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## **The Ecology of Deadhorse Cave**

### **Abstract**

A lava cave of south central Washington, Deadhorse Cave, is described along with four cave organisms which exhibit varying degrees of cave adaptation. Various chemical and biological parameters of the cave were measured at different seasons.

Lava caves of the Pacific Northwest have been virtually overlooked by biospeleologists, even though these caves possess fauna which exhibit cave adaptations. Some papers have described new species of cave organisms, but little has been mentioned of the cave environment itself. An overview of some of the important species that are found in various regional caves was presented by Peck (1973). In the study presented here, four cave organisms have been studied and their particular cave adaptations described.

Lava caves, like limestone caves, can be considered isolated ecosystems, in that they often restrict gene flow between populations to the extent that factors such as genetic drift and inbreeding can affect the evolution of representative fauna. If isolation from surface populations is maintained for a sufficiently long time, these factors of genetic drift and inbreeding, along with natural selection, can cause sufficient divergence to bring about speciation. The analogy by Culver (1970) of caves to islands is applicable and appropriate to Deadhorse Cave, a lava cave of south central Washington discussed in this paper.

Deadhorse Cave is located in Skamania County, approximately seven miles northwest of Trout Lake. The cave is immediately south of road N88, and west of Deadhorse Creek. The cave was formed by a surface pahoehoe lava flow in the Mt. Adams area, and although the cave's existence has been known for some years, no extensive exploration or mapping was done until 1969 (Nieland, 1971).

As with many of the entrances of caves in this area, the lower entrance to Deadhorse Cave is a sink which was formed when parts of the ceiling collapsed. The upper entrance is an air hole, located approximately 1,000 ft uphill from the lower entrance. The cave has numerous lava features characteristic of this area, such as multiple passage levels, stalactites, extensive breakdown, and laval seals. The cave differs, however, in that it exhibits a complex network of passages, many on different levels, with numerous side branches. The cave was formed on the side of a hill, and this unusual characteristic may explain the irregular pattern of lava flow.

Numerous pools of water are located in the cave, some arising from springs and some formed by water dripping from the ceiling and seeping from the walls. This large amount of seepage causes the interior of the cave to be extremely damp throughout the year. A stream in the central part of the cave feeds pools of water at various locations along its length, and a spring approximately 100 ft from the lower entrance feeds a small pool which varies in size throughout the year.

## Materials and Methods

Field trips to the cave were made on October 21, 1973, March 27, 1974, and July 6, 1974. On the first trip the lower pool was approximately 8 ft long, 2 ft wide, and varied from 2-12 in in depth. Aquatic organisms were collected from the pool, and water samples were taken for chemical and bacteriological studies. Within 24 hours the samples were analyzed for concentrations of dissolved oxygen, carbon dioxide, carbonates, and chlorides, using standard techniques (see Welch, 1948). Titration reagents used for the determinations were 0.025 M  $\text{Na}_2\text{S}_2\text{O}_3$  for oxygen, 0.010 M NaOH for carbon dioxide, 0.010 M HCl for carbonates, and 0.010 M  $\text{AgNO}_3$  for the chlorides. Measurement of pH was made in the field, using Van Waters and Rogers pH paper, and air and water temperatures were taken. Serial dilutions were made from the samples, and bacteria were cultured using nutrient agar as the growth medium. Bacterial cultures were grown for 24 to 48 hours, and plates containing between 50 and 200 colonies were counted. Soil was very sparse throughout the cave and was seldom more than an inch in depth. A few soil organisms were collected and were preserved in ethyl alcohol.

During March, the passage was filled with water to a level approximately 75 ft from the lower entrance. Aquatic organisms were collected at this location, and water samples were again taken and analyzed. In July, the water level had receded sufficiently to allow passage through the cave, although the level was still much higher than in October. Aquatic organisms were collected from the lower pool, as well as from a pool in a major side branch of the main passage. Water samples were taken and measurements were made of the pH and temperatures as before.

## Results and Interpretations

### *Chemical and Bacteriological Studies*

Concentrations of the dissolved gases and ions, along with the pH, water and air temperatures, and bacterial counts, are listed in Table 1. Six countable plates (those containing between 50 and 200 colonies) were obtained in October, five in March, and five in July. The number reported in Table 1 is the average of these countable plates.

The large increase in volume of water in the lower end of the cave between October and March obviously affected some of the characteristics of the lower pool. Indeed, the small pool was transformed into a sizable lake with a much smaller

TABLE 1. Various chemical and biological parameters of the lower pool of Deadhorse Cave measured at different seasons.

Parameters	October 21, 1973	March 27, 1974	July 6, 1974
Air Temperature	7°C.	6°C.	6°C.
Water Temperature	5°C.	4°C.	4.5°C.
pH	5.0 ± .5	4.5 ± .5	4.5 ± .5
Dissolved O <sub>2</sub> Content (ppm)	23 ± 4	13 ± 4	16 ± 4
Dissolved CO <sub>2</sub> (ppm)	40 ± 5	10 ± 2	29 ± 3
CO <sub>3</sub> <sup>=</sup> (ppm)	56 ± 5	33 ± 3	34 ± 3
Cl <sup>-</sup> (ppm)	0.0012 ± .0005	0.0010 ± .0005 <sup>1</sup>	0.0017 ± .000
Bacteria (bact/ml)	9,500 ± 500	1,250 ± 500	7,500 ± 500

<sup>1</sup> All chemical measurements are averages of triplicate titrations except those marked with a superior figure which are averages of duplicates.

surface-volume ratio. The spring that fed the small pool in October imparted an appreciable amount of turbulence to the pool and thus provided substantial aeration in the shallow water. However, with the great increase in depth of the pool in March and July, this turbulent effect of the spring was far less pronounced. Relative movement of water, therefore, was considerably less in March and July than the movement observed in October: movement seemed negatively correlated with the increase in volume.

#### *Classification and Description of Collected Organisms*

Macroscopic aquatic and soil organisms collected are described individually below. Detailed morphological descriptions of three of these are already in the literature, and the reader is directed to the original papers if greater descriptive detail is desired. The fourth species is currently being studied by the author, and will be the subject of a later paper.

Phylum Arthropoda  
Class Crustacea  
Order Amphipoda  
Family Gammaridae

#### *Stygobromus elliotti* Holsinger

This is one of 18 species of *Stygobromus* from western North America, all of which are found in caves or cave-like, freshwater habitats such as seeps and wells. This species found in Deadhorse Cave (its type locality) was recently described by Holsinger (1974). Like the other members of the genus, this species lacks eyes and pigmentation.

Three females were collected in October on the bottom of the lower pool. They were maintained in the laboratory for three to five months in darkness at 10° C. The largest individual had a body length of 8 mm. Antenna 1 was 4.5 mm in length with 19 segments on the primary flagellum and was approximately 50 percent longer than antenna 2. The second individual had a body length of 7.5 mm; antenna 1 was 4.3 mm in length with 19 segments on the primary flagellum, and was approximately 60 percent longer than antenna 2. The smallest individual collected had a body length of 6 mm; antenna 1 was 3.5 mm long with 17 segments on the primary flagellum, and was 45 percent longer than antenna 2. No individuals were seen in March, but in July many were observed in both the lower pool and in the side-branch pool mentioned above.

Phylum Arthropoda  
Class Diplopoda  
Order Chordeumida  
Family Conotylidae

#### *Troglotyla skamania* Causey

Recently described by Causey (1972), this species has been found only in caves of the Mt. Adams area, and is the only species of the genus. (Deadhorse Cave is the type locality.) This species is a relatively large conotyloid millipede, the whole of which, including the ocelli, is unpigmented.

A single male specimen was collected in October from under a small stone, approximately 200 ft from the lower entrance. The body was 21 mm in length and 1.5 mm wide with 30 segments. Appendages of this species are not exceptionally elongated compared to epigean conotyloids. Millipedes generally are relatively conservative in cave adaptation (Causey, 1960).

Phylum Arthropoda  
Class Insecta  
Order Orthoptera  
Family Grylloblattidae

*Grylloblatta* sp.

Nine species of *Grylloblatta* occur in the western United States and Canada. They live mainly in caves or under rocks in cool habitats, usually at high altitudes (Kamp, 1963). The body is thysanuriform and the general coloration is light yellow. The eyes are small and dark brown in color but lack ocelli. All species lack wings but are adapted for rapid movement, running much like a centipede (Walker, 1914).

Gurney (1961) has described *Grylloblatta chirurgica* from three caves of the Mt. St. Helens flow, approximately 20 miles west of the Mt. Adams caves. Most of the morphological characteristics of my specimens seem to be similar to those described by Gurney, but exact species determination has been difficult because only one adult specimen was collected.

A single nymph was collected in October from under a small stone in the central part of the cave. The body was 10 mm in length and had the characteristic straw-yellow coloration. Both antennae were 7.5 mm long and had 29 segments. The cercus was 4 mm long. An adult female and two additional nymphs, floating on the surface of the lower pool, were collected in March. They had obviously been flooded out from their preferred locations because two were dead and the third was struggling while being carried along by the slow movement of water.

The female had the following measurements: body length 18.5 mm, cercus 8.5 mm, and antennae 17 mm (with 34 segments, left, and 32 segments, right). Nymphs had body lengths of 8 mm and 12 mm, cerci of 3.5 mm and 4.5 mm, and antennae of 6.5 mm (with 34 segments on both) and 8.5 mm (with 28 segments, left, and 29 segments, right). Body color of the female was light tan and the head was light brown. The two nymphs were irregularly colored straw-yellow and white. Two additional nymphs were found floating on the surface of the lower pool in July but were dead and partially decomposed, which made detailed study impossible.

Phylum Platyhelminthes  
Class Turbellaria  
Order Tricladida  
Family Planariidae

*Polycelis coronata* Girard

To date, cave planarians that have been described in North America have been from the family Dendrocoelidae (Hyman, 1939, 1954, 1956) and from three genera of the family Planariidae, *Phagocata*, *Kenkia*, and *Sphalloplana* (Hyman, 1937, 1939,

1945, 1954; Kenk, 1970; Mitchell, 1968). Hyman (1960) postulated that *Kenkia* and *Sphalloplana* may have evolved from *Phagocata*, and that the adhesive organ found in both *Kenkia* and *Sphalloplana* (but not *Phagocata*) and in many of the Dendrocoelidae may be the result of extensive parallelism.

*Polycelis* is only the fourth genus of Planariidae to be found in a cave, so its occurrence is of special interest. Exact species determination is uncertain at this time because none of the individuals collected were sexually mature. An additional complication is that no extensive study of freshwater flatworms has been undertaken in the state of Washington. Kenk (1973) indicates that only one species of *Polycelis* occurs north of California, and epigeal specimens collected a few miles from the cave seem to be of this species, but as yet none have been sectioned. There seem to be a few differences, aside from the reproductive structures, between the cave form and the epigeal specimens collected: the body pigmentation is lighter in the cave form, the eye spots are fewer in number, and the auricles are less pointed (see Fig. 1). These characteristics are not species-determining criteria, however, and until sexually mature individuals are collected, no conclusion can be made.

Nineteen individuals were collected in October, 7 in March, and 12 more in July. They ranged from 4 mm to 12 mm in length and were colored white to light tan. All were sexually immature when collected, and are presently being maintained in the laboratory in darkness at 10° C. The factors that induce sexuality are unknown, and, indeed, the constancy of the cave environment throughout the year may restrict maturity. A more complete study of the genus *Polycelis* in Washington is being undertaken by the author, and a future paper may shed more light on the variation

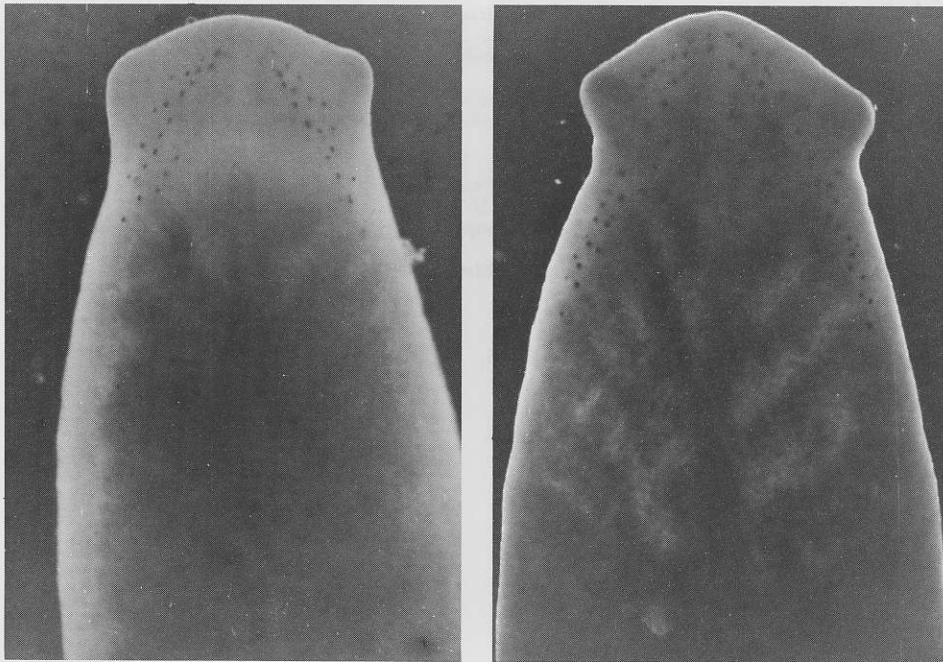


Figure 1. Anterior ends of cave (left) and epigeal (right) *Polycelis* showing eye spots.

that exists in *Polycelis* in the Pacific Northwest and the possible speciation of the cave forms.

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