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Physiochemical Parameters affecting Trichoptera Communities in Limestone and Sandstone Streams

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Senior Departmental Honors Project
Abstract

Trichoptera are a silk spinning order of stream macroinvertebrates that play an important role in stream ecosystems. Commonly used in metrics used to evaluate water quality and stream health, Trichoptera are a valuable source of information, and as such the most detailed understanding of them available is desirable. This project sought to achieve better understanding of how physiochemical parameters affect Trichoptera populations. Since geology is a key determinant of physiochemical factors in streams, Trichoptera populations were sampled from a limestone stream, a sandstone stream, and the mix zone where the two streams converged in order to determine if the differing physiochemical habitats affected the community structures. Collections and environmental sampling took place throughout the late summer to early spring, and gut analysis of three Hydropsychidae genera were conducted to detect food preferences. General Pearson-Correlations were used to examine preferences among genera for physiochemical parameters and revealed that free-living Hydropsychidae were positively correlated to certain chemical parameters while case building Glossosoma had negative correlations to numerous chemical parameters. Analysis of rock pick samples showed a preference from Hydropsychidae for larger surface areas. Overall populations were significantly larger in the fall. Gut analysis revealed that more animal content was found in Hyrdopsycshe as compared to the other two genera, and less plant material was found in Cheumatopsyche. These findings reveal practical insights into the ecology of Trichoptera based on physiochemical parameters and food preferences.
Introduction

Streams represent a valuable freshwater resource, the health of which has a direct impact on human life. As such, the proper monitoring of stream integrity is a major area of interest in environmental conservation and management programs. The use of bioindicators – species that reliably populate a habitat and react to alterations in that environment – is an important aspect of assessing overall biological integrity (Nahmani 2006, Iliopoulou-Georgudak et al. 2003). The basic premise of their use in assessing streams lies in the fact that the organisms found inhabiting polluted waters will differ from those in healthy waters (Iliopoulou-Georgudak et al. 2003).

Trichoptera have proven to possess bioindicator potential due to numerous factors. They are common in almost every type of freshwater environment, and as such play an integrative role in the aquatic ecosystems they inhabit, particularly in regard to food webs, transfer of energy, and the processing of organic matter (Wiggins 1979, Wiggins & Mackay 1978). Studying what factors affect Trichoptera can shed light onto what factors affect overall stream health. Their commonality also makes them ideal for comparing sites (Metzeling et al. 2003), and the wide range of pollution tolerance levels contained within the order allows Trichoptera to be good indicators of stream health (Bonada et al. 2004).

In order to make the most efficient use of Trichoptera as bioindicators, however, a fine-tuned knowledge of what specific factors and changes affect their population assemblages is required. This study attempted to achieve a better understanding of which physiochemical parameters shape Trichoptera communities. Since many of these physiochemical parameters are directly influenced by the geology of streams (Neff & Jackson 2011), the study looked at the Trichoptera communities of a limestone and a sandstone stream, as well as the mixed area after the two converged. By comparing the Trichoptera communities in each stream, as well as the physiochemical differences, a better understanding of how these parameters shape the communities was achieved.
Materials and Methods

The study sites were located along Dogwood Run located in Coover Park in York County, Pennsylvania (Figure 1). Dogwood Run was selected because of the opportunity it provides to study the effects of sandstone and limestone geology in separate branches of the same stream, as well as in the mix zone after the two branches converge. The limestone sampling site was located approximately 100 meters upstream from the convergence point; the sandstone site was located just prior to the convergence point; and the mix site was approximately 60 meters downstream from the convergence point.

Five collections occurred throughout late summer 2012 to early spring 2013 utilizing three different environmental sampling techniques. The first technique, utilized in the 3 September collection, involved collecting Surber samples from areas of open canopy coverage, partial canopy coverage, and closed canopy coverage in each of the streams. This sampling method allowed for analysis of the effect of canopy coverage. Other physical data was collected in the form of average stream velocity, depth and width in addition to water temperature, pH, and conductivity. Visual assessment of the percentage of substrate size classes represented was also noted.

A rock pick collection was conducted on 21 September in which 10 rocks were chosen from each stream section and Trichoptera specimens picked off of them. Measurements were taken of the rocks’ length, width, and height and a visual assessment of the percent of the surface area covered by algae was made. In addition, the velocity and depth of the water at each stone was recorded. Water temperature, pH, and conductivity in each of the streams were measured as well. This collection technique was performed again on 8 April.

The final sampling technique was utilized during the 16 November and 18 March collections. D-net samples were collected in riffle, run, and pool habitats of the three streams to ensure a full diversity of physical habitats was represented. The full set of physical parameters, including stream velocity,
depth, and width; temperature, pH, and conductivity; and substrate types were recorded during the November collection.

Water chemistry samples were collected in each stream during the 3 September, 21 September, 16 November, and 8 April collections. The samples were measured for nitrate and phosphate levels (mg/L) using a Hach® DR/800 Colorimeter and calcium hardness, chloride hardness, total hardness, and alkalinity (mg/L) from titrations using Hach® Reagent Sets.

Collected Trichopteran specimens from all sampling days were identified to the genus level. A gut analysis of the three Hydropsychidae genera most abundantly represented – Hydropsyche, Ceratopsyche, and Cheumatopsyche – was conducted on specimens gathered during the 21 September collection. Ten specimens from each of these three genera, made up of specimens from each of the three stream types, were dissected and their gut contents extracted. The gut contents were examined qualitatively for evidence of the presence of animal, plant, and detritus material.

Basic population statistics of richness and abundance were compared between streams and habitat types. In addition, a Pearson-Correlation was conducted to determine the correlation between physiochemical parameters and genera representation in each stream. One-way ANOVA results were used to assess the affect of seasonality on the Trichoptera populations in each the streams individually, as well as cumulatively. The gut analysis was conducted on a straightforward presence-or-absence basis, and the results compared among the three genera.
Results

A total of seven families and thirteen genera were represented. The general population statistics clearly marked some genera as the most commonly occurring. The Hydropsychids (Hydropsyche, Cheumatopsyche, Ceratopsyche) and Chimarra were the most abundant in every stream type and with every collection technique (Figure 2).

Looking at each genus’s representation individually, the three Hydropsychids and Potamyia occurred more often in the limestone stream than in the sandstone or mixed streams. Neophylax and Pycnopsyche occurred in similar numbers in both the sandstone and limestone stream. Dolophilodes, Glossosoma, and Polycentropus were most highly represented in the sandstone stream. The Polycentropus found in the sandstone stream was the only one collected. Rhyacophila had similar representation in both the sandstone and mix streams. Chimarra had its highest representation in the mix stream, and the only Wormaldia were found there. Diplectrona had equal representation in the limestone and mixed stream (Table 1).

The collection techniques were also designed to examine differences in populations between various physical stream habitats. Riffle habitats offered the most specimens in terms of abundance, producing 462 specimens compared to the 73 and 42 specimens offered by run and pool habitats, respectively (Figure 3a). However, there was only minimal variation between the habitat types in terms of species richness (Figure 3b). There were only two genera that appeared in run and pool locations but not riffle: Diplectrona and Pycnopsyche. Canopy coverage offered little evidence of an effect on populations, with open, partial, and closed habitats producing similar results.

The Pearson-Correlation applied to the rock pick samples showed that seven genera demonstrated significant correlation to certain physiochemical parameters (p ≤ 0.05). The most significant correlations involved the free living Hydropsychids Hydropsyche and Cheumatopsyche. Both showed positive correlation to increased alkalinity (p=0.032, p=0.011, respectively), total hardness
(p=0.039, p=0.015), calcium hardness (p=0.038, p=0.016) and very strong positive correlation to phosphate levels (p=0.009, p=0.000), as well as increased surface area (p=0.000, p=0.001).

Cheumatopsyche also showed positive correlation to increased conductivity (p=0.030) (Table 2). In contrast to this Glossosoma showed significant negative correlation to increased conductivity (p=0.018), alkalinity (p=0.018), total hardness (p=0.019), calcium hardness (p=0.016), and chloride hardness levels (p=0.024), and very strongly negatively correlated with increased nitrate levels (p=0.003) (Table 2).

Other genera showed significant correlations as well. Ceratopsyche were positively correlated with increased temperature (p=0.006), while Rhyacophila were negatively correlated with increased temperature (p=0.032). Diplectrona were positively correlated with increased phosphate levels (p=0.025). Neophylax were positively correlated with increasing pH (p=0.006) and chloride hardness (p-0.021) but negatively correlated with increasing temperatures (p=0.001) and velocity (p=0.031) (Table 2).

One-way ANOVA comparing all streams across the seasons showed that the November collection had significantly higher abundance (p = 0.03), with 418 specimens collected, than collections done in early September (115 specimens) or March (158 specimens) (Figure 4). Only four genera had their highest instance of collection in a month other than November; Rhyacophila, Neophylax, Pycnopsyche, and Polycentropus were collected in higher numbers in March than in November. Similar one-way ANOVA tests considering each stream individually across each season showed that there was no significant difference between the collections in early September, November, and March.

Because of limited expertise, the gut analysis was performed in a qualitative, presence-or-absence manner which limited what statistical analysis could be applied. From this qualitative data, it was apparent that there was a higher occurrence of animal material in the guts of Hydropsyche than in Ceratopsyche or Cheumatopsyche, which had equal amounts (Figure 5). There was a lower occurrence of plant material in Cheumatopsyche than in Hydropsyche or Ceratopsyche, which had equal amounts (Figure 5).
Discussion

In terms of richness and abundance, the results showing more specimens collected from riffle habitats is not surprising, as riffle habitats provide a more varied habitat and usually support larger populations. However, over half of the specimens collected in riffle habitats were *Cheumatopsyche* and *Chimarra*. Thus, even thought the richness was also slightly higher in riffle habitats, the diversity for riffles overall was very limited, considering the dominance of these two genera.

The results from the Pearson-Correlation were most interesting in terms of the three genera that showed the most significant correlations: *Cheumatopsyche, Hydropsyche*, and *Glossosoma*. The positive correlations of *Cheumatopsyche* and *Hydropsyche* suggest a preference for the conditions of limestone streams, as conductivity, alkalinity, hardness, and phosphate levels are higher in such streams. These genera did occur in higher numbers in the limestone stream in this study; however, they also were among the most commonly collected in each of the other streams as well (Figure 2). This is most likely due to the interplay between tolerance and preference that exists in macroinvertebrates (Skuja and Spungis 2010). While there is evidence for a preference for limestone streams, there is also evidence that *Hydropsyche* and *Cheumatopsyche* may act as generalists based on their high rate of occurrence in the other stream types. In addition, both genera showed a very strong correlation to a larger rock surface area. The preference for large rocks speaks to their dependence on life in fast moving waters which usually involve larger, stable substrate (Georgian & Thorp 1992).

In contrast, *Glossosoma* showed negative correlations to levels of conductivity, alkalinity, and all types of harness. This indicates a preference for the conditions of the sandstone stream since these levels were lowest in that stream. *Glossosoma* were indeed found in the highest numbers in the sandstone stream, and the lowest numbers in the limestone stream. *Glossosoma* was also very negatively correlated to nitrate levels, which are usually regarded as a parameter shaped more by environmental than geological inputs. Two main sources of nitrates include wastewater treatment
plants and runoff from fertilized farmland and lawns (EPA). In the case of Dogwood Run, the nitrate levels are most likely tied to the golf course located upstream of the limestone sampling site on which fertilizers are surely used. Thus *Glossosoma* favoring lower levels of nitrate would be more apt to appear in higher numbers in the sandstone stream.

In terms of the seasonal data, the spike in population in November was not surprising and could be attributed to the common lifecycle of Trichoptera. A common lifecycle trend is that adults emerge in the spring and early summer, lay eggs by late summer, and the larva are then most prevalent in the fall (Robinson, Minshall & Van Every 1993). However, this is a general trend and there are known exceptions. Three notable exceptions in this study involved *Rhyacophila, Neophylax, and Pycnopsyche*, which were all more common in the spring (Figure 4). For *Neophylax* and *Pycnopsyche* the explanation could again be a matter of lifecycle trends. Each is known to have lifecycles in which the adults emerge in late summer or early fall, in which case eggs would be laid in the fall and larva would be more prevalent over the winter-spring time period (Wiggins 1977; Mendez & Resh 2008). For *Rhyacophila* it is less straightforward and may involve ties to a common food source. *Rhyacophila* are predatory during their last instar stages, which was the most common stage during the spring collections when *Rhyacophila* were most commonly encountered, and a common prey for them during this time in Plecoptera nymphs (Manuel & Folsum 1982). In temperate streams Plecoptera can commonly display synchronous emergence (Brittain 1991) and many have adult emergence restricted to the spring and summer months (Stewart & Harper 1996) which may influence the increase in predatory *Rhyacophila* populations during this time.

The gut analysis offered limited useful results based on the manner in which it was conducted. Limited ability to identify partially digested gut material restricted the data to a qualitative presence/absence nature, which in turn limited the analysis it could be subjected to. From the results, it was gathered that *Hydropsyche* guts contained the most animal material and *Cheumatopsyche* the least.
plant material. This second result seems problematic, as *Cheumatopsyche* are largely regarded as being herbivorous (Rhame & Stewart 1976).

However, the results regarding *Hydropsyche* tie to interesting results in other literature. Rhame and Stewart (1976) recorded *H. simulans* changing their diet based on micro-crustacean availability. Micro-crustaceans made up a majority of what was classified as animal material in the guts of *Hydropsyche* in this study. Rhame and Stewart observed *Hydropsyche simulans* diets shifting from consisting mainly of micro-crustaceans in April through October to filamentous algae over the winter months when micro-crustacean populations decrease. It would be interesting to investigate if this is the case for more *Hydropsyche* than just *H. simulans*, and if it would be observed in Dogwood Run. The gut analysis was performed on only specimens collected during the September rock pick collection, and further research with more refined gut analysis techniques could shed light on the supposition that increased evidence of plant material would be evident in early spring.
Acknowledgements

I would like to thank Messiah College’s Department of Biological Science for the opportunity to conduct this research as well as for the use of the equipment and facilities employed throughout this study. Even more importantly I would like to thank Jeff Erikson for his magnanimous advice and guidance throughout the course of my project.
Literature Cited


Figure Captions

Figure 1. Location of limestone (LS), sandstone (SS), and mix (M) sites along the two branches of Dogwood Run in Coover Park in York County, Pennsylvania.

Figure 2. Total specimens of each genera collected from each stream type. *Cheumatopsyche, Hydropsyche, Ceratopsyche,* and *Chimarra* had a significant presence in every stream type during every collection occasion.

Figure 3. Total abundance (A) and richness (B) of combined riffle, run, and pool data. Riffle habitats demonstrated the highest abundance, but it consisted mainly of 2 genera: *Cheumatopsyche* and *Chimarra*.

Figure 4. ANOVA of seasons demonstrating that the fall collection in November collection had significantly higher abundance (p=0.03) than the late summer or spring collection. Error bars showing 95% confidence interval.

Figure 5. Occurrence of animal and plant material observed in the guts of *Hydropsyche, Ceratopsyche,* and *Cheumatopsyche.*
<table>
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<th>Family</th>
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<th>M</th>
<th>SS</th>
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<td>0</td>
<td>1</td>
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</tbody>
</table>

Table 1. The representation of each genus in each stream.
Table 2. Pearson-Correlation for the seven genera demonstrating significant correlations (p≤0.05) to physiochemical parameters. Blue highlighted cells denote significant correlations.
Figure 1.
Figure 2.
A. Figure 3.

B. Figure 3.
Figure 4.
Figure 5.