Growth Performance of Nile Tilapia (*Oreochromis niloticus*) under a Locally Formulated Feed in Concrete Ponds

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Abstract

In Sub-Saharan Africa a large proportion of population rely on fisheries from aquaculture as a source of both food and income. However, little is known about the performance of local feed used as fish feeds such as tilapia in the aquaculture sector. The purpose of this study was to compare the growth performance in terms of standard length, total length and weight for Nile Tilapia (Oreochromis niloticus) in a concrete pond fed on locally formulated feeds versus imported fish feed. The local feeds were designed to meet the protein and energy needs of growing fish. The local feeds were composed of blood meal and fish meal as a source of protein, whereas rice and maize bran, as well as multivitamins, provided energy. The Mwamapuli Aquaculture Development Centre in Igunga district hosted the experiment for 30 days. Nile tilapia fingerlings (Oreochromis niloticus) were cultured in six fish ponds (P1, P2, P3, P4, P5 and P6); which were stocked with 10 fingerlings from the same batch from the Mwamapuli hatchery. The feeding program was conducted three times per day at 8:00 a.m., 12:00 p.m. and 4:00 p.m. and were fed according to their body weight. The results revealed that the commercial imported fish feed insignificantly performed better in the growth of Nile tilapia (Mean=5.16±0.35g) than the local formulated fish feed (Mean=4.40±0.21g) (P>0.05). On the other hand, the local formulated feed performed significantly better in terms of mean growth weight (Mean=4.40±0.21g) than the control (mean=3.00±0.12g) (P>0.05). Conclusively, the locally made fish feed performed similarly to the commercially imported fish feed while outperforming the control. As a result, aqua farmers must be educated on how to make local fish feed that is both cheaper and more profitable in aqua culture production.

Keywords: Growth Performance, Nile Tilapia, Local Formulated Feed

Introduction

Aquaculture currently produces approximately 50% of the global supply of fishery products for direct human consumption, thus increasing income, reducing the reliance on wild capture and its impacts and promoting good health and nutrition (ES, 2018). Although fishing in natural waters have been used as a source of protein from fish for many years, their potential is waning, and they are thus being discouraged while aquaculture is promoted. Other report have shown that, in Africa, approximately 5% of the population depends wholly or partly on the fisheries sector for their livelihood and the estimated sector growth rate was 2.5% in 2016 (Chan *et al.,* 2019; Mmanda *et al.,* 2020; FAO, 2018). In this case, the management and feeding of fish under aquaculture depend entirely on human supply. However, In Tanzania, few studies have been conducted on fish feeds and how their diversity (commercial and local feeds) contributes to the production of fish in aquaculture farming systems.

Tanzania has identified aquaculture as an alternative source for fish supply to reduce national dependency on capture fisheries (Musiba *et.al.,* 2013). African catfish (*Clarias gariepinus*) and Nile tilapia (*Oerochromis niloticus*) are the commonly aquacultured species in different places such as lakes, coastal, northern, and southern zones (Mmanda *et al.,* 2020). Workable practices of aquaculture farming have made it possible for local communities to adopt this system of fish production which ensures sustainable conservation in the wild.

Farming of fish in Africa started during the colonial era (since the 1940s), but it has remained undeveloped and the major obstacles in this farming are the unavailability of quality feed for the different fish production systems (Ndimele *et al.,* 2011); especially the reliance on commercial feeds, which are expensive and unaffordable for most farmers (Bureau *et al.,* 2009). Imported commercial feeds account for more than 60% of the total farm production investments in these feeds (Gabriel, 2007); and their reliance increases the cost of production thus indirectly reducing the benefits to farmers. These calls upon the fish farmers opt to make their own feeds by using locally available food materials such as maize and rice bran, food and garbage from their farms (Peter *et al.,* 2009-2011). However, information on how locally made feeds perform in terms of growth in fish is not well documented in Tanzania.

This study was aimed at assessing the growth performance of Nile tilapia using locally formulated fish feed. The focus was to compare the body growth performance in terms of weight and length for fish fed with locally formulated feeds verses commercial (imported) feedstuffs.

Materials and methods

Study area

The experiment was conducted at Mwamapuli Aquaculture Development Center, which is located in Tabora region (Igunga district) at Mwanzugi village, which is 9 km from Igunga town. This is among of the seven-aquaculture centers owned by the Department of Aquaculture in the Ministry of Livestock and Fisheries. The center focuses on ensuring constant supply of quality tilapia and catfish fingerlings as well as to provide education to the aquaculture farmers and other stakeholders including students and researchers.

Study design

The experimental study involving both cross-section and longitudinal designs was planned. Six concretes ponds each 300cm length x 130cm width x 55cm height were used in this study (Plate 1). The ponds were filled with fresh water from Mwamapuli dam. Each pond was stocked with 10 tilapia fingerlings of the same batch obtained from Mwamapuli Aquaculture Development Center hatchery. Two fish feeds, a locally formulated fish feed (LFFF) and commercial fish feed (CMFF) were used to feed the fish. The calculated analysis for commercial formulated feed was Fry crumble 1 (0.5-0.8mm) with a contents of 47% Crude Protein, 3.5% ether extract (EE), 4% crude fiber (CF), and 14.0% ash, 11% Moisture, 1.3% Phosphorus, 1.5% Calcium and 2% Lysine as manufactured by DE HEUS LLC. The LFFF was made at the center and comprised of protein obtained from blood and fish meals, energy from rice and maize brans, and multivitamins. The composition percentages of each category of fish meals are specified below as suggested by Cruz (1997): -

a. Fish meal with 93.80% Dry matter (DM), 42.00% Crude Protein, 6% ether extract (EE), 6% crude fiber (CF), and 31.50% ash.
b. Blood meal with 89.00% Dry matter (DM), 76.70% Crude Protein, 1.1% ether extract (EE), 1.2% crude fiber (CF), and 4.0% ash
c. Maize bran with 91.00% Dry matter (DM), 9.00% Crude Protein, 4.0 % ether extract (EE), 2.2% crude fiber (CF), 1.9% Ash
d. Rice bran had 89.90% Dry matter (DM), 21.65% Crude Protein, 1.82% ether extract (EE), 8.45% crude fiber (CF), 12.08% ash

There were three treatment in these ponds which are local feed, commercial and no feed. The two ponds had fish which were fed with local formulated feed stuff, 2 ponds had fish which were fed with commercial formulated feed stuff while the other remaining two ponds were left as control without provision of feed, and thus they depended on the natural feed such as insects and other surround materials from the environment. The feeding of fish in the ponds was done depend on their body weight and fed three times a day that is at 8:00 a.m., 12:00 p.m. and 4:00 p.m. The amount of feed was adjusted after two weeks based on the total fish weight. The monitoring of the experiment was done for thirty days (30).

Data collection

Data were collected after an interval of six days in six ponds. The data collected from each fish in each pond were weighed (g) using an electrical balance, length (cm) using a tape measure. In addition, samples for water quality changes were taken throughout the data collection and forwarded to the biology lab at the University of Dodoma's College of Natural and Mathematical Sciences. To ensure safe transportation to the laboratory, the water samples were maintained in a cold box at 4°C. The water quality parameters measured in the laboratory were: Dissolved oxygen (DO) and pH using a D.O meter (mg/L) and pH respectively.

Plate 1: The pond used in this study and how they were arranged

Data analysis

The variation in performance of weight, standard length and total mean length among ponds was analyzed using the Kruskal Wallis statistical test, while the Mann-Whitney statistical test was used to compare the variation between the two feed stuffs (the commercial and locally formulated feedstuffs). These were used because the data were non-parametric in nature with kurtosis greater than 3. In addition, the data were further analyzed using a general linear model to determine the influence of water quality parameters (dissolved oxygen (DO) and pH using a D.O meter (mg/L) and pH) and total length on the increasing weight of fishes.

Results

Performance of fish growth in different ponds

A total of 60 fish were sampled 5 times resulting in a total of 300 samples. The general growth performance of Nile tilapia had mean weight of 3.92±0.13 (g), mean standard length of 4.491±0.126 (cm) and the general total mean length of 4.75±0.09. There was a significant variation in the growth performance of fish in the ponds (P<0.005). For instance, the highest mean weight (Mean=5.16±0.35) was recorded in

Table 1: The average growth performance of fish in terms of weight (g), standard length (cm) and total length for each sampled pond

Pond Number	Weight (g) (Mean ± S.E)	Standard Length (cm) (Mean ± S.E)	Total Length (cm)
PO1	4.37±0.30	4.72±0.23	4.99±0.23
PO2	4.44±0.30	4.82±0.23	5.09±0.23
PO3	5.16±0.35	5.39±0.25	5.65±0.25
PO4	5.16±0.35	5.33±0.25	5.59±0.25
PO5	2.99±0.17	3.28±0.09	3.52±0.09
PO6	3.02±0.17	3.33±0.09	3.56±0.09
P-VALUE	< 0.0001	< 0.0001	< 0.0001

Note: PO=Pond number, P-Value =Probability value, S.E=Standard Error, PO1 and PO2 = Local formulated, PO3 and PO4=Control ponds P3 and P4 while the lowest was recorded in P5 and P6 (Table 1). The data was collected five times in each pond. We were to find the average for each pond so as to understand if there would be any variation among ponds. We anticipated that, apart from feed, other factors such as water quality would have an impact on the growth performance.

Variations in Growth performance in different fish feed stuff and water quality

The average mean weight was higher in commercial formulated feed (Mean=5.16±0.22, n=100) followed by local feed (mean=4.40±0.21, n=99) while it was lowest in the control (mean=3.00±0.12, n=97). The same trend was observed for standard length, and total length (Table 2).

A comparison between the commercial and local formulated feed staff revealed a significant difference in performance between the two treatments (P=0.001). The growth performance between the local formulated feeds and the control, showed a significantly higher performance in terms of weight in locally formulated feed (mean=4.40±0.21, n=99) than in the control (mean=3.00±0.12, n=97) (p<0.0001).

fish (local, and commercial) insignificantly lowered the pH and DO (table 3).

Discussion

Growth performance

Overall, both commercial and locally formulated feed performed better than the control. The better performance of commercial and locally formulated fish feed could be explained by the composition of the feed. Among other components in the feed make up for these feed stuffs are protein, energy and mineral sources which are essential for the growth of fish. For instance, the local formulated feed was composed of Blood meal 60% crude protein, Fishmeal 49% crude protein, and maize bran 12% crude protein, rice bran 5.5% crude protein, multivitamins 0.2% while commercial feed was composed of soyabean meal, fishmeal, meat meal, poultry, rice bran, salmon oil, vitamins, minerals with crude protein 40%, crude fat 6.5%, crude fiber 5.0%, moisture 11.0%, ash 14.0%, phosphorous 1.3, and Phosphorous 1.3, Calcium 1.5%. All these compositions have high nutritional value with a well-balanced amino acid profile and minimal anti-nutritional factors (Jones, De Silva, & Mitchell, 1996).

A study in Srinagar, India showed that, the proper feeding of fish with 40% dietary protein resulted in significant growth performance in Freshwater Fish, Cyprinus Carpio Var. Specularis (Ahmed and Maqbool, 2017). The effect of protein composition in fish feed has also been reported in other studies to contribute significantly to the growth of performance of fish (FAO, 2018; Aanyu *et al.,* 2012). The low growth performance

Table 2: The average growth performance of fish in terms of weight (g), standard length (cm) and total length as well as water characteristics such as pH and dissolved oxygen (mg/L) for each feed category

S/N	Feed Category	Mean Weight (g)	Standard Length (cm)	Total Length (cm)	pH	D.O (mg/L)
1	Local Feed	4.40±0.21	4.78±0.161	5.05±0.16	7.59±0.04	4.35±0.06
2	Commercial Feed	5.16±0.22	5.36±0.174	5.623±0.18	7.59±0.038	4.37±0.09
3	Control	3.00±0.12	3.30±0.064	3.54±0.06	7.61±0.043	4.44±0.06
4	P-Value	< 0.0001	< 0.0001	< 0.0001	0.873	0.413

Note: P=Probability, g= gram, cm=centimeter, D.O=Dissolved Oxygen

Factors affecting weight gain in fishes

There was a significant positive effect of ponds P5 and P6 which were control ponds on growth performance in terms of weight (P<0.05). 14 Similar positive effects on growth performance were observed for water quality in terms of dissolved Oxygen (P<0.05). These results showed that the feed stuff provided to

Table 3: The effects of types of feeds, length and water quality (pH and dissolved oxygen) affect the weight gain of the fish

S/n	Variable	Level	Coeff±S.E	t	P=Value
		Intercept	-18.3±3.2	-5.76	2.27
1	Ponds	PO2	0.17±0.1	1.27	0.20
		PO3	-0.09±0.1	-0.84	0.40
		PO4	0.25±0.1	1.83	0.07
		PO5	0.78±0.1	5.8	1.75
		PO6	0.35±0.1	2.62	0.01
2	Length	Total length	1.49±0.7	2.19	0.03
		Standard length	-0.21±0.68	-0.30	0.76
3	Water quality	pH	1.86±0.42	4.45	1.25
		D.O	0.46±0.17	2.71	0.01

Note: PO=Pond number, P-Value=Probability value, S.E=Standard Error, g=gram, cm=centimeter, D.O=Dissolved Oxygen, Coeff=Coefficient Estimate, PO1 and PO2 = Local formulated, PO3 and PO4 Control

in a control can be associated with the minimal lack of essential protein, energy, minerals and other sources of balanced nutrition to fish as they depending entirely on what is offered in the environment such as insects, leaves, and other detritus through different mechanisms such as catching, filtering, digging, gnawing, clipping, scraping, crushing, and biting-out (Pavlov and Kasumyan, 2002).

Effect of length, feed type and dissolved oxygen in weight gain of the fish

It was clear from this study that, the weight gain of fish was significantly affected by the standard length, total length, feed type, and water parameters. Other studies have shown a correlation between the length and weight (Khan *et al.,* 2012). Furthermore, the type of feed provided to the fish influenced the growth of fish. For instance, a study in farmed Atlantic salmon showed that, plant protein diets significantly influenced the growth of fish due to its composition and anti-nutritional composition (Król *et al.,* 2016). The length and type of feed are not sufficient to explain the growth performance of fish in terms of weight. Other factors such as water chemistry and quality need to be evaluated.

Water parameter on the cultured tanks

The levels of pH and dissolved oxygen (D.O) recorded from the culture tanks during the study period were within the appropriate range for tilapia culture. However, slight changes affected the growth performance. Dissolved oxygen in ponds had a positive effect on the growth of fish. The positive relationship between growth performance and dissolved oxygen can be explained by the relationship between dissolved oxygen and the feed conversion ratio. For instance, dissolved oxygen has a positive effect on the growth of fish. Other studies have shown that sufficient dissolved oxygen in ponds has significant effect on the conversion ratio of feed in fish to affect growth. Other findings have also been reported. For instance, a study in Atlantic halibut concluded that, the level of oxygen saturation affects the growth and feed conversion ratios of fish. A higher growth rate was observed at an oxygen level between 80% and 120% with rare cases that reported lower conversion ratios for halibut if appropriate at 120% oxygen saturation (Mallya, 2007). Other studies have reported that, dissolved oxygen is an important factor in aquaculture for growth performance (Tilapia) (Abdel-Tawwab *et al.,* 2015). Tilapia are highly tolerant to low dissolved oxygen concentrations of up to 0.1 mg/L, however, optimum growth is attained at concentrations greater than 3 mg/L, pH of 7-9 and temperature of 22°C-29°C (Ross, 2000). In addition to DO, studies on Nile tilapia, *Oreochromis niloticus* (L.) have revealed that, diseases and immunity can significantly affect the growth of fish in aquaculture (Abdel-Tawwab *et al.,* 2015).

Conclusion and recommendation

By comparing the local and commercial feeds, the commercial feed performed better. Growth performance in fish was affected by the length of the fish, type of feed given and water quality. To increase the productivity of fish at low cost, farmers can opt using locally formulated feed while other factors that affect the growth performance of fish such as water quality (D.O), pH, Temperature and diseases should be monitored. Monitoring water quality parameters in aquaculture is important because it influences the physiological processes of fish. Feed waste may lead to water deterioration, thus causing significant changes in ecosystem structure and functioning.

Ethical consideration

The University of Dodoma provided ethics approval for this study (Reference number MA.84/261/02). During the implementation of the study, all animal experimentation regulations were observed.

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