Title: Utilizing native isopods to assess the connectivity and quality of Oklahoma groundwater

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Congressional District: 1 (University of Tulsa), 2 (Oklahoma Ozarks)

Focus Category:

GW, HYDROL, ECL, NC, SW, WL

Descriptors: Isopods, Biodiversity, Water Quality

Students:

Student Status	Number	Disciplines
Undergraduate	0	
M.S.	0	
Ph.D.	1	Biodiversity, Biogeography, Ecology
Post Doc	0	
Total	1	

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Publications:

Utilizing native isopods to assess the connectivity and quality of Oklahoma groundwater. Hess, A.J. and Bonett, R.M. 2018. NSF EPSCoR Annual State Conference. Poster presentation.

Problem and Research Objectives:

This study aims to assess native groundwater isopod distributions as a method to delineate watershed boundaries, as a tool to identify surface-groundwater interactions, and as a possible indicator of water quality.

Understanding the distribution and connectivity of groundwater and its relationship to surface flow is critical for the management and conservation of this invaluable resource. The Ozark aquifer system occurs in parts of four states and is subject to range-wide extraction. Therefore aquifer border delimitation is essential to accurately measure rates of recharge and sustainable withdrawal limits. Aquifer borders typically follow the extent of drainage basins, but subterranean karstic boundaries like those of the Ozark Plateau are not necessarily correlated with surface relief and can change with fluctuating water tables. Regional declines in Ozark groundwater have been noted repeatedly since the turn of the century and local depressions have been observed around major pumping centers (reviewed Pope et al. 2009).

Receding well levels increase concerns about the sustainability of the water supply and the risk of declining water quality. With the reduction in regional water levels the risk of saline water migration from western regions of the aquifer or upwelling from lower geologic strata increases (Pope et al. 2009). Furthermore, as surface disturbance grows concurrent with population, agricultural contaminants present a growing risk. Runoff can rapidly enter groundwater due to the thin soil and extensive network of near surface karstic faults and fractures (Imes and Emmett 1994). Degrading regional water quality presents risks to human health and ecosystem integrity.

Due to their abundance and the ease of distinction between surface and subterranean species, isopods present a potentially powerful tool for assessing watershed connectivity and quality. The geographic genetic distribution of isopod diversity will likely mirror the hydrologic connectivity and discontinuity within the region. By developing distributional maps of both surface and subterranean species throughout the Oklahoma Ozarks, the limits of surface and sub-surface drainage systems can be delineated. In conjunction with water quality data, identification of species-level environmental limits can be identified to evaluate their use as a tool for understanding water quality. Continued monitoring of isopod species composition and density could serve as an indicator of changing groundwater quality.

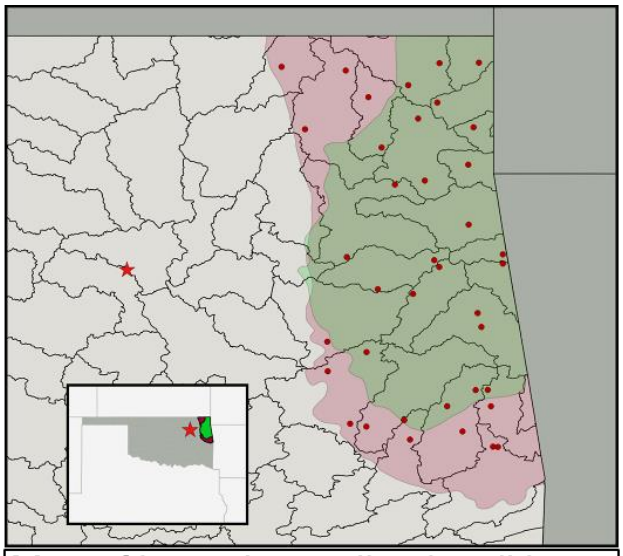
Methodology:

Genetic Distributions of Native of Ozark Isopods: Isopods were collected from more than 50 Ozark streams. So far, thirteen sets of expressed genes (transcriptomes) and the mitochondrial gene *cytochrome oxidase 1* (*Co1*) have been sequenced for Ozark isopods to identify variable and conserved genomic regions (7 *Lirceus*, 6 *Caecidotea*). These regions will be targeted for analyzing the distribution of genetic diversity across the Oklahoma Ozarks. This will allow us to build a robust map of relationships between isopod populations of different watersheds using 100-200 genomic regions. Concurrent with measuring abundance, all isopods found at each sampling locality have been collected

and stored for genetic analyses, providing sampling resolution across both aquifers and all watersheds within the Oklahoma Ozarks.

Species: Sequenced species include *Caecidotea ancyla, Caecidotea steevesi, Caecidotea stiladactyla Lirceus garmani, Lirceus hoppinae*

Isopod Abundance: To examine isopod abundance in relation to various water chemistry features we surveyed 38 Ozark streams for isopods and water chemistry. The Oklahoma Ozarks were divided into Hydrologic Unit Codes for Watersheds (HUC10) watersheds using Quantum Geographical Information Systems (QGIS). To maintain consistency of habitat type, low order streams were chosen in each watershed for sampling. At each sampling locality, bottle traps outfitted with iButton dataloggers were deployed to measure both temperature and isopod abundance during the sampling periods. All sites were checked for abundance a minimum of 2x during October – December 2017. Concurrent with isopod collection, a water quality meter (YSI proDSS) was used to measure water chemistry parameters. These include pH, conductivity, pressure, nitrates, dissolved oxygen, and total dissolved solids. These measurements were collected during each isopod sampling period. We analyzed the data using multivariate statistics in the program R to determine which environmental features were significant predictors of isopod abundance.



Map of isopod sampling localities (red circles). Green and pink layers represent the two aquifers of the Oklahoma Ozarks (green – Boone, red – Roubidoux). Polygons represent the HUC10 watersheds.

Principal Findings and Significance:

There are clearly identifiable ecological and body size differences among the Ozark isopods these include cave-dwelling *Caecidotea*, swamp-dwelling *Caecidotea*, and surface-dwelling *Lirceus*. There is also significant size variation within these groups. Genetic data thus far indicate geographic structure and described species may contain multiple cryptic lineages.

Lirceus

Type II Analysis of Variance Table with Satterthwaite's method

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)	
tempstd	0.21353	0.21353	1	33.622	0.5445	0.465679	
tempavg	0.36455	0.36455	1	32.147	0.9297	0.342146	
Nitrates	0.47602	0.47602	1	61.529	1.2140	0.274842	
pH	0.50638	0.50638	1	59.612	1.2914	0.260344	
Pressure	3.02678	3.02678	1	43.569	7.7188	0.008031	**
log10(TDS)	0.22582	0.22582	1	47.844	0.5759	0.451653	
log10(Conductivity)	0.32916	0.32916	1	45.290	0.8394	0.364419	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

Caecidotea

Type II Analysis of Variance Table with Satterthwaite's method

	Sum Sq	Mean Sq	NumDF	DenDF	F value	Pr(>F)	
tempstd	0.001627	0.001627	1	61.847	0.0324	0.85765	
tempavg	0.020710	0.020710	1	60.981	0.4130	0.52284	
Nitrates	0.201748	0.201748	1	61.761	4.0237	0.04925	*
pH	0.115437	0.115437	1	58.872	2.3023	0.13454	
Pressure	0.011300	0.011300	1	60.688	0.2254	0.63668	
log10(TDS)	0.053214	0.053214	1	54.227	1.0613	0.30749	
log10(Conductivity)	0.033195	0.033195	1	52.269	0.6620	0.41953	

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

The isopods collected in our abundance analyses were identified to genus as either *Lirceus* (surface) or *Caecidotea* (groundwater). Analyses were then run separately on each group to identify which environmental parameters were most relevant to their abundance while controlling for site specific effects. Based on our analyses so far, *Caecidotea* isopods are abundant when nitrates are high (p = 0.049). In contrast, *Lirceus* is more abundant at higher elevation sites, which may be associated with increased oxygen content. We will further assess these parameters across a second sampling round (May – June 2018).

References

Imes, J.L., and Emmett, L.F. 1994. Geohydrology of the Ozark Plateaus aquifer system in parts of Missouri, Arkansas, Oklahoma, and Kansas. U.S. Geological Survey Professional Paper 1414D. 127 p.

Pope, L.M., Mehl, H.E., and Coiner, R.L. 2009. Quality characteristics of ground water in the Ozark aquifer of northwestern Arkansas, southeastern Kansas, southwestern Missouri, and northeastern Oklahoma. 2006-07: U.S. Geological Survey Scientific Investigations Report 2009-5093. 60 p.