Impacts of Altitude on Aquatic Macroinvertebrates

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Methods

I visited 21 streams and lakes in Southeast Wyoming ranging in altitude from 2130 m to 3230 m (Fig. 2), sampled aquatic macroinvertebrates (Fig. 3), and measured DO, temperature, and other site characteristics. Invertebrates were sorted by phylum, identified to family and life stage (where possible), and photographed to measure body size.

Figure 2. Map of sites visited in Southeast Wyoming.

Gellat	Lake	41°14'13.3"N 105°50'11.9"W	7/23/2020	2225
Twin	Lake	41°14'09.0"N 105°51'52.6"W	7/23/2020	2215
Alsop	Lake	41°23'34.7"N 105°47'15.1"W	7/23/2020	2190
NFSLbridge	Stream	41°21'03.7"N 106°09'53.7"W	7/26/2020	2790
BLMonolith	Stream	41°15'23.9"N 105°40'00.2"W	7/29/2020	2160
DCcinnabar	Stream	41°13'21.2"N 106°14'06.9"W	8/12/2020	2900
LLPullOff1	Stream	41°19'46.8"N 106°09'41.1"W	8/4/2020	2650
NashFgreenrock	Stream	41°20'53.2"N 106°13'03.2"W	8/4/2020	3000
NFLLnorthforkM1	Stream	41°22'36.1"N 106°13'38.5"W	7/9/2020	3050
LCsprucemtn	Stream	41°19'11.1"N 106°09'48.5"W	8/17/2020	2640
Owen	Lake	41°09'01.7"N 106°06'29.2"W	8/12/2020	2760
HangingLake	Lake	41°20'43.7"N 106°10'40.5"W	8/4/2020	2780
Granite	Lake	41°10'32.9"N 105°14'25.8"W	8/3/2020	2200
Crystal	Lake	41°09'16.9"N 105°12'12.9"W	8/3/2020	2130
Marie	Lake	41°19'58.4"N 106°19'30.0"W	7/21/2020	3200
Mirror	Lake	41°20'17.0"N 106°19'14.4"W	7/21/2020	3230
BigBrooklyn	Lake	41°22'18.8"N 106°14'49.2"W	7/21/2020	3220
LittleBrooklyn	Lake	41°21'43.1"N 106°14'47.0"W	7/21/2020	3160
Hattie	Lake	41°14'17.8"N 105°54'10.2"W	7/23/2020	2220
UNorthCrow	Lake	41°14'06.8"N 105°16'48.5"W	7/22/2020	2300

Figure 3. Riffle section of the North Fork of the Little Laramie. This and other stream sites were sampled by moving cobbles and gravels and catching drifting invertebrates via a net downstream. DO was measured by collecting water in a bucket with the probe submerged.

Figure 4. Green caddis larva from Libby Creek and Stonefly Nymph from Nash Fork at Green Rock. Invertebrates are separated by location and phylum and then measured.

Introduction

Dissolved oxygen (DO) profoundly influences aquatic systems and is determined primarily by temperature and atmospheric partial pressure of oxygen (PO_2; Jacobsen 2008). Rising global temperatures may reduce DO, particularly at high altitudes where PO_2 is already low (Fig. 1). Such reductions may compromise high altitude aquatic ecosystems through effects on local populations of aquatic organisms. Aside from direct effects on survival, warming-induced changes in DO may also strongly affect body size of invertebrates, altering size structure of communities. I therefore asked two related questions:

How do characteristics of altitude impact DO concentrations?

Does body size of aquatic macroinvertebrates shift with DO?

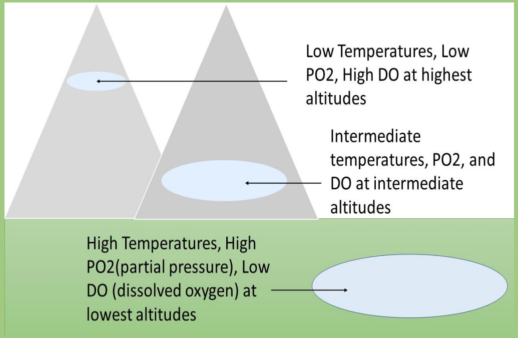


Figure 1. Temperature and PO_2 interact to determine dissolved oxygen (DO) across elevation. Colder water holds more oxygen, but decreased atmospheric PO_2 reduces the oxygen dissolved in water.

Results

Morphological measurements and data analysis are still in progress, but we can see that water temperature increases with ambient temperature across sites (Fig. 6). DO did not change with elevation (Fig. 7), likely because reductions in water temperature kept pace with reductions in PO_2.

Other studies have observed a relationship between oxygen availability and body size/length in several taxa. In 1,853 species of benthic amphipods ranging from polar, tropical, freshwater, and marine ecosystems, a strong correlation between DO concentrations and amphipod length was discovered (Chapelle & Peck 1999). During my field sampling, I noticed that within phyla, certain species were found more often in higher elevation water systems and others in lower waters. For example, in the North Fork of the Laramie River (3050 m), I found several mayflies belonging to the family Heptageniidae (Flat-Headed Mayfly and Stream Mayfly). These mayflies, compared to Leptophlebiidae mayflies (Prong-gilled Mayflies) which were found more often in lower elevations, appeared to show relatively larger body sizes on average; however, until all of the data is collected and processed, this is only considered field observation.

Figure 6. Temperature of water at site compared to the ambient temperature at time of sampling.

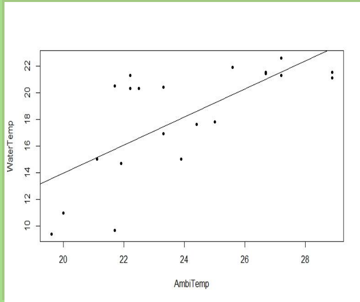
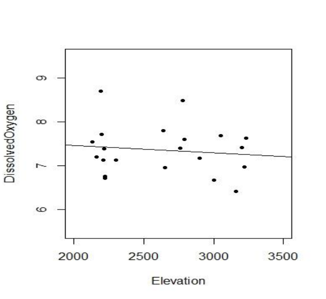


Figure 7. Concentration of dissolved oxygen at the various elevations sampled.



Conclusion

Understanding how altitude and temperature affect aquatic ecosystems can inform management and conservation strategies to ensure these systems remain healthy. It is crucial that we continue to assess current damage and possible future challenges to these ecosystems due to climate change. Accurate predictions of climate change effects on sensitive areas such as alpine ecosystems will facilitate continued progress in mitigating these effects.

References

1. Chapelle, G., Peck, L. Polar gigantism dictated by oxygen availability. *Nature* 399, 114–115 (1999). https://doi.org/10.1038/20099
2. Gardner, J. L., Peters, A., Kearney, M. R., Joseph, L., & Heinsohn, R. (2011). Declining body size: A third universal response to warming? Trends in Ecology and Evolution. https://doi.org/10.1016/j.tree.2011.03.005
3. Jacobsen, D. (2008). Low oxygen pressure as a driving factor for the altitudinal decline in taxon richness of stream macroinvertebrates. Oecologia. https://doi.org/10.1007/s00442-007-0877-x
4. Lardies, M. A., & Fernández, M. (2002). Effect of oxygen availability in determining clutch size in Acanthina monodon. Marine Ecology Progress Series. https://doi.org/10.3354/meps239139