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Status of the Small-Footed Bat, Myotis leibii leibii, in the Southern Ozarks

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Immunization with somatic extracts provided essentially the same degree of protection as seen in the Table. With both second and third stage extracts, the decrease in larval recovery was approximately 25 per cent. It is possible that the antigenic makeup of both preparations is sufficiently similar so that immunization with either would provide protection against the early phase of the larval migration. Since the extract contains somatic antigens as well as enzymes released during homogenization, an immune response could be directed against the enzymes and against the larva itself. It would seemingly offer a number of possible mechanisms for interfering with its growth, migration, moulting, etc.

Table. Protective immunization with hatching fluid, excretions and secretions and somatic extract antigens from *Ascaris suum* developmental stages.

Sample	Viable larvae recovered after challenge[a]	% Decrease in larval recovery
Second stage		
Nonimmune control	26,780 ± 825	———
Excretions and secretions	21,812 ± 834	17
Somatic extract	19,320 ± 995	26
Hatching fluid	21,245 ± 716	19
Third stage		
Nonimmune control	23,039 ± 931	———
Excretions and secretions	21,387 ± 360	7
Somatic extract	18,364 ± 516	24

[a]Values represent the mean of five separate trials (± standard deviation).

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STATUS OF THE SMALL-FOOTED BAT, *MYOTIS LEIBII LEIBII*, IN THE SOUTHERN OZARKS

Although three vespertilionid bats of the southern Ozarks (the gray bat, *Myotis grisescens;* the Indiana bat, *M. sodalis;* and the Ozark big-eared bat, *Plecotus townsendii ingens*) are listed by the U. S. Fish & Wildlife Service as endangered, the small-footed bat, *M. leibii leibii*, is actually the rarest and least known bat occurring in the region. While the range of this bat is extensive (Hall, 1981), it is often regarded as the rarest bat of the eastern United States (Robbins et al., 1977). Interestingly, western subspecies are at least locally abundant (Webb and Jones, 1952; Farney and Jones, 1980).

Studies of the distribution and/or biology of the small-footed bat are hampered by the confusing nomenclature associated with earlier studies. Many workers in the past, and Hall recently, have utilized the specific epithet *subulatus* for the small-footed bat. This is confusing because prior to 1928, the specific epithet *subulatus* was applied to Keen's bat, *M. keenii*. We utilize the name *M. leibii* for the small-footed bat in compliance with recent checklists by Jones et al. (1979).

The small-footed bat is one of the smallest North American members of the nearly cosmopolitan genus, *Myotis*. It has a reported head and body length of only 34.4 to 48.0 mm. Adult pelage is normally long and somewhat silky in appearance. Dorsal coloration ranges from a light buff to a golden brown, and the venter ranges from buffy to almost white (Hall, 1981). The ears and face are noticably black, imparting a masked appearance. However, the most diagnostic feature of this bat is its disproportionately small foot.

The skull of *M. leibii* is understandably small and delicate. The braincase is obviously flattened, and slopes upward only gradually from the rostrum; the prominent forehead of many species of *Myotis* is lacking. Hall (1981) reported a greatest length of skull for the small-footed bat of 13.1 to 14.7 mm. However, in a mensural examination of *Myotis* skulls from the Ozarks, we found an average greatest length of skull of only 12.8 mm and a range of 12.1 to 13.4 mm for eight adults. Hall reported zygomatic breadth to range from 8 to 9 mm, but Ozark specimens averaged only 7.4 mm and ranged from 7.1 to 7.5 mm. Hall reported breadth of braincase to range from 6.2 to 7.1 mm, but Ozark specimens averaged only 6.3 mm and ranged from 6.1 to 6.4 mm. Finally, Hall reported maxillary tooth row to range from 4.8 to 5.5 mm in length, but Ozark specimens averaged only 4.5 mm and ranged from 4.1 to 4.7 mm in length of maxillary tooth row. Clearly, for these and other characters, our Ozark specimens of *M. leibii* are smaller than specimens from east and west of the Ozarks.

Although the biology of *M. leibii* is somewhat speculative, our observations permit some interesting comments. The small-footed bat is generally acknowledged to be basically a cave bat (Schwartz and Schwartz, 1981), but it is much less restricted to caves than is the gray bat, *M. grisescens*. Usually the small-footed bat overwinters in caves or mines. During summer months, it has been found in caves, buildings, and man-made cavities in the ground. Webb and Jones (1952) mentioned finding two small-footed bats under a loose strip of pine bark. All our Ozark records, except one from the face of a rock bluff, were from caves. Webb and Jones (1952) also reported the small-footed bat as frequently associated with big brown bats, *Eptesicus fuscus*, in Nebraskan barns. Our observations indicate that *M. leibii* selects a wide array of roost sites in the southern Ozarks, and only occasionally utilizes the same cave roost sites as *Eptesicus*. Similar behavior was reported by Barbour and Davis (1969). Gunier and Elder (1973) reported Missouri specimens of *M. leibii* from dry, deep-cave passages only. Only a few of our specimens were taken from similar environs.

Sealander (1979) reported *M. leibii* from only two Arkansas counties, Searcy and Newton, and indicated an Arkansas range for this bat only slightly larger than the area of the two counties. Further, he suggested that the small-footed bat probably occurs at scattered localities throughout the western Ozark Mountains. We have accumulated numerous additional records of this bat from the Ozarks and can now substantially modify Sealander's hypothesized range. These records include additional records from Newton and Searcy counties, Arkansas, and the first records from two additional Arkansas counties and one Missouri county. Some of these records were retained as skin and skull preparations in the Collection of Recent Mammals at Arkansas State University (ASUMZ) and others were positively identified, sexed, weighed in some cases, and released unharmed. None of the released bats were banded or in any way marked, and there was the possibility of repeated capture on a few nights. While many of the following records (Table) were netted at cave mouths, others were found beneath rocks on cave floors, hanging near the floor on cave walls, or wedged tightly into cracks in the manner of *Eptesicus*.

These new records clearly extend the range of *M. leibii* to the extreme eastern edge of the Ozark plateau of Arkansas and Missouri. Additionally, the number of individuals encountered indicates a viable, established population rather than an occasional rare record. Finally, preliminary mensural data intriguingly suggest the possibility of an, as yet, undescribed Ozark subspecies of this diminuitive bat.

Table. Records of *Myotis leibii* from the southern Ozarks.

Date	Sex(es)	Location*	ASUMZ # if not released
6 Dec 1975	1M	Searcy Co., AR	1572
18 Jan 1976	1F	Newton Co., AR	1820
24 Jan 1976	2F, 1M	Madison Co., MO	1881, 1887, 1900
6 Feb 1976	1F, 1M	Newton Co., AR	1927, 1967
16 Feb 1979	1F	Stone Co., AR	
8 Mar 1979	1F	Newton Co., AR	
18 Aug 1979	1F, 1M	Newton Co., AR	
19 Aug 1979	1M	Newton Co., AR	
11 Sept 1979	1F, 2M	Newton Co., AR	
18 Sept 1979	3M	Newton Co., AR	
2 Oct 1979	1M	Newton Co., AR	
20 Oct 1979	1M	Stone Co., AR	7218
30 Oct 1979	1M	Newton Co., AR	
14 Feb 1980	1M	Newton Co., AR	
15 Jun 1980	1M	Independence Co., AR	
20 Feb 1981	1M	Newton Co., AR	
8 Feb 1982	1F, 1?	Newton Co., AR	

*Specific cave locations are omitted since several of the caves represent maternity sites, hibernacula, etc. for the endangered bats of Arkansas.

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STRATIGRAPHY OF A PENNSYLVANIAN DELTAIC SEQUENCE IN RUSSELLVILLE, ARKANSAS

A well exposed outcrop of the Upper Atoka Formation, the Hartshorne Sandstone, and the McAlester Formation is located in a road-cut two miles south of the Russellville city limits along the east side of State Highway 7. It consists of north dipping strata (75°) of Upper Atoka, Hartshorne, and McAlester units of Pennsylvania age, including the Hartshorne coal. The rock units are the south flank of the Shinn Syncline, where the Hartshorne Sandstone forms a resistant ridge.

The outcrop has been interpreted as a prograding delta complex. A coarsening, thickening upward sequence from the base supports this interpretation (Figure).

The outcrop grades from shales at the southern end of the exposure, through silts and sands, into medium-grained, massive sands. Forty-six feet of organic rich silts including the Hartshorne coal are at the north end of the Hartshorne coal seam.

Deltaic Sequence. The exposure is a small delta complex with the total thickness of the study area being 238 feet. The outer fringe consists of shales and silty shales with lenses of fine sand. The sand-shale ratio increases upward progressively in the section. Bioturbation is evident in the shales. The inner fringe consists of interbedded wavy, thinly laminated, fine-grained sands; bedded fine- to medium-grained sands; and massive, fine- to medium-grained sands. The coarser, thicker sands contain mica fragments and carbonized fossil plant debris. Two possible channel fills consist of massive medium-grained sands, although these two units could be proximal inner fringe deposits under higher energy conditions.

Cross-bedding in both the inner fringe and channel(?) sands indicates a southern source (a northerly prograding delta). But cross-bedding observed perpendicular to the outcrop, along the ridge, shows a possible eastern source (a westerly prograding delta). Both cross-bed sets are probably diagonal sections of the true cross-bedding which would indicate a south-eastern source (a northwesterly prograding delta).

Ripple marks in the inner fringe sands suggest a north-flowing paleocurrent (a southerly source) because the downstream slopes of the ripples are steeper than the upstream slopes (Ehlers, 1980, p. 334). This situation applies to the ripples marks of the inner fringe sands. Blatt (1980, p. 162), however, does warn that ripples marks are an inadequate method of current direction indication as proven by dye experiments with modern shallow water sands. The upper sands of the inner fringe and channel(?) sands contain interference ripple marks with no current direction indication.

In Atoka time, deltaic sourcelands were generally to the north (the Ozark Plateau). But in Hartshorne time, uplift in the frontal Ouachita Mountains shifted deltaic patterns to an east-west flow (LeBlanc, 1981). The north-flowing paleocurrent, as seen in the beds, leads the authors to believe that the outcrop was possibly a small lobe flowing to the north of the major Hartshorne deltaic system. Wanless (1970, p. 234) also sees deformation of the Ouachita Basin as "providing new sourcelands for late Paleozoic deltas."

INTERPRETATION

The Outer Fringe—Unit 1 (Figure). The outer fringe is indicated by shales and silts with lenses of fine sands. Silts and clay are more prominant with occasional fine sand lenses probably deposited by traction. The sand-shale ratio increases with progradation.

Bioturbation is abundant in the shales, although an invertebrate fauna is absent. This lack of fauna is probably due to continuous deposition and the possibility of water salinity being lowered by fresh water input (Reading, 1978, p. 127). The silty nature of the rocks would indicate continuous deposition of sediment from suspension while the presence of sand lenses indicates a close proximity to a sand source where periodic sand inflow would accompany a fluctuation in salinity.

The Inner Fringe—Units 2-14 (Figure). The inner fringe consists of a sequence of wavy, thinly laminated, fine-grained sandstone interbedded with bedded fine- to medium-grained sandstones and massive beds of fine- to medium-grained sandstone.

The wavy, thinly laminated (1/8 to 1/4 inch thick) sands (units 3,4,6,8,12,14,16) represent periods of relatively inactive deposition. Drier climates and droughts could account for a decreased river flow and less sediment being transported to the delta system.