Evaluation of Performance of Different Tilapia Species

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ABSTRACT

A growth trial was carried out for 90 days to compare the growth performance and survival rate of Nile tilapia (*Oreochromis niloticus)* and Jipe tilapia (*Oreochromis jipe*), Wami tilapia (*Oreochromis urolepis hornorum)* and Ruvuma tilapia *(Oreochromis ruvumae)*.. The study was conducted on-station at Sokoine University of Agriculture (SUA) and on-farm in ponds of small-scale fish farmers at Mkuyuni, Morogoro, Tanzania. In the on-farm experiment, the mean final weight, weight gain, growth rate, final length and final width differed significantly ($P<0.001$) among the species. Nile tilapia (*O. niloticus*) gained more weight (61.3g) than *O. hornorum* (35.3g) *and O. ruvumae* (13.8g). The final weight, length and width of *O. niloticus* exceeded that of *O. hornorum* by 26.2g, 2.4cm and 0.7cm, respectively. The mean final weight, length and width of *O. hornorum* were higher than those of *O. ruvumae* by 23.6g, 2.7cm and 1cm, respectively.

The results from the on-station experiment showed that there was no significant ($P>0.05$) difference between *O. niloticus* and *O. hornorum*, but the two species differed significantly ($P<0.01$) from *O. ruvumae* and *O. jipe*. The *O. niloticus* had the highest weight gain (24.2 g), growth rate (0.3g/d), final length (11.5cm) and final width (3.3cm) and it was followed by *O. hornorum.* The *O. ruvumae* and *O. jipe* showed poor performance in all parameters. The growth performances of *O. niloticus* and *O. hornorum* were significantly ($P<0.05$) higher in the on-farm experiment than in the on-station experiment, but that of *O. ruvumae* were not significantly ($P\geq0.05$) different between the two locations. The highest survival rates (85.6% (on-farm) and 100% (on-station)) were observed on *O. niloticus*, followed by *O. ruvumae*. *Oreochromis urolepis hornorum* had the lowest survival rate (63.5 – 66.7%) in both experiments. For all species, fish reared at the on-station showed higher survival rate (66.7 – 100%) compared to those reared in farmers' ponds (63.5 – 85.6%).

The results for chemical composition of the fish bodies indicated that the species did not differ significantly in dry matter (DM) and ash contents, but differed significantly ($P<0.05$) in crude protein (CP) and fat (EE) contents for the on-farm experiment. *Oreochromis urolepis hornorum* had the highest CP content (58.09%) and EE (30.12%) while *O. niloticus* had the lowest values (52.23% CP and 16.83% EE). For the on-station experiment, the DM, CP and ash contents of the species were not significantly ($P\geq0.05$) different. It is concluded that *Oreochromis niloticus* is superior to *Oreochromis urolepis hornorum, Oreochromis jipe*, and *Oreochromis ruvumae* in terms of growth performance and survival rate.

INTRODUCTION

Aquaculture in Tanzania started in the 1950's with the pond culture of the tilapia species native to the region, including Mozambique tilapia (*Oreochromis mossambicus*), Nile tilapia (*Oreochromis niloticus*) and Zanzibar tilapia (*Oreochromis urolepis hornorum*) (Rice *et al*., 2006). Other species which have been used commercially in Aquaculture include *O. urolepis hornorum* originating from the Wami river of north-central Tanzania and *O. karongae* native to Lake Nyasa (Lake Malawi). At the moment, more than 95% of the farmers culture Nile tilapia (*Oreochromis niloticus*) in earthen ponds under mixed-sex culture (Kaliba *et al*., 2006). Pond culture of Nile tilapia is now viewed as a possible source of livelihood for farmers residing in proximity to the urban markets of cities and towns. The emphasis of the national fisheries policy (URT, 1997) is on a semi-intensive integrated mode of fish culture, focusing on Nile tilapia. The Nile tilapia is given first priority due to their better characteristics that include fast growth, short food chain, efficient conversion of food, high fecundity (which provides opportunity for distribution of fingerlings from farmer to farmer), tolerance to a wide range of environmental parameters, and good product quality (Hussain *et al*., 2000; Neves *et al*., 2008).

In Tanzania, fish farmers obtain fingerlings from government fry centres and fisheries institutes. Some fish farmers produce their own fingerlings and sell them to other farmers. Because of the lack of controlled breeding, most ponds in the country are yielding only small-sized tilapia and production of fish is not encouraging. Quite a number of farmers feel that their fish are small due to stunted growth, and this is discouraging them from continuing with fish farming operations. Therefore, there is a need for bio-prospecting for various species of tilapia to identify the species suitable for aquaculture in Tanzania. Because Tanzania is a region with very high natural tilapiine fish diversity (Rice *et al*., 2006), the ability to tap into the diverse natural pool of tilapiine fish genes is very important. This study was intended to evaluate the productive performance (growth rate, feed conversion ratio and market body weight) of different species of tilapia.

The objectives of the study were;

1. To compare the performance (growth rate, survival, feed conversion ratio and mature body size) of different species of Nile tilapia
2. To carry out economic analysis of raising the different species
3. To determine the management requirements of the best tilapia species identified under objectives one and two.
4. To train farmers on the proper methods to culture the improved tilapia species.

MATERIALS AND METHODS

Study location and experimental Fish

Growth performances of Nile tilapia (*Oreochromis niloticus)*, Jipe tilapia (*Oreochromis jipe*), Wami tilapia (*Oreochromis urolepis hornorum)* and Ruvuma tilapia *(Oreochromis ruvumae)* were studied. The study was undertaken on-station in ponds at Sokoine University of Agriculture (SUA) and on-farm in ponds of small-scale fish farmers at Chang'a and Kibwaya villages in Mkuyuni division, Morogoro rural district, Tanzania. Nile tilapia (*Oreochromis niloticus*) fingerlings were collected from Kingolwira Fish Farming Centre. The fingerlings of *Oreochromis jipe* were collected from Lake Jipe in Mwanga district while *Oreochromis urolepis hornorum* and *Oreochromis ruvumae* were collected from river Wami at Dakawa sub-town, Mvomero district and river Ruvuma at Litapwasi village, Songea district, respectively. The fingerlings were collected from their respective sources and brought to SUA. At SUA the fingerlings of each species were kept separately in concrete tanks prior to the start of the experiment**.**

Experimental procedure

The experiment was conducted for 90 days, from April to July 2011. For the on–station experiment, two

earthen ponds (300 m^2 each) were used and each pond was fitted with four hapas of 6 m^2 surface area and one meter depth each. In total eight hapas were used and each tilapia species was allocated to one hapa in each pond at random. Prior to commencement of the experiment the ponds were drained, cleaned and allowed to dry for one week. Then the hapas were set and the ponds were refilled with water and poultry manure was added at a rate of 7.5 kg per pond. Stocking density was 2 fingerlings per m^2 in each hapa. All Fish in the hapas were supplemented daily with concentrate comprised of soybean meal (40%), maize bran (59%) and mineral (1%). The concentrate diet was provided at a level of 10 %, 7% and 5% of fish biomass during the first month, second month and third month of the experiment, respectively. Body weights of fish were measured using a digital weighing balance at the start of the experiment and then at monthly intervals for a period of 90 days. Similarly body length and width were measured at the beginning of the experiment and then at monthly intervals by using a measuring board with a ruler. Water quality parameters were measured at weekly intervals. Temperature and dissolved oxygen (DO) were measured by using YSI 55 instrument; water pH, nitrate, nitrite by using JBL Easy Test strips and water transparency by using secchi disk. The experiment was completed on 20th July 2011.

For the on–farm experiment, a total of six farmers from Chang'a and Kibwaya villages participated in the experiment. Each species of tilapia was distributed to two different farmers, making two replications for each species. The pond size varied from farmer to farmer and ranged between 50 m^2 and 200 m^2. The ponds were filled with water by using channels available in the villages and fertilized by using farm yard manure. The fingerlings were stocked at a density of 2 fish per m^2 in each pond. The farmers provided supplementary feeds to their fish. The supplementary feeds included maize bran, vegetables and kitchen left overs that were obtained within the farmers' homesteads. Body measurements (weight, length and width) of fish and water quality parameters were measured as in the on-station experiment, at the start of the experiment and then at monthly intervals. The experiment was completed on 19th July 2011.

In both experiments growth parameters that were determined included body weight gain (W_1- W_0) and average daily body weight gain (W_1 -W_0)/t, expressed as weight gain per fish per day, whereby W_0 and W_1 are initial weight and final weight, respectively, and t is time interval in days. Survival rate was calculated as ((N- D)/N) x 100, where by N is total number of fish stocked and D is number of fish died.

The profitability of raising each species was computed using Gross Margin Analysis as follows:

GM = TR – TVC

Where:
GM = Gross margin
TR = Total revenue (Sales from fish)
TVC = Total variable costs (Costs of feeds, fingerlings, transport and labour)

Data analysis

The data were analyzed using the General Linear Model (GLM) of the Statistical Analysis System (SAS 1998) software. The effect of species on body weight, body length, body width and growth rate of the fish was tested. Factors tested were species, location and their interactions. Initial body measurements were used as a covariate during the analysis of growth data. Descriptive statistics were generated for water quality parameters. The Chi-Square (χ^2) test was used to assess the effect of species on survival rate of the fish.

RESULTS

The water quality parameters that were measured in this study include water temperature, Dissolved oxygen, pH, nitrite and nitrate and their mean values during the experimental period are shown in Table 6.

The results show that water pH and transparency differed significantly (P<0.01) between on - farm and on – station, but there were no significant differences between on-station and on-farm water temperature, nitrate and nitrite values. Generally the observed values were within the optimal range that has been recommended for normal tilapia growth.

The results for growth performance and survival rate of the three tilapia species (*O. ruvumae, O. hornorum and O. niloticus*) for both on-farm and on-station experiments are show in Table 7. Growth performance is indicated by final weight, weight gain, growth rate, final length and final width of the fish. For the on-farm experiment the mean final weight, weight gain, growth rate, final length, increase in length and final width differed significantly (P<0.001) among the species. Nile tilapia (*O. niloticus*) gained more weight (61.3 g) than *O. hornorum* (35.3 g) *and O. ruvumae* (13.8 g). The final weight, length and width of *O. niloticus* exceeded that of *O. hornorum* by 26.2 g, 2.4 cm and 0.7 cm, respectively. On the other hand the mean final weight, length and width of *O. hornorum* were higher than those of *O. ruvumae* by 23.6 g, 2.7 cm and 1 cm, respectively. For the on-station experiment the analysis of variance showed that there was no significant (P>0.05) difference between *O. niloticus* and *O. hornorum*, but the two species differed significantly (P<0.01) from *O. ruvumae*. As for the on-farm experiment, the *O. niloticus* had the highest final weight (26.7 g), weight gain (24.2 g), growth rate (0.3 g/d), final length (11.5 cm) and final width (3.3 cm) and it was followed by *O. hornorum.* The *O. ruvumae* showed poor performance in all parameters.

When the results for on-farm and on-station experiments were compared, the analysis of variance showed that location influenced significantly (P<0.05) the growth performance of the fish throughout the study period. The growth performances of *O. niloticus* and *O. hornorum* were significantly (P<0.05) higher in the on-farm experiment than in the on-station experiment, but that of *O. ruvumae* were not significantly different between the two locations. The values observed in the on-farm experiment for final weight, weight gain, growth rate, final length and width exceeded the values observed in the on-station experiment by 40.9 g, 37.1 g, 0.4 g/d, 3.6 cm and 1.2 cm, respectively for *O. niloticus. For O .hornorum* the on-farm values were higher by 14.8 g, 13.5 g, 0.16 g/d, 0.6 cm and 0.4 cm than the on-station values for final weight, weight gain, growth rate, final length and width, respectively.

Table 7 also shows the results for survival rate. Survival of the fish was significantly influenced by the species and location. In both experiments the highest survival rate (85.6% (on-farm) and 100% (on-station)) was observed on *O. niloticus*, followed by *O. ruvumae*. *Oreochromis urolepis hornorum* had the lowest survival rate (63.5 – 66.7%) in both experiments. For all species, fish reared at the on-station showed the higher survival rate (66.7 – 100%) compared to those reared in farmers' ponds (63.5 – 85.6%).

A total of three fish from each species were analyzed for chemical composition of their bodies. The results for chemical composition of the fish are indicated in Table 8 below. For the on-farm experiment the species did not differ significantly in dry matter and ash contents, but differed significantly in crude protein and fat contents. *Oreochromis hornorum* had the highest CP content (58.09%) and ether extract (30.12%) while *O. niloticus* had the lowest values (52.23% CP and 16.83% EE). For the on-station experiment the DM, CP and ash contents of the species were not significantly different. The CP content was slightly higher in *O. niloticus* (62.86%) and lower in *O. ruvumae* (56.3%). On fat content, *O. hornorum* had significantly higher EE (36.75%) compared to the other species which had EE contents between 16.92 (*O. niloticus*) and 18.77% (*O. ruvumae*). *Oreochromis niloticus* showed significant (P<0.05) difference in CP contents between the fish reared on-farm (52.23%) and on-station (62.89).

The results for economic analysis (Table 4) revealed that the highest total revenues per ha from sales of fish was observed on farmers who were raising *O. niloticus* (TZS 6,086,250.00 ≈ US$ 3518.06) while the farmers who culture *O. ruvumae* had the lowest revenue (TZS 1,584,000.00 ≈ US$ 915.61). Likewise the

highest variable costs per ha (2,577,280.00 ≈ US$ 1460.86) was found on fish ponds of the farmers who cultured *O. niloticus* while those who cultured *O. ruvumae* had the lowest variable cost (2,359,080.00 ≈ US$ 1363.63). The farmers who cultured *O. niloticus* had the highest profit per ha (3,558,970.00 ≈ US$ 2,057.21), followed by those who cultured *O. hornorum* (1,262,320.00 ≈ US$ 729.67). The culture of *O. ruvumae* resulted into a loss of TZS 775,080.00 (≈ US$ 448.02) per ha.

CONCLUSIONS

1. The Nile tilapia (*Oreochromis niloticus)* is superior to Jipe tilapia (*Oreochromis jipe*), Wami tilapia (*Oreochromis urolepis hornorum)* and Ruvuma tilapia *(Oreochromis ruvumae)* in terms of growth performance and survival rate.
2. The Wami tilapia (*Oreochromis urolepis hornorum)* is better than the other species (*Oreochromis jipe* and *Oreochromis ruvumae)* and can be cultured in ponds and give performace like that of Nile tilapia.
3. The culture of Nile tilapia (*O.niloticus*) in small-scale fish ponds is more profitable than the culture of Wami tilapia (*O. hornorum*) and Ruvuma tilapia (*O. ruvumae*).
4. Instead of looking for other tilapia species to replace the Nile tilapia, other means of improving the performance of the Nile tilapia should be sought, including selective breeding and better feeding.

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Table 1: Water quality parameters in the experimental fish ponds

Variable	**On – Farm Mean values**	**On–station – Mean values**
Temperature ^{0}C	25.1 ± 1.3	25.2 ± 2.0
DO	5.14 ± 1.4	5.4 ± 1.0
pH	7.4 ± 0.7	6.7 ± 0.2
Transparency	34.4 ± 8.2	42.2 ± 7.6
Nitrate	0-0.5	0-0.5
Nitrite	0-10	0-10

Table 2: Comparison of growth performance (mean ± se) of different tilapia species reared on-station and on-farm

Variable	**On–farm Species**			**On–station Species**			
	Oreochromis urolepis hornorum	*Oreochromis niloticus*	*Oreochromis ruvumae*	*Oreochromis urolepis hornorum*	*Oreochromis niloticus*	*Oreochromis ruvumae*	*Oreochromis jipe*
FnWt (g)	41.2±2.4^{b}	67.6±2.4^{a}	17.6±2.4^{d}	26.4±3.8^{c}	26.7±3.1^{c}	23.4±3.2^{cd}	16.3±2.0^{d}
Wt gain (g)	35.3±2.5^{b}	61.3±2.5^{a}	13.8±2.5^{d}	21.8±4.0^{c}	24.2±3.2^{c}	17.4±3.3^{cd}	12.3±2.0^{d}
GR (g/d)	0.4±0.03^{b}	0.7±0.03^{a}	0.15±0.03^{d}	0.24±0.04^{c}	0.3±0.04^{c}	0.2±0.04^{cd}	0.14±0.02^{d}
SGR	2.04±0.14^{a}	2.2±0.14^{a}	1.61±0.14^{b}	2.0±0.22^{a}	2.4±0.2^{a}	1.23±0.2^{b}	1.5±0.1^{b}
FnL (cm)	12.7±0.2^{b}	15.1±0.2^{a}	10.0±0.2^{d}	12.1±0.4^{b}	11.5±0.3^{bc}	11.0±0.3^{c}	10.15±0.3^{c}
FnWD (cm)	3.8±0.1^{b}	4.5±0.1^{a}	2.8±0.1^{d}	3.4±0.1^{c}	3.3±0.1^{c}	3.0±0.1^{d}	2.7±0.1^{d}
Length gain (cm)	6.0±0.3^{b}	8.5±0.3^{a}	4.1±0.3^{c}	6.0±0.5^{b}	6.3±0.4^{b}	4.0±0.5^{c}	
Survival rate (%)	63.5	85.6	78.0	66.7	100	95.8	95.8

Table 3: Comparison of chemical composition (mean ± sd) of different tilapia species reared on-station and on-farm

Location	Species	DM (%)	CP (%)	EE (%)	Ash (%)
On - farm	*O.niloticus*	27.99±3.13[a]	52.23±2.7[b]	16.83±1.64[b]	13.27±1.37[a]
On – farm	*O.hornorum*	25.59±1.95[a]	58.09±1.2[a]	30.12±10.86[a]	14.46±1.53[a]
On - farm	*O.ruvumae*	30.74±0.48[a]	53.15±0.66[b]	17.9±2.83[b]	13.56±0.28[a]
On - station	*O.niloticus*	33.83±8.49[a]	62.86±3.91[a]	16.92±2.8[b]	14.08±0.30[a]
On – station	*O.hornorum*	27.50±1.92[a]	55.86±5.88[a]	39.75±4.45[a]	15.80±0.28[a]
On – station	*O. ruvumae*	29.35±3.4[a]	56.30±5.23[a]	18.77±3.92[b]	14.40±2.12[a]
On - station	*O.jipe*	25.76±1.17[a]	61.46±1.09[a]	17.46±1.15[b]	14.92±0.57[a]

Table 4: Gross margin analysis of the different tilapia species cultured in ponds of small-scale farmers

Parameter	**Species**		
	O.niloticus	*O.hornorum*	*O.ruvumae*
Fingerlings costs/ha	1,600,000.00	1,600,000.00	1,600,000.00
Feed costs/ha	237,280.00	155,680.00	69,080.00
Labour/ha	540,000.00	540,000.00	540,000.00
Transport	150,000.00	150,000.00	150,000.00
Total variable costs/ha	2,527,280.00	2,445,680.00	2,359,080.00
Fish yield, kg/ha	1352.50	824.00	352.00
Fish price/kg	4500	4500	4500
Total revenue/ha from sales of fish	6,086,250.00	3,708,000.00	1,584,000.00
Profit/ha	3,558,970.00	1,262,320.00	-775,080.00

Note: The costs and revenue are computed in Tanzanian shillings (1730 TZS = 1 US$)