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Comparative Growth Performance and Proximate Nutrient Composition of Three Local Strains of Nile Tilapia (*Oreochromis Niloticus L.*) Collected From Different Locations in Uganda

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Abstract

The availability of *O. niloticus* fingerlings remains a problem in South Western Highland Agro-Ecological Zones. Most fish farmers produce only small sized fish probably because of inbreeding in Uganda. Brood stocks of Nile tilapia, *Oreochromis niloticus L*. were collected from Lakes Victoria, Kyoga and Kayumbu, a minor lake in SWHAEZ. The brood-stock were conditioned and bred. Fingerlings of F1 generation of each strain were fed diet containing 35% Crude Protein for 90 days. The results showed that Victoria strain growth performance was better compared to other tilapia strains in growth performance. Survival rate was not significantly different among Nile tilapia strains. Crude protein contents in fish body was higher in Victoria (69.30%) followed by Kayumbu strains (68.125%) with Kyoga having the least crude protein content (64.5%). Fish body of Kayumbu strains contained higher values of crude fat (11.70%) followed by Victoria strain (9.90%) while Kyoga strain had the least crude lipid (8.50%). The Victoria strain (47.8 g feed/fish) had significantly higher feed intake and PER than all the other strains. Kyoga and Kayumbu strains were comparable in terms of feed intake. However, the Kayumbu strain had significantly the least PER (2.46). The lowest FCR value was obtained in Kayumbu strain (1.67), while the higher ones were obtained in Kyoga and Victoria strains 1.82 and 1.78, respectively). The poor performance of kayumbu strain was probably due to in breeding and other environmental factors like temperatures. Therefore, exploitation of the genetic variation within the different native wild strains through selective breeding can help to improve growth performance of the Kayumbu strain in South Western Highland Agro-Ecological Zones (SWHAEZ).

Keywords: Nile tilapia; Strains; Growth performance; Feed utilization; Proximate analysis

Introduction

Aquaculture has a great potential to improve food security in Uganda and the world, especially in the current state of declining capture fisheries potential as a result of the overfishing, environmental degradation and the introduction of the alien species which has been the major source of food fish for humans [1,2]. Therefore, there is need to improve the aquaculture sector so as to reduce the pressure on capture fisheries.

Aquaculture production in Uganda involves different species; Nile Tilapia, African catfish, mirror carp, silver carp. Nile tilapia production has proved to be the most cultured species in Uganda because it grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling [3]. Nile tilapia culture in Uganda has expanded exponentially until a more recent overtaken by the catfish making Tilapia now, Uganda's second most cultured fish species.

Despite the increasing Ugandan aquaculture production, production in South Western is still at subsistence level [4]. Among the reasons for the slow growth of the industry is short supply of good quality fish seed in sufficient quantities, poor quality feed which is also not constant, poor management practices and lack of the coordinated market. These, however, can only promote limited growth and further growth is restricted by insufficient and poor quality seed. The Nile tilapia strains native to inland waters of Uganda vary based on the location of the water body but little research on their performance in ponds have been conducted.

The availability of *O. niloticus* fingerlings remains a problem in South Western Highland Agro-Ecological Zones. Most fish farmers produce only small sized fish probably because of inbreeding. Other Nile tilapia strains exist almost in all freshwater bodies in SWHAEZ [5] but their performance in culture conditions is not known. Furthermore, information on growth performance of tilapias native to SWHAEZ like tilapia strainsfrom Kayumbu is scanty. Also, there is limited research conducted to compare the growth performance of *O. niloticus* with the species native to SWHAEZ under the same conditions. Therefore, the study compared the growth performance of different tilapias native to SWHAEZ so as to come up with the strains that will complement *O. niloticus* from Lakes Victoria and Lake Albert in Uganda. The findings from the study will guide fish farmers to culture tilapia strains which are native to SWHAEZ so as to improve fish farming in areas where these strains are readily available and reduce the costs which could be incurred by getting *O. niloticus* fingerlings from distant hatchery centers.

Objectives

General objective

To assess the growth performance and proximate nutrient composition of Nile tilapia strains suitable for aquaculture production at farmers' level in South Western Highland Agro-Ecological Zones (SWHAEZs).

Specific objectives

To compare growth rate, survival, and final yield at harvest of three different tilapia strains and to compare feed utilization efficiency of different tilapia strains in Uganda. To determine the nutrient composition of the F1 generation of the Nile Tilapia strains.

Materials and Methods

Study area

The experiment was carried at Kyanamira fish ponds (Figure 1) (0169742E, 9860391N) with the altitude 1794M above the sea level, a research facility for Kachwekano Zonal Agricultural Research and Development Institute.

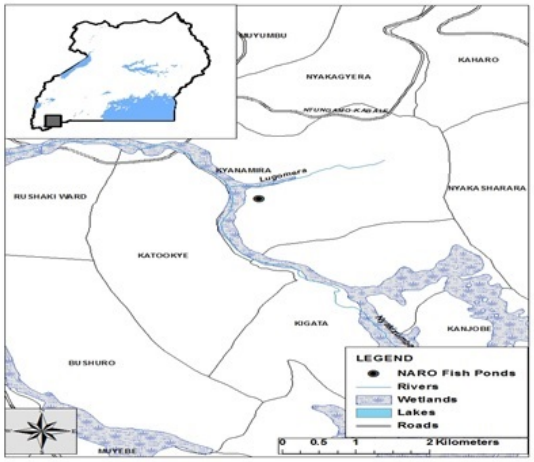

Figure 1: Map showing the location of the experiment site.

Research design

The evaluation consisted of two growth phases namely: fingerlings and juveniles-adults.

Phase 1: The fry (0.5 g-1.0 g) of each strain 100 in number were stocked into 1 × 1 × 1 happas and nursed to 5 g for 42 days. Ponds were fertilized with chicken droppings manure (100 kg [dry wt]/ha/ months. The fry were also given supplementary feeds (35% CP) at rate of 15% of body weight. Growth and survival were determined for each happa at the end of the production period.

Phase 2: The fingerlings (5.0 g) were then stocked into 2 × 2 × 1 happas and reared for 90 days. Ponds were fertilized with chicken droppings manure (100 kg [dry wt]/ha/month). The fish were also given supplementary feeds (35% CP) at rate of 10%, 8% and 5% for months 1, 2, & 3 respectively of body weight. The fish in each happa were sampled weekly to determine the average body weight and the survival of each strain of fish.

Water quality

Water quality parameters were monitored in both experiments to ensure the survival of the fish. The pond water quality parameters measured included water temperature, dissolved oxygen and pH. Measurements were taken at different points of the ponds and then average. Total ammonia and Nitrogen were measured bi-weekly.

Proximate analysis of fish strains

The fish strain from each treatment was chemically analyzed according to the standard methods of AOAC [6] for Dry matter, Crude protein, Crude fat, Ash, Crude fiber.

Crude protein determination

This was determined using the Kjeldahl process as described by AOAC. To 2 g of appropriately homogenized fish sample weighed into a Kjeldahl flask, 10 g of catalyst, 25 mL of concentrated Sulfuric Acid, and three glass beads were added. The contents were then digested with a mixture of powdered potassium sulphate, copper sulphate, and selenium mixed in the ratio of 94.8: 5: 0.2 until being clear. Contents were cooled and diluted and 100 mL of 40% sodium hydroxide was added. Exactly 50 mL of 4% boric acid was poured into a separate conical flask and connected to the distillation unit. The mixture was distilled and the distillate was collected into the boric acid containing 3 drops of indicator until the volume was above 150 mL. Ammonia was converted to ammonium metaborate and titrated with standardized 0.1 M hydrochloric acid. The percentage of protein was calculated using the following formula:

$$\%\ \text{Crude Protein} = \frac{(\text{titre vol Sample-titre vol blank}) \times 0.014 \times 0.1 \times 6.25}{\text{Weight of sample used}} \times 100$$

Proximate analysis of crude fat

Crude fat was analyzed using the ether extract method. A 2 g dried fish sample was inserted into a pre-dried porous thimble allowing rapid flow of petroleum ether. The sample was wrapped in filter paper, placed into the thimble, and covered with glass wool. Anhydrous ether was placed into a weighed boiling flask, which, together with the Soxhlet flask and condenser, was assembled into the Soxhlet apparatus. Fat was extracted into a Soxhlet extractor for 6 hours, by heating solvent in the boiling flask. The boiling flask with extracted fat was dried in an air oven at 100°C for 30 minutes, cooled in a desiccator, and weighed. The fat content was estimated as follows:

$$\%\ \text{Fat} = \frac{(\text{Weight of flask and fat extacted-Weight of empty flask})}{\text{Weight of dried sample used}} \times 100$$

Determination of dry matter

Moisture was determined using the AOAC method of proximate analysis. Exactly 0.5 g of homogenized fish sample, taken in triplicate, was placed in a pre-weighed Aluminium dish and placed in a hot air

oven maintained at 105°C for 1 hour. The sample was cooled in a desiccator to room temperature and the loss in weight was calculated as a percentage as follows:

$$\%\text{Moisture} = \frac{(\text{Weight of sample before drying- Weight of sample after drying})}{\text{Weight of sample before drying}} \times 100$$

Determination of ash content

A 5 g fish sample, taken in triplicate, was weighed into an empty pre-weighed crucible and placed in a muffle furnace which was then ignited for 12 hours at 550°C. The furnace was turned off to cool to 250°C before sample removal. Sample was desiccated prior to weighing. The ash content was calculated as follows:

$$\%\ \text{Ash Content} = \frac{(\text{Weight of crucible plus sample after ashing- Empty Weight of Crucible})}{\text{Weight of sample before ashing}} \times 100$$

Growth parameters

Growth performance and feed utilization was calculated as following:

Weight gain=W2–W1

Specific growth rate (SGR)=100 (ln W2–ln W1)/T where W1 and W2 are the initial and final fish weight, respectively, and T is the number of days in the feeding period.

Feed conversion ratio (FCR)=Feed intake/Weight gain Protein efficiency ratio (PER)=Weight gain / Protein intake Protein productive value (PPV)=Protein gain / Protein intake

Statistical analysis

Data of growth, survival rate and proximate chemical composition of whole fish body of each strain were subjected to one-way ANOVA following Snedecor et al. [7].

Differences between means were done at the 5% probability level using Duncan's new multiple range test [8].

Results

Data in Table 1 and Figure 2 show that the highest final weight was obtained in Victoria (40.6 g/fish) followed by Kyoga (32.8 g/fish) Kayumbu strains exhibited approximately 28.7 g/fish. Similarly, weight gain and specific growth rate (SGR) exhibited the same trend. Kayumbu strain had the highest survival rate (100%) followed by Kyoga and Victoria (Table 1).

Results of feed intake, feed conversion ratio (FCR), protein efficiency ratio (PER) among the tilapia strains are shown (Table 2).

The Victoria strain (47.8 g feed/fish) had significantly higher feed intake and PER than all the other strains. Kyoga and Kayumbu strains were comparable in terms of feed intake. However, the Kayumbu strain had the least PER (2.46). The lowest FCR value was obtained in Kayumbu strain (1.67), while the higher ones were obtained in Kyoga and Victoria strains 1.82 and 1.78 respectively).

Tilapia strains	Final weight (g/fish)	Weight gain (g/fish)	Survival rate (%)
Kyoga	34.8 ± 0.3	22.6 ± 0.4	96.7 ± 2.04
Victoria	40.6 ± 0.3	28.3 ± 0.4	93.3 ± 2.04
Kayumbu	31.5 ± 0.3	19.6 ± 0.4	100.0 ± 0.4

Table 1: Growth performance of different strains of Nile tilapia, *O. niloticus* fed diets containing 35% crude protein.

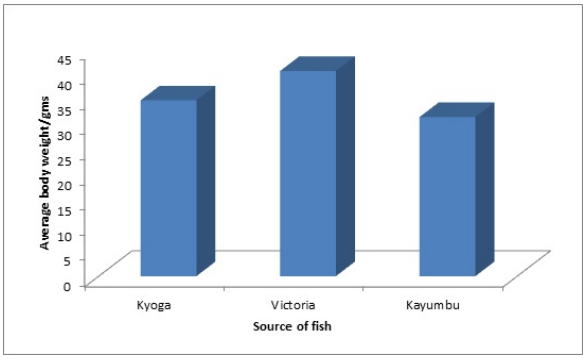

Figure 2: Changes in live body weight (g/fish) of different strains of Nile tilapia (*O. niloticus*) fed diet containing 35% crude protein.

Tilapia strains	Feed intake (g/fish)	FCR	PER
Kyoga	41.4 ± 1.2	1.82 ± 0.06	2.51 ± 0.04
Victoria	47.8 ± 1.2	1.78 ± 0.06	2.69 ± 0.04
Kayumbu	37.4 ± 1.2	1.67 ± 0.06	2.46 ± 0.04

Table 2: Feed intake, feed conversion ratio (FCR) and protein efficiency ratio (PER) of different strains of Nile tilapia; *O. niloticus* fed diet containing 35% crude protein.

Tilapia strains	Item				Crude fiber
	Dry matter	Crude protein	Crude fat	Ash	
Kyoga	98.70 ± 0.1	64.50 ± 0.2	8.50 ± 0.6	8.50 ± 0.3	2.51 ± 0.3
Victoria	98.70 ± 0.1	69.30 ± 0.2	9.90 ± 0.2	17.10 ± 0.3	2.92 ± 0.3
Kayumbu	98.80 ± 0.1	68.12 ± 0.2	11.70 ± 0.2	11.70 ± 0.3	2.88 ± 0.3

Table 3: Carcass proximate chemical analyses (mean ± SE) of different strains of Nile tilapia; *O. niloticus* fed diets containing 35% crude protein.

Results of body composition of each fish strain fed diet containing 35% CP are summarized in Table 3. Lake Victoria strain had the highest crude protein content (69.30%) followed by Kayumbu strains (68.12%) whereas the less protein content was observed with Kyoga strain (64.51%). On the other hand, fish body of Kayumbu strains contained higher values of crude fat (11.70% followed by Victoria strain (9.90%) while Kyoga strain had the least crude lipid (8.50%).

Discussion

The results from the study indicated significant differences of growth rate and final body weight of the three tilapias. The body weight differences might be due to strain differences in genetic makeup, culture conditions used and feed diets whiles in natural environment of the fish. The superiority in growth performance shown by Victoria strains compared to the other strains in the study is supported by the literature [9].

A number of studies in recent years have demonstrated that there are large differences in the relative culture performance of different populations and strains of tilapia across a range of different environments [2,10].

The findings showed that the best performing strain in terms of growth performance was the Lake Victoria followed by Kyoga while the strain from Kayumbu was the least in terms of growth performance (Table 1). The good performance of the Lake Victoria and Kyoga strain is probably attributed to the environmental factors like oxygen levels, temperature variations and genetic constitution of the fish strains. The fish finds itself into Lake Victoria, which allows for genetic exchange between the different stocks of the species leading to higher genetic diversity. Environmentally, Lake Victoria is served by many tributaries, rivers and basins that bring in fish into the lake from different places of the catchment. Macaranas et al. [11] reported on comparison of genetic changes in brood-stocks of five cultured fish species and showed them to be influenced by the intensity of selection pressure and/or history of culture.

The cosmopolitanism movements allows for genetic exchange between the different stocks of the strains leading to higher genetic diversity. Lakes Victoria and Kyoga are productive lakes that are threatened with eutrophication, so tilapias next to the primary trophic level do not have to invest a lot of energy in hunting for food. This probably explains why Victoria and Kyoga strains performed best in growth rate compared to the Kayumbu which is less productive.

The strain from Kayumbu had the highest FCR followed by the strains from lakes Victoria and Kyoga in that order (Table 3). The high FCR of the Kayumbu strain could be attributed to the fact that it was well acclimatized to the cold conditions of the zone compared to other species from the warmer zones of the country.

Based on the FCR, Growth rate and PER, the findings indicate that the best performing strain was Lake Victoria strain followed by Lake Kyoga Strain and finally Kayumbu strain. The poor performance of the Kayumbu strain could be attributed to inbreeding caused by limited space as a result of genetic drift while in the wild and natural environment. The lake being small and shallow has few inlets and outlets which make the fish to inbreed within themselves compared to the open waters of Victoria and Kyoga.

The high protein efficiency ratio for the Kayumbu strain is most probably attributed to the fact that the strain's environmental conditions blends well with the captivity for culture in ponds since the Kayumbu strain was captured from the minor lake within SWHAEZ making it well acclimatized to feeding in captivity and good utilization of proteins in the fish feeds [12]. The difference in the protein efficiency ratio among the fish strains is probably attributed to the differences in environment of the sources of these strains.

The results in the present study indicated that crude protein (CP) content was higher in all strains with Victoria strain having the highest value. The diet used in the experiment contained fish meal (35%) crude protein. As reported by Kwikiriza et al. [13] fish meal protein in the diet does not alter proteins of the fish, therefore, significant differences observed for CP might be due to the source of the strain and its natural environment. The findings in the present study are lower than the observations reported by Kumar et al. [12] (70.4%) for *O. niloticus*. The differences could be attributed to the environmental and culture conditions of the brood-stock. Differences in nutritional components of the fish could be as a result of the rate at which these components are available in the particular water body [14]. The capacity of the fish to absorb and assimilate the essential nutrients from the harvest water where they habitat or the available diet could also vary the nutrient composition of the fish strains [15]. The nutritional components of freshwater fish differ between geographical localities [16]. The flesh lipid is controlled by the available nutrition [17] the feeding frequency, sex, and maturity of the fish [18-23]. The minerals composition of fish body is determined by the harvest waters [24-26]. The concentration of minerals in the harvest waters influences the content of those minerals in the habitat fish [27].

Conclusion

Crossing between the different identified strains while selecting for fast growth and lower FCR, we expect to greatly improve the performance of resultant progeny mostly form Victoria strain and Kayumbu strain. These improved strains when distributed to seed multipliers and farmers will greatly improve fish production and productivity and consequently have a positive impact on the livelihoods of the farmers.

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