence, 2 (KU); 6 mi. NNE Lawrence, 1 (KU); 5 mi. N Lawrence, 2 (KU); $4^8/_{10}$ mi. N, $^7/_{10}$ mi. E Lawrence (T.12S, R.20E, sec. 5), 1 (KU); $2^2/_{10}$ mi. N, $^8/_{10}$ mi. E Lawrence, 2 (KU); 2 mi. N Lawrence, 1 (KU); 2 mi. N, 2 mi. E Lawrence, 2 (KU); 1½ mi. N, 1¾ mi. E Lawrence, 7 (3 KU, 4 MHP); 1½ mi. N, $1^1/_5$ mi. E Lawrence*, 11 (KU); 1 mi. N, 4 mi. W Lawrence, 1 (KU); ½ mi. N, 1 mi. E Lawrence, 1 (KU); 2½ mi. W Lawrence, 1 (KU); 1 mi. W Lawrence, 4 (KU); Lawrence*, 14 (KU); $^8/_{10}$ mi. S, 2½ mi. W Lawrence, 1 (KU); $3^9/_{10}$ mi. S, $2^6/_{10}$ mi. E Lawrence, 1 (KU); 5¾ mi. S, ¾ mi. W Lawrence, 1 (KU); 7 mi. SW Lawrence, 4 (KU); 7½ mi. SW Lawrence*, 2 (KU); ½ mi. S, ½ mi. E Pleasant Grove, 1 (KU); Rock Creek, 1 (KU); 1 mi. S, 1¼ mi. W Vinland, 1 (KU); no locality specified, 13 (KU). *Ellis Co.:* 1 mi. S, 6½ mi. W Antonino (T.15S, R.20W, sec. 2), 5 (MHP); Ellis, 1 (MHP); 16 mi. N, 1 mi. W Hays, 2 (MHP); 9 mi. N, 4 mi. W Hays (T.12S, R.19W, NE ¼ sec. 14), 2 (MHP); 8½ mi. N, 4 mi. W Hays (T.12S, R.19W, SE ¼ sec. 14), 1 (MHP); Hays (T.14S, R.18W, sec. 4), 1 (MHP); 2½ mi. SW Hays, 1 (MHP). *Geary Co.:* 5 mi. S Grandview Plaza (T.12S, R.5E, NE ¼ sec. 25), 1 (MHP).

Greenwood Co.: Hamilton, 30 (2 CM, 22 KU, 1 MMNH, 5 UMMZ); ½ mi. E Hamilton, 2 (KU); ¼ mi. S Hamilton, 2 (KU); ¼ mi. SE Hamilton, 1 (KU); ½ mi. S Hamilton, 5 (KU); ½ mi. SE Hamilton, 1 (KU); ¾ mi. S Hamilton, 1 (KU); 1 mi. S Hamilton, 2 (KU); 1½ mi. S Hamilton, 4 (KU); 8½ mi. SW Toronto (*in* Woodson Co.), 1 (KU). *Jackson Co.:* Holton, 1 (KU); 5½ mi. E Holton, 2 (KU). *Jefferson Co.:* 5 mi. N, 2 mi. E Lawrence (*in* Douglas Co.), 1 (KU); 4 mi. N, 2 mi. E Lawrence (*in* Douglas Co.), 1 (KU). *Labette Co.:* 2 mi. SW Parsons, 1 (KU); 3 mi. S, 2 mi. E Parsons, 1 (KSCP). *Leavenworth Co.:* 1 mi. N, 4 mi. W Bonner Springs (*in* Wyandotte Co.), 2 (KU); no locality specified, 1 (KU). *Linn Co.:* ½ mi. N, 4 mi. W Prescott, 1 (KU). *Lyon Co.:* Emporia, 1 (UMMZ). *Marion Co.:* 1 mi. N, ½ mi. E Lincolnville, 1 (KU). *Marshall Co.:* 2 mi. N, ½ mi. E Oketo, 5 (MHP); 1½ mi. N, ½ mi. W Oketo (T.1S, R.7E, NW ¼ sec. 11), 1 (MHP); 1½ mi. N Oketo, 2 (MHP); 1 mi. N Oketo, 3 (MHP); 1 mi. W Oketo, 1 (MHP); Lake Idlewild, 1½ mi. N, ½ mi. E Waterville, 1 (KU); 1 mi. N Waterville, 1 (KU); ½ mi. NW Waterville, 1 (KU); 1 mi. E Waterville, 4 (KU); ½ mi. SW Waterville, 2 (KU). *Miami Co.:* 11 mi. SSE Paola*, 1 (KU). *Montgomery Co.:* Coffeyville, 1 (OU); Independence, 1 (KU). *Morris Co.:* 4⅛ mi. S, 5½ mi. W Council Grove, 1 (KU). *Nemaha Co.:* 6 mi. N Sabetha, 1 (KU); 2½ mi. S Sabetha, 2 (KU); 3½ mi. S, ¾ mi. E Sabetha, 3 (KU). *Osage Co.:* 1¾ mi. S, 1⁷⁄₁₀ mi. E Berryton, 1 (KU); 8 mi. N, 9 mi. E Osage City, 10 (MHP); 1 mi. S, 4 mi. E Scranton (T.15S, R.16E, NE ¼ sec. 7), 3 (MHP). *Osborne Co.:* T.9S, R.12W, NE ¼ sec. 30, 1 (MHP). *Phillips Co.:* 1 mi. S, 1 mi. W Agra, 1 (MHP); ¾ mi. S, ¼ mi. W Kirwin (T.4S, R.16W, NE ¼ sec. 33), 1 (MHP); 1 mi. S Kirwin, 1 (MHP); 3¾ mi. S, 3 mi. W Kirwin (T.5S, R.17W, E ½ sec. 13), 2 (MHP); 4½ mi. S, 3¼ mi. W Kirwin (T.5S, R.17W, NE ¼ sec. 4), 1 (MHP); 5 mi. S, 4 mi. W Kirwin (T.5S, R.17W, SE ¼ sec. 23), 1 (MHP). *Pottawatomie Co.:* Manhattan, 2 (USNM); Onaga, 2 (USNM); 5 mi. N Westmoreland, 2 (MHP). *Riley Co.:* Fort Riley, 1 (USNM); Manhattan, 2 (1 KU, 1 UMMZ). *Rooks Co.:* 3 mi. S, 3 mi. W Stockton, 1 (MHP). *Rush Co.:* ¹⁄₁₆ mi. E LaCrosse (T.17S, R.18W, S ½ sec. 34), 1 (MHP). *Russell Co.:* 5 mi. N, 1 mi. E Dorrance (T.13S, R.11W, NE ¼ sec. 17), 1 (MHP); 8½ mi. S, ½ mi. E Lucas (T.13S, R.11W, NE ¼ sec. 10), 1 (MHP). *Shawnee Co.:* 1 mi. N, 3 mi. W Auburn, 5 (KU); 4½ mi. N, 3 mi. W Topeka, 1 (KU); 1⁶⁄₁₀ mi. N, 1 mi. E Wakarusa, 1 (KU). *Trego Co.:* ½ mi. N, 3 mi. W Ellis (*in* Ellis Co.) (T.13S, R.21W, NE ¼ sec. 11), 1 (MHP). *Woodson Co.:* Neosho Falls, 3 (2 KU, 1 USNM); 2½ mi. N Toronto, 1 (KU); 2 mi. S Toronto, 1 (KU).

MISSOURI. *Adair Co.:* ½ mi. (by road) W Brashear*, 2 (CM). *Andrew Co.:* Amazonia, 1 (MOU); St. Joseph, 3 (MOU). *Barry Co.:* no locality specified, 1 (MOU). *Boone Co.:* Ashland, 1 (MOU); Hinkson Creek, 2 (MOU); Columbia, 25 (MOU); McBaine, 3 (MOU); no locality specified, 6 (MOU). *Callaway Co.:* Alles, 1 (MOU). *Camden Co.:* Hahatonka, 2 (UMMZ). *Chariton Co.:* Forest Green, 1 (MOU). *Clark Co.:* 1½ mi. N, 3 mi. W Antioch (T.64N, R.8W, NW ¼ sec. 14)*, 1 (CM). *Douglas Co.:* T.27N, R.13W, sec. 1, 1 (MOU). *Franklin Co.:* Meramec State Park, 2 (MOU); Washington, 1 (MOU). *Gentry Co.:* King City, 1 (MOU). *Greene Co.:* Springfield, 4 (MOU). *Grundy Co.:* 3½ mi. (by road) S Modena (*in* Mercer Co.)*, 1 (MHP); 5 mi. (by road) S Modena (*in* Mercer Co.), 1 (MHP); 6½ mi. (by road) S Modena (*in* Mercer Co.)*, 2 (CM); 2½ mi. S Tindall*, 1 (CM). *Holt Co.:* ½ mi. W Fortescue (T.61N, R.39W, W ½ sec. 32), 8 (4 CM, 4 MHP); Mound City, 1 (MOU). *Jackson Co.:* Independence, 1 (USNM); Kansas City (56th and Swope Parkway), 1 (KU); Kansas City, 2 (MOU); T.48N, R.32W, sec. 22, 1 (MOU); no locality specified, 2 (MOU). *Jefferson Co.:* Kimswick, 1 (USNM). *Johnson Co.:* Warrensburg, 1 (MOU). *Lewis Co.:* ½ mi. S, 2½ mi. E Deer Ridge (T.62N, R.9W, E ½ sec. 2)*, 1 (MHP); 2½ mi. S, 3 mi. E Deer Ridge (T.62N, R.9W, E ½ sec. 13), 1 (CM). *Lincoln Co.:* ½ mi. S, 2½ mi. W (by road) Foley, 1 (CM); 1½ mi. N Winfield, 2 (1 CM, 1 MHP). *McDonald Co.:* ½ mi. N, 4 mi. E Noel, 1 (KU). *Mercer Co.:* 1 mi. (by road) N Goshen*, 2 (1 CM, 1 MHP). *Morgan Co.:* Gravois Mills, 1 (MOU). *Nodaway Co.:* Burlington Junction, 1 (MOU). *Pettis Co.:* T.44N, R.21W, sec.

3, 1 (KU). *Ray Co.:* no locality specified, 1 (MOU). *Saline Co.:* 4 mi. (by road) W Glascow (*in* Howard Co.), 1 (CM); no locality specified, 2 (MOU). *St. Clair Co.:* no locality specified, 1 (MOU). *Wright Co.:* Mountain Grove, 1 (MOU).

OKLAHOMA. *Cleveland Co.:* Norman, 2 (1 KU, 1 OU); 2 mi. S, 1 mi. W Norman, 1 (OSU); 4 mi. S Norman, 1 (OU); 5 mi. S Norman, 1 (OU). *Garvin Co.:* 3 mi. N, 2 mi. W (by road) Davis (*in* Murray Co.), 1 (MHP). *McClain Co.:* 8 mi. W Norman (*in* Cleveland Co.), 1 (KSCP). *Murray Co.:* Platt National Park, 5 (KU); $1^3/_{10}$ mi. S, $2^2/_{10}$ mi. W (by road) Davis, 4 (MHP); $5^7/_{10}$ mi. S, $2^3/_{10}$ mi. W (by road) Davis, 1 (MHP). *Payne Co.:* Lake Carl Blackwell, 9 mi. W Stillwater, 1 (OSU); Lake Carl Blackwell, 7 mi. W Stillwater, 1 (OSU); 6 mi. W Stillwater, 1 (OSU); 3 mi. W Stillwater, 2 (OSU); Stillwater, 1 (OSU); 2 mi. S, ½ mi. E Stillwater, 1 (OSU); 2½ mi. S Stillwater, 2 (OSU); T.18N, R.2E, sec. 2, 1 (OSU); no locality specified, 1 (OSU).

ACKNOWLEDGMENTS

LITERATURE CITED

BAKER, R. J. 1970. Karyotypic trends in bats. Pp. 65–96, *in* Biology of bats (W. A. Wimsatt, ed.), Academic Press, New York, 1:1–406.

BOLE, B. P., JR., AND P. N. MOULTHROP. 1942. The Ohio Recent mammal collection in the Cleveland Museum of Natural History. Sci. Publ. Cleveland Mus. Nat. Hist., 5:83–181.

BOWLES, J. B. 1975. Distribution and biogeography of mammals of Iowa. Special Publ. Mus., Texas Tech Univ., 9:1–184.

CHOATE, J. R. 1968. Dental abnormalities in the short-tailed shrew, *Blarina brevicauda.* J. Mamm., 49:251–258.

———. 1972. Variation within and among populations of the short-tailed shrew in Connecticut. J. Mamm., 53:116–128.

COCKRUM, E. L. 1952. Mammals of Kansas. Univ. Kansas Publ., Mus. Nat. Hist., 7:1–303.

ELLIS, L. S., V. E. DIERSING, AND D. F. HOFFMEISTER. 1978. Taxonomic status of short-tailed shrews (*Blarina*) in Illinois. J. Mamm., 59:305–311.

GENOWAYS, H. H., AND J. R. CHOATE. 1972. A multivariate analysis of systematic relationships among populations of the short-tailed shrew (genus *Blarina*) in Nebraska. Syst. Zool., 21:106–116.

GENOWAYS, H. H., J. C. PATTON III, AND J. R. CHOATE. 1977. Karyotypes of shrews

of the genera *Cryptotis* and *Blarina* (Mammalia: Soricidae). Experientia, 33:1294–1295.

GEORGE, S. B., J. R. CHOATE, AND H. H. GENOWAYS. 1981. Distribution and taxonomic status of *Blarina hylophaga* Elliot (Insectivora: Soricidae). Ann. Carnegie Mus., 50:493–513.

GEORGE, S. B., H. H. GENOWAYS, J. R. CHOATE, AND R. J. BAKER. 1982. Karyotypic relationships within the genus *Blarina*. J. Mamm., in press.

GRAHAM, R. W., AND H. A. SEMKEN. 1976. Paleoecological significance of the short-tailed shrew (*Blarina*), with a systematic discussion of *Blarina ozarkensis*. J. Mamm., 57:433–449.

HALL, E. R. 1981. The mammals of North America. John Wiley and Sons, New York, 1:xv + 1–600 + *90*.

HELWIG, J. T., AND K. A. COUNCIL (eds.). 1979. SAS user's guide. SAS Institute, Raleigh, North Carolina, 494 pp.

HOFFMANN, R. S., AND J. K. JONES, JR. 1970. Influence of late-glacial and post-glacial events on the distribution of Recent mammals on the northern Great Plains. Pp. 355–394, *in* Pleistocene and Recent environments of the central Great Plains (W. Dort, Jr., and J. K. Jones, Jr., eds.), Spec. Publ. 3, Dept. Geol., Univ. Kansas, 433 pp.

JONES, J. K., JR. 1964. Distribution and taxonomy of mammals of Nebraska. Univ. Kansas Publ., Mus. Nat. Hist., 16:1–356.

JONES, J. K., JR., AND J. S. FINDLEY. 1954. Geographic distribution of the short-tailed shrew, Blarina brevicauda, in the Great Plains. Trans. Kansas Acad. Sci., 57:208–211.

JONES, J. K., JR., AND B. P. GLASS. 1960. The short-tailed shrew, Blarina brevicauda, in Oklahoma. Southwestern Nat., 5:136–142.

NIE, N. H., C. H. HALL, J. G. JENKINS, K. STEINBRENNER, AND D. H. BENT. 1975. Statistical package for the social sciences. McGraw-Hill, New York, xxiv + 675 pp.

ROHLF, F. J., J. KISHPAUGH, AND D. KIRK. 1974. Numerical taxonomy system of multivariate statistical programs. State Univ. New York, Stony Brook.

YATES, T. L., AND D. J. SCHMIDLY. 1977. Systematics of Scalopus aquaticus (Linnaeus) in Texas and adjacent states. Occas. Papers Mus., Texas Tech Univ., 45:1–36.

APPENDIX 1

Counties included within samples 1–22 (with sample sizes indicated in parentheses) were as follows: 1) Iowa—Fremont, Guthrie, Mills, Montgomery, Page, and Pottawattamie (30); 2) Iowa—Adams, Decatur, Ringgold, Taylor, and Union (56); 3) Iowa—Keokuk, Lucas, Mahaska, Marion, Monroe, and Poweshiek (62); 4) Missouri—Grundy and Mercer (20); 5) Missouri—Adair, Clark, and Lewis (10); 6) Kansas—Douglas and Miami, and Missouri—Buchanan (5); 7) Iowa—Fremont (47); 8) Iowa—Page and Taylor (21); 9) Iowa—Keokuk and Marion, and Missouri—Adair, Clark, Grundy, Lewis, and Mercer (11); 10) Kansas—Geary, Marshall, Nemaha, Pottawatomie, and Riley (20); 11) Kansas—Atchison, Brown, and Doniphan (13); 12) Kansas—Leavenworth, and Missouri—Andrew, Gentry, Holt, Jackson, and Ray (19); 13) Kansas—Dickinson, Marion, and Morris (7); 14) Kansas—Jackson, Jefferson, and Shawnee (10); 15) Kansas—Chase, Greenwood, and Lyon (27); 16) Kansas—Anderson, Coffey, and Osage (11); 17) Kansas—Douglas and Miami (54); 18) Kansas—Butler, Chautauqua, and Cowley (8); 19) Kansas—Allen, Cherokee, Crawford, Labette, and Woodson, and Missouri—McDonald (12); 20) Missouri—Camden, Greene, Morgan, Pettis, and Wright (7); 21) Missouri—Boone (23); 22) Missouri—Franklin and Lincoln (6).