The Impact of Instream Water Temperature Variability Upon Larval Ephemeroptera Population Density in Two Vermont Streams

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Abstract

In this study, we investigated the effect of variable instream water temperatures upon dissolved oxygen levels and their impact on larval Ephemeroptera population density in two Vermont streams. We hypothesized that fluctuations in instream water temperatures would lead to a decrease in population density of larval Ephemeroptera in Vermont streams. Ephemeroptera larvae are very sensitive to low dissolved oxygen levels, and are therefore intolerant to major increases in water temperature. This investigation was completed by recording the instream water temperatures of two streams in Stowe, Vermont and comparing this data to the population density of larval Ephemeroptera as an effect of water temperature variability. We found there was a significant relationship between high summer water temperatures and low Ephemeroptera population density. In Trib A, where the water temperature ranged from 13°C to 24.5°C in the month of August, there was a significantly smaller population of larval Ephemeroptera in two of three years compared to Gold Brook, where the water temperature constantly remained below 20°C. This suggests variability in instream water temperature lowers the dissolved oxygen levels in the stream, thus decreasing the population density of larval Ephemeroptera.

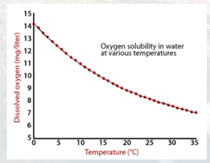
Relationship Between Temperature and DO

Dissolved oxygen (DO) is a measure of the amount of oxygen dissolved in the water. There is a direct correlation between dissolved oxygen levels and temperature. As temperature increases, the solubility of gases such as oxygen decrease. This means warm water holds less dissolved oxygen than cool water, and may not contain enough dissolved oxygen for the survival of different species of aquatic life[1].

Temperature and Oxygen Solubility [2]

Temperature (degrees C)	Oxygen Solubility (mg/L)
0	14.6
5	12.8
10	11.3
15	10.2
20	9.2
25	8.6
100 boiling	0

Dissolved Oxygen (mg/liter) as a Function of Temperature (°C) [3]



Factors Affecting Water Temperature

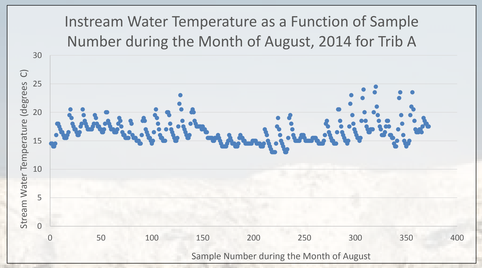
The most important source of heat for fresh water is generally the sun[4], although temperature can also be affected by several other factors. Water temperature also fluctuates between day and night, and changes between seasons[5]. Since the temperatures of both Gold Brook and Trib A were recorded in August in Stowe, the variability in water temperature should not be largely affected by the season. However, the two streams vary significantly in depth, volume, surrounding land use, and canopy cover. Gold Brook is a larger stream, with a more varied and generally deeper depth of about 0.198 meters and a significant canopy. Trib A, on the other hand, is narrow in comparison and only about 0.096 meters deep with very little shading from the surrounding environment. Shallow and slow waters are more susceptible to changes in water temperature because it takes less energy to heat up the smaller volume of water. Land use could also alter the instream water temperature. The relatively high instream temperatures in Trib A could be explained by the construction, urbanization, and channelization in the surrounding area.

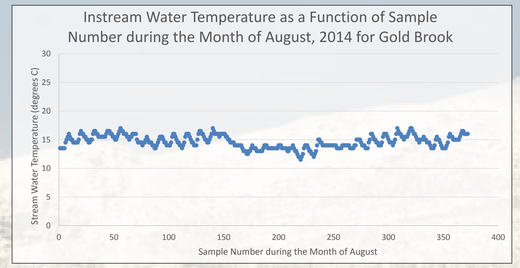
Our Study

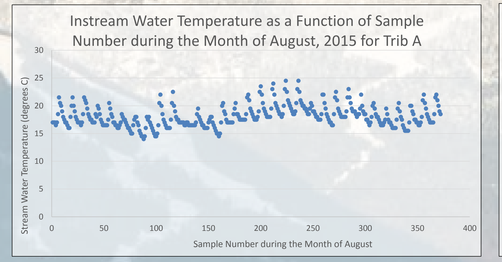
To begin the study, we found the instream water temperature patterns in two streams in Stowe, Vermont, Trib A and Gold Brook. Instream water temperatures were recorded every two hours for the month of August. These data were found in 2014, 2015, and 2016. This led us to look closer into the macroinvertebrate life within the stream. A total of four macroinvertebrate samples were taken each summer at each site. Macroinvertebrates were collected using the standard kick sample method. The number of Ephemeroptera for each sample in both sites was recorded as well as the total amount of macroinvertebrates in the sample. The Ephemeroptera families were then determined to see which family was the most prevalent. For the two sites, the average percentages of Ephemeroptera in each sample and the standard errors were calculated.

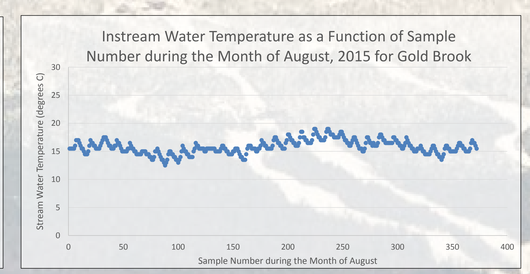
References

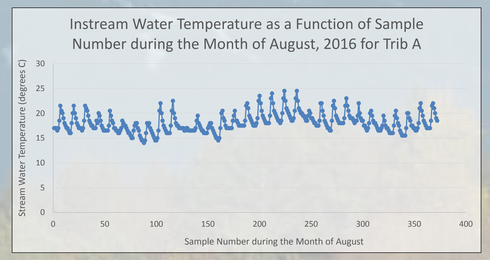
1. http://water.usgs.gov/edu/temperature.html
2. http://www.ecy.wa.gov/programs/wq/plants/management/joysmanual/dissolvedoxygen.html
3. https://www.uky.edu/WaterResources/FF/Nutrient%20Management/qustion27oxygenstreamhealth.html (Graph)
4. http://www.ramp-alberta.org/river/water+sediment+quality/chemical/temperature+and+dissolved+oxygen.aspx
5. http://www.fondriest.com/environmental-measurements/parameters/water-quality/water-temperature/#watertemp15
6. http://www.lakesuperiorstreams.org/understanding/bugs_ephem.html

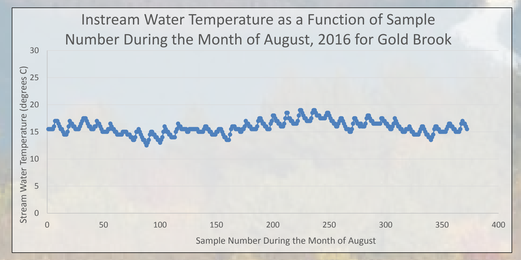




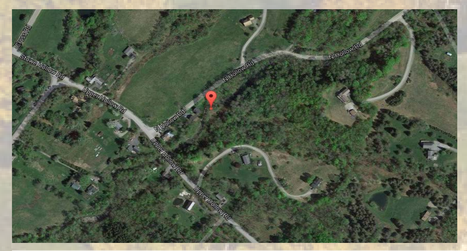








Aerial Photo of Trib A Sampling Site Showing Land Use



Aerial Photo of Goldbrook Sampling Site Showing Land Use

Map of Sites

Population Density from All Four Samples and Nutrient Sensitivity by Family of Ephemeroptera for 2014

Family of Ephemeroptera	Trib A Total #	Gold Brook Total #	Sensitivity to Nutrient Enrichment and DO Levels [6]
Baetidae	36	120	Moderately tolerant
Ephemerellidae	16	18	Intolerant to moderately intolerant
Heptageniidae	4	74	Intolerant to moderately intolerant

Population Density from All Four Samples and Nutrient Sensitivity by Family of Ephemeroptera for 2015

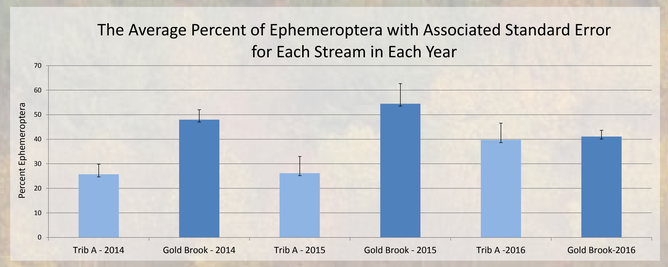
Family of Ephemeroptera	Trib A Total #	Gold Brook Total #	Sensitivity to Nutrient Enrichment and DO Levels [6]
Baetidae	37	139	Moderately tolerant
Ephemerellidae	27	5	Intolerant to moderately intolerant
Heptageniidae	11	19	Intolerant to moderately intolerant
Leptophlebiidae	0	22	Moderately intolerant

Population Density from All Four Samples and Nutrient Sensitivity by Family of Ephemeroptera for 2016

Family of Ephemeroptera	Trib A Total #	Gold Brook Total #	Sensitivity to Nutrient Enrichment and DO Levels [6]
Baetidae	91	89	Moderately tolerant
Ephemerellidae	8	19	Intolerant to moderately intolerant
Heptageniidae	9	13	Intolerant to moderately intolerant

Average Percent of Ephemeroptera Per Sample with Standard Error by Year

Year	Trib A	Gold Brook
2014	26.15 ± 6.82	54.47 ± 8.20
2015	25.65 ± 4.22	47.977 ± 4.02
2016	39.63 ± 6.93	41.09 ± 2.54



Conclusion

This study supported our hypothesis and suggests that fluctuation and higher water temperatures decrease the population density of larval Ephemeroptera. The data shows a correlation between instream water temperatures and population density of larval Ephemeroptera. In Trib A, the stress put on the larval Ephemeroptera by fluctuating water temperatures decreased their chance of survival. Gold Brook acted as a control because there was less variation of instream water temperature and therefore less stress put on the Ephemeroptera. The data supports the correlation between instream water temperatures and population density of Ephemeroptera because the standard error bars do not overlap between Trib A and Gold Brook in two of the three years. We found that when observing the two streams Gold Brook was more forested and had a denser canopy cover while the area around Trib A is more urbanized. If Trib A had more canopy cover it would be expected to have colder water temperatures than Gold Brook because it is smaller and mostly spring fed. This data is significant because other organisms rely on Ephemeroptera as a food source. Our data concludes that fluctuating water temperatures can put a large amount of stress on larval Ephemeroptera. This most recent study suggests a need for further investigation to determine if 2017 in an anomaly.

RACC Research on Adaptation to Climate Change In the Lake Champlain Basin

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Funding Provided by NSF Grant EPS-1101317

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