

Quaternary Records of the Pygmy and Smoky Shrews from South-central Indiana Caves

RONALD L. RICHARDS, Indiana State Museum
202 North Alabama Street, Indianapolis, Indiana 46204

Both the Pygmy (*Microsorex hoyi*) and the Smoky (*Sorex fumeus*) Shrews were just recently trapped in south-central Indiana (7; John O. Whitaker, Jr., personal communication, November, 1982). Lyon (1936) had noted that the Pygmy Shrew might possibly occur in Indiana, anywhere in the state, and that the Smoky Shrew might possibly occur in the northern counties as well as around the cold cave entrances in southern Indiana (23). Hall and Kelson (1959) and Burt and Grossenheider (1964) had correctly indicated the presently known range of the Smoky Shrew in Indiana, though without any specimens for documentation (19; 5). Mumford (1969) made no mention of either shrew (24). The only reference to fossil and sub-Recent shrews in Indiana was in 1972 (29). Further identification of those and additional shrew remains form the basis of this paper.

Identifications were with Guilday's "Keys" to the genera and species of Eastern North American soricids based on lower jaws (11), and with comparative material donated and on loan from the Department of Life Sciences, Indiana State University, and material examined at the Museum, Michigan State University, and the Field Museum of Natural History, Chicago. Comparative measurements, made with an ocular micrometer at 15X, are illustrated in Figure 1. The cave remains, generally from undescribed faunas, are temporarily on file with the author. Abbreviations: L, left; R, right; i, p, m, lower incisor, premolar (unicuspid), and molar, respectively; P, M, upper premolar and molar; \bar{X} , Mean; O.R., Observed Range; N, Number of individuals; B.P., Before Present (1950 A.D.); mm., millimeters.

Remains of 8 individuals of *Microsorex hoyi* (4L, 6R dentaries; 2 palates; 1R maxilla) were recovered from Freeman's Pit, northwest Monroe county, Indiana (Figure 2). Six of the shrews occurred with an abundant microfauna in the top 11 inches of a 24 inch laminated silt/clay deposit at the bottom of the 97 foot pit. Palates of two individuals were from nearby deposits. A single radiocarbon date on bone from the lowermost level of *Microsorex* occurrence in the laminated deposit (Level SL-1) gave a date of $2,315 \pm 65$ years B.P. Remains of *Microsorex* showed no difference in size or morphology throughout the laminated deposit.

Microsorex has been found fossil in 14 sites of 10 other states (Figure 3). *Microsorex pratensis* has been reported from the Middle Pleistocene of Kansas (20), and *M. minutus* from the Late Pleistocene of Arkansas (3). All other fossils are of *M. hoyi*. If the small *M. h. thompsoni* and *M. h. winnemana* of the Appalachians are to be regarded as a separate species, *M. h. thompsoni* (22), then most of the eastern North American cave fossils should be placed in that taxon. While several of the sites appear to be out of the modern range of *Microsorex* (eg. Crankshaft Cave, Missouri; Meyer Cave, Illinois; Freeman's Pit, Indiana; Robinson Cave, Tennessee; Peccary Cave, Arkansas and Little Box Elder Cave, Wyoming), the rarity of the Pygmy shrew and its often sporadically recovered specimens makes its modern distribution difficult to determine. It is apparent, however, that it was more common and widespread in the east and had extended its range further south in the Late Pleistocene (14; 16).

Microsorex exhibits a Bergmann's Response, with the largest individuals in Alaska and Canada, and the smallest in the Rocky and Appalachian Mountains

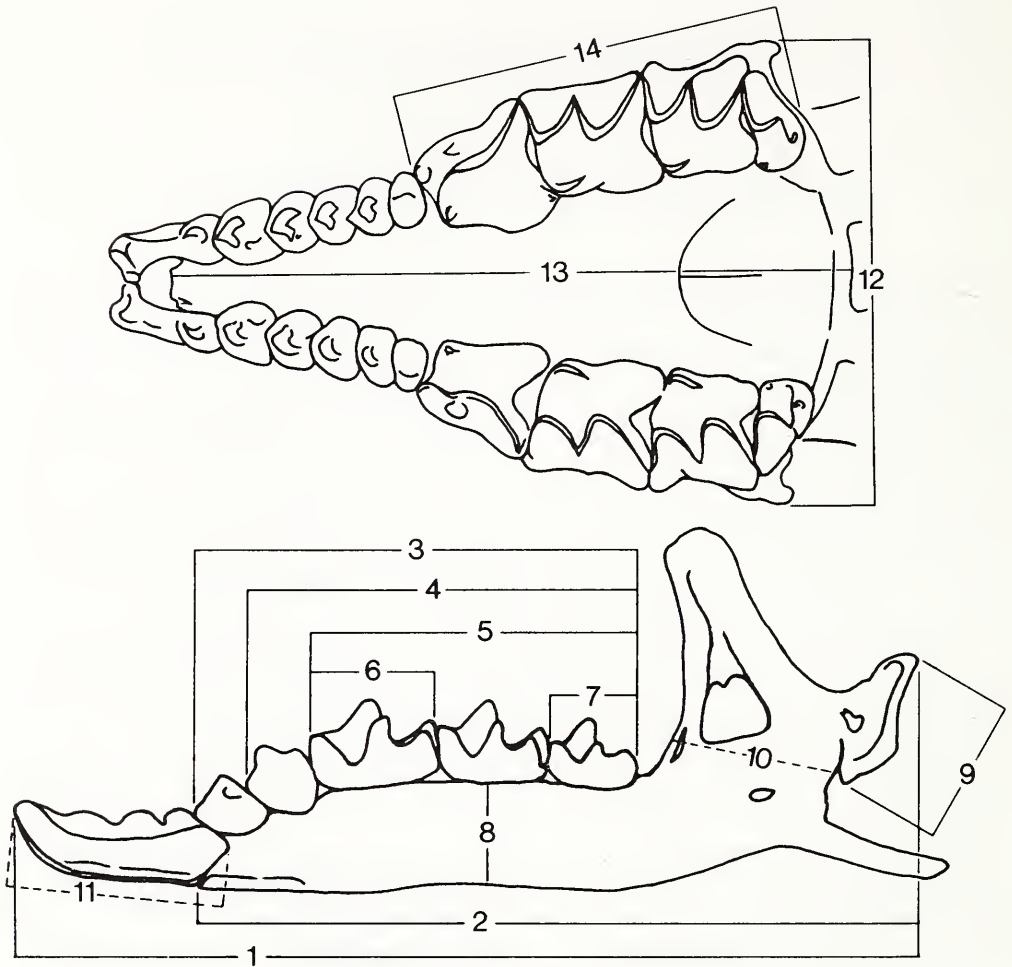


FIGURE 1. Palate (above) and right dentary (below) of *Sorex fumeus*, illustrating comparative measurements. 1, Total length of mandible (including incisor); 2, Total length of dentary; 3, p3-m3; 4, p4-m3; 5, m1-m3; 6, Length, m1; 7, Length, m3; 8, Depth of dentary at m2; 9, Width of condyle; 10, Width (least) of vertical ramus; 11, Length of incisor; 12, Maxillary width; 13, Palatal length; 14, P4-M3. Note, dentary lays flat on labial side for measuring. Measurements with dotted lines are taken from the opposite side.

(22). Most of the eastern North American fossils (eg. from New Paris #4, Pa.; Bootlegger Sink, Pa.; Clark's Cave, Va.; Robinson Cave, Tn. and Welsh Cave, Ky.) have the small size of *M. h. thompsoni/winnemana* in the Appalachians today (17). Absent were bones of the larger northern *Microsorex* perhaps to have been anticipated from late glacial age sites. The Pygmy shrews from Freeman's Pit were small (Table 1; Figure 4). They do have some size overlap with the smallest individuals from Robinson and Baker Bluff Caves, Tennessee.

Long (22) suggested that the Pleistocene glaciations displaced *Microsorex* populations into refugia, with the warm Recent epoch restricting some to mountain ranges. The several subspecies would have developed from the isolated populations, with *M. h. hoyi* ranging into the region formerly covered by the Wisconsinan glacial ice. Guilday et. al. (17) suggest the possibility that *M. hoyi* may have spread into eastern Canada from the west during postglacial times. They note that "except for the Gaspé Peninsula, where it is replaced by *M. hoyi*, the nor-



FIGURE 2. Locations of Indiana caves containing shrew species discussed in text. *Microsorex hoyi*: F, Freeman's Pit, Monroe Co.; *Sorex fumeus*: H, Hidden Pit Cave, Owen Co.; F, Freeman's Pit, Monroe Co.; S, Showcase Cave, Monroe Co.; A, Anderson Pit Cave, Monroe Co.; K, King Leo Cave, Harrison Co.; D, Devil's Staircase Cave, Harrison Co.; J, N. Jim Cave, Harrison Co.; R, Owl Roost deposit, Harrison Co.; Misc. shrew faunas: 1, Sullivan's Cave, Lawrence Co.; 2, Carcass Crypt Cave, Lawrence Co.; 3, Gibbs Pit, Harrison Co..

thern limit of *M. thompsoni* appears to be defined by the Great Lakes—St. Lawrence waterway, which may have acted as a barrier to its northward spread in postglacial times". The Freeman's Pit *Microsorex* also suggest that the larger *M. h. hoyi* had been absent in eastern North America from the Late Pleistocene and thereafter, suggesting, as Guilday et. al. had pointed out, that *M. hoyi* and *M. thompsoni* were at one time geographically separated populations, arguing for specific distinction. To date, the Freeman's Pit bones represent the smallest Pygmy Shrews known, and appear to have genetic affinities with the populations inhabiting the southern Appalachians today.

Sorex fumeus, the Smoky Shrew, is documented in Indiana by fossil and Recent age specimens representing about 47 individuals (30L, 45R dentaries; 10 palates; 9L, 8R maxillae) from 7 caves in Owen, Monroe and Harrison counties (Figure 2). One palate was recovered from an "old" owl pellet deposit on a Harrison county bluff. Lack of *S. fumeus* bones from caves of interjoining counties is probably due to insufficient collecting. In the two Indiana caves where the deposits were excavatable in sequential units (Freeman's Pit, Monroe Co. and N. Jim Cave, Harrison Co.) the lowermost levels produced larger *S. fumeus* den-

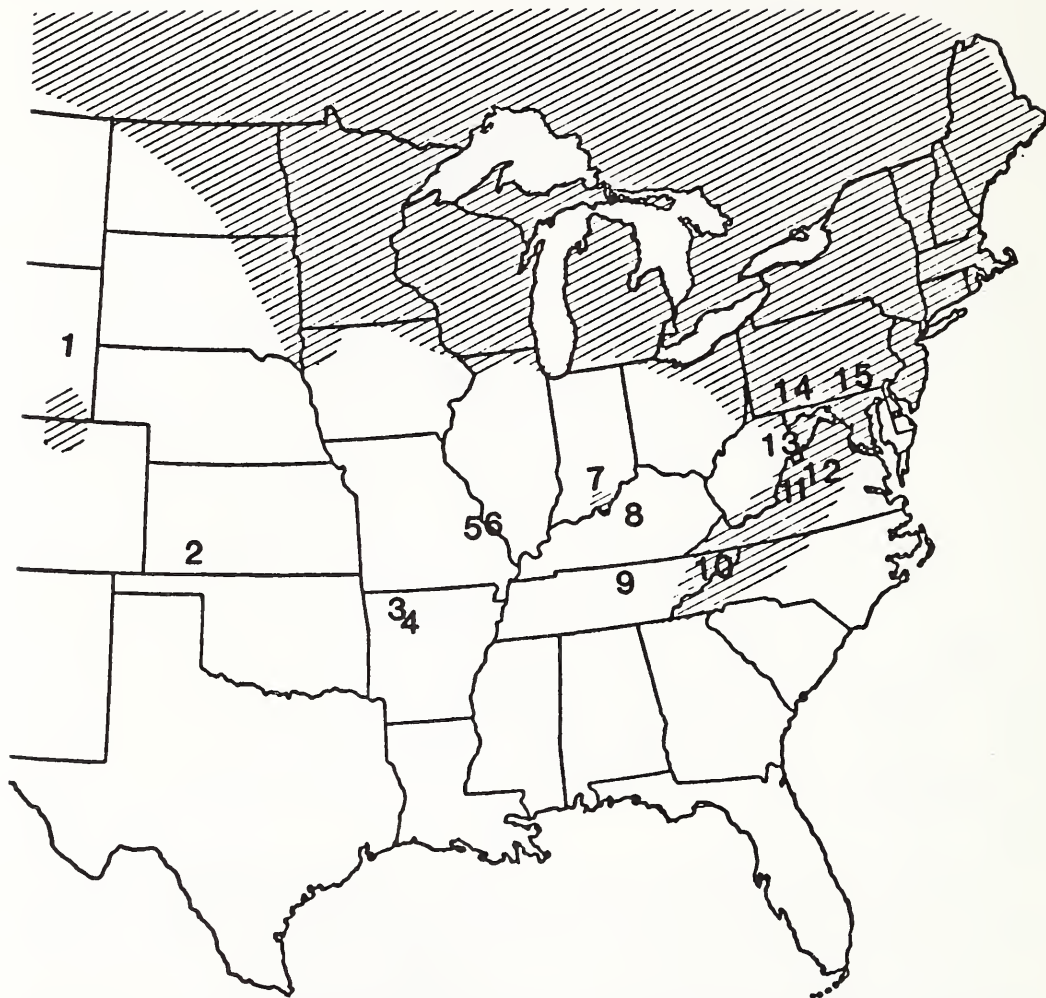


FIGURE 3. Recent and fossil range of *Microsorex*. Hatched area: modern range (data modified from Hall and Kelson, 1959, Long, 1972 and Caldwell, 1980). Fossil sites (and literature citation): 1, Little Box Elder Cave, Converse Co., Wyo. (1); 2, *M. pratensis*, Meade Co., Kan. (20); 3, *M. minutus*, Conard Fissure, Newton Co., Ark. (3); 4, Peccary Cave, Newton Co., Ark. (9); 5, Crankshaft Cave, Jefferson Co., Mo. (27); 6, Meyer Cave, Monroe Co., Il. (26); 7, Freeman's Pit, Monroe Co., In.; 8, Welsh Cave, Woodford Co., Ky. (15); 9, Robinson Cave, Overton Co., Tn. (14); 10, Baker Bluff Cave, Sullivan Co., Tn. (18); 11, Clark's Cave, Bath Co., Va. (17); 12, Natural Chimneys, Augusta Co., Va. (11); 13, Eagle Cave, Pendleton Co., W. Va. (12); 14, New Paris #4, Bedford Co., Pa. (16); 15, Bootlegger Sink, York Co., Pa. (13).

taries and teeth (Figures 5 and 6). The change is gradual in Freeman's Pit, perhaps because of the number of excavation units and/or a continuous deposition, and quite abrupt in N. Jim Cave, with only a sparse representation of the smaller *S. fumeus*.

The great discrepancy in size of the large N. Jim Cave *S. fumeus* from all other Indiana cave specimens (Figure 5 and Table 2) made their identification at first questionable, since they ranged into the large size of *Sorex palustris*, the Water Shrew and *S. arcticus*, the Arctic Shrew. Characters of the ml (used by Guilday) to separate these species appeared intermediate in some instances. Scrutiny of the lower incisor, however, allowed separation of 64 of 67 modern

TABLE 1. *Measurements of Microsorex, Freeman's Pit, Monroe Co., Indiana (mm).*

Measurement	\bar{X}	O.R.	N (of elements)
Total length of mandible (including i):	7.38	7.20-7.57	8
Total length of dentary:	5.95	5.81-6.10	9
p3-m3:	3.50	3.43-3.60	4
p4-m3	3.19	3.13-3.25	5
m1-m3:	2.64	2.50-2.76	9
Length, m1:	1.04	0.95-1.09	10
Length, m3:	0.72	0.60-0.77	9
Depth of dentary at m2:	0.88	0.80-0.97	10
Width of condyle:	1.36	1.30-1.40	8
Height of vertical ramus:	2.90	2.78-3.07	9
Maxillary width:	3.75	3.70-3.80	2
Palatal length:	4.71	4.61-4.8	2
P4-M3:	3.07	2.97-3.17	2

comparative specimens (*S. palustris*: British Columbia, 1; Ontario, 3; Maine, 2; Vermont, 1; Wisconsin, 5; Wyoming, 1; Colorado, 3; California, 10; *S. arcticus*: Alaska, 2; Canada, 2; Minnesota, 2; Wisconsin, 7; *S. fumeus*: Quebec, 1; Maine, 2; New Brunswick, 1; New York, 1; West Virginia, 4; North Carolina, 1; Indiana (modern), 18). Incisors of 3 specimens from Harrison Co., In. were too worn to make a *S. fumeus/palustris* distinction. In *S. palustris* and *S. fumeus* a ridge extends along the inner inferior edge of the lower incisor: it rises gradually upward at

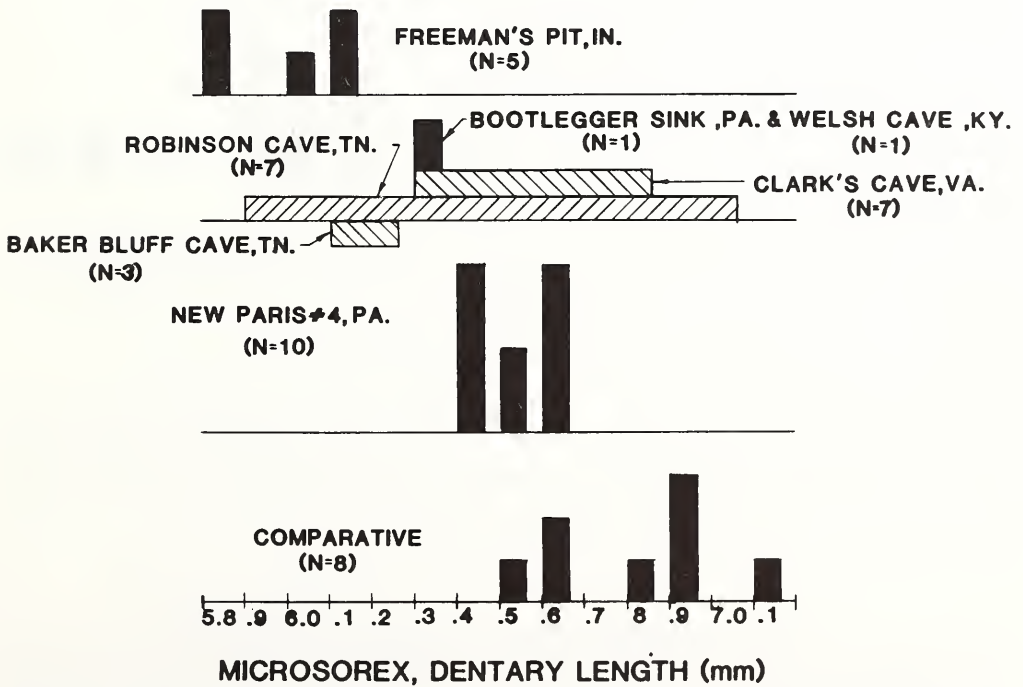


FIGURE 4. *Variation of dentary length in Microsorex, eastern North American sites. Black vertical bars, individual measurements. N= number of individuals. Hatched horizontal bars, encompass the Observed Range (individual measurements not available). Modern comparative specimens, left to right: Alberta; New York/Pennsylvania (New Paris #3, Guilday, et. al., 1977); Wisconsin; Illinois/Wisconsin/Maine; Wisconsin.*

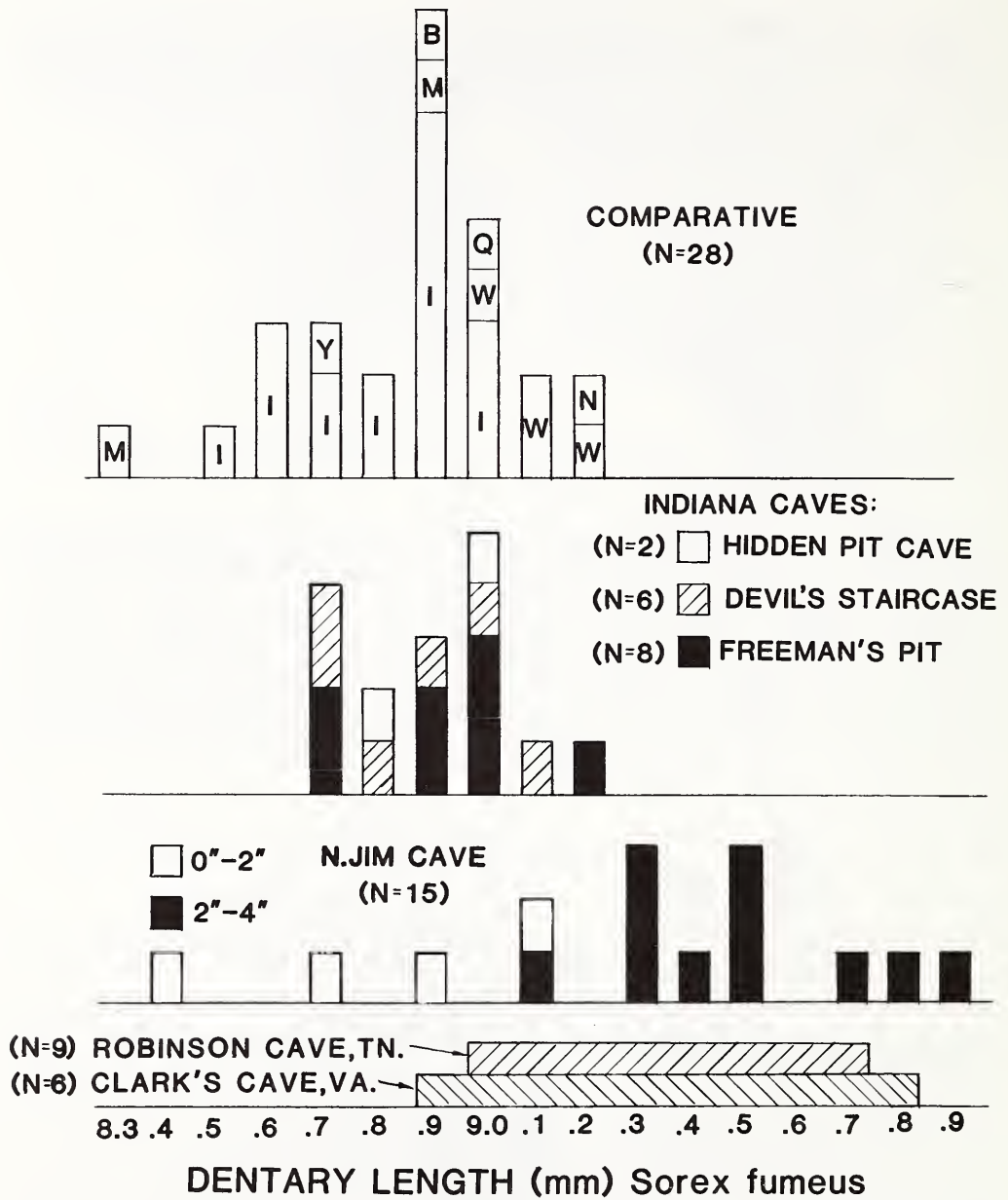


FIGURE 5. *Sorex fumeus*, variation in dentary length. Vertical bars, individual measurements. N= number of dentaries. Horizontal bars, encompass the Observed Range (individual measurements not available). Modern comparative specimens: B, New Brunswick, 1; I, Indiana (Harrison/Crawford Cos.), 18; M, Maine, 2; N, North Carolina, 1; Q, Quebec, 1; W, West Virginia, 4; Y, New York, 1.

the tip of the tooth in *palustris*, but bows strongly upward in *fumeus*. In *S. arcticus* the ridge extends nearly along the midline of the tooth. Guilday's use of the postmandibular foramen in identifying *S. arcticus* was supported. By lower incisor criteria, all medium and large size Indiana cave *Sorex* in this study appear to represent *Sorex fumeus*.

The Smoky Shrew has been found fossil on 9 sites of six other states (Figure 7). The earliest record is from the Conard Fissure deposit, Arkansas (3). Relying on relatively mature forest cover, *S. fumeus* is presently the most common *Sorex*

TABLE 2. *Measurements of Indiana Sorex fumeus, modern and cave specimens (mm.).*

Site	\bar{X}	O.R.	N (of elements)
Total length of mandible (including incisor):			
Modern, Harrison/Crawford Cos.:	10.82	10.49-11.08	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	10.91	10.74-11.01	3
Level II:	11.13	--	1
Level SL-1:	11.26	--	1
Other deposits: "Chimney":	10.74	--	1
"Attic, Room #4":	11.26	--	1
Hidden Pit Cave, Owen Co.:	11.0	10.99-11.0	2
Devil's Staircase Cave, Harrison Co.:	10.95	10.81-11.12	5
N. Jim Cave, Harrison Co.: 0-2":	11.0	10.63-11.5	4
2-4":	11.79	11.42-12.38	10
Total length of dentary:			
Modern, Harrison/Crawford Cos.:	8.80	8.37-9.04	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	8.92	8.67-9.18	4
Level II:	8.92	--	1
Level SL-1:	9.0	--	1
Other deposits: "Chimney":	8.67	--	1
"Attic, Room #4":	9.0	--	1
Hidden Pit Cave, Owen Co.:	8.89	8.78-9.0	2
Devil's Staircase Cave, Harrison Co.:	8.86	8.68-9.911	6
N. Jim Cave, Harrison Co.: 0-2":	8.77	8.41-9.11	4
2-4":	9.48	9.13-9.88	11
p3-m3:			
Modern, Harrison/Crawford Cos.:	5.19	5.01-5.32	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	5.26	5.20-5.37	3
Level II:	5.27	--	1
Hidden Pit Cave, Owen Co.:	5.20	--	1
Devil's Staircase Cave, Harrison Co.:	5.30	5.26-5.33	2
N. Jim Cave, Harrison Co.: 0-2":	5.37	5.10-5.54	3
2-4":	5.39	5.02-5.60	4
p4-m3:			
Modern, Harrison/Crawford Cos.:	4.58	4.41-4.75	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	4.61	4.54-4.71	5
Level I&II:	4.68	--	1
Level II:	4.63	--	1
Other deposits: "Attic, Room #4":	4.57	--	1
Hidden Pit Cave, Owen Co.:	4.60	4.51-4.68	2
Devil's Staircase Cave, Harrison Co.:	4.67	4.63-4.72	3
N. Jim Cave, Harrison Co.: 0-2":	4.71	4.49-5.01	4
2-4":	4.73	4.41-4.90	4
m1-m3:			
Modern, Harrison/Crawford Cos.:	3.74	3.60-3.90	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	3.77	3.70-3.81	5
Level I&II:	3.77	--	1
Level II:	3.76	--	1
Level SL-1:	4.02	--	1
Other deposits: "Chimney":	3.76	--	1
"Attic, Room #4":	3.80	--	1
Hidden Pit Cave, Owen Co.:	3.80	3.74-3.86	2
Devil's Staircase Cave, Harrison Co.:	3.82	3.76-3.90	5
N. Jim Cave, Harrison Co.: 0-2":	3.89	3.68-4.14	4
2-4":	3.95	3.63-4.07	7

TABLE 2. — Continued

Site	\bar{X}	O.R.	N (of elements)
Length, ml:			
Modern, Harrison/Crawford Cos.:	1.47	1.41-1.54	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I:	1.49	1.43-1.54	7
Level I&II:	1.51	1.48-1.56	3
Level II:	1.54	1.50-1.57	2
Level SL-1:	1.61	1.60-1.61	2
Other deposits: "Chimney":	1.52	1.50-1.55	3
"Attic, Room #4":	1.47	—	1
Hidden Pit Cave, Owen Co.:	1.50	—	2
Showcase Cave, Monroe Co.:	1.50	—	1
Anderson Pit Cave, Monroe Co.:			
Woodrat Den #1: Upper Level:	1.50	—	1
Deposit 13.2	1.58	—	1
King Leo Cave, Harrison Co.:	1.50	—	1
Devil's Staircase Cave, Harrison Co.:	1.52	1.45-1.57	5
N. Jim Cave, Harrison Co.: 0-2"	1.55	1.45-1.65	4
2-4":	1.60	1.48-1.66	23
Maxillary width:			
Modern, Harrison/Crawford Cos.:	5.21	5.00-5.47	17
Owl Roost Deposit, Harrison Co.:	5.20	—	1
Devil's Staircase Cave, Harrison Co.:	5.20	—	1
N. Jim Cave, Harrison Co.: 2-4"	5.54	5.48-5.6+	2
Palatal length:			
Modern, Harrison/Crawford Cos.:	7.59	7.30-7.83	17
Owl Roost Deposit, Harrison Co.:	7.54	—	1
Devil's Staircase Cave, Harrison Co.:	7.58	—	1
N. Jim Cave, Harrison Co.: 0-2":	8.10	—	1
2-4":	8.42	8.30-8.54	2
P4-M3:			
Modern, Harrison/Crawford Cos.:	4.55	4.36-4.73	18
Freeman's Pit, Monroe Co.:			
Laminated deposit: Level I&II:	4.70	—	1
Owl Roost Deposit, Harrison Co.:	4.70	—	1
Devil's Staircase Cave, Harrison Co.:	4.50	—	1
N. Jim Cave, Harrison Co.: 2"-4":	4.87	4.77-5.05	3

in the central and southern Appalachians; it was relatively scarce, however, on most mid-Appalachian faunal sites, perhaps indicating more open woodlands in the Late Pleistocene than at present (17).

Sorex fumeus appears to exhibit a reverse Bergmann's Response, the southern populations (eg. West Virginia) having larger individuals than those to the north; there is a general conformity with the cave fossils (Figure 5). Dentaries from N. Jim Cave, Indiana have the large size of the fossils from Clark's Cave, Va. and Robinson Cave, Tn.

The Indiana data suggests that there was a change to a smaller *S. fumeus* in more recent periods. Perhaps this size change can be used in correlating at least local faunal deposits. If so, the N. Jim Cave bones would be older than those from Freeman's Pit, among others. If the clinally variable *S. fumeus* populations did adjust their ranges to the rigorous glacial climates of the Pleistocene, perhaps the size of *S. fumeus* (as well as *Microsorex*) fossils could be used in paleoclimatic interpretation (eg. larger *S. fumeus*, warmer climates), as has been done with *Blarina brevicauda*, the Short-tailed Shrew (10). More C-14 dated, stratigraphically excavated, shrew faunas are needed from the Midwest.

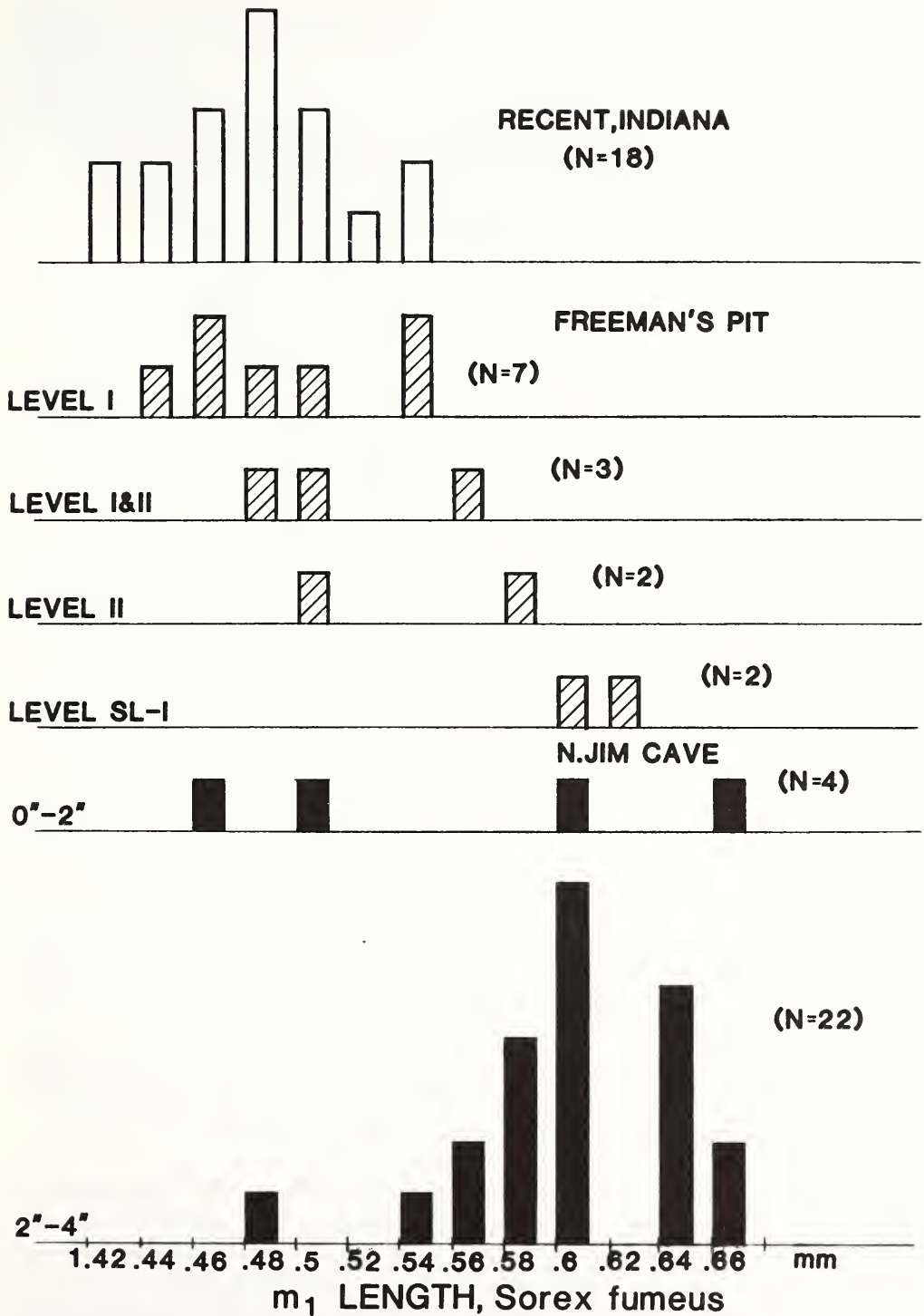


FIGURE 6. Indiana *Sorex fumeus*, variation in *m*₁ length. Vertical bars, individual measurements. N= number of *m*₁'s measured. Recent, Indiana from Harrison/Crawford counties.

To put the abundance of *Microsorex hoyi* and *Sorex fumeus* in perspective, total shrew faunas from several Indiana caves are listed (Table 3). *Blarina brevicauda*, the Short-tailed Shrew, one of Indiana's most abundant mammals, usually dominated the shrew component of a cave fauna. A dozen other cave

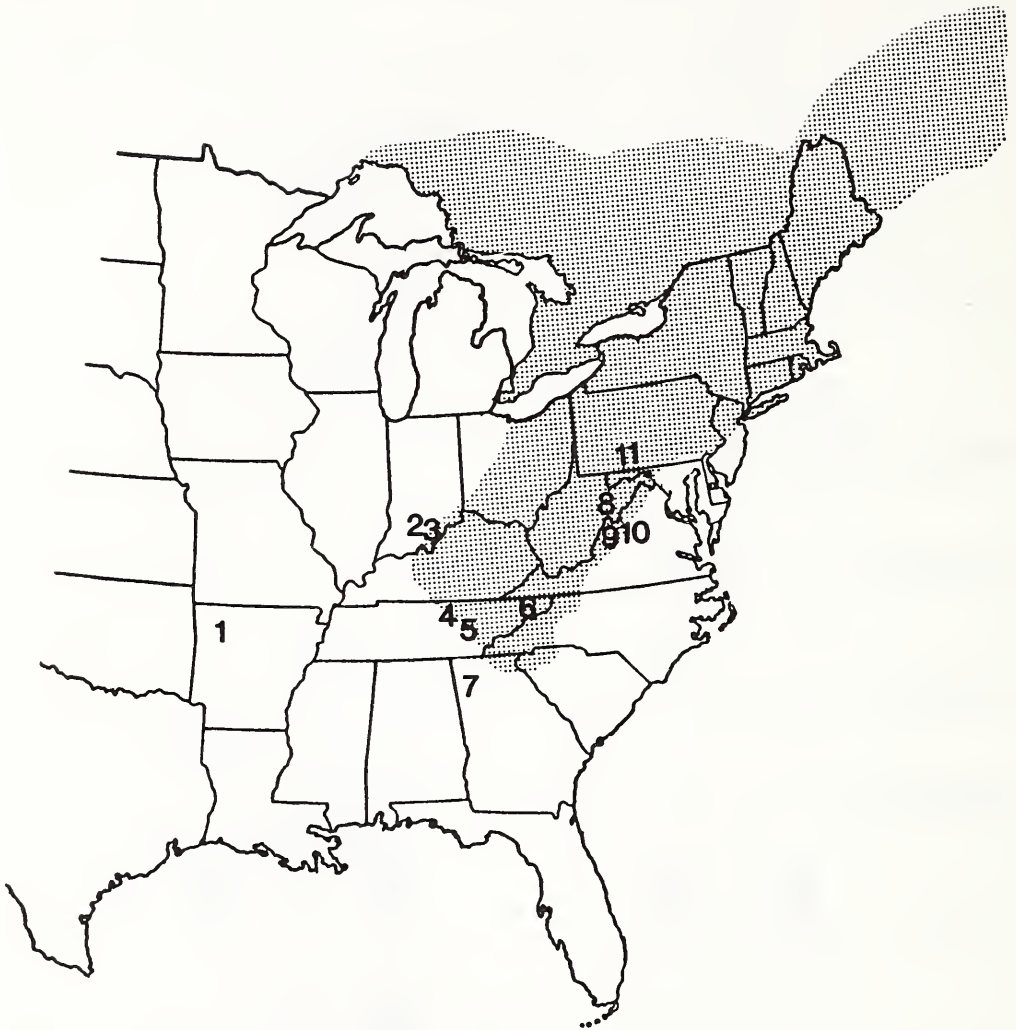


FIGURE 7. Recent and fossil range of *Sorex fumeus*. Stippled area: modern range (after Hall and Kelson, 1959). Fossil sites (with literature citation): 1, Conard Fissure, Newton Co., Ark. (3); 2,3 Owen/Monroe and Harrison Co., In. sites (see Fig. 2); 4, Robinson Cave, Overton Co., Tn. (14); 5, Banshee Hole, Cumberland Co., Tn. (8); 6, Baker Bluff Cave, Sullivan Co., Tn. (18); 7, Ladds, Bartow Co., Ga. (28); 8, Eagle Cave, Pendleton Co., W. Va. (12); 9, Clark's Cave, Bath Co., Va. (17); 10, Natural Chimneys, Augusta Co., Va. (11); 11, New Paris #4, Bedford Co., Pa. (16).

deposits, not listed in Table 3, contained *B. brevicauda* as the only shrew. It is presently found in most habitats except those that are excessively wet (24). *Cryptotis parva*, the Least Shrew, was usually absent, or represented less than 8.0% of a shrew fauna. In the Harrison county owl roost deposit, however, this grassland-inhabiting species accounted for 38.0% of the shrews, reflecting its availability for owl predation. *Sorex fumeus* inhabits moist woodlands where rocks, fallen trees, or brush provide good ground cover (2). It consistently represented 5.0-7.0% of the shrews throughout the upper four levels of Freeman's Pit, Monroe county. In extreme south-central Indiana, where the shrew has been recently trapped, the percent was much higher: 33.0% in Devil's Staircase Cave, Harrison county, and 79.0% in N. Jim Cave, Harrison County, where the predominantly large version of *S. fumeus* outnumbered *B. brevicauda* 5 to 1. It was nearly absent from the "old" owl roost deposit of the same county. *Microsorex*, often found in a wooded

TABLE 3. *Indiana Cave Deposit Shrew Faunas*¹

Site	<u>Blarina</u>	<u>Cryptotis</u>	<u>Microsorex</u>	<u>Sorex</u>	<u>Sorex</u>	<u>Sorex</u>	<u>Sorex</u>
	<u>breviceauda</u>	<u>parva</u>	<u>hoi</u>	<u>fumeus</u>	<u>longirostris</u>	<u>cinereus</u>	<u>cinereus/ longirostris</u>
Owen County							
Hidden Pit Cave	2 (40%)	--	--	3 (60%)	--	--	--
Monroe County							
Freeman's Pit:							
Laminated sequence: ²							
Level I:	46 (72%)	1 (2%)	3 (5%)	4 (6%)	10 (16%)	--	--
Level I & II:	27 (69%)	2 (5%)	--	2 (5%)	7 (18%)	1 (3%)	--
Level II:	11 (61%)	1 (6%)	2 (11%)	1 (6%)	2 (11%)	1 (6%)	--
Level SL-1:	9 (64%)	--	1 (7%)	1 (7%)	2 (14%)	1 (7%)	--
Level SL-2	3 (75%)	--	--	--	--	--	1 (25%)
Level SL-4:	1 (50%)	--	--	--	--	--	1 (50%)
Other Deposits:							
"Chimney":	3 (43%)	--	1 (14%)	2 (29%)	--	--	1 (14%)
"Bank":	7 (70%)	1 (10%)	1 (10%)	--	1 (10%)	--	--
"Attic, Room #4":	5 (63%)	--	--	1 (13%)	--	1 (13%)	1 (13%)
Showcase Cave	11 (92%)	--	--	1 (8%)	--	--	--
Anderson Pit Cave:							
Woodrat Den #1: ³							
Upper Level:	33 (89%)	--	--	2 (5%)	--	2 (5%)	--
Lower Level:	12 (86%)	--	--	--	--	2 (14%)	--
Deposit 13.1:	7 (88%)	--	--	1 (13%)	--	--	--
Deposit 13.2:	4 (80%)	--	--	1 (20%)	--	--	--
"Ledge #1":	2 (67%)	--	--	--	1 (33%)	--	--
"Ledge #2":	16 (94%)	--	--	--	--	1 (6%)	--
Lawrence County							
Sullivan's Cave:	34 (100%)	--	--	--	--	--	--
Carcass Crypt Cave:	2 (33%)	2 (33%)	--	--	2 (33%)	--	--
Harrison County							
King Leo Cave:	34 (94%)	1 (3%)	--	1 (3%)	--	--	--
Gibbs Pit:	2 (67%)	--	--	--	1 (33%)	--	--
Devil's Staircase Cave:	7 (58%)	--	--	4 (33%)	--	1 (8%)	--
N. Jim Cave: ⁴							
0-2":	1 (25%)	--	--	3 (75%)	--	--	--
2-4":	3 (12%)	2 (8%)	--	20 (80%)	--	--	--
Owl Roost Deposit:	49 (58%)	32 (38%)	--	1 (1%)	2 (2%)	--	--

1, The shrew component of faunas from predominantly silt/clay deposits in caves are listed. Cave locations given in Figure 2.

2, The 24-inch, laminated silt/clay deposit was arbitrarily divided into 8 units. From uppermost down: Level I, Level I & II, and Level II (each 3-4 inch units); Level SL-1, SL-2, SL-3, SL-4, SL-5 (each 2-3 inch units).

3, A 5-9 inch deep silt/clay deposit on a ledge, arbitrarily divided into Upper and Lower units.

4, A small bone deposit arbitrarily recovered in 2-inch increments: uppermost (0-2") and below (2-4").

area or grass clearing bordering it (4), represented 0-11.0% of the shrews in Freeman's Pit, Monroe county, but was absent from all other cave sites. *Sorex longirostris*, the Southeastern Shrew, was common in south-central Indiana cave faunas. It accounted for 11.0-18.0% of the shrews in Freeman's Pit. Though Rose (30) trapped most of his specimens in oldfields, it does also inhabit forested areas. *Sorex cinereus*, the Masked Shrew, with few records from south-central Indiana (25), was recovered in lesser numbers (0-8.0%) and more sporadically from cave deposits than the Southeastern Shrew. It occurs in a variety of moist habitats (5).

Some authors have had difficulty in separating fragmented fossils of *Sorex cinereus* and *Sorex longirostris* (14; 17). *Sorex longirostris* is slightly smaller than

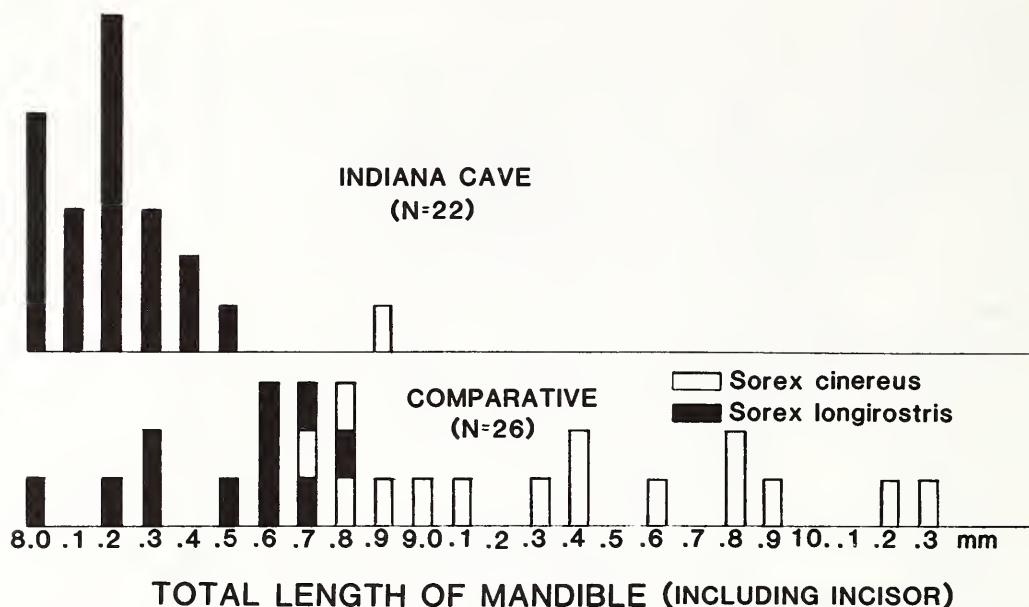


FIGURE 8. Separation of *Sorex cinereus* and *Sorex longirostris* by Total length of mandible. Upper, all Indiana cave specimens combined. Lower, modern comparative specimens: *Sorex longirostris* (black): 8.0, In.; .2, Al.; .3-.5, In.; .6-.8, S. Car. *Sorex cinereus* (white): .7, Mi.; .8, Mi./In.; .9, In.; 9.0-.1, Mi.; .3-.4, In.; .6-.8, Mi..

S. cinereus. Both display clinal variation in size. *Sorex cinereus* becomes larger to the north (16), and by the few specimens examined by the author *S. longirostris* appears to get larger to the south. The relative sizes of the 3rd and 4th upper unicuspsids, a somewhat unreliable but often used character in separating skulls of the two species (2), can rarely be used since the unicuspsids are usually lost in the recovery of fossil material. It was found that any of four measurements of the lower jaw (dentary) will separate most *Sorex* "cinereus/longirostris" jaws recovered: Total length of mandible; Total length of dentary; Length of lower incisor, and width of vertical ramus (Figure 1; eg. Figure 8). The latter two measurements were based upon limited material. Measurement of the width of the vertical ramus allows identification of a commonly recovered fragment.

TABLE 4. Percent of species in eastern North American shrew faunas (no. of individuals).

Species	New Paris #4, Pa.	Natural Chimneys, Va.	Clark's Cave, Va.	Baker Bluff Cave, Tn.	Robinson Cave, Tn.	Crankshaft Cave, Mo.	Meyer Cave, Il.
<i>Blarina brevicauda</i>	35% (37)	42% (56)	42% (97)	54% (149)	36% (83)	86% (663)	20% (262)
<i>Cryptotis parva</i>	—	4% (5)	—	1% (3)	2% (5)	.6% (5)	78% (1049)
<i>Microsorex hoyi</i>	10% (11)	5% (7)	3% (7)	3% (9)	7% (17)	1% (10)	—(1)
<i>Sorex arcticus</i>	6% (6)	5% (6)	6% (13)	1% (3)	4% (10)	—(1)	—
<i>Sorex palustris</i>	1% (1)	3% (4)	3% (7)	—	1% (2)	2% (12)	—
<i>Sorex fumeus</i>	1% (1)	8% (10)	4% (10)	8% (22)	16% (37)	—	—
<i>Sorex dispar</i>	4% (4)	—	2% (4)	3% (9)	4% (9)	—	—
<i>Sorex cinereus</i>	33% (35)	34% (45)	29% (67)	19% (53)	30% (70)	3% (19)	—
<i>Sorex longirostris</i>	—	—	—	—	—	—	2% (27)
<i>Sorex</i> sp.	11% (12)	—	11% (26)	11% (30)	—	8% (61)	—
Total No. Individuals	(107)	(133)	(231)	(278)	(233)	(771)	(1339)

The percentages of shrew species from other eastern North American sites are compared in Table 4. *Blarina brevicauda* was usually the dominant shrew (note exception: Meyer Cave, Il.). *Sorex cinereus* was quite abundant within its modern range (New Paris #4, Pa., 33.0%; Clark's Cave, Va., 29.0%; Natural Chimneys, Va., 34.0%), and occasionally out of its modern range (extralocally): Robinson Cave, Tn., 30.0%. *Sorex longirostris*, a southern form, was usually absent on Late Pleistocene sites, even within its modern range (eg. Robinson Cave, Tn. and Clark's Cave, Va.). *Sorex arcticus* was found well south of its present range, in small numbers, on most of the sites. *Sorex palustris* was extralocal in small numbers on several sites. *Microsorex* usually represented under 10.0% in a given fauna. *Sorex fumeus* was usually of a minor percent, even within its modern range, but sometimes occurred in greater numbers when the larger form was represented (Robinson Cave, Tn., 16.0%; N. Jim Cave, In., 79.0%). *Sorex dispar*, an Appalachian form, was occasionally present in small numbers, and was extralocal at Robinson Cave, Tn. The shifting ranges of shrews on most eastern sites was presumably in response to the cool, moist glacial climates.

As more late glacial shrew faunas become known in Indiana the following components may be recognized: dominance of *Blarina brevicauda*; abundance of *Sorex cinereus* with suppressed numbers of *S. longirostris*; *Sorex fumeus* in small to medium numbers; *Microsorex* in small numbers; presence of *Sorex arcticus* and *S. palustris* in small numbers. The large size of some *Sorex fumeus* and small size of *Microsorex* fossils often in deposits of presumed late glacial age, as well as the structure of interglacial shrew faunas of the Midwest need to be further investigated.

Acknowledgments

I wish to thank Dr. John O. Whitaker, Jr., Professor of Life Sciences, Indiana State University, for the loan and donation of comparative material and for information on modern Indiana shrew occurrences. Dr. J. Alan Holman, the Museum, Michigan State University and Dr. William D. Turnbull, Field Museum of Natural History, Chicago arranged use of comparative materials in those institutions. Identifications were confirmed by Dr. Holmes A. Semken, Professor of Geology, University of Iowa, Iowa City. David Rieger produced Figures 2-8, and Joseph Nichter, Indiana State Museum, produced Figure 1. The Indiana State Museum Society awarded a grant of \$150.00 for the Freeman's Pit radiocarbon date (UGa-4624, processed by the Geochronology Lab., Center for Applied Isotope Studies, University of Georgia). A hearty thanks is also extended to cave comrades too numerous to mention who made the field recovery of specimens possible.

Literature Cited

1. ANDERSON, E. 1968. Fauna of the Little Box Elder Cave, Converse Co., Wyoming: The Carnivora. Univ. Colorado Stud. Ser. Earth Sci., 6:1-59.
2. BARBOUR, R.W. AND W.H. DAVIS. 1974. Mammals of Kentucky. Univ. Press of Kentucky, Lexington. 322 p.
3. BROWN, B. 1908. The Conard Fissure, a Pleistocene bone deposit in northern Arkansas: with description of two new genera and twenty new species of mammals. Mem. Amer. Mus. Nat. Hist. 9 (4): 157-208.
4. BURT, W.H. 1975. Mammals of the Great Lakes region. Univ. of Michigan Press, Ann Arbor. 246 p.
5. BURT, W.H. AND R.P. GROSSENHEIDER. 1964. A field guide to the mammals. The Houghton Mifflin Co., Boston. 284 p.

6. CALDWELL, R.S. 1980. First records of *Sorex dispar* and *Microsorex thompsoni* in Kentucky with distributional notes on associated species. *Trans. Kentucky Acad. Sci.*, 41 (1-2): 46-47.
7. CALDWELL, R.S. AND J.O. WHITAKER, JR. 1982. First records of the Dusky Shrew, *Sorex fumeus* and Pygmy Shrew, *Microsorex hoyi* from Indiana. *Proc. Indiana Acad. Sci.*, 91 (in press).
8. CORGAN, J.X. 1976. Vertebrate fossils of Tennessee. Tennessee Dept. Conserv. Div. Geol. Bulletin 77. Nashville. 100 p.
9. DAVIS, L.C. 1969. The biostratigraphy of Peccary Cave, Newton Co., Arkansas. *Proc. Arkansas Acad. Sci.*, 23: 192-196.
10. GRAHAM, R.W. AND H.A. SEMKEN, JR. 1976. Paleocological significance of the short-tailed shrew (genus: *Blarina*) with a systematic discussion of *Blarina ozarkensis*. *J. Mammal.*, 57: 433-449.
11. GUILDAY, J.E. 1962. The Pleistocene local fauna of the Natural Chimneys, Augusta County, Virginia. *Ann. Carnegie Mus.* 36: 87-122.
12. GUILDAY, J.E. AND H.W. HAMILTON. 1973. The late Pleistocene small mammals of Eagle Cave, Pendleton County, West Virginia. *Ann. Carnegie Mus.*, 44 (5): 45-58.
13. GUILDAY, J.E., H.W. HAMILTON AND A.D. MCCRADY. 1966. The bone breccia of Bootlegger Sink, York County, Pennsylvania. *Ann. Carnegie Mus.*, 38 (8): 145-63.
14. GUILDAY, J.E., H.W. HAMILTON AND A.D. MCCRADY. 1969. The Pleistocene vertebrate fauna of Robinson Cave, Overton County, Tennessee. *Palaeovertebrata* 2: 25-75.
15. GUILDAY, J.E., H.W. HAMILTON AND A.D. MCCRADY. 1971. The Welsh Cave peccaries (*Platygonus*) and associated fauna, Kentucky Pleistocene. *Ann. Carnegie Mus.* 43 (9): 249-320.
16. GUILDAY, J.E., P.S. MARTIN AND A.D. MCCRADY. 1964. New Paris No. 4: A Pleistocene cave deposit in Bedford County, Pennsylvania. *Bull. Nat'l. Speleol. Soc.* 26 (4): 121-94.
17. 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.* 2: 1-87.
18. GUILDAY, J.E., et al. 1978. The Baker Bluff cave deposit, Tennessee, and the late Pleistocene faunal gradient. *Bull. Carnegie Mus. Nat. Hist.* 11:1-67.
19. HALL, E.R. AND K. KELSON. 1959. The mammals of North America. The Ronald Press, New York. 2 vols. 1083 p.
20. HIBBARD, C.W. 1944. Stratigraphy and vertebrate paleontology of Pleistocene deposits of southwestern Kansas. *Bull. Geol. Soc. Amer.* 55: 718-44.
21. KURTÉN, B. AND E. ANDERSON. 1980. Pleistocene mammals of North America. Columbia University Press, New York. 442 p.
22. LONG, C.A. 1972. Taxonomic revision of the mammalian genus *Microsorex* Coues. *Trans. Kansas Acad. Sci.* 74 (2): 181-196.
23. LYON, M.W., JR. 1936. Mammals of Indiana. *Amer. Midl. Natur.*, 17: 1-384.
24. MUMFORD, R.E. 1969. Distribution of the mammals of Indiana. *Indiana Acad. Sci. Monogr.* 1. Indianapolis. 114 p.
25. MUMFORD, R.E. AND J.O. WHITAKER, JR. 1982. Mammals of Indiana. Indiana Univ. Press, Bloomington. 537 p.
26. PARMALEE, P.W. 1967. A Recent cave bone deposit in southwestern Illinois. *Bull. Nat'l. Speleol. Soc.* 29 (4): 119-47.
27. PARMALEE, P.W., R.D. OESCH AND J.E. GUILDAY. 1969. Pleistocene and Recent vertebrate faunas from Crankshaft Cave, Missouri. *Illinois State Mus.*

- Rept. Invest. No. 14. 37 p.
28. RAY, C.E. 1967. Pleistocene mammals from Ladds, Bartow County, Georgia. Bull. Georgia Acad. Sci. 25 (3): 120-50.
 29. RICHARDS, R.L. 1972. The woodrat in Indiana: Recent fossils. Proc. Indiana Acad. Sci. 81: 370-375.
 30. ROSE, R.K. 1980. Habitat associations of small mammals in southwestern Indiana. Proc. Indiana Acad. Sci. 89: 432-39.

