Nile Tilapia (*Oreochromis niloticus*) production using Black Soldier Fly (*Hermetia illucens*) larvae-based aquafeed in a recirculating aquaculture system

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Introduction

Problem: Today over 1 billion people are food insecure (FAO. 2016). It has become evident that conventional agriculture methods have devastating effects on the environment. Agriculture currently holds one of the largest shares in greenhouse gas emissions. With environmental effects in mind, current agricultural methods can't sustain population growth.

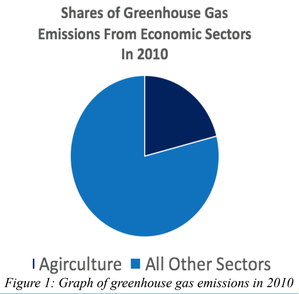

Figure 1: Graph of greenhouse gas emissions in 2010

Solution: In order to reduce global food insecurity, we must explore sustainable methods of food production. Aquaculture has emerged as a promising candidate to address these pressing issues. Although, aquaculture faces a critical problem: a vast majority of aquaculture systems depend on fishmeal which is derived from pelagic fish. Pelagic fish populations can no longer sustain this growing demand. This supply and demand conundrum will soon cause the most widely used aquafeed to be too expensive for use in any aquaculture system.

Figure 2: Our subjects before being measured

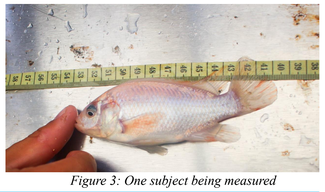

Figure 3: One subject being measured

Previous Studies: Previously investigated alternatives to fishmeal that proved successful feed were Blood Meal (BM) and meat and bone meal (MBM) because of the high protein levels they possess and the similarities between essential amino acid profiles. Although, insect-based feeds are continuously becoming more popularized. In light of this, the EU passed a new regulation making it legal to use insect based protein in fish and poultry feed.

Figure 4: Measuring subjects

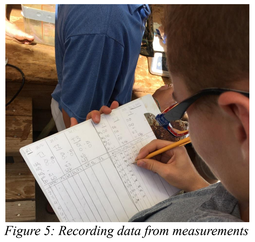

Figure 5: Recording data from measurements

Why BSFL: Black Soldier Fly Larvae is a promising alternative to fishmeal as the fly is native to the Bahamas allowing for a cost-effective replacement, as well as being easily harvestable. Without mouths during the adult stage of life, BSFL is not known to carry diseases and possesses a protein content of 30%-40%, sufficient for the production of Tilapia.

Figure 6: BSFL used in homemade feed.

Methods

We began the creation of our recirculating aquaculture system by constructing three tank stands and adding three tanks to each stand. We then connected those tanks to a pump and Biofilter using PVC pipes. Then we started making our own insect based feed. We measured our fish twice, once on October 2nd and another time on November 6th. During our five-week trial period, we tested the water quality parameters (ammonia, nitrite, nitrate, pH, and dissolved oxygen) daily. Finally, we carried out an analysis of variance test (ANOVA) to determine whether our results are statistically significant.

Figure 7: Measuring fish length

Figure 8: Our recirculating aquaculture system

We dried our BSFL in the sun, then heated them at 170° Fahrenheit. We blended them into a powder, and added guinea corn meal, soy bean meal & oil, wheat flour, a vitamin and mineral premix, and water to make our substance a dough. Afterwards, we extruded it through a meat grinder, and chopped the strings into pellets after we dried them in the sun. Our three treatments were 0% BSFL protein, 50%, and 100%, with a corresponding decrease in fishmeal protein. We only created the 50% and 100%, and our 0%, which is our control, is the regular fishmeal we import from the United States and use in our larger aquaponics system.

% Black Soldier Fly Larvae	% Fishmeal
0%	100%
50%	50%
100%	0%

Table 1: Our three experimental diets

Figure 9: Extruding homemade feed dough

Results

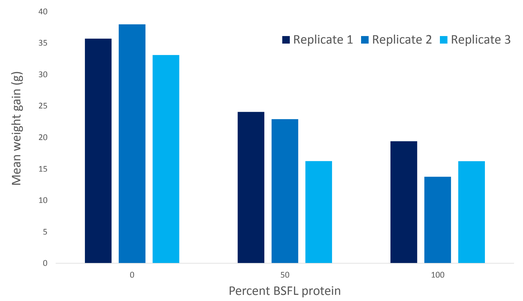

Figure 10: Graph of the average weight gain in our subjects per treatment. P-value < 0.05

Figure 11: Graph of the average length gain in our subjects per treatment. P-value < 0.05

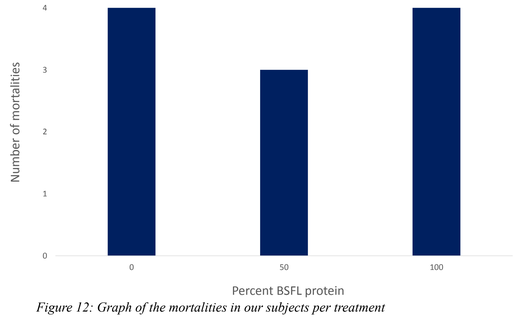

Figure 12: Graph of the mortalities in our subjects per treatment

In both cases (weight, and length gain), the fish within the control treatment grew the most, and seemed to grow less with increasing BSFL incorporation. An ANOVA test was conducted, and concluded that the difference in means was statistically significant since the p-value was less than 0.05. The mortality rate was consistent across treatments and the water quality parameters did not change over the trial period.

Discussion

When BSFL increased in our feed, the growth rate decreased. This could be because even though we fulfilled the protein requirements of a tilapia, we might not have fulfilled their amino acid profile. This is because Tilapia require higher levels of lysine and arginine (Katya et al. 2017). Tilapia also digest chitin differently which could lead to mix results (Devic et al. 2017). However, since the mortality was equal in all the feeds, it shows that our feed is still viable because they are still growing and it doesn't affect their mortality. Our results allude to potential future research projects that the Island School could undertake. We could examine our feed trials' three diets to see the effected fish growth over the entirety of a tilapia fish's life span. Since we saw the effect that BSFL has on fish growth, we could also examine the effect on plant growth. Another possibility is conducting a research project in which we use all Eleutheran ingredient when formulating our fish-feed. Additionally, we can view the viability of the island School being able to produce its own food. While it could be a labor-intensive process, a task we could have to overcome is acquiring the right resources such as mechanical grinder to grind our own feed.

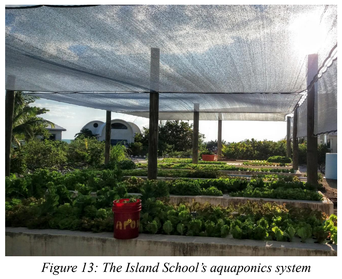

Figure 13: The Island School's aquaponics system

Figure 14: One subject being measured

Acknowledgments

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