Impacts of Mollusca and Gastropoda shell production and their possible role as ecosystem engineers in Missisquoi Bay

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Abstract

Shell production in aquatic ecosystem has proven to be an important process with many ecological implications especially in benthic communities. Caddisflies and zebra mussels have been shown to facilitate benthic communities because their cases and shells stabilize the substrate, increase habitat heterogeneity, and provide hard substrates in soft sediment habitats. In this study, I looked for relationships between snail shell and mollusk shell accumulation and the abundance and species richness of benthic macroinvertebrates. I hypothesized that a higher number of shells would be associated with increased species richness and total abundance of the benthos. To test these hypotheses we obtained 332 samples from the benthos of Missisquoi Bay in Lake Champlain using a petite ponar sampler. The macroinvertebrates were preserved and later identified. There was a subtle but statistically significant increase in species richness with abundance of empty snail shells. There was an average of 1.5 more species found in samples that included 1 or a few mussel shells as compared with samples lacking shells. I rarified the sums of samples in each of 3 categories: zero mussel shells present; 1 or 2 shells present; 3 or more shells present. Both curves for samples with mussels present fell slightly below but within the 95% confidence interval of the zero shells present curve. This result supports the passive-sampling model of succession: mussel shells intercept more individual colonists and so local abundance increases. Because abundance is higher, there tend to be more species present at sites with mussel shells. This result expands upon previous marine work and draws important connections between freshwater and marine ecology.

Introduction

- Shells of dead mussels and snails provide substrate for attachment, refuge from predation or physical stress, and have important transformations on solute and particle transport in benthic communities (Gutiérrez et al. 2003).
- In areas with limited hard substrate, these shells become an essential resource (McLean 1983). The shells in soft-bottom areas help stabilize the substrate and increase habitat complexity (McCabe and Gotelli 2003).
- The interactions between live and dead organisms are referred to as taphonomic feedback and are believed to be important drivers of ecological successions in benthic communities. The accumulation of dead snail and mussel shells significantly alter the physical composition of the substrate making it easier for other species who depend on harder substrate to colonize the area (Kidwell 1986).
- Even though it is less observed, shell accumulation may also have an inhibitory effect on benthic fauna. This is due to movement restriction caused by the lack of space (Kidwell 1986).
- The purpose of this study was to determine relationships between shell accumulation and species distribution, richness, and specific species abundance. I hypothesized that with a higher number of both snail and mussel shells there would be higher species richness, a higher abundance of native mussel shells, and a higher abundance of species that depend on hard substrate for habitat (e.g., clingers).

Methods

Field Methods

- A sampling grid was created with 370 sample sites in Missisquoi Bay with a distance of 500m between sites (SedTtrend 2013).
- We collected 332 samples from the bottom of the bay using a petite ponar sampler.
- We deposited the samples in a 0.5mm sieve and rinsed them to remove sediment. We then placed the samples inside whirl packs with 100% EtOH.

Lab Methods

- In the lab we processed the samples using a 0.6mm sieve in which we rinsed the samples and picked all the macroinvertebrates found. The samples were labeled and put in glass vials with 70% EtOH and 1% glycerin.
- We identified macroinvertebrates to the lowest possible taxonomic level with keys published by Bouchard (2004), Thorp & Covich (2010), Merritt, Cummins, & Berg, (2008), & Wiggins (1996).

Data Analysis

- I used ANOVA and linear regression to determine the effects of the presence and absence of mussel shells and snail shells on average species richness and abundance. I also used an ANOVA to compare average species richness between samples with a presence of 1 to 2 mussel shells and samples with a presence of 3 or more mussel shells. Linear regression was used to determine a relationship between live snails and empty snail shells.
- I also used a rarefaction to compare expected species richness in samples with no mussels, 1 to 2 mussels, and 3 or more mussels. Rarefaction was also used to compare expected species richness in samples with no snail shells, samples with 1 to 25 snail shells, and samples with more than 25 snail shells (ECOSIM software).

Results

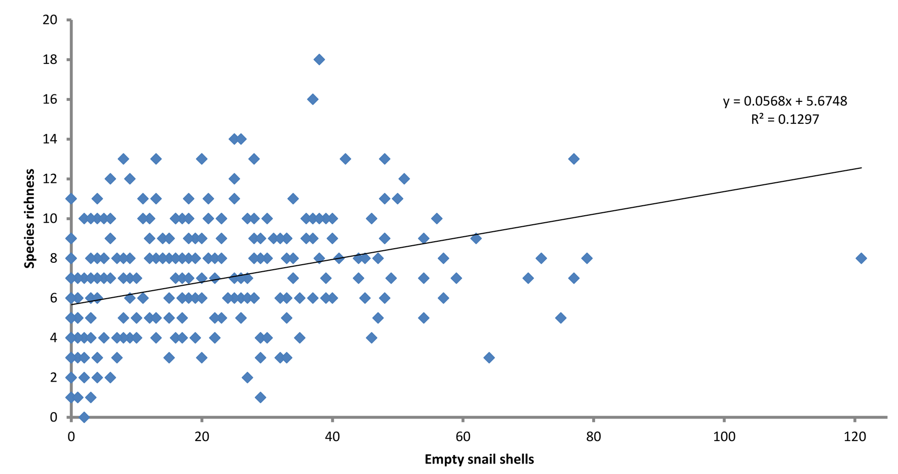

Figure 1. Relationship between empty snail shells and species richness in 332 samples in Missisquoi Bay. There is a significant positive relationship between empty snail shells and species richness (Linear regression; p<0.001).

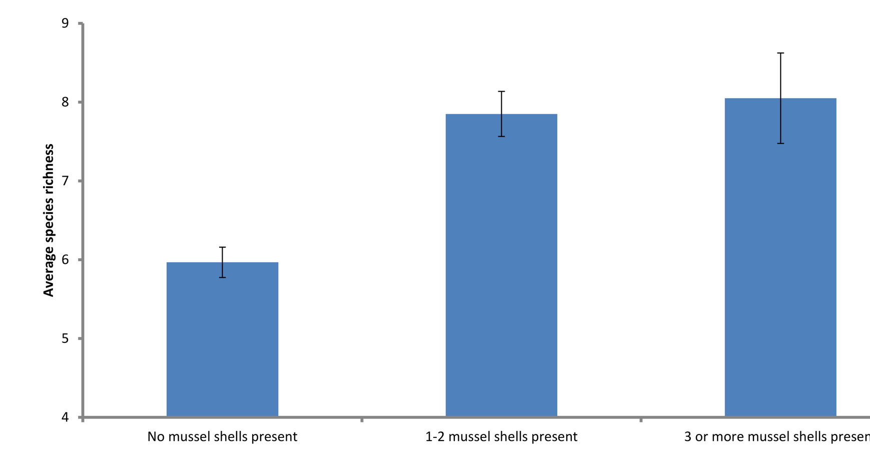

Figure 2. Effects of mussel shell absence and presence on average species richness in 332 samples in Missisquoi Bay (ANOVA; p<0.001).

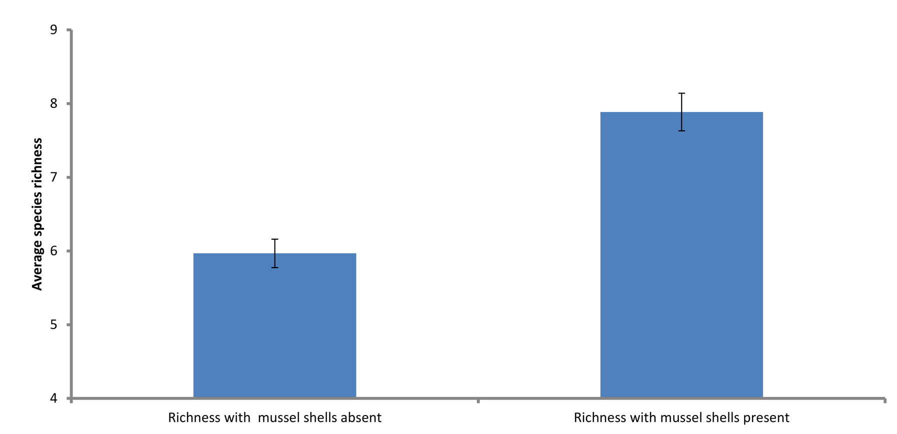

Figure 3. Effects of mussel shell absence and mussel shell presence on average species richness in 332 samples in Missisquoi Bay (ANOVA; p<0.001).

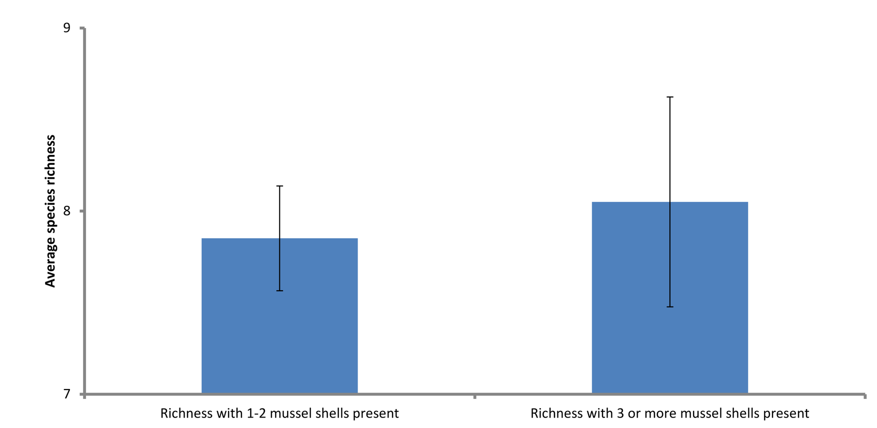

Figure 4. Differences in average species richness between samples with 1 to 2 mussel shells and samples with 3 or more mussel shells in Missisquoi Bay (ANOVA; p>0.05).

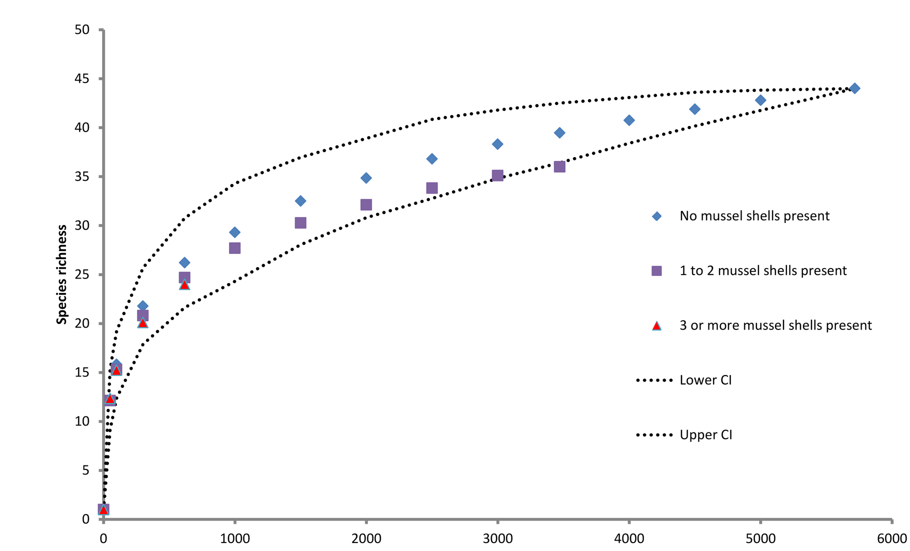

Figure 5. Rarefaction curves for expected species richness in samples with no mussel shells present, samples with 1 to 2 mussel shells, and samples with 3 or more mussel shells. There is no significant difference between the samples.

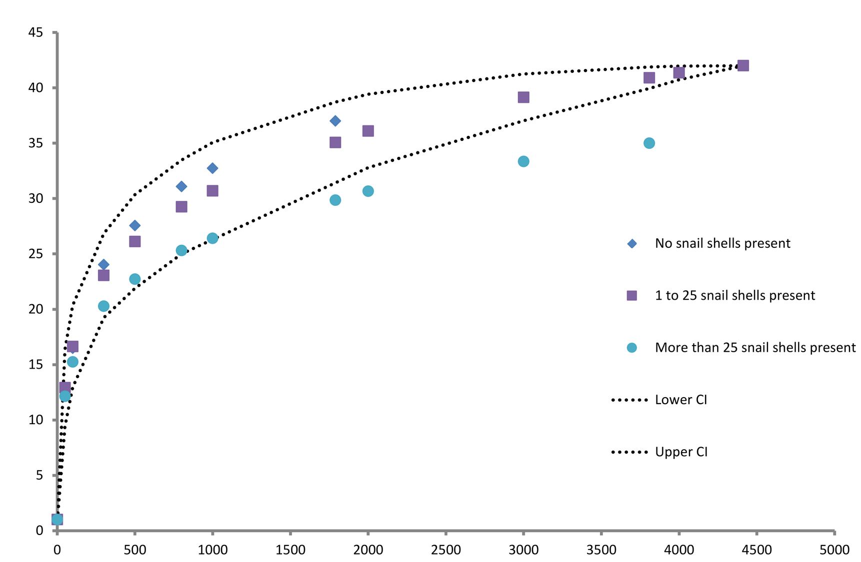

Figure 6. Rarefaction curves for expected species richness in samples with no snail shells present, samples with 1 to 25 snail shells and samples with more than 25 snail shells. There is no significant difference between samples with no snail shells and samples with 1 to 25 snail shells but a significant difference is observed between these two categories and samples with more than 25 snail shells.

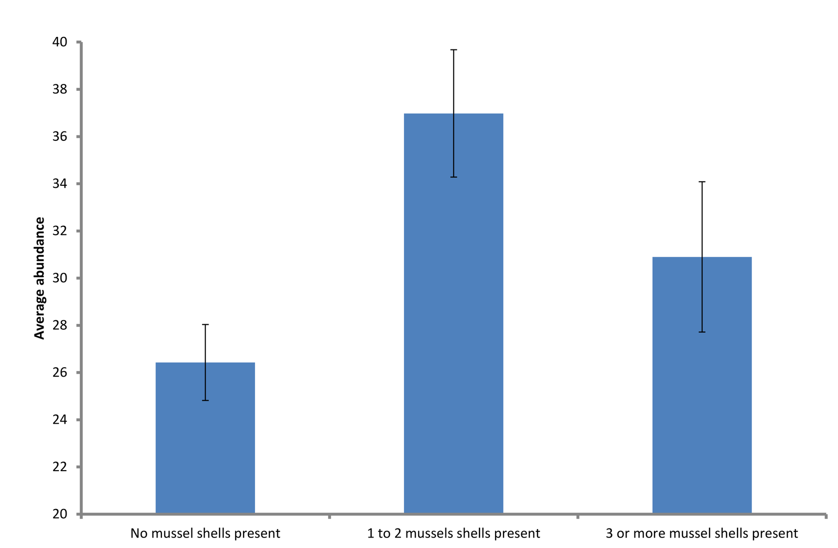

Figure 7. Differences in average abundance in samples with no mussel shells present, samples with 1 to 2 mussels shell, and samples with 3 or more mussel shells. There is a significant difference (ANOVA; p<0.01).

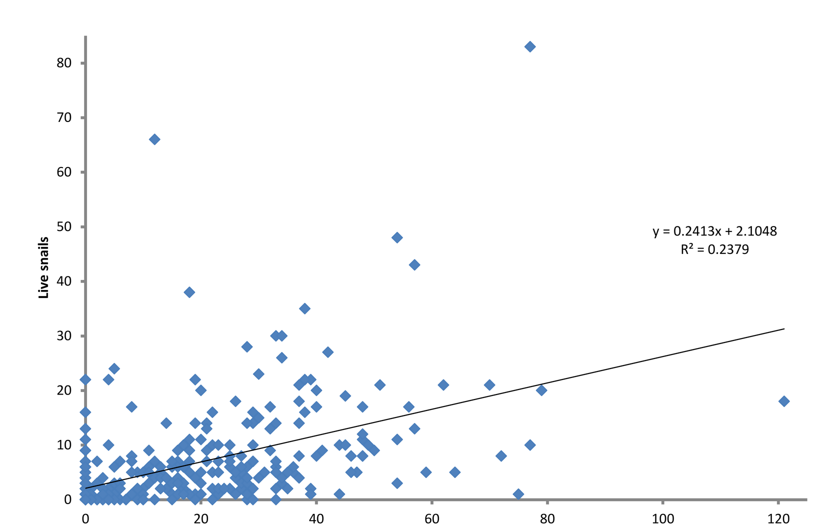

Figure 8. Illustrates the relationship between empty snail shells and the abundance of live snails in 332 samples in Missisquoi Bay (Linear regression; p<0.001).

Discussion

Our analysis using student t-tests demonstrated that with a higher number of gastropod shells there was a higher number of species richness (Figure 1). As presented by McLean (1983), the gastropod shells provide shelter and attachment substratum for a wide variety of species which gives way for a higher species richness. The effects of mussel shells on average species richness also proved to be significantly positive (Figure 2). There was no significant difference between species richness average in samples with 1 to 2 samples and samples with 3 or more mussels (Figure 4). These results demonstrated that different levels in mussel shell presence have no significant impact on species richness. Contrary to what was expected, accumulation is not a significant factor in habitat composition and its impact on macroinvertebrate communities. Our results show that species richness is simply dependent on mussel shell absence or presence and not on quantity of mussel shells in the habitat (Figure 3). Only the presence of hard substrata is needed to improve habitat complexity, facilitate species colonization, and significantly increase species richness (Kidwell 1986).

Rarefaction analysis for expected species richness in samples with absence and presence of mussel shells (Figure 5) supported the passive sampling model of community succession. A different analysis approach shows us that with a higher abundance, samples with mussel shells present would have approximately the same species richness as samples with no mussel shells. Rarefaction curves for expected species richness in samples with no snails shells, samples with 1 to 25 snail shells, and samples with more than 25 snail shells showed a significant difference only between the first two categories and samples with more than 25 snail shells with the latter having less species richness. These results clearly demonstrate an inhibitory effect of snail shell accumulation and how it could be restricting habitat occupation after a certain point (Kidwell 1986). This rarefaction analysis also shows us the importance of employing different statistical analyses in community ecology with the purpose of getting different perspectives. Impacts of mussel shells on average abundance are demonstrated in Figure 7 and show that samples with a presence of 1 to 2 mussel shells have approximately 10 more individuals than samples with no mussel shells. This is expected because of higher habitat heterogeneity.

Future studies could integrate macroinvertebrate data from streams and try to determine which ecosystem is more depend on shell production. This study is valuable in determining mollusks and gastropods as ecosystem engineers in these aquatic ecosystems.

Works Cited

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