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*How does algal biomass and species composition in caddisfly nets differ from adjacent rocky substrate?*

Abstract

This study attempts to characterize differences in algal biomass and species composition in caddisfly nets relative to their adjacent rocky substrate. To test this, we compared algae species present in caddisfly nets versus substrates and characterized differences in biomass by comparing chlorophyll a content in each sample. Results showed a significantly higher biomass in net relative to rock samples and a high degree of overlap between algae species in net and rock samples. This suggests that net-spinning caddisflies act as a non-selective trap for particulate matter in the drift and have little effect on the abiotic variables directly affecting algae composition.

Introduction

Algal communities are highly variable due to influences by both biotic and abiotic factors. In river systems, substrate type, current velocity, and macroinvertebrates are all key to this variability (Finlay et al. 1999, Stief and Becker 2005). In general, lower velocity currents allow for higher levels of algal biomass to accumulate (Poff et al. 1990), although some studies have shown that biomass accumulation increases with higher currents after initial establishment (DeNicola and McIntire 1990). The effects of current velocities can also change with substrate composition, which influence algal species establishment and thus, species composition (DeNicola and McIntire 1990). These factors also play a role in determining macroinvertebrate establishment, which have their own distinct effects on algal communities (Wallace 1996).

Much of the studies on algal composition in river systems have been based on the influence of abiotic factors. The effects of biotic factors, macroinvertebrates in particular, may be equally important but lack the same degree of research. Macroinvertebrates can perform a critical role in river systems via a wide range of activities, including feeding, waste production, and movement (Bergey and Resh 1994, Wallace 1996). Algae are often affected, reacting to changes in nutrient levels and herbivory by macroinvertebrates (Pan and Lowe 1995). Research on case-making and net-spinning macroinvertebrates has shown that there is a significant difference between algae biomass on macroinvertebrate cases relative to river substrates. This difference in biomass may be higher or lower depending on the species of macroinvertebrate (Bergey and Resh 1994). However, there has been little research performed to characterize the effects that they have on algae communities and their composition.

Net-spinning caddisflies (family: Hydropsychidae) establish silk-spun retreats in low-current streams on underwater substrates such as rocks or fixed vegetation, acting as filter-feeders by removing diatoms and animal drift from suspension for consumption and thereby altering the quantity and composition of particulate organic matter in the system (Wallace and Webster 1996). Hydropsychids are generally found in low current streams and build silken capture nets consisting of three parts; the funnel, located at the anterior of the net, the drop zone, or the bend in the net, and the retreat, located at the rear of the net (Richardson 1984). In addition to being a caddisfly food source, algae can colonize on and around the caddisfly nets, using them as a substrate and utilizing nutrients from caddisfly excretions (O'Connor 1993).

In order to better understand the effects of net-spinning macroinvertebrates on algal composition, we analyzed the composition and biomass of algal communities on Hydropsychid nets relative to the substrate upon which the nets were established. We sought to determine whether there was a significant difference in biomass and species composition and frequency between caddisfly nets versus their corresponding rock substrate. Because algal communities respond to changes in nutrients, substrate, and current velocity, all of which can be altered by net-spinning caddisflies (DeNicola and McIntire 1990, Bergey and Resh 1994), we predicted that we would see a difference between the two communities. To test this, we compared algae species present in caddisfly nets versus substrates and characterized differences in biomass by comparing chlorophyll a content in each sample.

## Methods

Data collection took place on the east branch of the Maple River in Emmet County, MI (USA) during the fourth week of July 2013. The study site was located in a shallow, low-current area of the river with submerged rocks lining one bank and partially vegetated sand forming the remainder of the riverbed. Hydropsychid caddisfly nets of various sizes were established on both rock and vegetative substrates.

Prior to sampling, current velocity was measured directly in front of each caddisfly net with a Marsh McBirney Flo-Mate flow meter. Only caddisfly nets located on rock substrates were sampled and only one net was taken per rock. The size of the caddisfly nets was measured with vernier calipers. Because the nets would collapse without support from the water current, measurements were taken while the nets were submerged. Measurements followed the methods outlined by Peterson et al. (1984) and included the funnel diameter, the length from the funnel to the drop zone, and the length from the drop zone to the rear of the retreat. Nets collected ranged in area from $9.90cm^2$ to $30.40cm^2$. Algae samples from the rock substrates associated with each net were taken using a soft-bristled brush from a $4cm^2$ area located adjacent to each net. Sample area was exact and acquired using a rubber 4x4cm cut-out. 15 net samples and 15 corresponding rock samples were taken.

Following collection, net and rock samples were homogenized with river water and the resulting volume was measured. A 10mL subset of each sample was tested for chlorophyll content via a spectrophotometer to determine biomass and the remaining volume of each sample was preserved with formalin (2%) to allow for species composition analysis. Using a Palmer Counting Cell at 430x magnification, a minimum of 300 algae cells were recorded by species for each sample to determine overall composition. Counting was done using random fields of view for net samples and transects for rock samples. Species that were found in two samples or less were not considered significant and therefore not analyzed. Biomass of net versus rock samples was analyzed using a paired t-test. Species composition of net versus rock samples was compared using a principle component analysis.

<u>Results</u>

The mean chlorophyll a concentration in net samples was approximately 10 times higher than that of the rock samples (paired t-test, t-value=7.087, d.f.=14, p-value<0.0001, Fig. 1). Chlorophyll a concentration in net samples ranged from 0.0180mg/L/cm$^2$ to 0.175mg/L/cm$^2$ with a mean of 0.0721mg/L/cm$^2$ (SE=0.00952, N=15, Fig. 1). Chlorophyll a concentration in rock samples ranged from 0.00165mg/L/cm$^2$ to 0.0209mg/L/cm$^2$ with a mean of 0.00785mg/L/cm$^2$ (SE=0.00137, N=15, Fig. 1).

In both net and rock samples, we found a mixture of 28 algae species, the most common of which included *Fragileria spp., Cymbella spp., Navicula spp.,* and *Synedra spp.* (Fig. 2).

Principle component analysis of algae species composition in net and rock samples showed a high degree of overlap between the algae species of net and rock samples (Fig. 3).

Currents directly in front of sampled caddisfly nets ranged from 0.0061m/s to 0.27m/s.

## Discussion

Chlorophyll a content was significantly higher in net samples and algae species composition was highly similar between the net and rock samples. Because chlorophyll a content is a biomass indicator, this implies that caddisfly nets differ enough from the adjacent rock substrate result in higher algal biomass, which may be explained by the structure of caddisfly nets. Unlike the adjacent rock substrates, these nets are designed specifically to catch particulate matter floating currents, including algae (Wallace 1974, Wallace and Webster 1996). Additionally, Hydropsychids have been shown to maintain nets for up to several months (Hauer and Stanford 1982). Combined with a continuous supply of periphyton from stream currents, these long-lived nets are ideal for algal biomass accumulation.

Since there is little documentation of Hydropsychid effects on algae composition specifically, our findings may be best explained by examining other variables related to this system. Algae composition in streams can result from ultimate and intermediate factors, such as climate and geography, as well proximate factors, including pH and turbulence zones (Stevenson 1997, Korte and Blinn 2004). Because our samples were taken from the same site, ultimate and intermediate factors would not have an effect. Furthermore, even though many proximate factors can vary on small scales it is unlikely that caddisfly nets would cause that variation. The primary environmental alterations made by net-spinning caddisflies include net establishment and excrements. While in some cases nets may alter turbulence zones on the substrate, any resulting differences would not factor into our results since each pair of net and rock samples were adjacent on the substrate. Thus, any differences in turbulence zones caused by the net would also affect the nearby substrate. However, even though individual sample pairs likely experienced similar turbulence zones, it is possible that differences in turbulence zones between sample pairs could have accounted for some of the differences in algae composition observed in our study. Additionally, variation due to excrements would be unlikely since stream currents relegate excrements to the retreat portion of the net and continue to carry it downstream.

While some macroinvertebrates have been shown to alter algae composition through selective feeding habits (Poore 1994), there is no such evidence regarding Hydropsychids. It has been shown that algae are consumed by these caddisflies, but it is a minority in their overall diet relative to invertebrates and detritus (Benke and Wallace 1980). Therefore, it may be more likely that larvae consume algae inadvertently as they consume other particles caught in their nets, since algae often catches in clumps near the other food sources (Wallace 1996).

Hydropsychidae nets are significantly higher in algal biomass with similar species composition to their adjacent substrates. The filtering nature of caddisfly nets likely results in their high concentrations of algal biomass, and close examination of abiotic determinants of algal species composition showed that caddisfly nets were unlikely to have an impact relative to the substrate. This suggests that net-spinning caddisflies act as a non-selective trap for particulate matter in the drift and have little effect on the abiotic variables directly affecting algae composition, although it may be beneficial to investigate whether this is true for substrates farther from caddisfly nets.

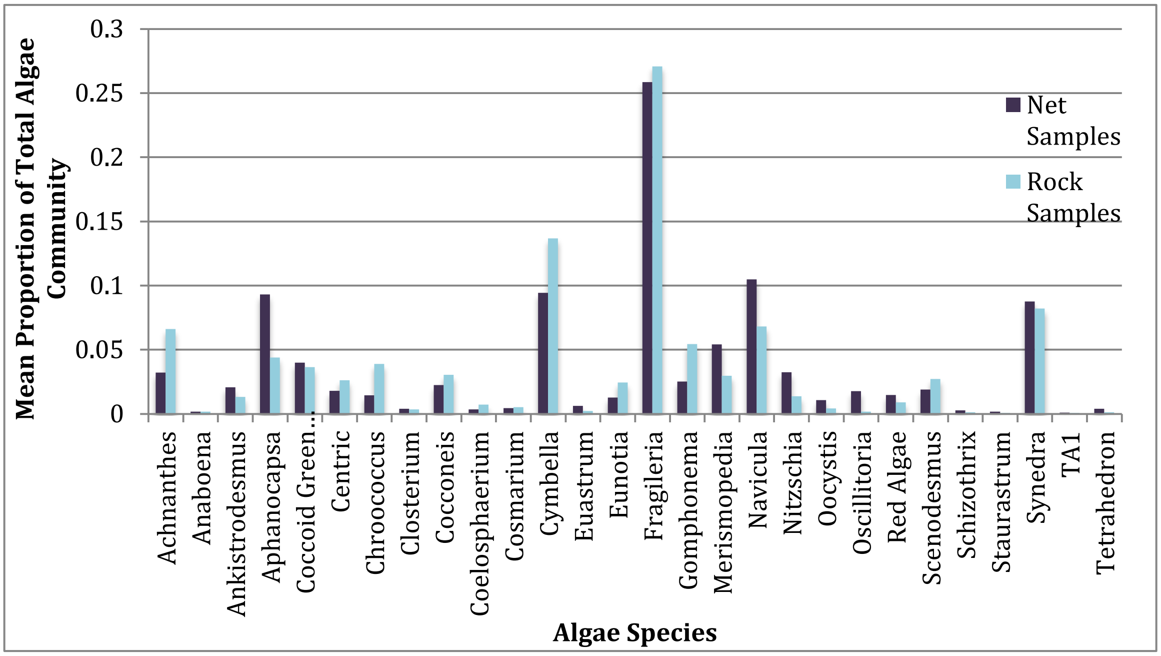


Fig. 2. Comparison of mean algae species proportions in net versus rock samples. Dominant species include *Fragileria spp.*, *Cymbella spp.*, *Navicula spp.*, and *Synedra spp.*

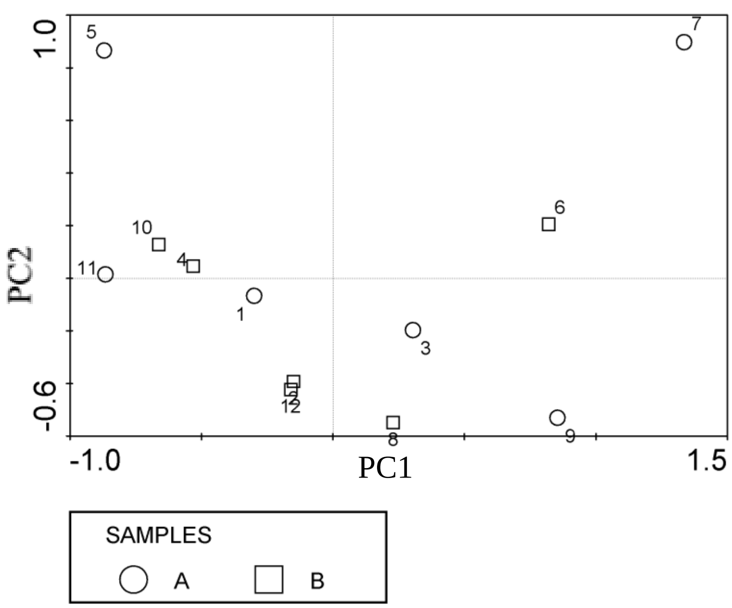


Fig. 3. Principle component analysis of algae species composition between net and rock samples, showing no statistically significant correlation in either net or rock samples. PC1=Principle Component 1, PC2=Principle Component 2.

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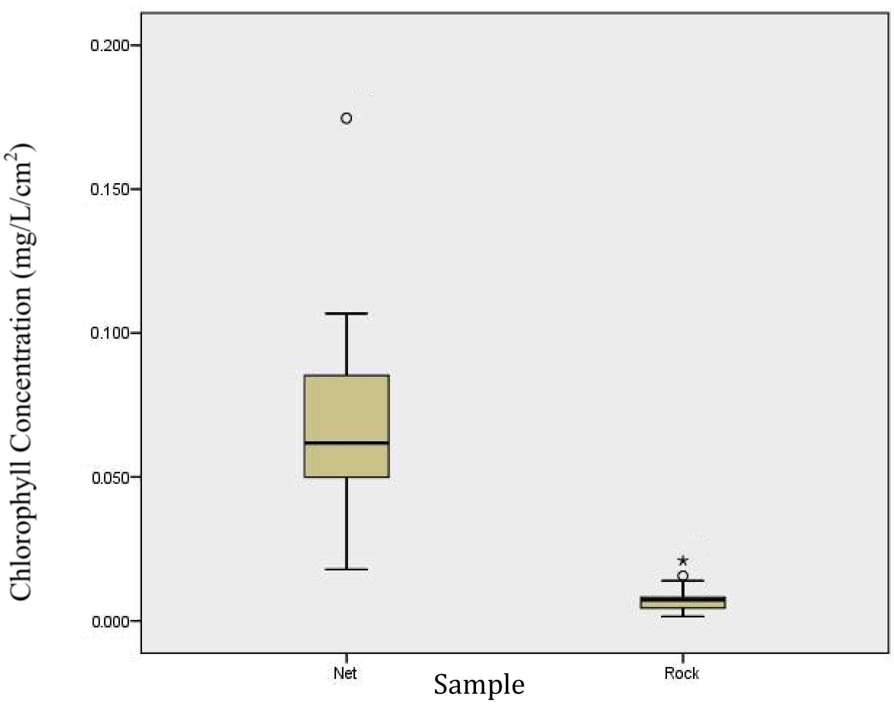


Fig. 1. Comparison of median chlorophyll content of net versus rock samples. The median chlorophyll content in the net samples was significantly higher than that of the rock samples (7.087, d.f.=14, p-value<0.0001). Net samples: median=0.0618mg/L/cm$^2$, lower extreme=0.0180mg/L/cm$^2$, upper extreme=0.107mg/L/cm$^2$. Rock samples: median=0.00731mg/L/cm$^2$, lower extreme=0.00165mg/L/cm$^2$, upper extreme=0.0209mg/L/cm$^2$. Circles and star represent outliers.

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