Species identity on organic matter processing rate and shredder colonization behavior

BIOS 35502: Practicum in Field Biology
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ABSTRACT

I conducted decomposition experiments in Brown Creek (BC) and Plum Creek (PC) at the UNDERC property to assess how decomposition rate vary between systems with similar abiotic characteristics and different shredder assemblages. I placed leaf packs in BC and PC for 35 days with removals every 7 days in replicates of four. Leaf packs were sorted and invertebrates were counted, preserved, and identified to the order level. Similar to past studies I found that shredder colonization increased over time in the leaf packs and that shredders colonized for food resources rather than habitat. The decomposition rate between streams followed the pattern predicted by a concordant mesocosm study. Fine particulate size distributions varied between the sites in the pattern predicted by a concordant mesocosm study. These results indicate that species identity play an important role in shaping organic matter dynamics in these two study systems.

INTRODUCTION

Due to increasing losses of biodiversity, relationships between important ecosystem processes and species richness have received greater attention (Swan & Palmer 2004). Ecosystem functions such as primary production, nutrient cycling, and decomposition are important measures of ecosystem fitness and are often utilized by humans as services. Understanding how species assemblages perform these services is essential given the rapid loss that is occurring.

Allochthonous inputs, subsidies from outside a system, of organic matter located in the stream bed drive the food webs of forested headwater streams (Allan 1995). Swan and Palmer (2004) showed that in deciduous forests leaf litter breakdown plays an important role in supporting the detritus based food web. These results by Swan & Palmer support the importance of the relationship between terrestrial-aquatic processes (Wallace et al. 1997).

Functional feeding groups (FFG) are groups of freshwater insects that have been classified together according to the morphology of their mouth parts because these characteristics determine their feeding behavior (Jonsson & Malmqvist 2003). These groups were created to simplify the complex organization of aquatic ecosystems. The problem with the system is that it tends to ignore the specific roles that each species perform (Jonsson & Malmqvist 2003).

The River Continuum Concept (RCC), by Vannote et al. (1980) proposed a model to explain changes that occur in biological ecosystems from small streams to larger rivers or lakes. Stream size is the key factor for analyzing changes in streams. Small streams will receive a higher leaf input because of close distance between the stream and the nearby riparian vegetation. The different quantities of leaf litter inputs determine the organisms that will be present. Because small headwater streams are driven primarily by allochthonous inputs, macroinvertebrates that specialize in leaf breakdown, known as shredders, comprise a large fraction of the whole macroinvertebrate population (Vannote et al. 1980).

Shredders are an arthropod specialized feeding group that process Coarse Particulate Organic Matter (CPOM, > 1mm). (Vannote et al. 1980; Webster & Benfield 1986; Merrit and Cummins 1995). CPOM is converted to Fine Particulate Organic Matter (FPOM, 50 µm-1 mm) by shredders through a feeding and excretion (Webster & Benfield 1986). After this, FPOM is collected and filtered by collecting and filtering insects. (Vannote et al. 1980). Shredders exhibit great taxonomic diversity. This make them susceptible to assemblage modification cause by habitat degradation. Variations on shredder's communities can have effects on organic matter processing and on the quality, size and shape of FPOM (Jonsson & Malmqvist 2003). Recent studies support the idea that species identity (composition) via individual actions and facilitation in addition to richness plays a major role in controlling ecosystem functions. Therefore species loss may result in changes to ecosystem processes despite replacements resulting in neutral net changes in species richness. (Jonsson & Malmqvist 2003). When there are changes in shredder species composition the breakdown rates may decrease, indicating that the species that compose a FFG are not redundant in the role they perform. Contrary to this perspective there is also an idea that members of a FFG compete for similar resources in a stream and by this they can produce role differences that reduces the competition between species. (Jonsson &

Malmqvist 2000). While some questions have been answered there are numerous unknowns including the exact mechanisms involved, how widespread this may be, effects of dominance, and most importantly whether these differences are of biological significance further down the food chain.

In light of this I ask the following questions. 1) Will decomposition rates differ between two streams with different shredder assemblages? 2) Will shredder colonization increase over time? 3) Will standing stocks of FPOM differ in terms of size proportions of particles between two streams with different shredder assemblages? I predict that 1) Organic matter processing will differ between two similar streams with different shredder assemblages. 2) Colonization will increase over time in both streams 3) Relative proportions of particulate size classes will vary between streams with different shredder assemblages

METHODS

Study Sites

My work was conducted in Brown Creek and Plum Creek, two streams located at the University of Notre Dame Environmental Research Center (UNDERC) in Gogebic County, Michigan. Brown Creek is second order stream, with a channel ~5 m wide, has an average depth of 19 cm and a discharge of 0.055 m^3/s. This stream has an average water temperature of 12.7 ºC for the whole summer and a water conductivity of 110.5 us/cm. The average weight for CPOM and FPOM is 34.76 g and 26.63 g respectively. Plum Creek is also a second order stream with a channel ~3 m wide; with an average depth of 15 cm. Water discharge recorded for this stream was 0.005 m^3/s while water temperature was 18.4 ºC. Conductivity for this stream was 65.9 us/cm. A survey conducted in both streams showed that the riparian vegetation around each of the two study sites and concluded that *Alnus incana* (Speckled Alder) was the dominant riparian tree species at both sites (Patrick 2007).

Experimental Design

I conducted two equal field experiments, one at each study site. First I collected 350 grams of *A. incana* (speckled alder) leaves and dried them in a drying oven for two days at 60ºC. These leaves were used for leaf packs. Each packs consisted of 3 grams of *A. incana* leaves in mesh citrus sacks zip tied closed. All leaf packs were tagged with number tags. A total of 60 leaf packs were constructed.

Thirty leaf packs were set up at each site. The bags were staked to the stream bed in a rectangular plot five bags wide and six bags long. I went two days after the initial set up, and picked up the downstream row of leaf bags at each site to measure mass loss due to leakage. The bags were picked up on days 2, 7, 14, 21, 28, and 35 after the initial set up to analyze decomposition rates.

Bag pickup consisted of putting the leaf pack inside a bag submerged in water and letting out the excess of water without losing organic matter. The packs were returned to the laboratory, rinsed using a 1mm sieve to collect colonizing invertebrates and to compare colonization between sites. All the packs with remaining leaf content were placed in tins and placed in the drying oven for two days at 60 ºC. Following the drying process we preceded with ashing each sample in a muffle furnace at 500 ºC for two hours. I reweighed each sample one more time to obtain AFDM (ash free dry mass). I examined all the leaf and blank packs to collect the invertebrates colonizing the packs. They were preserved in 70% ethanol, counted and keyed to order level.

Statistical Analysis

I used SYSTAT 12 and Microsoft Office EXCEL 2003 to analyze my statistical results. All the raw data collected was arrange in Excel spreadsheets in order to be bar graphed or scatter plotted for later interpretation. An ANCOVA and a Two Sample T-Test were conducted to see if decomposition rate differs between Brown Creek and Plum Creek. For the ANCOVA, I used the final organic weight obtain per stream and day. Weight was the dependent variable, day was the covariant and stream treatment the factor. The T-test was made to compare the final organic matter per stream on day 35 (final day). I used the eight different organic matter weights vs. the different treatments. The selected variable for this test was the weight in grams and the grouping variable was the treatments (BC or PC).

Shredder colonization was analyzed with ANCOVAS and T-Tests. First I used several ANCOVAS to analyze the increase in shredder colonization over time. My first ANCOVA compared the total number of invertebrate with day and stream treatment, again the total number of invertebrates was the covariant, the depended variable was the day and the factor was the stream treatment. I did two more identical ANCOVAS with the only difference that the covariant was total number of shredders and amphipods respectively. Also three more T-test was done to compare invertebrates, shredders and amphipods for day 35. For all three T-test the selected variable was the total number of invertebrates, shredders and amphipods respectively and the stream as grouping variable.

For my hypothesis concerning the differences in size proportions of the FPOM standing stock, we performed a T-test in which the selected variable was the biomass from the different samples and both streams as the grouping variables. I created a sub-hypothesis for shredder colonization which states that shredders colonize leaf packs for food. I graphically compared colonized leaf packs versus blank packs to see if shredders colonize for food value rather than habitat.

RESULTS

The scatter plot used in Fig. 1b, showed two trendlines with values near one. This graph appears to show a difference in the weight of OM between (processing of leaf packs) both streams (Figure 1a). But I didn't obtain statistical significance to support this trend because the p-value for this ANCOVA was 0.795, with an f-ratio = 0.071 and a multiple R-value = 0.910. Figure 2 shows organic weight for day 35 in both streams. Again the T-test used to prove these results did not came out significant (p = 0.086 and t = -2.053). The T-test used for the FPOM standing stocks showed no significant differences for the relative proportion of particles with sizes from 1mm - 850 µm, 850 µm – 500 µm and for 125 µm – 63 µm between the two streams. The relative proportion of particles between 500 µm – 125 µm is significantly different. (P-value = 0.008)

The ANCOVA that compared total number of invertebrates per stream and day, was not significant (p-value = 0.321, f-ratio = 1.007). I performed another ANCOVA with the same factor and depended variable but with shredder as covariant that was significant (p-value = 0.006, f-ratio = 8.286). Figure 3 showed that shredder colonization increases over time in both streams as expected.

Figure 4a shows that shredders prefer to colonize leaf packs rather than blank packs. Amphipods were more abundant in BC (mean total number of amphipods = 60; mean total number of amphipods in PC = 20) (Fig 4b).

The T-test for shredder species composition and the OM decomposition rate result with a p-value of 0.00127 (Fig. 5)

DISCUSSION

We can see in Figure 1a that the OM decomposition rate is higher for PC than for BC. These results may seem like a contradiction because shredder species appear to be more abundant in BC than in PC and it is believed that CPOM consumption and removal is dependent on the shredder FFG (Cuffney et al. 1990). The apparent contradictory trend is worth talking about it. However, I believe that the data indicating that PC has a lower number of shredders is unreliable. PC's soil is sandier than BC's and some of leaf packs at PC were completely buried in the soil, which would obstruct colonization. In addition to this, survey work by Patrick (2007) found a higher number of amphipods at PC than BC, and similar numbers of total shredders in contrast to my colonization data. This confounding effect helps explain the wide spread of points on the PC scatter plot of remaining organic matter

Figure 2 shows that opposite the graphed trends, BC had a lower amount of OM remaining than PC for day 35. Once again I believe this occurred because the PC leaf packs were buried in the fine sand sediment. PC should has a faster processing rate, despite this confounding effect is because those packs unaffected lost mass so much faster than the packs in BC.

The survey of particles in BC and PC gave the expected results. Particles that ranged from 500 µm – 63 µm showed proportions that I expected. PC, the site which I believe has more number of amphipods had a higher percent of particles between 500um and 125um and a lower proportion of particles between 125-63um relative to BC. This matches with a mesocosm study using amphipods and isopods (Ortiz 2007). I believe that amphipods are faster at turning CPOM into FPOM, however the particles produced by this rapid transformation tend to be larger than those produced by Isopods the other major shredder at BC. .

Since shredders communities are responsible for FPOM consumption and processing, we expect that as the time interval increases shredder colonization will increase. Figure 3 shows that in both BC and PC shredders increases over time. These findings can be related by the results by Barnes et al. (1986) in which it was found out that the consumption of CPOM is most significantly done by shredders. We can correlated this idea with our significant findings, because as time increases it would be expected that more shredders communities would be aware of the leaf packs present at the stream bed and would colonize them for food resources.

By comparing red alder leaf packs and polyester cloth packs, J.S. Richardson (1992) proved that shredders colonize leaf packs for food value rather than habitat. His study showed that both non-shredders and shredders colonize red alder leaf pack, with almost zero colonization of polyester packs. I used blank leaf packs to establish a relation between the colonization behaviors of shredders communities. Shredders communities would colonize leaf packs rather than blank packs because they are searching for food. My raw data sustain this idea; Figure 4 shows that the total number of shredders colonizing blank packs was less than leaf packs. With this data I can make the assumption that shredders did not colonize the leaf packs for habitat, they did colonize this packs because of the higher food value available in them (Richardson 1992).

Swan & Palmer (2006) find out that species composition (identity) had a significant effect in the amount of leaf breakdown. When certain species of a FFG are absent the leaf breakdown occurred at a slower rate. I found significant data that support this theory for shredders. I used day 35 versus mean total number of shredders for this hypothesis because at day 35 is supposed to be the higher amount of shredder individuals and the highest decomposition rate. Our data supports the idea that in that in the absence of amphipods in PC for day 35 affects the decomposition rate. Amphipod richness was lower for PC (Fig. 4b), which has the effect of lowering the total number of shredders for the same stream at day 35 (Fig 5). Mean weight for OM in PC is higher which means that the decomposition rate was less than BC (Fig.2). I can make a relation between these results since the decrease in amphipod (which is a key species in my shredder group) for PC created a decrease in the total shredder community with a final result of lowering the decomposition rate for this stream.

For future experiments, higher number of leaf packs per site would be necessary. Having more leaf packs replicates will give me a more accurate results for decomposition rate as well as shredder colonization. A highly important recommendation for the future is to add more blank pack replicates per each row. This will let us run an ANCOVA to make statistically comparisons for shredders colonization between leaf packs and blank packs in our streams. A new method to attach the leaf packs to the stream bed has to be done, because some stream's sandy soil burry the leaf packs, which can obstruct shredder colonization. For next experiment we can key each organism to genus level and if possible to species level to see the species composition and which species are playing major roles in decomposition of OM.

Healthy streams perform processes that benefit human, i.e. preserving water quality, moderating flooding, providing habitat for both flora and fauna and by supplying nutrients for all these processes. Also healthy streams lock in pollutants from fertilizer and sediments and maintain the productivity of river, lakes and estuaries. Many organisms have aquatic stages that depend on headwater streams, or rely on the specific type of shelter that is found in these ecosystems.

If we keep destroying our streams we will experience fatal consequences that will endanger our own healthiness. Recharge of water would decreases, creating an ineffective trapping of sediments and pollutants and recycling of nutrients. These results will decrease our water quality and will significantly affect our biodiversity. I propose that headwater systems with similar abiotic variables, similar shredder abundance, but different shredder species identities will have different rates of decomposition, because of the absence of redundancy in their ecological roles. This assessment helps us to know the degree of healthiness in a stream and can give us clues on how to approach and contribute to stream ecosystem conservation.

FIGURES

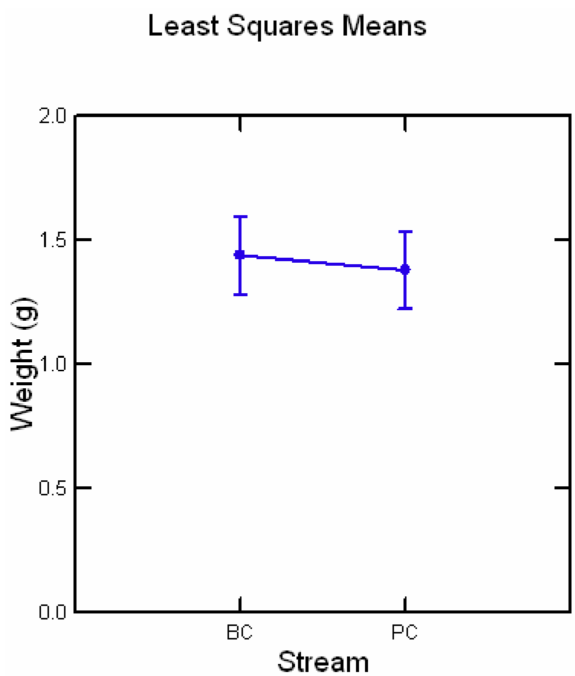

Figure 1a: ANCOVA: showing that decomposition at PC is higher than BC

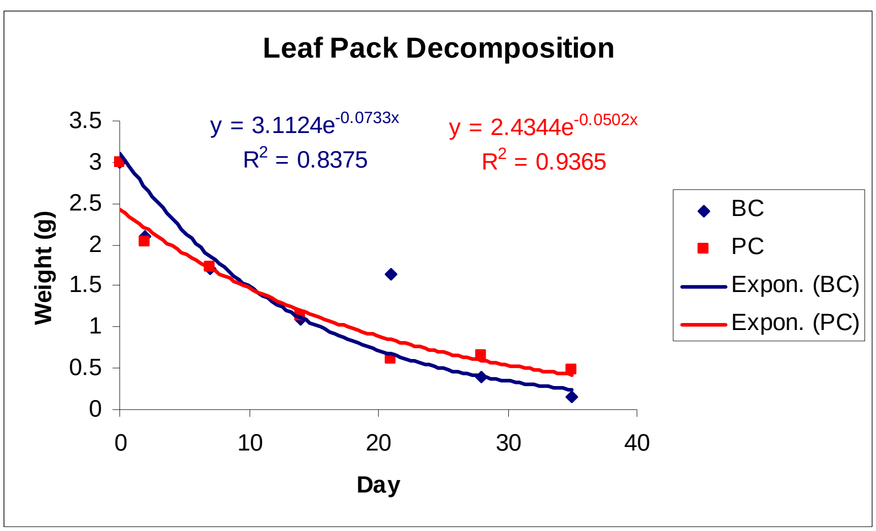

Figure 1b: Scatter plot showing the increasing decomposition rate over time.

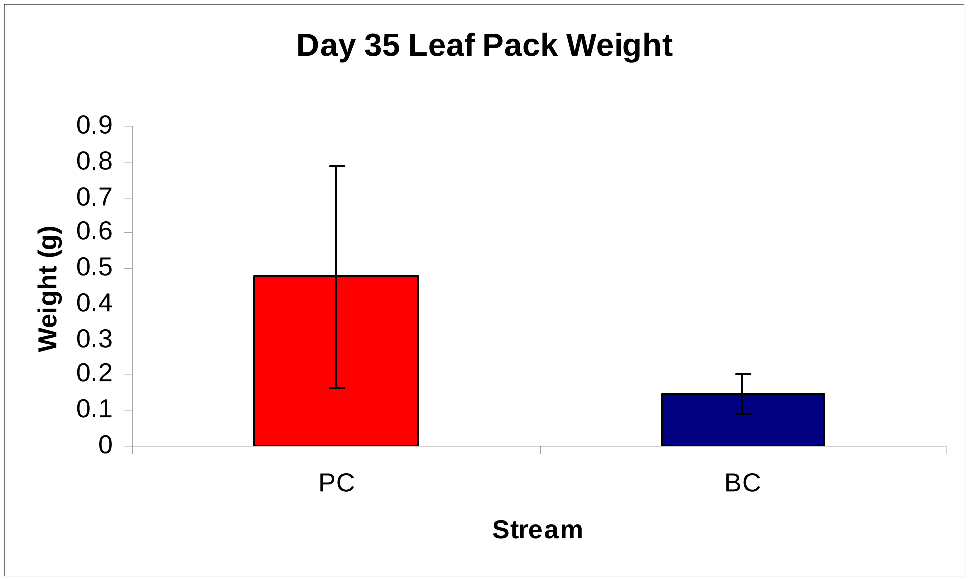

Figure 2: Weight of final OM obtain for both streams for day 35. Less weight means that higher decomposition rate occurred at this site.

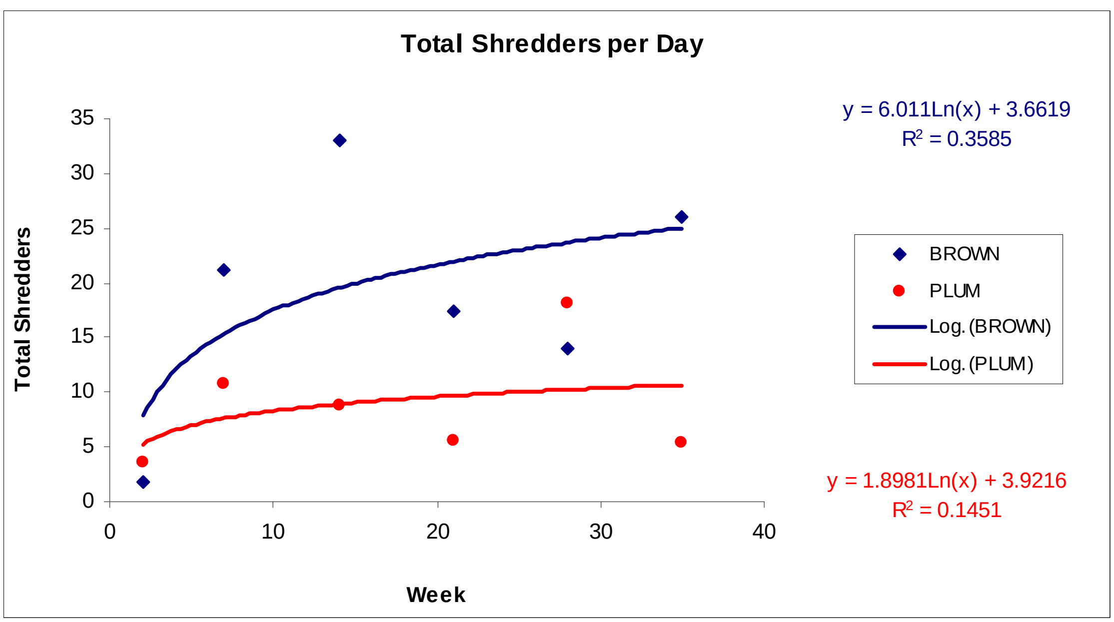

Figure 3: Increase of total number of shredders for both streams due to that CPOM consumption is mainly done by shredders

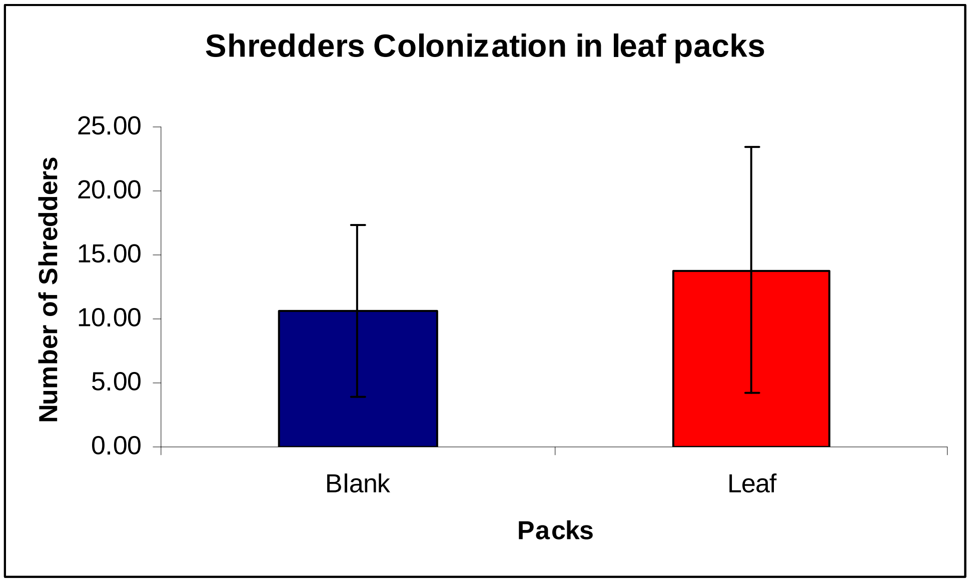

Figure 4a: Shredders prefer to colonize leaf packs rather than blank packs because they colonize pack for food value rather than habitat.

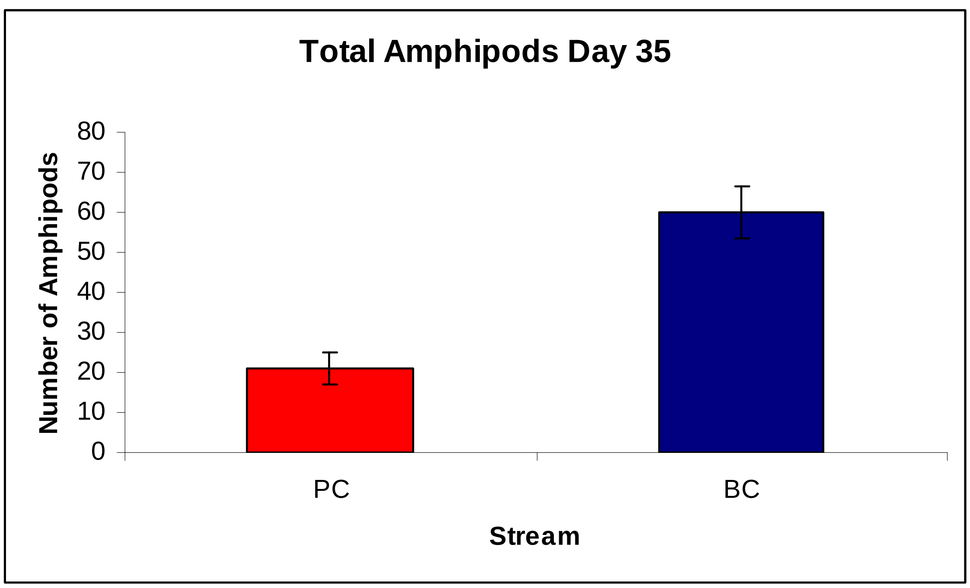

Figure 4b: Number of amphipods was lower for PC than BC for day 35.

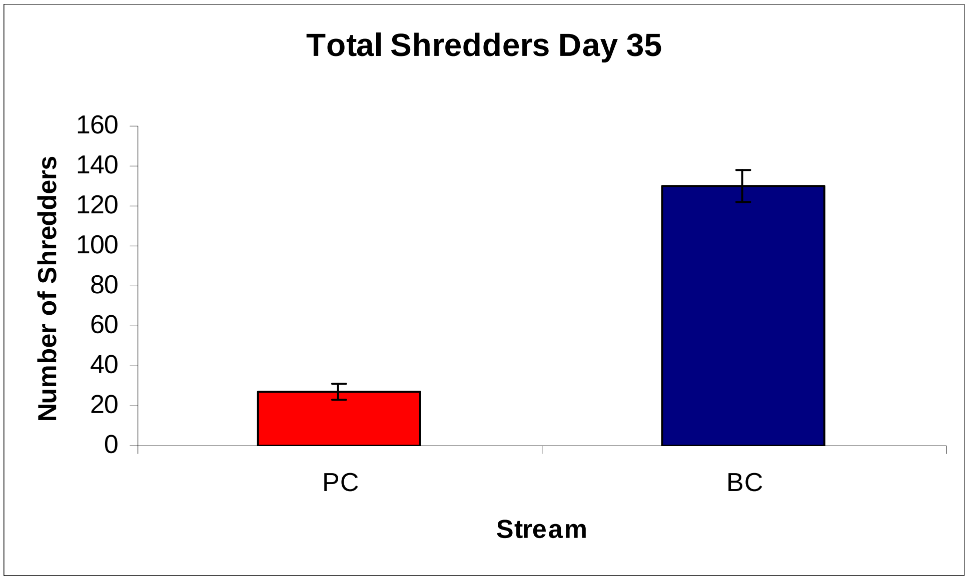

Figure 5: Total mean number of shredders colonizing leaf pack at day 35 for both BC and PC.

ACKNOWLEDGMENTS

I would like to thank my advisor Christopher J. Patrick for his help in the field, laboratory and the statistical analysis; I will also like to thank Vanessa Ortiz for helping me in the field also and in literature analysis. Highly special thanks go to Quiquito Delano Rosado for leading me into be biology major. Funding for this research was provided by Bernard J. Hank Family Endowment.

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