PHOLEOS

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PHOLEOS

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PHOLEOS

Pholeos (Greek - *cave)* is a biannual journal of the Wittenberg University Speleological Society (WUSS), an internal organization of the National Speleological Society (NSS).

Purpose
The Wittenberg University Speleological Society is a chartered internal organization of the National Speleological Society, Inc. The Grotto received its charter in May 1980 and is dedicated to the advancement of speleology, to cave conservation and preservation, and to the safety of all persons entering the spelean domain.

WUSS Web page
http://www.wusscavers.com

Subscription rates are $10 a year for two issues of *Pholeos*. Back issues are available at $5.00 an issue.

Exchanges with other grottoes and caving groups are encouraged. Send all correspondence, subscriptions and exchanges to the grotto address.

Membership
The Wittenberg University Speleological Society is open to all persons with an interest in caving. Membership is $10 a semester or $20 a year and comes with a subscription to *Pholeos*. Life membership is $150.

Meetings
Meetings are held every Wednesday at 7:00 p.m. when Wittenberg University classes are in session. Regular meetings are in Room 319 in the Barbara Deer Kuss Science Hall (corner of Plum St. and Bill Edwards Dr. - parking available in the adjacent lot).

Submissions
Members are encouraged to submit articles, trip reports, artwork, photographs, and other material to the Editor. Submissions may be given to the Editor in person or sent to the Editor at the Grotto address. Guidelines for submitting research papers can be found on the inside back cover of this issue.

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Front Cover: Students standing in one of the Gothic arches (windows) of Rock House, Hocking Hills State Park, Hocking County, Ohio. Photo by Horton Hobbs III

EDITOR'S NOTE

Hey there cavers! It's that time of the year again, the next issue of *Pholeos* has finally arrived! And what an exciting year it has been. We've been neck deep in surveys (and have been particularly thrilled for the opportunity to don wetsuits and continue work in the Boundary Cave system in Carter County, KY) and have had a blast visiting the TAG area for some beautiful vertical caves not once but twice! In the following pages, we feature several research projects, including one looking at nutrient uptake in cave streams as well as a piece by a former student on the Mexican Free-tailed Bat. The survey section in this issue brings to light Rock House of Hocking Hills and Black Cave, both from our home state of Ohio! We also honor the memory of a longtime friend to the WUSSes and former owner of the Seneca Caverns. As always, we welcome questions, comments, photographs, and articles, so please feel free to contact any of the WUSSes. We hope you enjoy this issue of *Pholeos*, and happy caving!

Kristen Shearer, Editor
WUSS #0579

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MESSAGE FROM THE PRESIDENT

I had promised myself over and over again in the writing of this piece that I would, under no circumstances, write the line "time flies, doesn't it?" There seems no way around it, though, and so former President Danielle Carey's challenge to future presidents goes undisputed. It seems like just yesterday that I was a freshman on my first trip surveying Ohio Caverns, freezing in the cold November weather with my boots glued to the cave under about a foot of mud. I must have been born with the caving gene because I loved every moment of it! (And I still chuckle when I remember how long it took me to figure out how to turn my helmet light on)

WUSS and I have really come a long way since that fateful November in 2010. Just this past year we have seen an increase in new members that are extremely interested in caving: we have had several students become involved in research, very successful surveying trips, and enough interest in vertical work that we were able to take two trips this year to the TAG region! WUSS made a strong showing this year at Winter Adventure weekend – four WUSS women placed in the squeezebox competition finals (with only minimum bloodshed as a result of the contraption). WUSS was also an active presence at the National Speleological Society Convention and Karst-o-Rama this summer - much caving and fun were had by all!

Despite the difficulties of WNS, we are looking forward to another great year with an amazing group of new freshmen. I want to thank everyone for their hard work on this issue, and would like to thank WUSSes past and present for welcoming me into their family. I am ecstatic to meet all of you in the coming years!

Samantha Swanton, President
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Baiting pitfall traps,
Adwell Cave, Hart Co., Kentucky.
(photo by Horton Hobbs III)

Relating nitrogen demand to nitrogen spiraling in Cascade Stream, Carter County, KY

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Abstract

Very little research attention has been paid to ecosystem functions in caves such as nutrient cycling, focusing rather on the ecology of cave organisms. The purpose of this study was to investigate the spiraling behavior of nitrogen in a stream coursing through Cascade Cave (Carter County, KY) and compare spiraling metrics to that of a surface stream, relating how nitrogen spiraling reflects demand in caves. Three separate nitrogen additions were performed during the fall, winter, and spring months of 2010/2011 employing two separate experimental methods. Uptake lengths calculated during the first experiment for the cave and surface streams were 12.41 and 9.36 m; while lengths for the second experiment were 16.67 and 13.35m, respectfully, reflecting higher demand for nitrogen in surface systems while uptake lengths for the third experiment were 14.75 and 17.97 m. Uptake velocities and areal uptakes calculated for all three experiments produced mixed interpretations with regards to nitrogen demand in these systems. Spiraling metrics generally followed expected relationships with discharge and nitrogen concentrations in both systems.

Introduction

Stream microbes require carbon (C), nitrogen (N), and phosphorous (P) in specific ratios for maximum growth (Cleveland and Liptzin, 2007). Though a wide range of these ratios have (e.g., Redfield, 1958; Redfield *et al.* 1963; Tezuka, 1990; Urabe *et al.*, 1995 Chrzanowski *et al.*, 1997; Elser and Urabe, 1999), it has been well established that C is required in much more substantial amounts than N or P. The cave stream environment is very different from that of surface streams and represents the extreme heterotrophic end of the stream trophic continuum. Because of the lack of primary production and the heavy reliance on imported C from the surface (Culver, 1985; Simon et al., 2007) these systems are thought of as C–limited as opposed to nutrient-limited (Simon and Benfield, 2001, 2002; Simon *et al.*, 2003; Simon *et al.* 2007), though no studies exist that address explicitly whether caves are generally C or nutrient-limited (Simon *et al.*, 2007). Some published studies have concluded certain caves to be nutrient-polluted (e.g., Boyer and Pasquarell, 1996; Simon and Buikema, 1999; Wood *et al.*, 2008; Bidwell *et al.*, 2010), which is to say the systems are C-limited.

Though Schade *et al.* (2011) investigated nutrient spiraling in surface streams on extreme ends of the trophic spectrum (i.e., heterotrophic vs. autotrophic streams), published studies investigating the spiraling behavior of nutrients in caves hardly exists save for Simon and Benfield (2002). Instead, most cave-related studies focus on evolutionary, community, and population ecology of caves (e.g., Gibert *et al.*, 1994; Hobbs and Lawyer, 2003; Hobbs and Hazelton, 2008). Nutrient cycling has been well documented in surface streams, however (Newbold, 1992; Allan and Castillo, 2009; Schade *et al.*, 2011). Nutrient spiraling refers to the cycling of nutrients through biotic and abiotic components while travelling downstream (Webster and Patten, 1979; Newbold, 1992). This spiraling process is quantified as spiraling length which refers to the distance a single nutrient particle travels between biotic and abiotic forms. The uptake length (S_W; a measure of retention), is the distance a nutrient particle travels in abiotic form. Spiraling metrics allow researchers to gain insight into relative demand in terms or resources in streams. Shorter uptake lengths and greater uptake velocities (V_f; how fast an inorganic nutrient particle travels from the water column to the benthos) and areal uptake rates (U; mass of nutrients taken up per unit area per unit time) indicate higher relative demand that particular element. This spiraling concept can certainly be applied to streams coursing underground and can be important in studying how streams react to nutrient pollution.

The purpose of this study is to compare the limiting nutrient (N in the case of Cascade Stream) uptake in a cave stream to that of a surface stream by way of the nutrient spiraling metrics and therefore gaining insight into the demand for N in a cave stream. While we are quantifying N spiraling, it is important to note that no published studies exist regarding limiting factors in the cave system studied here and that we are referring to the limiting nutrient that we found in this system, not necessarily the limiting element (i.e., C). Since nutrient spiraling behavior in surface streams is well studied and better-understood than cave stream systems, the surface stream addition and subsequent nutrient metrics act as the control to the cave addition in order to understand better how nutrient demand in streams changes as a result of going underground.

Site Description

All cave addition experiments were performed in the same experimental reach of a stream (called Cascade Stream by the Wittenberg University Speleological Society) coursing through Cascade Cave in Carter County, KY. This is an approximately 3,500m long cave developed in the Slade stratigraphic limestone formation (Carter County Cave files, Wittenberg University). The reach is located roughly 200m north-northwest of the Backdoor Entrance to the cave and the only change to this experimental reach was the elongation from 40 (16 October 2010), to 50 (12 February 2011), and finally to 130m (26 March 2011; all expanded in the upstream direction). This reach was chosen by gross examination immediately upon arrival during the 2010 experiment based on the minimal pooling observed.

The surface reference site selected for the 16-October 2010 experimentation was located approximately three kilometers upstream of the site in Cascade Cave, located along St. Route 182 in Carter County. This section of the stream was chosen (by gross examination) because of similar hydrological characteristics to that of the site in Cascade Cave on that day. From the surface reach, the stream continues to flow above ground, goes over Fort Falls, and then sinks and flows through Tire Creek, Jones, Sandy, and Cascade caves and then surfaces for approximately 150m where it serves as a tributary to Tygarts Creek.

The site used as a reference during the 12 February 2011 and 26 March 2011 experiments is named Cave Run and is an effluent from Bat Cave that is also a tributary to Tygarts Creek. Cave Run receives water from Horn Hollow as well as Hidden Cave and Hidden Spring (Horton H. Hobbs, Wittenberg University, Springfield, OH, personal communication). This stream surfaces for several hundred meters before reaching our experimental section located roughly 150m prior to the confluence of Tygarts Creek.

Materials and Methods

Slug addition experiments were conducted on three separate dates. The first experiment was performed on 16 October 2010, the methodology of which is described in Rigsby and Shearer (2011) and then two additional experiments took place on 12 February 2011 and 26 March 2011. The surface stream reference site was changed for both 2011 additions. Additional changes between experiments was the calculation of Q at both ends of the experimental reach in both 2011 experiments, the increased mass of N added between all experiments, and the use of the Tracer Additions for Spiraling Curve Characterization (*TASCC*) method described by Covino *et al.* (2010; details below) as opposed to the pulse-chase method used in the 2010 experiment. Since the 2010 injection has been described previously, only the 2011 experiments are discussed in this material and methods section. See Rigsby and Shearer (2011) for details regarding the experimentation used in the 2010 experimentation.

Slug solution chemistry

It was determined during the first experiment that N is the limiting nutrient in the Cascade Stream system according to the Redfield ratio of N:P = 16 (Redfield, 1958), we therefore investigated N spiraling in all experiments. For the 12 February experiment slug solution chemistry for the cave slug comprised 1 L deionized water, 141.204 mg N (in the form of KNO_3) and 200.7 g NaCl as a conservative tracer. Solution chemistry for the surface stream was 1L deionized water, 131.118 mg N (also in the form of KNO_3), and 401.2 g NaCl. The mass of NaCl was chosen to be increased so that we could measure a larger pulse of specific conductance and therefore better able to know when to take grab samples (explained below). Solution chemistry for the 26 March experiment for both cave and surface slugs included 500 mg N (in the form of $NaNO_3$), and 403.2 g NaCl dissolved in 4 L of stream water collected on site in a 20 L carboy for the cave site and 797.3 g NaCl in 6 L of stream water at the surface site. We chose to increase the mass of NaCl added at the surface site after gross examination of the site as well as the decision to increase the reach length; in other words we decided to increase the mass of NaCl because the NaCl would be diluted greatly in the increased volume of water as well as the longer distance the slug had to travel before reaching the end of the reach where grab samples were taken (Stream Solute Workshop, 1990).

Discharge

Discharge was calculated in all experiments by way of the conservative solute tracer method (Stream Solute Workshop, 1990). Briefly, NaCl in the slug injectate causes an increase in specific conductance (μS cm^{-2}); as the slug passes a given point the specific conductance will increase and then decrease as the highest concentration of Cl^- (the "peak" specific conductance value) moves downstream. Integrating the curve of the $[Cl^-]$ plotted as a function of time gives Q of the stream in L s^{-1} (see Figure 1 for example). Specific conductance values can be converted to $[Cl^-]$ with Eq. 1 (Damon Ely, University of Maine, Orono Maine, personal communication):

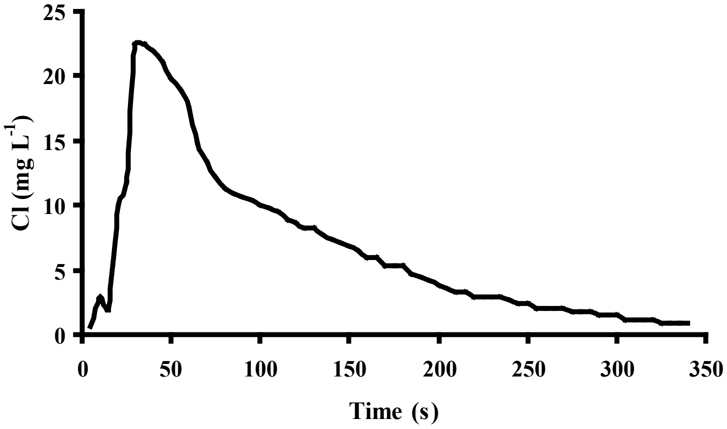

Figure 1. Example of a plot of Cl concentration as a function of time that is used to calculate disharge. Discharge is calculated by integrating the curve

$$\text{(1)}\quad \textbf{Specific Conductance}/3.3783 = [\text{Cl}^-]$$

Specific conductance was tracked using a YSI 6920 multi-parameter sonde programmed to log physicochemical parameters at 5 s intervals that was placed at the end of each reach prior to adding injectate solutions and removed after the final sample was pulled from the stream.

Stream physicochemical parameters

Stream physicochemical parameters measured were temperature (°C), specific conductance (μS cm^{-2}), dissolved oxygen (DO; mg L^{-1}), and pH. All discharge and physicochemical measurements were made with the same multi-parameter sonde used for the calculation of discharge described above.

Experimental methodology and sample processing

Immediately upon arrival at each site, background physicochemical parameters were logged and an experimental reach was designated (see above). The prepared slug was then added approximately 5 m upstream of the head of the reach in order to attempt to mix adequately the injectate solution with the stream water before it arrived at the reach head. This was the case for all three experiments.

For all experiments conducted in 2011, we chose to employ the field methodology of the *TASCC* method described by Covino *et al.* (2010). Specifically, an approximately 40mL water sample was collected using a syringe at 10 µS cm^{-2} intervals of specific conductance on 12 February 2011 and at 5 µS cm^{-2} intervals on 26 March 2011. We are using the same pulse in specific conductance used to calculate Q to aid in the timing of the collection of samples.

After collecting from the water column, samples were either stored in Zip-Loc bags until able to be filtered once back at the vehicle (12 February 2011) or they were filtered immediately once pulled from the water column (26 March 2011) into 50mL HDPE sample bottles. Once filtered, samples were placed on ice in a cooler until arrival back at the lab where they were immediately frozen at -10°C.

NO_3-N analysis

Processing and analysis of samples for NO_3-N were methodologically the same as the 16 October 2010 experiment described previously in Rigsby and Shearer (2011). Briefly, samples were thawed completely and then analyzed for NO_3-N concentrations using a Hach spectrophotometer (model DR2800; Loveland, CO) using the Cadmium Reduction Method (0.1 – 10.0 mg NO_3-N L^{-1}). Not all samples from the cave were 40 mL during the 12 February 2011 experiment and some collections contained only enough volume for a control and two replicates used for the measurement of NO_3-N as per the method; however all samples collected from the surface injection contained enough volume for a control and three replicates. Replicates of each sample were then averaged and background-corrected.

Uptake metrics

After analysis of samples for NO_3-N concentrations, uptake metrics were calculated in accordance with traditional nutrient uptake studies (e.g., Mulholland *et al.*, 2002; Simon and Benfield, 2002; Tank *et al.*, 2008; Rigsby and Shearer, 2011). Briefly, the ln-transformed ratio of background-corrected NO_3-N and Cl^- concentrations (i.e., the uptake rate coefficient; K_C) were plotted as a function of experimental reach distance and the slope of the trendline was designated as K_C (m^{-1}) and the inverse of K_C was designated as S_W (m; Eq.2).

$$\textbf{(2)} \qquad S_W = K_C^{-1}$$

Uptake velocity (mm min^{-1}) and U (µg m^{-2} min^{-1}) were then calculated with equations 3 and 4 below (w is stream width in meters and C is N concentration in µg m^{-3}).

$$\textbf{(3)} \qquad V_f = Q\,(w\,S_W)^{-1}$$

$$\textbf{(4)} \qquad U = V_f\,C$$

Results

Discharge and physicochemical parameters

Discharge increased with each experiment in both cave and the repeated surface site. The flow rate was extremely low during the first cave addition with a rate of 5.76 L s^{-1}. This increased during the last two experiments with Q calculated as 59.44 and 103.97 L s^{-1} during the 12 February and 26 March experiments, respectfully. This was also the case for surface injections with discharge during the first experiment of 3.31 L s^{-1}, with rates of 70.65 and 197.54 L s^{-1} for the last two experiments. It is important to keep in mind that the surface site was changed for both of the 2011 experiments and that this particular stream is not connected to the Cascade system.

Physicochemical parameters measured appeared to be similar between sites, but not similar temporally, with substantial changes between 16 October 2010 and 12 February 2011, and even to 26 March 2011. All streams were within normal ranges considering the time of year and geology of the region. A summary ofQ and all physicochemical parameters measured during the three experiments is presented as Table 1.

Nitrogen uptake

Uptake lengths calculated from 16 October 2010 experimentation were 12.41 and 9.36 m in the cave and surface streams, respectfully. Uptake velocity and areal uptake in Cascade Cave for this experiment were 54 mm min^{-1} and 1.8 x 10^{-5} µg m^{-2} min^{-1}. Surface stream calculations resulted in 18 mm min^{-1} and 1.8 x 10^{-6} µg m^{-2} min^{-1} for uptake velocity and areal uptake, respectfully.

		Physicochemical Parameters				
		Q	Temp	Sp Cond	DO	pH
Cave	16 Oct	5.76	14.17	326	8.19	7.57
	12 Feb	59.44	2.70	280	19.08	7.40
	26 Mar	103.97	7.99	217	10.48	7.81
Surface	16 Oct	3.31	15.94	407	9.17	7.67
	12 Feb	70.65	5.28	273	20.56	7.01
	26 Mar	197.54	9.05	204	11.23	8.99

Table 1. Summary of discharge and physicochemical parameters measured on three separate additions during this study. Q is discharge in L s^{-1}; Temp is stream water temperature in °C; Sp Cond is specific conductance in µS cm^{-2}; DO is dissolved oxygen in mg L^{-1}; and pH.

Uptake metrics calculated for the 12 February 2011 experiment for the site at Cascade Cave were as 16.67m, 29.8 mm min^{-1}, and 4.9×10^{-4} µg m^{-2} min^{-1} for S_W, V_f, and *U*. Uptake length in the surface stream increased to 13.35m, while V_f and *U* were calculated as 5.52 mm min^{-1} and 0.37 µg m^{-2} min^{-1}, respectfully.

N uptake lengths calculated for the 26 March 2011 were 14.75 and 17.97 m in the cave and surface streams, respectfully. Uptake velocity and areal uptake in the cave stream was 149.40 mm min^{-1} and 39.85 µg m^{-2} min^{-1} while the same metrics were calculated as 109.92 mm min^{-1} and 21.98 µg m^{-2} min^{-1} in the surface stream. We note here that these metric values for added nutrients were best estimates at peak N concentrations. A summary of uptake metrics for the three experiments is found as Table 2.

	S_W		V_f		*U*	
	Cave	Surface	Cave	Surface	Cave	Surface
16-Oct	12.41	9.36	54.00	18.00	1.8×10^{-5}	1.5×10^{-6}
12-Feb	16.67	13.35	29.80	5.52	3.3×10^{-3}	3.7×10^{-1}
26-Mar	14.75	17.97	149.40	109.92	39.85	21.98

Table 2. Summary of all the uptake metrics calculated in the three separate experiments. S_W is uptake length in m, V_f is uptake velocity in mm min^{-1}, and *U* is areal uptake in µg m^{-2} min^{-1}.

Discussion

General trends between the three experiments reflect longer uptake lengths in Cascade Stream, with the exception of the 26 March 2011 experiment, suggesting lower relative demand for N in the cave stream compared to the surface streams. This was expected due to caves generally being C-limited rather than N-limited, allowing inorganic nutrients such as N to travel farther downstream in the water column before biotic or abiotic uptake (Simon and Benfield, 2002). Uptake lengths, however, strongly influenced by discharge and with increases in discharge, longer uptake lengths are usually calculated (Webster *et al.*, 2003) which was also the case with these experiments. Discharge in all streams increased through the course of the three experiments (Table 1), remarkably affecting uptake length in both stream environments (Figure 2).

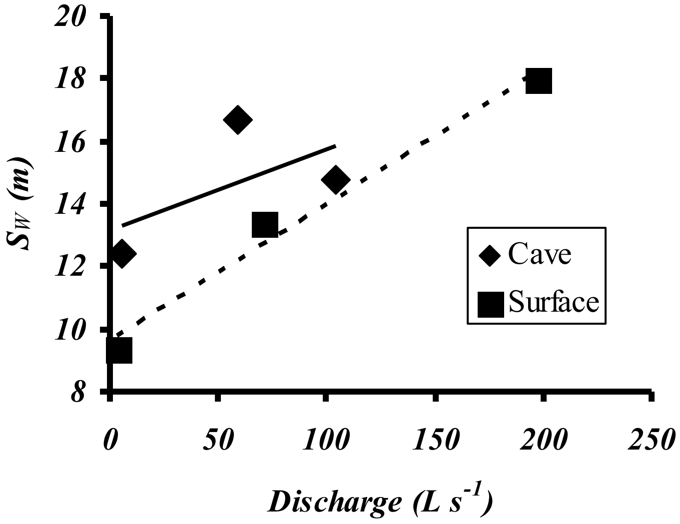

Figure 2. Uptake length as a function of discharge in both stream environments

Since S_W is drastically affected by discharge, V_f normalizes S_W and is a better comparison between systems (Davis and Minshall, 1999). Uptake velocities calculated here suggest the Cascade Stream has a higher demand for N rather than the surface systems which was not expected. Instead we expected to see lower uptake velocities reflecting the lower demand for N thought to be the case in cave stream systems.

The relationship between V_f and the mass of N added to the system reflected expectations with the exception of the last experiment. As N concentrations are elevated in streams, V_f is expected to decrease according to a logarithmic function (Covino *et al.*, 2010). When V_f calculated in both streams during the 26-March 2011 experiment was omitted, this relationship was indeed seen (Figure 3).

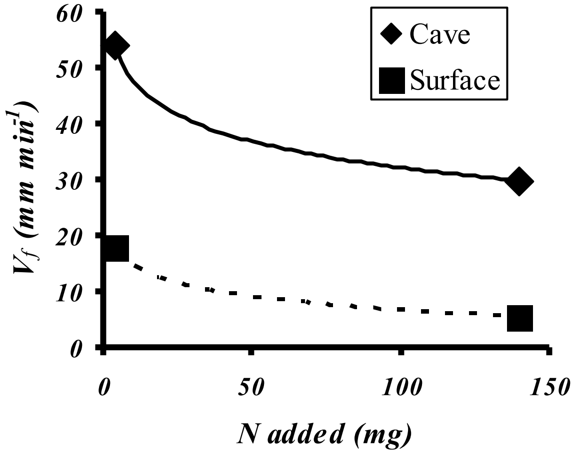

Figure 3. Uptake length as a function of the mass of N added to the system.

We do note that the relationship expressed in this figure is weak and that more experiments would be necessary to confirm such a relationship. Never the less, we did see this correlation in metrics calculated for the first two experiments. Areal uptakes calculated for the initial set of experiments did reflect the expected relationship of lower N demand in Cascade Stream relative to the surface streams tested with lower areal uptake values calculated. Again however, the third experiment produced metrics that were contrary to this relationship with a higher areal uptake calculated in the cave stream. The expected relationship between N concentrations and areal uptake (Covino *et al.*, 2010) was seen when U was plotted using a logarithmic scale as a function of mass of N added and a power function was fit to these data points (Figure 4).

Issues were suspected with metrics calculated for all experiments. We believe we were unable to raise N concentrations high enough above ambient to detect clearly changes in N concentrations with the N analysis methods used (i.e., the Hach kit). Even samples that were taken at peak specific conductance values were only slightly elevated in terms of N concentrations which, if accurate, would actually allow for the calculation of uptake metrics at concentrations close to ambient concentrations and therefore reflecting uptake similar to ambient conditions. However no relationship could be drawn to N concentrations and uptake in terms of a gradient in these systems because of the issues realized with our N concentration analysis.

Work done so far in Cascade Stream has produced mixed results. Higher uptake velocity values indicate higher demand for N in the cave system relative to the surface systems tested, however uptake lengths agree with the hypothesis of N being in less demand in the cave. Areal uptakes calculated for the first two experiments agree with this hypothesis as well, with the last pair of areal uptakes indicating a greater demand for N in the cave. When strictly considering uptake velocities, Cascade Stream appears to have a higher demand for N relative to the surface sites tested.

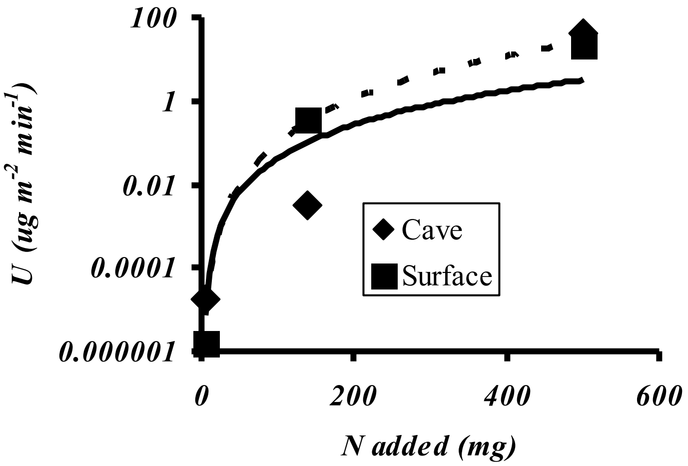

Figure 4. Areal uptake expressed as a function of the mass of N

Future Work

In light of these mixed results, more N slug additions do need to be performed to establish a better general relationship between the two system types. Along with these however, we would also like to perform combined N and C additions in both systems, which would either confirm or disprove the excepted notion that caves are generally C-limited. With the addition of C as well as N, we would expect to see decreased uptake lengths coupled with increased uptake velocities and areal uptake for N, indicating the system would then be in demand for N with C demands satisfied. With more experimentation performed in these systems we could also develop a "calibration curve" with respect to uptake as a function of concentrations.

We also would like to quantify the relative fraction of uptake due to biota relative to abiotic uptake. This can be accomplished with newly developed methods involving these types of slug additions and experimental field methods (see Covino *et al.*, 2010). We would expect to see much less biotic uptake in Cascade Stream relative to surface streams because there is simply less biomass found in cave systems although we have no estimates for microbes. We also wish to perform these same experiments with P to see if the same general patterns are seen and because, to our knowledge, there has never been any spiraling experiments in cave streams with P.

We are also considering experiments at additional sites, both cave and surface. This is because Cascade Stream courses above ground before travelling into Cascade Cave, and therefore may in fact receive enough C allochthonously for the system not to be C limited. This is the opposite case with Cave Run, where water does not travel along the surface first and therefore no (?) C inputs from the surface make it into these inputs. So in fact, with respect to C, these systems we are comparing may be limited inversely (i.e., the surface systems may be N-limited and the cave system may be C-limited).

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We wish to thank Horton H. Hobbs III and William A. Stitzel for guiding us through Cascade Cave as well as suggestions for experimental sites. We also wish to thank Kevin S. Simon, Timothy P. Covino, John B. Ritter, and Damon T. Ely for methodological suggestions. Thanks also to Richard York for chemicals used in this experiment as well as suggestions regarding chemistry. We also wish to thank the Wittenberg University Speleological Society for transportation funds and the use of equipment. This research was supported by a Wittenberg University Student Development Board Spring Project Grant, # SDB-S-19-11.

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TO THE UNKNOWN

Through passages small and crawlways tight,
we've journeyed forth bringing with us light.
Through the depths unknown we've traveled down,
descending further and further beneath the ground.

Through passages dark and unexplored,
we sought the secrets hidden behind closed doors.

Through the winding corridors following winding lives,
we've gone through spaces of endless time;
where the darkness reigns over all that is there,
and only the water can accept its dare.

It drips, it falls, it changes to stone,
creating mysterious new realms in the vast unknown.

Through the waters dark and strange to eyes,
we've waded and swam, so as not to be denied
the thrill of going where no one's ever been,
and seeing things that have never been know to men.

Dale Pate
October 22, 1971
Southwest Texas Student
Grotto Newsletter
'71 - '72

The Mexican Free-tailed Bat

Kyler W. Cowgill (2010 Cave Ecology Class)

Abstract

The Mexican free-tailed bat (*Tadarida brasiliensis mexicana*) is found in parts of North America, Central America, and South America. Its range in the United States is predominantly the southwestern part of the country. Each summer large numbers of Mexican free-tails migrate to the region, and particularly central Texas, to give birth to their young. The bats form maternity colonies that can number in the millions. These large aggregations of bats consume many insects each night when they leave their cave to feed. Mexican free-tails perform a service to people while they are feeding because many of the insects they eat could be agricultural pests.

The Mexican free-tailed bat is dark brown to grey in color with wrinkled lips and a tail that protrudes freely behind it. Mexican free-tails exist in Mexico, Central America, western South America, and the southwestern United States. A large number of these bats migrate each summer to the southwestern United States to form maternity colonies and give birth to their young. These maternity colonies can have millions of individuals present, and the population nearly doubles when the females give birth. While in the United States, Mexican free-tails consume large amounts of insects. The Mexican free-tails exhibit a daily cylce of emergence from and return to their roost. The bats emerge each night around sunset and return around dawn after feeding. The Mexican free-tailed bat is a vital resource to humans because they consume a large amount of agricultural pests (Tuttle 1994, Anonymous 2010).

The largest populations of Mexican free-tailed bats in the United States are found in central Texas. Over 100 million bats migrate in groups to this region every summer to give birth to their young. The Mexican free-tails form maternity colonies that can number in the millions. These bats mate just before they begin their journey north. The colonies of expecting females are formed most often in limestone caves, but can also be found in abandoned mines, under bridges, or in empty buildings (Tuttle 1994, Anonymous 2010).

Each female typically gives birth to just one young. The period of time between the first and third weeks of June is the peak time for females to give birth. During this time pups are in large aggregations that typically have densities of around 4,000 pups per square meter of roost surface. Each mother nurses her own pup multiple times per day. However, finding her own pup can be a difficult task for a female Mexican free-tail when so many pups are packed into a single square meter. Mothers roost apart from their pups as well, adding to the difficulty. In order to locate their pups, the bats use a combination of vocal cues, contact, and memory of where in the cave their pup is located. The memory of where their pup was last located allows mothers to narrow their search. Mexican free-tailed bats reach adult mass and learn to fly after four to five weeks. Learning to fly is a dangerous time for all of the pups. Collisions that break wings are deadly. Also, a collision that sends a bat to the cave floor means that it will be rapidly consumed by the insects that colonize the floor of the cave (McCracken 1993, Tuttle 1994, Altringham and Fenton 2003).

A colony of Mexican free-tailed bats emerges from their cave each night to feed. The emergence of some colonies can take hours. A stream of bats can stretch from the cave entrance to the horizon. The feeding area for Mexican free-tails could be up to 50 kilometers from their roost. Also, these bats have been recorded at altitudes over 3,000 meters, which is higher than any other bat flies. One possible reason that Mexican free-tails travel far from their roost could be to escape competition from other bats in their roost. The diet of Mexican free-tails consists almost exclusively of flying insects which are located by using echolocation. The bats in central Texas consume around 909,090.9 kilograms (1,000 tons) of insects each night. This is a huge benefit to farmers, and all people, because many of the insects eaten by Mexican free-tails are agricultural pests. By consuming agricultural pests, the bats protect crops from becoming damaged. This allows the crops to be harvested and eaten by people. When returning to the cave, Mexican free-tails drop very rapidly from great heights. Some bats have been observed to drop from 3,000 meters (Tuttle 1994, Richardson 2002, Altringham and Fenton 2003, Anonymous 2010).

Variation in patterns of evening emergence and dawn return have been observed in maternity colonies of Mexican free-tails. As the summer season progresses, the bats begin to emerge earlier and return later in relation to sunset and sunrise. The bats need to leave earlier than the sunset and return later than dawn in the late summer in order to feed for as long as they need to feed. Mexican free-tails also adjust the timing of their emergence and return patterns to reflect changes in the environment. For example, during a drought Mexican free-tails emerge earlier and return later in order to feed enough because there is a decrease in the number of insects available to eat. During the summer, a high proportion of reproductive females emerge earlier and return later due to the need for reproductive females to consume more insects. The opposite pattern is observed for non-reproductive females, who emerge later and return earlier than their counterparts (Lee and McCracken 2001).

An example of a Mexican free-tailed bat maternity colony is found in Carlsbad Caverns. A colony of Mexican free-tails spends the summer in Carlsbad Caverns, New Mexico and disperse nightly in every direction. While the bats are feeding and foraging, they encounter many habitats that differ in quality and quantity of food. The maternity colony from Carlsbad Caverns consumes a wide variety of insects, which is influenced by spatial and temporal distribution of prey, time of emergence, weather conditions, and the amount of moonlight available. It is thought that the bats from Carlsbad Caverns, and all Mexican free-tails, are opportunistic feeders. They do not necessarily search for one type of prey, but will consume any insect that happens to cross their path. It is thought that many insects eaten by the bats from Carlsbad Caverns are agricultural pests. Therefore, people benefit from the nightly feeding of Mexican free-tails (McWilliams 2005).

A decline in the numbers of Mexican free-tails has been observed. This decline is partly attributed to pesticides used on farms over which the bats feed. The pesticides become present in the prey of Mexican free-tails. This presents an ironic situation. The farmers are harming the bats because they are attempting to perform a service that Mexican free-tails provide. Some areas have seen a major decline in the number of Mexican free-tailed bats. One of these areas is Eagle Creek Cave in Arizona. The estimated population of Mexican free-tails in this cave in the summer of 1963 was 25 million. Six years later the estimated population was 30,000 (Entwistle and Racey 2003).

The Mexican free-tailed bat begins its southward migration in October. The exact timing of departure depends on weather conditions and coincides strongly with the first strong cold front. The mothers and newborns leave their maternity colonies to return to their winter habitat. The Mexican free-tailed bat is a valuable resource to the United States during its summer residence. The bat protects crops from destruction at the hands of pests, leaving more food available for humans to eat. The Mexican free-tailed bat should be appreciated for the ecological service that it provides (Tuttle 1994).

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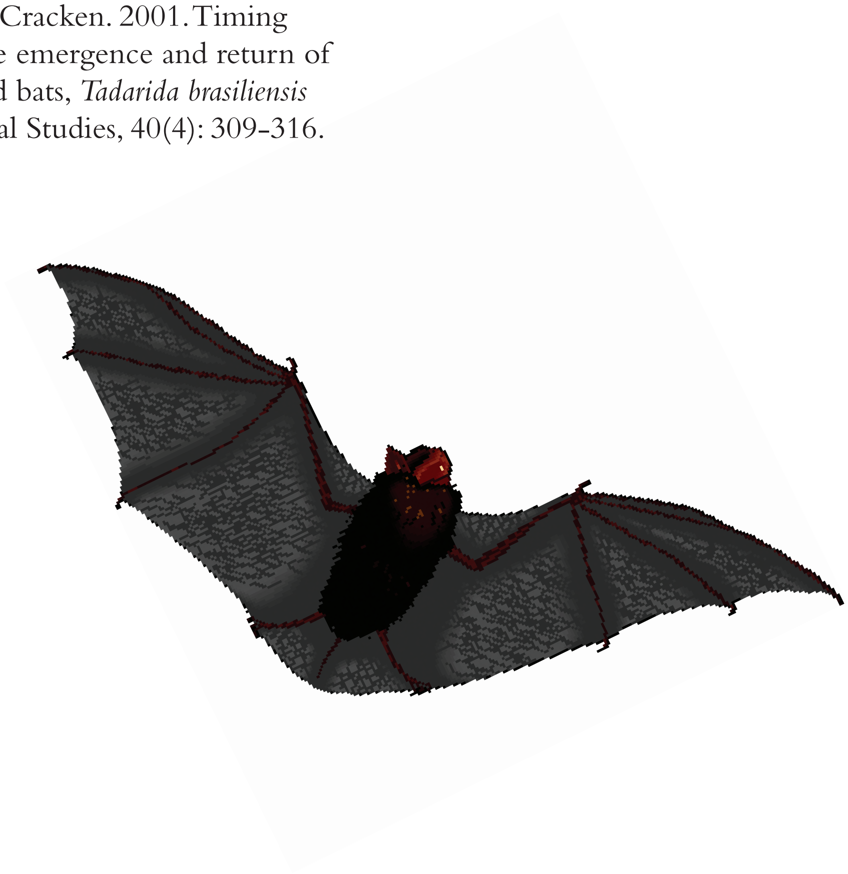


Description of four small caves in Highland County, Ohio

Kristen M. Shearer (WUSS #0579, NSS $62890 RE)

After being contacted by Mr. Richard Black concerning a cave on some land that he owned, nine WUSSes converged on a gravel road in Highland County, Ohio on 20 March 2011. The purpose of the trip was to survey the cave as well as to look for additional karst features. Black Cave was named by and for Mr. Richard Black and the entrance is located near the formerly commercial Seven Caves in a wooded area, just uphill from a small stream.

The entrance (Figure 1) is situated at the base of a dolomite cliff and is 3.17m wide and 1.44m tall. Upon entering, the passage (Figure 2) led east for 2.58m and we encountered a floor-to-ceiling brick wall covering the left half of the passage. Immediately past the wall, the soil floor was covered in a black tarp underneath leaf litter. Along the right side floor of the approximately 1.5m wide tunnel were old brick shelves (Figure 3), which Mr. Black told us were used by his grandfather for storage. After passing a brief constriction (Figure 4) (0.85m wide and 0.97m tall) that sloped slightly upward, we entered a room tall enough for us to stand up. The room has a soil floor, like the rest of the cave, and was home to biota including an Eastern Phoebe (nest), a terrestrial isopod, a large orange and a small whitish millipede, a tiny fly, a small grey spider (located near an egg sack, probably immature), several male *Meta ovalis* (Figure 5), many crickets (*Ceuthophilus* sp.) and harvestmen (*Leiobunum* sp.), the moth (*Scoliopteryx libatrix*), and a centipede. In this area we began to see flowstone along the back walls and small features on the ceiling (Figure 6). There was silver graffiti spray-painted on the walls and additional black plastic tarp on the floor, as well as scat and fungi. In the back (southeast) of the room, the passage constricted to 1.49m wide and 1.42m tall, decreasing to 0.89m wide and 1.45m tall within 1.5m distance. This area became damper, dominated by flowstone on the walls and ceiling that narrowed the passage non-uniformly. This continued for another 1.61m, then the floor sloped sharply upward at 42°as it became covered in flowstone. A very narrow twisty 2m later, a much smaller room, Standing Room Only, is reached. In this room, barely wide enough to turn around (Figure 7), the walls were covered by layers of thick flowstone although the floor was still compacted dirt. Remains of small nuts were lying on a ledge, indicative of activity by a rodent. The ceiling was 2.95 meters high, and about half a meter from the ceiling was a neck-like constriction about a meter in diameter which opened up again into a small dome (Figure 8). The center of the ceiling of this dome was covered with small round hollow features, in which the bottom third of the spheres were broken off to expose the interior. Along a short section of the right (southwest) wall, a shelf approximately 1.3m from the floor was cut back into the rock, also extensively covered in flowstone. At the eastern end of the room was a small rectangular opening, 0.19m wide and 0.56m tall. This tunnel continued for a visible meter then turned sharply east, but the passage was too narrow to see beyond. In total, accessible length was 17.8m.

The other caves on the property were along the same ridgeline, moving parallel to the road. We could only search the ridge for a short distance, however, because the property ended and the next was clearly marked that the owners wanted nothing to do with trespassers. In all, we found four additional caves worthy of recording. The second cave, Black's Overhang (Figure 9), opened low to the ground. The entrance was 0.63m tall and 6.39m wide. We able to take one additional measurement: the cave was 7.81m deep. The cave was very odiferous and the flower, Hepatica, was present.

Coon Scat Cave (Figure 10) contained, as its name implies, droppings. Some oligochaetes were present.

Solution Pocket (Figure 11) was at ground level and the entrance was 0.62m tall and 5.71m wide. The cave was rather short (3.82m deep) and hooked to the left.

The entrance to Walking Fern Cave (Figure 12) was several meters up the dolomite rock face. The opening was 0.66m tall and 1.32m wide. The cave itself was 3.58m deep, with a compass reading of 150° and an incline of 0°.

Acknowledgments

Many thanks go to Mr. Richard Black for allowing our team access to survey the caves, and for his interest in the project. Thanks also to all survey team members, including Kristen Baughman, Travis Croxall, Mike Goltzene, Erin Hazelton, Sam Heaston, Horton Hobbs, Chad Rigsby, Kristen Shearer, and Bill Stitzel.

Figure 1. Entrance of Black Cave. (photo by Horton Hobbs III)

Figure 2. Just past the entrance to Black Cave. The individual furthest back is seated past the constriction in the room. (photo by Horton Hobbs III)

Figure 3. Looking out the entrance of Black Cave. Seated is Mr. Black, property owner. (photo by Horton Hobbs III)

Figure 4. Erin Hazelton surveys the room in Black Cave, seated in front of the constriction. (photo by Horton Hobbs III)

Figure 5. Meta ovalis, spider, found within Black Cave. (photo by Horton Hobbs III)

Figure 6. Features on the ceiling of the room in Black Cave. (photo by Horton Hobbs III)

Figure 7. Floor of Standing Room Only, with foot for scale. (photo by Kristen Shearer)

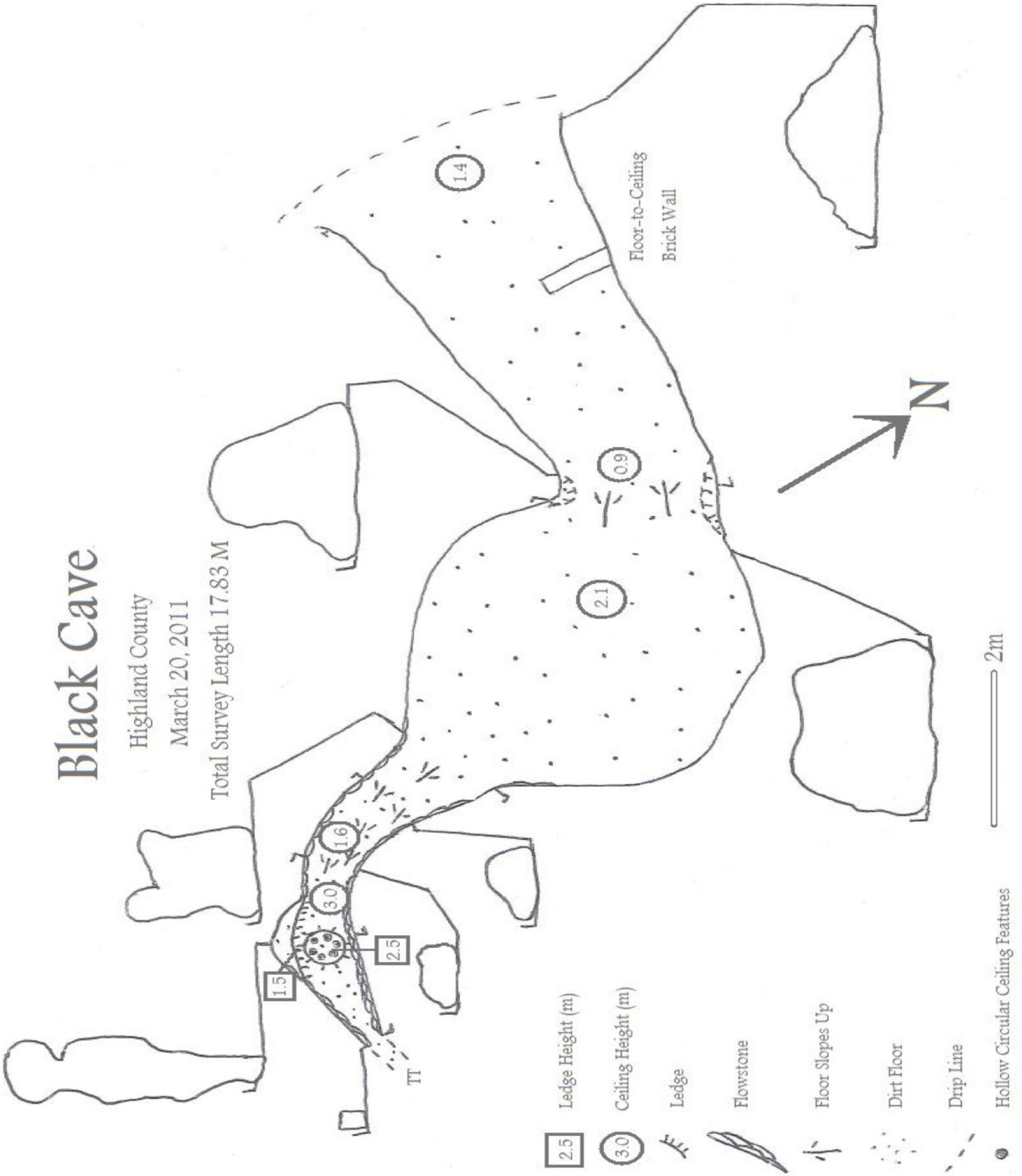
Figure 8. Ceiling of Standing Room Only. Note the flowstone shelves and the small spherical features on the ceiling. (photo by Kristen Shearer)

Figure 9. Entrance to Black's Overhang.
(photo by Horton Hobbs III)

Figure 10. Entrance to Coon Scat Cave.
(photo by Horton Hobbs III)

Figure 11. Entrance to Solution Pocket. (photo by Kristen Shearer)

Figure 12. Entrance to Walking Fern Cave. (photo by Horton Hobbs III)


Black Cave
Highland County
March 20, 2011
Total Survey Length 17.83 M
1.4
Floor-to-Ceiling
Brick Wall
0.9
2.1
N
2m
1.6
3.0
2.5
1.5
TT
2.5 Ledge Height (m)
3.0 Ceiling Height (m)
Ledge
Flowstone
Floor Slopes Up
Dirt Floor
Drip Line
Hollow Circular Ceiling Features

Gothic Arches in the Sand, with a Preliminary Bibliography of Rock House, Hocking County, Ohio

Horton H. Hobbs III (WUSS #0001, NSS #12386 HM, CM, SC, FE)
Kevin M. Kissell (WUSS #0530, NSS # 54578 RE)

A loud "two point four" was spoken, repeated, and recorded in a field notebook over the din of tourists as several clusters of students worked to gather survey data for Rock House, an impressive "cave" developed in the Black Hand sandstone. As part of a field trip to study the caves and rock shelters of Ohio, 23 students from Wittenberg University's Cave Ecology class divided into two groups and traveled on separate days (24, 25 September 2011) to Hocking Hills State Park in southwestern Hocking County, Ohio. On both days, students broke into crews of 2-4 individuals and were assigned the task of using tapes, lasers, compasses, and clinometers in order to survey the cave physically and biologically. Learning and applying survey techniques and looking for small animals is not an easy task under ideal conditions. Here, in the semi-darkness of this geological feature and contending with large numbers of visitors, this job was particularly difficult. In spite of these obstacles, the students tackled the assignment and during the two days provided sufficient data and sketches concerning dimension, slope, passage orientation, and observations of organisms. These resulted in the map drafted by one of us (KMK) as well as a list of organisms and their occurrences and habitats noted within Rock House.

Description of "Hocking Hills"

The Hocking Hills area of southeastern Ohio is strikingly different from the much flatter plains of the western part of the state. It is characterized by rugged regional relief of approximately 90 – 120m (300-400 feet) along the western border of the Appalachian Plateau (Carman 1946). To set the stage for why this is the case, the geological history of parts of Ohio is summarized briefly.

During the Paleozoic Era (relevant to Ohio, around 500-250 million years ago) sediments accumulated typically as flat layers (strata) beneath the shallow seas that covered Ohio. As time progressed, these sediments were compressed and gave rise to sedimentary rocks (sandstones, conglomerates, and some shale) during the late Paleozoic (350-250mya). Few of those layers remained horizontal since some portions of the earth's crust either rose or sank, resulting in arches or basins. Around 450 million years ago (late Ordovician Period) rock strata in what is today southeastern Ohio began to sink, forming the western edge of the Appalachian Basin. As the Appalachian Mountains to the east subsequently began to uplift, eroded sediments from the mountains' western edge accumulated in the Appalachian Basin thus depositing more, younger materials over the underlying older rock strata. Those strata to the west of the Hocking area that did not sink make up what is known as the Cincinnati Arch. This north-south trending broad feature resembles an anticline and is the major structural characteristic of the state, with rocks dipping west into the Illinois Basin and east into the Appalachian Basin and descending on either side at about 7.5m/km (40 feet/mile) (Hansen 1975, Camp 2006). Relatively old rocks (Ordovician and Silurian) are exposed along its crest and younger ones along its western and eastern flanks (Figure 1).

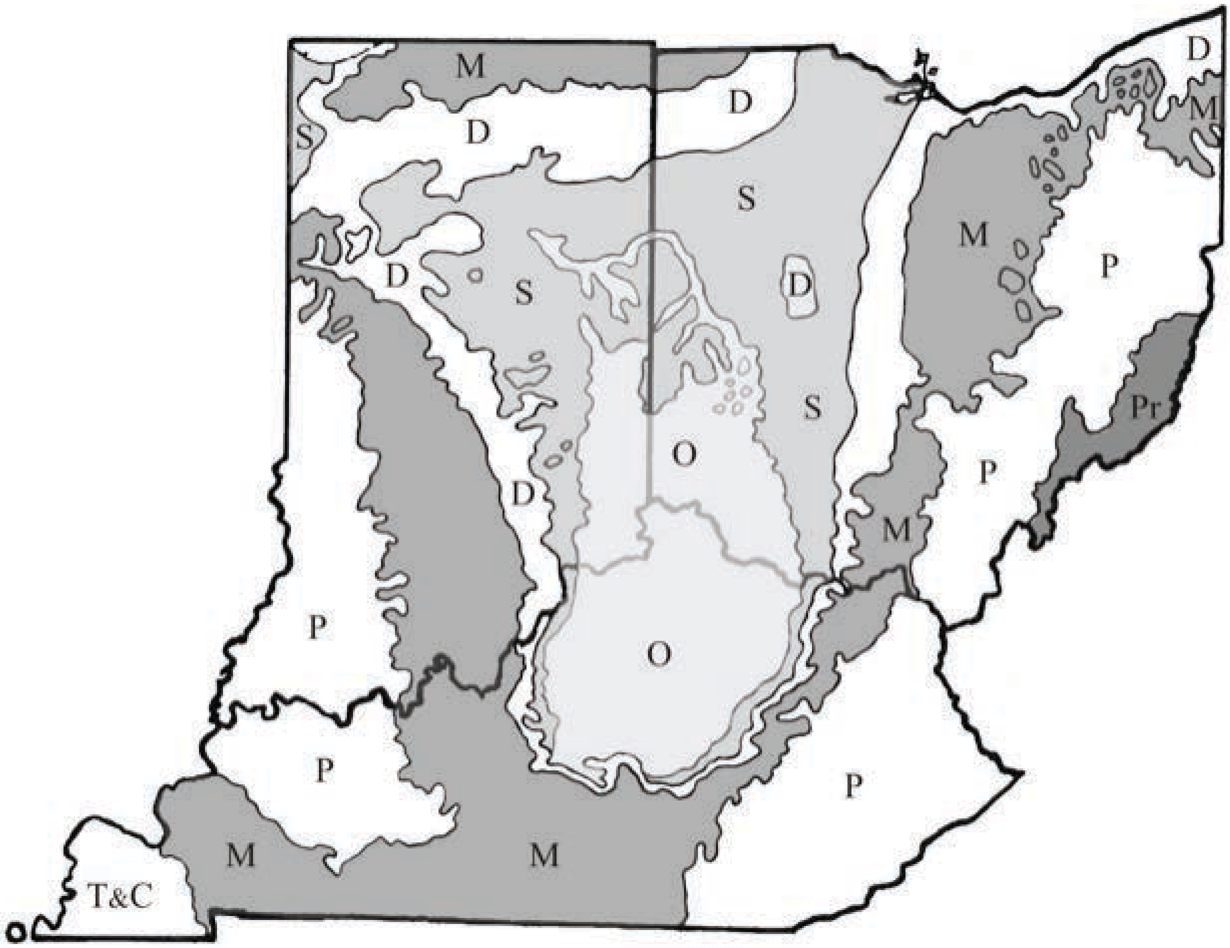


Figure 1. Generalized geologic map of Indiana, Kentucky, and Ohio showing the Cincinnati Arch and successively younger rocks appearing at the surface in relation to the Ordovician high at the political juncture of the three states; O = Ordovician and Cincinnati Arch, S = Silurian, D = Devonian, M = Mississippian, P = Pennsylvanian, Pr = Permian, C = Cretaceous, T = Tertiary (after Hobbs & Hazelton, 2011).

The rocks currently exposed at the surface in the Hocking Hills area were deposited during the Pennsylvanian and Mississippian periods, approximately 325 and 345 million years ago, respectively. Streams arising primarily to the southeast carried sediments into the shallow sea covering the area and formed a series of deltas, the main one represented by the Black Hand Sandstone which is characterized primarily by crossbedding and pebble lenses.

As long ago as 318mya, the North American and Eurasian plates collided, resulting in the formation of the supercontinent Pangaea and folding and faulting on the eastern margin of North America thrust up the Appalachian Mountains. Southeastern Ohio was still part of the slowly sinking Appalachian Basin that persisted as a sediment trap. Overall, these sediments that were eroding off the western flanks of the Appalachians continued to accumulate in the Basin, forming additional layers of sandstone and shale as well as clay, coal, and limestone. Today, the hilltops of the region are capped by these younger, Pennsylvanian-age rocks.

Much of the geologic history of the area for the remainder of the Paleozoic and most of the Cenozoic eras is obscure. Certainly weathering as well as deposition of eroded sediments and erosion of previously deposited rocks ensued with much dissection of the region occurring during the late

Pliocene and early Pleistocene epochs (5.3-1.8 and 1.8-0.01mya, respectively). Also, during the late Pleistocene Epoch continental glaciers advanced into Ohio. Although the ice sheet progressed as close as 1.8km (6 miles), it played no direct, active role in sculpturing the scenic features of Hocking Hills State Park. However melt waters from the ice eroded the bedrock, resulting in the deeply carved gorges of the region. The erosional effect of streams, gravity, ground water, and the varying resistances of different layers within primarily the Black Hand Sandstone to weathering are responsible for the unique and spectacularly rugged geological features of Hocking Hills (Hansen 1975) (Figure 2).

The Black Hand Sandstone is particularly resistant to erosion due primarily to its firm cementation by iron oxide. The degree to which sand particles are cemented together is variable, resulting in differential resistance to weathering. Based upon these factors, the Black Hand Sandstone is typically divided into three zones. The lowermost zone is massive (about 30m thick), firmly cemented, coarse grained, and is thus very resistant to weathering (e.g., Lower Falls at Old Man's Cave). The middle zone of the Black Hand Sandstone is crossbedded, about 12m (40 feet) thick, weakly cemented, and thus less resistant to erosion. Numerous recesses and reentrants have developed in this unit (e.g., Ash Cave, Old Man's Cave, Rock Bridge, and Rock House). The uppermost zone of the Black Hand Sandstone, like the lowermost, is massive (up to 12m thick), firmly cemented, coarse grained, and is thus very resistant to erosion. This zone forms the rims of the gorges and roofs of numerous rock shelters (e.g., Ash Cave – Figure 3, Rock House – see below). Additionally, where streams flow over the uppermost zone, waterfalls occur (e.g., Ash Cave – Figure 3, Cedar Falls, Upper Falls of Old Man's Cave).

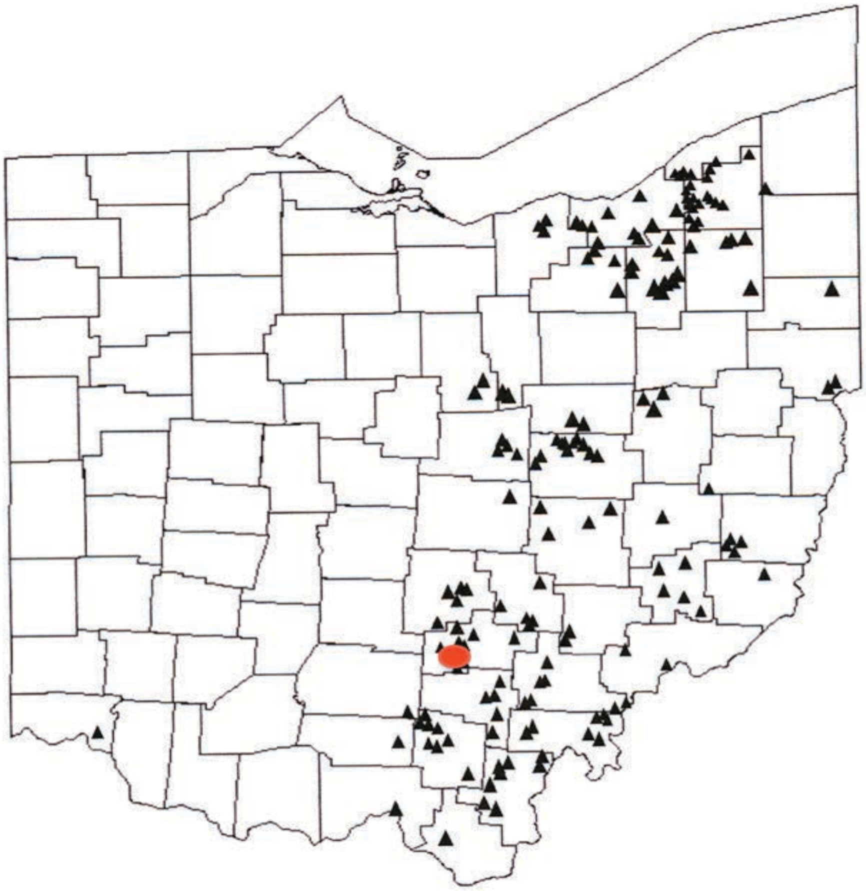


Figure 2. Map of Ohio showing the eastern cave region and locations of known entrances of caves, shelters, and rock houses. A single filled triangle may represent more than one entrance; red dot denotes location of Hocking Hills State Park in Hocking County.

Figure 3. Ash Cave (photo courtesy of Bill Stitzel)

For a more detailed account of the stratigraphy and/or geological history of the area, the reader is referred to Stout 1944, Ver Steeg 1947, Hall 1971, Hansen 1975, Luther 1989, and Camp 2006.

Rock House

Discussed briefly above are the three zones of the Black Hand Sandstone, each playing some role in the development of the scenic features of the Hocking Hills area. A second attribute that plays an integral role in the formation of unusual features in the Hocking Hills is the system of joints (fractures) that are developed within the Black Hand Sandstone. These joints are nearly vertical and two major intersecting, generally north-south and east-west trending joint systems are prominent in the region. These fractures have had no significant horizontal or vertical movement associated with them and provide access for water to move through the rock. In so doing, the joint may be enlarged due to the dissolution of sand-binding cement and/or as a result of expansion from freezing. The fractures are paths of least resistance and thus water, and certainly streams, follow the joint patterns. In addition to differential weathering of various strata, all the features of the area display joint-controlled weathering and erosion and this is particularly well demonstrated at Rock House.

Rock House is certainly a unique feature in Ohio. It is developed in a mass of Black Hand Sandstone approximately 35m in height and that juts out (NNW) some 30m from a cliff and forms the head of a small tributary valley to Laurel Run (Figure 4). It and The Keyhole (Highland County) are classified as caves but also are the only two natural tunnels (defined "…as a natural arch whose width is equal to or greater than three times its span" - Snyder 2009:43) in the state. Although there are difficulties with defining natural arches, Horowitz (1993) proposed an appropriately inclusive one that Snyder (2009) and others have adopted. He states, "A natural arch or related type of natural opening in a rock exposure with a hole completely through it, created by the natural removal of some of the rock to leave an intact rock frame around the hole." Of interest, this definition would be appropriate for any cave having two or more entrances regardless of the distances between them. Snyder (2009:191) also acknowledges that Rock House is the largest natural arch in the state.

Rock House is a classic example of the impact that erosion and differential weathering can have along joints in the Black Hand Sandstone. Several maps have been drafted previously, all of which are adapted from the original by Carman (1946) – see Hansen 1975, Snyder 2009 - and none are particularly rich in detail. They show the location and orientation of the joints along which the passages are developed. The main passage is oriented along a major (master) joint and extends for some 72m (230 feet) in a SW-NE orientation, is open at both ends, and is generally 6-9m (20-30ft) wide and 6-11m (20-36ft) high (Figure 5). The western-most opening is by far the largest with a width of 8m (24ft) and a height of 26m (83ft). This is the only opening whose floor reaches into the very bottom of the valley whereas the rest of the openings are situated along the cliff line some 16m (51ft) above the valley floor.

Figure 4. View looking ESE at the Black Hand Sandstone cliff on the north side of the face of Rock House. The dark area in the upper right is the most westerly and largest opening developed along the master joint. (photo by Horton Hobbs III)

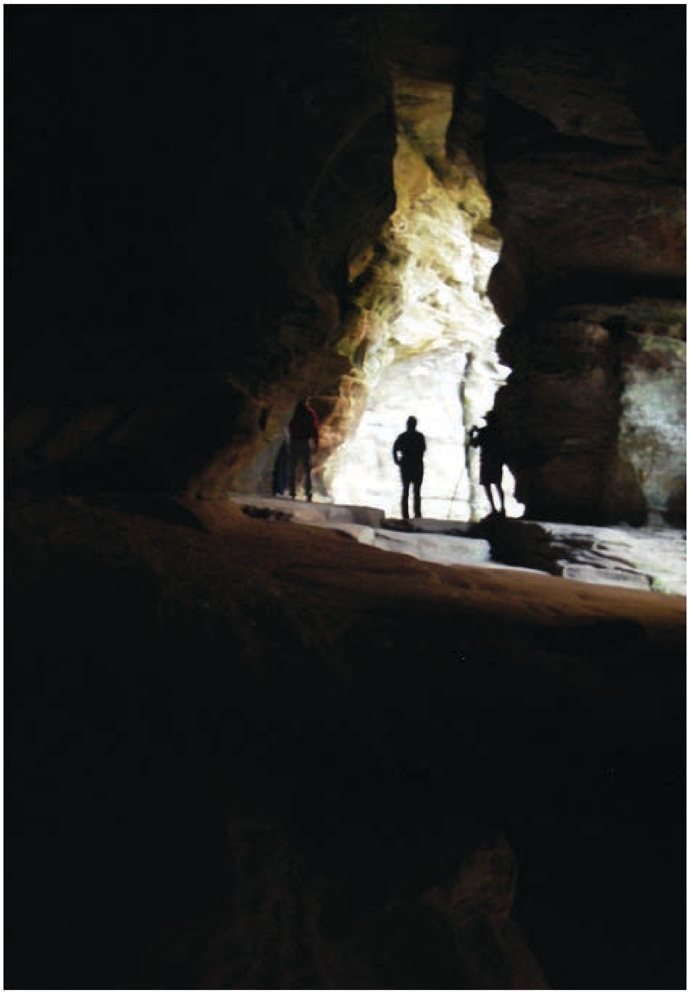


Figure 5. View looking NW at the main passage that is developed along a master joint. (photo by Horton Hobbs III)

Five "Gothic arches" (windows) open onto the cliff face from the main corridor and are developed along a second set of fractures that are oriented generally in a NW-SE direction, are unequally spaced, and run perpendicular to the major joint. Each of these windows is an enlarged fracture and differs in size and shape from the others (Figures 6 and 7).

A Gothic arch is a sharp-pointed, vaulted pergola that is formed of two arc segments and the lower part of the arch is parallel sided and extends up to the level of the arc segments (see Figure 8). At Rock House these portals between blocks of sandstone (supports for the cave) serve as windows and one or more function as informal entrances. The joints on which are developed the Gothic arches extend across the main passage to the opposite (south) wall and three of these fractures serve as "guides" for their erosive expansion by ground water into small side passages (see map and Figures 9 and 10). Entry to each of these is nearly 2m above the level of the floor of the main passage and the middle alcove is the largest, extending southerly for 5m (16ft) with a maximum passage height of 1.5m (5ft).

Figure 6. View looking north through one of the five Gothic windows. (photo by Horton Hobbs III)

Figure 7. View facing west showing Cave Ecology students surveying the major passage that terminates in the large opening in the distance as well as other Gothic windows developed on cross-joints along the northern wall of Rock House (photo courtesy of Bill Stitzel).

Figure 8. The Bayley Alumni House on the campus of Wittenberg University with Gothic arches supporting a porch. (photo by Horton Hobbs III)

Figure 9. Cave Ecology students in one of the intersecting side passages.(photo by Horton Hobbs III)

Figure 10. Cave Ecology students in the eastern-most side passage looking for biota (photo by Horton Hobbs III)

The entire cave is very dry with little hydrologic activity. During the two days of survey, a few trivial puddles and a very small trickle were noted. The floor of the main passage, as well as that of the alcoves, consists of heavily compacted, fine-grained sediment that is no doubt a result of the substantial and continual visitation by tourists to the Hocking Hills area. The walls of the cave are littered with graffiti, both the carved (mostly 1800's vintage) and the more modern, painted variety.

Fauna of Rock House

The fauna inhabiting Rock House (Table 1) is not represented by any obligate, troglobiotic or stygobiotic organisms. In spite of the lack of these highly specialized animals, Rock House supports a relatively complex community consisting of gastropods (slug), arachnids (daddy long-legs, spiders), insects (crickets, neuropteran, fly, beetle), amphibians (salamanders), a bird, and mammal (see also Haub 1942, Seibert and Brandon 1960, Hubbs and Norton 1978, Hobbs and Flynn 1981, Hobbs and Hazelton 2011). All but salamanders and a slug were not found on the floor of the main cave or the side passages. In fact, most species were observed only in the side passages and on the walls near the ceiling or actually on the ceiling where light levels were lowest and where the temperature and humidity were least variable. The pigeon population was small with only six individuals observed and they were limited to the highest portions of the main cave.

Table 1. List of fauna observed in Rock House.

Phylum	**Class**	**Order**	**Species**
Mollusca	Gastropoda	Pulmonata	"Slug"
Arthropoda	Arachnida	Opiliones	*Leiobunum bicolor* (Wood)
Arthropoda	Arachnida	Araneae	*Achaearanea* sp.
Arthropoda	Arachnida	Araneae	*Dolomedes* sp.
Arthropoda	Arachnida	Araneae	*Meta ovalis* (Gertsch)
Arthropoda	Insecta	Orthoptera	*Ceuthophilus* sp.
Arthropoda	Insecta	Orthoptera	*Euhadenoecus puteanus* (Scudder)
Arthropoda	Insecta	Neuroptera	*Myrmeleon immaculatus* De Geer
Arthropoda	Insecta	Coleoptera	"Weevil"
Arthropoda	Insecta	Diptera	*Tipula* sp.
Chordata	Amphibia	Caudata	*Eurycea bislineata ravicola* Seibert & Brandon
Chordata	Amphibia	Caudata	*Eurycea longicauda* (Green)
Chordata	Amphibia	Caudata	*Plethodon glutinosus* (Green)
Chordata	Aves	Columbiformes	*Columba livia* Gmelin
Chordata	Mammalia	Rodentia	*Peromyscus* sp.

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Matt Culley getting some sketching pointers from Kevin Kissell during the survey of Rock House. (photos by Horton Hobbs III)

Necrology

Richard C. "Caveman" Bell

November 5, 1928 – March 29, 2011

A very good friend of WUSS passed away on 29 March 2011. Dick Bell and his wife, Denise, owned and operated Seneca Caverns in Seneca County, Ohio and over the years were incredibly helpful to WUSS in allowing entry to their show cave as well as showing off the karst features in Seneca County and environs.

Dick was a founding member and Past President of the National Caves Association, served in the Army Air Corps during World War II, was member of the Sandusky Sailing Club, a board member of the American Cave and Conservation Association, and had been knighted in Edinburgh, Scotland for his genealogy work.

Although Seneca Caverns was discovered in 1872, it was not until 1933 that Dick's father, Don Bell, purchased, developed, and opened the cave to the public. As a boy Dick was a tour guide and was inspired to become a geological engineer. He purchased the cave from his dad in 1964.

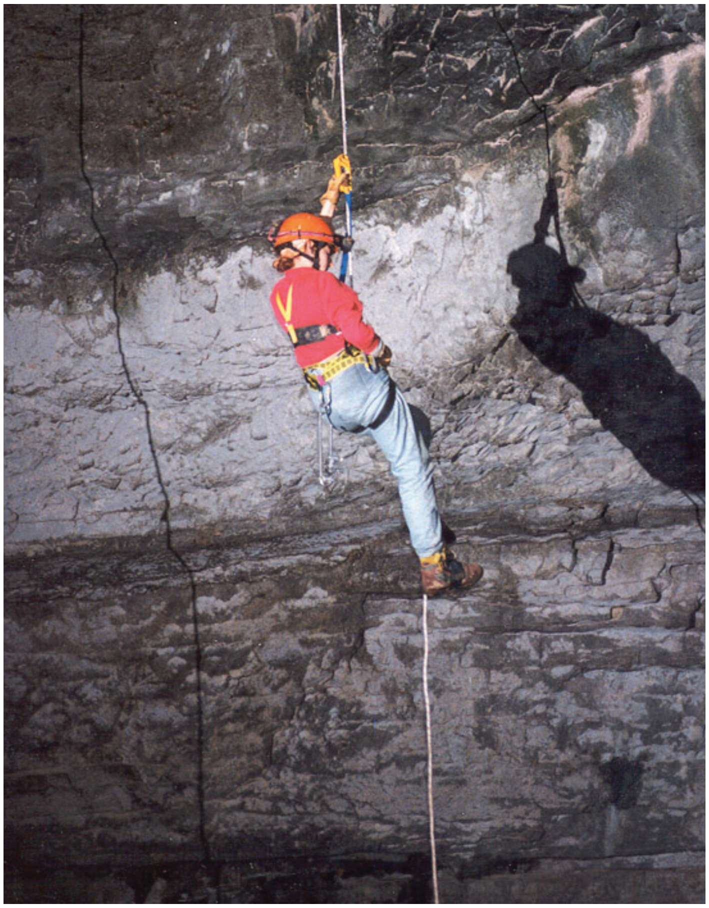
One particularly interesting and informative day of discussion and field excursion was spent with Dick on 12 August 1986. Two former students, Naomi Mitchell (now Bentivoglio – WUSS #116) and Todd Zimmerman, were helping me sample caves for biota as well as survey some of them. Dick accompanied us, showing numerous sinkholes and ultimately a small, unnamed cave. With the aid of his nephew, Dale Wing, we surveyed the cave and named it Bell Cave in honor of Dick [*Pholeos* 7(1):5-13].

If you are ever in the vicinity of Bellevue, stop by Seneca Caverns and introduce yourself to Denise. She would certainly appreciate it and I know that Dick would too!!

Denise and Dick Bell

Dick Bell

MISCELLANEOUS



Balcony Pit, Jackson Co., AL. (photo by Horton Hobbs III)

Skocjan caves, Slovenia. (photo by Horton Hobbs III)

Inclination, Cascade Cave, Carter Co., KY. (photo by Horton Hobbs III)

Setting bolts, Sinks of the Run Cave, Greenbrier Co., WV. (photo by Horton Hobbs III)

Clinometer short shot, Cascade Cave, Carter Co., KY. (photo by Horton Hobbs III)

Natural Tunnel, Carter Co., KY - pic by Travis Holden. (photo by Horton Hobbs III)

Planinska Jama, Slovenia. (photo by Horton Hobbs III)

Clinometer & glowstick. (photo by Horton Hobbs III)

Searching in Rimstone Cave, Carter Co., KY. (photo by Horton

Laurel Creek Cave, Monroe Co., WV. (photo by Horton Hobbs

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Marking isopods, Mayfield's Cave, Monroe Co., IN. (photo by Horton Hobbs III)

Establishing a transect, upper Laurel Cave, Carter Co., KY. (photo by Horton Hobbs III)

Bill & Nikki, Canyon Cave, Carter Co., KY. (photo by Horton Hobbs III)

WUSS patches. (photo by Horton Hobbs III)

INFORMATION FOR CONTRIBUTORS

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   Moore, G.W., and N. Sullivan. 1997. Speleology: Caves and the cave environment. St. Louis, Missouri: Cave Books.

   Chapter:

   Hobbs, H.H. 1992. Caves and springs. *IN*, C.T. Hackney, S.M. Adams, and W.A. Martin (eds.), Biodiversity of Southeastern United States/Aquatic Communities. John Wiley & Sons, pp. 59-131.

8. *Figures and Tables* should be self-explanatory, with captions of tables placed above and those for figures situated beneath. Each table and figure should start on a separate sheet. Headings and format should be consistent. Originals for all figures and tables should be submitted with the manuscript or, if in electronic form, should have a minimum resolution of 300 dpi.

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