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November 4, 1994

David M. Lee
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Denver, CO 80225-0287

Dear David:

Enclosed are two copies of the preliminary report by Dean Blinn and I on the invertebrate surveys of the Roaring Springs Cave, conducted under Work Order 91443PX20094183. The final report will be ready by January 15, 1994. Please give me a call if you have any questions on this (602/556-7311).

Thanks for all of your help and interest in this project.

Best wishes,

Charles

Charles Drost
Zoologist

**Invertebrate Survey of Roaring Springs Cave,
Grand Canyon National Park - September 1994**

Charles A. Drost

**National Biological Survey
Colorado Plateau Research Station
Northern Arizona University
Flagstaff, AZ**

- and -

Dr. Dean W. Blinn

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Flagstaff, AZ**

Report submitted to National Park Service, Denver Service Center,

in partial fulfillment of Work Order 91443PX20094183

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BACKGROUND

The Roaring Springs Cave is the source of the fresh water used to supply both the north and south rims of the Grand Canyon. The cave is located in the Muav formation, in the Bright Angel Creek drainage. The stream that courses through the cave flows out of the cave entrance and cascades down a steep slope to form a tributary of Bright Angel Creek. The intake for the Park water system is just inside the cave mouth, in the light zone of the cave. It has been proposed that the entrance to the cave be sealed to obtain an upgraded water classification from the State of Arizona and reduce treatment requirements. Information about the fauna of the Roaring Springs cave is necessary to determine the effects of this proposed closure of the cave. Earlier surveys (e.g. Peck 1980) found that some of the invertebrate species living in the cave are unique - apparently found nowhere else in the world. This study was initiated to survey the invertebrate fauna of the cave, and assess the likely effects of closing the cave entrance.

OBJECTIVES

- 1) Survey aquatic invertebrates in the Roaring Springs cave system in Grand Canyon National Park. Determine species composition, distribution, and general habitat relationships within the cave system.
- 2) Identify unusual, endemic, or otherwise sensitive species that live within the cave.
- 3) Evaluate likely effects of closing the main entrance of the cave on the invertebrate fauna, particularly on unique species.

SURVEY METHODS

A total of 14 hours were spent surveying the Roaring Springs cave on September 27 and 28. Survey personnel included David Lee (NPS / DSC), and Tim Snow and Shawn Castner (Arizona Game and Fish Department, and Charles Drost. Tim and Shawn were primarily involved in evaluating possible bat use of the cave. On September 27, the entire length of the main stream passage through the cave was explored, from the main cave entrance back a distance of approximately 1.3 km, to a point where the cave passage ended. Survey and collecting were confined to the twilight zone of the cave (from the entrance back a distance of about 80 m) on September 28.

We examined the floor, walls, and ceiling of the cave as we moved through it, and searched in and around boulder and debris piles. We turned and searched beneath boulders for invertebrates hiding underneath, both in dry boulder piles, and in boulders in the stream. For boulders underwater, we carefully searched both the stream bottom under the rock, and also the lower surface of the rock that had been under water. The area around spider webs was searched for the spiders that built them. Organic debris (dead insects, small mammal droppings) was carefully examined for small detritus-feeding insects.

Aquatic samples were taken in three main locations along the length of the cave. These were: 1) the "dome room" at the back of the cave, approximately 1.2 km from the cave entrance; 2) the back of the first passage, approximately 350 m back from the entrance; and 3) immediately in from the cave entrance, in the light zone of the cave. At each site replicate water samples were taken. Between 5 and 10 sweep samples were taken with a heavy-duty, D-ring aquatic net, sweeping the bottom, side channels, and any sediments present in the vicinity. Three or more sweeps with a plankton net were also taken, sampling main channel, side pools, and sediments, where present. Some sweeps were also taken with a small hand net, and macroscopic invertebrates were captured using the hand net. Additional sweeps and hand net samples were taken at other points in the cave that appeared to offer suitable habitat. Adult, flying aquatic insects were collected where seen, and shed skins (exuvia) of immature aquatic insects were collected from the walls of the cave.

Temperature (air and water) were measured on-site, and pH, conductance, and other water quality parameters were determined in the lab from the water samples collected at each site.

RESULTS

Physical environment

Most of the rock forming the floor, ceiling, and walls along the length of the cave is limestone. In the back reaches of the cave, there are sections of bedded shale or siltstone, which crumbles easily to form a silty sediment. This is apparently the source of the only fine sediments found along the length of the cave, in protected pockets in the back third of the cave. The cave is very angular in form, both in the cross-section of the passages, and in the pattern of long straight passages and angular turns and corners. Only in the back third of the cave does the pattern differ. In parts of the back third, the cave follows a more curving, sinuous course (these passages may be associated with the siltstone mentioned above).

Along most of its course, the cave is a hall-like passage. The ceiling of the cave is either low and

flat (so that the cave is rectangular in section) or a high narrow crack (so that the cave is sharply triangular in section). Average height ranges from 2 - 3 m (where the ceiling is flat) to ca. 8 m. Average width along much of the cave's length is about 2 m, widening in places to 4 - 5 m. In boulder fall areas, the open passage narrows to less than 1 m high and 1/2 m wide in a few places. The stream covers most of the floor of the cave, ranging in width from 1 m up to 2 - 3 m across. Along most of the stream's course, there is only a sloping shoulder of the lower wall to stand on. Depth of the stream varied from 5 - 10 cm to about 1.25 m at the time of our survey.

Most of the stream is a rapid (estimated 1 - 1.5 m/s), turbulent "sluice" covering essentially the entire cave floor. The bottom is mostly bare rock, swept clean by the fast-flowing water. In places there are scattered boulders 1/2 to 1 m in size larger, fallen from the cave ceiling. The back third of the cave has scattered pockets where there are shale and limestone cobbles (1/2 - 2 cm in size), and a few small (less than 1 m across) protected backwaters and side channels where there are deposits of silty and sandy sediments.

Water temperature throughout the cave ranged from 10-11° C. Specific conductance ranged from 275 μ S at the back of the cave (Dome Room) to 254 μ S at the cave entrance. Air temperature was a relatively constant 13° C.

Aquatic Taxa

Fourteen out of the 18 samples collected throughout Roaring Springs cave have been thoroughly examined with a compound microscope for biota. All identifications are preliminary at this time and need further verification. The following tentative identifications have been made:

1. First passage and twilight zone: There were two adult caddisfly taxa (Trichoptera) collected in this region. It is likely these adults entered the cave from Roaring Springs just outside the cave, since no larvae were collected in the cave. Usher et al. (1984) reported a rich fauna of caddisfly larvae in the Roaring Springs stream outside of the cave, including *Chimarra* sp., *Polycentropus* sp., *Hydropsyche* sp., *Rhyacophila* sp., *Glossoma* sp., *Ochrotichia* sp., *Neotrichia*

2. Dome Room (back of cave): We found only one taxon in this region which is tentatively identified as *Stygobromus* (Amphipoda). *Stygobromus* is found in caves, wells, seeps, springs, and cavemicolous and interstitial habitats. Due to the isolation of this organism at the back of the cave, this species may be endemic to Roaring Springs cave. We are in the process of verifying the identity of this organism.

We also noted small fragments of organic particles (typically $\mu 50 \mu\text{m}$ in diameter) near the back of the cave. It is likely that these organic fragments are derived from ground water and provide a major food source for the *Stygobromus* population. It is noteworthy that these organic fragments become less abundant with distance from the groundwater source.

Microscopic observations also revealed numerous bacteria, which could also provide food for *Stygobromus*. There were no protozoans, copepods, or rotifers found in any of the samples examined thus far. This implies a very simple food web in the back of Roaring Springs cave, i.e., bacteria/organic fragments and *Stygobromus*.

Terrestrial Taxa

Terrestrial invertebrates were limited to the shallow reaches of the cave. Most of the species, and the great majority of individuals, were in the twilight zone of the cave, back from the entrance approximately 100 m. At this point is the first of three rockfall "bridges" along the first passage of the cave, formed by collapse of large boulders from the ceiling of the cave. The bridge forms a light barrier as well as a physical barrier; beyond this first bridge is the beginning of the dark zone of the cave. Only two insect species were found beyond this point: one of the stonefly species, and the collembolan *Tomocerus* sp.

The twilight zone of the cave before the first bridge supported the greatest diversity of invertebrates. Two species of web-building spiders were present in this region: *Achaearanea* sp., a medium-small (5 mm body length) comb-footed spider (see also Peck 1980); and *Lepthyphantes* sp., a tiny (2 mm) member of the line-weaving spider family. One ground-dwelling spider, *Loxosceles* sp. (one of the recluse spiders), was seen among boulders but not collected.

The endemic springtail *Tomocerus* sp. (see Peck 1980) was noted at mouse droppings and at exuvia of stoneflies, both of which are probably important food sources for this tiny scavenger. A single beetle - an as-yet unidentified ground beetle (family Carabidae) - was found in boulder rubble. Several crane flies of two different species - one of the large *Tipula* species and a small species in the subfamily Limoniinae - were hanging in dark pockets and crevices in the cave ceiling.

Exuvia of stoneflies were fairly numerous on the walls of the cave throughout the twilight zone.

Several adult caddisflies and two adult stoneflies were seen on the ceiling and walls of the cave. The majority of the stoneflies (from the numerous exuvia seen) had apparently transformed over a month earlier; David Lee reported seeing these shed skins during a trip into the cave during the summer. The identification of the caddisflies and stoneflies is discussed under the aquatic taxa section.

DISCUSSION

The proposed closure to the entrance to Roaring Springs cave does not appear to have any major ramifications on the invertebrate biota near the entrance of the cave. Although several caddisfly and stonefly taxa enter the twilight zone of the cave, it does not appear that they use this region for any special reproductive and/or feeding habitat. However, to make sure these are taxa common to Roaring Springs and not endemic to the cave, we would like to verify the identity of these insects. We hope to have final identifications by January 1995.

Similarly, most of the terrestrial invertebrate taxa use the shallow reaches of the cave on an opportunistic basis. The crane flies live outside of the cave, and use the cave as a daytime (and probably winter) retreat. Most of the spider species live out their lives in the cave habitat, but the same species are distributed in habitats outside the cave as well; the cave only supports a small part of the local populations. The major exceptions to these generalizations are the springtail, *Tomocerus* sp., and the telemid spider, *Telema* sp. (Peck 1980), which are endemic to the Roaring Springs cave -- apparently found nowhere else in the world. We did not find the leiodid beetle *Ptomaphagus cocytus* (Peck 1978), but earlier surveys found this species in both the Roaring Springs cave and the Tapeats cave. This species is also apparently endemic to a few cave areas in Grand Canyon National Park.

All three of these endemic species are dependent on a food chain based on inputs to the cave from the outside. The springtail and leiodid beetle feed directly on droppings of mice and woodrats, and on other organic material (e.g. dead insects, or nest material carried in by woodrats) entering the cave through the openings to the outside. Closure of the main entrance of the cave would probably have some negative impact on these endemic species, as it would limit inputs of organic materials from the outside.

However, most of the habitat for these endemic species is in the dry side passages of the cave, linked to the outside by other entrances. Organic inputs from the outside will continue through these passages, and the food chain for these endemic species should not be seriously affected. Considering the amount of habitat in other parts of the cave, and the other cave entrances which will not be blocked off, closure of the one entrance at the stream outfall should not be a serious concern for these species.

The *Stygobromus* population near the back of the cave may be endemic to the Roaring Springs cave, therefore its identity needs to be verified and precaution needs to be taken to protect this taxon. We hope to have final identifications on this amphipod by January 1995. Our preliminary assessment is that closure of one entrance to the cave seems unlikely to negatively affect this population for the following reasons: 1) it appears its primary and perhaps only food source comes from the ground water at the back of the cave; and 2) it is unlikely that the atmospheric-aquatic gas relationship will change as long as there are other contiguous openings to the cave proper.

MANAGEMENT RECOMMENDATIONS:

- 1) We recommend that algal populations be monitored prior to and following closure of the entrance to Roaring Springs cave. These data would determine the overall success of the closure. We (Dean W. Blinn) would be willing to analyze the composition of planktonic algae immediately prior to closure and one month after closure (2-3 samples on each date) on work order 91443PX20094183.
- 2) We recommend the atmospheric gas (especially CO₂) be periodically monitored at the back of Roaring Springs cave in order to determine if the closure has modified the gas equilibrium between air and aquatic environments. This would ensure that the habitat for *Stygobromus* near the back of the cave has not undergone major changes.
- 3) Based on this preliminary report, we recommend that no action be taken on the closure of the cave entrance until after January 1995 when all identifications should be completed.

OTHER DELIVERABLES

The final report from this survey, containing confirmed identifications and final analyses of the information collected, will be delivered by 15 January 1995.

LITERATURE CITED:

- Peck, Stewart B. 1978. New montane *Ptomaphagus* beetles from New Mexico and zoogeography of southwestern caves (Coleoptera: Leiodidae: Catopinae). *Southwestern Naturalist* 23: 227-238.
- Peck, Stewart B. 1980. Climatic change and the evolution of cave invertebrates in the Grand Canyon, Arizona. *National Speleological Society Bulletin* 42:53-60.
- Usher, H., W. C. Leibfried, D. W. Blinn, and S. W. Carothers. 1984. Survey of present and future impacts of water deletions and additions on the aquatic and terrestrial habitats of Roaring Springs, Bright Angel, Garden and Pipe Creeks, Grand Canyon National Park. *Museum of Northern Arizona Research Series*. 224pp.

Table 1. Invertebrates found during surveys of Roaring Springs cave, September 1994.

Crustaceans

ORDER AMPHIPODA: AMPHIPODS

Stygobromus sp.

Spiders

FAMILY LINYPHIIDAE: LINE WEAVING SPIDERS

Lepthyphantes sp.

FAMILY LOXOSCELIDAE: RECLUSE SPIDERS

Loxosceles sp.

FAMILY THERIDIIDAE: COMB-FOOTED SPIDERS

Achaearanea sp.

Insects

ORDER COLLEMBOLA

FAMILY ENTOMOBRYIDAE: ELONGATE-BODIED SPRINGTAILS

Tomocerus sp.

ORDER PLECOPTERA

FAMILY CHLOROPERLIDAE: GREEN STONEFLIES

Plecoptera sp. 1

FAMILY PERLODIDAE: PERLODID STONEFLIES

Plecoptera sp. 2

ORDER TRICHOPTERA: CADDISFLIES

UNDETERMINED FAMILY

Trichoptera sp. 1

Trichoptera sp. 2

ORDER COLEOPTERA

FAMILY CARABIDAE: GROUND BEETLES

Carabidae sp. 1

ORDER DIPTERA

FAMILY TIPULIDAE: CRANE FLIES

(subfamily Limoniinae): Tipulidae sp. 1

(subfamily Tipulinae): Tipula sp. 2

