Intraspecific competition between two invasive snail species (*V. piscinalis* Vs. *B. tentaculata*) in Missisquoi Bay of Lake Champlain, Vermont and Quebec

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Abstract

•Both the European valve snail (*Valvata piscinalis*) and the Faucet snail (*Bithynia tentaculata*) are exotic species in Missisquoi Bay of Lake Champlain. They are known for their high tolerance to adverse environmental conditions and fairly long lifespan. They are efficient feeders and can survive in a variety of habitats. Both gastropods have the potential to be highly competitive with other species for food and space because of their rapid growth rate and high fecundity. I hypothesize that *Valvata* and *Bithynia* snails will have reciprocal negative effects on each other's abundance and will also reduce abundances of other snail species as the combined abundance of *Valvata* and *Bithynia* increases. To test my hypothesis over 332 petite Ponar macro invertebrate samples were collected in Missisquoi Bay and sorted and identified in the lab. I used a null-model to investigate if snails tended to co-occur less frequently than would be expected if snails were randomly distributed. The *C*-score value for the data matrix indicates that snails co-occurred less frequently than would be expected based on a random distribution. This pattern is consistent with competitive exclusion as well as other mechanisms. Contrary to our hypothesis, there was a positive correlation between the abundances of *Valvata* and *Bithynia*. Furthermore, higher total abundance of macroinvertebrates occurred in samples with high exotic gastropod abundances. This combination of results suggests that either exotic snails may facilitate invertebrate colonization or that snails and other invertebrates preferentially colonize the same habitats. High *C*-score values are less likely to be attributed to competitive exclusion by exotic snails but may indicate competition or differential habitat preferences in native snails.

Background

•*Bithynia tentaculata* was found in Lake Champlain in 1879 where it competes with native Pleuroceridae and dominates snail fauna (Fiske and Levey 1996, as cited by, Marsden et al. 2009). Few years later the European valve snail was found in Lake Champlain 40 years after it was introduced to Lake Ontario in 1897 (Kipp et al., 2013).
•Harman (1968) states that the faucet snail dominates competition between native snails and benthic faunas where it's found (Harman, 1968).
•Grigorovich et al. (2005) discusses how the European valve snail may adversely affect other gastropods communities by competing for food and space. Also describing how the snail's different characteristic may enable invasion success.
• *B. tentaculata*'s invasion, on the Oneida Lake, reduced pleucerid snail population (Harman 2000 as cited by Grigorovich 2005). Another non-indigenous snail, *V. piscinalis*, reduced the abundance of native hydrobiid snails in the same lake due to competition (I.A. Grigorovich, unpubl. data).
•*Valvata piscinalis (V. piscinalis)* is capable of suspension-feeding similar to the *B. tentaculata* making it an effective competitor in eutrophic waters (Tsikhon-Lukanina 1961a, 1961b as cited by Grigorovich 2005). In eutrophic conditions filter feeding increases competitive ability. (Schaefer 1953 cited by H. Brendelberger).

Methods

- We collected 332 samples in Missisquoi Bay, Lake Champlain, Vermont.
- We sampled with a 15.5x15.5 ponar on a 500m sampling grid. We rinsed all samples in a 0.5 mm sieve bucket. We preserved all samples with 100% alcohol.
- Once in the lab we picked bugs under 2X magnification and sieved on 0.6 mm sieves. Sample were preserved in glass vials with 70% alcohol and 1% glycerin.
- We used keys to identify to lowest taxonomic level (Wiggins 1996, Thorp & Covich 2010, Bouchard 2004).

Results

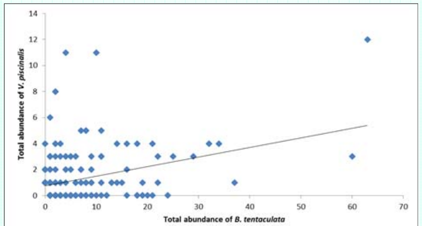

Fig. 1. Relationship between *V. piscinalis* and *B. tentaculata* populations in Missisquoi Bay. Samples with no snails where removed from the graph to show better relationship between snils. Points where y>6 and x<30 snails are in competition, and points where y<6 and x<30 snails are coexisting.

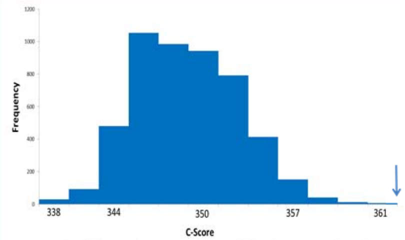

Fig. 2. Null model of native ad exotic gastropods in assemble distributions. Arrows observed C-score values of 372, whch has low co-ocurrence between gastropods. This analysis is based upon 7 gastropod species.

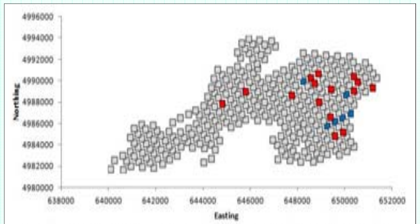

Fig. 3. High density locations versus low density locations in Missisquoi Bay of Lake Champlain. Easting and northing data, and population densities were collected and sorted. Low densities are gray. High densities of *Bythinia* are red and high densities of *Valvata* are blue.

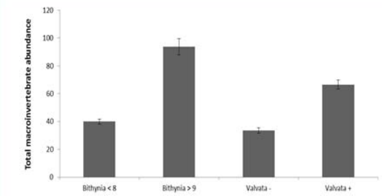

Fig. 4. Relationship between total macroinvertebrate abundance with presence of *V. piscinalis* and *Bithynia* snails in Missisquoi Bay. Each category is analyzed differently. *Valvata* is analyzed by dividing samples with snails present and no snail present; Bithynia is analyzed by dividing samples with less than 8 snails per sample and greater than 9 snails per sample. (n=332). Error Bars are standard error.

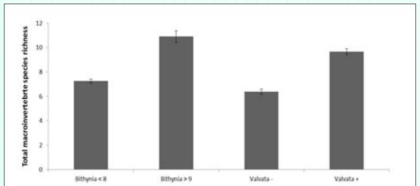

Fig. 5. Relationship between total richness and V. piscinalis or B. tentaculata present in Missisquoi Bay. Species richness is analyzed with presence or no presence of V. piscinalis and Bithynia's breaking point of 9, less than 8 Bithynias per sample and greater than 9 Bithynias per sample. (n=332). Error bars are standard error.

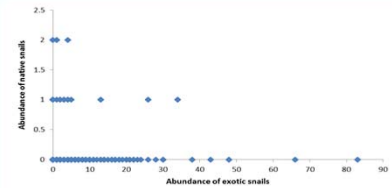

Fig. 6. Relationship between the abundance of Native and Exotic snails in Missisquoi Bay. When exotic snails reach closer to 0 the abundance of native snails increases and when the abundance of exotics snails reach higher numbers native snail abudance decreases.

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Discussion

•A significant positive relationships exists between the abundances of *V. piscinalis* and *B. tentaculata* (Fig. 1), but this pattern was strongly shaped by one influential outlier. More commonly, the two snails co-exist at low population densities. With the exception of the outlier, the 4 highest densities of *V. piscinalis* occurred in samples with low *B. tentaculata* density. Competition between the snails would be a reasonable expectation based on an ecological principle that two species cannot co-exist at equilibrium, because they share similar resources and physiology (Hutchingson's 1959, cited in Strearns 2009).

•As the population densities of these two snails increase, the probability of exploitation competition for food and space increases. With a *p*-value less than 0.05 shows there's a very significant relationship between numbers of *B. tentaculata* present and number of V. piscinalis present in each sample. With an R square value of 0.16586, *Bithynia tentaculata* can explain 16% of the variability of *Valvata* observed. The other 84% can be explained by other external factors such as vegetation present, temperatures, water quality, etc.

•Presence of both *Bithynia* greater than 9 and *Valvata* greater than 0 increases total abundance and species richness of macroinvertebrates (Fig.4). This could occur because the snails create a more variable ecosystem and facilitate colonization, or snails and other macroinvertebrates are attracted to similar habitats. A similar graph was made for the relationship between *V. tricarinata* and macroinvertebrates. Results show same positive relationship with species richness and abundance.

•Data analysis shows a negative relationship between exotic and native snails (Fig. 6). This may explain why exotic snail abundance is much greater than native snail abundance. The invasion of exotic snails may have decreased native snail abundance due to competition and indeed this contention is supported by the null model analysis of co-occurrence between native and exotic species (Fig. 2).

•The *Bithynia* and *Valvata* snails are two species that are coexisting. For two competing species with limited resources to coexist they must vary within their ecological niche (Gause 1934, as cited by Hanski 1983). In circumstances of resource limitation, exotic organism lacking access to their natural food sources, maybe compelled to expand their diets leading to intraspecific competition. Interspecific competition can lead to niche diversification and directional selection (Svanbäck et al., 2006).

•In conclusion, both *Bithynia* and *Valvata* snails live in coexistence not proving my hypothesis. They increase macroinvertebrate richness and abundance in areas where they're present. In contrast exotic snails have a negative effect on native snails' population. With no further investigation on their behavior or interspecific competition analysis, I can only predict exploitation competition between *B. tentaculata* and other gastropods, due to its high abundance and competing abilities in Missisquoi Bay.

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