Black Soldier Fly larvae (*Hermetia illucens)* as an alternative protein source for Nile Tilapia (*Oreochromis niloticus)* feed in an aquaponics system

Asha Delcogliano, Troy Dillon, Donovan Hepburn, Maggie Kearney, Brenna Kerin, & Shaw Miller
Advisors: Michael Bowleg, Mark Young, & Celine Terfloth

Introduction

Aquaponics: Aquaponics is a more environmentally sustainable way to produce both plants and fish in one closed system, where the ammonia byproduct of aquaculture is transformed into nitrate fertilizer which facilitates the growth of plants in the hydroponics component.

Problem: One of the largest problems the Earth faces today is overpopulation. Over 7 billion people live on the earth today and over 1 billion are food insecure. By 2050 there will be a projected 9 billion people, and 2 billion will be food insecure. (Ayoola, 2010, & Leschin-Hoar, 2017). Human population growth has driven the development of the aquaculture and aquaponics industries due to increased demand for fish protein. 36% of all wild-caught pelagic fish each year are used in fishmeal production, and 90% of those fish, mostly sardines and anchovies, are food-grade. (Ogello *et. al*, 2014). Capture of these fish has reached the sustainable limit, gradually depleting wild stocks. Transportation of this fishmeal also increases the carbon footprint of aquaculture and aquaponics operations, causing fishmeal to become more expensive as it rises in demand.

Solutions: Many studies have concluded that alternative protein sources such as Blood Meal (BM), Meat and Bone Meal (MBM), Feather Meal (FeM), and Soybean Meal (SBM) in the diets of aquaculture fish do not have a negative impact on fish growth (Ogello et. al., 2014). Plant based meals like duckweed and azolla meal have also been used. These are successful in developing countries because of their ease of production and low cost. The Black Soldier Fly *Hermitia illucens,* have a similar crude protein content and fat content to fishmeal, suggesting that its usage in aquaculture operations would be beneficial (Stamer et. al., 2014). By finding an economically and environmentally viable replacement for fishmeal, enough food could be saved to provide a protein source for all the food insecure people on the earth.

BSFL Benefits: The Black Soldier Fly is an ideal candidate for replacing fishmeal because they are native to the Bahamas, so it is easy and cheap to obtain them, facilitating their capture and growth. They are not known to be a carrier of any diseases, eliminating the risks of using them in food production. BSFL protein content is sufficient for tilapia production, ranging from 30%-40% depending on environmental factors. They also have an approximate food conversion ratio of 95%, making them a cheap and viable method of food waste disposal.

Methods

Feed ingredients	Weight (kg)	Percentage of total (%)
Corn meal	1.0	10
Wheat flour	4.0	40
Soybean meal	1.5	15
Soybean oil	0.2	2
Fishmeal	3.0	30
Vitamin and mineral premix	0.3	3
Total amount	**10.0**	**100**

Table 1: The experimental diet was created according to the above recipe from the Food and Agriculture Organization, with the fishmeal component being the manipulated variable. BSFL were collected, baked and powdered before being combined in different rations with fishmeal.

Treatment	BSFL meal (%)	Fishmeal (%)
1 (control)	0	*
2	25	75
3	50	50
4	75	25
5	100	0

Table 2: Percentages of protein constituents (42-46% crude protein) in each treatment

The experimental setup consisted of a total of 5 treatments each with replicates, creating a total of 10 tanks. 3 fingerling Nile Tilapia were placed in each tank and fed 7% of their body weight in their respective experimental diets over 2 daily feedings. Water quality was tested for Ammonia, Nitrite, and Nitrate using an API freshwater test kit, and dissolved oxygen was measured using a YSI probe. The fish were tagged before the experiment, allowing each fish to be weighed and its standard and total lengths to be measured before and after the 22 day feeding trial.

Results

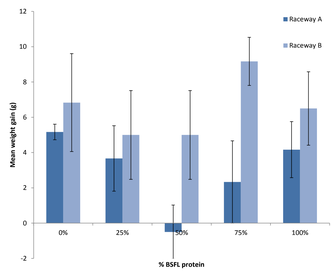


Figure 1: Mean length gain across treatments within both replicates

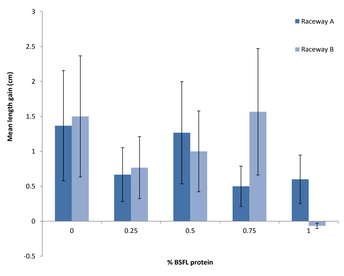


Figure 2: Mean weight gain across treatments within both replicates

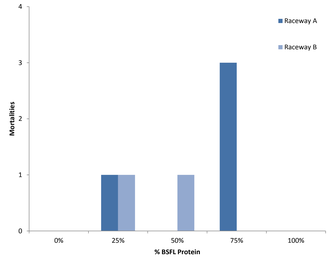
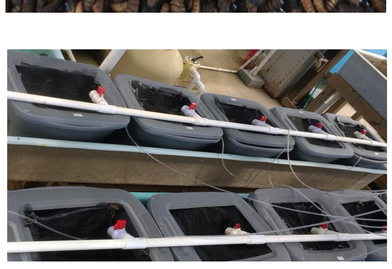


Figure 3: Mortalities across treatments within both replicates

An ANOVA statistical analysis of the relationship between BSFL protein content and growth returned a p-value of >0.05, showing that there is no statistically significant difference in length or weight gain from the control to the experimental diets.

Discussion

Our results showed that there was not a significant difference in the mean growth of the differing meals. This provides evidence that the Black Soldier Fly could be used as an alternative to fishmeal in the diet of the Nile Tilapia without hindering performance. However, this is a pilot study and it is encouraged that others replicate this study. When replicating this study, a few aspects could be improved upon. The first is a larger sample size. This would allow one to find more data. Trial length could also be improved. This would allow for specific growth rate and food conversion ratios to be assessed. Tank conditions could also be made more consistent. This could be the reason for the increased mortalities and a lack of growth for some treatments. Future research could investigate the replacement of plant carbohydrates and proteins in this aqua-feed with locally sourced alternatives.



Acknowledgements

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