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Ecology of Blanchard Springs Caverns, Ozark National Forest, Arkansas: 42 Years Later

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Running Title: Ecology of Blanchard Springs Caverns

Abstract

Interrelationships between subterranean and epigean environments affect dispersion and distribution of cave organisms among the macro and microhabitats. This study examined the environmental impact of 42 years of tourism and development in the two lower sections of Blanchard Springs Caverns found in Stone County, Arkansas; and contributes to a better understanding of the seasonal fluctuations of the abiotic and biotic parameters.

Temperature, water quality, and fauna data were collected. A new entrance, lighting, and approximately 12,500 visitors during the 12-month study had no observable effect on cavern temperatures. Stream water quality measurements were comparable to Grove's 1974 study. Gray bat, *Myotis grisescens*, populations and distributions increased from an estimated maximum of 5000 (Grove 1974; Grove and Harvey 1974) to 372,726 reported by U.S. Forest Service (personal communication, Jessica Hawkins, Sylamore District of the Ozark National Forest, Mountain View (AR), 2016). This study reported 5 obligate cave species all recorded in previous studies.

Introduction

Blanchard Springs Caverns is a limestone cave system located in the Sylamore Ranger District of the Ozark-St. Francis National Forest, which is 25 km northwest of Mountain View, in Stone County, Arkansas. It is the second largest cave in Arkansas, with 13.7 km in mapped length (Graening *et al.* 2011) and a delineated recharge area of 39.6 sq. km [15.3 sq. miles] (Aley 1980).

The U.S. Forest Service administers 3 guided tours for the public on the Dripstone Trail, the Discovery Trail and the Wild Cave Trail. The Dripstone Trail opened to the public in 1973 and is open all year round. It is approximately 1.6 km long and its largest room is 55 m wide and 366 m long. The Discovery Trail lies below the Dripstone Trail and is 1.9 km long and averages approximately 100 m underground. The Discovery Trail opened to tourist in 1977 and is open June through August. It includes a natural pit-entrance, an underground stream, which exits lower in the valley as Blanchard Springs, and exits from the Ghost Room. The Wild Cave Trail extends beyond the Discovery Trail and continues into undeveloped portions of the cave to the farthest point easily accessed by visitors. Access to the Wild Cave Trail is through the Ghost Room door. It is 2 km long, opened to tourist in 2000, and is open from April to October. The seasonal schedules of the Discovery Trail provide protection to bats hibernating in the lower sections of the cave during the winter months.

Blanchard Spring Caverns is a living cave, meaning speleothems are actively forming and undergoing change due to calcite deposition and dissolution. Monitoring abiotic and biotic factors of such a dynamic environment is essential for successful cave management. It is generally assumed that caves are characterized by relatively stable internal microclimates (Mohr and Poulson 1966); however, such cave ecosystems are not typically subjected to tourism and development, which have the potential to alter temperature, relative humidity and cave airflow. Altered airflow may have a greater impact on a cave environment than cave visitors. Hypothetically, during the warmer months, surface temperatures and relative humidity are generally high. This warm moist air may be drawn into the cave driven by convective airflow and differences in elevations of entrances. When this warm, moist, surface air is cooled by cooler cave temperatures, condensation occurs. In the cooler months, when surface temperatures and relative humidity are generally lower than cave temperatures, no condensation occurs and drying may occur. Aley and Aley (1978) measured air flow exchanges in Blanchard Springs Caverns between the surface and cave as high as 1415.8 cubic meters [50,000 cubic feet] per minute when all cave doors were opened. They further reported that this air was capable of drying the cave 80% of the time. The reasons attributed to such high air exchanges were the larger size of the caverns, the 120 meters [240 feet] vertical extent of the cave between the elevator shaft and natural entrance, and the numerous entrances for air to pass.

In the winter of 1972, 6 months prior to the Dripstone Trail opening to the public, and prior to the development of the Discovery Trail, Grove (1974) conducted a baseline ecological study of Blanchard Springs Caverns. Data for temperature, humidity, water hardness, alkalinity, and cave fauna were recorded. At that time, temperatures near the entrance fluctuated between -7°C and 15°C, but generally remained a constant 14.5°C deeper in the cave. Relative humidity was generally 100%. The total alkalinity and total hardness of the cave stream fluctuated from 68-137 ppm to 111–205 ppm, respectively (Grove 1974). Aley and Aley (1978) analyzed data between June 1972 and January 1977 during the period of new construction of the lower Discovery Trail. They found that, between the natural entrance and the new tunnel into the Ghost Room, average temperatures fell 0.78 degrees C [1.4 degrees F] and mean relative humidity fell 2.7%.

The current study duplicates Grove's original 1974 study of the lower sections of Blanchard Springs Caverns and provides additional temperature and relative humidity data to the Aley and Aley (1978) meta-analysis. The current study determines the impact of 42 years of tourism and whether a more stable environment has been reestablished following the development of the Discovery Trail and Wild Cave Trail sections of the cavern. This research is of special importance because Blanchard Springs Caverns appears to be a major winter hibernaculum for endangered gray bats, *Myotis grisescens*, as well as other rare cave organisms. Graening *et al*. (2011) ranked [Blanchard Springs Caverns] as the second highest cave in Arkansas for biodiversity and as the most biologically important cave in Arkansas by number of rare species.

Materials and Methods

This study took place from June 2015 to May 2016. Humidity, water hardness, alkalinity, and cave fauna observations were obtained quarterly. Temperature sensors were placed (Smart Button Temperature Loggers, ACR Systems, Inc., Surrey, British Columbia, Canada, model ACRSB) in similar locations to the Taylor maximum/minimum thermometers from Grove's original study. The constant temperature zones, bat hibernacula areas, small rooms frequented by cave visitors, and the bottom of the natural pit entrance were of special interest. Additional sensors were placed in the constant temperature zone of the Wild Cave Trail and near the new artificial entrance and passages in the Ghost Room. Additionally, sensors were placed outside the artificial entrance of the Ghost Room to record epigean temperatures. The sensors were programmed to log temperatures every 90 minutes, for 90 days, at which time they were exchanged. Relative humidity was obtained using a sling psychrometer during the quarterly visits. Water quality was measured quarterly using titration field test kits (Hach Company, Loveland, Colorado, models OX-2P; 5-EP; and AL-AP-MG-L) for dissolved oxygen, total hardness, and alkalinity. Graening *et al*. (2003) completed extensive faunal surveys; therefore, no organisms were removed from the cave for the current study. Cave faunal observations were conducted during visits to retrieve temperature sensors and by cavern tour guides between research visits. Sterilized horse manure was used as bait in Petri dish traps. Any organisms observed were identified, photographed, and immediately released. Daily tourist visitation numbers, dates, and yearly bat population numbers were obtained from the U.S. Forest Service.

Results

During this study, 12,493 visitors toured the Discovery Trail and the Wild Cave Tour (personal communication, William Avey, U.S. Forest Service, 2017). More specifically, 11,990 visitors toured the Discovery Trail over 92 days on 431 tours, which were at 73.8% capacity. The average number of visitors per tour was determined to be 28 and each of these tours lasted approximately 1.5 hours. This calculates to 17,985 visitor-hours in the cave, with an average visitor-hour per tour of 41.73 (Sasser 2016).

During the study, 503 visitors toured the Wild Cave Trail over 82 days on 83 tours, which were at 74.4% capacity (Avey 2017). The average number of visitors per tour was found to be 6 and lasted approximately 5 hours. This calculates to 2515 visitor-hours with an average visitor-hour per tour of 30.3 (Sasser 2016).

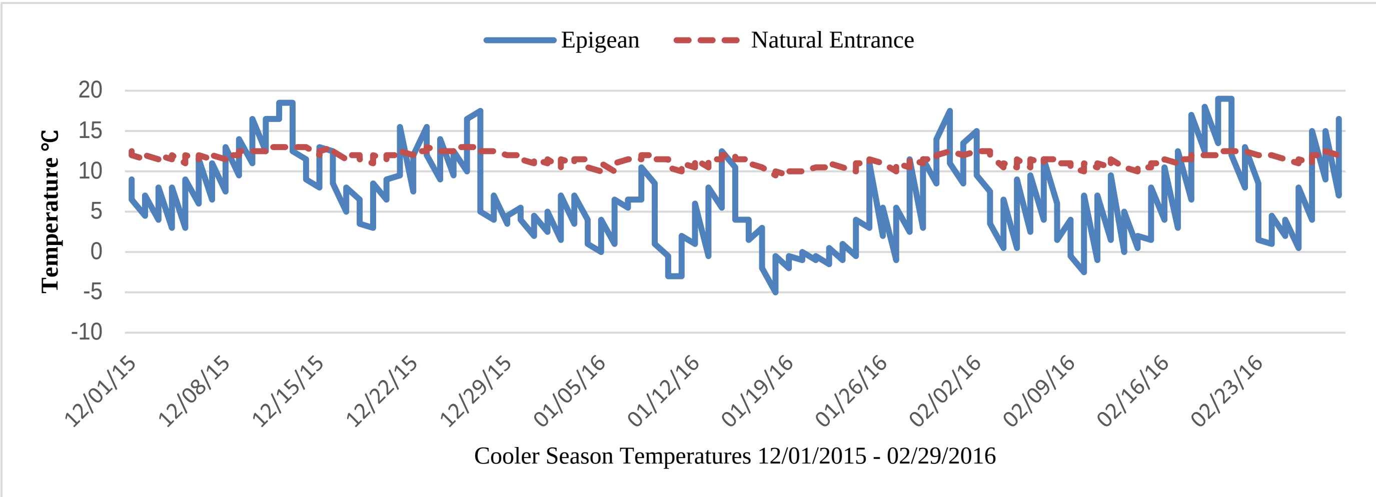

Figure 1. Comparison of epigean and natural entrance cooler season temperatures.

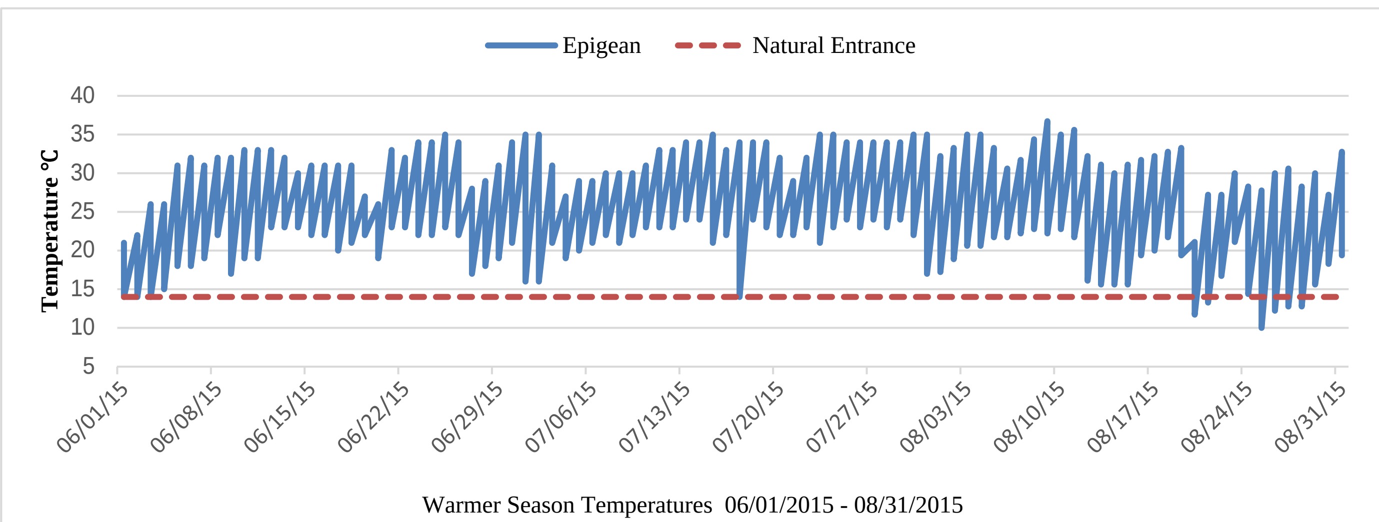

Figure 2. Comparison of epigean and natural entrance warmer season temperatures.

The researchers observed no temperature changes that could be attributed to visitor presence. The physical changes to accommodate tourism appear to have had no negative impact on temperature in the cave. The current study's cavern temperatures varied between 9.5°C to 14°C. The area near the natural entrance had the greatest variation in temperature during the cooler months, 9.5 to 12.5 (See Figure 1). During the warmer months, the temperature remained 14°C (Figure 2).

In the deepest cave zones, temperatures remained 14°C. Temperature sensors can only resolve 0.5°C; therefore, temperature fluctuations of 0.5°C were considered acceptable (*personal communication*, Eric Durand, eric@acrsystems.com, ACR, 2017).

A passage room, called the Reed Rock Room, was of special interest because it was a small area approximately 150 m^3 where visitors would congregate to listen to tour guides. If the 17,985 cavern visitor-hours (Sasser 2016) affected cave temperatures, it would be expected to be recorded in this room; however, temperatures did not vary from 14°C throughout the collection period. Additionally, temperatures in the Ghost Room, adjacent to the artificial entrance, remained 14°C. Stream quality measurements of dissolved oxygen ranged from 8-10 ppm. Alkalinity ranged from 95-135 ppm. Total Hardness ranged from 153-171 ppm. Stream quality measures fell within similar ranges as reported by Grove (1974) (Table 1).

Table 1. Stream Quality Comparison 1974-2016

	1974	2016
Dissolved Oxygen	9.5-10.5 ppm	8-10 ppm
Alkalinity	68-137 ppm	95-135 ppm
Total Hardness	111-205 ppm	153-171 ppm

Cave fauna observed were 5 obligate, troglobitic species including cave millipedes, cave spiders, pseudoscorpions, diplurans, and grotto salamanders, *Eurycea spelaea*. Other species observed included troglophiles, cave salamanders, cave crickets, gray bats, *Myotis grisescens,* northern long-eared bats, *Myotis septentrionalis*, and Indiana bats, *Myotis sodalis*. The *Myotis grisescens* winter population during the study was estimated to be 372,726 (U.S. Forest Service 2016).

Discussion

Tourist visitation did not have a measurable effect on temperatures in the sampled areas. The artificial entrance did not affect temperatures in the adjacent Ghost Room. This is most likely due to the presence of airlock doors and limited visitors relative to the volume of the cave passages.

Blanchard Springs Caverns made significant changes through the years to accommodate tourism in the lower sections of the cave, including a new tourist entrance, numerous concrete walkways, and incandescent lighting. The lack of any measurable detriment to the caverns resulting from such modifications is most likely attributed to the conservation efforts on the part of the U.S. Forest Service.

The U.S. Forest Service has many procedures in place that contribute to the preservation of the caverns. For example, airlock doors at entrances control changes in airflow; daily tour numbers and tour size are limited; lights are turned off, after tourists have left the area, to control heat and algal growth; and visitors on the Wild Cave Tours are required to wear clean cave clothing provided by the U.S. Forest Service. In addition, they must thoroughly wash cave boots to prevent the spread of white-nose syndrome, *Pseudogymnoascus destructans,* a fungus that infects hibernating bats. Prior to embarking, and after returning from the Wild Cave Tour, visitors are required to change shoes or put on shoe coverings to minimize the spread of organics to new areas of the cave and other caves.

In the initial base line study, Grove (1974) reported 36 taxa composed of 7 troglobites, 3 troglophiles, 12 trogloxenes, and 14 accidentals. Animal groups represented included rotifers, gastropods, isopods, amphipods, pseudoscorpions, spiders, millipedes, centipedes, collembolans, cave crickets, flies, diplurans, amphibians, birds, and mammals. Graening *et al*. (2004) reported Blanchard Springs Caverns complex as the "most species rich cave in Arkansas" with 96 taxa. Graening *et al*. (2011) later reported 126 taxa including 11 species of bats. The current study reported five obligate species, all previously reported. An increase in the number of fauna is most likely due to the time and effort of many cave scientists in the last 42 years and the decision of managers to allow accessibility for scientific research.

Populations and distributions of gray bats, *Myotis grisescens,* were found to have steadily increased from an estimated maximum of 5000 (Grove 1974; Grove and Harvey 1974) to 372,726 reported by U.S. Forest Service (2016). The increase in populations is most likely due to the favorable conditions Blanchard Springs Caverns provides during winter hibernation.

Conclusions and Recommendations

Tourism and development does not appear to have affected Blanchard Springs Caverns adversely as evidenced by the limited abiotic changes recorded and the growing number of fauna reported in the last 42 years. The temperature and relative humidity increases reported by Aley and Aley (1978) during the construction in the lower passages between the natural entrance and Ghost Room appear to have reestablished to pre-development levels reported by Grove (1974).

The dramatic increase in the gray bat population is especially significant. Blanchard Springs Caverns may have displaced significant caves on U.S. Forest Service land as the major winter hibernaculum. The authors recommend that research be undertaken to establish if this has occurred.

The U.S. Forest Service tour guide personnel are an integral part of the conservation and quality of tourism experienced while caving in Blanchard Springs Caverns. The authors recommend that an identification of cave fauna pamphlet and fauna inventory card be developed that could be used to assist tourists in becoming "citizen scientists" while in the cavern on the Wild Cave Trail. This would aid in recording fauna and educating tourist of the importance of fragile cave ecosystems. The authors also believe it would promote the beauty and educational benefit of Blanchard

Springs Caverns to the public.

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This paper is dedicated to the memory of Dr. Michael (Mick) J. Harvey.

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