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**How Does Streambed Heterogeneity, Light Intensity, and Near-bed
Current Influence Algal Accrual, Ash Free Dry Mass, and
Macroinvertebrate Richness, and Abundance?**

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Abstract

Research in stream ecology has become imperative to protect the ecosystem from natural and human induced disturbances. By indulging in the variation of substrate makeup, light intensity, and current velocity, we can evaluate the composition of living organisms as well as the nutrients around them. This will help establish the causes and consequences of a damaged stream ecosystem.

Introduction

Natural disturbances are an intricate component in stream ecosystems. Both natural and anthropogenic induced disturbances can alter substrate and water flow modifying the habitat of benthic communities. In addition, the severity and frequency of disturbances has also been shown to greatly influence biotic benthic populations in streams (Peckarsky, 1986). It has been suggested, in areas where disturbances are frequent, succession of the community will not take place (Fisher, 1983), or occur at a slower rate depending upon the intensity of the disturbance (Minshall, 1983). Clifford (1982) gradually (over 2.5 months) decreased the heterogeneity of a stream in Alberta, Canada and found that the densities of 20 out of 24 macroinvertebrate taxa decreased as the substrate became homogeneous. Peckarsky (1986) showed that without a major flood disturbance and not interfering with competition or natural predators, 13 of 19 macroinvertebrate species showed an increase in total abundance. However, little is known about how changes in benthic habitat affects the functional composition of macroinvertebrate communities and algal accrual.

If the environment of certain species undergoes catastrophic change that the species may not be adapted to, the species will likely attempt to seek preferred habitat in which their morphological composition is best suited. For example, stream macroinvertebrate herbivores of different functional feeding groups may perform better under varying near-bed velocities. Alterations in the environment may cause a reduction or an increase in preferred near-bed velocities. The herbivores behavior depends upon the spatial limitations and/or advantages as well as resource availability (Palmer, 1994). Certain species might prefer a niche where there is a variety of food, or perhaps a variety of space.

In another study, with no influence of resource distribution, two taxa of mayfly nymphs grew larger in faster currents (Palmer, 1995). Palmer (1995) also showed that drift from current velocity play a key role in foraging strategies of some macroinvertebrates in streams. In other studies, results showed that greater distances were traveled by nymphs at a higher velocity (35 and 55cm/s) when they were dead than when they were alive (Allan and Feifarek, 1989). This is an indicator physical adaptations of macroinvertebrate species and current velocity modify in growth of the species and the substrate they decide to graze upon. The degree of the current also affects the drift of macroinvertebrate species which is important in the dispersal and colonization of the stream invertebrates (Ciborowski, 1987).

Substrate heterogeneity and homogeneity are important factors in understanding macroinvertebrate species of different phenotypic trait sizes. Substrate heterogeneity, or the degree of variation in substrate (higher variation indicates greater heterogeneity), creates different niche spaces that macroinvertebrate species physically adapt to. Depending on the size of the macroinvertebrate species, the species may prefer to colonize a larger area between the

substrate over smaller areas between the substrate because their spatial biological interactions are suitable in this particular habitat. Homogeneity, or substrate uniform in size, have little variation among the cobble. This creates habitats similar in nature and, in turn, reduces genetic variation within a species. Where the macro-invertebrate species colonize depends upon the adapted varying traits of the species.

Substrate heterogeneity and homogeneity may also important algal accrual. Algae growth depends on light intensity and the surface area in which the algae will grow. A larger greater variation in substrate size (i.e. cobble) may promote greater algae abundance; a smaller cobble size has less surface area and may ultimately reduce algal abundance. Heterogeneous cobble arrangements organize a variety of area that constant homogeneous cobble arrangements cannot offer.

Varying stream velocities support different abundances of macroinvertebrate species of different phenotypes. The current velocity may be ideal for a species specialized trait, in which case the abundance of the species would be greater. The current velocity may also be rapid enough to alter the sedimentation, which would either destroy the habitat or create a new habitat that the specialized species could survive in. The velocity of the stream also affects the algae growth. The stream current might be fast enough to wash away all or most of the algae trying to grow, leaving a minuscule abundance of algae or no algae at all. The velocity of the stream may also affect the reproduction rate of the algae by facilitation or impediment.

It is important to extend on this field of knowledge because streams are naturally heterogeneous systems and by understanding this system we can understand how environmental factors like variation in substrate make-up and current velocity effect algal accumulation and macroinvertebrate diversity. Algal growth is important to support many trophic levels, while diversity of macroinvertebrate is important to maintain genetic variation. My studies will provide critical insight to understanding how cobble and stream current heterogeneities influences algal accumulation and macroinvertebrate diversity.

Cobble heterogeneity and homogeneity and stream velocity are important predictors in the response of the varying phenotypic traits of macroinvertebrate species and algae growth. I am proposing to do an manipulative experiment that examines how streambed heterogeneity influences 1) algal accumulation, 2) Ash Free Dry Mass 3) macroinvertebrate richness and abundance, and 4) light intensity.

Methods

I will begin by locating areas in Copper creek with stream velocities range from 0-60cm/s. I will then create 10 substrate trays, 5 of which will be heterogeneous packed with different sized cobbles, and 5 homogeneous trays that will be packed with the same sized cobbles. Mean cobble size will be kept constant between treatments. Nine cobble from each tray will have 2.6 x 2.6 cm (1 inch square) ceramic tiles attached with silicon sealant. These will be used for the sampling algae accumulation.

I will then pair the heterogeneous and homogeneous treatment trays and place them at 5 locations along Copper Creek. For each substrate tray tile I will record the final and initial near-bed current (cm/s) at the 12 tile loactions for each tray, which will be placed in the centeer of the trays to reduce edge effect.

The trays will be left for a period of 3 weeks and checked daily. During this time algae will accumulate and the macroinvertebrates will colonize the trays.

The trays will be sampled by removing tiles to measure algal accumulation. Each tile and its associated algae will be put into opaque, 200 ml Nalgene bottles and chlorophyll-a will be extracted with 90% buffered ethanol. Three random rocks per tray will be sampled for chlorophyll by using a 30mm cylinder that will be pressed to create a seal to the rock. An eyedropper will add water to the inside of the cylinder and a dremel tool will loosen the sedimentation and algae. The eyedropper will then remove the liquid and be put into a container. The processes will be repeated. Then, the liquid will be filtered out. The filter containing the algae and sedimentation will be labeled, wrapped in tinfoil, and frozen until extraction of chlorophyll-a. 90% buffer alcohol will be used for the rock extraction.

After removing tiles, trays will be sampled for macroinvertebrates by agitating each cobble and dislodging macroinvertebrates into a kicknet placed around the end of the tray downstream. The macroinvertebrates will be identified to species when collected and counted. Traits such as body length and cerci/body ratio will be measured, and functional feeding group and body shape will be assessed.

In order to measure light intensity, 2 loggers will be placed near each paired tray. One logger will go above water, while the other will go below the water. Intensity will be measured in Lux.

Statistical Data Methods

The statistical methods that will be used for this experiment is ANCOVA. The independent variables are heterogeneous and homogeneous cobble structures, light intensity and velocity. The two dependent variables are algae biomass, Ash Free Dry Mass, and the invertebrates.

Results

Heterogeneity and homogeneity of stream substrate was without importance to species richness, species abundance, chlorophyll-a and Ash Free Dry Mass. There was no difference between species richness and heterogeneous and homogeneous substrate ($p = 0.9072$). The abundance of each species showed little difference between the two substrate treatments ($p = 0.5486$). However, Plecopetera appeared a significant amount more in the heterogeneous substrate treatment than in the homogeneous treatment ($p = 0.0587$). Although the AFDM (g) in the heterogeneous substrate was greater than in the homogeneous substrate, there was not a significant difference between the two treatments (0.7541).

While light intensity (lux) had a negative affect on the Chlorophyll-a, the near-bed current velocity (cm/s) exponentially decreased. As light intensity decreased, chlorophyll-a decreased ($p = 0.1061$). Chlorophyll-a accrual (mg/m^2) did stand out boarder-line significantly between the near-bed current velocity ($p = 0.0538$).

Discussion

Although streams are naturally heterogeneous environments, the heterogeneous and homogeneous substrates had little variability on Species Richness, Abundance, and AFDM. The variability in the extremes of how heterogeneous and homogeneous the substrate is should be looked at on a wider prospect of cobble size in larger scale of heterogeneity.

As the near-bed current velocity increases exponentially, the chlorophyll-a decreases exponentially. This creates a threshold that suggests a facilitation of chlorophyll-a in slower current. One hypothesis is that the algae is not disturbed by the force of current and therefore can grow in a greater abundance. Another hypothesis incorporates another variable, the stream insects. The stream insects graze and crawl over the algae, knocking it free which in turn reduces the amount of resource partitioning and some competition, allowing the algae to grow more.

LITERATURE CITED

- Allan JD; Feifarek BP. 1989. Distances travelled by drifting mayfly nymphs: factors influencing return to the substrate. *Journal of the North American Benthological Society* 8(4):322-330.
- Clifford HF. 1982. Effects of periodically disturbing a small area of substratum in a brown-water stream of Alberta, Canada. *Freshwater Invertebrate Zoology* 1(2):39-47.
- Ciborowski, J. J. H. 1987. Dynamics of drift and micro distribution of two mayfly populations: a predictive model. *Canadian Journal of Fisheries and Aquatic Sciences* 44:832-845.
- Fisher, S. G. 1983. Succession in streams, p. 7-27 In J.R. Barnes and G. W. Minshall [ed] *Stream ecology. Application and testing of ecological theory*. Plenum Press, New York, NY. 399 p.
- Minshall, G. W., D. A. Andrews, and C. Y. Manuel-Faler. 1983. Application is island biogeographic theory to streams: macroinvertebrate recolonization of the Teton River, Idaho, p.297-297. In J.R. Barnes and G. W. Minshall [ed] *Stream ecology. Application and testing of ecological theory*. Plenum Press, New York, NY. 399 p.
- Palmer TM. 1995. The influence of spatial heterogeneity on the behavior and growth of two herbivorous stream insects. *Oecologia* 104:476-486.
- Peckarsky, B. L. 1986. Colonization of Natural Substrates by Stream Benthos. *Canadian Journal of Fisheries and Aquatic Sciences* 43:700-709.

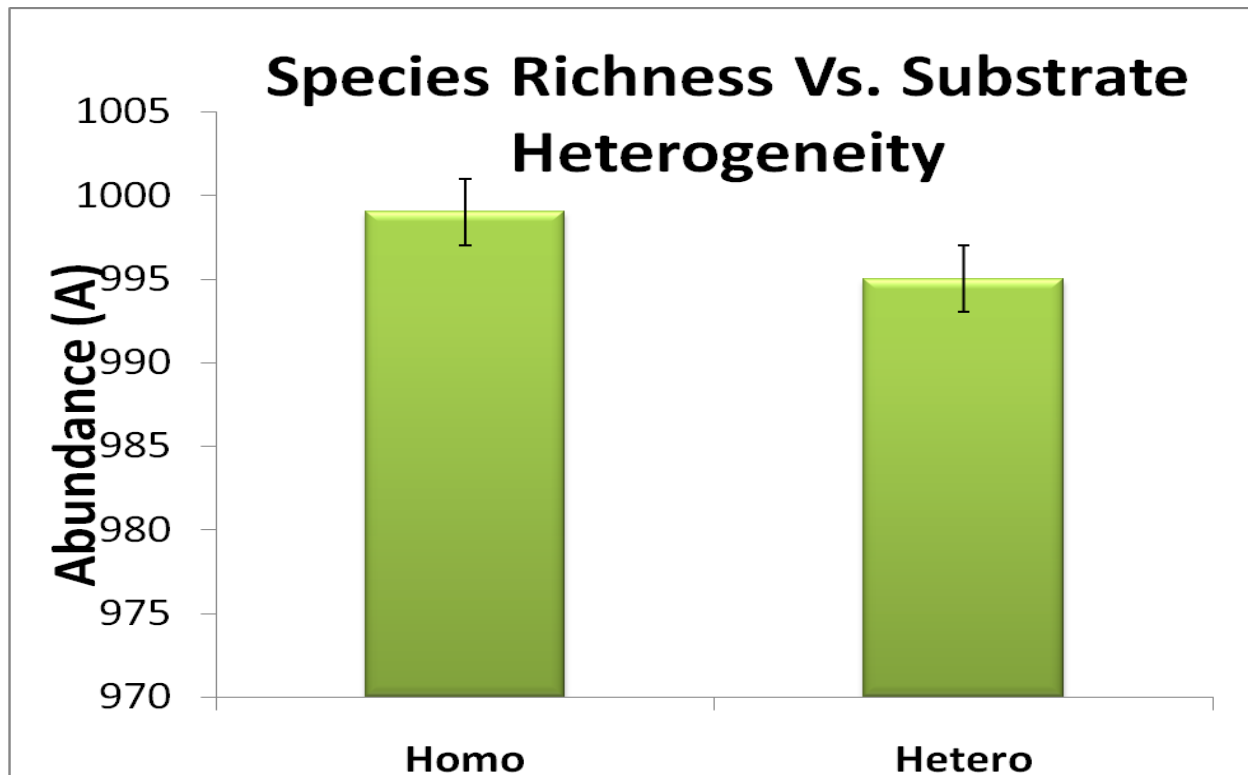


Figure1: Hetero and Homogeneity and its affect on Species Abundance. Data were collected June 12-26 in Copper Creek, Gothic CO.

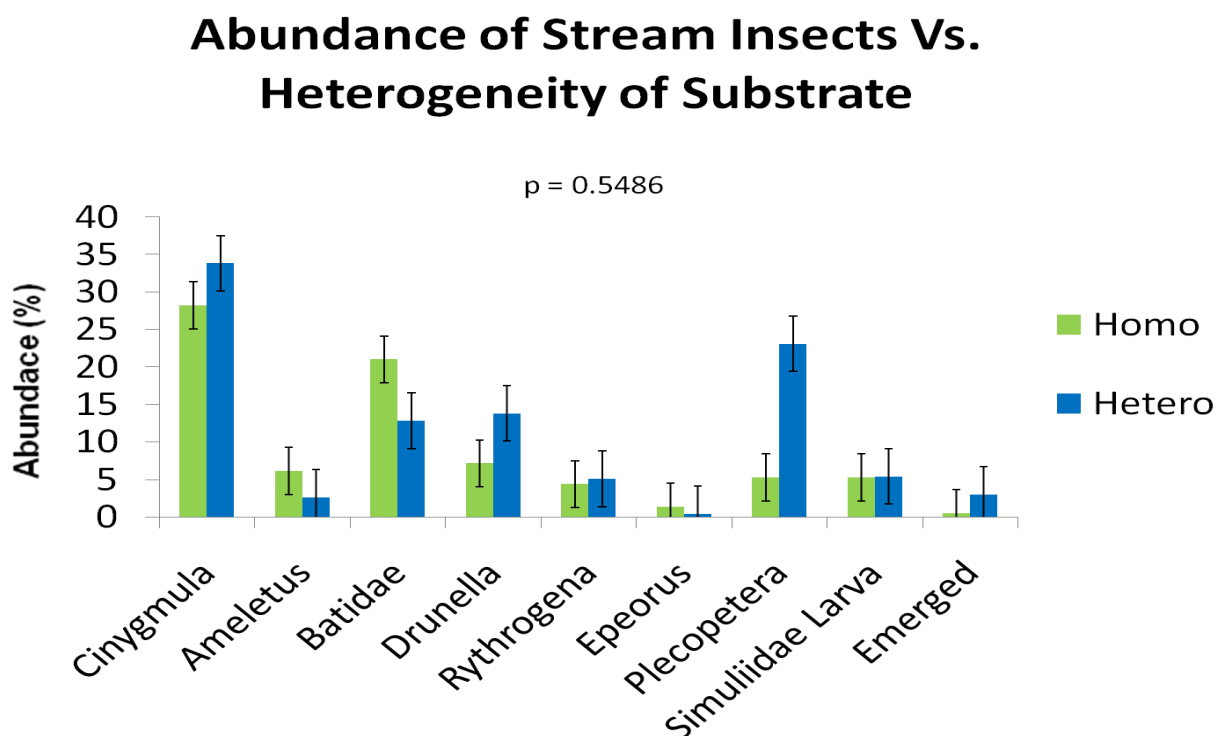


Figure 2: Homo and heterogeneity of substrate and its affect on each species and their abundance. Data were collected June 12-26 in Copper Creek, Gothic CO.

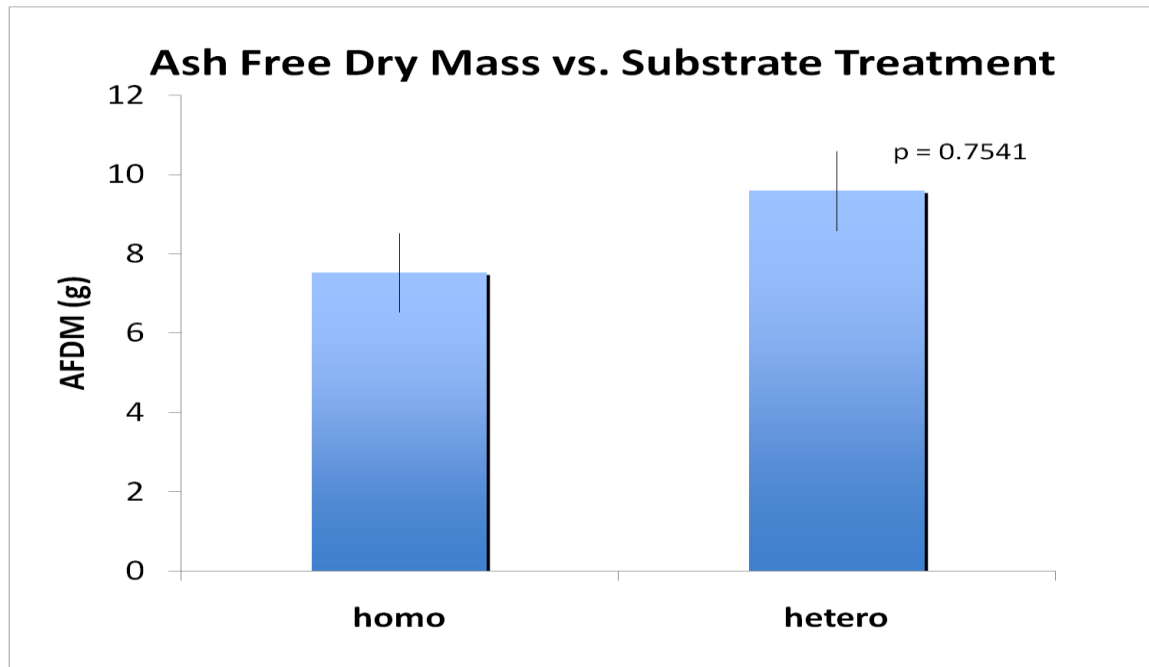


Figure 3: Homo and heterogeneity of substrate and its affect on Ash Free Dry Mass. Data were collected June 12-26 in Copper Creek, Gothic CO.

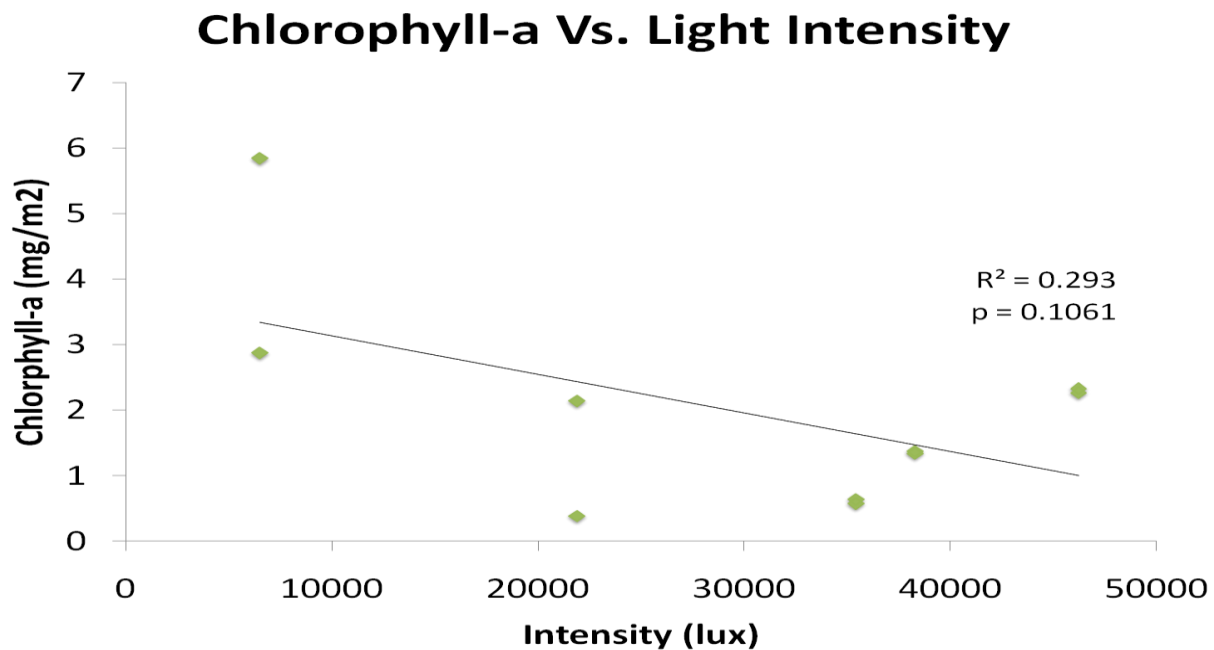


Figure 4: Light intensity and its affect on chlorophyll-a. Data were collected June 12-26 in Copper Creek, Gothic CO.

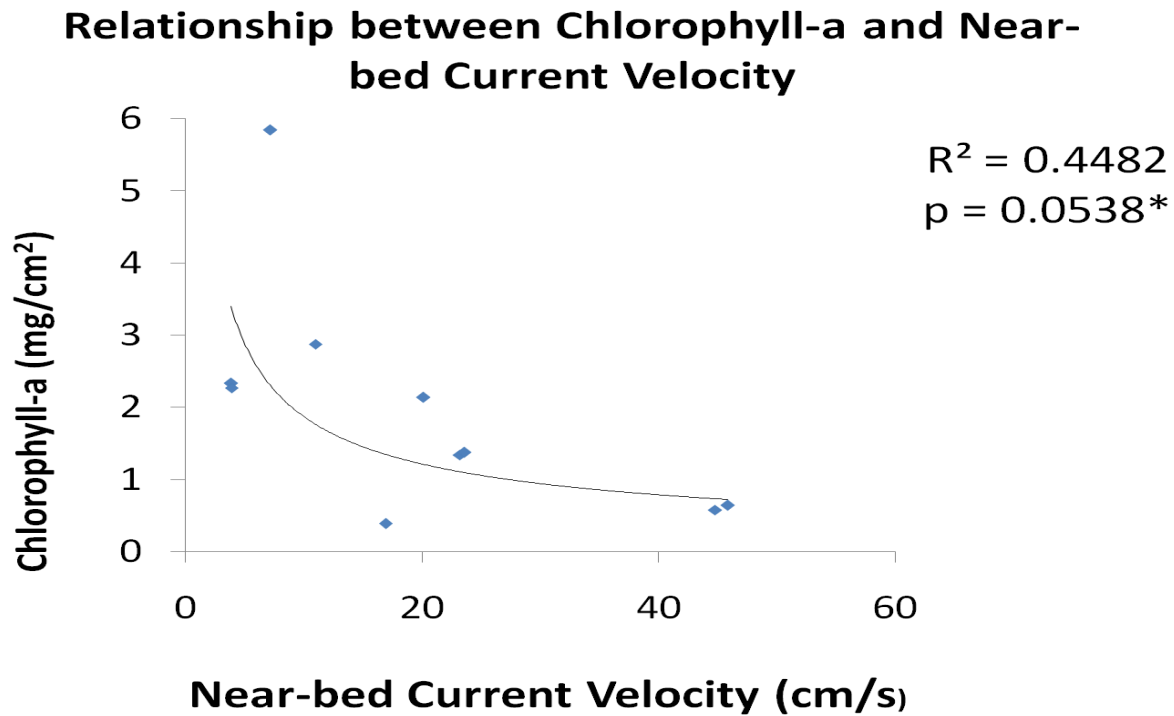


Figure 5: Near-bed Current velocity and its affect on chlorophyll-a. Data were collected June 12-26 in Copper Creek, Gothic CO.