PHOLEOS

JOURNAL OF THE WITTENBERG UNIVERSITY
SPELEOLOGICAL SOCIETY

Volume 13 (2) August, 1993

The Wittenberg University Speleological Society

The Wittenberg University Speleological Society is a chartered internal organization of the National Speleological Society, Inc. The Grotto received its charter 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.

The National Speleological Society

This is to certify that

Wittenberg University Speleological Society

having fully complied with all the requirements established by the Board of Governors, and having accepted the responsibility which such status entails, is hereby chartered in the National Speleological Society, and is entitled to all due rights and privileges: in testimony whereof the President and the Chairman of the Internal Organizations Committee have hereunto set their hands and the Seal of the Society, this 14th *day of* May, 1980.

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G-268
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Cover: Students investigating inland blue hole, San Salvador Island, Bahamas. Photo by Horton H. Hobbs III.

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SUBSCRIPTION RATE: 1 Volume - $5.00 (2 issues), Single issue $3.00. Send to Grotto address.
EXCHANGES: Exchanges with other grottoes and caving groups are encouraged. Please mail to Grotto address.
MEETINGS: Wednesday evening, 7:00 p.m., Room 206, Science Building, Wittenberg University, Springfield, Ohio.

Editors' Note

As editor of *Pholeos*, I would like to extend a warm welcome to all of our subscribers. This edition contains many exciting, interesting articles which you are guaranteed to enjoy. Our feature article concerns oceanic blue holes and was written by Megan Porter, a biology student here at Wittenberg University. Another study in this edition is Jeff Lapp's work in Bat Cave, Kentucky, on the drift of *Gammarus minus*, an amphipod. The remaining articles are reports of our members' experiences and two records of "first caving experiences." Also included are pictures revealing some of the work W.U.S.S. has been involved with. As I leave you to read this issue of *Pholeos*, I encourage you greatly to send in the attached membership form either to continue membership or start it for the very first time. Happy Caving!!!

– Jason Bauserman

A special congratulations goes out to Mike Hood (Dayton, OH), Andrea Futrell and Mike Futrell (Springfield, OH) for being named Fellows to the National Speleological Society. This is a distinguished award for cavers. All three of these recipients are past due for this recognition. Also, Horton Hobbs received (along with Dave Culver of The American University) a Certificate of Merit for their work in cave conservation at the Cave Biology Field Camp offered during the past three summers in West Virginia. Once again, congratulations and a job well done!

The die-hards for WUSS in 1992-1993; this was the last meeting of the term, during which Frank Reid gave an excellent discussion on the use of electronics for caving.

The Formation and Biota of Inland and Oceanic Blue Holes

by
Megan Porter

ABSTRACT

Blue holes are formed by a combination of the dissolving of limestone at the halocline (the freshwater/saline water interface), the enlargement of fracture-controlled caves by the intersection of the fracture and the halocline, and by normal (dry) cave development during sea level lowering during Pleistocene glaciations. The environment of a blue hole is a limited ecosystem and is discussed in terms of current speed and direction, salinity, temperature, concentration of oxygen, the halocline, and the discovery of Remipedia, a new class of crustaceans.

INTRODUCTION

One of the problems with studying blue holes is the lack of a widely accepted definition of the term. There are many conflicting definitions of the term "blue hole." According to Warner and Moore (1984), blue holes are the entrances to complex cave systems that lie beneath the islands of the Bahamas. According to Mathews (1991), blue holes are vast cavernous sinkholes beneath the sea. According to Smart (1984), a blue hole is a lake deeper than the thickness of the freshwater lens. For this paper, the term "blue hole" represents a flooded cave system formed by solutional dissolving of limestone at the halocline and by normal, dry cave development during the sea level fluctuations of the Pleistocene glaciations.

In terms of geography, there are two types of blue holes: i) inland blue holes, or cenotes, and ii) oceanic blue holes, or boiling holes.

The inland blue holes, or cenotes, are circular, often deep shafts that bell out beneath the surface into a wider cavern. Few cenotes have evident horizontal cave development associated with them (Farr and Palmer 1984). Some inland holes are also referred to as anchialines - pools with no surface connection to the sea, containing brackish water, which fluctuates with the tides (Iliffe et al. 1984).

The oceanic blue holes, or boiling holes, are cave systems that open out on the surface, generally beneath sea level, containing horizontal and usually vertical development. Most boiling holes have strong tidal currents associated with them; the tide is generally 2 1/2 to 3 hours out of phase with tides at the surface (Farr and Palmer 1984). The inflow is called the "suck current" and the outflow is called the "blow current." These tidal currents carry organic material into the cave, supporting biological activity far inside the blue hole (Warner and Moore 1984).

Oceanic blue holes can be further classified into "doughnut" holes. These are oceanic holes that are encircled by a ring of coral reef growth (Palmer 1986a). The increased food supply from the inflow current can influence the formation of a doughnut hole (Palmer 1987).

In terms of cave formation, there are three types of blue holes: i) lens based, ii) cenote, and iii) fault-controlled. The majority of Bahamian caves are lens based caves, owing their morphology to the freshwater/saline water interface, the halocline. Cenotes are typically circular, deep shafts. Fault-controlled caves form where the faults, which run along the Bahama Bank parallelling the Tongue of the Ocean, are horizontally intersected by the halocline. The Tongue of the Ocean is a marine trench up to 2000 m deep that continues north from the Bahamas to the Atlantic Ocean. The intersection of the halocline and a fault-controlled cave encourages horizontal enlargement of the fracture at a particular level, or where lateral displacement of rock opens an associated void (Palmer 1986a).

Many of the cenote-type blue holes have been the result of successive aston collapse, the collapse of the roof of a cave that has formed underwater when the buoyant support of the water is suddenly removed; the sea level lowering during the Pleistocene could do this. Since Bahamian limestone is horizontally layered, this collapse can have a domino effect, with each roof collapsing into the next chamber (Palmer 1985). The result is a large, often circular, entrance to the cave system.

Most of the known blue holes are found in the limestone that composes the Bahamas Islands. Under the Bahamas Islands a lens of fresh or brackish (saline) water floats on top of the denser salt water that has permeated the islands from the ocean. The mixing zone between the two waters is called the halocline. Blue holes are the result of phreatic development within the freshwater lenses at the halocline of the Bahamas Islands (Farr and Palmer 1984), with further modification during periods of low sea levels in the Pleistocene.

The largest sea level drop during the Pleistocene was approximately 120 m between 15-18,000 years before present (Palmer and Heath 1985a). During this drop, caves and passageways that had been formed by the dissolution of limestone at the halocline were left above sea level. They were enlarged by water flowing through the passages and by acidic rain dissolving the limestone (Benjamin 1970). The blue holes were re-flooded as the seas rose at the end of these phases (Warner and Moore 1984).

METHODS AND MATERIALS

For this research, I began by reading two books on blue holes to get an understanding of the ecosystem of blue holes. From the general information that I gathered, I began looking through Biological Abstracts, starting with the most recent years and working backwards; I searched under the key terms blue hole, anchialine, and marine cave. After finding very little information through this method, I tried a CD-ROM search using the same key words. I was able to find much more information this way.

Many of the articles that I needed I found in Dr. Horton Hobbs' personal library. My search for information also included trips to Wright State and Ohio State Universities to look for journal articles that Wittenberg does not own in either Thomas Library or the Science Library.

The researchers that I am citing gathered the data conducted directly at blue holes. Whitaker and Smart (1990) used Aanderaa RCM4 recording current meters in Rat Cay and South Mastic (two offshore blue holes) to monitor flow velocity and direction, water salinity, and temperature of the current flowing in and out of the blue holes. Warner and Moore (1984) recorded the speed and direction of currents on magnetic tape using a Plessey Current Meter. They also measured the particulate organic carbon (POC) content of water samples using a wet oxidation method and an analysis performed by a carbon/sulphur determinator.

All of the researchers collecting data from the blue holes must have a high degree of skill and experience in diving, due to the extreme danger and difficulty involved in getting into and out of the holes. Special diving equipment is required for cave diving and any scientific equipment used must be bought or modified for underwater use. It is also necessary to take into the cave anything that might be needed in case of emergency, adding weight and bulk to what the diver must carry.

Specialized cave-diving equipment consists of: twin tanks, connected with a dual valve manifold; full exposure suit; multiple heavy-duty, long-lasting lights; full instrumentation; two masks, fins; specialty cave reels and lines; two regulators, one with an extra long (1.52 to 2.74 meters) hose; buoyancy compressor; knife and backup line cutter; decompression tables slate; directional line markers; and a compass (Sleeper 1990).

The twin tanks are mounted on either side of the diver, rather than on the back, for easier maneuverability. It is necessary for divers to have at least three sources of light, and use a guideline, properly anchoring it while exploring the cave. Every diver must be equipped with two regulators, one with a longer hose in case a diving partner has difficulty with his air tanks. While cave diving, divers follow the one-third rule; they plan on using one-third of the air in the tanks to enter the cave, one-third of the air to exit, and save one-third for safety precautions.

In blue holes that have alternating current cycles, divers need to time the dive around the phases of the current in order not to get caught trying to exit the cave during the height of either the suck or the blow phase. During the suck phase it may be impossible to swim out of the cave against the strong current; during the blow phase the current may be strong enough to pull a diver out of a cave before he has time to decompress.

STUDY AREAS

The majority of the blue holes that have been explored and mapped have been in the Caribbean, specifically in the limestone that makes up the Bahama Banks. The Bahama Islands (Figure 1) are the above-water parts of this chain of limestone platforms, or banks, stretching in a 1206.75 km arc southwest of Florida (Benjamin 1970).

The limestone that makes up the Bahamas has never been folded, uplifted, or otherwise altered from the horizontal sheets of accumulated marine sediments that form the base of the entire Bahama Banks (Palmer 1987). These accumulated sediments represent one of the most tectonically stable limestone provinces known (Palmer 1986a).

The Great Bahama Bank is an extensive limestone plateau with origins that date back to the early Cretaceous Period, of which the upper 120 m have been exposed during several periods of glacio-eustatic activity within the Pleistocene. The part of the Banks above the water, the Bahama Islands, support a series of freshwater lenses which are replenished by heavy rains (Palmer 1986a).

Andros is the largest of the Bahamas, lying on the western side of the u-shaped Great Bahama Bank. Its surface rock, to a depth of approximately 12 m below mean sea level, is composed of oolitic and ooliclastic limestones, and below that, to a depth of approximately 160 m, of fossiliferous limestones. Beneath that, limestones continue at least 5000 m (Palmer and Williams 1984). There are at least 2000 blue holes on Andros Island, including entrances offshore (Palmer 1986a).

RESULTS

A limited ecosystem is defined by the biotic and abiotic factors of an ecological community that are restricted by confining physical and chemical parameters. Due to the physical isolation of the environment and limiting factors (the halocline, tides, lack of light, low oxygen concentrations, and salinity), blue holes are considered a limited ecosystem.

The salinity of water discharging from South Mastic Blue Hole reaches a maximum of 38 - 39 parts per thousand (ppt) at the end of the blow phase, which is approximately 4 0 ppt more saline than the water drawn into the cave during the suck phase. In Evelyn Green's Blue Hole (Figure 2), salinity remains constant at approximately 10 ppt above the mixing zone; measurements increase dramatically when passing through the halocline, but level out again after the mixing zone at about 39 ppt (Smart et al. 1988).

Bermuda cave temperatures are close to 15° C at the surface and then rise to near oceanic winter isotherm of 20° C as depth increases. Temperature profiles of the inland blue holes, Big Fountain, Gaitor's Hole, and Mermaid's Pool, are given in Figure 3. The surface temperature of Church Cave (Figure 4) on two different dates varied from approximately 16° C the first day to approximately 18° C the second. However, the temperature recorded deeper in the cave stayed constant both days at approximately 20° C (Hobbs 1985).

Oxygen concentration decreases with depth. In Church Cave, the surface water is close to 100% saturated with oxygen. As depth increases, the oxygen saturation levels out at approximately 60%. In polluted Government Quarry Cave, the oxygen saturation decreases to 0% at a depth of 1 m and then increases with depth to approximately 30% (Figure 5).

Warner and Moore (1984) found current cycles in Conch Sound 1 (CS1) to have no obvious pattern, but it should be noted that: i) current speeds were greatest when tabulated tides were at high and low extremes, ii) there was a greater variation in the peak current speeds during suck phases than during blow phases, iii) peak current speeds during blow phases were consistently greater than during peak suck phases during the same cycle, and iv) if the area under the curve in Figure 6 is proportional to the volume entering or leaving CS1 during that phase, then the total volume of water discharged during the two days of recording was greater than the total volume sucked in.

Stargate Blue Hole has distinct zones. From the surface to a depth of -5 m, temperature changes in response to surface temperature because of wind-induced mixing and evaporation. Salinity and temperature rise at -5 m and then correspondingly fall and stabilize at -10 m. Salinity and temperature are stable from -10 m to -16 m. There is a sharp increase in salinity and temperature (24° C to 25° C) from -16 m to -22 m. This narrow zone of rapid increase occurs at the halocline, beneath which the water becomes static (Palmer 1986b).

The halocline, typically being 2 to 10 m thick, acts as a barrier, catching organic detritus on the denser salt water beneath the mixing zone. The mixing zone waters were highly colored, with hydrogen sulphide present in the lower parts (Smart et al. 1988).

Yager (1981) discovered a new Class of Crustacean in Lucayan Cavern (an anchialine cave on Grand Bahamas Island, Bahamas), the Remipedia (from the Latin Remipedes meaning "oar-footed"), at this level; it travels between the halocline and the denser, static saline water underneath. Remipedes inhabit other caves that are characterized by layers of increasingly saline water and have been found only in caves with a dissolved oxygen concentration of less than 1 ppm. The geographic distribution of Remipedes are concentrated in the Bahamian archipelago (Yager 1987). The physical and chemical parameters of the caves Remipedes have been found in are described in Table 1. Of this new class, new species, genus, and families have also been found, including *Speleonectes lucayensis*, of the family Speleonectidae (from the Greek words spelaion, meaning cave, and nectes, meaning swimmer).

DISCUSSION

Formation of Blue Holes

Several factors influence cave development beneath South Andros: i) the position of massive fractures running parallel to the Tongue of the Ocean; ii)the halocline plays a large role in the basic horizontal morphology of the Bahamian caves; and iii) vertical morphology can be modified during glacio-eustatic changes (Palmer 1986b).

Slump faulting, associated fractures, and fracture-controlled caves that run parallel to the Tongue of the Ocean are closely associated with anchialines. Mixing zone activity at the base of ancient lenses has preferentially enlarged these pre-existing weaknesses through solution and associated wall collapse (Palmer and Heath 1985b).

Rainwater collects underground in lens-shaped reservoirs; these freshwater lenses sit atop a layer of denser salt water that has saturated the rock beneath the island surface. At the halocline, where these two waters mix, the limestone is dissolved. Tidal flow carries the limestone out to sea, more fresh water flows down, and more limestone is dissolved (Palmer 1987). Because both the fresh and saline layers of water are already pre-saturated with $CaCO_3$, no dissolving of the limestone in these layers takes place. At the halocline, however, there is a major density gradient produced by the mixing of the freshwater and the denser, saline water. Thus, the halocline is the site of limestone dissolution, with the addition of other key factors.

First, organic materials tend to accumulate on the top of the denser salt water found at the bottom of the halocline. At this location, bacteria that can tolerate low oxygen concentrations break down the detritus, releasing organic acid and carbon dioxide. The carbon dioxide reacts with water to form carbonic acid. This carbonic acid is the reason for the more aggressive water found at the halocline. Secondly, rapid recharge of the freshwater lens at times of heavy rainfall enhances the mixing process at the halocline, encouraging the removal of limestone in solution (Palmer and Williams 1984). Lastly, the decreased saturation levels of dissolved aragonite, calcite, and dolomite also indicate the aggressive water type found at the halocline (Figure 7).

Lowering of the sea during the present epoch left sections of the developing cave system above the water level. During this time, these parts of the blue holes developed like normal, drier caves. There is evidence for this in the speleothem formations found in many of the Bahamian blue holes, indicating they could only be formed if the cave was once above water.

Tides

The tidal currents of oceanic blue holes have not yet been explained. Whirlpools are formed on the suck current; a clear upwelling of water forms on the blow current. One theory, according to Benjamin (1970) is that the freshwater lens resembles a piston in a cylinder.

The tides of oceanic blue holes have created a curious phenomenon; the total volume of water blown out of a cave was recorded to be greater than the total volume sucked into the cave, indicating there is an apparent net loss of water from blue holes (Warner and Moore 1984). This additional water could come from the depths of the Tongue of the Ocean. It is possible that cold sea water is drawn in through cracks or tunnels in the face of the Wall of the Tongue of the Ocean and, by geothermal warming, be pushed upward and discharged through blue holes (Benjamin 1970).

The suck current consists of surface water, often slightly turbid, containing plankton, detritus, and silt. The water also has normal surface temperature, salinity, and chemical composition. In comparison, the blow current is limpid, usually slightly cooler than the surface water, and may contain dissolved hydrogen sulphide. As a result, suck current serves as the main nutritive input in oceanic blue holes carrying organic debris, plankton, and algal fragments into the holes. Organisms deep within marine caves depend on the suck current to carry in food because the absence of light limits photosynthetic organisms to the entrance of the blue holes (Warner and Moore 1984).

Biota of Blue Holes

The blue holes of the Bahamas form one of the oldest and most continuously stable environments in the world; they are relics of the Pleistocene Bahamas (Palmer 1987). The origins of the blue holes may lie in Pangea, the ancient continent that spread apart and split into fragments, forming the modern continents. When Pangea broke apart and the Atlantic Ocean began to form, limestone sediments shaped the Bahama Banks. The direct ancestors of the species found in marine caves today may have been present in the fissures of the early limestone.

Today, Bahamian cave life exists for the most part within a narrow range of chemical and physical parameters, dependent on the organic overburden for its primary food source causing the number of endemic species to increase with distance into the cave (Palmer 1986c). In oceanic blue holes there is definite zonation in blue holes due to these parameters. The richest zone in, and near, the entrance, is the daylight area (Palmer 1985). The daylight zone is where there is the most food, sunlight, and access to the open sea (Palmer 1985). Also, most fishes do not go further than this zone.

The next zone is the transitional zone, which is between total darkness and the entrance where some light still filters into the cave. In the transitional zone, the walls may be covered with sponges, coral polyps, and anemones competing for the nutrients carried into the cave by the inflowing current (Palmer 1985). Inflowing currents have been found to contain more planktonic organisms and fresh algal detritus, as well as higher concentrations of particulate organic matter than outflowing currents, which contain more fecal material and sand (Warner and Moore 1984).

With increasing distance into the caves, life becomes less apparent. Corals and hydroids are the first to disappear as the flow carrying the organic material, or detritus, they feed on dissipates into the numerous cracks and fissures of the cave. Small crustaceans, such as ostracods, feed directly on detritus and live close to the primary halocline, seemingly able to integrate through it in search of food. Amphipods, shrimps, and a few of the larger crustaceans feed on both small crustaceans and detritus. At the top of the food chain is the new class of crustacean, Remipedia, and the blind cave fish, *Lucifuga speleotes* (Palmer 1986c). This is the only, truly cave-adapted fish in the Bahama blue holes and usually is the inhabitant of the deeper saline region below the halocline (Palmer 1987).

In general, marine caves (blue holes) contain relict fauna; that is, species derived from groups that were formerly widespread and diverse, but now surviving as endemics in a particular cave system, possibly because of reduced competition or predation (Iliffe et al. 1984). The species found in caves can be classified as three distinct groups: i) cave-limited, relict species; ii) ubiquitous species; and iii) accidental species (Iliffe et al. 1984).

An example of a cave-limited, relict species would be Remipedia. The Remipedia's closest relatives appear to be those found in fossil sediments over 150 million years old (Palmer 1986c). Most of the cave crustaceans, such as Remipedia, carry their young in a brood pouch beneath their carapace to protect them from the harsh cave environment (Palmer 1987).

Ubiquitous species are those that seek out caves, but are also found outside them. Accidental species are those that are rarely found inside caves and cannot survive in that environment for long. They are often drawn into caves by the tidal current but cannot complete their life cycle within it (Iliffe et al. 1984).

The fauna of blue holes depend on nutrients from detritus. Due to surface and groundwater migration, detritus percolates through to the freshwater lens and eventually to the deeper salt water of the halocline interface. Held in suspension in the density gradient of the halocline, and helped by bacterial action, the detritus decays into an acidic, organic broth that feeds the micro-crustaceans of the cave, helping the formation of the cave by corroding the limestone (similar to carbonic acid). The nutrient broth is the bottom of the food chain (Palmer 1987).

The layer of decaying organic material that sits on top of the halocline is visible in most cenotes as a distinctive orange layer - the sulphur layer (Palmer and Williams 1984). In the lower part of the halocline, hydrogen sulphide (H_2S) is present. This, along with the highly colored mixing zone waters, suggests that the lower part of the mixing zone is anaerobic, causing bacterial reduction of sulphates to drive organic-matter oxidation (Smart et al. 1988). The optimal conditions for these bacteria are strictly defined, which dictates why they occupy such narrow zones within the blue holes (Smart 1984). The increase in H_2S content near the halocline appears to deter cave fauna from straying into the deepest region of the cave (Palmer 1986b).

CONCLUSION

Blue holes are limited ecosystems that have possible formation and biota connections dating back to the ancient continent Pangea. The halocline acts as a barrier between the freshwater or brackish lens and the deeper, static, saline waters below the mixing zone.

The discovery of Remipedia suggests that blue holes have been isolated systems for at least 150 million years. Little is known about the biota of blue holes, both due to numerous cracks and crevices organisms may live in and the difficulty in sampling these limited ecosystems.

Blue holes have had little data collected about them. There are many that have not been explored. Studying the ecosystems of blue holes will give researchers a better understanding of other isolated environments in the world.

ACKNOWLEDGMENTS

I would like to thank Dr. Horton Hobbs III for always being available and willing to answer my numerous questions, my roommate, Angela Fraifogl, for listening to the many problems I encountered while researching and writing this paper, and Steve Spielman for receiving a speeding ticket while providing transportation to and from the Ohio State University library! I am also grateful to Kristin Sholl for taking the time to proof-read my paper when no one else would.

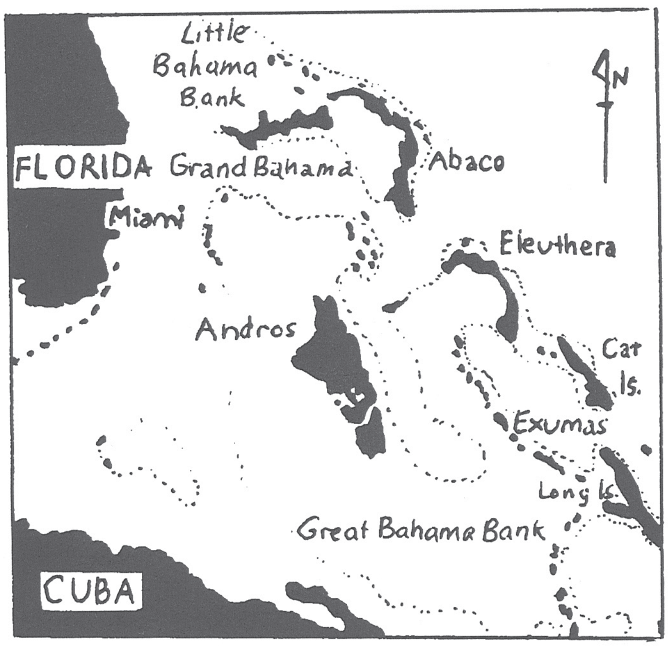

Fig. 1. The Bahama Banks (taken from Palmer, 1989).

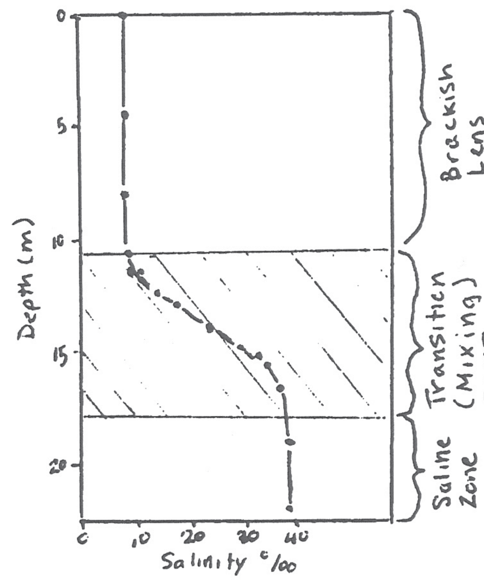

Fig. 2. Salinity profile of Evelyn Green's Blue Hole (data from Smart et al., 1988).

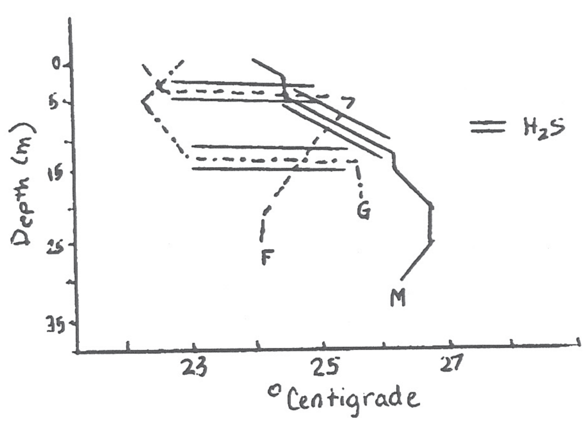

Fig. 3. Temperature profiles for Big Fountain (F), Gaitor's Hole (G), and Mermaid's Pool (M) (data from Palmer, 1986b).

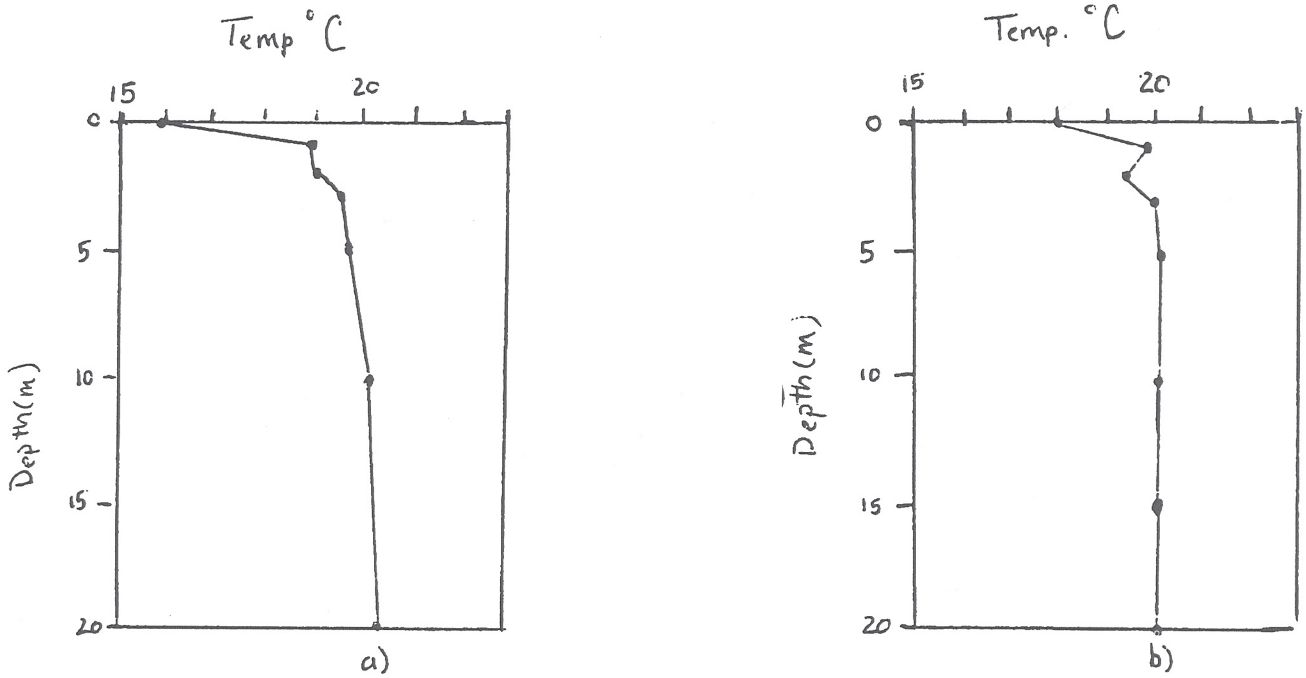

Fig. 4. Temperature profiles in Church Cave. (a) 28 February 1982; (b) 11 July 1982 (data from Hobbs, 1985).

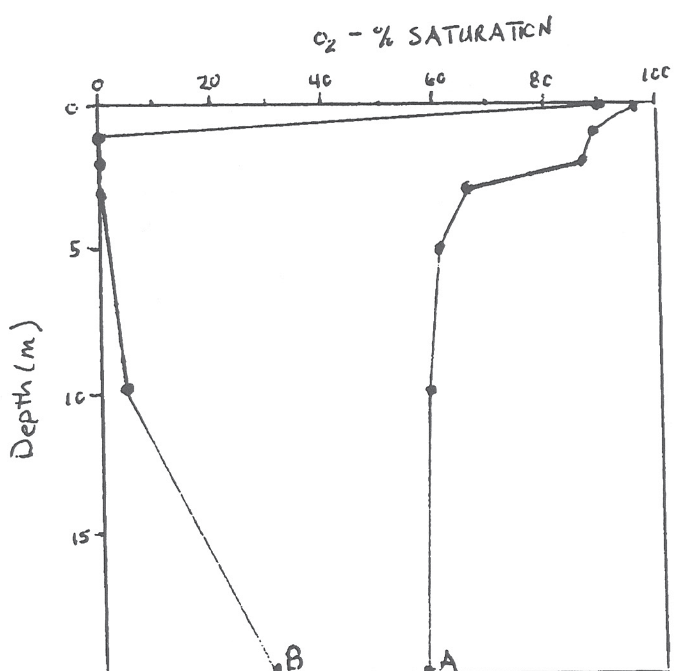

Fig. 5. Oxygen sqturation profiles from; (a) unpolluted Church Cave and (b) polluted Government Quarry Cave (from Iliffe et al. 1984).

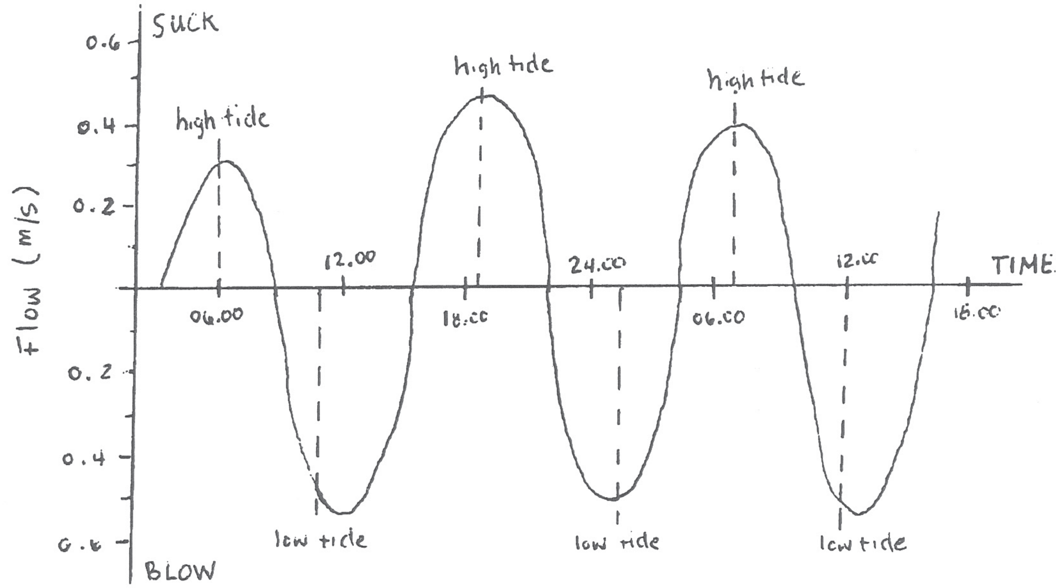

Fig. 6. Current cycles measured in CS1 from 04.oo h on 27/8/81 until 16.00 h on 28/8/81 (data from Warner and Morre, 1984).

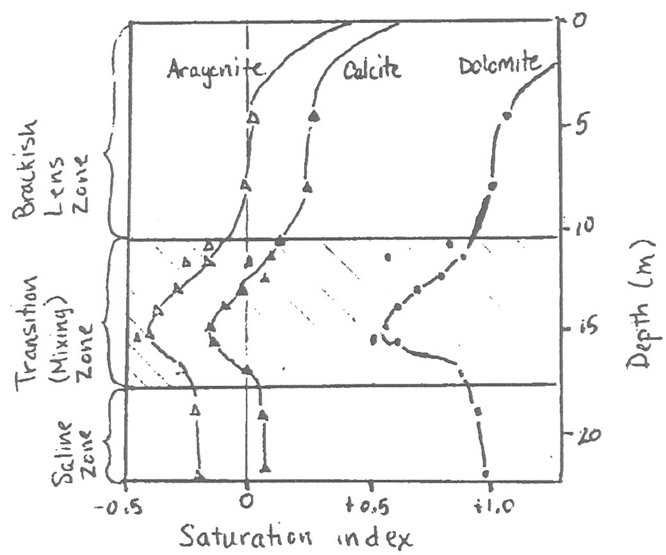

Fig. 7. Aragonite, calcite, and dolomite saturation indices in Evelyn Green's Blue Hole (Smart et al., 1988).

Table 1. Physical and chemical parameters measured from Bermuda cave pools where Remipedia have been found (data from Angel and Iliffe, 1987)

cave name	Salinity x 10 at surface	Salinity x 10 at 1m	Temperature C at surface	Temperature C at 1m	Tidal lag time (min)
1. Crystal Cave	17-22	25-27	17-21	20-22	70
2. Wonderland Cave	9-16	23-24	20-21	21	68
3. Green Bay Cave	23.6	29.5	24.9	25.4	151
4. Christie's Cave	6.9	19.5	18.2	20.4	-
5. Roadside Cave	30.2	31.8	23.0	23.7	71
6. Tucker's Town Cave	23-24	27-30	18-21	20-21	58
7. Walsingham Sink Cave	17.9	33.3	22.2	23.5	61
8. Fern Sink Cave	18.0	26.7	21.6	22.1	-

Table 1. Physical and chemical parameters measured from Bermuda cave pools where Remipedia have been found (data from Angel and Iliffe, 1987).

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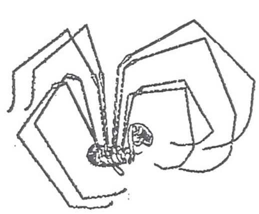


Frasier's Pits

by
Annette Summers NSS 31319R

Earlier this year, Jason Bauserman, Steven Johnston, and I walked a ridge near Canyon Cave, Carter County, Kentucky, in order to verify some pit locations on an old topographic map. The ridge was much more productive then we imagined, yielding ten pits of substantial depth, as well as numerous sinkholes (Figure 1).

Fig. 1. Area overlooking Frasier's Pits, Carter Co., KY. Canyon Cave, on next ridge, is in the distance. Photo by Annette Summers

A month later, with Toby Dogwiler, Steven Johnston, and Megan Porter, we dropped two pits. The first, Dumb Dead Cow Dome, proved to be more interesting. The landowner mentioned he had lost a cow several years before to one of the caves on his property. Upon descending the 20.40 m pit, we were witnesses to other items the cave was currently claiming as its possessions. Figure 2 shows the treasures we found; the cow is to the left of the 7-up bottle and egg carton. We held a brief moment of silence in memorial for the cow, then laughed (of course) at the noises we made trying to duplicate sounds a cow makes as it crashes to its doom!

Fig. 2. Bottom of Dumb Dead Cow Dome (Frasier's Pits), Carter Co., KY.

We were to discover later that the cow we saw was put there deliberately seven years before - to keep wild animals from eating it! Also, most of the trash was old according to the landowner. Styro-foam egg cartons, two-ply garbage bags, and old Coke and Pepsi cans convinced us he was correct.

The pit itself is large, opening into a spacious room/dome at the bottom, approximately 5 to 6 m across. The far wall is fluted and clean, showing the common cross-bedded limestone so prominent in some caves in the area. A small lead continues off to the left, however mud and trash made it very constraining. T. Dogwiler attempted at pushing it, but when the passage shrunk to 18 cm, he stopped.

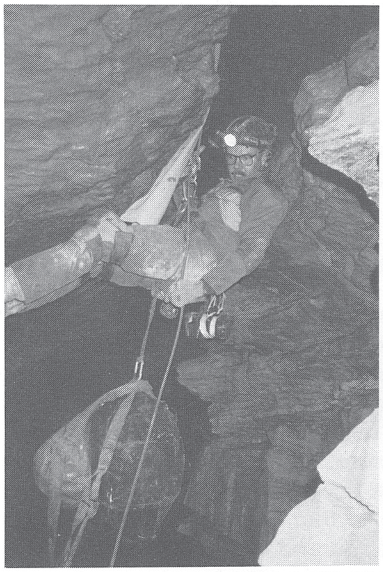
The second pit was dropped by M. Porter and S. Johnston, simply because no one else could fit inside the tiny room at the bottom. Wanna-be-a Cave is a canyon-controlled pit, with cracks continuing on both sides; unfortunately, they are not accommodating to humans. Wanna-be-a Cave is 9.13 m deep. It is decorated by flowstone down the walls of the pit (Figure 3).

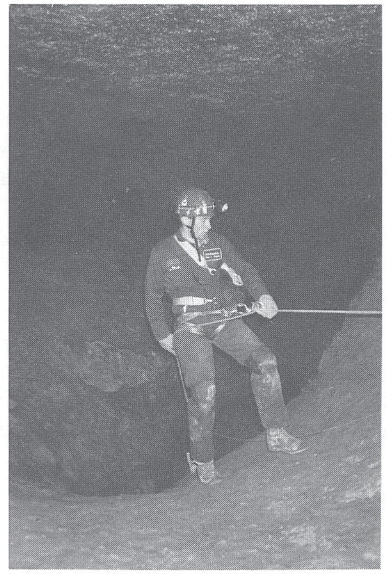
Fig. 3. Steve Johnston ascending out of Wanna-be-a-cave, (Frashier's Pits), Carter Do., KY. Photo by Annette Summers

All in all, the day was filled with fun, even if the caves did not amount to much (everyone always wishes to find the "Big One" someday). It is my hope to return again to drop several more holes, eventually finishing off work to the area.

Relations with the landowner are comfortable at this time. People living in the region are very frightened of injury to cavers in caves they own. Some landowners are extremely against cavers requesting permission to cave, and obliging them is important. Caution should be taken (as always) when doing any work in this area.

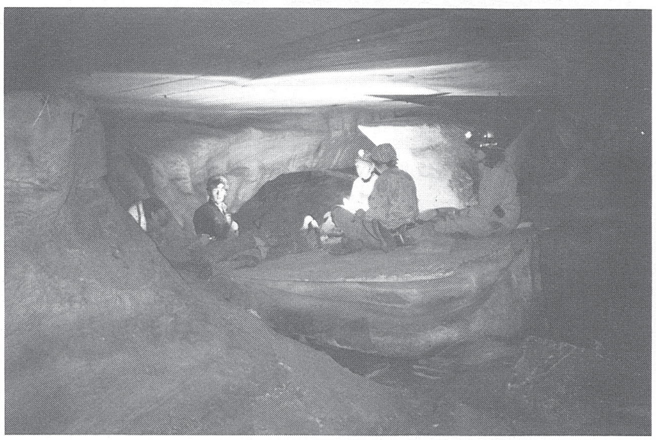
WUSS IS WORKING HARD!



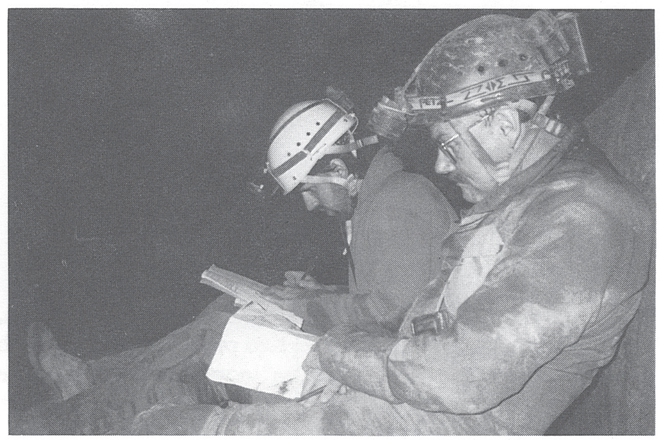


◁ Dr. Hobbs rappelling pit in Canyon Cave, KY. Photo by Dawn Fuller

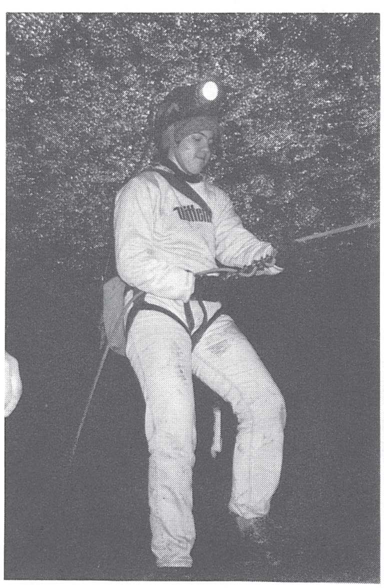
▷ Toby Dogwiler on rope in Canyon Cave, KY. Photo by Dawn Fuller.



Taking a break (from working hard on the survey) in the Junction Room, Canyon Cave. Pictured here are Scott Engel, Annette Summers, Toby Dogwiler, Megan Porter, and Dawn Fuller. Photo by Horton H. Hobbs III

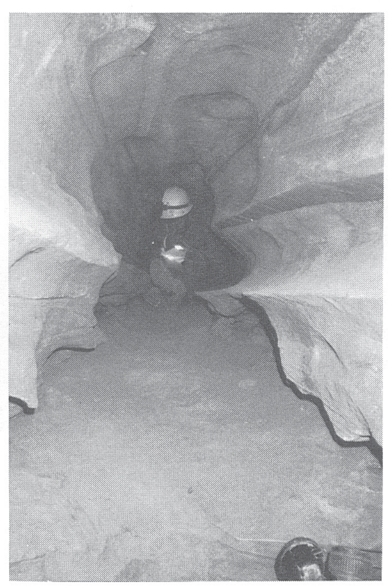


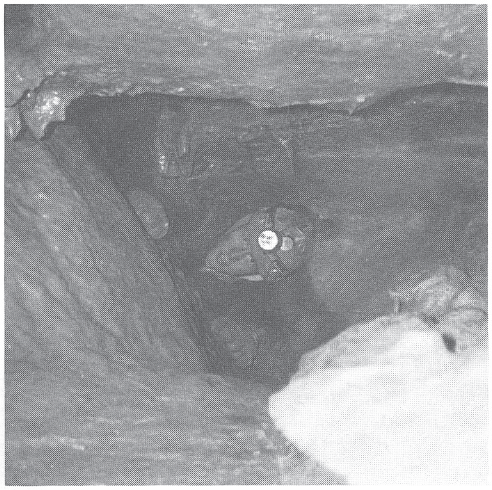
Dr. Hobbs and Scott Engel organizing survey books in Canyon Cave, Carter Co., KY. Photo by Dawn Fuller



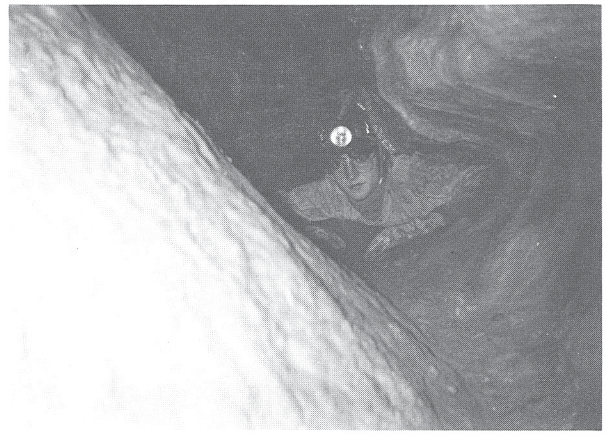
◁ Megan Porter getting ready to decend into Canyon Cave. Photo by Dawn Fuller

▷ Scott Engel doing survey work in Canyon Cave, Carter Co., KY. Photo by Dawn Fuller.

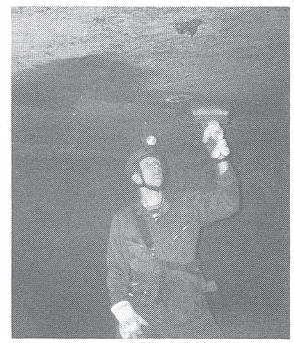




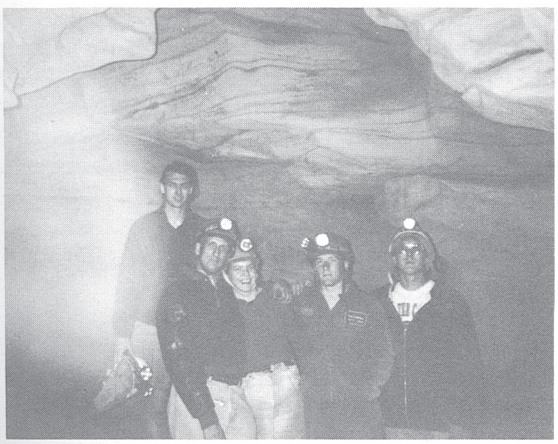
Toby Dogwiler in Doghill - Donnehue Cave, IN. Photo by Annette Summers.



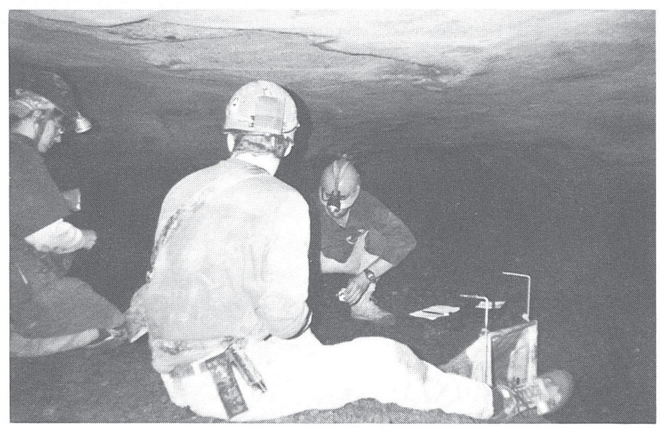
Annette Summers inching through Doghill - Donnehue Cave, IN. Photo by Toby Dogwiler.



Mike Hood in Sullivan Cave, IN, for Under Earth Day.. Photo by Annette Summers.

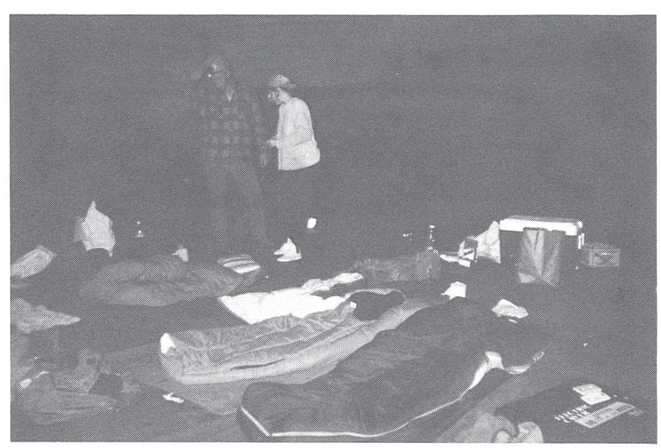


Steven Gregory Mike Hood, Megan Porter, Toby Dogwiler, and Steven Johnston having fun in Great Salt Petre Cave, Rockcastle County, Kentucky.



Annette Summers, Chris Frost, and Jeff Lapp taking measurements for the experiment in Bat Cave.

The back gate of Bat Cave, Carter Caves State Resort Park, Kentucky.



Jeff Lapp and Annette Summers at "camp" inside Bat Cave.

Responsible Caving

by
Mike Hood NSS 24166RLF

How responsible a caver are you - especially when taking someone on his/her first cave trip? Would you take them to a challenging cave with a cave pack full of beer? You're probably saying, "Of course not! That's crazy!" Unfortunately, that is exactly what I saw happen recently while touring Crooked Creek Ice Cave (CCIC), [Rockcastle County] Kentucky. A member of a well-known grotto (I won't mention which one), supposedly an experienced caver, was taking some folks on their first cave trip.

CCIC is a moderately difficult cave with numerous exposed climbs and traverses - some as much as 50 feet above the floor. While on our trip, our party happened to observe this other group making the descent down the pole ladders. Once at the bottom of this 15 foot climbdown, I watched as one of the members tossed down a rather heavy pack. The person at the top told them to be careful as it had their 12-pack of beer in it. While the climbs and traverses in CCIC are not too difficult for the most part, they still present a danger and demand caution and attention. I would think twice about subjecting a first time caver to the exposed climbs and traverses of CCIC, and doing so while possibly being under the influence of alcohol is only asking for disaster. Fortunately, there were no incidents and everyone in this other group exited the cave safely just after us.

As a grotto, we need to ensure our members and trip leaders are responsible and competent, and that their trips are within the experience level of their group. Under no circumstances should a NSS or grotto member take beer into a wild cave - especially with first time cavers. What kind of an example did this "experienced" grotto member set for his group? Should these types of "responsible" cavers/trip leaders be allowed in the NSS? Think about it.

REI Recall

The Huntsville Times recently reported that REI is recalling 21,000 seat harnesses because of a design flaw that could lead some users to wear them incorrectly and lose their lives because of it. This recall was also recently discussed on the InterNet "Caver's Forum" remailer.

The problem has not currently led to any injuries according to REI. The recall affects "On-Sight" and "Alpinist" seat harnesses sold in 1990 through 1993 for $30 and $40 through mail-order and in 36 stores in Oregon and Washington.

If you own one of these harnesses, contact REI.

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A Study of the Drift of the Amphipod, *Gammarus minus*, in Bat Cave, Carter County, Kentucky

by
Jeff Lapp NSS 35825

ABSTRACT

This study seeks to determine which factors, if any, induce the drift of the amphipod, *Gammarus minus*, in Bat Cave, Carter Caves State Resort Park, Carter County, Kentucky. Information on the number of amphipods drifting on each sampling date are presented. A statistical analysis of the data was performed, and the strongest correlation was that between the number of amphipods and the site. Finally, meter data and various water chemistry test results are also presented.

INTRODUCTION

Invertebrate stream drift refers to the accidental or purposeful detachment of benthic organisms from the substrate and their movement downstream with the current. The first report of drift came from Needham (1928), when he set nets in a surface stream to measure downstream movement of terrestrial insects. Waters (1962) divided drift into three categories: 1) catastrophic drift due to such unusually severe physical disturbance of the environment such as flooding, 2) constant drift due to ordinary accidental dislodgment, and 3) behavioral drift due to active response by the individual organism.

Little research on drift has been conducted in cave systems. Death (1989) examined the phenomenon in Cave Stream, New Zealand, in a 362 m long limestone tunnel. Death's study compared invertebrate communities at the affluent, effluent, and inside the passage. He concluded that the cave acted as a barrier to the drift of many of the observed species. This project is a restructured version of a previous study conducted in bat cave by Cathy Pederson in the summer of 1990. Pederson's experiment (1990) was designed primarily to demonstrate that drift actually does occur within the cave. The present study seeks to find a correlation between the observed physicochemical factors and the number of *Gammarus minus* Say drifting in the stream in Bat Cave. Some of these factors include specific conductance, dissolved oxygen, and water temperature. Each one of these may affect the others, and all (or none) of them may have an impact on the drift of the amphipods.

SITE DESCRIPTION

Bat Cave serves as a hibernaculum for the endangered Indiana Bat, *Myotis sodalis* Miller and Allen; therefore, entry into the cave in the winter months is only by permission of the park naturalist. With 3681 meters of total horizontal passage, this is the longest known cave in the park. There are two entrances: the Historic and the North Entrance. The Historic Entrance is characterized by large breakdown blocks on the floor, and there is a gate 70 m into the cave (Hobbs 1989). The northern end of the system is also protected by a similar gate, located about 10 m inside the entrance.

The stream that flows through the cave originates from a spring approximately 100 m inside the North Entrance, but the ultimate source of the water for the system is currently unknown. The substrate of the stream within the cave consists of a mixture primarily of sand, gravel, and cobble. There are also many large pools along its length.

METHODS AND MATERIALS

A total of three 24-hour sampling periods was conducted in Bat Cave during the fall of 1991: 20-21 September, 28-29 September, and 25-26 October. At the beginning of each study period, drift nets constructed of 363 mm Nitex were set at two locations within the cave, and these were checked at three-hour intervals for 24 hours. Station 1 was located in a riffle 350 m from the Historic Entrance, and Station 2 was situated approximately 50 m downstream (Figure 1) (Pederson 1990). After counting the number of organisms in the nets, the amphipods were returned to the water on the upstream side of each net.

During each sampling interval, the following data were collected: number of organisms in each net, water temperature, specific conductance, dissolved oxygen, and pH. Specific conductance was first measured with a YSI Model 33 SCT Meter, and later a Cole-Palmer 1481-55 Conductivity Meter was used since it was more compact. Data for dissolved oxygen were collected with a YSI Model 54 Oxygen Meter, but Vitro B.O.D. bottles were substituted on one trip when the meter was unavailable. The azide modification of the Winkler method was used to obtain the dissolved oxygen content of these samples. Values for pH were recorded with a Markson Model 85 pH Meter; however, the meter failed to produce consistent readings, so wide range pH paper was used for the remainder of the study. Water samples were also collected twice during each 24-hour period and analyzed for calcium, iron, nitrogen, phosphorus, sulfur, and total hardness using a Hach Kit Model Drel/5.

RESULTS

The null hypothesis for this experiment was that there would be no difference in the number of amphipods drifting over a 24-hour period. Based on the data collected, I am unable to reject this hypothesis. Tables 1 and 2 present statistical analyses of the data. (Multiple regression analysis was used for Table 1.) As can be seen by the fairly large P-value for time in Table 2, there is almost no correlation to the number of amphipods. Table 1 even shows a negative correlation of amphipods to time. Figure 2 presents the data graphically, and upon inspection one can see that there are no peak times when individuals of *G. minus* are drifting.

The analyses demonstrate a fairly strong positive correlation with the location. The P-value of 0.0001 in Table 2 indicates that the observed behavior is very significant, and Table 3 shows a one-way Analysis of Variance (ANOVA) test comparing the two sites. The mean number of *G. minus* captured at site 2 was more than three times that for site 1, and a P-value of 0.0002 reflects this difference. Figure 3 shows that the second site (right side of plot) has a higher average number of individuals captured.

The values for specific conductance, water temperature, dissolved oxygen, and pH are presented in Table 4, and the results of the Hach Kit analyses are shown in Table 5.

DISCUSSION

That data show no peak times for the drift of *G. minus* is very interesting. Caves are fairly static ecosystems, with few perturbations occurring therein. Some studies of invertebrate drift in surface steams have shown that the organisms demonstrate a diurnal periodicity for drift. Obviously, stream invertebrates deep within a cave have no light with which to relate, so there is no reason why they should drift at certain times of the day or night due to differences in light intensity.

One factor that may control the drift of cave organisms is the velocity of the water moving through the passage. An event such as a spate will definitely increase the flow of water passing through the cave. This may have the effect of transporting invertebrates much further downstream than they might have traveled on their own. Low flow in the system could also have an effect on the number of drifting individuals. This was the condition of the stream in Bat Cave during the study period. Due to the drought the summer before, the water level in the channel was much lower than normal for the autumn season. The level dropped about 15 cm over the course of the experiment, and this may account for the low numbers of amphipods captured in the nets during each sampling interval. The population of *G. minus* appeared quite large, as evidenced by observations of large numbers of individuals crawling through the substrate.

Another factor that may affect the drift of stream invertebrates is population density. When the number of individuals becomes high in one area, some of them may drift to find a more suitable living environment. Culver (1971) observed that *G. minus* showed a density-dependent distribution in some caves in West Virginia. Three attempts were made to collect Surber samples, but the velocity of the stream was so low that accurate samples could not be obtained. There are still many unanswered questions from this study that require more research. Ultimately, the hope is to find a cause for the drift of *Gammarus minus*.

ACKNOWLEDGMENTS

I would like to thank those individuals who helped carry equipment into the cave and aided in sampling: Dave Boone, Scott Engel, Chris Frost, Jessica Hoane, Anne Huddle, Annette Summers, Julie Thorp, and Alan Wallace. Special thanks are extended to John Tierney, Carter Caves State Park, for permission and encouragement to conduct this study in Bat Cave, and to Dr. H. H. Hobbs III for his guidance throughout the project. Finally, I wish to thank Dr. Doug Andrews for assisting in the statistical analyses of the data.

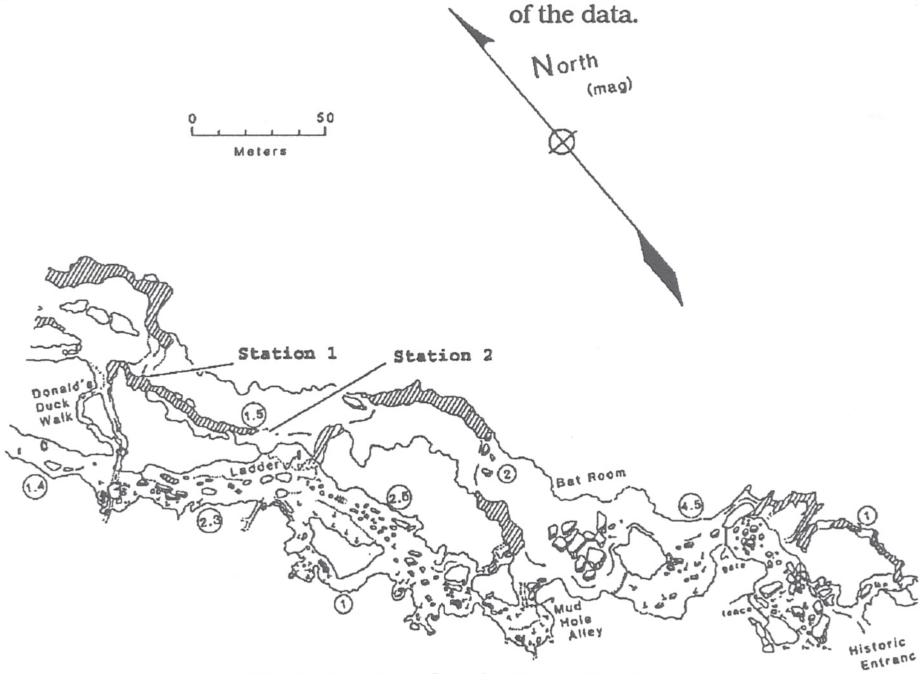

Fig. 1. Location of study sites in Bat Cave (map modified after Hobbs 1989.)

Table 1 SIMPLE CORRELATIONS

	PODS	SITE	TIME	COND	TEMPC	O_2
PODS	1.0000					
SITE	0.5492	1.0000				
TIME	-0.0667	-0.0000	1.0000			
COND	-0.1613	0.2836	-0.0003	1.0000		
TEMPC	0.0555	-0.2733	0.2148	-0.6742	1.0000	
O_2	0.0201	0.4274	0.0950	0.5819	-0.4518	1.0000

Note: PODS = AMPHIPODS
COND = CONDUCTIVITY
TEMPC = TEMPERATURE (°C)

Table 2 UNWEIGHTED LEAST SQUARES LINEAR REGRESSION OF AMPHIPOD

PREDICTOR VARIABLES	COEFFICIENT	STD ERROR	STUDENT'S T	P
CONSTANT	8.0914	17.888	0.45	0.6539
SITE	5.2812	1.1405	4.63	0.0001
TIME	-3.5208E-04	7.7328E-04	-0.46	0.6518
CONDUCT	-1.6805E-02	1.1364E-02	-1.48	0.1484
TEMPC	9.6559E-02	9.4567E-01	0.10	0.9193
O_2	-6.2947E-01	1.3013	-0.48	0.6317

Note: CONDUCT = CONDUCTIVITY
TEMPC = TEMPERATURE (°C)

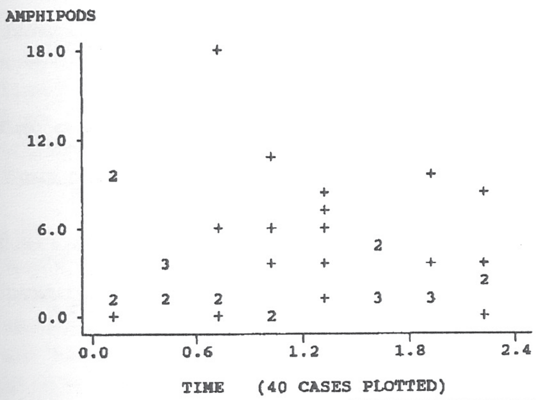

Fig. 2 AMPHIPODS vs TIME

Table 3 ONE WAY ANOVA FOR AMPHIPODS = SITE

SITE	MEAN	SAMPLE SIZE	GROUP VARIANCE
1	2.000	24	4.435
2	6.313	16	20.76
TOTAL	3.725	40	

SOURCE	DF	SS	MS	F	P
BETWEEN	1	178.5	178.5	16.41	0.0002
WITHIN	38	413.4	10.88		
TOTAL	39	592.0			

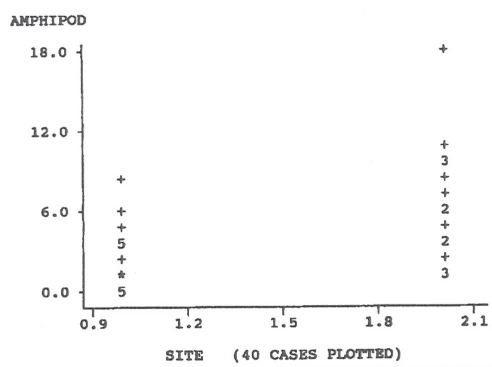

Fig. 3 AMPHIPOD VS SITE

Table 4 Meter Data

Site	Time	Cond. (µmhos/cm)	Temp. (°C)	O_2 (mg/l)	pH
20-21 September					
1	2200	340	11.6	9.4	7.55
1	0100	313	11.6	9.3	7.05
1	0400	332	11.6	9.0	6.65
1	0700	311	11.6	9.0	6.75
1	1000	340	11.4	9.6	7.20
1	1300	324	11.5	9.1	6.50
1	1600	324	12.1	9.0	6.35
1	1900	321	12.1	9.4	6.00
28-29 Sepetmber					
1	1300	349	11.8	10.3	6.55
2	1300	349	11.4	9.1	5.65
1	1600	359	11.6	10.2	----
2	1600	349	11.2	9.2	6.45
1	1900	348	11.7	9.6	----
2	1900	341	11.4	9.3	----
1	2200	351	11.7	9.8	----
2	2200	344	11.5	9.9	----
1	0100	350	11.6	10.1	----
2	0100	342	11.5	9.3	----
1	0400	356	11.6	9.4	----
2	0400	339	11.5	9.5	----
1	0700	335	11.5	9.3	----
2	0700	349	11.1	9.2	----
1	1000	321	11.5	9.7	----
2	1000	345	11.5	9.8	----
25-26 October					
1	0100	537	10.2	9.5	7.70
2	0100	419	10.2	10.6	7.80
1	0400	439	10.1	9.5	7.80
2	0400	403	10.1	10.4	7.45
1	0700	472	10.1	9.7	7.80
2	0700	402	10.8	10.5	7.50
1	1000	348	10.8	9.6	7.70
2	1000	570	10.8	10.6	7.35
1	1300	320	10.9	9.3	7.95
2	1300	462	10.9	10.4	7.90
1	1600	332	10.9	9.6	7.35
2	1600	400	10.9	10.7	7.50
1	1900	430	10.9	9.6	7.85
2	1900	560	10.9	10.6	7.70
1	2200	450	11.0	9.7	7.80
2	2200	442	11.0	10.5	7.95

Table 5 Hach Kit Analysis

Date	Time	Turb. (FTU)	Iron (mg/l)	Nitrate (mg/l)	Phosphate (mg/l)	Sulfate (mg/l)	Hardness (mg/l $CaCO_3$)	Calcium (mg/l $CaCO_3$)
20-21 September	0400	3	0.031	1.98	0.034	15.1	159	132
20-21 September	1600	5	0.063	1.97	1.20	15.42	159-160	140
28-29 September	0400	3	0.030	1.51	0.18	19.5	244-245	226
28-29 September	1600	3	0.022	2.64	0.059	18.7	255	229-230
25-26 October	0400	7	0	0.69	0.047	18.81	238	205
25-26 October	1600	5	0	1.21	0.050	20.0	232-233	209-210

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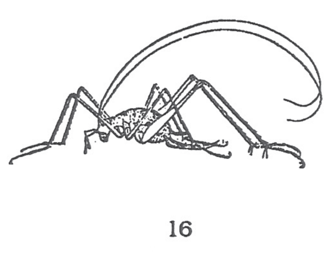


The Maquoketa Caver

by
James Hedges
NSS 3848RL, CM

My family would occasionally visit state parks when I was a child; my "first cave" probably was the main cave at Maquoketa Caves State Park, Jackson County, Iowa. My "first caving," as a deliberate exploration, was in one of the smaller caves at the park.

My circle of friends in high school included upwards of 3 or 4 serious-minded fellows. One of them had a car, and when he was available, or when we could borrow a family car, we spent our weekends funning around eastern Iowa. We'd go there looking for fossils, agates, geodes, and whatever else seemed geologically interesting. One of these adventures led us back to the Maquoketa Caves.

The Maquoketa Caves consist of two natural bridges and several related small caves. The area is somewhat similar to "The Seven Caves" in Ohio. The main cave (the bridges) has electric lights and a flagstone walkway. The smaller caves are scattered along the adjacent valley and are "wild." A system of trails connects all of them. The trails were built by the Civilian Conservation Corps in the 1930's. By the 1950's, they were mostly overgrown and difficult to follow. We lived in Central Iowa, where rocky gorges and thick woods are rare. The park appeared to us to be a wilderness, although it had been logged over 60 years previously.

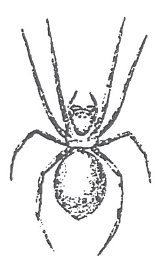
We poked into several entrances, finding most of the caves to be large but shallow. One, though, caught our attention. A few weeks later, we returned. One boy's mother also came along - her son was not going to be lost in any cave (ugh!). We had old clothes, flashlights, and, at the mother's insistence, a field telephone from an army surplus store. Fighting our way along the bluff to the cave, we deposited our lunches, equipment, and extra supplies at the entrance - a real cave, and we were going to get to the end of it!

As it happens, Shinbone "Cave" is just an irregular void between the overhanging cliff and the talus pile at its base. A stream channel leads away from it; however, it seems that somewhere back behind the talus is the severed end of a nearby solution cave with an intermittent stream. We had none of this enlightened cynicism, however. This was a hole in the ground big enough to enter. It was rocky, dirty, and dark. It was a cave!

We took turns crawling in, field telephone clenched tightly in one hand, the mother's anxious command to "talk to me every five feet" ringing in our ears. I think we left the wire reel outside and just dragged the telephone wire in and out as we explored. After some struggling, sneezing, bruising, and ripping, we found the end: a rathole a few inches in diameter, away from which the stream channel led.

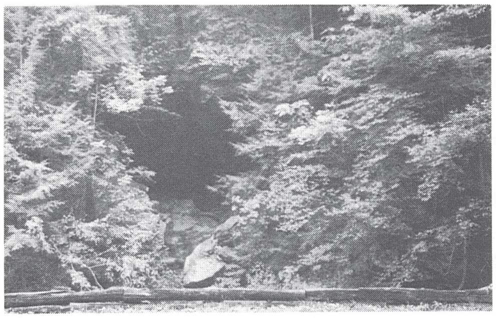
Years later, a survey would show that we had succeeded in penetrating no less than 76 feet of passageway, stretching from the furthest part of the dripline to the furthest part of the rathole. In terms of enclosed cave, we had gone perhaps 50 feet.

The mother's voice came weakly over the miles-long telephone line: "Did you say it doesn't go any further? Alright then, come back out of there and let's go somewhere safe!"



Laurel

by
Annette Summers NSS 31319R


Laurel Cave, Carter Caves State Resort Park, Kentucky. Photo by Annette Summers.

I was twelve, seeking adventure and parental defiance. My mother was horribly frightened at the idea of her daughter wanting to go into a cave - and even more scared that I would like it! Nevertheless, I got my way. I was going to a High Adventure camp, sponsored by the Brethren Church Camps, Inspiration Hills (Burbank, Ohio), Woodland Altars (Peebles, Ohio), and Camp Swatara (Bethel, Pennsylvania). The main objective of the camp was to provide an environment of physical risk within a cocoon of security, venturing forth into new sights and sensations. To those that participated, the camp was called "Venture Forth."

The first cave I explored was Laurel Cave, located within Carter Caves State Resort Park, Kentucky. Every time I go into Laurel I cannot help but remember how I felt that first time. The entrance still appears large and forbidding - a black hole full of broken rock reflecting a geologic history ancient and mysterious. Cool air continues to breathe in and out of Laurel's nostrils, refreshing my body on a hot, summer day and warming it in winter. The water, coursing through the rock like blood in my veins, brings life to the cave. The rock is still cold to the touch, wet from water making its way from the surface to the inner depths of the earth; the rock seems so full of tiny spirits that hide in pockets and crevices, peeking out just after I pass by.

Laurel was an unknown, secret world. Animals and insects lived within it so intimately that my presence there almost defied any reality. I was a visitor, completely alienated. I did not know the language or the culture. I wandered from one attraction to the next, stumbling on loose rocks. I was a farm girl in a big city, awed by the skyscrapers. I tripped over sidewalk cracks and ran into people ahead of me as I gazed into the sky full of metal and glass. I was transformed, my imagination running wild.

The cave not only revealed its secrets to me, but there were others. Ten eager, open-minded teenagers (in the presence of three adult leaders) explored Laurel that day. I was the only female among nine, robust males. Perhaps they drove me to extend my physical capabilities in order to maximize the experience. Perhaps I drove them. The day after caving in Laurel and surrounding caves, I can remember awakening to so much pain. My muscles were exhausted, tight from only four hours of caving the day before. It was difficult to get out of my sleeping bag, and even to roll over! After much effort, however, I finally crawled out of my tent to realize the boys were in just as much pain as myself. I still smile at my reaction - misery loves company.

There are no difficult portions of Laurel now. Practice has helped. Over eight years have passed, and over seventy caves have been explored. Practice has been the key element in my enjoyment of caving. I have realized that it was not ability I lacked in order to cave, but rather the rehearsal of such activities. I had to become an actress on opening night; I had to know my lines forward and backward, able to recite them in my sleep. I had to abandon any second guessing, being absolutely sure in everything I did.

I am a different person from the twelve-year-old Laurel saw years ago. Besides physical differences, my emotional status has been altered. Laurel sees me as a leader not a follower. I evolve in mind and spirit, second by second, trying to transfigure prejudices of life into free-flowing ideas without bias. I am my own thinker, an oracle in which I seek answers within myself. I no longer am one of the chorus members, but a solo performer alone on an empty stage.

If someone told me when I first began caving that I would be where I am now, know (and love) all the people I know, and enjoy the most insane of activities, I probably would have laughed or stared blankly at him. Caving has been more than an activity; it has been a way of life for me - a life full of science and imagination rolled into one entity. I cannot think of any other existence for myself. Caving has presented me with a life full of adventure, strapping me in and taking me on a ride unmatched by any roller coaster ever created.

Laurel has inevitably been that spirit which has driven me. Her unconditional strength and fortitude has swept me up into her passages, mesmerizing me with her enigma. These passageways have not only led me to seek Laurel, but they also have been symbols of different avenues in my life; each route represents a path chosen or avoided. With every visit to Laurel, I again make the same decision to skip down an old route that is familiar to me. But, like when I was younger and explored all of Laurel for the first time, I use that incentive to seek the unknown in other caves, in other facets of my life. No one who caves can doubt the control the sport has over each of us. No one can deny that special bond we all have to the dark, mysterious world hidden from us. Geologic time has given Laurel her grace and beauty. Her existence survives with an understanding that time is so infinite that any change of her, within her, is unseen. I, however, am not as resistant. In the short amount of time I have been exposed to caving, I have changed irreversibly.

Living in the Dreaming Body

by
Scott Engel NSS 32520

Damn, it's cold. I really should get up and close the window, but I'm too tired to move. Maybe I can just ignore it and go to sleep. No, no! I have to get up.

"Four dead in Ohio. Four dead in Ohio."

"If you two don't stop that horrid singing, I'm getting out and walking," Susan yells above the din.

"That's fine with me, " Kurt smirks, dodging his truck around a mud hole in the dirt road we had been following for the last several miles. "I'll be more than happy to let you out here. It should only take you a day or two to get back to civilization, and it would sure make my day a lot nicer."

"Watch it buddy, or you'll regret it when we get home."

Susan is giving Kurt one of her perfected looks that you can never decide if she is going to kiss someone or hit them. Either way, this would be a good time to intervene.

"So Kurt, since you brought up the subject of being in the middle of no where, do you know where you're going? All these roads look the same to me. You aren't dragging us on another wild cave chase are you?"

"Relax, I know where we're going. We're on the right road. You know, the one just past the sharp left with the big pine tree next to it two miles down the road from where the red barn used to be. The cave should be in the ridge just ahead of us." He sticks his head out the window and takes a deep breath. "Can't you smell cave in the air?"

"All I can smell is your feet," quips Susan.

She always has to have the last word.

I should get up and do some of my work, but I'm just too tired right now. Maybe later.

My phone is ringing for the tenth time in the last three hours. "If that phone rings again it's going out the window," I coolly inform the potted plant sitting next to my desk as I reach for the phone.

"Hey Joe, it's Kurt. Your caving equipment is too clean and Susan and I feel it is our responsibility to take you out this weekend and give you a chance to dirty it up a little."

"I don't know Kurt. I have a ton of work to do this weekend and I haven't had a good night's sleep in weeks."

"Oh, stop whining you wimp. You don't have a choice in this. We haven't been caving together in months. You're the one who always said that you'd go crazy without caving."

"I know but..."

"No buts and no excuses. You need a break. I can tell by the tone in your voice."

"Okay, okay. But only a one day trip. I can't afford to stay overnight. Too much to do. Your snoring would just keep me awake anyway."

"Good enough. I'll call you Friday so we can figure out the details."

I wonder how much longer it is going to take them to get here. They're never on time anywhere. If they don't hurry up I'm going to fall back asleep.

I'm just so tired. I feel like I haven't slept for days. But I can't go to sleep yet. Not yet. I wish I had a deck of cards so I could play solitaire or something to help keep me awake.

"Wake up Joe! We have two more hours till sunrise."

"I'm not falling asleep. You're the one falling asleep, you wimp."

"Am not."

"Are too."

"Am NOT!"

"Shh... You'll wake Mom. Want to play another game of Uno?"

"What do you think you're doing outside in the cold and rain dressed like that, young man? You know better than that. You're going to get yourself sick."

"Man, you look like hell."

"Thanks, I needed to hear that. I stayed up most of the night studying for my Chem midterm this morning."

"I noticed you were nodding off in class there."

"Yeah. Just one more class and me and my bed are going to take a nice, long vacation together."

Some get-away this has turned into. I hope they get back soon. I don't think I can hold out much longer.

"Can't believe how cold it is out here. I sure hope the bus comes soon."

"Hey, wouldn't it be great if the bus broke down and it never comes?"

"I'm giving it five more minutes and then I'm going home."

God I wish someone would come soon before I freeze.

I'm sick again. That means another couple of days home from school. But I'm so tired of being sick. I think

I would rather go to school at this point. This sucks.

There's the alarm clock. It feels like I just went to sleep. I've got it get up, they'll be here soon.

Did I just hear something or was I dreaming? How much longer can they take?

"Sorry we're late. I couldn't find my kneepads."

I check my watch. "Actually, you're right on time. Your time, that is. When you told me six o'clock, I knew you wouldn't get here till at least quarter to seven."

"Yeah, yeah. Is this all your stuff? Susan is waiting in the car. You know she doesn't speak before 8:00 a.m."

I hope they're not too late this time. I can feel myself drifting off.

"Are you two ready? The cave is just a short walk up the hill. Everybody remember where we parked."

"Doesn't he ever get tired of saying that?" I ask Susan under my breath.

She just smiles and shakes her head.

"We'll be back soon. I won't leave you here too long," says Susan as she squeezes my hand.

Her hands are trembling.

I watch as Susan tries to brush a strand of hair out of her face and only succeeds in smearing the mud around. She looks tired but she'll never admit that to Kurt.

"Hey Kurt, I'm getting pretty tired. I think we should turn back now. We've seen most of the cave and it's at least a three hour push to get out."

Looking up from the map spread out on his lap, Kurt starts putting things back in his pack. "Yeah, maybe you're right. I wanted to get to this other section, but it's getting pretty late. What do you think, honey?"

"Sounds okay to me. I've seen enough cave for today," Susan replies, flashing a quick smile in my direction.

Too bad Kurt found her first.

"Joe, I'm going to ask Susan to marry me tomorrow night."

Wow, I think this is the first time I have ever seen Kurt scared. Like she would say no.

"I should have known better than to follow you on one of your short-cuts. Especially when it's through waist deep water."

"Well it looked like a short-cut on the map."

"Kurt, how many times do I have to explain to you the difference between maps and reality?"

"I know, I know, but if that rock hadn't been in the way...."

"Will you two men stop bickering and get me out of here! I'm getting cold."

"Aye, aye Ma'am," we chorus.

Kurt gets hit in the side of the face with a mud ball. Always the last word.

"No more arguments. You are coming caving with us."

I've got to get up and close that window before I freeze. But my leg hurts too much to move. "Mom, Mom... Come shut my window for me. Mom?" Maybe if I just take a little nap.

"Joe. Joe wake up. You're going to be late for school if you don't get moving. And don't forget your breakfast."

"Here," Kurt says with a poor attempt at a smile. "You can have my Snickers. I was saving it for later, but I guess I'll let you have it."

"Gee, you're so kind, " I reply with an equally poor attempt.

Don't fall asleep. They'll be back soon. Maybe they forgot where they parked.

"But I don't know the way out of here," Susan whimpers with a trace of panic creeping in the edges of her voice. "You'll have to go Kurt. I'll stay."

"Kurt, she can't stay here with me. She's already shivering; she'll freeze in here," I manage to choke out while trying to fight back tears of pain and frustration.

"But we can't leave you here by yourself."

"You have no choice. She can't stay here."

Why wasn't I more careful? We were all cold and pushing the pace to get out, but I shouldn't have been so careless.

Was that a noise? Oh great. My candle is about to go out. I wonder how long those candles are supposed to last anyway.

I've heard that sound once before in my life; it's one I'll never forget. The echo off the cave passage makes it seem even louder than I remember. My knees buckle and I hit the ground still thinking about the sound. And then the pain comes. No question, it's broken.

"Shh, don't make so much noise. You're in a church. Show some respect. And stay awake."

This silence is going to drive me crazy. At least I could talk to my plants at home.

Damn, the phone's ringing again. Where did that thing go? I can hear it but I can't find it. I can't even find the damn light switch.

"We'll pick you up at 6:00 a.m."

"Four dead in Ohio. Four dead in Ohio."

"Will you please turn that radio down!"

"Mom... Mom... My ankle really hurts. I think I broke it."

"Here. Sit down and let me look at it, how did this happen?"

"I was playing football... ouch. And I tripped over David and ..."

"Yep, it's swelling pretty badly. We better take you to the hospital. I'll go call your dad."

The tears started right after the word hospital and they just won't stop. I'm too old to cry. All the other kids will think I'm a wimp.

"Joe, Joe. You fell asleep. Your test is in fifteen minutes."

Great, I don't know anyone here. Why did I decide to go away to school? Why didn't I stay home where I wasn't lost? That big guy over there looks like he is in charge, maybe he can help. I guess I can ask him where I'm supposed to go, but I can't seem to make my voice work. Wait, he's coming over here. But why is he shining that light in my face? "Joe, Joe. Your name's Joe, right? My name's Steve. I've brought some people with me and we are going to get you out of here."

But I just got here, didn't I?

"Mom, I don't feel so good, and I'm really cold." She reaches down and puts her hand on my forehead like she always does. Why does she do that anyway?

"You're burning up. Climb up here and sit with me. We've got a sick boy again."

"I'm not burning, Mom. I'm freezing."

"I know honey. Here. Put this blanket around you and rest."

"Here. Grab that end of the blanket and get it under him. Watch his leg."

The doctor grabs my foot and asks, "Does it hurt if I move it this way?"

Pain immediately shoots up my entire leg. "Ouch! Yes!" Can't this guy figure out that it's going to hurt anyway he turns it? It's broken! If he does that again I'm going to kick him with my good leg.

"Bobby if you don't stop bouncing on the bed I'm going to kill you. It makes my leg hurt. Now go away and let me sleep or I am going to call Mom in here."

Just as the guy finishes checking my harness the cars start moving down the tracks.

"This is the best roller coaster. Isn't it Kurt?" I ask, looking over at the seat next to me. But there's no one over there. Where did Kurt go? He was right next to me. The car is moving and the straps are so tight I can't move. I've got to get out of here and find Kurt. But I'm stuck. Where could he have gone? I can't move my arms. Why can't I move my arms? I can't move...

"He's having problems breathing! Put him down. Put him down!"

Great. There's a party going on upstairs. Now I'll never be able to go to sleep with all this noise. Why won't anyone let me sleep?

"Okay everybody, let's take a break."

"Why don't you get up and help us you lazy bum?" We're doing all this work while you're just laying around watching."

"Leave me alone. Mom said I didn't have to do any work because I was sick."

Boy does my leg hurt. I hope we get to the hospital soon.

"How much further, Dad?"

"We're doing good. Should be another hour or so, Joe."

I didn't realize the hospital was so far away.

What was the name of this guy that keeps talking to me? I wish he would just go away and let me get some sleep. If he tells me everything is going to be okay one more time I'm going to scream.

This roller coaster seems to go forever. I wish it would hurry up and end so I can find Kurt.

"If we don't hurry up, we're going to be late for dinner."

"Hey, Joe, we can see light. Everything's okay; we're going to make it."

He said it again, but screaming takes too much energy. Maybe next time.

Ah, fresh air... I don't think I could stand to be on that bus another minute. All that stale air, and the thing definitely needs a new suspension.

Geez, all that light hurts my eyes. It must be morning but I don't remember going to sleep last night. I hate waking up tired.

Is it over?

I can't believe I fell asleep. That movie was really scary but I just couldn't keep my eyes open.

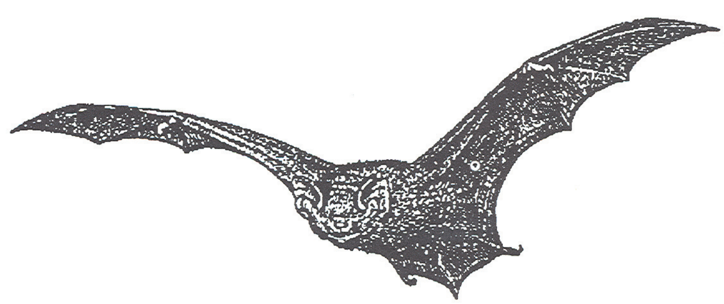
"Joe, can you hear me? You're out. Joe?"

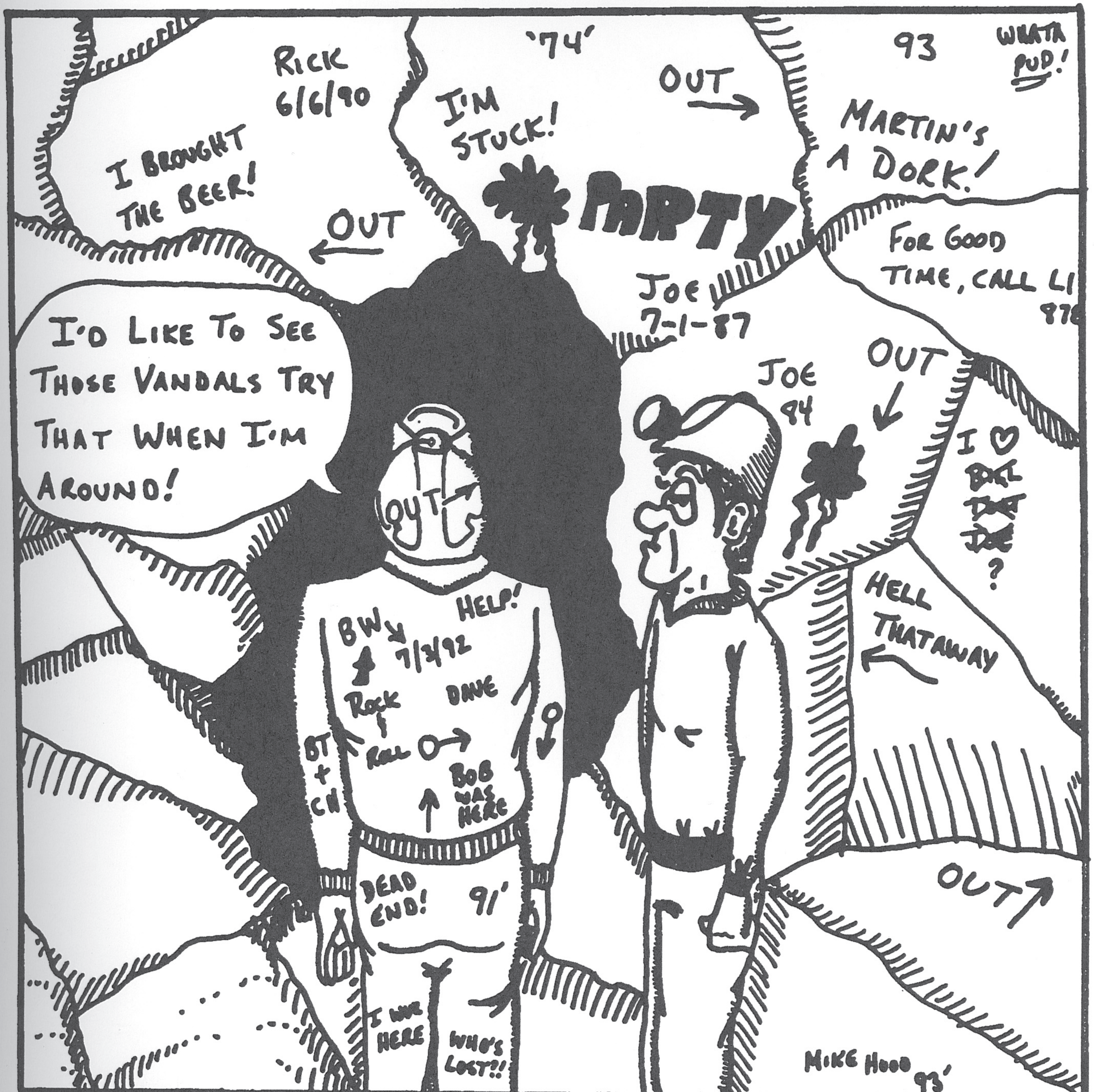
Slowly Susan's face hovering over me comes into focus. Late as usual.

"It's okay now; you're out. God, am I happy to see you. You had me scared to death. They're going to take you to the hospital now. Me and Kurt will see you there."

"You're late again," I succeed in mumbling as she bends over and kisses me on the forehead.

Now I can finally sleep.




I'D LIKE TO SEE THOSE VANDALS TRY THAT WHEN I'M AROUND!
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WHATA PUD!
I BROUGHT THE BEER!
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