Experimentation with Sustainable Alternative Feeds for Nile Tilapia

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Background

Due to an increasing global population and limited resources, there has been a steady decline in wild-caught fisheries because of overfishing (FAO 2014). Undernutrition is another problem globally and regionally (Martínez et al. 2009). Aquaponics could alleviate the pressure on both of these issues. Aquaponics is a system that combines aquaculture and hydroponics. Aquaculture is the growing of fish and hydroponics is the growing of plants. Both use water as a medium.

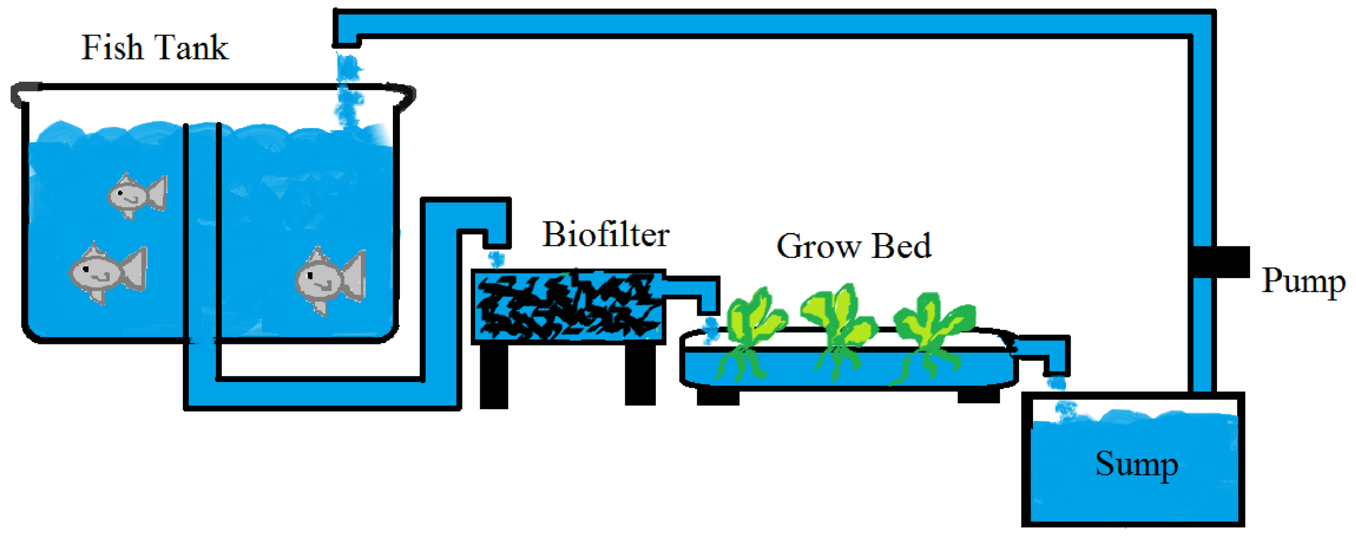

Image 1: Aquaponics is a closed recirculating system that combines aquaculture and hydroponics. In the system ammonia from fish waste is released in to the water. The water is then circulated into the bio filter that converts the ammonia into nitrate that the plants in the grow bed can use as a natural fertilizer. Finally, it is pumped back to the tank with the fish (Klinger & Naylor 2012).

Image 2: Nile tilapia (*Oreochromis niloticus*) as seen in our system

Nile tilapia (*Oreochromis niloticus*) is a breed of fish commonly used in aquaponics and aquaculture systems around the world. This is because they are very resilient, prolific breeders and they are omnivorous. Also, they are also a very healthy and delicious fish for consumption (FAO 2014).

Currently in our system we feed our fish commercial feed. Commercial feed has ambiguously labeled ingredients, such as "animal product" and "plant product". The animal product in the feed is made from wild caught fish that are feeling the pressure of over fishing. The plant product in the feed is likely a soy product that is grown on monoculture farms that use a lot of pesticides. The production and transportation of the imported feed creates a large harmful carbon foot print. Reducing the environmental and economic costs behind our input would make aquaponics a more sustainable system.

The feeds researched in this study are from backyard ingredients such as: black soldier fly larvae, crickets, red worms and duckweed. All but the duckweed can be found and cultivated in South Eleuthera. Black soldier fly larvae would make for a healthy alternate source of protein, fatty acids and Omega-3s. Crickets and red worms are healthy alternate sources of protein. Duckweed is simple to grow and easy to harvest. These ingredients would make aquaponics a viable source of food for Eleutheran settlements (Martínez et al. 2009).

Methods

Feed trials were conducted by integrating duckweed into the normal commercial feed diet of the Nile tilapia. There were four different feeding treatments tested with different percentages of duckweed replacement. 120 juvenile tilapia were split up into 12 different happas; happas are the small nettings in the tank that were used to enclose the fish. This diagram shows how these happas were laid out and how the fish were split up. There was a triplicate of each feeding treatment.

Another part of the methods consisted of the development of insect cultures, especially crickets and black soldier fly larvae. Approximately 60 crickets were collected and placed into the constructed bins with cardboard for bedding, soil for breeding, a wet sponge for drinking, and lettuce for food. The black soldier fly bin was set up with food scraps, two wooden ramps, and tin cans below the ramps. The adults would lay their eggs in the scraps and when the larvae reach a level of maturity, they would climb up the ramps and fall into the tin cans. These were set up to quantify how many could be produced and to throw some in to test if the fish would eat them.

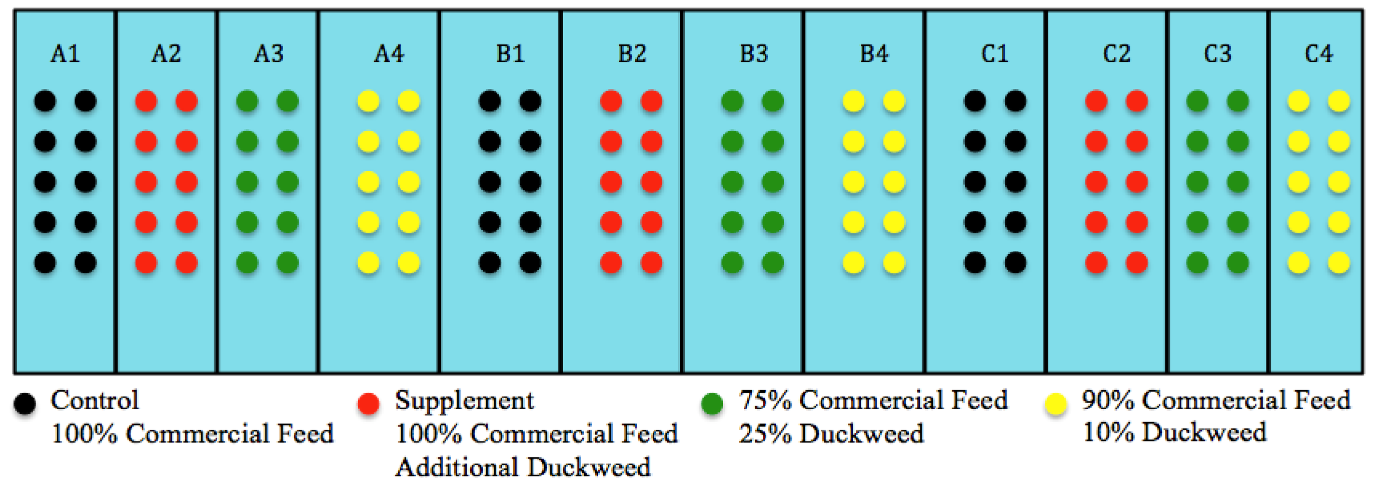

Image 3: This image represents the experimental set up of the feeding trials.

Results

The tilapias' mean weight for each treatment was compared at week five (Figure 1). The control had the highest growth rate. The supplement and the 25% duckweed were statistically significantly different than the control, but the 10% was not.

Then the condition index was found and each treatment was compared from its initial weights to its final weights (Table 2). The control and the supplement both slightly increased, but the 10% and the 25% significantly decreased.

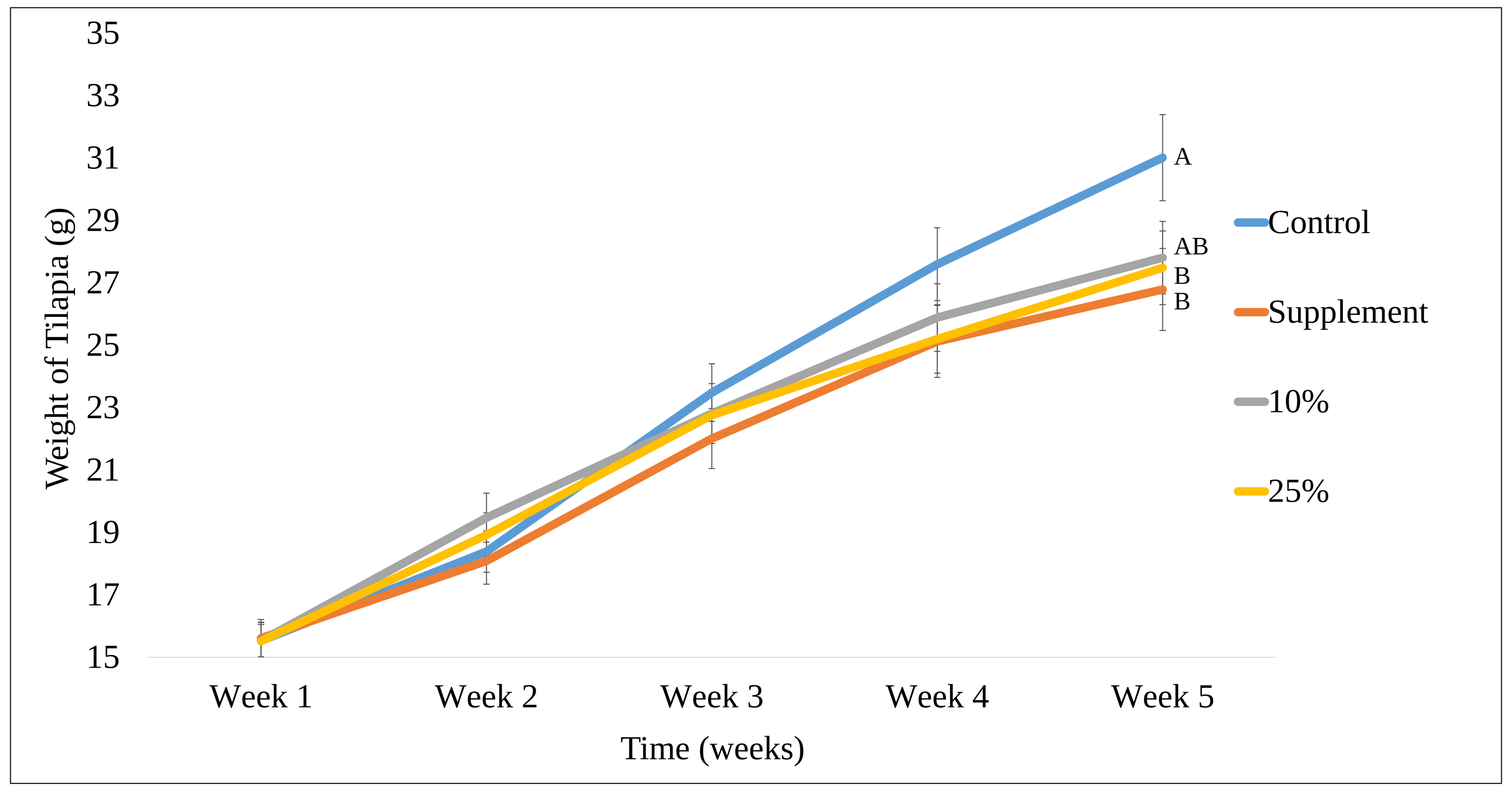

FIGURE 1: Mean weight of tilapia per week for each feed trial with standard error bars (significant differences are represented by different letters).

TABLE 2. Condition index (Ann 2005) comparing each treatment's initial v. final weight and length data.

	Control	Supplement	10%	25%
Week 1	1.7	1.68	1.81*	1.79**
Week 5	1.76	1.7	1.72*	1.7**

TABLE 3. Growth rates (g/week) for the first v. second half of the experiment

	Control	Supplement	10%	25%
First Half	3.98	3.2	3.64	3.62
Second Half	3.77	2.39	2.5	2.36

TABLE 4. Weeks 1, 3 and 5 mean lengths (cm) of tilapia

	Control	Supplement	10%	25%	Total Mean
Week 1	9.6	9.7	9.5	9.5	9.6
Week 3	10.2	10.0	10.2	9.9	10.0
Week 5	12.0	11.6	11.7	11.7	11.7

Sexual maturity (FAO 2014)

In Figure 1, a slight s-curve trend was noticed. The first three weeks followed an upward trend which declined in the second half of the experiment . The graph was taken and divided at the midpoint of the experiment into two graphs. The trend lines were found for the data points and the slopes taken from those (Table 3). Each treatment's slope declined from the first half to the second. The mean length (Table 4) at week three was then found and it was 10 cm. That is the length the Food and Agriculture Organization (2014) states that tilapia reach sexual maturity at.

Discussion

The fact that the tilapia reached sexual maturity during the experiment could have been the cause for the decreased growth rate seen in figure 1. The fish reached sexual maturity during week three, which is around the time that the growth rates began to decrease. This decrease could be brought on by reproduction; if the fish are putting energy into reproduction, less energy will be put into growth. There was also a decrease in the water temperatures that could have caused this. At the beginning of the experiment the temperatures started at 27^{0} C and dropped to 25^{0}C. This could have contributed to the decrease in growth rates as well.

There also could have been a few errors in the experimental design. These errors mostly consisted of possible feed transfer between hapas and time constraints. Small amounts of feed were able to move through the mesh that separated the feed trials, which could have skewed the results slightly. In the future, the mesh between the hapas should be smaller to prevent any cross contamination. Time should also be taken into account for future studies as more time would yield more statistically different results.

This study could also pave the road for experiments to find alternative feed sources to replace commercial fish feed. One possible alternative would be the insect cultures that had already been started. It is known that black soldier fly larvae are high in protein and omega-3 fatty acids, which means that using them as a substitute for duckweed could yield more growth (St Hilaire et al. 2007). Pelletized byproduct from fisherman could also be used as a substitute; tilapia will eat smaller fish in their natural habitat, so this could be a more sustainable alternative to the commercial fish feed (which also contains fish product).

Using these alternative feeds could possibly make small scale aquaponics easier and cheaper to maintain. This could help developing countries with food instability due to over population (Martínez et al. 2009). Eliminating commercial fish feed would also make aquaponics an even more sustainable system. It would take pressure off of the wild fish populations that are incorporated in the production of the feed.

Alternative Feed	Successful?	% Increase/Time	Consumed?
Duckweed	Yes	100%/3 days	Yes
Red Worms	Yes	50%/6 weeks	Yes
BSFL	N/A	N/A	Yes
Crickets	Yes	1000%/1 month	Yes

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