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MACROINVERTEBRATE SURVEY OF TYTOONA CAVE

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ABSTRACT

Pennsylvania caves contain distinct assemblages of macroinvertebrates. However, the macroinvertebrate fauna of Tytoona cave has not been studied. We predicted that macroinvertebrate abundance and taxic diversity should decline from the entrance to the rear of the cave. As expected, taxic richness and diversity did decrease significantly toward the rear of the cave, whereas only a marginally significant difference was found for macroinvertebrate abundance. Decreasing light and detritus supply with cave depth may help explain the patterns we observed.

Keywords: Abundance, diversity, macroinvertebrates, stream ecology, Tytoona Cave

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INTRODUCTION

The caves of Pennsylvania contain several unique invertebrates. According to John R. Holsinger (Old Dominion University, VA), Pennsylvania caves contain 15 troglobitic animal species that are specialized for and restricted to cave habitats (White, 1976). These animals include 1 flatworm, 2 isopods, 7 amphipods, 3 spiders, 1 collembolan, and 1 beetle species. Other invertebrates found in Pennsylvania caves include "troglophiles" (species that frequently inhabit caves and complete their life cycles there), "troglorenes" (species that occur in caves, but frequently return to the surface for food), and "accidentals" (species that wander, fall, or are washed into caves and can only exist in these habitats temporarily). According to a 1953 study by Charles Mohr, a total of 126 invertebrate species have been found in Pennsylvania caves. However, to our knowledge, no one has previously carried out a survey of the invertebrates found in Tytoona Cave.

FIELD SITE

Samples were taken in the stream entering Tytoona Cave on April 4, 2001. Four riffle stations were chosen within the cave with similar physical properties, including substrate (mostly cobbles), depth (~ 40 cm) and flow rate (1-2 m/s: see Table 1). The distance to each site was measured from the cave entrance to the center of the sampling site. At each station, 5 random samples were chosen from a 10 X 10-m grid. The station centers were located the following distances from the entrance of the cave: #1: 8.5 m, #2: 56 m, #3: 109 m, and #4: 134 m.

METHODS AND MATERIALS

This study was conducted under the supervision of Dr. Douglas Glazier, a professor at Juniata College who has had extensive experience sampling macroinvertebrate populations in Pennsylvania springs (e.g., Glazier and Gooch 1987, Glazier 1991, 1998, Gooch and Glazier 1991). Our survey contained two components: a qualitative survey and a quantitative survey. The qualitative survey involved identifying all aquatic and terrestrial macroinvertebrates that were found in the cave. The quantitative survey, which is analyzed here, involved using kick-net samples to determine the abundance of aquatic macroinvertebrates at various distances into the cave. At each sampling station, 5 randomly positioned samples were collected from substrate within 1 m of a 33-cm wide D-net, following standard DCNR kick-net procedure. Samples were then placed in plastic containers, labeled, and taken back to the lab for identification. All specimens were returned to the cave, except for voucher specimens used as representative species for our study. The sampling intensity represents a balance between obtaining statistically useful results and minimizing disturbance of the cave fauna.

Taxic diversity was estimated using Simpson's Diversity Index, as follows:

$$D = 1/\sum_{i=1}^{s} P_i^2$$

where s = taxic richness (calculated by adding up the number of taxa found in each sample), and P = the proportion of the total number of individuals in the sample that belong to the i th species. Since all data were normal, taxic diversity and abundance were compared among sampling stations using a one-way ANOVA test.

At each sampling station, we also determined the light intensity (light meter), detritus levels (qualitative estimates), water temperature (temperature probe), pH (pH meter), conductivity (conductivity meter) and dissolved oxygen concentration (oxygen meter).

RESULTS

Not surprisingly, light intensity decreases with cave depth (Table 1). The stream water was also slightly colder, slightly less oxygenated, and had somewhat higher pH and lower conductivity at deeper points in the cave (Table 1).

Table 1. Selected environmental features at 4 sites in the Tytoona Cave stream

Environmental features	Site 1	Site 2	Site 3	Site 4
Temperature (°C)	6.7	6.5	6.4	6.4
pH	7.05	7.16	7.31	7.34
Conductivity (μS)	241	234	213	219
Dissolved oxygen (mg/L)	13.8	13.8	13.6	13.5
Light intensity (LUX)	56	10	0	0
Water velocity (m/s)	1.94	1.37	1.07	1.5

Total macroinvertebrate abundance appeared to be highest at site 2 where the light was still dim (Table 2). However, macroinvertebrate abundance varied among sites only with marginal significance (F = 2.51, df = 3,16, P = 0.095). Both taxic richness (F = 4.40, df = 3,16, P = 0.019) and diversity (F = 5.18, df = 3,16, P = 0.01) decreased with distance into the cave (stations 1 and 4 were significantly different for both taxic richness and diversity, according to Tukey's pairwise comparisons tests; Table 3).

Table 2. Mean number (± SD) of individuals of various macroinvertebrate taxa collected at 4 sites in the Tytoona Cave stream.

Sample stations	Diptera Chironomidae	Plecoptera Perlodidae	Diptera Simuliidae	Plecoptera Nemouridae	Plecoptera Peridae	Oligochaeta	Amphipoda *Gammarus minus*	Trichoptera Uenoidae *Neophylax*	Isopoda Caecidotea	Mollusca	Ephemeroptera Ephemerellidae	Megaloptera Sialidae	Perciformes Cottidae	Total Abundance
Site 1 (Mean)	**2.8**	**2.8**	**0.2**	**0.2**	**0.4**	**10.6**	**0.4**	**9.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.0**	**26.6**
SD	1.6	1.6	0.4	0.4	0.5	7.1	0.5	7.6	0.4	0.0	0.0	0.0	0.0	10.6
Site 2 (Mean)	**2.8**	**0.2**	**0.0**	**0.0**	**0.2**	**9.2**	**37.4**	**4.0**	**0.0**	**0.4**	**0.0**	**0.0**	**0.0**	**54.2**
SD	3.8	0.4	0.0	0.0	0.4	1.5	40.0	3.2	0.0	0.9	0.0	0.0	0.0	38.5
Site 3 (Mean)	**0.8**	**0.0**	**0.2**	**0.2**	**0.0**	**10.0**	**14.6**	**0.4**	**0.0**	**0.0**	**0.2**	**0.0**	**0.0**	**26.4**
SD	1.3	0.0	0.4	0.4	0.0	14.7	14.3	0.9	0.0	0.0	0.4	0.0	0.0	21.9
Site 4 (Mean)	**0.4**	**0.0**	**0.0**	**0.0**	**0.0**	**11.2**	**3.0**	**0.2**	**0.0**	**0.0**	**0.0**	**0.2**	**0.2**	**15.2**
SD	0.5	0.0	0.0	0.0	0.0	10.7	4.1	0.4	0.0	0.0	0.0	0.4	0.4	11.0

Table 3. Mean (± SD) taxic richness, taxic diversity and macroinvertebrate abundance (animals per m²) at 4 sites in the Tytoona Cave stream.

Sample stations	Taxic richness	Taxic Diversity	Taxic Density
Site 1 (Mean)	**5.20**	**3.00**	**80.61**
SD	1.64	0.71	32.04
Site 2 (Mean)	**4.00**	**2.50**	**164.24**
SD	1.41	1.28	116.72
Site 3 (Mean)	**2.80**	**1.66**	**80.00**
SD	1.30	0.51	66.27
Site 4 (Mean)	**2.00**	**1.07**	**46.06**
SD	1.58	0.68	33.43

DISCUSSION

As we predicted, taxic richness and diversity of macroinvertebrates decreased with distance into Tytoona cave. This pattern may have been due to decreasing food resources (both detrital and photosynthetic) toward the back of the cave. Decreasing light would result in less primary productivity, and we also noticed decreasing amounts of detritus (i.e., dead leaf and stem material) with increasing distance into the cave.

However, contrary to expectation, macroinvertebrate abundance did not show a regular decrease with distance into the cave. This decrease was only observed from sites 2 to 4 (Tables 2 and 3), and it was only marginally significant. This pattern was largely due to the most abundant macroinvertebrate in the cave, the amphipod *Gammarus minus* (see Table 2). Perhaps the high flow rate of the stream at the time of this study carried many animals into the interior of the cave, thus increasing their abundance. In addition, the highest water velocity was observed near the entrance to the cave (site 1; see Table 1), which may have contributed to the relatively low abundance of macroinvertebrates found there.

Future research should re-examine patterns of macroinvertebrate abundance and diversity in Tytoona Cave during other seasons of the year when stream velocity is lower and biological productivity greater, and also at greater distances into the cave than we examined. Quantitative studies of macroinvertebrate feeding guilds and their available food resources, including algae and detritus, at various distances into the cave should also increase our understanding of the taxic diversity patterns that we have observed. Finally, further studies are needed to assess the kinds of cave adaptations shown by both aquatic and terrestrial invertebrates in Tytoona Cave.

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