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MANAGEMENT OF THE OZARK BIG-EARED BAT, *PLECOTUS TOWNSENDII INGENS*, IN ARKANSAS

The Ozark big-eared bat, *Plecotus townsendii ingens*, is one of 5 recognized subspecies of Townsend's big-eared bat, *P. townsendii* (Handley, 1959). Of the 5 races, only the Ozark big-eared bat and the Virginia big-eared bat, *P. t. virginianus* (occurring in Kentucky, Virginia, West Virginia, and North Carolina), are currently listed as endangered by the U.S. Fish and Wildlife Service.

Ozark big-eared bats are cave residents year-round, although different caves are usually occupied in winter and summer. They hibernate in caves (sometimes mines) where the temperature is 12° C or less, but generally above freezing. Cave hibernation sites are often near entrances in well-ventilated areas. If temperatures near entrances become too extreme, they move to more thermally stable parts of the cave. Ozark big-eared bats hibernate in tight clusters of a few to a hundred or more individuals. During hibernation, the long ears may be erect or coiled. Solitary bats sometimes hang by only 1 foot.

Ozark big-eared bat maternity colonies are usually located in relatively warm parts of caves. During the maternity period, males are apparently solitary. Where most males spend the summer is unknown. Mating begins in autumn and continues into winter. Young females apparently mate during their first autumn. Sperm are stored during winter, and fertilization occurs shortly after arousal from hibernation. A single pup is born during June.

Prior to 1975, Ozark big-eared bats had been reported in small numbers from only a few caves in northwestern Arkansas, southwestern Missouri, and eastern Oklahoma (U.S. Fish and Wildlife Service, 1973; Handley, 1959). The U.S. Fish and Wildlife Service (1973) estimated the total number surviving to be less than 100 and reported that no more than 4 individuals had ever been found at one time. That information was incorrect; Sealander (1951) reported collecting 11 Ozark big-eared bats from a Washington County, Arkansas, cave in 1951.

It was not until 24 years later that a number greater than 11 was reported. Harvey (1975) and Harvey *et al.*, (1978) reported finding 60 hibernating *P. t. ingens* in a western Arkansas (Washington Co.) cave in February 1975.

During the summer of 1978, the first known Ozark big-eared bat maternity colony was discovered, in a Marion Co., Arkansas, cave. The colony consisted of ca. 120 females and young (Harvey *et al.*, 1981). During the following winter (March 1979), a hibernating colony of ca. 255 *P. t. ingens* was discovered in another Marion Co. cave, only ca. 6 km from the maternity cave (Harvey *et al.*, 1981).

The Washington Co. hibernating population has fluctuated since 1975, with no more than 60 reported during any 1 winter. During February 1990, only 8 individuals were observed in the hibernaculum, however, ca. 60 were present during the winter of 1988. The Marion Co. hibernating population has varied from a high of 420 in 1980 to a low of 140, during February 1990.

The Marion Co. maternity population has varied from a high of 170 in 1979 to a low of 46 during the summer of 1986. During the most recent estimate (July 1989), ca. 83 adults and young were observed exiting the maternity cave.

These 3 sites are the only Arkansas caves where colonies of Ozark big-eared bats have regularly been found, although scattered individuals or groups of 2-40 have been reported from other caves. We currently estimate the total Arkansas population at ca. 200 individuals.

During recent years, both hibernating and maternity colonies of Ozark big-eared bats have been discovered in several eastern Oklahoma caves. Approximately 1400 are currently estimated to occupy Oklahoma caves (Brenda S. Clark, pers. comm.). None are presently known to exist in Missouri caves. Thus, the total known *P. t. ingens* population numbers ca. 1600 individuals.

The Marion Co. hibernation cave (housing ca. 140 *P. t. ingens*) and ca. 83 ha of surrounding land were purchased by the Nature Conservancy and are now under the jurisdiction of the Arkansas Natural Heritage Commission. The cave has not been gated or fenced, and there are currently no plans to do so. A warning/interpretive sign has been placed at the entrance and the access road to the cave has been gated. The bats hibernate in a section of the cave where humans are not likely to find them, and the cave apparently receives relatively little human visitation. It is felt that a gate is unnecessary (and would be very expensive to construct).

The Washington Co. hibernation cave is located in Devil's Den State Park. A management plan for the cave is being formulated, but has not been completed. Park naturalists are very much concerned about the welfare of the bats and take precautions to prevent park visitors from disturbing the colony when it is present. A warning/interpretive sign has been placed at the cave entrance, and a security alarm system will be installed in the near future.

The Marion Co. maternity cave has been offered protection through a cooperative agreement with the landowner and by an angle-iron gate constructed in 1987 by the Arkansas Game and Fish Commission, utilizing endangered species funds from the U.S. Fish and Wildlife Service.

Ozark big-eared bat populations at these 3 important caves are monitored annually or biennially. Spelogers, battery operated electronic devices that record the date and time of human intrusion into the caves (triggered by light), have been used to determine the extent of disturbance. Attempts are also being made to locate additional *P. t. ingens* colonies.

A program to educate the public about the beneficial nature of all Arkansas bats and their importance in the ecosystem is also being conducted. Numerous bat programs have been presented to the public, and several thousand copies of a 48-page booklet entitled "Arkansas Bats: A Valuable Resource" (Harvey, 1986) have been distributed. Hopefully, management measures taken or planned will result in stable or increasing populations of the endangered Ozark big-eared bat, as well as all Arkansas bats.

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PELLET ANALYSIS OF WINTER-ROOSTING LONG-EARED OWLS *(ASIO OTUS)* IN ARKANSAS

The Long-eared Owl *(Asio otus)* is rather rare in Arkansas, with only about two dozen individuals recorded in the state in the past 30 years (James and Neal, Arkansas birds: their distribution and abundance, 1985, p. 210); (Muth, Am. Birds 39:177, 1985; Am. Birds 40:291, 1986; Am. Birds 42:277, 1988). Herein I report on the contents of owl pellets from 2 Long-eared Owls found in northeast Arkansas. On 6 December 1988 I discovered a dead Long-eared Owl on railroad tracks at the NE corner of the Jonesboro municipal airport, Craighead County. Subsequently 2 live individuals roosting close to the trunk of a small oak tree at a height of 3 meters, in a wet scrubby area along the railroad tracks were observed. They could be found each day in the identical spot until 19 January 1989, after which they were not seen. Sixty-two pellets were picked up under their perch and analyzed for the animal remains they contained as an index of the owls' feeding. Pellet contents and percent occurrence in total pellets were as follows: house mouse *(Mus musculus)* 41.3; unidentified bird species (Passerines) 14.9; unidentified rodent remains 11.5; marsh rice rat *(Oryzomys palustris)* 6.9; *Microtus* spp. 5.7; southern short-tailed shrew *(Blarina carolinensis)* 4.6; least shrew *(Cryptotis parva)* 3.5; prairie vole *(Microtus ochrogaster)* 3.5; Norway rat *(Rattus norvegicus)* 3.5; hispid cotton rat *(Sigmodon hispidus)* 2.3; and southern bog lemming *(Synaptomys cooperi)* 2.3. The species taken, and the percentages of each, conformed closely to the types and numbers of small vertebrates likely to be encountered at that time and place (Van Rick McDaniel, pers. comm.), and indicated that the Long-earned Owl, during the winter in Arkansas, is an opportunistic nocturnal predator. This agrees with the results of other studies of feeding habits of this species (e.g. in Bent, Life histories of North American birds of prey, part two. U.S. Natl. Mus., Bull. No. 170, 1938).

The author thanks Van Rick McDaniel for help in the identification of mammal species.

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ENHANCING AN ENGINEERING LEARNING ENVIRONMENT

As part of a Title III grant from the Department of Education, Christian Brothers University initiated a focused effort to incorporate critical thinking and enhanced communication abilities into the freshman engineering sequence. One of the first courses targeted for this incorporation was the introductory FORTRAN course which is required of all engineering and engineering physics majors. This course is an elective for computer science and science majors.

The modification to the course consisted of 4 major components. The first component was the introduction and use of a problem solving paradigm. Research by Charles Wales of West Virginia University (Wales, ASEE Volume 78, Number 7, p. 687, 1988) and Donald Woods of McMaster University (Woods, Strategies, p. 4-1, 1985) determined that student performance improved with the use of a problem solving paradigm. The paradigm that was used consists of seven steps:

1. I want to and I can — Students were encouraged to motivate themselves and prepare before starting a problem.
2. Define the situation — Students were prompted to try to understand the words of the problem, to analyze the statements concerning the problem, to identify constraints, to identify criteria, and, where applicable, draw diagrams and sketches.
3. State the objective — Students were required to write down exactly what they wanted to accomplish.
4. Explore the options — Students were expected to play around with ideas, make connections, collect information, and postulate possible solutions.
5. Plan — Students selected and developed a plan for solving the problem.
6. Do It — Students worked the problem in this step.
7. Look back — Students were asked to evaluate their performance. They were asked to check and double check, identify experience factors, extend to similar problems encountered, and determine what they learned about problem solving.

This same problem solving paradigm has been used in chemistry and physics courses. The student response to the problem solving paradigm was generally positive. Hesitation about the paradigm centered around the concern that following the 7 steps made the problem solving process longer. A typical student comment about the problem solving paradigm was, "Using the paradigm makes me stop and really think about what I am doing. It requires me to organize my thoughts, but this sometimes takes too long." A typical student misconception concerning the paradigm was that the problem solving paradigm is serial. Some students believed that once they completed the "define the situation step" that they should never return to that step! The majority of students expressed the opinion that the problem solving paradigm had been helpful in solving problems.

The second modification introduced was the use of guided design and discovery techniques. Prior to the modification, students were given lectures explaining programming theory before writing or seeing programs which exhibited those techniques. The student interest in the theory was low and little concerning the theory was retained. Kobl (Kolb, The Modern American College, Chapter 10, 1981) has suggested that students learn better when they start with a concrete experience. Now students are given a structured and well documented program which exhibits the desired programming theory before the theory is discussed. For example, on the first day of class, students are taken to the computer lab and asked to create a simple program. The program prompted the student to enter 3 numbers and then the program displayed the average of the 3 numbers

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