The Quaternary Distribution of the Eastern Woodrat, *Neotoma floridana*, in Indiana

Ronald L. Richards
Indiana State Museum and Historic Sites
202 North Alabama Street
Indianapolis, Indiana 46204

Introduction

The eastern woodrat (*Neotoma floridana*) was first noted in Indiana in Wyandotte Cave, Crawford County in the 1870s (5,27). Twenty years later Blatchely noted that those woodrats had disappeared (3). The first Indiana specimens were taken by Hickie and Harrison around 1930 from a small cave one mile east of Wyandotte Cave, and from Rat Cave, Tobacco Landing, both in Harrison County (19). In the 1940s Kirkpatrick and Conaway recovered additional evidence of living woodrats along the Ohio River in Harrison County, as well as apparent woodrat lodge debris (piles of sticks with nuts, bones and rocks), though no specimens, in what was apparently Stroud cave, Valeene Quadrangle, Orange County (22). Jackson recalled when he and Robert Louden had, many years earlier, explored a 35 foot deep pit near the Harrison-Crawford county line, "passing through the largest concentration of cave rats" that he had ever seen (20). (The cave is among the many located in sections 26 and 27, T3S, R2E in Harrison and Crawford Counties, respectively, near where Hickie and Harrison, 19, collected their specimens.) In the 1950s archaeological investigation of rockshelters and paleontological studies of cave faunas revealed woodrat remains north of the present range in Missouri (31), Illinois (30), Indiana (1) and Ohio (12; Figure 1). The Indiana bones, from Sullivan Cave,

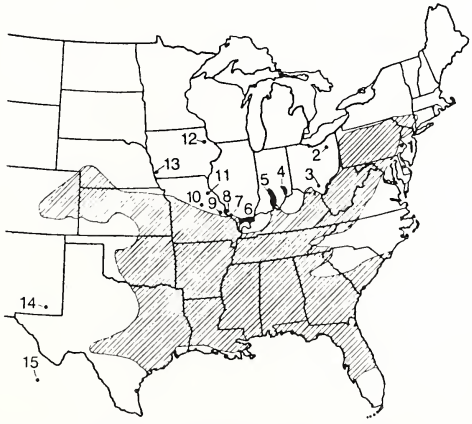

Figure 1. Fossil and sub-recent extralimital occurrence of *Neotoma floridana*. Hatched: Modern range, generally after Hall (17), with updated detail in Indiana (6), Ohio (21) and Kentucky (2). Numbers: extralimital localities (with references): 1. Durham Cave, Bucks Co., PA (23); 2. Twinsburg Rock Shelter, Summit Co., OH., (12); 3. Canter Caves, Jackson Co., OH (12); 4. Southeastern karst, IN (this report); 5. South-central karst, IN (this report); 6. Southern IL (26); 7. Modoc Rock Shelter, Randolph Co., IL (28); 8. Meyer Cave, Monroe Co., IL (29,30); 9. Crankshaft Cave, Jefferson Co., MO (34); 10. Brynjulfson Caves, Boone Co., MO (33); 11. Jerry Long Cave, Ralls Co., MO (31); 12. Willard Cave, Delaware Co., IA (9); 13. Pleasant Ridge local fauna, Mills Co., IA (10); 14. Dry Cave, Eddy Co., NM (18); 15. Jimenez Cave, Chihuahua, Mexico (18).

Lawrence County were associated with remains of such extirpated (historically exterminated) mammals as the porcupine, spotted skunk and elk, and clearly indicated a much more extensive past distribution of the woodrat in Indiana. Richards (35) recorded woodrat bones from several counties in south-central, and one county (Jennings) in southeastern Indiana, many associated with remains of resident as well as of extirpated species. Mumford and Whitaker (24) gave an extensive review of the Indiana woodrat. Richards (36) noted extralimital (occurring out of the historic range) woodrat remains from Shelby, Jennings and Jefferson Counties. Cudmore (6) made an extensive search for active and inactive woodrat sites in south-central Indiana, locating living woodrats only in the Ohio River region of Harrison and Crawford Counties (Figure 2). He found that extensive

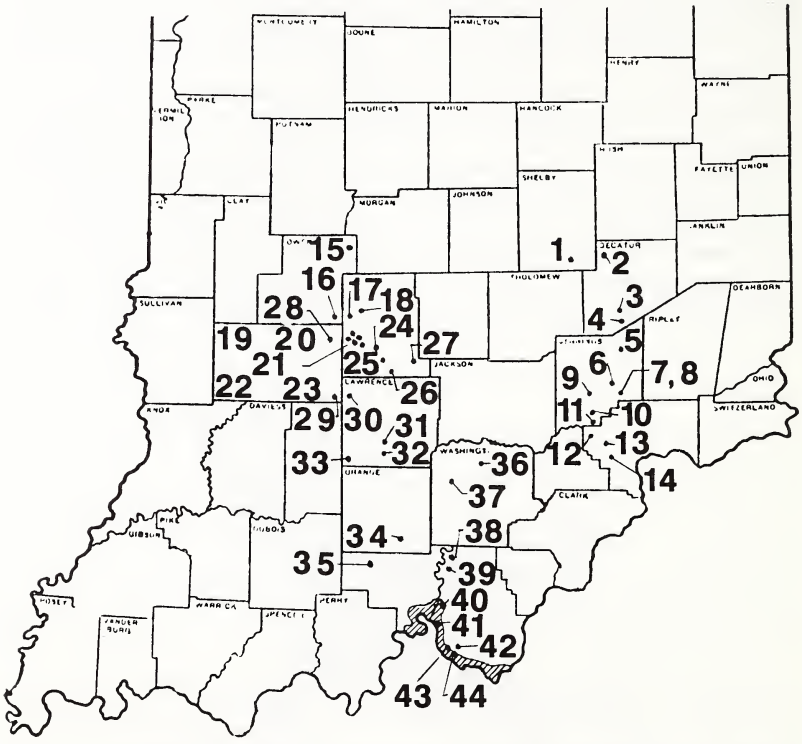

FIGURE 2. Quaternary distribution of the eastern woodrat, *Neotoma floridana*, in Indiana. Modern range (hatched) after Cudmore (6). Fossil and sub-recent localities numbered as in Table 1.

limestone bluffs which had some southern facing component harbored the greatest concentration of woodrats, and that there was a positive correlation between the density of juniper (*Juniperus virginiana*) and the density of woodrats. Wet caves did not harbor woodrats, nor did sandstone outcroppings provide suitable denning opportunities. In contrast, there are active woodrat populations in some of the sandstone bluffs in southwestern Illinois (26), and they are "particularly common" in the sandstone cliffs of the Cumberland Plateau of Kentucky (2).

Methods

The objective was to determine the distribution of past woodrat activity in Indiana, with special emphasis upon the poorly investigated karst area of southeastern Indiana. This involved the location and recovery of woodrat bones from cave deposits. Cave locations were acquired from the "Indiana State Cave List", with caves on the periphery of both karst areas, particularly those of the southeastern, receiving investigative priority. This insured examination of marginal woodrat habitat, with possibility for the greatest range extension. Caves more centrally located in the karst areas were also investigated; I attempted to recover one woodrat bone locality per quadrangle map as time permitted. Low, water crawls were only partially investigated, unless larger, dry cavern development was anticipated beyond. Several small caves were investigated in northern Indiana (Wabash, Tippecanoe and Fountain Counties); I recovered very sparse bone accumulations, and no woodrat. Ledges and cavities of the massive sandstone outcroppings (Mansfield fm) prevalent in Martin and Fountain Counties were not examined.

Woodrat indicators sought were areas of disintegrated wood and vegetation, concentrations of nuts and seeds, and especially rodent-gnawed bone fragments, usually anticipated upon ledges, sometimes near cave ceilings, and in floor silt/clay deposits, within both wet and dry cave passages. Deposits appearing possibly productive were sampled or removed entirely (e.g. thin veneers of sediment upon ledges) and later washed through 1.2 mm mesh screen. This concentrate was examined under 15X magnification, and the faunal/floral remains removed for study. Materials from the field study, largely of undescribed faunas, are presently on file with the author.

Results

Woodrat remains from 48 minimum individuals (MNI) were recovered from 13 caves in Shelby, Decatur, Jennings and Jefferson Counties in southeastern Indiana, with remains of 60 MNI collected from 19 caves in Owen, Monroe, Greene, Lawrence, Crawford, Washington and Harrison Counties in south-central Indiana (Table 1). With the previous woodrat localities of Richards (35), the Harrodsburg Crevice (32), the Indun Rockshelter (Richards and Munson, in prep.) and Fair-to-Middlin Well (37) there are now 30 woodrat bone localities recorded in south-central and 14 localities in southeastern Indiana (Figure 2).

Most of the caves in the southeastern karst area were relatively small, often stream-bearing passages in the lowlands bordering streams and rivers. As in southern Illinois (26), these outcrop-lined tributaries provided natural avenues for woodrat dispersal. These caves commonly contained organic deposits composed of splintered bone (usually of mice, small fish, birds and eastern cottontail), fish scales, sphaerid clam valves, aquatic snails, crayfish and insect exoskeletons, and seeds, indicating areas of disintegrated carnivore scat. Fox, mink, striped skunk and especially raccoon are known to enter caves (24), the last routinely entering in search of bats (25). These carnivore generated bone deposits, often on ledges and perched clay banks, did not usually contain woodrat bones. Other niches and crevices perched above cave floors often contained concentrations of seeds (especially of hackberry), and occasionally small vertebrate bones, marking white-footed mouse (*Peromyscus leucopus*) dens. These deposits rarely contained woodrat bones or teeth.

The northwestern caves of the south-central karst area (Putnam and northern Owen Counties) were relatively small, often low, wet crawlways, and usually devoid of bone accumulations. Some of the drier caves, however, had crawlways floored with abundant dessicated (sometimes fresh) scat, reflecting heavy carnivore traffic. These areas, also, were not productive for woodrat bones.

In the caves more centrally located within the karst areas, woodrat bones could

TABLE 1. Indiana *Neotoma floridana* bone localities, with important associated taxa.[1]

	Cave/Site	Quadrangle	County	MNI	Important Associated Taxa
*1.	Flat Rock Cave	Waldron	Shelby	1	**_Crotalus horridus_, timber rattlesnake; _Lynx_ sp. (_Lynx rufus_, bobcat, suggested by modern distribution)
*2.	Dead Man's Cave	Adams	Decatur	2	**timber rattlesnake
*3.	Horsethief Cave	Westport	Decatur	2	bobcat (see * 1)
*4.	Faultz Cave	Westport	Decatur	5	_Castor canadensis_, beaver
*5.	Muscatatuck Caverns I	Butlerville	Jennings	12	--------
*6.	Henchman Cave	Vernon	Jennings	7	beaver; _Ursus americanus_, black bear
*7.	Crawl Cave	Vernon	Jennings	5	beaver; black bear
*8.	Cox Cave	Vernon	Jennings	1	--------
9.	Cave near North Vernon	Hayden	Jennings	3	in surficial sediments: black bear; _Cervus elaphus_, elk
				1	in lower reddish stratum: **_Phenacomys_ cf. _P. intermedius_, heather vole.
*10.	Jesse Tate Cave	Deputy	Jennings	8	_Canis_ cf. _C. lupus_, timber wolf
*11.	Paris Spring Cave	Deputy	Jennings	1	--------
*12.	Deputy Cave	Deputy	Jefferson	1	--------
*13.	Wilson Cave	Volga	Jefferson	2	--------
*14.	Kent Cave	Kent	Jefferson	1	--------
*15.	Porter's Cave	Quincy	Owen	1	--------
16.	Hidden Pit Cave	Whitehall	Owen	3	--------
17.	Freeman's Pit	Whitehall	Monroe	18	black bear; **_Spilogale putorius_, spotted skunk; _Erethizon dorsatum_, porcupine.
*18.	Galyan Pit Cave	Whitehall	Monroe	1	--------
19.	Brinegar Cave	Stanford	Monroe	2	black bear
*20.	Showcase Pit Cave	Stanford	Monroe	3	black bear; porcupine
21.	Bee Tree Cave	Stanford	Monroe	3	porcupine
*22.	Small Dull Cave	Stanford	Monroe	1	--------
*23.	Rock East Cave	Stanford	Monroe	1	--------
24.	Anderson Pit Cave	Clear Creek	Monroe	14	in main den: +_Dasypus bellus_, beautiful armadillo; black bear; **_Oryzomys palustris_, rice rat; **_Parascalops breweri_, hairy-tailed mole; **_Spermophilus tridecemlineatus_, thirteen-lined

					ground squirrel; ***Tamiasciurus hudsonius*, red squirrel; ***Opheodrys vernalis*, smooth green snake; +*Ectopistes migratorius*, passenger pigeon.
				5	in four other deposits, one with porcupine, another with a human (*Homo sapiens*) molar.
25.	Harrodsburg Crevice	Clear Creek	Monroe	12	+*Canis* cf. *C. dirus*, dire wolf; +*Smilodon fatalis*, sabertooth cat; +*Panthera onca augusta*, jaguar; +*Equus* cf. *E. complicatus*, horse; +*Platygonus* cf. *P. vetus* (= *cumberlandensis*), Leidy's peccary; **hairy-tailed mole; ***Geomys* cf. *G. bursarius*, plains pocket gopher; **Spotted skunk; black bear; bobcat
*26.	Indun Rockshelter	Clear Creek	Monroe	2	**Spotted skunk; +*Mylohus* sp., long-nosed peccary
*27.	Patton Cave	Allens Creek	Monroe	3	--------
*28.	Mill Cave	Stanford	Greene	1	--------
*29.	Batey Cave	Owensburg	Greene	2	black bear; beaver
30.	Sullivan Cave	Owensburg	Lawrence	7	in ledge den: black bear; **spotted skunk; porcupine; elk (last by Bader and Hall (1) only).
				16	in floor deposit: +beautiful armadillo; **spotted skunk; **heather vole; ***Clethrionomys gapperi*, red-backed vole; **plains pocket gopher; **thirteen-lined ground squirrel; black bear; porcupine.
31.	Carcass Crypt Pit Cave	Bedford West	Lawrence	4	in wall den: black bear; **spotted skunk
				6	in floor deposits: **hairy-tailed mole; **spotted skunk; black bear; bobcat; porcupine.
*32.	McCart Pit Cave	Georgia	Lawrence	2	black bear
*33.	Connelly Cave	Huron	Lawrence	2	--------
34.	Stroud Cave	Valeene	Orange	1	porcupine
*35.	Megenity Peccary Cave	Taswell	Crawford	3	+*Platygonus compressus*, Flat-headed Peccary; ***Martes pennanti*, fisher; **Plains Pocket Gopher. (collection in progress)
*36.	Suicide Cave	Kossuth	Washington	6	--------
*37.	Waterfall Cave	Smedley	Washington	6	--------
*38.	Gibbs Pit	Fredericksburg	Harrison	2	--------
*39.	King Leo Pit Cave	Depauw	Harrison	9	**spotted skunk; black bear; elk
*40.	Devil's Staircase Pit Cave	Leavenworth	Harrison	1	--------
*41.	Passenger Pigeon Cave	Leavenworth	Harrison	10	**cf. spotted skunk; **rice rat; +passenger pigeon; beaver.
*42.	Horse Pit Cave	Mauckport	Harrison	1	--------
43.	N. Jim Cave	Mauckport	Harrison	4	**plains pocket gopher; **red-backed vole; **red squirrel
44.	Fair-to-Middl'in Well Pit	Mauckport	Harrison	5	**spotted skunk; black bear

[1] *, new woodrat bone localities; +, extinct; **, extralimital; others listed are extirpated. MNI, *Neotoma*, minimum number of individuals.

usually be recovered from deposits that contained rodent-gnawed larger bone fragments (usually of White-tailed deer), located in wall niches and crevices, on ledges, and in general bone accumulations on dry cave floors. These deposits occurred in stream-bearing as well as dry passages in both walk-in and vertical pit entrance caves.

Discussion

It appears that the woodrat once occurred in suitable habitat throughout most of Indiana's karst area. Small caves on the peripheries of the karst areas apparently do not provide extensive denning possibilities, and, with often discontinuous bluff outcroppings for dispersal, supported lower densities of woodrats. In addition, heavy carnivore traffic in these small caves leaves the woodrat particularly susceptible to predation. These confrontations would appear to be less frequent in the larger, more centrally located caves, where greater vertical development of rooms and passage proliferation provide for more obscure woodrat denning.

Southern Illinois woodrat populations have undergone dramatic range reductions within historic time, perhaps due to abnormally cold winters with greater than average snowfall (26). Mortality was the heaviest in small, isolated populations in marginal habitat. Juterbock noted that the cached greens of Ohio woodrats used for winter food was often depleted in January or February (21). If, due to low winter temperatures and extended periods of snow cover, fresh buds and greens were not available, winter mortality might be higher than normal. This mortality would be felt especially in small populations due to the woodrat's low reproductive rate (two or three young/litter; one or two litters/year), and territoriality (young leaving den to establish home range become vulnerable for predation). She noted that juniper was sometimes the only winter food available to the woodrat. Cudmore noted the high association of juniper with active Indiana woodrat populations (6). Juniper prefers calcareous soils, and is common in much of the unglaciated region of southern Indiana (7). Notably, juniper thrives in areas where the woodrat no longer occurs, suggesting that winter access to juniper may not be a dominant factor in population survival.

The association of woodrat with such extralimital boreal forms as the heather (*Phenacomys* cf. *P. intermedius*) and red-backed (*Clethrionomys gapperi*) voles in Jennings, Lawrence and Harrison County cave deposits (38; Table 1), suggests that the woodrat was not particularly sensitive to at least some of the cooler glacial environments present in southern Indiana some 12,000 years ago. The woodrat was also part of the cool, Late Pleistocene fauna at New Paris No. 4 Sink, Pennsylvania (15), Clark's Cave, Virginia (16) and Robinson Cave, Tennessee (14). Cool, glacial environments may not have had a pronounced impact upon winter food stores, because of the greater abundance and diversity of winter greens available from the coniferous (8) forest.

The fossil occurence of the woodrat, and its relatively northern distribution in the eastern and western portions of its modern range suggest that lack of suitable habitat, rather than climatic conditions *per se* may be a limiting factor to the northern distribution of the woodrat (15, 16).

In Indiana, the woodrat has been recovered from deposits as early as the Sangamonian (last) interglacial at the Harrodsburg Crevice, and as late as 2,315 ± 65 years before present in Freeman's Pit, both in Monroe County. Notably, the woodrat evacuated over 95% of its former Indiana range sometime between 2000 years ago and the European settlement of the state.

Iowa has produced at least two extralimital woodrat localities with Late Holocene dates: the Pleasant ridge local fauna, Mills County (1450 years before present; 10), and Willard Cave, Delaware County (post-Altithermal; 9). The woodrat depopulation of southern Illinois, in contrast has been relatively recent, with dramatic range reductions perhaps in the early 1900s and in the 1930s-1950s, as evidenced by corn cobs, cow

dung, broken glass and rusty nails in extralimital woodrat middens near human dwellings (26). Common within the cliff and cave habitat in the Ridge and Valley province of Tennessee, the woodrat apparently does not persist in settled areas (13).

There is thus far a lack of European materials in the extralimital woodrat middens in Indiana. Nor has the woodrat been associated with bones of the black or Norway rats (*Rattus* sp.), the house mouse (*Mus musculus*), or with rodent gnawed remains of domestic livestock or poultry. (Teeth of *Rattus* and *Neotoma* recovered from a deposit in Waterfall Cave, Washington County, could not be shown to be contemporary, considering the bulk method of recovery.)

The cause of the Late Holocene and historic depopulation of the woodrat from the northern periphery of its range in the midwest, whether related to severe winters, their effect upon winter food availability, or the effect of human contact in marginal habitat, is unclear.

Considering that endemic populations of such animals as the smoky (*Sorex fumeus*) and pygmy (*Sorex hoyi*) shrews (4), and the cottonmouth (*Agkistrodon piscivorus*; 11) were first recorded in Indiana in 1981 and 1983, respectively, it is understandable that small disjunct populations of the nocturnally active woodrat might exist undetected in Indiana's karst area. Sightings of rat-like animals have been reported in Owen (Hopper Cave, Cataract Quad.), Monroe (Salamander Cave and Studebaker Pit, Whitehall Quad.; Bee Tree Cave, Stanford Quad.), Lawrence (Donaldson's Cave, Mitchell Quad.), Washington (Endless Cavern and Lamplighter Cave, Campbellsburg Quad.) and Crawford (Wildcat Cave, Leavenworth Quad.) Counties within the past thirty years. Most of these observations can probably be attributed to glimpses of the white-footed mouse, which does den within the caves (24), and has been observed on numerous instances by the author, occasionally while scampering from its nest cup. Night investigation of these and other cave areas might provide records of disjunct woodrat colonies.

Acknowledgments

The Indiana State Museum Society kindly provided a grant to support part of the southeastern Indiana field work. Gordon Lindamood and Jim Riley supplied lists of cave locations. Dave Rieger produced Figures 1 and 2. I am indebted especially to Ted Sparks and also Gordon Lindamood, Dave Rieger, Richard Cornell, Howard Ely and many others for aid in the field.

Literature Cited

1. Bader, R.S. and J.S. Hall. 1960. Mammalian remains from an Indiana cave. J. Mammal. 41: 111-112.
2. Barbour, R.W. and W.H. Davis. 1974. Mammals of Kentucky. Univ. Press Kentucky, Lexington. 322 pp.
3. Blatchley, W.S. 1897. Indiana caves and their fauna. 21st Ann. Rept. Indiana Dept. Geol. Nat. Res.: 121-212.
4. Caldwell, R.S., C.K. Smith and J.O. Whitaker, Jr. 1982. First records of the Smoky Shrew, *Sorex fumeus*, and Pygmy Shrew, *Microsorex hoyi*, from Indiana. Proc. Indiana Acad. Sci. 91: 606-608.
5. Cope, E.D. 1872. Report on the Wyandotte Cave and its fauna. Third and Fourth Ann. Repts. Indiana Geol. Surv.: 157-182.
6. Cudmore, W.W. 1985. The present distribution and status of the Eastern Woodrat, *Neotoma floridana*, in Indiana. Proc. Indiana Acad. Sci. 94: 621-627.
7. Deam, C.C. 1940. Flora of Indiana. Indiana Dept. Conserv., Div. Forestry. 1236 pp.
8. Delcourt, P.A. and H.R. Delcourt. 1981. Vegetation maps for eastern North America: 40,000 years B.P. to the present, *in*: R.C. Romans (ed.), Geobotany II, p. 123-165. Plenum, New York.

9. Eshelman, R.E. 1971. The paleoecology of Willard Cave, Delaware County, Iowa. M.S. thesis, University of Iowa, Iowa City. 72 pp.
10. Fay, L.P. 1980. Mammals of the Garrett Farm and Pleasant Ridge local biotas (Holocene), Mills County, Iowa, *in*: Amer. Quat. Assoc., Sixth Bien. Mtg., Abstr. with Program: 74-75. Inst. for Quat. Stud., Univ. Maine, Orono.
11. Forsyth, B.J., C.D. Baker, T. Wiles and C. Weilbaker. 1985. Cottonmouth, *Agkistrodon piscivorus*, records from the Blue River and Potato Run in Harrison County, Indiana (Ohio River Drainage, USA). Proc. Indiana Acad. Sci. 94: 633-634.
12. Goslin, R.M. 1955. Animal remains from Ohio rock shelters. Ohio J. Sci. 55(6): 358-362.
13. Guilday, J.E., H.W. Hamilton, E. Anderson and P.W. Parmalee. 1978. The Baker Bluff Cave deposit, Tennessee, and the Late Pleistocene faunal gradient. Carnegie Mus. Nat. Hist. Bull. 11: 1-67.
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., P.S. Martin and A.D. McCrady. 1964. New Paris No. 4: A Pleistocene cave deposit in Bedford County, Pennsylvania. Natl. Speleol. Soc. Bull. 26: 121-194.
16. 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. Carnegie Mus. Nat. Hist. Bull. 2: 1-87.
17. Hall, E.R. 1981. The mammals of North America. 2nd ed. John Wiley and Sons, New York. 2 vols. 1181 pp.
18. Harris, A.H. 1984. *Neotoma* in the Late Pleistocene of New Mexico and Chihuahua. p. 164-178, *in*: H.H. Genoways and M.R. Dawson (eds.). Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday. Carnegie Mus. Nat. Hist. Spec. Publ. 8. 538 pp.
19. Hickie, P.F. and T. Harrison. 1930. The Alleghany wood rat in Indiana. Amer. Midl. Nat. 12: 169-174.
20. Jackson, G.F. 1972. Notes and News: Old timers fewer now. Natl. Speleol. Soc. News, 30(11): 151.
21. Juterbock, J.E. 1986. Eastern woodrat. Cincinnati Mus. Nat. Hist. Quart. 19(4): 5-8.
22. Kirkpatrick, C.M. and C.H. Conaway. 1948. Some notes on Indiana mammals. Amer. Midl. Nat. 39(1): 128-136.
23. Lundelius, E.L., Jr., R.W. Graham, E. Anderson, J.E. Guilday, J.A. Holman, D.W. Steadman and S.D. Webb. 1983. Terrestrial vertebrate faunas, p. 311-353, *in*: S.C. Porter (ed.), Late Quaternary environments of the United States: Vol. 1, The Late Pleistocene. Univ. Minnesota Press. Minneapolis. 407 pp.
24. Mumford, R.E. and J.O. Whitaker, Jr. 1982. Mammals of Indiana. Indiana University Press, Bloomington. 537 pp.
25. Munson, P.J. and J.H. Keith. 1984. Prehistoric raccoon predation on hibernating *Myotis*, Wyandotte Cave, Indiana. J. Mammal. 65(1): 152-155.
26. Nawrot, J.R. and W.D. Klimstra. 1976. Present and past distribution of the endangered southern Illinois woodrat (*Neotoma floridana illinoensis*). Nat. Hist. Misc. Chicago Acad. Sci. 196: 1-12.
27. Packard, A.S. 1888. The cave fauna of North America, with remarks on the anatomy of the brain and origin of the blind species. Mem. Nat. Acad. Sci. 4: 3-156.
28. Parmalee, P.W. 1959. Animal remains from the Modoc Rock Shelter site, Randolph County, Illinois, Appendix II, p. 61-65, *in*: M.L. Fowler. Summary report of Modoc Rock Shelter. Illinois State Mus. Rep. Invest. 8: 1-72.
29. Parmalee, P.W. 1967. A Recent cave bone deposit in southwestern Illinois. Natl. Speleol. Soc. Bull. 29(4): 119-147.

30. Parmalee, P.W., R.A. Bieri and R.K. Mohrman. 1961. Mammal remains from an Illinois cave. J. Mammal. 42(1): 119.
31. Parmalee, P.W. and K.W. Jacobson. 1959. Vertebrate remains from a Missouri cave. J. Mammal. 49(3): 401-405.
32. Parmalee, P.W., P.J. Munson and J.E. Guilday. 1978. The Pleistocene mammalian fauna of Harrodsburg Crevice, Monroe County, Indiana. Natl. Speleol. Soc. Bull. 40: 64-75.
33. Parmalee, P.W. and R.D. Oesch. 1972. Pleistocene and Recent faunas from the Brynjulfson caves, Missouri. Illinois State Mus. Rep. Invest. 25: 1-52.
34. Parmalee, P.W., R.D. Oesch and J.E. Guilday. 1969. Pleistocene and Recent vertebrate faunas from Crankshaft cave, Missouri, Illinois State Mus. Rep. Invest. 14: 1-37.
35. Richards, R.L. 1972. The woodrat in Indiana: Recent Fossils. Proc. Indiana Acad. Sci. 81: 370-375.
36. Richards, R.L. 1984. The Pleistocene vertebrate collection of the Indiana State Museum with a list of the extinct and extralocal Pleistocene vertebrates of Indiana. Proc. Indiana Acad. Sci. 93: 483-504.
37. Richards, R.L. 1984. It's the pits: explorer discovers black bear bones. Outdoor Indiana 49(7): 25-27.
38. Richards, R.L. 1986. Late Pleistocene remains of boreal voles (Genera *Phenacomys* and *Clethrionomys*) from southern Indiana caves. Proc. Indiana Acad. Sci. 95: 537-546.
39. Semken, H.A., Jr. 1984. Paleoecology of a Late Wisconsinan/Holocene micromammal sequence in Peccary Cave, northwestern Arkansas, p. 405-431, *in*: H.H. Genoways and M.R. Dawson (eds.), Contributions in Quaternary Vertebrate Paleontology: A Volume in Memorial to John E. Guilday. Carnegie Mus. Nat. Hist. Spec. Publ. 8. 538 pp.