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Zooplankton (*Daphnia magna)* as an Energy Efficient Fish Food in Aquaponic Food Production

Aquaponics is a food production system which mimics a naturally occurring cyclical process that uses fish waste to nourish plants (Goddek et al. 2015). Though it is currently promoted as a sustainable alternative to conventional food production, there are still substantial energy inputs (Goddek et al. 2015) and difficulties maintaining ideal water nutrient ratios for plants. In this research I investigate the addition of *Daphnia magna,* a genus of small planktonic crustaceans naturally found in freshwater ecosystems, as a way to reduce one of the least sustainable energy inputs, manufactured fish food (Zeigler n.d.), as well as to correct imbalanced water nutrient ratios delivered to plants. Since *Daphnia magna* are easy to breed in a lab (Miner et al. 2012) and contain adequate nutrition for fish (Clare 2002), they are a good source of nourishment in an aquaponic system. Moreover, published nutrient studies state that *Daphnia magna* are frequently rich in phosphorus (DeMott et al. 1998), a limiting nutrient in aquaponic systems. These studies suggest that the waste of fish that consume *Daphnia magna* may provide superior nutrient profiles to plants by balancing the ratio of nitrogen to phosphorus in the water.

To study the utility of *Daphnia magna* as a fish food, I replaced the current manufactured food in the Ithaca College Aquaponic system with the volume, protein, and/or lipids equivalent of *Daphnia magna* (Cheban et al. 2017). I hypothesized that the nutrition profile of *Daphnia magna* will influence the waste of the fish that consume them and, in turn, affect the water chemistry in the tank to result in the desired 2:1 nitrogen to phosphorus molar ratio. Three experimental trials were run for two to four weeks each and consisted of one control group, fed the manufactured food, and one experimental group, fed *Daphnia magna*. Both set-ups contained one blue tilapia (*Oreochromis aureus*) in a 30-gallon fish tank that pumped water to a grow bed filled with hydroton, a porous grow medium to host bacteria. The *Daphnia magna* were bred in Aachener Daphnien Medium (ADaM) and fed green algae. I determined the molar ratios of nitrogen to phosphorus by measuring nitrite, nitrate, and phosphate concentrations in mg/L using Ion Chromatography twice per week.

The results of this ongoing research, thus far, demonstrate that inclusion of *Daphnia magna* as a fish food in an aquaponic system can influence fish waste and affect water chemistry (Fig 1). Though none of the treatments have resulted in the desired 2:1 ratio of nitrogen to phosphorus, the results show the experimental group has had a lower N:P molar ratio in 12 of the 18 samples taken (Fig 1). While these results are only suggestive support for the hypothesis, it is also possible that the inconsistencies of the resulting N:P molar ratio could be affected by other variables, such as the sex of the fish, the size of the fish, and the amount of nutrients removed by plants as the water circulates. Future trials should be repeated using both male and female tilapia of various sizes in order to conclude the exact effect that feeding *Daphnia magna* has on fish waste and in turn water chemistry.

In our rapidly changing environment, it is imperative to explore a diversity of efficient alternative food production methods. Aquaponics already offers a versatile alternative to modern food production systems due to its adaptability to indoor and urban environments, its relatively low water use, and its nearly closed loop production system (Goddek et al. 2015). Easy alternatives to what is traditionally one of the most energy intensive and environmentally harmful inputs, manufactured fishmeal-based pellets (Gamble 2012), can significantly increase efficiency and sustainability of aquaponic food production.

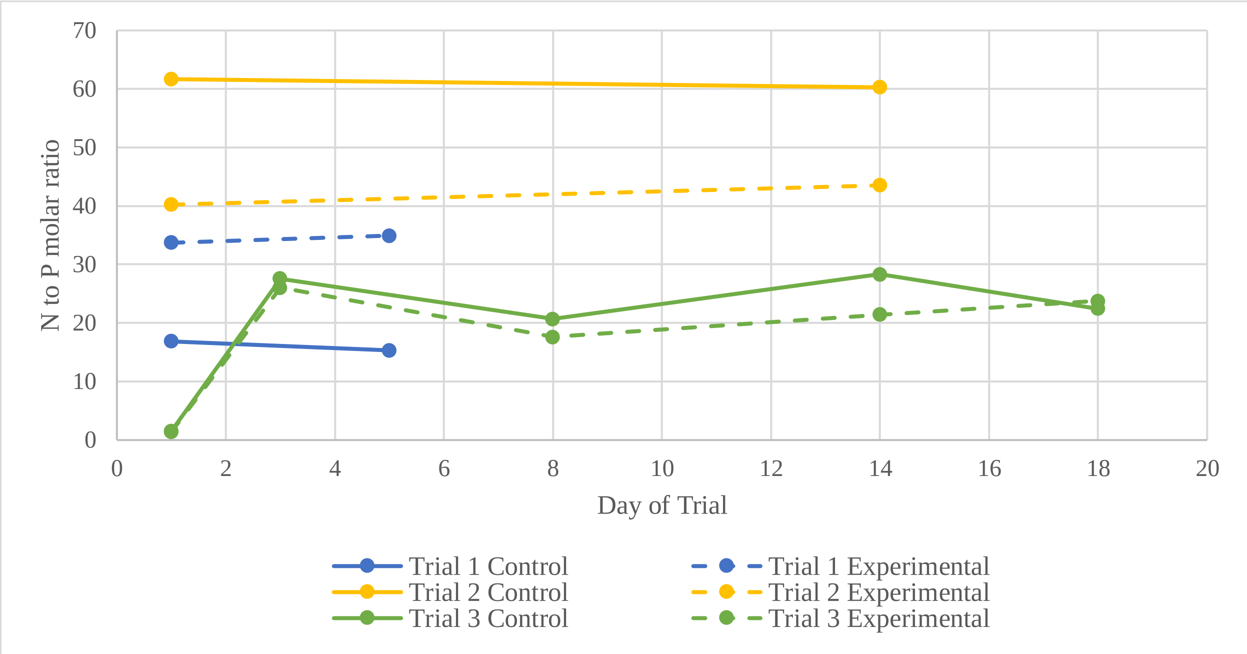

Figure 1. Nitrogen to phosphorus molar ratios in water samples obtained from the control group, fed manufactured food, and the experimental group, fed *Daphnia magna*, across multiple trials.

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