Final Report

A biological inventory of eight caves in Great Basin National Park.

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ABSTRACT

Eight caves in Great Basin National Park (GRBA) were biologically inventoried. In addition to at least two probable new species (a milliped and a globular springtail), we collected data on location of species in each cave, microhabitat, temperature, humidity, water chemistry parameters. We created collection and monitoring protocols, and made recommendations for management actions based on what we know of the ecological/biological requirements of the taxa. We performed a thorough literature review of all cave fauna from GRBA, and created species lists for each cave that are inclusive of all phyla that have ever been reported from caves in the park.

INTRODUCTION

GRBA is on the eastern edge of central Nevada, in the basin and range province of the western United States. The caves of the park exist in a significant altitudinal gradient, and their presence only in the range part of the local topography makes them island-like, and thus good candidates for containing endemic species. Indeed, prior to this study there were two troglobitic (cave-limited) endemic species described from the park.

However, the vast majority of the information on invertebrate cave fauna was from only a single cave (Lehman Caves), and the information was limited to a very few taxa (this is outlined in the Literature Review, below). Recent investigations by land managers (GRBA 1988) highlighted the need to perform a thorough cave bioinventory in order to create a management plan that can adapt to the increasing visitation by both tourists and recreational cavers to commercial and wild caves in the park.

The objectives of this study were to: 1) conduct a biological inventory of cave-adapted macroinvertebrate species in eight permit caves at GRBA; 2) train accompanying GRBA personnel in techniques for making biological collections in caves; 3) review literature pertinent to the biota of caves at GRBA; 4) develop a preliminary list of taxa based on our collections; 5) create a collection of color digital images and black and white slides of all common cave-dwelling invertebrate taxa of GRBA; 6) identify current and potential future threats to the cave invertebrate communities of the eight caves sampled in GRBA; 7) suggest methods to lessen threats to the cave invertebrate communities in the eight caves; 8) recommend specific cave invertebrate

Cover Photo:.*Cryptobunus ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman (Opiliones: Triaenonychidae). The large, raptorial pedipalps are obvious anteriorly on this individual. Lateral ocelli are evident on the dorsal tubercle on the cephalothorax. This individual exhibits the typical golden orange color found in adults. Photo by Jean Krejca & Steve Taylor.

monitoring techniques for the eight caves; and 9) identify areas of speleology, especially pertaining to biospeleology, needing further research at GRBA.

MATERIALS AND METHODS

Field work took place between 21 May and 29 May 2003, and the caves visited and techniques used are outlined in Table 1.

Our focus was on troglobitic species, but invertebrates that are trogloxenes or troglophiles were also collected. This focus was facilitated by concentrating our efforts deeper in the caves, thus placing less emphasis on the entrance area. Accidental taxa – typically most abundant in the entrance and twilight zones of caves – were not a major focus of this study. Only representatives of dominant accidental taxa were collected in the entrance zone. Collections of cave-adapted taxa were limited only to representatives of each taxon when additional collecting could significantly impact the cave community. Field collections included only macroinvertebrates – no effort was made to collect fungi, bacteria, protists, nematodes, and other microfauna. Vertebrates were not collected.

Our sampling was qualitative in nature, with a focus on maximizing diversity of taxa and habitats within each cave. The primary technique was hand collecting, facilitated by use of forceps, aspirator, or a fine paintbrush as conditions and taxa dictatee (aspirator for fast-moving taxa, forceps for taxa too delicate for hand collecting, paintbrush for smallest and most delicate taxa). For aquatic habitats, a baster (used to collect larger aquatic taxa, such as amphipods and isopods), fine mesh net (used to dip out samples of debris or larger organisms and to wash sediment in search of benthic macroinvertebrates), and a plankton net (where flowing streams are sufficiently deep and have sufficient flow to attempt plankton sampling) were utilized. Baited pitfalls were also utilized at some sites (Table 1). On return visits, we were careful to examine the area around the bait in addition to the trap itself, as predatory taxa are sometimes only attracted to the general vicinity of the bait, and are only recovered through careful search of the surrounding area. Samples were collected into 70% ethanol (or into formalin for some aquatic samples, such as aquatic oligocheates) in nalgene containers. At significant points in each cave (by zone: Entrance, Twilight, Middle+Dark), temperature and humidity measurements were recorded on the field forms. Data on field forms includes: cave name, collectors, sample number, trap or sample type (eg. pitfall, hand collection, photograph), set or sample date (date of collection or date the trap was set), recover date (for traps), organism (to most convenient taxonomic level), habitat, and location in cave. Copies of the completed forms, including maps with marks showing where collections were made, are in Appendix 1.

In the laboratory, material was sorted by taxon and curated in glass museum vials with Nalgene stoppers and internal labels with complete locality and habitat data. These data are summarized in the results section.

These collections will be deposited in the collections of the Illinois Natural History Survey and the Texas Memorial Museum – both institutions have large, well curated permanent research collections. Some material will first be sent to taxonomic experts (by GRBA staff), and this material will also ultimately be deposited in one or both of these collections, except for material retained by specialists (a common practice among taxonomists). Material for which there is no available (or willing) taxonomist will be deposited in one of the above two collections, ready to be loaned when suitable taxonomic expertise becomes available. Vouchers of common cavernicoles will also be provided to GRBA as a reference collection for the cave fauna of the park. Some taxa may be too rare to be provided for such a collection, but digital photographs of these taxa will be made available whenever possible. All material collected remains property of the park, and thus museum specimens and material to be sent to appropriate specialists is "on loan".

LITERATURE REVIEW

Very few caves in Great Basin National Park have been examined biologically, and very little is known of the invertebrate biota of caves throughout Nevada (Desert Research Institute 1968, Baggs 1993, McLane 1975). Only three troglobitic species have been described from the state, two of which are in the park. In addition, two phreatobitic amphipods have been described from non-karst groundwater in Nevada. Beyond the species descriptions, the studies that have been done are nearly entirely in grey literature, and all of these are reviewed below.

In 1879 the Lehman Caves entrance was discovered and exploration and tours began in 1885. In 1912 the property went under control of the Forest Service and in 1933 the National Park Service took over administration of the cave. Electric lights were installed in 1941, and it was the presence of these lights, combined with the proposal to open a new entrance, that spurred the first biological research (Trexler 1966, Quate 1993, Anon. 1997, Anon. A [no year], Anon. B [no yea]r). The issues addressed in this research related primarily to impact of electric lights. For example, the differences in faunal composition near electric lights versus far from electric lights was studied by Stark (1969), plant growth parameters were studied by Sheps (1972) and the control of algal and moss growth was studied by Lynn (1978). In the work by Lynn (1978), algae, blue-green algae and diatoms are identified and options for growth control were explored. The light duration and intensity was examined in order to determine how low is necessary to eliminated or drastically reduce algae growth. During Lynn’s (1978) study springtails were found with blue green algae and algae in their gut contents. Finally, the impact of herbicides and poison are explored as methods of control. Several studies made measurements of air, water, and soil chemistry parameters as a correlation with plant growth and as a before and after study of the development of the new entrance (Sheps 1972, Bamberg 1972).

Research on geology, hydrology, and related topics is not reviewed in detail here, but some pertinent literature is worth mentioning. In one paper, Bridgemon and Meyer (1967) review cave pseudoscorpions, and the paper includes nine references that cover topics directly relating to their report, however an additional 37 references are attached to the copy of the report in the GRBA files. These additional references are largely grey literature, but they cover relevant topics to cave management such as hydrology and stream piracy, cave development, and geology. A second reference to physical cave parameters included a section of a book (Moore and Sullivan, 1997) that showed a plot of depth against temperature taken in Model Cave in 1952. The study hypothesized that temperature changes according to progression into a cave are due to a lag created by the slow conductance of limestone. This lag would create modern temperature patterns that reflect recent historic weather events.

Some studies have focused on specific taxa from caves in Great Basin National Park, including the cave pseudoscorpion *Microcreagris grandis* described by Muchmore (1962) from a single male and a tritonymph from Lehman Cave. In his description, Muchmore (1962) states that "it is reasonable to suppose that *M. grandis* is exclusively troglobitic in spite of the retention of eyes and pigmented derm". He goes on to note that the proportions of this new species are similar to previously described troglobitic pseudoscorpions, and the large size and attenuated appendages would render epigean existence difficult. Muchmore (1969) later described a female collected from the same cave and provided a key to cavernicoulus species of the genus. The species was also studied by Bridgemon and Meyer (1967) and Schmitz (1986). Bridgemon and Meyer (1967) chronicled the history of the discovery and description of the species, as well as an overview of the basic biology of pseudoscorpions in general. Bridgemon (1967) also noted the range extension for this pseudoscorpion into Pictograph Cave, which at that time was thought to only occur in Lehman Caves. Schmitz (1986) noted several interesting aspects of the species, including apparent seasonality observations of the species – fewer being found in the summer. Schmitz (1986) also noted that they are concentrated near cave entrances in both Little Muddy Cave and Lehman Caves. Also the sex ratio of individuals found by Schmitz (1986) is extremely skewed, with only 1 in 14 individuals being female. Ecological studies placed this species in the role of secondary consumer, and it is suggested they eat flies and springtails (Desert Research Institute 1968, Stark 1969). Schmitz (1986) suggested that they may be preyed upon by mice.

The Model Cave Harvestman, *Cryptobunus ungulatus ungulatus* was described by (Briggs 1971) on the basis of specimens collected from Model Cave, GRBA in 1952 by R. de Saussure. Briggs (1971) described the genus as "exclusively cavernicolous," thus this species can be considered a troglobite. Another subspecies was described in the same paper from North Madhouse Cave near Provo, Utah County, Utah, and is called *Cryptobunus ungulatus madhousensis*.

Bridgemon (1967) reports that another closely related species, *Sclerobunus robustus* (Packard) was seen in Model, Deep, and Halliday's Deep Caves and collected from Deep Cave. The collected specimen was sent to Clarance J. Goodnight for identification. This is probably an incorrect identification because at the time *Cryptobunus ungulatus ungulatus* was not described. We suspect that Bridgemon's (1967) specimens were in fact *Cryptobunus ungulatus ungulatus*.

South of Great Basin National Park, a dipluran (*Condeicampa langei* [Diplura: Campodeidae] has been reported from Whipple Cave, Lincoln County (Ferguson 1996). In addition, at least two amphipods are known from non-karst groundwater in Nevada: *Stygobromus lacicolus* (Cranogonyctidae) is known from Douglas County groundwater (Holsinger 1974, 1978), and *Stygobromus tahoensis* (Crangonyctidae) is known from groundwater in Douglas and Washoe counties (Holsinger 1974). Several troglophilic and/or trogloxenic taxa also occur in Nevada caves (e.g., Graham 1968).

Studies of fungi in caves of GRBA are mostly limited to occasional observations reported in papers examining other topics (Stark 1969, Desert Research Institute 1968, Sheps 1927). However, Went (undated) specifically examined fungal hyphae at the growing tip of active stalactites, and even cultured a fungus and bacteria from Lehman Caves.

Small mammal research in caves at GRBA mainly focuses on bats, but at least one trapping, spatial activity, and attempt at a mark-recapture was performed by the Desert Research Institute (1968). During these studies, in Lehman Cave, researchers observed and trapped deer mice and cliff chipmunks, and also mention pack rats as historical and probably wintertime occupants, though none were seen. Stark (1969) attributes their absence to the installation of electric lights. Stark (1969) also mentions that at Lehman Cave "beetle galleries and frass are common under old dung and another type burrows into pellets, but no beetles are known to be active in the dung of the caves today."

Bats are an important part of the cave ecosystem, bringing energy into the cave in the form of guano, insect remains, bat parasites, and remains of the bats themselves that perish in the cave. An early study by the Desert Research Institute (1968) notes the presence of one species in Halliday's Deep Cave, and also recommended that opening the natural entrance of and leaving a large unscreened opening may greatly increase the population in Lehman Caves. Baldino (1998) identified many different species from all of the eight permitted caves in our study, and also from other caves, mines, and water sources in the park and on adjacent lands. In Baldino's (1998) report there is some evidence given for declining bat populations. More recent mistnetting (GRBA 2002) data corroborates the locations of some of the species and adds at least two more sites to the list of places inventoried for bats.

Bone from Lehman Caves have been examined by Orr (1952) and Mead (1980). Orr (1952) composed a letter that tentatively identifies some collections by common name, and assigns them to six species, denoted either recent or possibly fossil remains, though no dates are given. Mead (1980) composed a letter tentatively identifying five species, and they were all judged probably Holocene, 10,000 years or younger.

In the ecology study by Stark (1969), and the reports leading up to that (Desert Research Institute 1968), numerous taxa were identified from Lehman Caves. These studies produced the largest taxon lists to date, and encompassed fungi, bacteria, moss, algae, diatoms, mastigophora, ciliophora, protozoans, rotifera, worms, arthropods and vertebrates. Stark (1969) then placed most of these taxa in ecological niches including producers, primary consumers, secondary consumers and reducers. Twelve types of microecosystems were characterized based on the interrelationships of organisms in these niches that he saw in the field.

More recently, literature created by land managers is calling for a thorough invertebrate bioinventoy in Great Basin National Park, noting that the high diversity and endemicity of some invertebrate taxa (butterflies, moths, and snails) points to a probable high diversity of other taxa (GRBA 1988). The relatively extreme elevational gradient present in the park was one factor named as contributing to high biodiversity. In relation to cave management in particular, it is recognized that detailed information is lacking for many of the caves, including what factors are important for the cave organisms and what are the carrying capacity of the caves for visitors (GRBA 1988).

RESULTS

These data will be referenced in both a cave by taxon format (listing all sites where that taxon occurs) and a taxon by cave format (listing all taxa for each cave). Taxa in bold type indicate organisms collected or observed during our study, while taxa in normal type are organisms collected or observed during previous studies. Taxa from previous studies are followed by a citation indicating where that information came from. Higher taxonomy follows the tree of life web project (http://tolweb.org/tree/) and lower taxonomy (Phylum, Class, Order, etc.) follows the Nature Serve website (http://www.natureserve.org/explorer/index.htm). As previously mentioned, Appendix 1 contains copies of all of the field sheets. All of the taxonomic identifications thus far, including microhabitat observations transferred from field sheets, is in a digital format as a separate file labeled Appendix 2. Habitat parameters that were measured for terrestrial organisms include 2 cm soil temperature and wet and dry bulb air temperature, and habitat parameters measured at aquatic sites were water temperature, pH, dissolved oxygen and conductivity. These data are provided in Appendix 3. In addition to the images in Figures 1 through 35, all digital color images collected during this study are in a separate file labeled Appendix 4. Finally, Appendix 5 is sent under separate cover and contains black and white slides of selected digital color images collected during the study.

Crevasse Cave

Phylum Chelicerata
- **Class Arachnida**
  - **Order Araneae (spiders)**
  - **Order Opiliones (harvestmen)**
    - **Family Triaenonychidae**
      - ***Cryptobunus* (probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**
  - **Order Pseudoscorpiones**
    - **Family Neobisiidae**
      - ***Microcreagris* (probably *grandis* Muchmore 1962, but this is a new locality)**

Phylum Mandibulata
- **Class Chilopoda (centipedes)**
- **Class Insecta (insects)**
  - **Order Collembola (springtails)**
  - **Order Coleoptera (beetles)**
    - **Undetermined coleopteran**
    - **Family Tenebrionidae (darkling beetles)**
  - **Order Diptera (flies)**
    - **Family Sciaridae**
  - **Order Hymenoptera (bees, wasps, ants)**
    - **Family Formicidae (ants)**

Phylum Mollusca
- **Class Gastropoda (snails)**

Phylum Craniata
- **Class Mammalia**
  - **Order Rodentia**
    - **(Rodent skull)**

Halliday's Deep

Phylum Chelicerata
- **Class Arachnida**
  - **Order Acari (mites)**
  - **Order Araneae (spiders)**
    - **Family Lycosidae (wolf spiders)**
  - **Order Opiliones (harvestmen)**
    - **Family Triaenonychidae**

Cryptobunus **(probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**

Phylum Mandibulata
- **Class Insecta (insects)**
  - **Order Coleoptera (beetles)**
    - **Family Tenebrionidae (darkling beetles)**
  - **Order Diptera (flies)**
    - **Family Heleomyzidae**
  - **Order Hymenoptera (bees, wasps, ants)**
    - **Family Ichneumonidae**
  - **Order Lepidoptera**

Phylum Craniata
- Class Mammalia
  - Order Chiroptera
    - Family Vespertilionidae
      - *Corynorhinus townsendii*

Ice Cave

Phylum Chelicerata
- **Class Arachnida**
  - **Order Acari (mites)**
  - **Order Araneae (spiders)**
  - **Order Opiliones (harvestmen)**
    - **Family Triaenonychidae**
      - ***Cryptobunus*** **(probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**

Phylum Mandibulata
- **Class Chilopoda (centipedes)**
- **Class Diplopoda (millipeds)**
- **Class Insecta (insects)**
  - **Order Diptera (flies)**
    - **Family Heleomyzidae**

Phylum Mollusca
- **Class Gastropoda (snails)**

Phylum Craniata
- **Class Mammalia**
  - **Order Chiroptera**
    - **Family Vespertilionidae (bats) skull**

Upper Pictograph Cave

Phylum Chelicerata
- **Class Arachnida**

Order Acari (mites)
Order Araneae (spiders)
Order Opiliones (harvestmen)
Family Triaenonychidae
***Cryptobunus* (probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**
Order Pseudoscorpiones
Family Neobisiidae
***Microcreagris* (probably *grandis* Muchmore 1962)**
Microcreagris grandis was also reported in "Pictograph Cave," by Bridgemon (1967), presumeably this is the same site as Upper Pictograph Cave.
Phylum Mandibulata
Class Insecta (insects)
Order Collembola (springtails)
Family Entomobryidae
Undetermined
***Tomocerus* sp.**
Order Coleoptera (beetles)
Phylum Craniata
Class Mammalia
Order Rodentia
(Rodent skull)
Family Cricetidae
***Peromyscus* sp. (mouse)**
Order Chiroptera
Family Vespertilionidae (bats)
Corynorhinus townsendii
***Corynorhinus townsendii pallescens* (Big-eared bats)**
Myotis ciliolabrum
Myotis evotis
Myotis volans

<u>Lower Pictograph Cave</u>

Phylum Mandibulata
Class Insecta (insects)
Order Collembola (springtails)
Family Entomobryidae
***Tomocerus* sp.**
Phylum Craniata
Class Mammalia
Order Chiroptera

Family Vespertilionidae
Corynorhinus townsendii

Wheeler's Deep

Phylum Chelicerata
Class Arachnida
Order Acari (mites)
Order Araneae (spiders)
Order Opiliones (harvestmen)
Family Triaenonychidae
***Cryptobunus* (probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**
Phylum Mandibulata
Class Diplopoda
Order Polydesmida
***Speodesmus* n. sp.?**
Undetermined
Class Insecta
Order Coleoptera (beetles)
Order Diptera (flies)
Family Mycetophilidae (fungus gnats)
Phylum Mollusca
Class Gastropoda (snails)
Phylum Craniata
Class Mammalia
Order Rodentia
(Rodent skull)
Order Chiroptera
Family Vespertilionidae
Corynorhinus townsendii
Myotis ciliolabrum
Myotis evotis
Myotis volans

Systems Key Cave

Phylum Platyhelminthes
Class Tricladida (flatworms)
Phylum Annelida
Class Oligochaeta (earthworms and aquatic worms)
Phylum Crustacea
Class Copepoda
Class Ostracoda

Phylum Chelicerata
- **Class Arachnida**
  - **Order Acari (mites)**
    - **Family Rhagidiidae**
    - **undetermined**
  - **Order Araneae (spiders)**
  - **Order Opiliones (harvestmen)**
    - **Family Triaenonychidae**
      - ***Cryptobunus* (probably *ungulatus ungulatus* Briggs 1971, the Model Cave Harvestman, but this is a new locality)**

Phylum Mandibulata
- **Class Chilopoda (centipedes)**
- **Class Diplpoda (millipeds)**
- **Class Insecta**
  - **Order Plecoptera (stoneflies)**
  - **Order DIptera (flies)**
    - **Family Chironomidae**
    - **Family Heleomyzidae**
    - **undetermined**

Phylum Mollusca
- **Class Gastropoda (snails)**

Model Cave

Model Cave seems to have a particularly rich fauna. During our first visit, when we were placing pitfall traps, we were enthusiastic about the prospects for a good diversity of specimens in the traps. Unfortunately, during our return trip to retrieve the traps, the cave was flooded to the point that we could not even get to the first junction, beyond which most of our traps had been placed. Baldino (1998) found Model Cave sumped at the first junction, which, in light of our experience, suggests that this happens with some regularity.

Phylum Annelida
- **Class Oligochaeta (earthworms and aquatic worms)**

Phylum Crustacea
- **Class Copepoda**
- **Class Ostracoda**

Phylum Chelicerata
- **Class Arachnida**
  - **Order Acari (mites)**
    - **Family Rhagidiidae?**
    - **undetermined**
  - **Order Opiliones (harvestmen)**
    - **Family Triaenonychidae**
      - ***Cryptobunus ungulatus ungulatus* Briggs 1971**

(Model Cave Harvestman)

Phylum Mandibulata
Class Diplpoda (millipeds)
Order Polydesmida
***Speodesmus* n. sp.?**
Undetermined
Class Insecta
Order Collembolda
Family Entomobryidae
***Tomocerus* sp.**
Undetermined
Family Onychiuridae
Family Arrhopalitidae
***Arrhopalites* n. sp.?**
Phylum Mollusca
Class Gastropoda (snails)

<u>Little Muddy Cave</u>

Phylum Chelicerata
Class Arachnida
Order Acari (mites)
Order Araneae (spiders)
Order Pseudoscorpiones
Family Neobisiidae
***Microcreagris* (probably *grandis* Muchmore 1962)**
Microcreagris grandis was also reported in Little Muddy Cave by Schmitz (1986).
Phylum Mandibulata
Class Diplopoda
Order Polydesmida
***Speodesmus* n. sp.?**
Class Insecta (insects)
Order Collembola (springtails)
Order Heteroptera (true bugs)
Undetermined
Order Siphonaptera (fleas)
Order Diptera (flies)
Family Cecidomyiidae
Family Muscidae
Family Sciaridae

Snake Creek Cave

Phylum Mandibulata
Class Diplpoda

Order Polydesmida
***Speodesmus* n. sp.?**
Class Insecta
Order Collembola (springtails)
Family Entomobryidae
Family Arrhopalitidae
***Arrhopalites* n. sp.?**
Order Pscopotera (book and bark lice)
Order Coleoptera (beetles)
Family Anthicidae
Undetermined
Order Diptera (flies)
Family Sciaridae
Family Tipulidae (crane flies)
Order Hymenoptera
Family Formicidae
***Aphaenogaster* sp.**
Phylum Craniata
Class Aves
Order Passeriformes
Family Troglodytidae
***Catherpes mexicanus* (Swainson, 1829)**
Class Mammalia
Order Chiroptera
Family Vespertilionidae
Antrozous pallidus
Corynorhinus townsendii
Myotis ciliolabrum
Myotis evotis
Myotis volans

Lehman Cave

All of the observations and collections from this cave are from past studies, and these are cited. Of note is that the citation for the study that mentioned the cave fauna sometimes follows both the original species author and an author that placed that species in a new taxonomic grouping. We did not collect from this cave in our survey.

Taxon List:

Eubacteria (true bacteria):
Cyanobacteria
Class Myxophyceae (blue-green algae)
Anacystis montana (Lightfoot) Drouet and Daily (Stark 1969)

Schizothrix calcicola (C. Agardh) Komont (Stark 1969)
Oscillatoria Vaucher sp. (Stark 1969)
Anabaena Bory sp. (Stark 1969)
Coccochloris Springel sp. (Stark 1969)

Eubacteria (true bacteria):
Bacteria:

In one culture made from a stalactite, an unidentified bacterial colony developed along with a fungus. (Went, undated)

“Bacteria were common in pools which dry during winter” according to Stark (1969)

Slime bacterium *Dictyostelium* sp. occurs on walls (Desert Research Institute 1968 and Stark 1969)

Slime mold *Stemonites* sp. is common on wood (is this a fungus or bacteria?) (Desert Research Institute 1968, Stark 1969)

Bacteria *Zoogloea ramigera* tentative identification by Stark found (Desert Research Institute 1968)

Chemotrophic bacteria *Leptothrix* sp. (iron bacteria) are producers (Desert Research Institute 1968).

Eukaryotes (organisms with nucleated cells):
Green Plants:

Embryophytes (land plants):
Bryophyta (mosses)
- Class Bryopsida
  - Order Hypnales
    - Family Amblystegiaceae
      - *Campylium chrysophyllum* (Bird) J. Lang identified by Sheps (1972)
  - Order Funariales
    - Family Funariaceae
      - *Physcomitrium* sp. identified by Sheps (1972)
- Class Bryopsida: *Bruchia* sp. identified by Sheps (1972)

Embryophytes (land plants):
Marchantiomorpha (liverworts)
Phylum Hepatophyta
- Class Jungermanniopsida
  - Order Jungermanniales
    - Family Metzgeriales

Closely resemble *Metzgeria* sp. but they are small. Identified by the Desert Research Institute (1968) and mentioned by Stark (1969) as "one species of Liverwort" from Lehman Cave

Embryophytes (land plants):

Filicopsida (ferns)

Order Filicales

Family Dryopteridaceae

Cystopteris fragilis (L.) Bernh were identified by Stark (1969)

Family Aspleniaceae

Asplenium sp. were identified by Stark (1969)

Green Plants:

Algae:

Division Chlorophyta

Class Chlorophyceae (green algae)

Mugeotiopsis calospora Palla (Stark 1969)
Chlorococcum humicola (Nageli) Rabenhorst (Stark 1969)
Protococcum viridis Agardh (Stark 1969)
Nannochloris Naumann sp. (Stark 1969)
Roya anglica G.S. West (Stark 1969)
Cosmarium corda sp. (tentative identification)(Stark 1969)
Chlorella vulgaris Beijerinck (tentative identification)(Stark 1969)
Coccomyxa dispar Schmidle (tentative identification)(Stark 1969)
Palmella miniata Liebl. (tentative identification)(Stark 1969)

Also, an unidentified species of alga was transplanted by Sheps (1972)

Eukaryotes (organisms with nucleated cells):

Animalia (Metazoa):

Phylum Annelida

Class Oligochaeta reported by Desert Research Institute (1968)

Phylum Chelicerata

Class Arachnida

Order Oribatida

Family Oribatidae reported by Desert Research Institute (1968), Stark (1969)

Order Araneae four undetermined species of spider from Lehman Cave (Desert Research Institute 1968, Stark 1969)

Order Pseudoscorpiones

Family Neobisiidae

Microcreagris grandis Muchmore 1969, type material (Muchmore 1969); and recorded by other authors (Desert Research Institute 1968, Stark 1969, Schmitz 1986)

Phylum Mandibulata

Class Insecta

Order Collembola

Family Entomobryidae

Entomobrya marginata Tullberg reported by Stark (1969)

Family Sminthuridae reported by Desert Research Institute (1968) – likely the same as our Arrhopalitidae

Family Poduridae reported by Desert Research Institute (1968)

Order Diptera

Family Sciaridae

Bradysia sp. (det. By R.J. Gagne, USNM) (Desert Research Institute 1968, Stark 1969)

Family Phoridae

Megaselia sp. (det. By W.W. Wirth USNM) (Desert Research Institute 1968, Stark 1969)

Family Psychodidae

Psychoda sp. (Desert Research Institute 1968, Stark 1969)

Family Ceratopogonidae

Culicoides sp. (det. W.W. Wirth USNM) (Desert Research Institute 1968, Stark 1969)

Family Streblidae (Desert Research Institute 1968, Stark 1969)

Family Heleomyzidae

Pseudoleria sp. (det. A. Steyskal, USNM) (Desert Research Institute 1968)

Order Lepidoptera

Family Tineidae

probably *Amydria* sp. (det. D.R. Davis, USNM), reported as fairly abundant (Desert Research Institute 1968, Stark 1969)

Order Coleoptera: referring to pack rat guano at Lehman Cave: Stark (1969) says “beetle galleries and frass are common under old dung and another type burrows into pellets, but no beetles are known to be active in the dung of the caves today”

Family Psyllipsocidae

Psyllipisocus ramburii Selys-Longchamps (det. E.L. Mockford, Ill.) (Desert Research Institute 1968, Stark 1969)

Family Cryptophagidae (Desert Research Institute 1968)

Phylum Craniata

Class Aves

Order Galliformes

Family Phasianidae “Grouse? (recent)” tentatively identified from skeletal remains by Orr (1952)

Class Mammalia

Order Carnivora

Family Canidae

Canis latrans Say, 1823 “Coyote (fossil?)” tentatively identified from skeletal remains by Orr (1952)

“Fox (fossil?)” tentatively identified from skeletal remains by Orr (1952)

Order Rodentia

Family Erethizontidae

Cf. *Erethizon* tentative identification of skeletal remains from Lost River Passage, “cf” indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Family Sciuridae

Tamias sp. tentative identification of skeletal remains from Lost River Passage, “cf” indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Tamias dorsalis (Baird, 1855) (Desert Research Institute 1968, Stark 1969)

Marmota cf. *flaviventris* (Audubon and Bachman, 1841) tentative identification of skeletal remains from Lost River Passage, “cf” indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980); also “Marmot (fossil?)” tentatively identified from skeletal remains by Orr (1952)

Family Muridae

Peromyscus maniculatus (Wagner, 1845) (Desert Research Institute 1968, Stark 1969)

Probably *Neotoma* sp. based on guano, (Desert Research Institute 1968, Stark 1969)

Reithrodontomys sp. tentative identification of skeletal remains from Lost River Passage, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Order Lagomorpha

Family Leporidae

Cf. *Sylvilagus* sp. (probably *S. nuttalli*) tentative identification of skeletal remains from Lost River Passage, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

"Jack rabbit (recent)" tentatively identified from skeletal remains by Orr (1952)

Order Primates

Family Hominidae

Homo sapiens "Human (recent)" tentatively identified from skeletal remains by Orr (1952)

Phylum Rotifera

Trichocera sp. identified by Drs. Wheeler (Desert Research Institute 1968)

Lepadella sp. identified by Drs. Wheeler (Desert Research Institute 1968)

Eukaryotes (organisms with nucleated cells):

Stramenopiles:

Class Bacillariophyceae (diatoms)

Navicula (6 species of naviculoid diatoms)(Stark 1969)

Coscinodiscus Her. Sp. (Stark 1969)

Stramenopiles:

Phylum Sarcodina (protozoans)

Superclass Rhizopoda (amoebae):

Cucurbitella sp. Penard, tentative identification (Desert Research Institute 1968)

Actinophyidae

Actinosphaerium sp. (Desert Research Institute 1968)

Amoebidae

Vahlkampfia sp. (Desert Research Institute 1968)

Amoeba sp. (Desert Research Institute 1968)

Eukaryotes (organisms with nucleated cells):

Alveolotes:

Phylum Ciliophora

Class Ciliata

Lagenophrys nassa Stein, tentative identification by Stark (Desert Research Institute 1968)
Strombidium viride Stein, tentative identification by Stark (Desert Research Institute 1968)
Mesodinium acarus Stein, tentative identification by Stark (Desert Research Institute 1968)
Paramecium sp. Hill (water) tentative identification by Stark (Desert Research Institute 1968)
Rhopalophrya sp. identified by Drs. Wheeler (Desert Research Institute 1968)
Oxytricha sp. identified by Drs. Wheeler (Desert Research Institute 1968)
Euplotes sp. identified by Drs. Wheeler (Desert Research Institute 1968)
Urostyla sp. identified by Drs. Wheeler (Desert Research Institute 1968)
Chilodonella sp. identified by Drs. Wheeler (Desert Research Institute 1968)
Vorticella sp. identified by Drs. Wheeler (Desert Research Institute 1968)

Eukaryotes (organisms with nucleated cells):
Fungi:

A single unidentified species of fungus was observed in situ and cultured from inactive and active stalactites. The fungus is described as slow-growing with very fine white mycelium. (Went, undated)

An unidentified fungus was found growing beneath an experimental light placed by Sheps (1972)
"Large numbers" of fungi were reported throughout the cave on moist walls, dead organic matter, dead flies and on stalactites by Stark (1969).

Chytrids live on dead algae and pollen (Desert Research Institute 1968, Stark 1969)

Marasmius fruiting body found on wood (Desert Research Institute 1968)

Phylum Mastigophora?
Anisonemidae
Peranema sp. (eat dead organic debris) (Desert Research Institute 1968)

Complete Taxon List
for caves of
Great Basin National Park

Eubacteria (true bacteria):
Cyanobacteria
Class Myxophyceae (blue-green algae)
Anacystis montana (Lightfoot) Drouet and Daily (Stark 1969) from Lehman Cave
Schizothrix calcicola (C. Agardh) Komont (Stark 1969) from Lehman Cave
Oscillatoria Vaucher sp. (Stark 1969) from Lehman Cave
Anabaena Bory sp. (Stark 1969) from Lehman Cave
Coccochloris Springel sp. (Stark 1969) from Lehman Cave
Eubacteria (true bacteria):
Bacteria:

In one culture made from a stalactite, an unidentified bacterial colony developed along with a fungus. (Went, undated) from Lehman Cave

"Bacteria were common in pools which dry during winter" according to Stark (1969) from Lehman Cave

Slime bacterium *Dictyostelium* sp. occurs on walls (Desert Research Institute 1968 and Stark 1969) from Lehman Cave

Slime mold *Stemonites* sp. is common on wood (is this a fungus or bacteria?) (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Bacteria *Zoogloea ramigera* tentative identification by Stark found (Desert Research Institute 1968) from Lehman Cave

Chemotrophic bacteria *Leptothrix* sp. (iron bacteria) are producers (Desert Research Institute 1968) from Lehman Cave

Eukaryotes (organisms with nucleated cells):
Green Plants:

Embryophytes (land plants):
Bryophyta (mosses)
Class Bryopsida
Order Hypnales
Family Amblystegiaceae

Campylium chrysophyllum (Bird) J. Lang identified by Sheps (1972) from Lehman Cave

Order Funariales

Family Funariaceae

Physcomitrium sp. identified by Sheps (1972) from Lehman Cave

Class Bryopsida: *Bruchia* sp. identified by Sheps (1972) from Lehman Cave

Embryophytes (land plants):
Marchantiomorpha (liverworts)
Phylum Hepatophyta

Class Jungermanniopsida

Order Jungermanniales

Family Metzgeriales

Closely resemble *Metzgeria* sp. but they are small. Identified by the Desert Research Institute (1968) and mentioned by Stark (1969) as “one species of Liverwort” from Lehman Cave

Embryophytes (land plants):
Filicopsida (ferns)

Order Filicales

Family Dryopteridaceae

Cystopteris fragilis (L.) Bernh were identified by Stark (1969) from Lehman Cave

Family Aspleniaceae

Asplenium sp. were identified by Stark (1969) from Lehman Cave

Green Plants:
Algae:
Division Chlorophyta

Class Chlorophyceae (green algae)

Mugeotiopsis calospora Palla (Stark 1969) from Lehman Cave

Chlorococcum humicola (Nageli) Rabenhorst (Stark 1969) from Lehman Cave

Protococcum viridis Agardh (Stark 1969) from Lehman Cave

Nannochloris Naumann sp. (Stark 1969) from Lehman Cave

Roya anglica G.S. West (Stark 1969) from Lehman Cave

Cosmarium corda sp. (tentative identification)(Stark 1969) from Lehman Cave

Chlorella vulgaris Beijerinck (tentative identification)(Stark 1969) from Lehman Cave

Coccomyxa dispar Schmidle (tentative identification)(Stark 1969) from Lehman Cave

Palmella miniata Liebl. (tentative identification)(Stark 1969) from Lehman Cave

Also, an unidentified species of alga was transplanted by Sheps (1972) from Lehman Cave

Eukaryotes (organisms with nucleated cells):
Stramenopiles:
Class Bacillariophyceae (diatoms)

Navicula (6 species of naviculoid diatoms)(Stark 1969) from Lehman Cave

Coscinodiscus Her. Sp. (Stark 1969) from Lehman Cave

Stramenopiles:
Phylum Sarcodina (protozoans)
Superclass Rhizopoda (amoebae):

Cucurbitella sp. Penard, tentative identification (Desert Research Institute 1968) from Lehman Cave

Actinophyidae

Actinosphaerium sp. (Desert Research Institute 1968) from Lehman Cave

Amoebidae

Vahlkampfia sp. (Desert Research Institute 1968) from Lehman Cave

Amoeba sp. (Desert Research Institute 1968) from Lehman Cave

Eukaryotes (organisms with nucleated cells):
Alveolotes:
Phylum Ciliophora
Class Ciliata

Lagenophrys nassa Stein, tentative identification by Stark (Desert Research Institute 1968) from Lehman Cave

Strombidium viride Stein, tentative identification by Stark (Desert Research Institute 1968) from Lehman Cave

Mesodinium acarus Stein, tentative identification by Stark (Desert Research Institute 1968) from Lehman Cave

Paramecium sp. Hill (water) tentative identification by Stark (Desert Research Institute 1968) from Lehman Cave

Rhopalophrya sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave

Oxytricha sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave
Euplotes sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave
Urostyla sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave
Chilodonella sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave
Vorticella sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave

Eukaryotes (organisms with nucleated cells):
Fungi:

A single unidentified species of fungus was observed in situ and cultured from inactive and active stalactites. The fungus is described as slow-growing with very fine white mycelium (Went, undated) from Lehman Cave

An unidentified fungus was found growing beneath an experimental light placed by Sheps (1972) from Lehman Cave

"Large numbers" of fungi were reported throughout the cave on moist walls, dead organic matter, dead flies and on stalactites by Stark (1969) from Lehman Cave

Chytrids live on dead algae and pollen (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Marasmius fruiting body found on wood (Desert Research Institute 1968) from Lehman Cave

Phylum Mastigophora?
Anisonemidae
Peranema sp. (eat dead organic debris) (Desert Research Institute 1968) from Lehman Cave

Animalia (Metazoa):
Phylum Rotifera
Trichocera sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave
Lepadella sp. identified by Drs. Wheeler (Desert Research Institute 1968) from Lehman Cave

Phylum Platyhelminthes
Class Tricladida (Systems Key Cave)

Phylum Annelida

Class Oligochaeta reported from Lehman Cave by Desert Research Institute (1968) **and found in (Model Cave, Systems Key Cave)**

Phylum Crustacea

Class Copepoda (Systems Key Cave, Model Cave)

Class Ostracoda (Systems Key Cave, Model Cave)

Phylum Chelicerata

Class Arachnida

Order Oribatida

Family Oribatidae reported from Lehman Cave by Desert Research Institute (1968), Stark (1969)

Order Acari

undetermined (Halliday's Deep, Ice Cave, Upper Pictograph Cave, Wheeler's Deep, Little Muddy Cave, Model Cave, Systems Key Cave)

Family Rhagidiidae (Systems Key Cave, Model Cave)

Order Araneae

Undetermined: four undetermined species of spider from Lehman Cave (Desert Research Institute 1968, Stark 1969) **also found from Crevasse Cave, Ice Cave, Upper Pictograph Cave, Wheelers Deep, Systems Key Cave, Little Muddy Cave**

Family Lycosidae (Halliday's Deep)

Order Pseudoscorpiones

Family Neobisiidae

Microcreagris grandis Muchmore 1969, type material from Lehman Cave (Muchmore 1969); and recorded by other authors from Lehman Cave (Desert Research Institute 1968, Stark 1969, Schmitz 1986); found in Pictograph Cave (presumably Upper Pictograph Cave?) (Bridgemon 1967 **and Upper Pictograph Cave, present study**); found in Little Muddy Cave (Schmitz 1986 **and present study**); **new records found in Crevasse Cave, unclear record confirmed in Upper Pictograph Cave**

Order Opiliones

Family Triaenonychidae

Cryptobunus ungulatus ungulatus Briggs, 1971, type material from Model Cave (Briggs 1971), **also found from Model Cave in present study**

***Cryptobunus* (probably *ungulatus ungulatus* Briggs 1971) new records found in Crevasse Cave, Halliday's Deep, Ice Cave, Upper Pictograph Cave, Wheeler's Deep, Systems Key Cave**

Sclerobunus robustus (Packard) was seen in Model, Deep, and Halliday's Deep Caves and collected from Deep Cave. The collected specimen was sent to Clarance J. Goodnight for identification. (Bridgemon 1967). This probably represents a misidentification since *Cryptobunus* was not yet described.

Phylum Mandibulata

Class Chilopoda

Undetermined (Crevasse Cave, Ice Cave, Systems Key Cave)

Class Diplopoda

undetermined (Ice Cave, Systems Key Cave, Wheeler's Deep, Model)

Order Polydesmida

Family Polydesmidae

***Speodesmus* n. sp.? (Wheeler's Deep, Snake Creek Cave, Model Cave, Little Muddy Cave)**

Class Insecta

Order Collembola

Undetermined (Crevasse Cave, Little Muddy Cave)

Family Entomobryidae

Undetermined (Snake Creek Cave, Upper Pictograph Cave, Model Cave)

Entomobrya marginata Tullberg reported by Stark (1969) from Lehman Cave

***Tomocerus* sp. Undetermined (Upper Pictograph Cave, Lower Pictograph Cave, Model Cave)**

Family Sminthuridae

Undetermined: reported by Desert Research Institute (1968) from Lehman Cave – likely the same as our Arrhopalitidae

Family Arrhopalitidae

***Arrhopalites* n. sp.?**

Snake Creek Cave and Model Cave

Family Poduridae

Undetermined: reported by Desert Research Institute (1968) from Lehman Cave

Family Onychiuridae

Undetermined (Model Cave)

Order Heteroptera

Undetermined (Little Muddy Cave)

Order Plecoptera

Undetermined (Systems Key Cave)

Order Diptera

Undetermined (Systems Key Cave)

Family Cecidomyiidae (Little Muddy Cave)
Family Muscidae (Little Muddy Cave)
Family Sciaridae
Undetermined (Crevasse Cave, Snake Creek Cave, Little Muddy Cave)
Bradysia sp. (det. By R.J. Gagne, USNM) (Desert Research Institute 1968, Stark 1969) from Lehman Cave
Family Phoridae
Megaselia sp. (det. By W.W. Wirth USNM) (Desert Research Institute 1968, Stark 1969) from Lehman Cave
Family Psychodidae
Psychoda sp. (Desert Research Institute 1968, Stark 1969) from Lehman Cave
Family Ceratopogonidae
Culicoides sp. (det. W.W. Wirth USNM) (Desert Research Institute 1968, Stark 1969) from Lehman Cave
Family Streblidae (Desert Research Institute 1968, Stark 1969) from Lehman Cave
Family Heleomyzidae
Pseudoleria sp. (det. A. Steyskal, USNM) (Desert Research Institute 1968) from Lehman Cave
Undetermined (Halliday's Deep, Ice Cave, Systems Key Cave)
Family Chironomidae
Undetermined (Systems Key Cave)
Family Mycetophilidae
Undetermined (Wheeler's Deep)
Family Tipulidae (Snake Creek Cave)
Order Hymenoptera
Family Ichneumonidae
Undetermined (Halliday's Deep)
Family Formicidae
Undetermined (Crevasse Cave)
***Aphaenogaster* sp. (Snake Creek Cave)**
Order Lepidoptera
Undetermined (Halliday's Deep)
Family Tineidae
probably *Amydria* sp. (det. D.R. Davis, USNM), reported as fairly abundant from Lehman Cave (Desert Research Institute 1968, Stark 1969)
Order Coleoptera
Undetermined: referring to pack rat guano at Lehman Cave: Stark (1969) says "beetle galleries and frass are common

under old dung and another type burrows into pellets, but no beetles are known to be active in the dung of the caves today”

Undetermined (Crevasse Cave, Upper Pictograph Cave, Wheeler’s Deep, Snake Creek Cave)

Family Psyllipsocidae

Psyllipisocus ramburii Selys-Longchamps (det. E.L. Mockford, Ill.) (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Family Cryptophagidae

Undetermined (Desert Research Institute 1968) from Lehman Cave

Family Tenebrionidae (Crevasse Cave, Halliday’s Deep)

Family Anthicidae (Snake Creek Cave)

Order Siphonaptera

Undetermined (Little Muddy Cave)

Family Dolichophysillidae (Desert Research Institute 1968) from Lehman Cave

Order Psocoptera

Undetermined (Snake Creek Cave)

Phylum Mollusca

Class Gastropoda (Crevasse Cave, Ice Cave, Wheeler’s Deep, Systems Key Cave, Model Cave)

Phylum Craniata

Class Aves

Order Galliformes

Family Phasianidae “Grouse? (recent)” tentatively identified from skeletal remains by Orr (1952) from Lehman Cave

Order Passeriformes

Family Troglodytidae

***Catherpes mexicanus* (Swainson, 1829) (Canyon Wren, nesting on wall ledge inside of gate of Snake Creek Cave)**

Class Mammalia

Order Carnivora

Family Canidae

Canis latrans Say, 1823 “Coyote (fossil?)” tentatively identified from skeletal remains by Orr (1952) from Lehman Cave

“Fox (fossil?)” tentatively identified from skeletal remains by Orr (1952) from Lehman Cave

Order Rodentia

Undetermined (Crevasse Cave, Wheeler's Deep, Upper Pictograph Cave)

Family Erethizontidae

Cf. *Erethizon* tentative identification of skeletal remains from Lost River Passage from Lehman Cave, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Family Sciuridae

Tamias sp. tentative identification of skeletal remains from Lost River Passage from Lehman Cave, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Tamias dorsalis (Baird, 1855) (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Marmota cf. *flaviventris* (Audubon and Bachman, 1841) tentative identification of skeletal remains from Lost River Passage from Lehman Cave, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980); also "Marmot (fossil?)" tentatively identified from skeletal remains by Orr (1952)

Family Muridae

***Peromyscus* sp. (Upper Pictograph Cave)**

Peromyscus maniculatus (Wagner, 1845) (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Probably *Neotoma* sp. based on guano, (Desert Research Institute 1968, Stark 1969) from Lehman Cave

Reithrodontomys sp. tentative identification of skeletal remains from Lost River Passage from Lehman Cave, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

Order Lagomorpha

Family Leporidae

Cf. *Sylvilagus* sp. (probably *S. nuttalli*) tentative identification of skeletal remains from Lost River Passage from Lehman Cave, "cf" indicates the identification is based solely upon visual inspection, judged probably Holocene (10,000 years or younger)(Mead 1980).

"Jack rabbit (recent)" tentatively identified from skeletal remains by Orr (1952) from Lehman Cave

Order Primates

Family Hominidae

Homo sapiens "Human (recent)" tentatively identified from skeletal remains by Orr (1952) from Lehman Cave

Order Chiroptera

Family Vespertilionidae

Undetermined (Ice Cave)

Antrozous pallidus (Le Conte, 1856) from Snake Creek Cave (GRBA 2002 and Baldino 1998))

Corynorhinus townsendii (Cooper, 1837) from Halliday's Deep Cave (Desert Research Institute 1968), from Snake Creek Cave, Wheelers Deep, Fox Skull, Upper Pictograph (GRBA 2002); from Crevasse Cave, Halliday's Deep, Wheeler's Deep, Can Young Cave, Forgotten Cave, Lincoln Canyon Mine, Lower Pictograph, Upper Pictograph, Rudolph Cave, Snake Creek Cave, Systems Key, Three Hole Cave, Lincoln Adit (a mine) (Baldino 1998)
Also found during current study from Upper Pictograph Cave

Eptesicus fuscus (Beauvois, 1796) from Mt. Washington (bulldozer pits) (GRBA 2002); from Lincoln Canyon Mine, Upper Pictograph, Lincoln Adit (a mine) (Baldino 1998)

Lasiurus cinereus (Beauvois, 1796) from Shoshone Ponds (water source) (Baldino 1998)

Myotis californicus (Audubon & Bachman, 1842) from Mt. Washington (bulldozer pits) (GRBA 2002)

Myotis ciliolabrum (Merriam, 1886) from Snake Creek Cave, Upper Pictograph (GRBA 2002); from

Wheeler's Deep, Lincoln Canyon Mine, Upper Pictograph (probably), Snake Creek Cave, Shoshone Ponds (water source), Lincoln Adit (a mine) (Baldino 1998)

Myotis evotis (H. Allen, 1864) from Snake Creek Cave, Wheelers Deep, Lincoln Adit (a mine), Mt. Washington (bulldozer pits) (GRBA 2002); from Wheeler's Deep, Lincoln Canyon Mine, Upper Pictograph, Snake Creek Cave, Shoshone Ponds (water source), Lincoln Adit (a mine) (Baldino 1998)

Myotis volans (H. Allen, 1866) from Wheelers Deep, Upper Pictograph (GRBA 2002); from Wheeler's Deep, Lincoln Canyon Mine, Upper Pictograph, Snake Creek Cave, Rowland Spring (water source), Shoshone Ponds (water source), Lincoln Adit (a mine) (Baldino 1998)

DISCUSSION

Our findings included many new records, some probable new species, and a baseline picture of cave macroinvertebrates in lower elevation caves of Great Basin National Park. This study inventoried many caves that had never been examined biologically, and thus we reported many range extensions and new records, even at this preliminary level of identification. The range extensions and new records are all in bold text in the Results section. Ultimately these collections will be sent to taxonomic specialists for complete identification. Even at this stage, however, we are fairly certain that some new species have been found, including a cave adapted millipede, (Polydesmida: Polydesmidae: *Speodesmus* n. sp.?), a globular springtail (*Arrhopalites* n. sp.?, Collembola: Arrhopalitidae), and possibly other springtails and mites.

Many taxa were known from Lehman Cave based on studies in the late 60's and early 70's (Desert Research Institute 1968, Stark 1969 and others in Literature Review), including some that we did not attempt to collect (fungi, plants, microfauna). However, these studies were nearly entirely limited to this one cave, and thus they missed some of the important diversity of troglobites. Recognizing how many more taxa were added to the historic species list at this early stage in identification, it is clear that sampling a diversity of caves is necessary to obtain an accurate picture of the cave fauna of the park.

Other researchers, beginning with the original description, have indicated that the pseudoscorpion, *Microcreagris grandis*, is a troglobite. They also recorded that the pseudoscorpions eat flies and springtails Desert Research Institute 1968, Stark 1969). We have confirmed that flies are a food item of the pseudoscorpion, as we photographed and captured one feeding on a fly (Muscidae), just inside the entrance gate of Little Muddy Cave. The location of this specimen, so close to the surface, suggests that there possibility it is only a troglophile. Careful searches under large rocks and crevices on the surface near Little Muddy Cave should be undertaken to see if the species is truly cave-limited.

Based on our findings, the cave community at GRBA is primarily based on guano of trogloxenes and leaf litter debris washed in from entrances. The fungus and bacteria that grow on small mammal scat and decomposing leaf litter is known to be eaten by springtails and other tiny arthropods, and serve as the base of the food chain for the cave ecosystem. Our observations were that a high diversity of fauna was found associated with these rich food sources when they were in the proper setting (e.g., away from the dry air and light of entrances, and with proper habitat nearby such as loose rocks). In most cases, troglobitic species such as harvestman and opilionids were found under loose rocks. In many cases troglobitic millipedes, mites, and springtails were found on or near rich soil with a high content of decomposing leaf litter. There are some other situations, such as in the very back of Snake Creek Cave we found two dead mice that were clearly providing a food source for cave springtails, which were seen in great abundance there, but very infrequently seen in other parts of the cave.

In Great Basin National Park, the impact of visitation may constitute a significant threat to cave life (GRBA 1988). Of the more than thirty caves in the park (K. Patel, pers. comm., October 2001) Leman Caves has received the majority of the attention. Elsewhere in the National Park Service (e.g., Mammoth Cave National Park, Sequoia and Kings Canyon National Parks) caves and their biota have been subject to careful study. Studies of caves and cave biotas provide land managers with important tools facilitating the long-term preservation of these fragile environs. Cleanup efforts in Lehman Caves have involved removal "foreign debris like old rotting wood from old handrails" (Jasper 1999) – such efforts, while commendable, should take into account cavernicole communities which may use rotting wood as a base to the communities' food web.

Management of the caves should focus around the microhabitat and food chain parameters mentioned above. Maintaining the microhabitat essentially means leaving the cave floors, walls, and ceiling in as natural of a state as possible. Threats to the microhabitat could include trampling and compaction in heavily visited caves, or caves with very small passage diameter. When soil gets compacted, tiny invertebrates such as springtails and mites can no longer find shelter in the spaces between soil particles, and thus these small animals that provide food for larger predators such as harvestmen and pseudoscorpions experience population declines. Also these larger predators rely on spaces beneath loose rocks for shelter, and trampling these rocks into the soil decreases this useable habitat. One way to prevent this problem is to flag off certain passages in some caves, disallowing visitation for a year or more, in order to let the passage recuperate from compaction. In time (which may vary from cave to cave), the soil will be restored by earthworms and other invertebrates to a less compacted state. Deciding which passages to do this in, and how long to do it, will depend on the particular situation. One example of a high priority site might be Little Muddy Cave, where the floor is mostly soil and the passage is small so compaction is evident. In this cave there are several dead-end side passages that harbor many pseudoscorpions (particularly near the entrance) where disallowing visitation would not hamper recreational use of the cave. Strategies for this type of management are obviously most effective when coupled with information on the biology of the species, and in this case the pseudoscorpion is known to have population lulls in the summer (Schmitz 1986). We will not attempt to give specific recommendations for each cave, but rather make suggestions about possible ideas that call for further study.

In order to maintain the energy sources for the cave, it is important to leave entrances as unimpacted as possible. For example, gate designs should not hinder trogloxenes such as bats, packrats, chipmunks, birds, marmots or mice from using the cave. Similarly, flood debris and fallen timber should be able to fall into the cave. In caves with horizontally oriented gates, this may mean ‘cleaning off’ debris that has fallen onto an entrance gate by opening the gate and tossing the material into the cave.

Trogloxene use of caves is often one of the major contributors to the ecosystem, and from our observations and past observations of large packrat dung piles, packrats either are or were a heavy user of caves in the park. Besides bats, our study found only the same two mammals noted by Desert Research Institute (1968) and Stark (1969), cliff chipmunks and deer mice, but also did not see pack rats. Possibly the packrats only use these caves in the winter (as suggested by Desert Research Institute), but possibly their populations are declining for other reasons. Stark (1969) attributes their absence in Lehman Cave to the installation of electric lights. Stark (1969) also mentions that in the packrat guano at Lehman Cave “beetle galleries and frass are common under old dung and another type burrows into pellets, but no beetles are known to be active in the dung of the caves today.” If the species is truly no longer using some of the caves, the implications for other cave species, such as the beetles he mentions, are very significant. Research on this species (seasonality, home range, habitat requirements, food, cave use) should be a priority.

Bats are clearly another important trogloxene, and they are known to be sensitive to disturbance, frequently leaving a cave after a disturbance event and never returning. Utmost care should be taken to manage caves for bat populations, including closing the cave to recreational use during breeding and hibernation periods, leaving entrances in a bat-friendly state, and preserving as much of the feeding and home range of the colony as possible.

A final management note stems from the literature search which revealed that in 1997, algae was cleaned from Lehman Caves (Anon. no date, A). The method was not specified, but bleach and herbicides were discussed as options by Lynn (1978). These have obvious detrimental effects to invertebrate populations. If algae must be cleaned, mechanical methods (scrubbing/scraping) or simply reducing light (but see Lynn 1978), are recommended.

Our recommendation for collection protocols for cave invertebrates are that collections for identification purposes should only be made at locations where that organism has not been verified before. In general, no more than ten individuals should be taken from any one cave. In some cases, however, additional individuals of a certain sex or lifestage may be needed to verify identification, or alternate preservation methods may be necessary to study some other aspect of the species biology (genetics, stable isotopes, etc.). Techniques for collection and presentation could follow our methods, or add on to what we were able to do. For example, no samples from leaf litter or guano were extracted using a berlese funnel, and this may yield new records for the caves.

Monitoring protocols are particularly important to establish for caves that have increasing visitation, for reasons mentioned above, including compaction of substrate and disturbance of trogloxenes. Monitoring for rare species is difficult because of the infrequency with which the individuals are seen and the lag time that can exist between impacts to the cave and changes to population levels. For this reason, we recommend monitoring both the rare species using timed area searches, and also monitoring the trogloxenes and organisms lower on the food chain using quantitative approaches.

Timed area searches for troglobitic predator species, such as *Cryptobunus ungulatus ungulatus* and *Microcreagris grandis*, are done in pre-designated areas of caves in which they are known to occur. An example of a typical monitoring transect might be 5 – 10 m of passage searched for 15 - 20 person minutes. These numbers may change depending on the complexity of the passage. By monitoring several transects like this in each cave up to 2 – 3 times a year, meaningful numbers for population levels can typically be inferred over the course of several years. If monitoring is possible only on a more infrequent basis, then it may take more years to see trends in population levels.

Other, taxa that occur in large numbers in particular caves might also be monitored. For example, in Model Cave, certain mites and springtails are abundant. After details of their identity are worked out, it might be appropriate to use a $0.1m^2$ quadrat, with at least ten replicate samples per study site and 2-4 sites in the cave, to census population levels of these organisms across time (seasons, years).

Research needs are partially covered in the preceding paragraphs, but will be specifically outlined here:

1. Pack rats: are they using caves? During what seasons? What is there range? What do they eat?
2. What taxa occur at other caves in the park? Are there other areas in the park with similar fauna? Is there another set of fauna at higher elevations? What fauna occur in nearby caves outside of the park?
3. Using a quantitative approach, what is the basis of the food chain that needs to be maintained? How much do these species rely on trogloxene guano vs. leaf litter vs. some other parameter?
4. What are the drainage basins of these caves? When severe impacts to the surface occur, such as fires, how does that affect these species?

Appendicies

All of the appendicies are digital except for Appendix 5 (black and white slides). See enclosed CD or associated files.

APPENDIX 1: Completed field forms and accompanying cave maps showing locations where collections were made.

APPENDIX 2: Digital version of all of the taxonomic identifications thus far, including microhabitat data transferred from field sheets.

APPENDIX 3: Habitat parameters that were measured for terrestrial organisms (2 cm soil temperature and wet and dry bulb air temperature), and habitat parameters measured at aquatic sites (water temperature, pH, dissolved oxygen and conductivity).

APPENDIX 4: Digital color images collected during the study.

APPENDIX 5: Black and White slides of selected digital color images collected during the study.

TABLES AND FIGURES

Table 1. Summary of GRBA cave visits during May 2003.

Date	Cave	Pitfall Traps	General Collecting
21 May 2003	Upper Pictograph Cave	placed	Yes
21 May 2003	Ice Cave	placed	Yes
22 May 2003	Crevasse Cave	placed	Yes
22 May 2003	Hallidays Deep Cave	no pitfall	Yes
23 May 2003	Model Cave	placed	Yes
23 May 2003	Little Muddy Cave	placed	Yes
24 May 2003	Upper Pictograph Cave	recovered	Yes
24 May 2003	Ice Cave	recovered	Yes
24 May 2003	Snake Creek Cave	placed	Yes
25 May 2003	Crevasse Cave	recovered	Yes
26 May 2003	Wheelers Deep Cave	no pitfall	Yes
26 May 2003	Systems Key Cave	no pitfall	Yes
27 May 2003	Model Cave	recovered[1]	No
27 May 2003	Little Muddy Cave	recovered	Yes
29 May 2003	Snake Creek Cave	recovered	Yes

[1]Due to flooding, only one pitfall was recovered

Figure 1. Wolf spider (Family Lycosidae) from Halliday's Deep.

Figure 2. An earthworm (Annelida: Oligochaeta) on moist, highly organic soil. Globular features in soil are probably earthworm tailings.

Figure 3. Heleomyzid fly on cave wall.

Figure 4. Unidentified moth on cave wall.

Figure 5. Big-eared bats, *Corynorhinus townsendii pallescens* (Chiroptera: Vespertilionidae) on ceiling in Upper Pictograph Cave.

Figure 6. The wing of an Underwing Moth (Lepidoptera: Noctuidae) on the floor of Upper Pictograph Cave in association with bat guano. Moth wings on cave floors typically occur where bats are roosting.


Figure 7. A mouse, *Peromyscus* sp. (Rodentia: Cricetidae), in Upper Pictograph Cave.


Figure 8. Chipmunks (Rodentia: Sciuridae, *Eutamias* sp.) dead at the base of the entrance drop in a cave. A beetle is present on the left foreleg of the individual on the right.

Figure 9. A darkling beetle (Tenebrionidae).

Figure 10. An unidentified beetle.

Figure 11. Webs created by the larva of a Mycetophilid fly on the ceiling of ??? cave.


Figure 12. Pupa of a mycetophilid fly hanging from the ceiling of ??? Cave.


Figure 13. A Rhagidiid mite on the floor of Systems Key Cave.


Figure 14. An Entomobryid springtail on the floor of Model Cave.

Figure 15. A milliped, perhaps *TIngupa* sp. (Chordeumatida: Conotylidae) or *Scoterpes* sp. (Chordeumatida: Trichopetalidae), on the wall of a cave.


Figure 16. An immature milliped, perhaps *TIngupa* sp. (Chordeumatida: Conotylidae) or *Scoterpes* sp. (Chordeumatida: Trichopetalidae), on the wall of a cave.

Figure 17. A probable new species of millipede (*Speodesmus* n. sp.?, Polydesmida: Polydesmidae).


Figure 18. *Cryptobunus ungulatus ungulatus* (Opiliones: Triaenonychidae) adult.

Figure 19. *Cryptobunus ungulatus ungulatus* (Opiliones: Triaenonychidae) immature, note paler coloration of the immature individuals.

Figure 20. *Cryptobunus ungulatus ungulatus* (Opiliones: Triaenonychidae) - dead, fungus-covered individual.

Figure 21. *Microcreagris grandis* (Pseudoscorpiones: Neobiisidae) in Little Muddy Cave.

Figure 22. *Microcreagris grandis* (Pseudoscorpiones: Neobiisidae) in Little Muddy Cave, male on left. Female from Upper Pictograph Cave on right, showing lighter color and more robust body (this individual is so plump that we suspect she either recently had a large meal or is about to reproduce).

Figure 23. *Microcreagris grandis* (Pseudoscorpiones: Neobiisidae) in the entrance of Little Muddy Cave with prey (Diptera: Muscidae).

Figure 24. *Microcreagris grandis* (Pseudoscorpiones: Neobiisidae) in the entrance of Little Muddy Cave with prey (Diptera: Muscidae).

Figure 25. *Microcreagris grandis* (Pseudoscorpiones: Neobiisidae) in Little Muddy Cave.

Figure 26. Typical passage near the back of Snake Creek Cave.

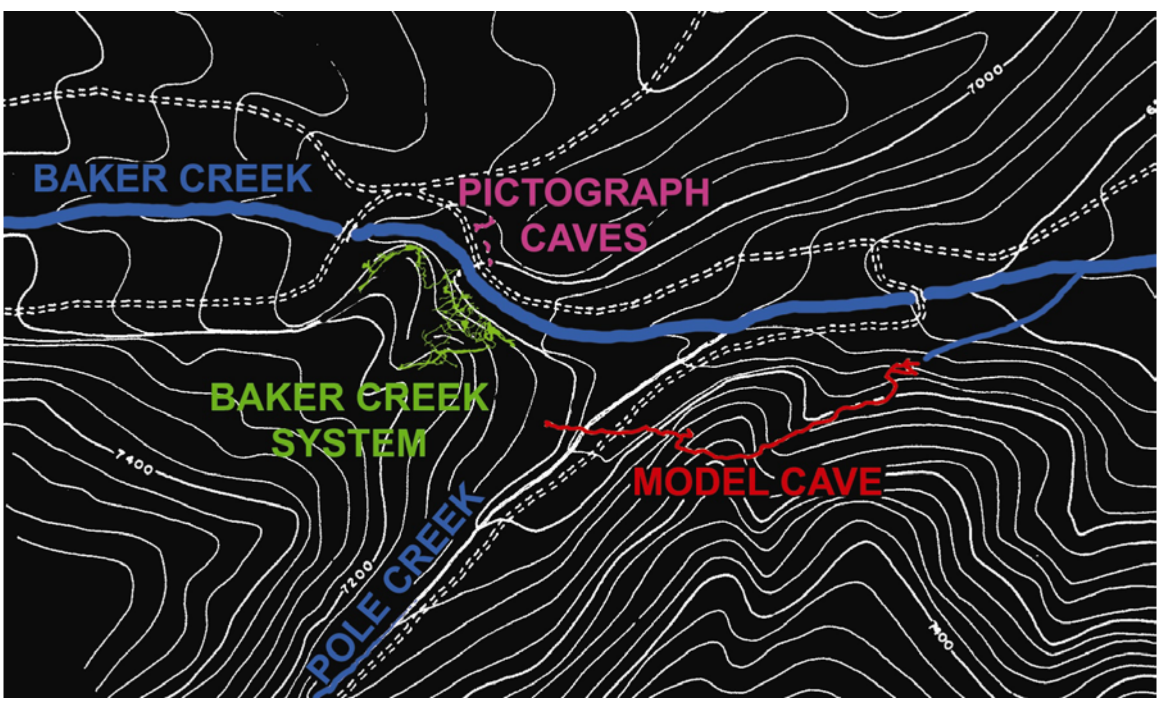

Figure 27. General overview of Baker creek area showing approximate location of caves of the Backer Creek System.

Figure 28. Looking south towards Model Cave, with surface terrain and approximate location of cave. Baker Creek System is largely to the right of this image.

Figure 29. Inside of Model Cave, towards intermittent spring. Note scallops on walls.

Figure 30. Typical streamside passage in a cave. Note accumulations of rich organic soils. This is typical habitat for troglobites.

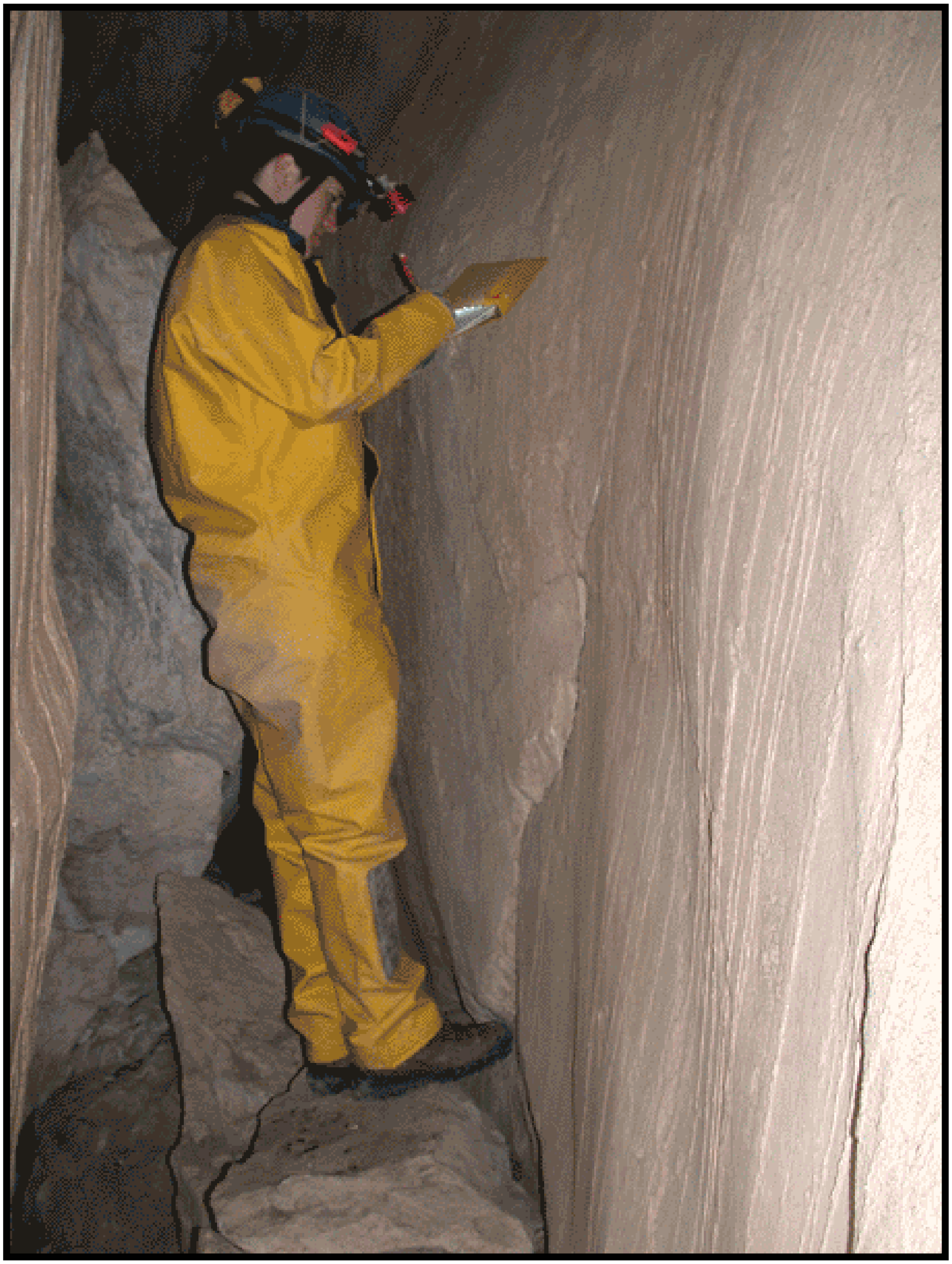

Figure 31. Vertical rift passage typical of the upper portions of caves in the Baker Creek system. Few troglobites are found in this habitat, which is typically very dry. Accumulations of packrat guano and feces of other rodents are fairly common in this habitat.

Figure 32. Plankton net in intermitten stream in cave. Note the large, well rounded cobbles which are suggestive of occasional much higher volume of flow at times.

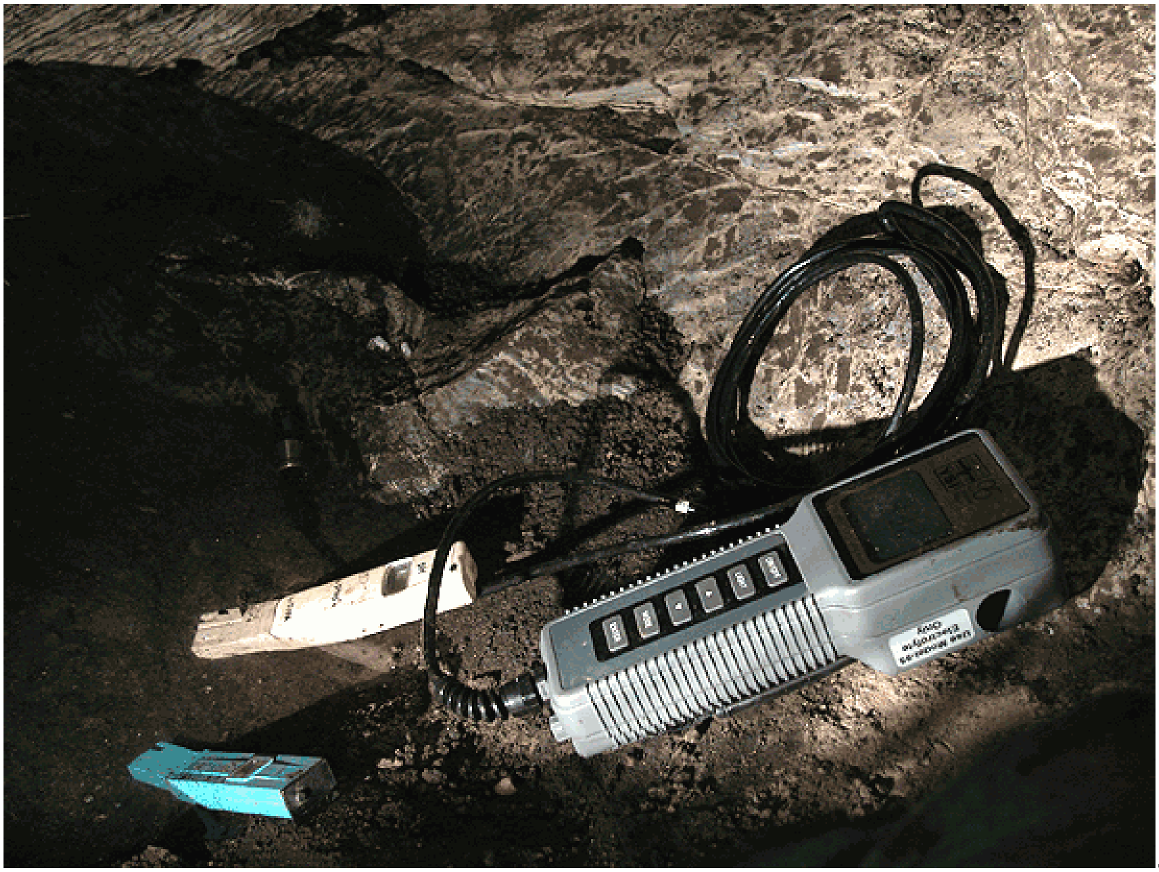

Figure 33. Collecting water data (temperature, dissolved oxygen, pH, and conductivity) at the downstream terminal sump (near intermittent spring resurgence) in Model Cave.

Figure 34. Gray box is wet-bulb/dry-bulb humidity meter, used to measure humidity and air temperature. White probe is used to measure soil temperature at 2 cm depth.

Figure 35. Typical pitfall trap setup. Green fluid is antifreeze. White material is limburger cheese.

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