PHOLEOS

Journal Of The Wittenberg University Speleological Society

Volume 30 (2) March, 2011

PHOLEOS

VOL. 30 (2)
March 2011

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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: "Happy climber with nourishments"

EDITOR'S NOTE

The cavers of Wittenberg University and their closest friends have worked to put out another issue of *Pholeos*. As the years' new editor I have seen a strong effort put forth by students, professionals, and enthusiasts to make their contribution to the success of WUSS and *Pholeos*. This issue contains its usual articles of well done research to update readers of the new work being done in the Ohio area. An exciting passage that does not make every issue is the comments from a first time caver's experience, which can be enjoyed by the most routine caver to the hesitant beginner. WUSS and its caving community are happy to make this journal available to the readers for another time and send out their thanks. As always feel free to be a part of the team by writing, emailing, or sending in articles; all contributions are welcomed. Enjoy reading *Pholeos* then go have a real caving adventure.

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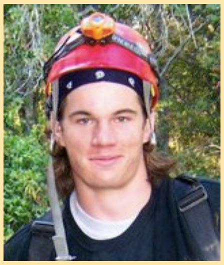

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MESSAGE FROM THE PRESIDENT

Has it really been four years already? It seems like yesterday that I was filling out the forms to go on my first trip to Carter County. My earliest memory in a cave was a messy one; I think I was getting mud out of my ears for a week. My trips may be less frequent now as White Nose Syndrome limits the number of caves and personal commitments get more numerous, but every trip is full of great memories. We've had a busy year with two officers studying abroad in the spring, Samantha Swanton (Fall Vice-President) at Duke Marine Lab, and Kayla Potter (Fall Treasurer) in Japan. Their trips have allowed newcomers to the club to learn how things are run. Kristen Shearer has done a great job as treasurer and Sam Heaston has filled the role of secretary flawlessly. Chad Rigsby and Kristen have been doing lots of trips lately for their research project. They are studying nutrient cycling in cave streams, a very interesting topic we should all know more about in the coming months.

As we prepare for the next year, we look forward to new faces at the meetings. Although caving may be limited, we are thankful to the private owners that still allow us to explore their caves. We recently had the pleasure of surveying a few small private caves near Hilllsboro, OH. Although the caves weren't the largest, they still allowed members to practice using the survey instruments and to get underground. A new relationship with Ohio Caverns has been very rewarding, allowing for several survey trips in the caverns. We hope to continue the vertical work as new members develop an interest in pits and enjoy the clinics in the science center stairwells. I look forward to coming to meetings in the future and to seeing how much the club will have grown! Best of luck to next year's officers!

Travis Croxall, President
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An Examination of Anthropogenic Effects on the Floridan Aquifer and Epigean Karst Features

Katherine Touzinsky
(Cave Ecology)

Introduction

Florida has recently been a hot topic of debate concerning the effects of rapid human expansion on a particular environment. While forests and swamps are immediately tangible to the public because of populations of unique and exciting animals like the Floridian panther and American alligator, what lies hidden underground is of interest to me and of particular relevance to this class. The Floridan Aquifer is one of the largest aquifers in North America and combined with over 19,942 square kilometers of the Suwannee River Basin, it provides the public with access to an immense amount of fresh ground water through a vast network of underground cave systems (Beck, 1998). Associated artesian springs are both fragile and critical in supporting the surrounding ecosystems and habitats for organisms that exist nowhere else in the world. Unfortunately, urban interface and booming development have threatened this precious commodity and many efforts have been undertaken not only to census and document the springs, but to monitor the influences that anthropogenic effects have had on their health and water chemistry. The issue is one that spans many different areas of expertise, and it is the purpose of this investigation to examine the headway that is being made in the areas of geology, biology, and management and summarize the integration of these specialties that will be so critical in resolving the issues.

Methods

Forida Aquifer's Geological History

Florida's geologic history is both complicated and fascinating. According to Lane (1994), ancient rocks indicate that Florida sits on a platform that was once a part of northwest Africa. This platform, as visible in Fig 1, is a result of deposition and erosion due to sea level changes during the Cenozoic Era. These changes were quite drastic and occurred during two phases: the Paleogene and Neogene. During the Paleogene period, carbonate sediments resulting from biological activity were deposited on the ocean floor. These deposits are made of small pieces of ancient biota including foraminiferans, bryozoans, and mollusks. During this time, very little siliclastic material (pieces of quartz sands, clays, and silts) were deposited in the area because the Gulf Trough separated the Florida Platform from the source of the less nutrient-rich materials—the Appalachian Mountains. During the Neogene period, however, the Gulf Trough was filled and the mountains were partially uplifted so the siliclastic sediments once held back were deposited in the area and eventually created one of the most prolific karst areas in the US (Lane, 1994).

The limestone types created by the oceanic sediments can be generally characterized into two groups: Ocala and Suwannee limestones. Ocala limestone has a light grey to whitish color and a very diverse amount of fossils. Suwannee limestone is a light to tan grey and is present in much of the southern Suwannee basin in south-central Florida (Florea). These limestone types are localized and their characteristics are used to divide the Floridan Aquifer into three parts: the upper aquifer, the middle semi-confining unit, and the lower aquifer. The Upper Floridan Aquifer (UFA) is correlated with Ocala limestone and is highly porous and permeable. This permeability is enhanced by abrupt variations in

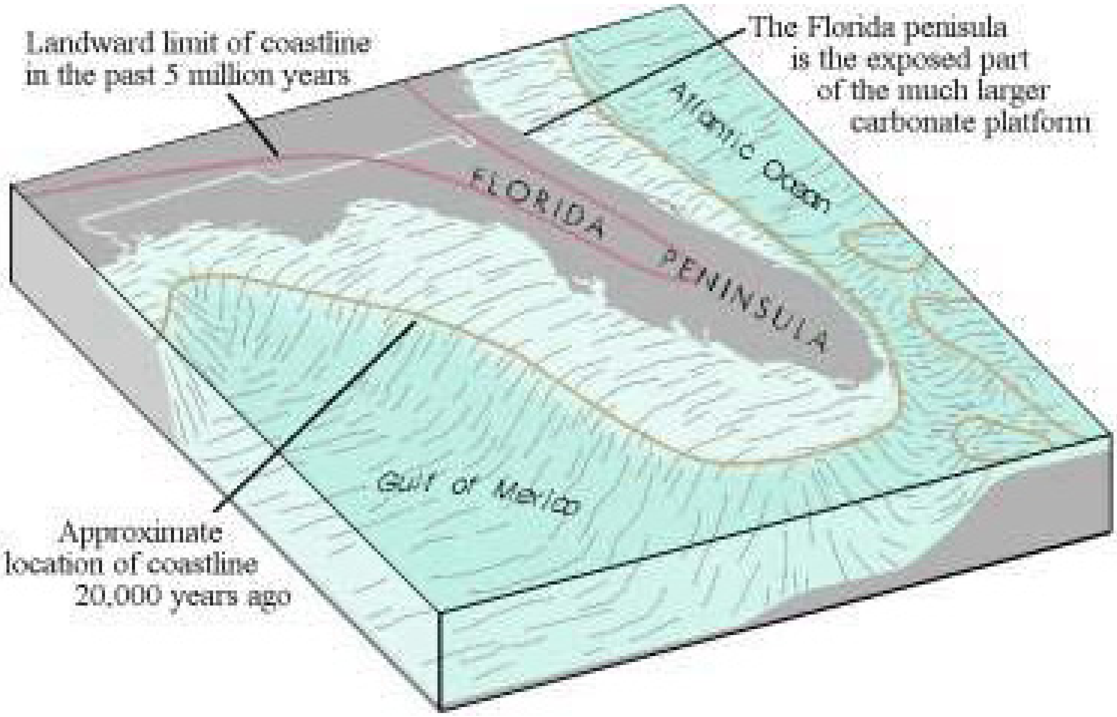

Figure 1. *Carbonate platform alternately exposed due to changes in sea level. (Tihansky, 1999)*

elevations that result in faults and dissolution along bedding planes (Phelps, 2001). The limestone there is generally 100 to 170 meters thick and manages a flow of groundwater that discharges over 7.5 million liters of water per day (Phelps, 2001) despite heavy industrial pumping and upward leakage through springs. The middle semi-confining unit is an area of comparable thickness to the UFA, but it is much less permeable. It contributes little to no flow to the system and acts as a separation between the two more productive layers (the UFA and the Lower Floridan Aquifer, or LFA). The LFA is a thick and highly productive layer of stratified limestone and dolomite. Its high productivity is proven by industrial wells that reach almost 300 meters into the bedding layer and the flow of water aligns with fractures, bedding planes, and joints in the limestone (Phelps, 2001).

These processes generate characteristically homogenous karst areas with rapid movements of flow and recharge. The porosity of the limestone bedding can lead to subsidence events that cause the collapse of the surface into underlying caves and create important direct pathways that introduce surface contaminants into the underground system (Tihansky and Knochenmus, 2001). Groundwater usually flows laterally across the landscape, filtering through and dissolving the limestone along fault lines and joints, but around springs water upwells vertically through shafts. The springs are not true groundwater flow—the only karst forms that have conduit through-flow are sinking streams. Any flow through a spring is concentrated diffuse flow from extra porous surrounding limestone (Beck, 1998). Interestingly, the water chemistry analyzed throughout the entire Floridan Aquifer varied within and among the three different zones with differences in levels of chlorine, sulfates, and other ions. According to Phelps (2001), these differences were a reflection of variance in watershed land use around the sample wells. Another factor in the increase in chlorine is the increase of well and industrial pressure on the aquifer system. From 1965 to 1995, groundwater withdrawals in northern Florida have increased from 508 to 580 million liters per day. This has led to a decrease in the groundwater levels at a rate of 9.144-22.86 cm/year and a high jump in the levels of sulfur and chloride in tested well sites (Phelps, 2001). These increasing numbers receive a lot of attention because of the limits on concentrations for public water supply as outlined by the U.S. Environmental Protection Agency.

Karst Springs in Florida

One of the most fantastic results of the Floridan Aquifer is the proliferation of Florida's springs. The state is home to over 600 freshwater springs centering

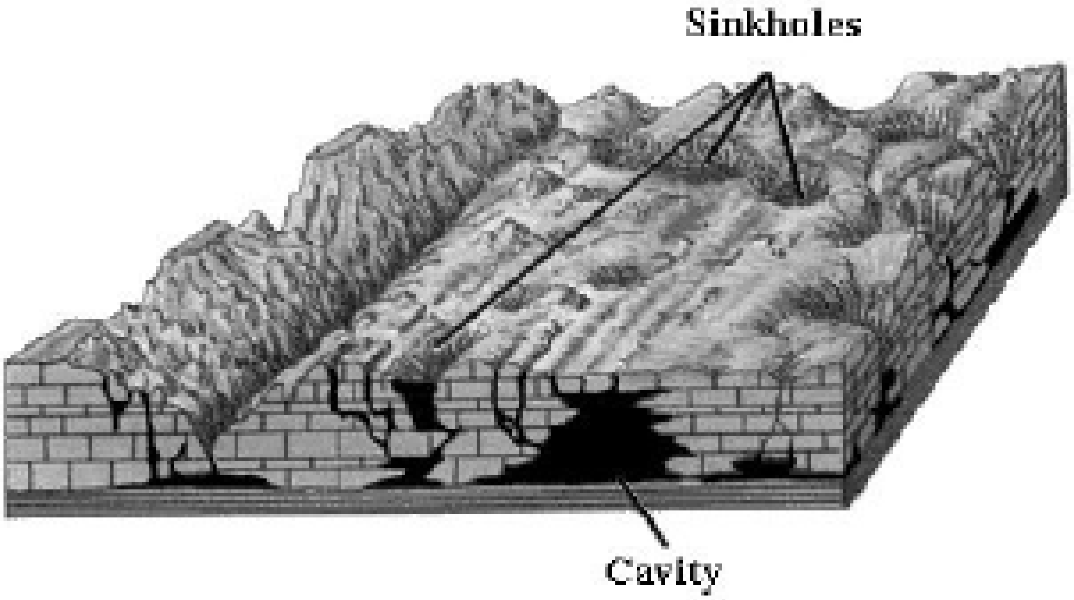

Figure 2. *A cross section of limestone illustrating the underground dynamics of sinkholes, solution cavities, and springs. (Brewer et al. ND)*

12 state parks, major tourist attractions, and strong economic and industrial benefits for local townships in bottling and providing a direct connection to groundwater supply. These springs are the result of acidic rainwater seeping through the carbonate rock and creating weak lines and cavities. These cavities can often shift and collapse to create sinkholes and a dangerous connection to surface pollution, as seen in Fig 2 (Brewer et al. ND).

Springs are classified by their discharge. Because environmental factors contribute to various fluctuations, the discharge used for classification is an average based on historic flows (Brewer et al. ND). They range from 256 million liters of water (first magnitude) to only 32 million liters of water per day (eighth magnitude). The larger first magnitude springs are most often used for recreation and industry, but the smaller springs are often the favorites of the public, with pristine surroundings and very unique biota. These springs are scattered throughout the state but are most often located along large watersheds like the Suwannee and Santa Fe rivers (Fig 3).

Spring Fauna

Because aquatic fauna represent 1/3 of all known cave species the biotic factors in Florida's springs are extremely important and fascinating. However, there is relatively little detailed research on the diversity and distribution of fauna found at these springs. Because the chemical and physical qualities of springs vary so much, there have been a few assimilations drawn out between productive and unproductive springs (dissolved oxygen levels, water chemistry, etc) (Walsh, 2001). The organisms that do live in springs are highly endemic because of the isolation and specific parameters to which they have evolved. Of these organisms, crustaceans and gastropods dominate the obligate macrobiota and many new species have been discovered. For example, four new species of *Cincinnatia* (very small aquatic snails) were discovered in springs in Seminole State Forest. (Walsh, 2001). Many other organisms use the springs, facultatively. They include fishes, gastropods, crustaceans, and other marine invaders (Atlantic Stingray, Gulf Pipefish, and West Indian Manatee) that are able to sustain themselves due to the ionic composition of the bicarbonate rocks around the springs.

Because the Suwannee River basin of northern to south-central Florida is most commonly referenced for use in both industry and recreation, it is important to have a detailed list of the fauna found within that spring system in the event that human activities begin to have a negative effect on species diversity. A study by Mattson et al. (1999) is a useful representation of a large-scale report of benthic communities found there. Collections resulted in a list of 168 algal species, and the first description of *Anorthoneis*, the

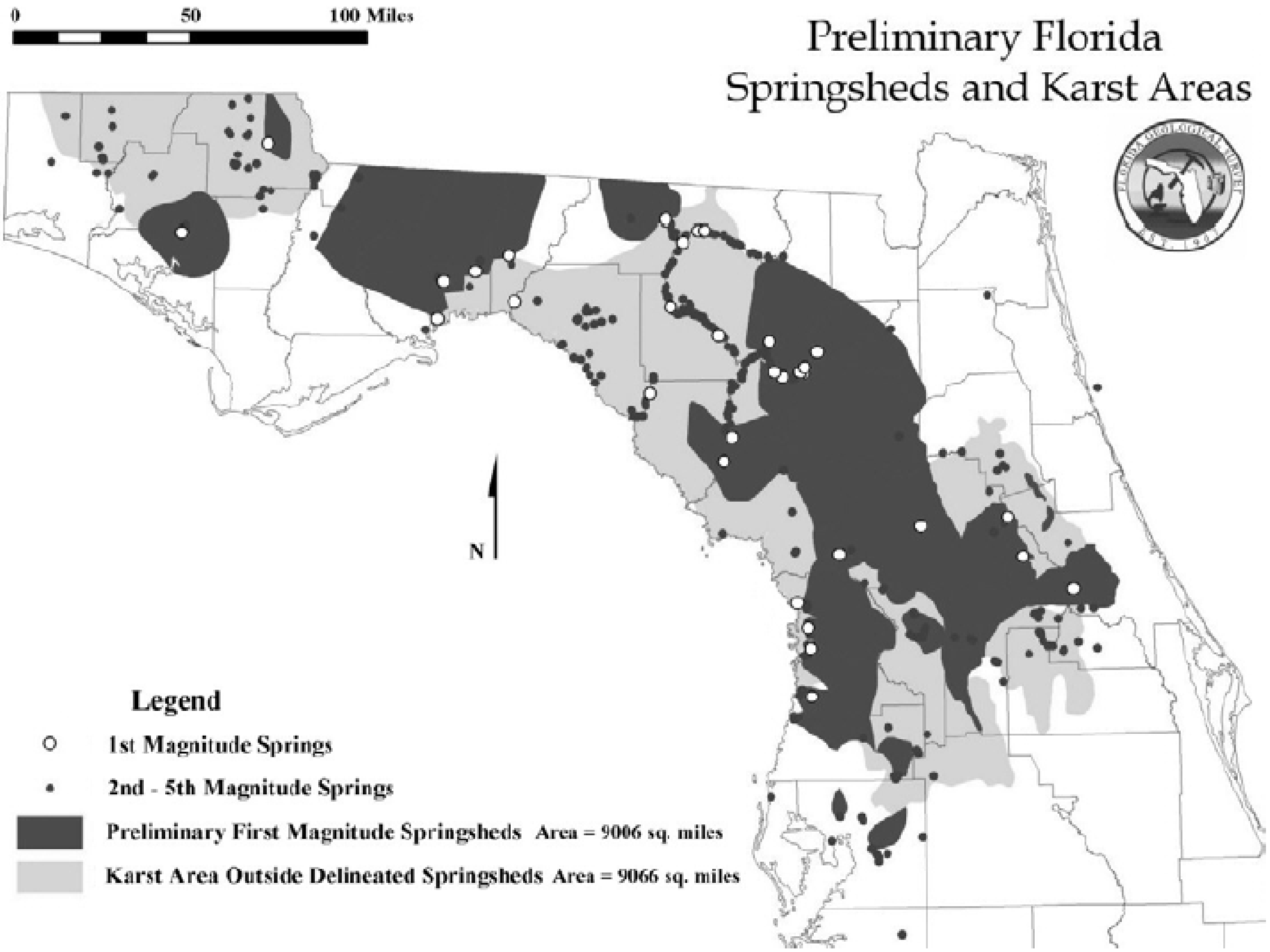

Figure 3. *A map showing Florida's currently known first through fifth magnitude springs and designated karst areas outside of the springs. Data are from Water Management Districts and the U.S. Geological Survey. Courtesy Florida Geological Survey (Brewer et al. ND).*

only known freshwater representative of a marine genus—completely confined to the spring-influenced portions of the Suwannee Basin. Other common submerged algal plants and macrophytes included *Chara* sp.*, Sagittaria kurziana, Vallisneria americana, Ceratophyllum demersun,* and *Myriophyllum* sp. Benthic macroinvertebrate communities displayed a dominance of chironomids with ephemeropterans, trichopterans, crustaceans, and mollusks composing the remainder of species richness. Hydrobid snails displayed a high degree of endemism with some species restricted to a localized area or even a single spring (Mattson, et al. 1995).

A third benthic community found in the study was the stygobionts associated with springs and spring-influenced watersheds (Hobbs, 1992). These extremely fragile populations are very well adapted to a particular spring or cave and have evolved morphological and physiological traits to enable them to survive in such an energy-limited system. These adaptations have also resulted in very specific parameters for survival and very fragile species. Most of the species are listed as endangered or threatened by the State of Florida, due to the fact that they will often depend on the health of one or two springs.

Other studies have focused on one species instead of a description of the ecosystem as a whole. These studies, like the one completed by Marshal (1947), allow us to interpret the specific habitat use of one population of organisms as a model for use in many other species epithets. The study species, *Erimystax harperi*, is best described alongside the characteristic stream qualities that it requires. In the north-central Florida study site, spring-fed streams average about 21.6 degrees C all year long. This, combined with a relatively constant flow rate, constant pH (7.2), low bacteria levels, and depletion of dissolved oxygen create the characteristic environment for this species. Because of these very specific ecological boundaries, other potential habitats can be predicted easily.

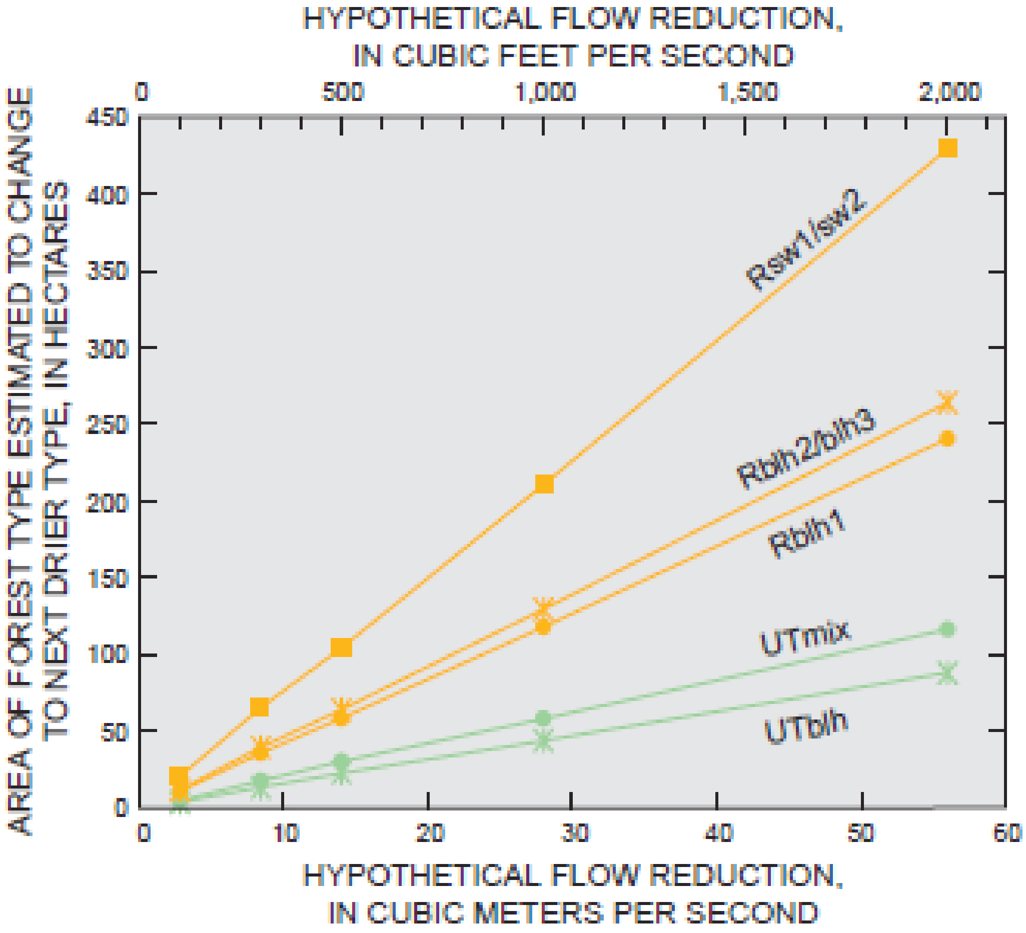

Figure 4. *Estimated effects of hypothetical flow reduction in the lower Suwannee River on areas of forest types. Hypothetical flows were derived from subtracting Branford-Fort White flows. (Light et al., 2002).*

There is also a wide variety of published papers describing newly discovered species. Harris (1998) describes two new species of microcaddisflies found in northern Florida. Northern Florida is notable for its large number of endemic caddisflies. Harris describes new species for two genera—*Hydroptila* and *Ochrotrichia*. Of the genus *Ochrotrichia*, *O. tarsalis* occurs in a wide variety of habitats, however, its discovery adds to a surprising total of only three species that have been found in spring-fed streams of northern and central Florida.

Discussion

Human Impact

The effects of groundwater usage have had severe impacts on the health and clarity of the water and surrounding ecosystem. This is a serious issue, and its importance is reflected in the staggering amount of reports and maintenance being performed and published on the Floridan Aquifer. Many areas of the US have experienced water shortages—a consequence of increased water use due to population pressures, industrial growth, and changes in agricultural irrigation practices. Many states have established instream-flow protection programs to ensure that water requirements for ecosystem maintenance are met. Florida is no exception—in 1972, legislation was adopted to establish minimum flows and levels for watercourses. In the past decade and a half, Florida has experienced exponential amounts of growth and development. The population has steadily increased at a rate of 23.5% between 1990 and 2000 (stateofflorida.com). The amazing growth rate also reflects an escalation of the stressors on the Floridan Aquifer groundwater supply. The demands include rerouting and reducing surface drainage, changing natural recharge patterns, and increasing development in groundwater resources for industrial, municipal, and residential areas (Tihansky and Knochenmus, 2001).

These increases do not go without ecological consequence: in 2002 the U.S. Geological Survey published a study by Light et al. (2002) on the effects that changes in groundwater flow have on the vegetation of forests, water conditions, and soils of the Suwannee River watershed from August 1996 to September of 2000. The river was divided into three sections: riverine, upper tidal, and lower tidal reaches. Flows were monitored and tested in correlation with changes observed in the surrounding ecosystems. The results led to an alarming indication of change—continued reduction of flow would result in replacement of forested tree lines along the river with marshes, reducing the structural canopy and felled woody debris that provides structure and habitat for a wide range of organisms. Continuation of the rate of decreased flow was hypothesized to affect large areas of forest type by drying them out over a very short time period (Figure 4).

Wetland forests and riverine swamps would be diminished, leaving the drier areas more open to human disturbance. In addition, organic soils would be lost to oxidation— diminishing their ability to retain water during drought periods, increasing risk of fire in upland areas, and isolating pools critical for fishes and aquatic invertebrates (Light et al., 2002).

Studies like those by Light and others are hard to ignore from a land management point of view. It is obvious that something has to be done—the question is what sorts of mitigations are fiscally and practically attainable. Currently, much of the effort is concentrated in outlining Florida's resources more completely—what is visible from the surface is a miniscule piece of the full groundwater picture. An excellent example of this effort is the Florida FGS Division of Resource Assessment and Management, Department of Environmental Protection Bulletin No. 66. This bulletin is an update of a continuation of an ongoing effort begun in 1947 to complete the state's inventory of artesian springs. It also accumulates water chemistry data for long-term analysis to allow policy makers to define better land use strategies and promote sustainable freshwater resources.

Future Work

It is apparent that a strategy for conservation of the Floridan Aquifer and the Suwannee River basin needs to be drawn up. The difficult thing about such an endeavor is the interplay between socioeconomics, changing hydrology, agriculture, industry, underlying geology, and unique biota. The proactive response of the Floridian government to address these ecological threats and leverage informational exchanges between Federal agencies (USDA, USGS, FWS, and EPA) and scientific groups (NSF, hydrologic observatories) has thus far been effective and will serve as an excellent guideline of management for other karst areas (Katz and Raabe, 2005). According to them, the partnership platform will give rise to an Integrated Watershed Information Tool that will make it even easier to access data collected from different studies and observatories throughout the state. Therein lies the future of groundwater research and management. The nature of scientific progress is changing—no longer does it rely on one solo scientist, but instead is an integration of many different backgrounds and specialties. If these types of exchange programs are adopted in other states and ecologically fragile areas, the potential to mitigate and share conservation ideas across the globe has no limit. While the Floridan Aquifer may have already been permanently damaged, the efforts behind halting the progression of harmful processes have been successful so far. As a collective unit, scientists with diverse backgrounds will continue to incorporate their expertise and troubleshoot as issues arise.

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Arachnocampa luminosa- Glowworms

Katherine L. Zane

Abstract

Arachnocampa luminosa *is only found in New Zealand and Australia. It is typically observed in dark, moist, limestone caves. The glowworm produces a light through the process known as bioluminescence, which involves ATP, luciferase, luciferin, and oxygen.* Arachnocampa luminosa *develops over four stages: the egg, the larva, the pupa, and the adult stage. In total, the glowworm will live anywhere from six to twelve months depending on the availability of food. Other populations of* Arachnocampa luminosa *exist in Queensland, New South Wales, Tasmania, and Victoria. However, gene flow between these populations is unlikely due to poor flight among adult* Arachnocampa*, as well as geographical limitations.*

Arachnocampa luminous, also known as glowworms or "fishing lines," are limited specifically to Australia and New Zealand. *A. luminosa* was first reported in 1871 and was initially thought to be related to the European glowworm, *Lampyris noctiluca*. By 1886, after much debate, G.V. Hudson found the glowworm to be part of the Mycetophilidae family or fungus gnats. Up until his death, Hudson contributed much of what is known about that habits and lifestyle of *A. luminosa* (Richards 1959). Originally, the species was assigned to genus *Bolitiphila*; not until 1924 was the new combination made, *Arachnocampa luminosa*, by F.W. Edwards. He coined the term *Arachnocampa* because of its spider-like habit of forming a web and utilizing the formation to capture prey. Edwards stated that "the insect differs not only from all Mycetophilidae, but from all other known dipterous larvae" (Edwards 1924). In 1927, after further study of the insects in New Zealand, *Arachnocampa luminosa* was shown to be the only luminous species in the family (Richards 1959).

The glowworm's name derives from their ability to produce a natural luminous substance, the process being called bioluminescence. This process is a biochemical reaction that includes the energy molecule adenosine triphosphate (ATP), the waste product luciferin, an enzyme known as luciferase, and oxygen (Mitchell 2005). The end result of bioluminescence has deemed the glowworms as "luminous larve."

A. luminosa is considered a troglophile, therefore it can spend its whole life in the cave but it does not show obvious adaptations other than reduced metabolism (Baker et al. 2008). Troglophiles, such as *A. luminosa*, are attracted to caves because of the moist and dark environment, however, this species can also live outside caves, being limited to dark damps areas (Kramer and Day 1995). Glowworms are typically found in dark, wet limestone caves and under rocky overhangs, as well as rainforest gullies; however, glowworms have also been reported in wet soil, in the hollow of trees, beside walking tracks, and in woodlands (Mitchell 2005).

Arachnocampa luminosa are exclusively predatory insects. The life cycle begins as an egg with the incubation time being about three weeks. Little difference can be seen between the size of the eggs located in or outside of the cave, described as spherical and about 0.75 mm in diameter. Interestingly enough, there have been no reports finding the eggs to be luminescent (Richards 1959). Once hatched, the larva turns into a cylindrical shape, with a soft body and a hard head capsule. Initially, the larva has been commonly reported at about 3-5 mm in length and 0.33 mm in width. By the end of the larval stage the species will have grown to 6mm in length and 0.5 mm in width (Richards 1959). The larval stage can last anywhere from several months to a year if the food supply, temperature, and humidity are at an ideal state. This is the longest period of an *Arachnocampa's* life. The larva produces a nest out of silk and will spread over the ceiling of caves where it hangs as many as seventy threads. Larvae are not confined to one location within the cave, and often will spread to create new nests (Richards 1959). Both larvae and adults contain large eyes that are able to see from ultraviolet wavelengths to green wavelengths (Meyer-Rochow 2007) (Figure 1).

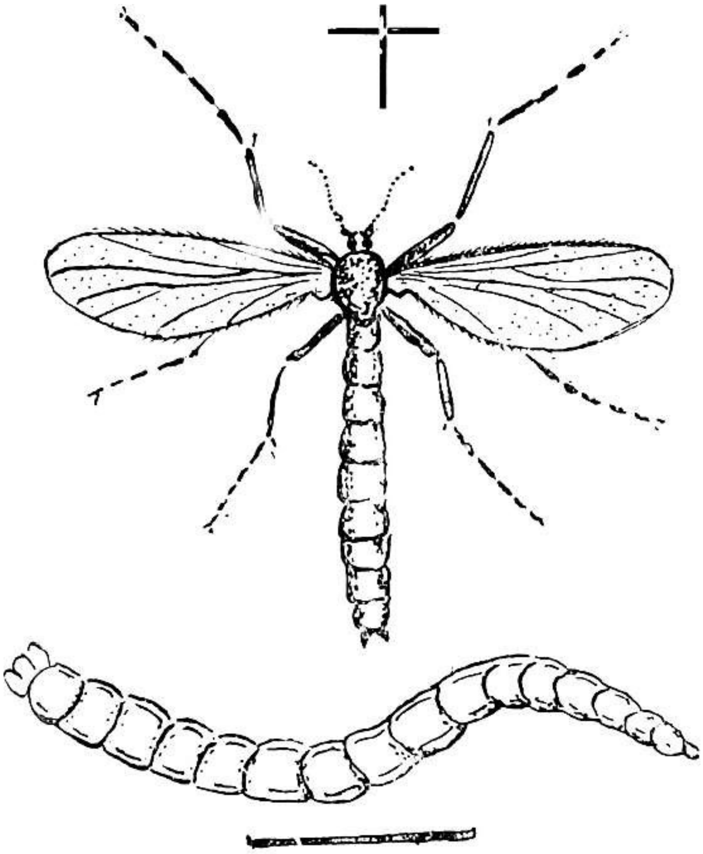

Figure 1. *The glowworm,* Arachnocampa luminosa*, larva and adult. The cross and line indicate the actual sizes of fly and larva, respectively. http://www.nzetc.org/tm/scholarly/Gov01_08Rail-fig-Gov01_08Rail022a.html*

Pupation takes about one week and causes the glowworm to shrink in size and also become sporadically translucent. There are two sexual differentiations between male and female pupae. Female pupae are typically larger and produce a brighter luminescence during this stage, whereas male pupae will stop glowing (Richards 1959). Once the glowworm becomes an adult, the mouth begins to degenerate which, in effect, prevents any source of nutrition. In contrast to the long lives of the larvae, adults live a very short life, typically 2-3 days for females, and 4-6 days for males. Adult *Arachnocampa's* also have been reported to have "sluggish flight," which contributes to their quick death. At this point, glowworms are eager to reproduce before death. Attraction of a male glowworm arises from the female glowworms' luminescence, which as stated above, increases in brightness towards the end of pupation (Hattan 2009). It is very typical for male flies to fight over the female fly, even during the fertilizing process. The longer life of adult male *A. luminosa* allows for the fly to fertilize multiple females. The laying of eggs typically takes place immediately after fertilization, where the female fly will search for an adequate location. The female fly experiences violent contractions and produces a flexing movement in order to lay each egg singly (Richards 1959). Once a female and male glowworm mate, the end result consists of as many as 120 eggs and an instantaneous death of the female. The larva will begin to glow almost immediately after it is hatched (Meyer-Rochow 2007).

There has been a notable difference between the size of larvae inside the cave and those located in tunnels, which is most likely credited to the amount of food supply (Richards 1959). The majority of the larval population pupates in late winter and early spring, producing a new generation by spring and early summer (Pugsley 1980). The distribution of glowworms is reliant on a sufficient food supply, as well as a cool, moist climate and most importantly, a horizontal rock surface in order to hang the "fishing lines" effectively. High humidity and protection from wind are vital living conditions for the sustainability of *A. luminous* (Broadley & Stringer 2001). The glowworms' diet consists of mostly freshwater insects including, small back flies, hunchback flies, midges, and small snails (Meyer-Rochow 2007). Typically these insects will arise from inside the cave; however some are brought into the cave from outside.

Bioluminescence is most commonly found in marine animals and is very rare on land. However, *Arachnocampa luminosa*, isolated in New Zealand, are known for their production of bioluminescence (Broadley & Stringer 2001). Glowworms use the natural light produced through their abdomen to attract prey, which typically consists of several different flies, small snails, and midges. The light organ of *Arachnocampa luminosa* can be found in the swollen distal tips of the Malpighian tubules. These tubules constitute a distinct luminescent organ, which has only been found in this species (Green 1979). Glowworms form a silk web, also known as a "snare," which is made up of mucus in order to immobilize and catch prey. The "fishing lines" that they produce have been reported to be up to 45 cm (Mitchell 2005). The formation of these "fishing-lines" is a continual process in which the larva progressively lengthens each line. The silk web is very delicate and the "fishing line's" hang close to one another, therefore any airflow will entangle the snare, forcing the larva to repair the snare (Richards 1959). The glowworm itself or the odor it produces is not the source of attraction; however the light it produces specifically draws in the prey. The glowworm is able to recognize the presence of food through the vibration of both mechanoreceptors and chemoreceptors and is then able to lure prey in with its mouth. Then it will either eat the insect whole or slowly suck all of the insect's juices as food supply (Mitchell 2005). After consumption, the glowworm removes the remains of the insect. This allows the "fishing-lines" to remain clean, which facilitates effective use of the snare (Richards 1959). Interestingly enough, when the glowworms' appetite is satisfied, it does not emit light. Once the glowworm salvages an appetite it is able to produce enough ATP to produce bioluminescence; the hungrier the glowworm, the brighter the bioluminescence is produced (Mitchell 2005) (Figure 2).

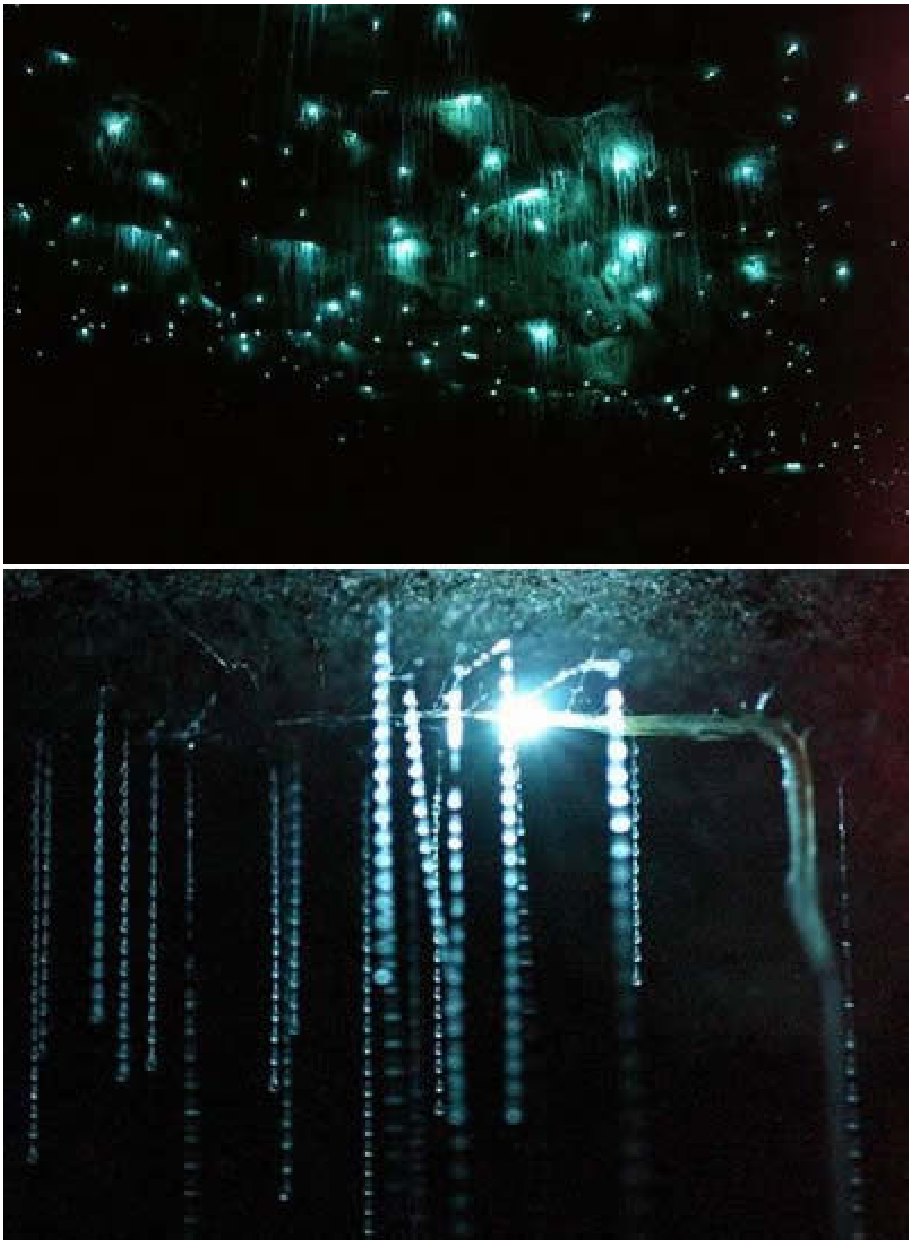

Figure 2. *The Glowworm in Waitomo Glowworm Cave, North Island, New Zealand. Upper photograph of cave ceiling and lower of larva and numerous "fishing lines". http://www.oddee.com/item_94349.aspx*

Many of the eggs are eaten by isopods and opiliones (Richards 1959). Desiccation of the *Arachnocampa luminosa* can be credited to *Tolypocladium*, a fungal infection that is most present during the heat of the summer. *Tolypocladium* is spread through the fluctuation of temperature, humidity, and airflow. Higher humidity may be attributed to the prevalence of tourism compared to the non-tourist caves. The first report of a glowworm fungal disease was found at Waitomo Cave in 1956 and was described as a "white, sausage-shaped fungus," which was referred to as Beauveria (Pugsley 1980). Reports of The Glowworm Cave show a gradual increase in climate change compared to earlier records, as well as other caves in Waitomo. Studies have suggested that the installation of an open grille on the Top Entrance of the Glowworm Cave in 1975 is one of the main factors accountable for the climate change (Pugsley 1980). Airflow is heightened between the two entrances of the cave, which in effect will change the climate and decrease the humidity, leading to dessication. In addition, shortage of food supply is one of the gravest threats to *A. luminosa*; the food supply can be severely affected by the removal of mud banks in the Grotto of the Waitomo stream. The mud banks serve as a living quarter for chironomid larvae that *A. luminosa* rely on as a food source. Therefore, the *A. luminosa* population has been reported as considerably affected upon the removal of the chironomid larvae. Oil being drained into the stream from roadwork will also diminish the food supply, which will ultimately affect the stability of the glowworms (Richards 1959).

Predators of *A. luminosa* also include *Megalopsalis tumida* and *Hendea myersi cavernicola*. *H. m. cavernicola* typically eat the larvae, while *M. tumida* will feed on the adults due to their sluggish movement (Richards 1959). However, these predators do not serve as much of a threat as floods and climate changes. During the dry period, glowworms will drop further down from the walls in order to search for food, however, winter floods typically eradicate those *A. luminosa*. Therefore, flooding causes extreme mortality among this population and restricts glowworm life to the upper region of the cave (Richards 1959). Cannibalism has also been reported to contribute to the death of *A. luminosa* (Meyer-Rochow 2007). Cannibalism often occurs when two larvae nest closely together, which promotes fighting and snapping at each other, ultimately causing one of the larvae to fall out of its nest. *A. luminosa* is easy to spot when fighting because each larva will produce a brighter luminescence (Richards 1959).

While *Arachnocampa luminosa* are isolated to the New Zealand area (The Waitomo Caves; figure 2), there are several other species of *Arachnocampa* that can be found in other areas of the world. *Arachnocampa richardse*, another subspecies, can be found in New South Wales, with its highest abundance being in the Newnes glowworm tunnel in the Blue Mountains. Also, *Arachnocampa flava* is limited to the Queensland area; a new parasitic wasp that has drastically reduced the population in the northern Queensland area has largely affected this species. More research is being conducted to analyze the detrimental effects of this wasp; however, findings show that it could pose similar effects to southern colonies if spread (Baker 2002). New research has proposed another subspecies, *Arachnocampa tasmaniensis* (Lucifera), which can be found in Tasmania. Also, *Arachnocampa buffaloensis*, has been recently reported in Victoria and is presently an endangered species (Baker 2010). The poor flying ability observed in the adults, as well as the large geographic distance between the habitats, allows very little gene flow among glowworms. Due to unlikely gene flow between populations, genetic analyses further report divisions between the subspecies of *Arachnocampa* (Baker 2002). Therefore, it is likely that *Arachnocampa luminosa* will forever be isolated within New Zealand, given the climate is suitable and tourism is under tight control. The sustainability of this species relies on both climate and food supply.

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A Pilot Study of Limiting Nutrient Uptake in Cascade Cave, Carter County, Kentucky

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Abstract

Ecological processes such as nutrient retention and nutrient spiraling are virtually unstudied in cave stream systems. We used the slug addition method to estimate discharge in addition to limiting nutrient dynamics in a stream running through Cascade Cave (Carter County, Ky), comparing it to an upstream portion of the stream that runs along the surface. Nitrogen was found to be limiting in this system and nitrate-nitrogen uptake length in the stream coursing through Cascade Cave was found to be greater than that calculated on the surface (12.41m and 9.36m, respectfully). Uptake velocity and areal uptake calculations deviated considerably from the expected range and therefore were reported as inconclusive. Discharge between sites was dissimilar (a difference of 2.54 L s^{-1}) which could have had an effect on nutrient dynamic calculations. We concluded that more experimentation is necessary to understand limiting nutrient dynamics in the stream running through Cascade Cave.

Introduction

Most biological research in caves has been focused on the evolutionary, population, and community ecology of cave systems (e.g., Gibert *et al.*, 1994; Hobbs and Lawyer, 2003; Hobbs and Hazelton, 2008). Since these systems have long been thought of as energy and nutrient limited, with carbon, rather than nitrogen or phosphorous likely the limiting factor in subterranean karst systems (Simon and Benfield, 2001, 2002; Simon *et al.* 2007), there is value for study in this area. However, ecosystem processes such as carbon budgets and nutrient spiraling are essentially unstudied in caves (Simon and Benfield, 2002) while nutrient cycling is well examined in surface streams (Newbold, 1992; Allan and Castillo, 2009). The methods and models used to study nutrient spiraling in surface streams should be applicable to cave streams (Simon and Benfield, 2002). 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 (S) which refers to the distance a single nutrient particle travels in the cycle between a biotic and an abiotic component and is illustrated in Eq. 1:

Eq. 1 $S = S_W + S_B$

where S_W is the uptake length, or the distance a single nutrient particle travels in abiotic form and S_B refers to the turnover length, or the distance the nutrient particle travels in biotic form. Uptake length is a measure of nutrient limitation and the efficient use of a nutrient in streams and is calculated as in Eq. 2:

Eq. 2 $S_W = 1/[K_C]$

Here, K_C is the slope of the ln transformed regression of the nutrient concentration to Cl^- concentration ratio plotted as a function of distance downstream, and is known as the uptake rate coefficient. Short uptake lengths indicate high demand relative to the supply and greater retention by the ecosystem (Allan and Castillo, 2009). Uptake length strongly depends on discharge and velocity, and therefore varies with stream size. Uptake velocity (V_f) is the uptake length standardized for discharge and is also referred to as the mass transfer coefficient. The uptake velocity (Eq. 3) allows for the quantification of the velocity at which a nutrient particle moves from the water column (abiotic form) to the stream benthos (biotic form):

Eq. 3 $V_f = Q/[(w)(S_W)]$

where w refers to stream width and Q refers to stream discharge. Since V_f is S_W standardized for discharge, it is best suited for comparison between stream ecosystems (Davis and Minshall, 1999). If the concentration (C) of the nutrient in question is known, the amount of inorganic nutrient taken up by the benthos per unit of time can be expressed as an areal uptake (U; Allan and Castillo, 2009) as in Eq. 4:

Eq. 4 $U = V_f\, C$

The only other study that quantified nutrient dynamics in cave streams was Simon and Benfield (2002). This study used typical surface stream methods to estimate ammonium uptake in cave streams in Organ Cave, Greenbrier County, West Virginia, and provided a benchmark for comparison between cave and surface streams. One weakness of the study was the lack of a direct comparison of comparable cave and surface streams (differences in discharge between streams were too great and streams with comparable discharges had other variables associated).

The purposes of this study are to compare the limiting nutrient uptake in a cave stream to that of a surface stream by measuring nutrient uptake in a single stream that courses continuously along the surface and then through a cave, as well as to establish the methodology of these experiments for future experimentation. While we are quantifying nutrient spiraling, it is important to note that cave systems are food-limited (i.e., carbon; Simon *et al.* 2007). Since nutrient spiraling behavior in surface streams is well studied and much more understood than cave stream systems, the surface stream addition and subsequent nutrient metrics will act as a control to the cave addition in these field experiments in order to better understand how nutrient spiraling behavior in this stream changes as a result of going underground.

Credit for photographers is provided for each of the following figures using the letters: BS – William A. Stitzel, HH – Horton H. Hobbs III, KS – Kristen M. Shearer.

Site Description

An experimental reach was chosen by gross examination upon arrival at Cascade Cave (Fig. 1), an approximately 3,500m long cave developed in the Slade stratigraphic limestone formation (Carter County Cave files, Wittenberg University). An appropriate reach was found approximately 200m north-northwest of the Backdoor Entrance to the cave which had minimal pooling and as close to a 40m experimental reach of exposed stream as possible (Figs. 1-5). Part of the stream (at ~27m) did cut under the substrate, but then reappeared several meters later (at ~ 32m) which was deemed acceptable.

The surface stream reach was located approximately three kilometers upstream of the site in Cascade Cave, located along St. Route 182 in Carter County (Fig. 6). This section of the stream was chosen (by gross examination) because of similar hydrological characteristics to that of the site in Cascade Cave.

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 ~150m where it serves as a tributary to Tygarts Creek (Fig. 1).

Methods

Slug Preparation

Upon arrival at the Cascade Cave study reach (the more downstream and first section of stream to receive a slug addition), a water sample was taken (Fig. 7) and analyzed for NO_3-N and PO_4-P concentrations using a Hach spectrophotometer (model DR2800; Hach Company, Loveland, CO) and the limiting nutrient was determined as per the Redfield ratio (N:P = 16; Redfield, 1958). Since nitrogen was determined to be the limiting nutrient, NO_3-N was added to the slug in the form of 7.92mL of a 0.5g L^{-1} KNO_3 stock solution mixed with deionized water, with NaCl added as a conservative tracer (Fig. 8).

Slug Injection

The slug injection followed the methods as described by Tank *et al.* (2008) and Álvarez *et al.* (2010) and can be described also as the pulse addition method. In a "pulse" or "slug" addition experiment, nutrients are released simultaneously as one addition and this pulse of nutrients moves rapidly downstream (Gordon *et al.* 2004). Briefly, water samples were taken at four pre-scouted stations (at 10, 20, 26, and 39 meters in Cascade Cave and 10, 20, 30, and 40 meters at the surface site) downstream of the injection sites in order to determine background levels of NO_3-N and specific conductance (measured with a model 30 YSI Instruments conductivity probe) (Fig. 6) at each station. The prepared slug was then added at the injection site (Fig. 9), which was chosen at a point that insured adequate mixing of the slug injectate into the water column, and water samples were obtained from the four stations downstream as specific conductance values reached a peak (Figs. 10,11). Water samples were placed on ice within four hours and frozen immediately upon arrival at the lab. Several measurements of stream widths and depths also were measured (Fig. 12) in order to calculate an average stream width value for the experimental reach at each site.

Calculation of Discharge and Stream Physicochemical Parameter Measurements

Discharge was calculated in accordance with the conservative solute tracer method (Stream Solute Workshop, 1990). Briefly, NaCl in the slug injectate causes an increase in specific conductance; as the slug passes any given point (i.e., at one of our stations) the specific conductance will increase and then decrease as the highest concentration (the "peak") moves downstream. Integrating the curve of the [Cl^-] plotted as a function of time gives discharge of the stream in L s^{-1}. Specific conductance values can be converted to [Cl^-] with Eq. 5 (Damon Ely, University of Maine, Orono Maine, personal communication):

Eq. 5 Specific Conductance/3.3783 = [Cl^-]

Stream physicochemical parameters measured were temperature (°C), specific conductance (μS cm^{-2}), dissolved oxygen (DO; mg L^{-1}), and pH (Table 1). All discharge and physicochemical measurements were made with a YSI 6920 multi-parameter Sonde (Fig. 13).

Analysis of Samples

Frozen water samples were completely thawed and immediately analyzed for NO_3-N concentration using a Hach spectrophotometer (model DR2800), using the Cadmium Reduction Method (0.1 – 10.0 mg NO_3-N L^{-1}). Both peak NO_3-N concentrations and peak specific conductance values were background-corrected for added levels according to Eq. 6 and Eq. 7:

Eq. 6 $\text{NO3-N}_{peak} - \text{NO3-N}_{amb} = \text{NO3-N}_{add}$

Eq. 7 $\text{SpCond}_{peak} - \text{SpCond}_{amb} = \text{SpCond}_{add}$

Where $_{peak}$ refers to the measured value, $_{amb}$ refers to the background or "ambient" measured value, and $_{add}$ refers to the levels added to the stream in the slug injectate. All SpCond_{add} values were then converted into Cl^- concentrations using Eq. 5. K_C (m^{-1}) was then calculated as the slope of the ln transformed regression of [NO_3-N]:[Cl^-] versus distance downstream of the injection site (Fig. 14). S_W (m), V_f(m s^{-1}), and U (mg m^{-2} s^{-1}) were all then calculated according to Eq. 2, 3, and 4, respectfully.

Results

Discharge and Physicochemical Parameters

The N:P ratio of the stream water at the Cascade Cave site was five, therefore designating nitrogen as the limiting nutrient. After the limiting nutrient was determined, a 4mg NO_3-N L^{-1} slug was prepared in order to keep the elevation of NO_3-N concentrations to a minimum so that uptake metrics could be calculated as close to ambient concentrations as possible (as background NO3-N concentrations were ~0.3 mg L^{-1}; Mulholland *et al.*, 2002; Álvarez *et al.*, 2010)

Discharge at the Cascade Cave site was calculated to be 5.76 L s^{-1} while Q at the upstream surface site was calculated as 3.31 L s^{-1} (Table 1). Physicochemical measurements are also listed in Table 1.

Uptake Metrics

Uptake length in Cascade Cave (Table 2) was found to be 12.41m, while the surface site had an S_W of 9.36 m. Uptake velocity was greater in the cave with a V_f of 0.91 mm min^{-1} while V_f on the surface was 0.00338 mm min^{-1}. Areal uptake was greater also in Cascade with a U of 0.27 mg N m^{-2} min^{-1} and a surface U of 0.00074 mg N m^{-2} min^{-1}.

Discussion

Discharge and Physicochemical Parameters

The large difference in discharge between sites was somewhat surprising considering both sites are the same stream, and the sites' close proximity to each other, although this dramatic change is certainly possible. Physicochemical parameters taken at each site did not appear to differ considerably by gross examination and most differences could be attributed to groundwater inputs and the water itself transferring from the surface through the epikarst into Cascade Cave.

NO_3-N Uptake Metrics

The relationship between uptake lengths at each site was as expected. In addition to biological demand, nutrient uptake lengths are highly dependent on stream velocity and depth (Newbold, 1992). High discharge (therefore higher velocities and depths) increases the length of nutrient transport, which increases nutrient uptake length (Valett *et al.*, 1996). Thus, our calculated $S_{W,\text{ Cascade}}$ could be attributed to the elevated Q_{Cascade} compared to Q_{Surface}. Uptake lengths are thought to be greater in caves anyway because of the lack of primary producers (Simon and Benfield, 2002) coupled with low nutrient demand. In light of this, we cannot contribute the greater $S_{W,\text{ Cascade}}$ to any one of these variables. We can conclude that more experimentation is needed in order to investigate this phenomenon in Cascade Cave.

Our calculation of V_f and U for both sites appears truly aberrant. The low nutrient demand in caves is thought to cause much lower values for V_f in cave streams than surface streams (Simon and Benfield, 2002). However, $V_{f,\text{ Cascade}}$ is orders of magnitude higher than the surface site causing our U_{Cascade} to be orders of magnitude higher as well (as per Eq. 4). Our calculated V_f and U values for both sites also deviated considerably from literature values. To us, this suggests an error occurred somewhere in our methodology and analysis and unfortunately we believe these results are ultimately inconclusive. Again, we feel more experimentation is needed in order to understand these uptake metrics in Cascade Cave.

Future work in stream nutrient dynamics in Cascade Cave, but also any cave stream system in general, has enormous potential. Within the last decade or so several studies have been published regarding methodological issues in stream nutrient addition experiments (e.g. Álvarez *et al.*, 2010; Payn *et al.* 2005; Covino *et al.*, 2010). Future research could include generating uptake dynamics as a function of nutrient concentration (a "calibration curve"), investigating ambient concentration uptake dynamics, and quantifying biotic and physical retention of nutrients in systems like Cascade Cave.

Acknowledgments

We wish to thank Horton H. Hobbs III and William A. Stitzel for their guidance and aid in selecting sites. We would also like to thank Kevin S. Simon, Damon T. Ely, John B. Ritter, and Richard York for their contributions and discussions regarding this experiment, and the Wittenberg University Speleological Society for transportation to Carter County, KY and the use of equipment and Cascade Cave data.

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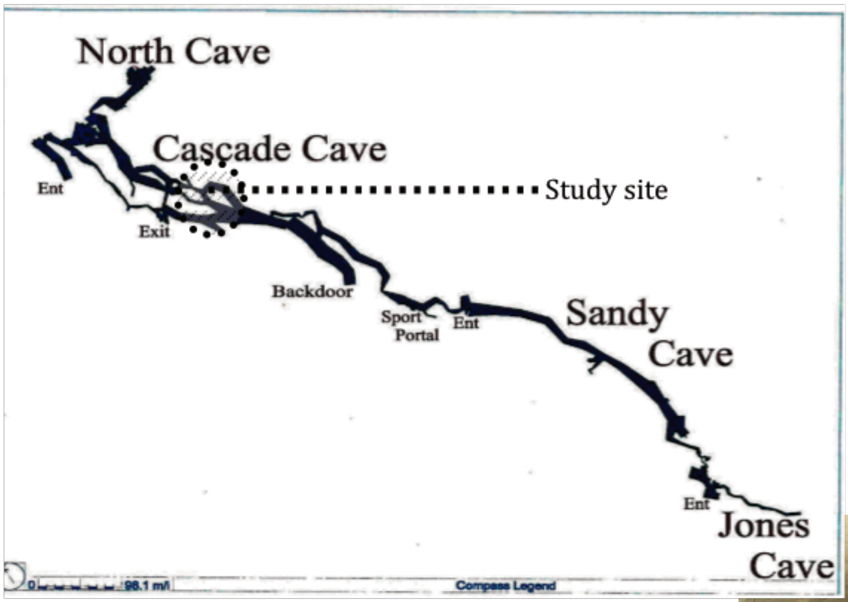


Figure 1. *Location of experimental site in Cascade Cave. The site was approximately 200m from the Backdoor Entrance to the cave. The experimental reach of the stream runs through the middle path of highlighted section (courtesy of Carter County Cave Files, Wittenberg University).*

Figure 2. *The upstream portion of the experimental reach in Cascade Cave. [BS].*

Figure 3. *Kristen Shearer and Chad Rigsby measuring 10m stations from injection site [HH].*

Figure 4. *Kristen Shearer and Chad Rigsby measuring the 26m station [HH].*

Figure 5. *Bill Stitzel seated near the 10m station, illuminating the passage [HH].*

Figure 8. *Kristen Shearer and Chad Rigsby filtering a water sample, to be analyzed later for background chemical levels [HH].*

Figure 6. *Chad Rigsby placing the conductivity probe in the surface stream [HH].*

Figure 9. *Chad Rigsby adding the prepared slug solution to the stream at the 0m station [KS].*

Figure 7. *Chad Rigsby collecting a water sample [HH].*

Figure 10. *Chad Rigsby collecting water sample as the slug addition moves downstream [HH].*

Figure 11. *Chad Rigsby filtering a water sample collected as the slug addition moves downstream [HH].*

Figure 12. *Chad Rigsby measuring depths across each station, to aid in calculating discharge [HH].*

Figure 13. *Chad Rigsby setting up the Sonde multiparameter probe [HH].*

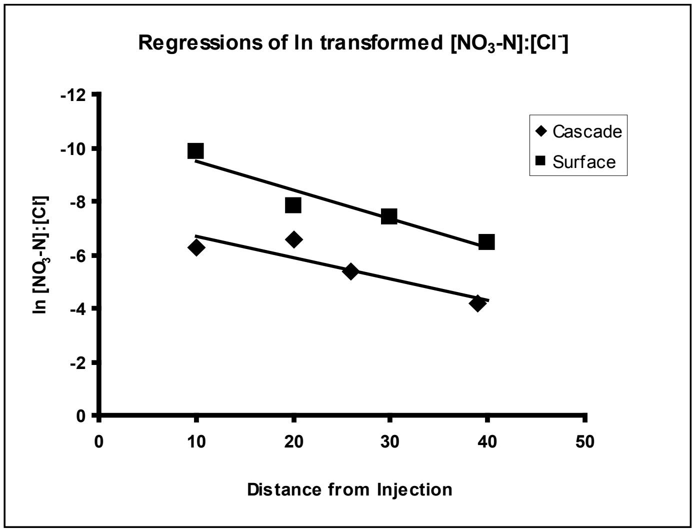


Figure 14. Plot of the regressions of the ln transformed [NO$_3$-N]:[Cl$^-$] versus distance downstream of the injection point. [slope of trendline]$^{-1}$ is used to calculate uptake metrics (S_W, V_f, and U). Both Cascade and surface site data are shown.

Parameter	Cascade	Surface
Temp (°C)	14.17	15.94
Sp Cond (µS cm^{-2})	326	407
DO (mg L^{-1})	8.19	9.17
pH	7.57	7.67
Q (L s^{-1})	5.76	3.31

Table 1. Physicochemical measurements and discharge calculations for the Cascade Cave and upstream surface site. Temp is temperature, Sp Cond is specific conductance, DO is dissolved oxygen, and *Q* is discharge.

Metric	Cascade	Surface
S_W (m)	12.41	9.36
V_f (m s^{-1})	0.91	0.00338
U (mg N m^{-2} s^{-1})	0.27	0.00074

Table 2. Calculated uptake metrics for Cascade Cave and the upstream surface site. S_W is uptake length, V_f is uptake velocity, *U* is areal uptake.

The Breakfast Caves

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

Bacon and sausages sizzled in the crud-crusted frying pan and some students were yelling for waffles while others were wolfing down short and tall stacks of golden pancakes. That early morning activity has been repeated on numerous cave trips taken by Wittenberg University Speleological Society members (WUSSes) over the past 30 years. In order to honor such breakfast delights, eight WUSSes, on a 07 June 2007 outing to northeastern Adams County, Ohio, located and surveyed five small caves. In the process of assigning names to these small karst features, their nomenclature quickly got out of hand and soon the five caves treated below were blessed with titles reflecting sumptuous breakfast cuisine (actually the christening of culinary names to these caves was initiated due to their proximity to "Bacon Flat Road"!!).

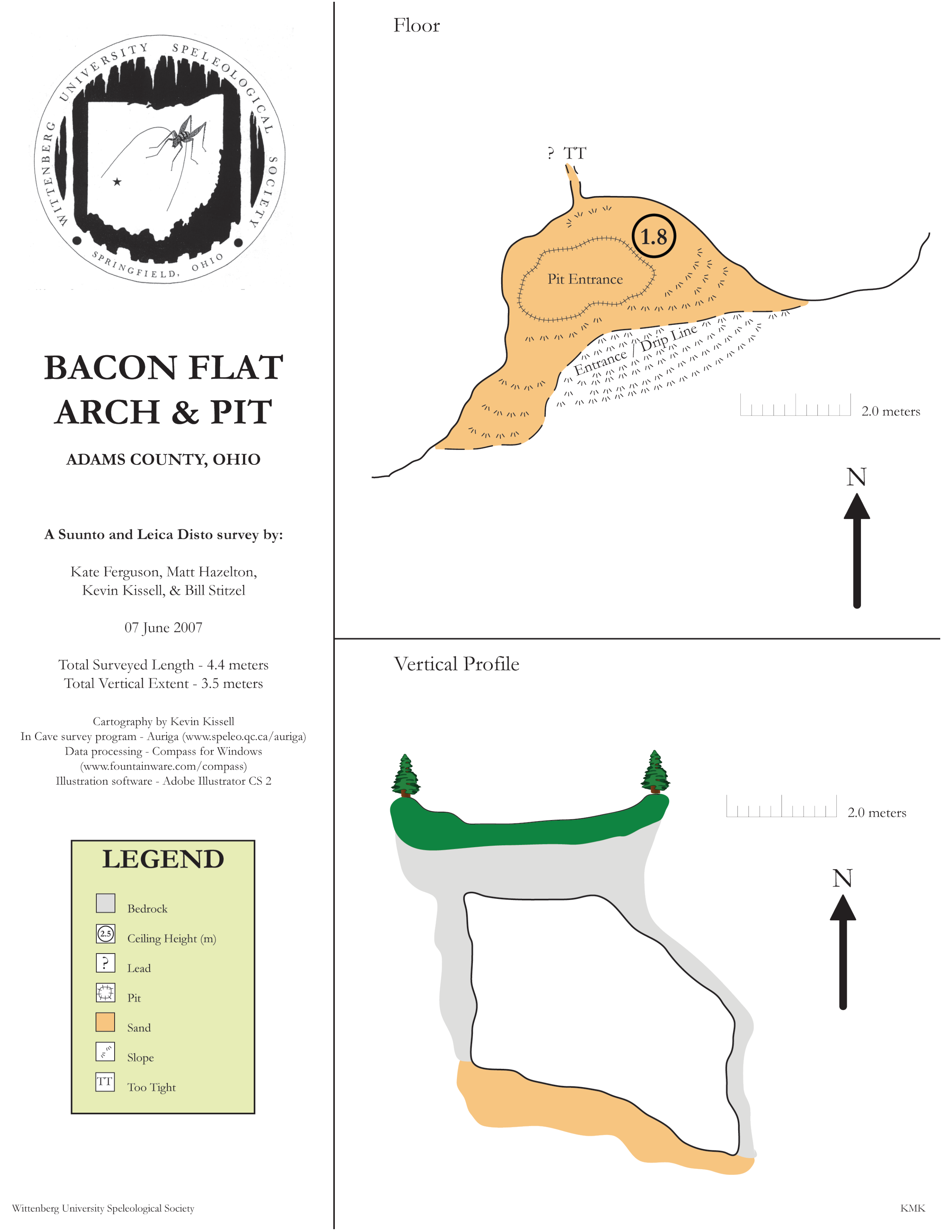
All of these caves are developed in the same unit of Silurian dolomite that outcrops along the west side of the small valley associated with Scioto Brush Creek in northeastern Adams County and are located on private property. No active stream is present in any of them nor are there any active epikarstic drip pools. Numerous additional caves and arches, maps of which will be featured in future issues of *Pholeos*, are found along the creek, including Roadside Cave (see Porter 1995) and Roadside and Scioto Brush Creek arches (see Snyder 2009 for information concerning Ohio's arches).

The southernmost of these features are Bacon Flat Arch and Pit that are associated with a small recess (approximately 2.5m deep) in a moss-covered dolomite outcrop. The forest floor is well decorated with herbaceous plants, including numerous Christmas ferns (*Polystichum acrostichoides*), however no fauna were observed in the pit or arch when surveyed. The pit is 3.5m deep and the 3.5m long arch (a remnant of the cliff face) are oriented generally in an east-west direction (Figs. 1-2). Although the pit is climbable, a hand line is recommended.

Approximately 60m to the northeast is Sausage Cave, the shaded entrance to which is situated at the base of a 5m high dolomite cliff (Fig. 3). A breakdown block (1.5 x 0.5m) partially obstructs the entrance and the cobble-floored passage continues north for about one meter where it turns east and continues past two small domes to its terminus, some 4.7 meters from the drip line (Fig. 4). To the north of the first dome is a low lead, too small for anything larger than a small mammal. No airflow was noted on the day of the survey. More than 30 crickets (*Ceuthophilus* sp.), a crane fly (*Tipula* sp.), and a midden of the Allegheny Woodrat, *Neotoma magister* Baird – see Balcom and Yahner 1996, were observed.

Forty meters northeast of Sausage Cave is the 3.5m wide by 1m high entrance to Waffle Cave (Fig. 5). A large piece of breakdown nearly covers the floor of the entrance area that leads west and southwest for 5m to the cave's terminus. A domed "room" with a small ledge on its north side is encountered prior to the terminal crawlway (Fig. 6). There is a small, 0.5m wide, passage that continues to the southwest, however little airflow was noted. During the survey a variety of fauna were observed, many of which were surface species: crane fly (*Tipula* sp.), cricket (*Ceuthophilus* sp.), harvestman (*Leiobunum* sp.), terrestrial isopod, surface orb web spider, and a funnel web spider.

Short Stack Cave is situated 40m north of the entrance to Waffle Cave. The 3 x 1m entrance (Figs. 7, 10) continues into a single low passage trending to the east for 5.9m (Fig. 8). Although a short cave, it does have some active soda straws, draperies, and popcorn speleothems within it (Fig. 9). The cave terminates in a belly crawl that is too narrow and low to enter. Fauna observed were the Eastern American Toad (*Bufo a. americanus* Holbrook), the crane fly (*Tiplula* sp.), and pigmented millipedes, terrestrial isopods, and a surface orb web spider, most of which were found in the vegetal debris at the entrance of the cave.



BACON FLAT ARCH & PIT

ADAMS COUNTY, OHIO

A Suunto and Leica Disto survey by:

Kate Ferguson, Matt Hazelton,
Kevin Kissell, & Bill Stitzel

07 June 2007

Total Surveyed Length - 4.4 meters
Total Vertical Extent - 3.5 meters

Cartography by Kevin Kissell
In Cave survey program - Auriga (www.speleo.qc.ca/auriga)
Data processing - Compass for Windows
(www.fountainware.com/compass)
Illustration software - Adobe Illustrator CS 2

LEGEND

- ▢ Bedrock
- (2.5) Ceiling Height (m)
- ? Lead
- ⊡ Pit
- 🟧 Sand
- ▨ Slope
- TT Too Tight

Wittenberg University Speleological Society

KMK

Figure 1. *Map of Bacon Flat Arch and Pit.*

The northernmost of these five caves is Tall Stack Cave, having its entrance (Fig. 10) only a few meters to the northwest of Short Stack Cave. The 2.5m wide and 1.5m high entrance continues as a crawlway (Figs. 11, 12) to the west for 9.3 m, resulting in this cave being the most extensive of all "The Breakfast Caves." Some speleothem development is apparent as demonstrated by the presence of soda straws and flowstone. Springtails (Collembola), various gnats (Diptera), terrestrial isopods, and crickets (*Ceuthophilus* sp.) were noted during the survey.

Figure 2. *Bacon Flat Arch and Pit (Photograph by Kevin Kissell).*

Figure 3. *Entrance to Sausage Cave (Photograph by Bill Stitzel).*

After completing the survey of these five small caves, the intrepid surveyors headed to a restaurant in nearby Peebles where not one of them ordered any breakfast food!!

Acknowledgments

We thank the following breakfast officianados for their help in locating, surveying, and relishing (burp!) these five small but interesting (and appetizing!!) karst features: Polly Bargar, Kate Ferguson, Matt Hazelton, Holly Kellar, Linda Oxenrider, and Bill Stitzel.

Figure 5. *Entrance to Waffle Cave (photograph by Horton Hobbs III).*

Figure 7. *Entrance to Short Stack Cave (photography by Bill Stitzel)*

Figure 9. *Speleothems in Short Stack Cave (photograph by Horton Hobbs III)*

SAUSAGE CAVE

ADAMS COUNTY, OHIO

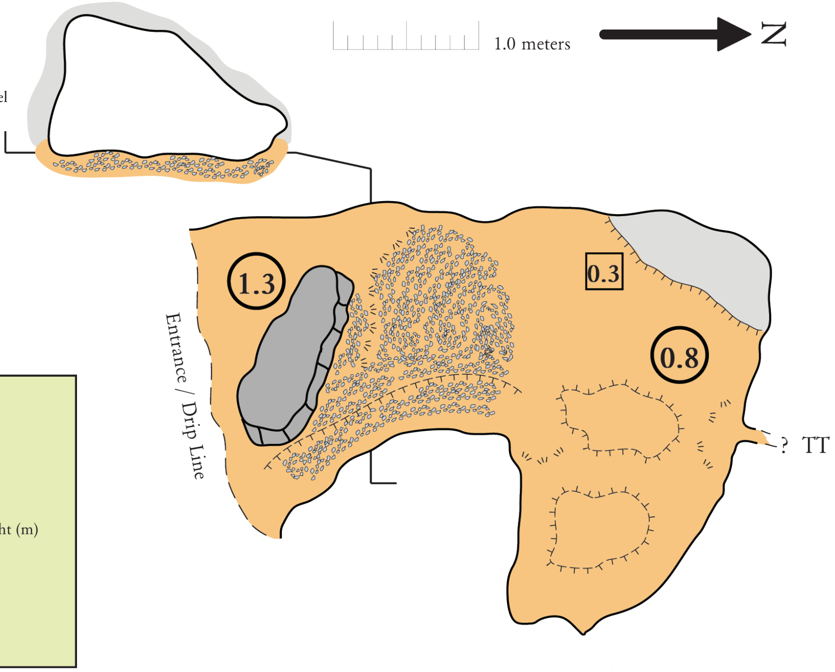
A Suunto and Leica Disto survey by:

Kate Ferguson, Matt Hazelton, Kevin M. Kissell & Bill Stitzel

07 June 2007

Total Surveyed Length - 4.7 meters

Cartography by Kevin M. Kissell
In Cave survey program - Auriga (www.speleo.qc.ca/auriga)
Data processing - Compass for Windows (www.fountainware.com/compass)
Illustration software - Adobe Illustrator CS 2



LEGEND

Bedrock	? Lead
Breakdown	Ledge
2.5 Ceiling Height (m)	0.5 Ledge Height (m)
Ceiling Ledge	Sand
Cobblestone	Slope
Dome	TT Too Tight

Wittenberg University Speleological Society

Figure 4. *Map of Sausage Cave.*

WAFFLE CAVE

ADAMS COUNTY, OHIO

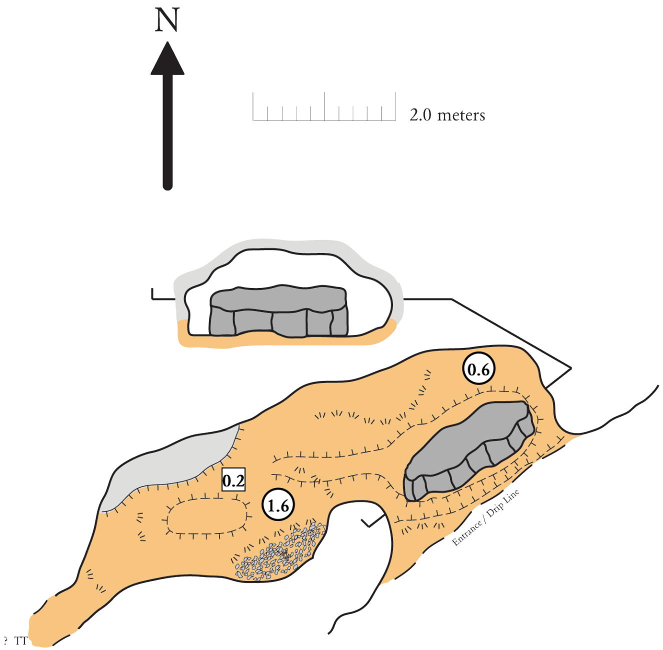
A Suunto and Leica Disto survey by:

Kate Ferguson, Matt Hazelton, Kevin M. Kissell & Bill Stitzel

07 June 2007

Total Surveyed Length - 5.0 meters

Cartography by Kevin M. Kissell
In Cave survey program - Auriga (www.speleo.qc.ca/auriga)
Data processing - Compass for Windows (www.fountainware.com/compass)
Illustration software - Adobe Illustrator CS 2



LEGEND

Bedrock	? Lead
Breakdown	Ledge
2.5 Ceiling Height (m)	0.5 Ledge Height (m)
Ceiling Ledge	Sand
Cobblestone	Slope
Dome	TT Too Tight

Wittenberg University Speleological Society

Figure 6. *Map of Waffle Cave.*

Figure 10. *Entrances to Short Stack (left) and Tall Stack (right) caves (photograph by Bill Stitzel).*

Figure 11. *View of interior of Tall Stack Cave (photograph by Kevin Kissell).*

Literature Cited

Balcom, Betsie J. and Richard H. Yahner. 1996. Microhabitat and landscape characteristics associated with the threatened Allegheny Woodrat. Conservation Biology, 10(2):515-525.

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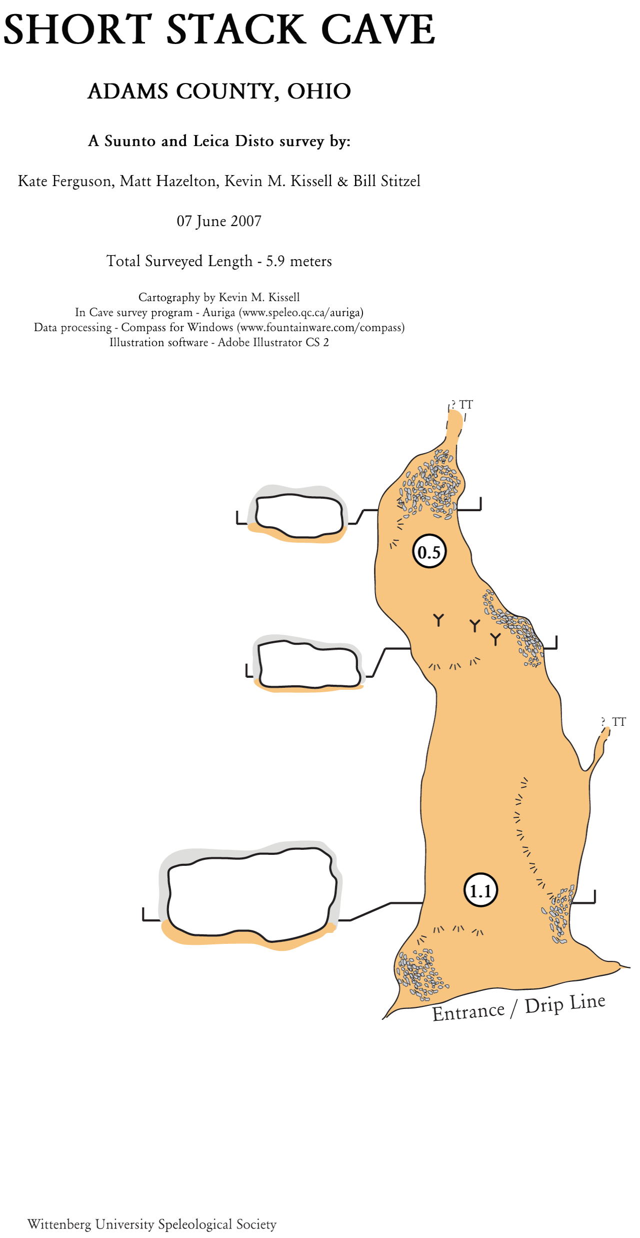


Figure 8. *Map of Short Stack Cave.*

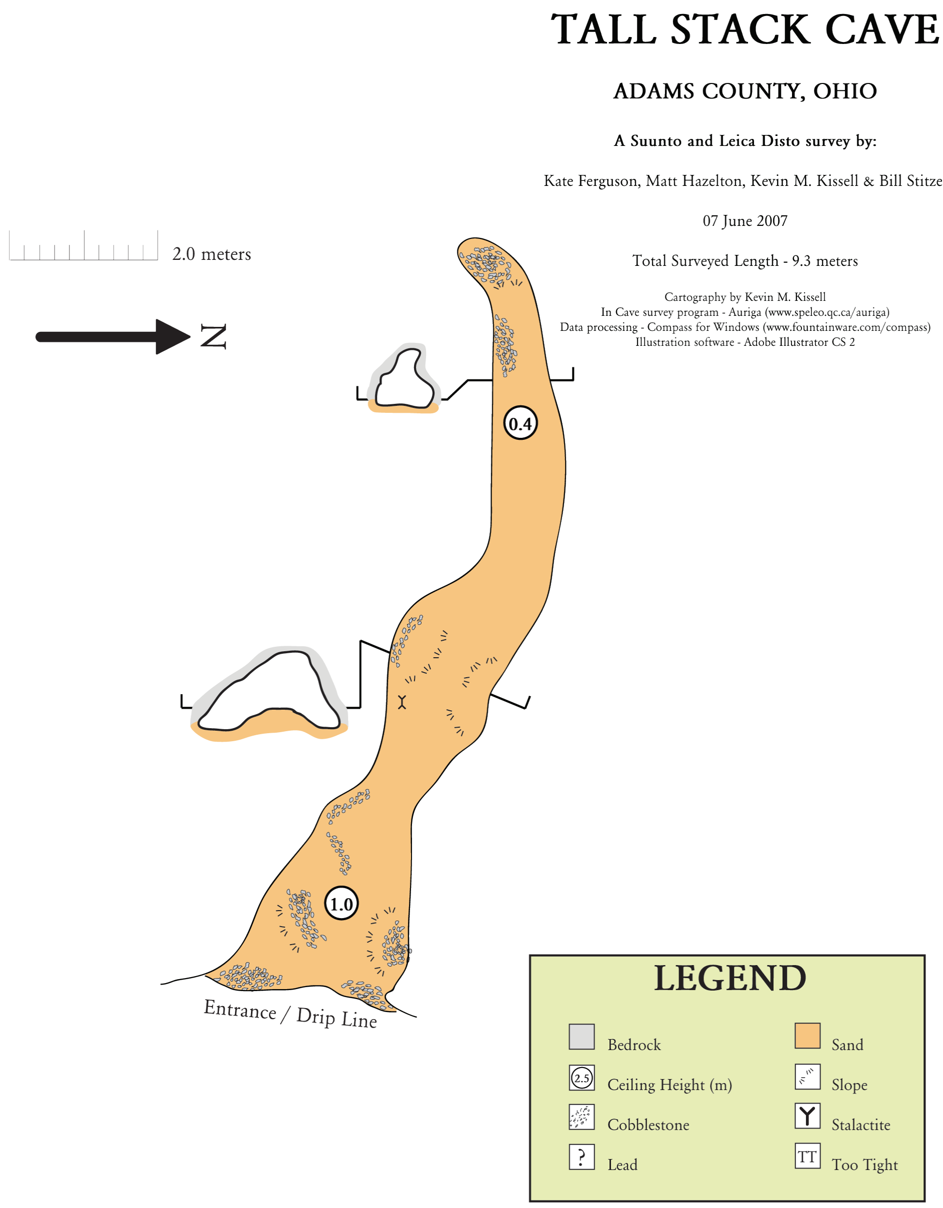


Figure 12. *Map of Tall Stack Cave.*

More Thoughts From A First-Time Caver: Facing Fears

Chad Rigsby (WUSS #576)

"Oh sure, this is fun. These crazy SOBs LIKE doing this?" were my thoughts as I re-entered the cave from what was supposed to be the exit. I had shut the door and couldn't see the empty blackness anymore. That's right; at least when I had the door open I could SEE that there was nothing there, now I just flat-out couldn't see. Isn't this where Frodo Baggins found Gollum? Didn't Gollum want to eat Frodo? Great. Walking down the stairs (death-gripping the handrail the whole way) I looked down the passage toward where I thought Hobbs and Bill were waiting for me. Ha! That's funny, looking… Looking at what? My headlight was turned on, but having been out by the spaceship (Hobbs' Armada) for the last 30 minutes had done my eyes a disservice; I just couldn't see a damn thing. I cranked up the light on my helmet so I could at least see the wall I was about to run into but I was low on battery power and the blinking light was sure to give me a ceasure down here. Jeez, this would be the worst place to sprain an ankle or something. I had to crank my light down to the lowest level, "just put it on the lowest level, you'll have light forever" Bill had said earlier. Thanks Bill, I'll remember you right before Gollum eats me. The hard, rocky surface turned into sand pretty quickly and I looked up for the bat that we had seen on the way out. It was gone. "Smart lad", I thought as I kept walking. I like bats, they are like little flying puffballs. Or rats with wings… The sand started taking me uphill at a pretty steep angle and I hit my helmet on the ceiling, or was it the wall? For all I knew I could have been walking on the ceiling. Well, I didn't hit my head on a wall on the way out of here so that must mean I'm going the wrong way. I turned around and went back about 30 meters and found another fork. My eyes were at least able to make that out by now. After about 10 meters of walking a meter every 5 seconds I ran into a nice pool of water. Crap. I didn't come from this way either unless I swam. Back the other way… Climbing up the sand hill I was sure to watch my head and dove over to the other side of the hill where I rolled down about a 2 meter slope. "That would have been a nice Abbott and Costello bit" I thought, dusting myself off. Crouching there with about 3 feet of clearance, "I am in the WRONG place" I thought. Chad, you are extremely claustrophobic, deathly afraid of heights, and constantly thinking about how the billions of tons of rock are just waiting to fall on you and squish you. Ugh… Taking inventory of the new scenery (or lack thereof), there looked to be two directions: to the left and to the right. Fumbling ahead I heard the gurgle of the stream. After another couple of head-bumps I made my way to the stream and turn to head downstream. By now I heard the low tones of voices coming from downstream. I never had been so greatful to hear Bill's cackle (Bill doesn't laugh, he cackles). I recognized where I was now. Walking about 10 meters paralleling the stream I saw the glow of headlamps and the "Ah, you made it!" from Hobbs. I jumped over the stream where it crossed over the path (didn't come all this way to screw up my experimental site). "Yep, just came back for my pack". "Oh, well we'll be here" said Hobbs. Smartass. I turned around and went back.

Even being the synical person I am, I am very proud to be a WUSS. My freshmen year I did some work with Jay Yoder here at Witt and he told me once that I should really think about caving. What?! Is this guy crazy? Why would I want to crawl around in a cave? Looking back now as a senior, I wish I would have taken his advice. When I came to Wittenberg, I admit I was pretty pathetic. I was the video gamer who sat playing Madden, taking a lunch break, and then going back to Madden all day. I was (and still am) claustrophobic to the max and afraid of heights like no other (just ask Kevin Kissell). It wasn't until the spring semester of my junior year when I met Holly Keller. One of the most fun and wonderfully wicked people I know. She told me to come to a cave club meeting one day, and I didn't go. She asked again the next week, and I didn't go. Finally on the third try she got me to go. That first meeting wasn't what did it for me, no, no. The thing that did it for me was a few weeks later when she texted me and told me to get my butt up to Hobbs' office to learn how to rappel. Ok whatever, I love ya Holly and I got an hour or so free so why not. It didn't hit me that rappelling means rappelling. So 40 minutes later I was dangling by some damn harness that was 5 sizes too tight (I tightened it that much intentionally), cutting off circulation, and pinching those "crochy" places fairly uncomfortably. But I could deal with the uncomfortableness, as long as this damn thing kept my 160lb (ok, 170lb) butt hovering 40 feet above the ground like it was supposed to. So there dangling on a rope on the verge of tears (with Holly, Travis, and Kevin surely taking some pleasure in my suffering) busts in Hobbs through the stairwell door, "So how's it going?!" he booms. "Shut up! Just shut up!" is all I could muster back. The point is that I did it. I climbed in a cave, I have squeezed in some uncomfortable places (at least to me), I have dangled in mid-air and I would have never done this even a year ago. This is what WUSS does to us. For us. For me at least. When Hobbs took his stream ecology class to Virginia for a field study, he took us up to a place called wind rock, essentially a cliff overlooking a valley. Goodness knows how many feet straight down, windy, perfectly named. I climbed up to the edge and chose a nice seat to watch the sunset, my legs almost dangling over the edge. Geez Chad, aren't you afraid of heights?!" asked another student. At first I didn't know how to answer. Yes, of course I was afraid. But then it hit me. "Well" I said "I have faced a lot of fears recently" and left it at that. I thought of Hobbs, Holly, Bill, Kevin… and WUSS.

Trips:
Judy Woosley of The Louisville Grotto/Speleofest Committee

May 26-30, 2011, Memorial Day Weekend: 40th Kentucky Speleofest hosted by The Louisville Grotto at the Lone Star Preserve, Bonnieville, KY. Please join us and bring old pictures, stories and help us celebrate 40 years of wonderful caving memories with old and new friends. We will have a food vendor, On Rope 1, camping, warm showers, howdy party with DJ, banquet, live band, kayaking, hiking, cave social, orienteering, geocaching, lots of children activities, 2 guest speakers, door prizes, wet-in-wild cavers decon speleo slide, first burning cave man bon fire, party camp and a vertical class. This year we are offering several new caves. All caving will be based on the most current information from the KY Fish and Wildlife. For more information check out our website: louisville.caves.org

Necrology

Horton H. Hobbs III (WUSS #0001, NSS #12386 HM, CM, SC, FE)

In January 2011 I walked down to my mailbox as I do nearly every day and pulled out a pile of mostly junk mail to get recycled. As I went through the stack, I was shocked and saddened to see a returned Christmas card that I had sent to Warren Luther with "deceased" written across the front of the envelope.

Warren Luther, circa 1960,
Wittenberg University Archives

Warren Phillips Luther (WUSS #0113, NSS #2438) was a 1961 graduate of Wittenberg University. He grew up in northeastern Ohio where he developed a passion for the sandstone caves and shelters of the area. He attended Wittenberg from fall 1957 to spring 1961, graduating with a Bachelors of Music. He was active with a group of students who purchased helmets and lights and went caving, the assemblage a precursor of WUSS. He was involved in some work associated with Tom Barr's 1961 book, *Caves of Tennessee*, and a picture of him lies between the covers (possibly page 191, Figure 55, in Custard Hollow Cave, Franklin County, and/or page 354, Figure 91, in Alexander Cave, Perry County, TN, and/or page 452, Figure 120, in Big Bone Cave, Van Buren County, TN?). During the early 1970's Warren took on the task of summarizing what was known about caves within Ohio and wrote a number of articles concerning his findings, some of which were subsequently published in *Pholeos* (eight articles from 1988 to 1991 and he was Guest Editor of *Pholeos* for both issues of volume 10). Today these publications still serve as the primary sources of information about certain areas of the state, particularly those caves in northeastern Ohio.

Although I am not absolutely certain about the date, I believe that it was during 1985 that Warren returned to Springfield and became an integral part of WUSS. He attended meetings regularly, hung out with students, and even lived close by at 480 N. Wittenberg Ave, Apt. 3. He got around in a pretty beat up old Chevette and although he no longer went caving, he was a resource for information and an inspiration to budding cavers. No one could ever forget his tall lanky build, topped with a French beret chapeau (hat), and sporting a violin case. Sometime during 1992 he moved to Kansas City, Missouri to be with his ageing parents who were in ill health. During the following years after his parents passed, he talked often about moving back to Springfield but his health deteriorated and financially he was not able to make the move and remained in Kansas City until his death in 2010 at the age of 71.

Warren was a likeable, somewhat eccentric individual, who had a wonderful sense of humor, and was one of the brightest individuals that I have known. I will miss his random calls in which he always started the conversation with, "Hello Professor Hobbs. How are you and how are Ohio caves?" He certainly was a proponent for studying the caves of the state and probably was the most knowledgeable person concerning their distribution, likely occurrence, and although not a trained scientist, had a marvelous understanding of the various forms of speleogenesis exhibited throughout the carbonate and non-carbonate caves.

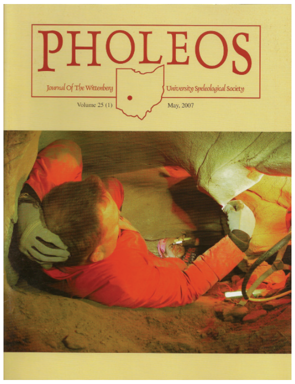
WUSS has lost another intrepid explorer. I am sorry that most of you who are reading this never had the opportunity to get to know him. He was a unique and highly talented individual. I will miss Warren...

NSS Awards for 2009 and 2010

Every year at the annual National Speleological Society (NSS) convention, the NSS recognizes members for their contributions to the Society's goals of exploration, scientific study, artistic expression, and conservation of caves. For the past two years members of WUSS have been the recipients of various awards and are noted below.

2009:

COVER ART SALON –
Photographic Category Honorable Mention



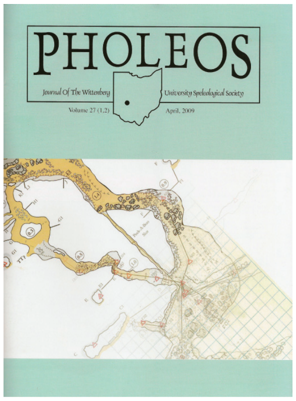
Pholeos, 25(1)
Layout/Design: *Emily Fink*
(NSS #56975, WUSS #0534);
Photography: *Kevin Kissell*
(NSS #54578, WUSS #0530)

THE SCIENCE AWARD –

Horton H. Hobbs III
(NSS #12386, WUSS #0001)

2010:

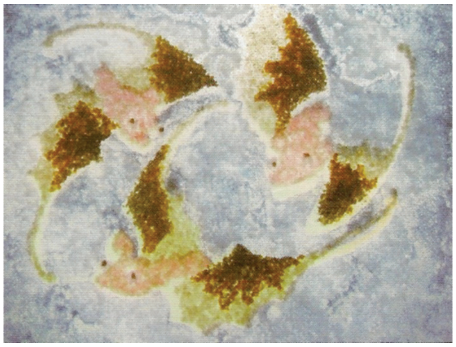
COVER ART SALON –
Computer Enhanced Category Merit Award



Pholeos, 27(1,2)
Layout/Design: *Kevin Kissell*
(NSS #54578, WUSS #0530);
Photography: *Kevin Kissell*
NSS #54578, WUSS #0530)

FINE ARTS SALON –
Mixed-Media Category Merit Award

Glass 1 – Vittoria Curl
(NSS #23500, WUSS #0497)



INFORMATION FOR CONTRIBUTORS

PHOLEOS
Journal Of The Wittenberg University Speleological Society

EDITORIAL POLICY: Manuscripts treating basic research in any aspect of speleology will be considered for publication. They must not have been previously published, accepted for publications, or be under consideration elsewhere.

All manuscripts are to be in English. Metric and Celsius units must be used, and SI units are preferred. The CBE Style Manual, the Handbook for Authors of Papers of the American Chemical Society, and Webster's Ninth Collegiate Dictionary are useful guides for matters of form and spelling.

The original of the manuscript must be typed double-spaced on one side of white bond paper approximately 8.5 x 11 inches, leaving margins of one inch. Use triple-space above headings.

The most effective way to submit a manuscript is as an attachment to an e-mail message sent to the editor. A second approach is to submit three (3) hard copies of the manuscript, figures, and tables along with a CD-ROM of the manuscript, figures, and tables in separate files.

Number pages consecutively at the top right-hand corner. Underline scientific names of genera and lower categories. Acknowledgments should be on a separate, double-spaced page. Each figure and table must be referred to in the text. Text references are by author, followed by year of publication.

The sequence of material in the manuscript should be as follows.

1. The *title* page should include the title, author's name, affiliation, WUSS and NSS membership number, and mailing address.
2. The *abstract* should not exceed one double-spaced page. It should contain a summary of significant findings and note the implications of these findings.
3. The *introduction*.
4. *Methods and materials.*
5. *Results.*
6. *Discussion*.
7. *Literature Cited*. List all publications referred to in the manuscript alphabetically by first author on a separate sheet of paper (double-spaced). Each citation must be complete, according to the following examples:

   Journal Article:

   Peck, S.B 1974. The food of the salamanders *Eurycea lucifugá* and *Plethodon glutinosus* in caves. NSS Bulletin, 36(4): 7-10.

   Book:

   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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