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No Significant Effect of Flow Rate on Macroinvertebrate Communities in Woods Creek

Introduction

Benthic macroinvertebrates are small backboneless animals that live on the bottom surfaces of bodies of water. In biological assessments of stream health, researchers collect data on macroinvertebrate communities to determine changes in water quality (Somers et. al. 1998).

Ecological preferences of macroinvertebrates provide background for understanding their usage as bio-indicators. There are two major categories of macroinvertebrates organized according to their tolerance to impairments in water quality: tolerant and intolerant. Tolerant macroinvertebrates are resistant to pollutants and indicate poor water quality. They include organisms such as aquatic worms and flatworms. Intolerant macroinvertebrates, like mayflies, stoneflies, and caddisflies are not resistant to pollutants and indicate higher water quality (Engel & Voshell 2002). The multimetric index is a metric that uses macroinvertebrates' relative abundances to determine water quality. The test yields a score from zero to twelve, where ranges from zero to six signal unacceptable conditions and ranges from seven to twelve signal acceptable conditions (Engel & Voshell 2002).

Flow rate is the volume of water that passes over a specific point over a fixed period of time (United States Environmental Protection Agency, 2012). There are additional categorizations of macroinvertebrates based on preferences for water currents. Macroinvertebrates have different preferences for water speed due to their physical adaptations. Macroinvertebrates with friction devices, like a bristled tail, can resist dislodgement in faster moving waters. (West Virginia Department of Environmental Protection Save Our Streams). Dragonflies, damselflies, aquatic worms, and beetles lack physical features for tolerance to fast waters and have preferences for slower moving currents. Macroinvertebrates such as caddisflies, hellgrammites, water penny beetles, stoneflies, blackflies, lunged and gilled snails, and mayflies have adaptations such as claws, hooks, and bristles so they can survive in lotic habitats with faster moving currents (Statzner & Holm 1989).

The relative abundances of different macroinvertebrates relate to both flow rate and water quality. Our investigation seeks to uncover the effects of flow rates on macroinvertebrate community composition and multimetric index scores. We hypothesized that higher flow rates in Woods Creek would be biased towards macroinvertebrates that have physical adaptations for faster water currents, but would create no significant difference in multimetric index scores. Specifically, there would be a higher percentage of macroinvertebrates with fast water habitat preferences in higher flow rates, and lower percentage of macroinvertebrates with slow water habitat preferences in lower flow rates. This investigation is important because the impact of flow rate on macroinvertebrate communities could have implications for stream bio-assessment.

Methods

To address the hypothesis, at each site, we calculated the flow rate in the sampling area using the cross-sectional float method outlined by the EPA (United States Environmental Protection Agency, 2012). Slight variations in materials were used. An apple was used as the floating device, and a tape measure was used to measure the width and depth. Three time measurements were taken for travel time and averaged. Six depth measurements were taken at each site, 3 on the upstream boundary and 3 on the downstream boundary of the site.

We manipulated one variable, flow rate, while keeping all other variables constant. Using the protocol outlined by Engel and Voshell (2002), we gathered two replicate measurements of macroinvertebrate communities on a site with high flow rate, Site 1, and another two replicate measurements on a site with low flow rate, Site 2. We collected samples at Site 1 on November 13, 2017 and samples at Site 2 on November 15, 2017. The two sites were located on Woods Creek just behind the Washington and Lee Science Center approximately a few hundred feet apart. To eliminate the effect of confounding variables that differ from site to site, each area of the stream we choose was relatively close together.

To take measurements for water quality we followed the methods outlined by Engel and Voshell (2002) and calculated the multimetric index scores. We calculated the mean multimetric index score, standard deviation, and standard error of the mean for each site. Additionally, we performed at two-tailed, type two t-test to determine if any statistically significant difference between the sites existed.

We recorded the number of macroinvertebrates with fast and slow current habitat preferences at each site. We calculated the mean percentage of macroinvertebrates with slow current habitat preferences, standard deviation, and standard error of the mean for each site. Then perform a two-tailed type two t-test to determine if there was any statistically significant difference between the sites. Then, we repeated these calculations for macroinvertebrates with fast current habitat preferences.

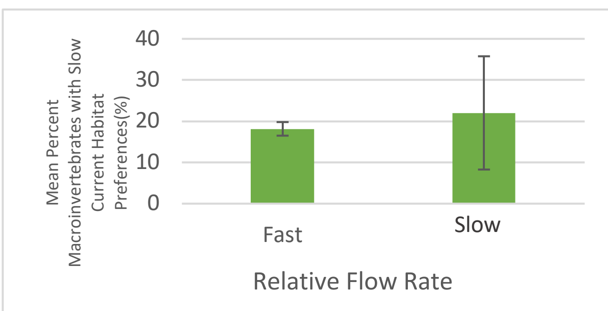

Figure 1: The mean percentage of macroinvertebrates with slow current habitat preferences at fast flow rates and slow flow rates. Error bars show standard error of the mean.

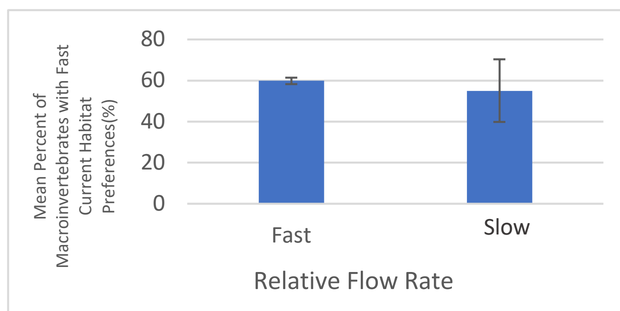

Figure 1: The mean percentage of macroinvertebrates with fast current habitat preferences at fast flow rates and slow flow rates. Error bars show standard error of the mean.

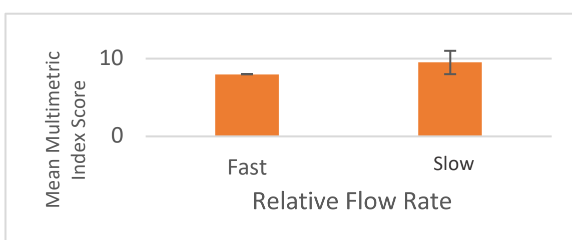

Figure 3: The mean multimetric index scores for fast and slow flow rates. Error bars show the standard error of the mean.

Results

The flow rate at Site 1 was 0.16 m^3/second, and the flow rate at Site 2 was 0.11 m^3/second. Site 1 had a relatively faster flow rate than Site 2.

The mean percentage of macroinvertebrates with slow current habitat preferences in fast flow rates, 18.15, is not statistically smaller than the mean percentage in slow flow rates, 22.03. (Figure 1; T-test, $p = 0.805$) The mean percentage of macroinvertebrates with fast current habitat preferences in fast flow rates, 59.82, is not statistically larger than the mean percentage in slow flow rates, 55.09. (Figure 2; T-test, $p = 0.787$) The mean multimetric index score of 8 for fast flow rate is not significantly smaller than the mean multimetric index score of 9.5 for slow flow rate. (Figure 3; T-test, $p = 0.423$)

Discussion

Macroinvertebrates with slow current habitat preferences were not significantly more abundant in slow flow rates, and macroinvertebrates with fast current habitat preferences were not significantly more abundant in fast flow rates. This suggests that flow rate had no impact on macroinvertebrate community compositions. Additionally, the insignificant difference in multimetric index scores suggests that flow rate had no impact on multimetric index scores. We hypothesized that there would be a higher percentage of macroinvertebrates with physical adaptations for faster currents in faster flow rates, but no difference in multimetric index scores. However, our results demonstrate that macroinvertebrate communities may be more resistant to flow rate than hypothesized.

The impact of flow rate on macroinvertebrate abundance and multimetric index scores could have implications for stream bio-assessment. Nevertheless, the insignificant differences in multimetric index scores support its robustness as a measure of water quality. The multimetric index scores still accurately reflected stream health, regardless of flow rate differences.

Our study assumes that the flow rates at Site 1 and Site 2 were substantially different. Future investigations of this phenomenon should include sites where flow rates differ by a substantial magnitude. Moreover, the limited sample size created highly variable standard errors, especially for slow flow rates at Site 2. Further samples could be collected to reduce this variability.

The flow rate measurements outline by the Environmental Protection Agency use velocities of floating objects. However, benthic macroinvertebrates do not live on the surface of the water where this measurement was recorded (Somers et. al., 1998). Water depth has been shown to impact current velocity (Mueller et. al., 2011). An alternate hypothesis for the observed results is that flow rate measurements only differed for surface level velocity. Velocities at the bottom surface could remain constant. To further the investigation, we research and implement methods for measuring velocity of water current along the bottom surfaces of streams.

Overall, this research shows the stability of macroinvertebrate communities regardless of flow rate. Furthermore, it demonstrates the robustness of the multimetric index score as a measure of water quality.

References

Engel, S. R., & Voshell, J.R. (Fall 2002). Volunteer Biological Monitoring: Can It Accurately Assess the Ecological Condition of Streams? *American Entomologist, 48 (3).*

Mueller, M., Pander, J., & Geist, J. (2011). The effects of weirs on structural stream habitat and biological communities. *Journal of Applied Ecology, 48*(6), 1450-1461. doi:10.1111/j.1365-2664.2011.02035.x

Somers, K., Reid, R., & David, S. (September 1998). Rapid Biological Assessments: How Many Animals Are Enough? *Journal of the North American Benthological Society*, 17 (3), 348-358.

Statzner, B., & Holm, T. F. (1989). Morphological adaptation of shape to flow: Microcurrents around lotic macroinvertebrates with known reynolds numbers at quasi-natural flow conditions. *Oecologia, 78*(2), 145-157. doi:10.1007/BF00377150

West Virginia Department of Environmental Protection. “WV Save Our Streams Guide to Aquatic Macroinvertebrates.” pp. 1-14.

“5.1 Stream Flow.” *EPA,* Environemental Protection Agency, 6 Mar. 2012, archive.epa.gov/water/archive/web/html/vms51.html.