

# Effects of Organism Density on Nutrient Uptake by *Dreissena polymorpha*

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## Abstract

Zebra mussels (*Dreissena polymorpha*) have severely impacted the natural ecosystems of the great lakes regions since their introduction in the 1980's. New management methods like Zequanox depend on the rate of nutrient uptake, to determine their efficacy. Our experiment aimed to show how different densities of zebra mussels can change nutrient uptake. We found that concentrations of nitrate, nitrite, calcium, and NH<sub>4</sub>-N changed significantly in the presence of zebra mussels in lab conditions. Previous studies on similar subjects have found results contradictory to ours, as well as changes that we should have found, but did not. Changes need to be made to the design of this experiment to get more significant data.

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Zebra mussels (*Dreissena polymorpha*) have severely impacted the natural ecosystems of the great lakes regions since their introduction in the 1980's. New management methods like Zequanox depend on the rate of nutrient uptake, to determine their efficacy. Our experiment aimed to show how different densities of zebra mussels can change nutrient uptake. We found that concentrations of nitrate, nitrite, calcium, and NH<sub>4</sub>-N changed significantly in the presence of zebra mussels in lab conditions. Previous studies on similar subjects have found results contradictory to ours, as well as changes that we should have found, but did not. Changes need to be made to the design of this experiment to get more significant data.

## Introduction

In the mid to late 1980s zebra mussels (*Dreissena polymorpha*) were introduced to the great lakes region in the ballast water of commercial ships from Europe (Roberts, 1990). Since then, populations of these mussels have spread to inland lakes, and have begun to outcompete native species for resources. Both species are filter feeders that feed on phytoplankton and zoo plankton. Both organisms are important in the diets of many native species (Horgan & Mills, 1997). Removing zebra mussels from communities will help to improve populations of native species. These mussels also have a large impact on infrastructure as colonies block pipes and cover pillars, costing thousands of dollars in damage (Roberts, 1990). Because of the impacts that these invasive mussels have on their environment, much study has gone into managing them.

Most of the methods used to manage established mussel populations have been unsuccessful and harmful to native species. Studies have been aimed at finding a product that will take aim only at the invasive mussel species. Marrone Bio Innovations has recently released

Zequanox, a biopesticide that could target the invasive species. The product uses a soil bacteria that targets and kills the mussels as they ingest it.

Our experiment studies the effect that density of zebra mussels has on the rate of nutrient uptake. An increase in the rate of uptake would likely mean an increase in the efficacy of a product like Zequanox as it is taken up. This could lead to a better idea of the amount of pesticides like Zequanox to use in different aquatic systems.

We hypothesized that varying densities of zebra mussels would be negatively correlated with nutrient concentration. Some studies have been done to predict how zebra mussels will colonize an area in terms of density (Rancharan et al., 1992). Another study looked at how the presence of zebra mussels impacts nutrient levels (Johengen et al., 1995) Using these studies as well as our own, one could potentially predict how much of a pesticide like zequanox would be needed in different areas.

## Methods

We filled five 10-gallon tanks with five gallons of water each. One control tank contained no zebra mussels. Four experimental tanks were used with varying amounts of zebra mussels roughly 200, 400, 600, and 800. 50mL samples were taken through a new filter every hour for eight hours. Each tank had its own air stone to supply oxygen. Filters were stored in a freezer for later chlorophyll testing, and liquid samples were stored in a refrigerator for later chemical analysis.

Chemical analysis for cations and anions was run using a ThermoFisher/Dionex Integriion HPIC. Silicates were analyzed using the molybdenum blue method on an Alpkem FS30000 rapid flow analyzer. Chlorophyll a was analyzed using a TD-3100 laboratory fluorometer by Turner designs

Linear regressions were performed using R and R commander version 3.2.3. Multiple comparisons Tukey ANOVAs were performed using SPSS.

## Results

Out of the 17 nutrients tested, only four showed statistical significance in any of our tests; NH<sub>4</sub>-N, calcium, nitrate, and nitrite. For calcium ( $R^2=0.452$ , negatively correlated), nitrate ( $R^2=0.486$ , negatively correlated), and NH<sub>4</sub>-N ( $R^2=0.343$ , positively correlated) there was a significant difference between concentrations of ions at different zebra mussel densities (Figure 1, graph 1, 2, 3). For NH<sub>4</sub>-N there was a significant difference over time for nutrient concentrations ( $R^2=0.39$ , positively correlated) (figure 1, graph 4). Multiple comparisons Tukey ANOVAs found many significant differences between concentration. There was a significant difference between the 800 density tank and all other tanks in nitrite concentration ( $p<0.001$  for all cases). There was a significant difference in calcium concentrations between our control tank and all other tanks ( $p<0.001$  in all cases). There was a significant difference between the control tank and all other tanks in nitrate concentration ( $p<0.001$  in all cases). For NH<sub>4</sub>-N concentrations there were only significant differences between the control and the 800 count tank ( $p<0.001$ ) as well as between the control and 600 count tank.

## Discussion

With the exception of ammonium, time in the tank did not influence the concentration in the water. This would indicate that the zebra mussels filtered the water either very slowly or not at all. What did vary was nutrient concentrations in different zebra mussel densities. Our results showed that mussels in higher densities can lead to a proliferation in NH<sub>4</sub>-N concentration, and a decrease in nitrate and calcium concentrations. We couldn't determine whether mussel density had a positive or negative correlation with nitrite levels.

Calcium is an important part in creating the zebra mussel's shell (Hincks & Mackie, 1997). Calcium is an important part in the diet of many animals coexisting with zebra mussels, clams and crayfish for example. High concentrations of zebra mussels could lead to a loss in

calcium concentrations, and in turn a decline in the populations of native mussels, clams, and crayfish. Many indigenous fish populations use these organisms as a food source, and could also be negatively impacted.

Nitrate is used by aquatic plants as a main source of nitrogen. In our study we found that the nitrate concentrations decreased as mussel density increased. If this is the case many aquatic species could be choked out of the area that zebra mussels inhabit. This is contradictory to other experiments where nitrate concentrations actually increased in the presence of zebra mussels, or did not vary at all (Johengen et al. 1995).

Ammonium is a chemical that can lead to eutrophication and acidification of a lake in large amounts. Those processes could lead to a negative impact on native fish. We found that the presence of zebra mussels increased the presence of ammonium. This could indicate that zebra mussels contribute to dead zones. Previous studies found no clear effect on the presence of zebra mussels, and the concentration of ammonium (Johengen et al. 1995).

In the study done by Johengen et al. in 1995 there were a large amount of nutrients that changed in concentration that we did not see in our experiment; chlorophyll, phosphates, silicates, and many more. There are several explanations for the disparity between the two experiments. First, our experiment was carried out over the course of 8 hours, rather than over the course of several years. It is possible that our experiment did not take place in a long enough time, to find significant differences in nutrients. Second, our experiment was done in laboratory settings, rather than in a lake setting. Zebra mussels may have a negative response to a change in their environment and thus, change the way they feed (Reeders et al. 1989).

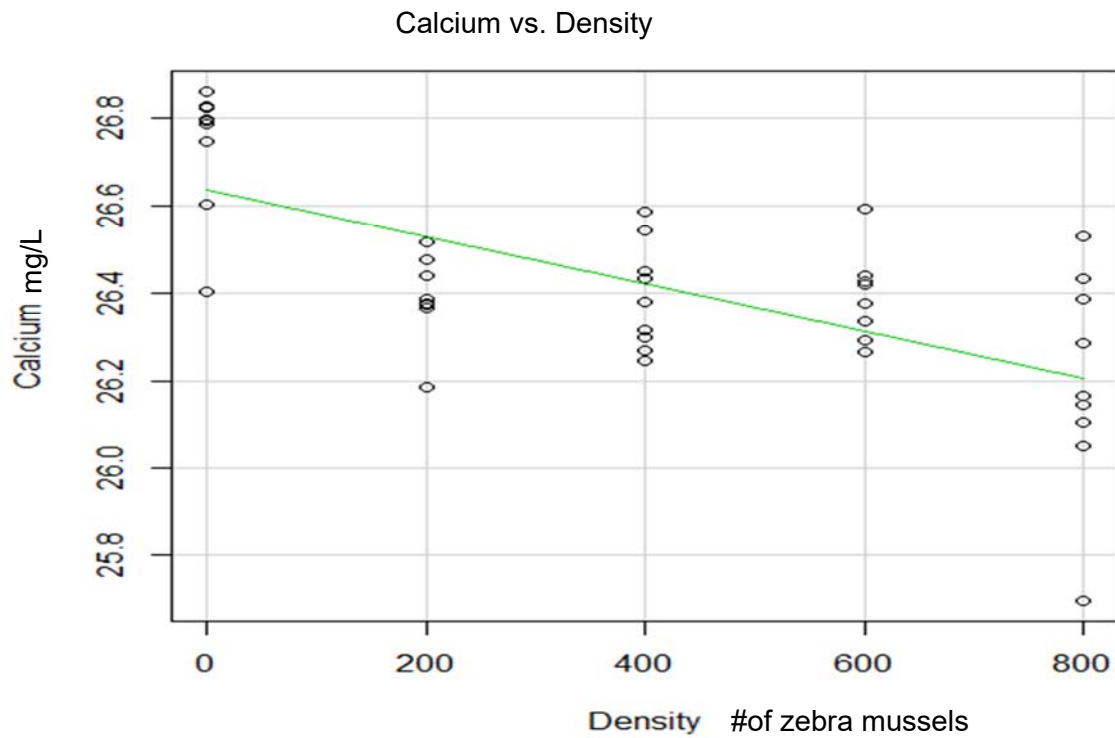
The next time this experiment is performed it would be advisable to hold the experiment over a period of years, rather than a period of hours. Moving zebra mussels out of their habitat is also not advisable, due to their change in behavior after moving them; thus, holding the experiment in their environment would be preferential.

Figures

Figure 1

Nutrient	Significant for Time, R <sup>2</sup>	Significant for density, R <sup>2</sup>
NH4N	Yes, 0.39	Yes, 0.343
Calcium	No, 0.018	Yes, 0.452
Nitrate	No, 0.01	Yes, 0.486
Nitrite	No, 0.017	No, 0.046

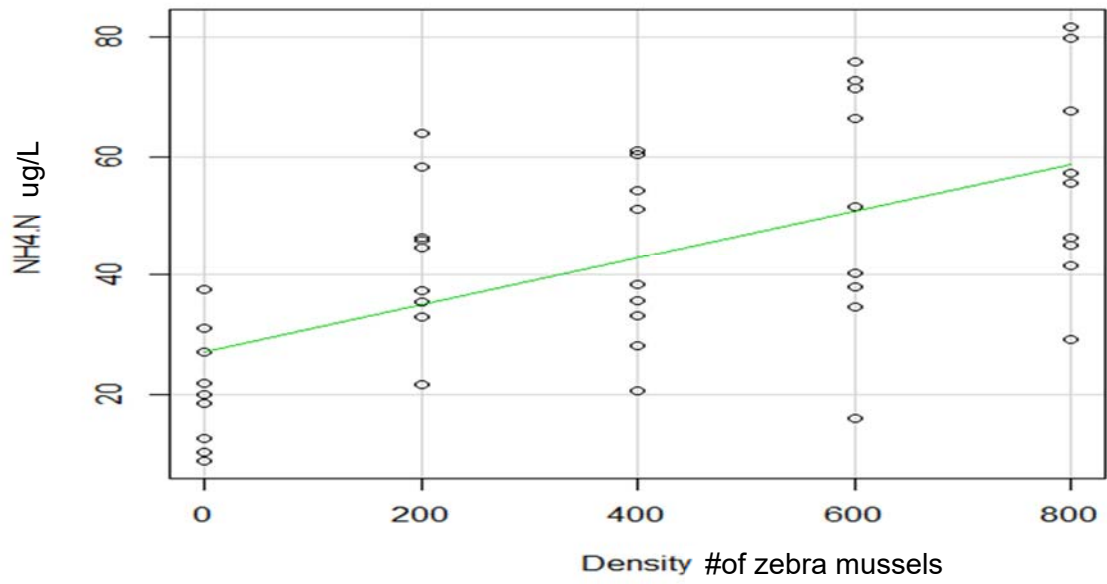
Graph 1



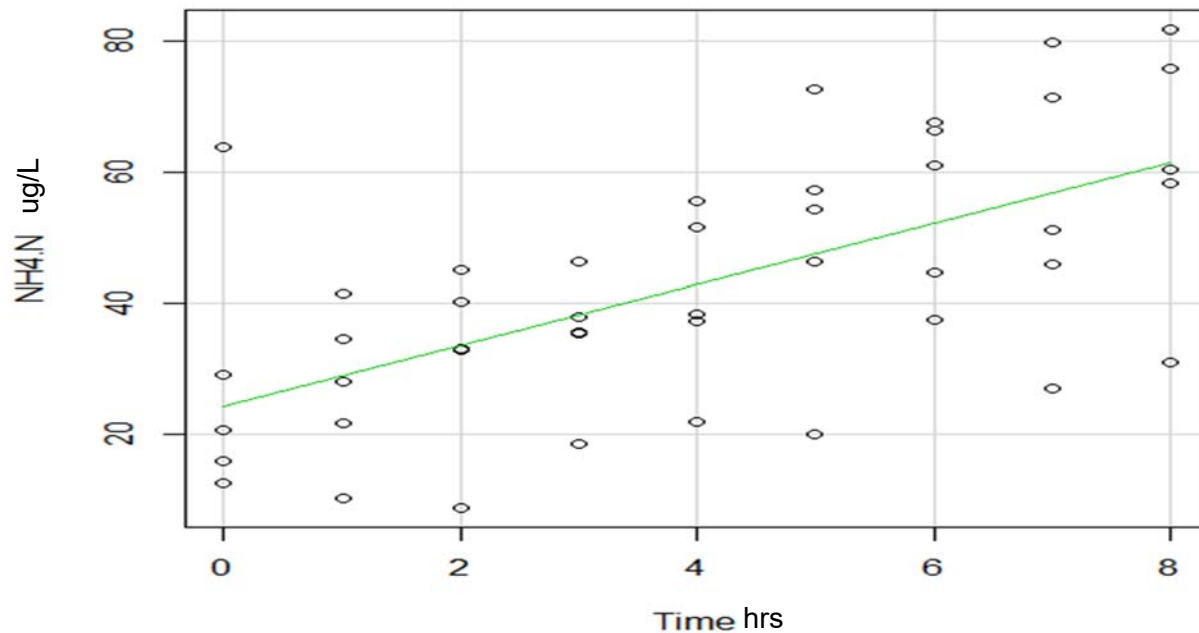
Graph 2



Graph 3



Graph 4



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