Epikarstic Groundwater Ecosystems of Illinois: A Sensitive But Unstudied Faunal Element

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Introduction

Karst terrains, regions of soil overlaying limestone bedrock, comprise nearly a quarter of the Illinois landscape. Over time, calcium carbonate in limestone bedrock has been solutionally dissolved via surface water infiltration, leading to a network of horizontal and vertical fissures through which groundwater flows. These networks harbor incredibly unique assemblages of groundwater-dwelling fauna, including many stygobionts (aquatic cave taxa), and are a major source of organismal and nutrient input from the surface into caves. Thus, many of Illinois' cave-dwelling species, including the federally listed Illinois cave amphipod (*Gammarus acherondytes*), are directly impacted by karstic dynamics, such as species assemblages and hydrology.

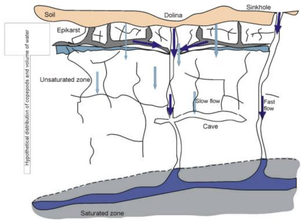


Figure 1. Conceptual model of epikarst water flow. Blue arrows indicate slow flow and black arrows indicate fast flow. Graphic attributed to Dr. David Culver and Dr. Tanja Pipan.

Within karst regions, the epikarst is the zone below the soil layer but perched above caves in which percolating groundwater slowly moves from the surface and drips into caves through stalactites and fissures (Fig. 1). Accessible caves with stalactite formations thus supply biologists with a unique opportunity to study the biota of epikarst habitats through sampling drip water. Perhaps surprisingly, little is known of this vital habitat in Illinois.

Aim

We sought to develop appropriate and effective stalactite drip sampling methods suitable for Illinois subterranean ecosystems while augmenting our understanding of the epikarsts' role in groundwater hydrology and subterranean ecology of Illinois' karst areas.

Specifically, this work aimed to:

- Improve our understanding of groundwater recharge in agricultural settings, by directly measuring cave drip hydrology in relation to precipitation and evapotranspiration
- Increase our understanding of climate change impacts on shallow groundwater ecosystems containing federally listed endangered species, such as the Illinois cave amphipod (*Gammarus acherondytes*)
- Provide a first look at epikarstic ecosystems in Illinois, a type of Illinois karst groundwater ecosystem that has not previously been examined

Methods

This project was conducted at the Illinois Caverns State Natural Area in Monroe County, southwest Illinois, about 35 miles south of Saint Louis (Fig. 2). As the only commercially operated cave in Illinois' history, Illinois Caverns provides ample opportunity for studying the impacts of tourism and development on epikarst habitats of Illinois.

Figure 2. A map of Illinois showing the location of the Illinois Caverns State Natural Area in Monroe County.
"USA Illinois location map" by Alexrk2 - Own work. Licensed under Creative Commons Attribution 3.0 via Wikimedia Commons - http://commons.wikimedia.org/wiki/File:USA_Illinois_location_map.svg#mediaviewer/File:USA_Illinois_location_map.svg

Figure 3. Cinel and Swanson measuring baseline water conductivity for use in calibrating persistent HOBO conductivity logger placed in rain gauge apparatus. Stalactite drip collector can be seen at top with rain gauge at bottom.

Potential study stalactites were monitored for drip rate and shape to ease collection of drip water. We used a Drip Sampling Apparatus constructed from plastic brown bottles with a 1.5 x 1.5 inch square cut 2 inches from the bottom of the bottle covered with 65 micrometer nylon mesh. About 6 inches of rubber bike tubing was attached to the mouth of each bottle using a zip-tie. These bottles were then attached to target stalactites by tightening a zip tie around the rubber tubing and the stalactite formation. Upon retrieval, we removed bottles from stalactites and rinsed via the mouth and through the mesh screen with DI water using a squirt bottle. We then emptied the collected water from the brown bottles into a 5 micrometer mesh filter which reduces the volume of water to be searched through later in the lab. 80% ethanol is then used to rinse filtrate from 5 micrometer mesh into small nalgene bottles and these bottles were stored on ice until analysis.

We also collected high resolution environmental data and epikarst hydrologic activity via combined use of a HOBO Rain Gauge Apparatus paired with a conductivity logger and temperature/relative humidity logger which collected data every 12 hours. Data included here span June – August 2014 and collection is ongoing.

Figure 4. Cinel and Swanson filtering collected stalactite drip water through 5 µm mesh in Illinois Caverns.

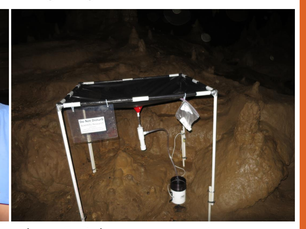


Figure 5. Rain gauge apparatus assembly with HOBO conductivity and temperature/relative humidity loggers attached.

Results

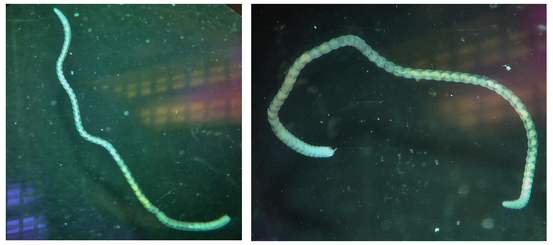
Thus far, we have collected and identified 128 copepods from 11 stalactite drips, comprising 8 genera including:

- *Bryocamptus* – 92 individuals (Figs. 6 & 7)
- *Paracamptus* – 3 individuals
- *Epactophanes* - 4 individuals
- *Microcyclops* - 10 individuals (Fig. 8)
- *Rheocyclops* - 4 individuals
- *Bryocyclops* - 2 individuals
- *Moraria* - 4 individuals
- *Parastenocaris* - 3 individuals

This dominance of a single genus with several less abundant genera present is well recorded in past research on epikarstic copepod communities.

Figures 6, 7 & 8. Dorsal (A) and side (B) views of Bryocamptus and ventral view of Microcyclops (C) copepods collected from stalactite drips in Illinois Caverns.

We also found several aquatic lumbriculids, a family of oligochaetes never before recorded in subterranean habitats of Illinois (*Figs. 8 & 9*).



Figures 8 & 9. Aquatic lumbriculid oligochaetes collected from stalactite drip water in Illinois Caverns, Monroe County, south-western Illinois.

Further taxonomic analysis of these lumbriculids is underway by Dr. Mark Wetzel.

Additionally, aquatic and terrestrial surface taxa were found in sample drip waters. Several midge larvae (Diptera: Chironomidae) and springtails (Collembola) were represented, indicating a direct connection to surface water in 10 of 11 drips.

Copepod occurrence frequency averaged across all drips was 0.011 copepods/L with an overall daily occurrence of 0.41 copepods/drip/day. These observed occurrence rates are comparable to past research on epikarst fauna in Europe.

Finally, we discovered that stalactites with faster drip rates harbored less copepods despite the larger volume of water passing through the epikarst (Fig. 10). This pattern likely represents the heterogeneous composition of epikarst habitats, with some conduits of fast flowing water leading to poor suitability for copepod population growth relative to slower flowing conduits.

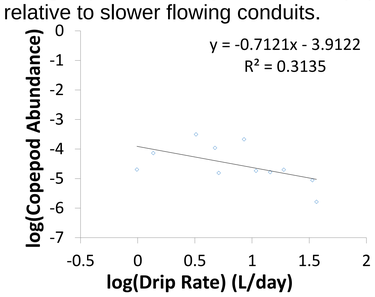


Figure 10. Log-transformed negative relationship between copepod abundance and stalactite drip rate.

Conclusions

- Illinois epikarst habitats harbor highly diverse and abundant communities of both stygobiont and incidental surface genera
- Copepod abundance is negatively correlated with drip rate, indicating that faster flowing epikarst water may be less suitable to copepod population persistence
- Further drip collecting and taxonomic work is in progress to fully characterize the unique epikarst fauna of Illinois

Acknowledgments

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