Alternative Feeds for Nile tilapia (*Oreochromis niloticus)* in an Aquaponics System

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Introduction

Aquaculture, the farming of aquatic organisms including fish and aquatic plants, is an alternative solution to reduce global reliance on wild fisheries. The rise in global population and subsequent increase in demand for consumable fish has put more stress on global fish stocks. The practice of farming fish is a logical alternative that would relieve much of the stress on global fisheries. Naylor, et. al. (2000) states that the long term growth of the aquaculture industry requires both ecologically sound practices and sustainable resource management. One of the most important problems facing aquaculture is the use of commercial feed, which is made up of fishmeal and fish oil. It is detrimental for the sustainability of aquaculture because it relies on wild fish stocks in order to feed farmed fish.

The aquaponics system at Cape Eleuthera Institute (CEI) is the symbiotic cultivation of plants and aquatic animals in a re-circulating system. By combining aquaculture and hydroponics, nutrient-rich wastewater from the fish tanks is circulated into the plant grow beds, which, in turn, sends filter oxygenated water back to the tanks. Currently the Tilapia in our system are being fed commercial feed containing fish meal and oil. The food is imported from Burris Specialty Feeds in Lousiana, which is a subsidiary of Cargill Incorporated.

The purpose of our study is identify a locally grown, sustainable feed for the farming of Nile Tilapia (*Oreochromis niloticus*) in an aquaponics system.

We hypothesize that if we feed *O. niloticus* with locally-grown plant-based feed sources, then their growth rates will meet or exceed current growth rates exhibited with commercial feed.

Methods

The integrated aquaponics system combined the elements of aquaculture and hydroponics. The aquaponics system was composed of 12 buckets to test four treatments with two replicates. Each bucket had 10 Nile tilapia fingerlings (totaling 120 fish) with an initial weight of 15 ± 0.36 g (mean ± standard deviation). The wastewater from the fish was filtered through a biofilter and lettuce bed, then into the duckweed trough. From there, the water was pumped back through the sump into the buckets.

The daily parameters measured were temperature (° C), dissolved oxygen (mg/L) and pH levels. Ammonia-nitrate levels were taken weekly. Each week all fish were removed to be weighed. These weights were used to calculate a mean biomass for each bucket and to calculate how much to feed those fish, based on feeding 5% of their body weight.

Duckweed was collected from a trough as part of the integrated aquaponics system and was subsequently dried, ground into a powder to emulate the texture of the commercial fingerling feed. Duckweed has a protein content of 33-38% (Tavares *et. al* 2008), in comparison to that of the commercial feed (Burris 35% protein).

The periphyton for this study naturally grows in waste water flowing into the mangrove adjacent to the cobia hatchery of Cape Eleuthera Institute. It was collected from rocks, rinsed, dried, ground into powder, and fed to the fish. Periphyton has a protein content of 12-30% (VanDam *et. al* 2002).

The four treatments were commercial feed (the control), 50:50 duckweed:commercial, 50:50 periphyton:commercial, 50:50 periphyton:duckweed.

Fig. 6: The Experimental Aquaponics system with Duckweed Trough.

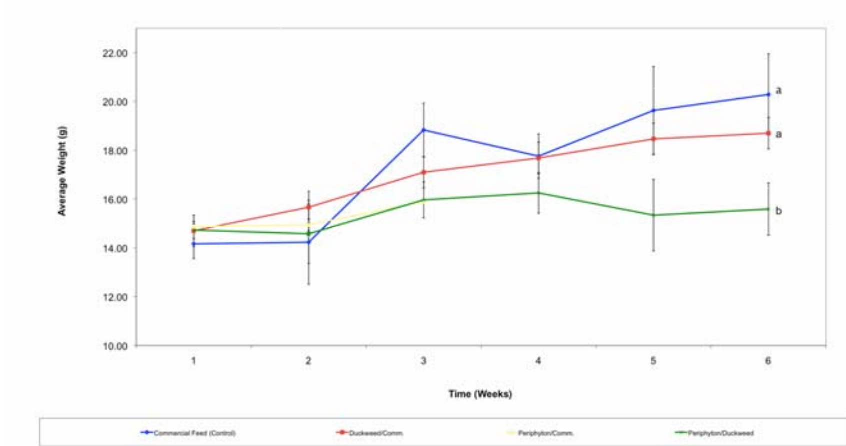

Fig. 1: Mean Weight Gain (g) of Tilapia by Treatment. March 23-April 17, 2009. Cape Eleuthera Institute. Eleuthera, Bahamas

Fig. 2: Nile Tilapia (*Oreochromis niloticus*)

Fig. 3: Duckweed (*Lemna* sp.)

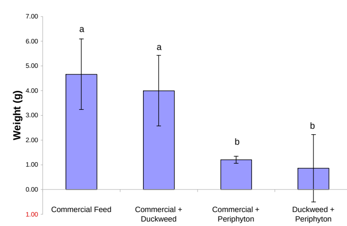

Fig. 4: Mean Weight Gain (g) of Tilapia by Treatment. March 23-April 17, 2009. Cape Eleuthera Insitute. Eleuthera, Bahamas

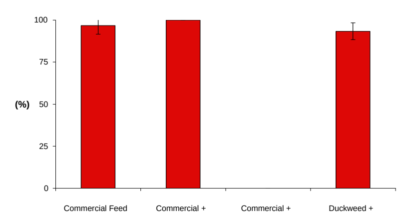

Fig. 5: Survival Rates of Tilapia by Treatment.March 23-April 17, 2009. Cape Eleuthera Institute. Eleuthera, Bahamas

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Results

Through ANOVA testing, no statistical difference was found in mean weights between any treatment at the start of the study. Each treatment grew over the month-long period, but to varying degrees depending on the treatment (figure 1). The fish fed commercial feed (control) had the most growth, followed by the fish fed commercial:duckweed, then by the fish fed periphyton:duckweed. The fish fed commercial:periphyton exhibited the least growth, at times decreasing in biomass (figure 1). Fish fed commercial feed gained an average of 3.59 g. The resulting mean weight was 17.76 g (SD 0.91 g) (figure 4). It grew up until week three, but the mean weight declined from week three to week four by 1.07 g.

Fish fed commercial:duckweed feed had a mean growth of 2.98 g. The final mean weight was 17.68 g (SD 0.9 g). (figure 4). The p-value between this treatment and the control was $p>0.05$ so there was no statistical difference between the two treatments.

The fish fed commercial:periphyton feed had a mean growth of 1.20 g. The final mean weight was 16.22 g (SD 0.17 g) (figure 4). This treatment also had the most mortalities, ultimately resulting in its termination (figure 1 and 4). The p-value between this treatment and the control was $p<0.05$ g meaning the difference in growth was statistically significant.

The fish fed duckweed:periphyton had an increase in weight by 0.86 g. The final mean weight was 16.25 (SD 0.83 g) (figure 4). This treatment had a high standard deviation because each bucket had an outlier with a high weight. For this treatment and the control $p=0.018$, so the growth between each treatment was statistically significant.

In conclusion, there was no statistical difference between the the control and commercial:duckweed meaning that the fish in both treatments exhibited similar growth perfomance. The fish fed commercial feed grew the most (figure 1) until week four when the final mean weight dropped. The fish fed commercial:periphyton stayed at about the same mean growths, as did the fish fed periphyton:duckweed which was supported by $p=0.964$.

Discussion

In support of our hypothesis, the trial fish showed no significant difference in growth rates when fed a composition of commercial feed and duckweed. The two treatments fed on periphyton, however, yielded less successful results, likely due to information by Huchette and Beveridge (2003) stating that the nutritional content of periphyton is based on the substrate that it is grown on. The success of duckweed has demonstrated that the Island School can lessen their reliance on imported feed containing substantial amounts of wild fish oil and meal, thus reducing our dependence on wild fisheries.

A contradiction found in our data was that the fish fed commercial:periphyton, suffered high mortality rates. However, the fish fed periphyton:duckweed had far fewer mortalities. Huchette and Beveridge (2003) found that fish fed solely periphyton had significantly lower growth rates than those that were given supplementary feed, which potentially explains the low growth rates of the fish fed periphyton:duckweed. The reasons for the high mortalities of the fish fed commercial:periphyton are unknown, as the parameters, feed, and fish health stayed regular. The large amount of finely ground periphyton discovered in the necropsy suggests that more research must be conducted to find better feeding practices. Additional research can also investigate the nutritional makeup and value for periphyton specifically grown in CEI's mangrove when grown on different substrates, as explored by Huchette and Beveridge (2003).

Duckweed as a feed could potentially sustain other types of herbivorous or omnivorous fish in an aquaculture or aquaponics system. CEI now has the ability to produce tilapia in a more sustainable way, creating a closed system with fewer imports. A substantial amount of duckweed would be needed to sustain an aquaponics system the size of CEI's. Further opportunities for experimentation involve finding the necessary duckweed needed for an operation such as ours. This research should experiment with conditions needed to grow duckweed best, whether it be specific environmental parameters, surface area requirements and/or fertilizer sources.

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