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Role of Salinity on Growth Performance of *Oreochromis niloticus*♀ and *Oreochromis urolepis urolepis*♂ Hybrids

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Abstract

Influence of salinity on hybrids descended from *O. niloticus*♀ and *O. urolepis urolepis*♂ was investigated for 63 days. A total of 120 fry of 0.29 ± 0.01g were stocked in 1m³ plastic tanks at a density of 10 fish/m³ per tank. The experiment involved three salinity treatments 15, 25 and 35 with fresh water (2 salinity units) as control. The hybrids were fed on a balanced diet of 40% crude protein at 5% body weight twice a day. Water quality parameters were measured once a week. However, results on SGR, average weight gain and survival rate were not significantly affected by salinity (p>0.05). FCR differed significantly among treatments (p<0.05). The 25 Practical Salinity Unit (PSU) showed better growth performance than other treatments. Surprisingly all treatments showed better growth than control. When examined at the end of the study all hybrids were found to be 100% males. Length-weight relationship "b" values and condition factor "K" showed that hybrids had isometric growth, good health and were properly managed. It was concluded that if proper management is followed, the studied hybrids can be good candidates in both intensive and semi intensive mariculture by coastal people. The hybrids can solve the problem of stunted growth, be an alternative to the use of hormones in sex reversal.

Keywords: Hybrids; Mariculture; Growth performance; Salinity; All males

Introduction

Salinity is defined as the sum of all ions in water which comprises mainly of sodium, chloride, calcium, magnesium, potassium, bicarbonate and sulfate ions [1]. Salinity is a vital water quality parameter for fish growth [2]. Küçük et al. reported on retarded fish growth at different saline conditions. Fish in marine or freshwater environments use energy to hold ions in or off their bodies respectively through osmoregulation [1]. Some studies indicate better fish growth in brackish water than Full Strength Sea Water (FSSW) and fresh water [3-6]. However, the salinity acclimation process forces fish to undergo endocronological, morphological and biochemical changes [1]. The modifications interrupt both energy and oxygen intake in fish. Some experiments were conducted on length-weight relationship and condition factor for *Tilapia zilli* and *O. urolepis urolepis* at FSSW and fresh water [7], effect of different salinities on growth and survival of *O. niloticus* [8] and *Oreochromis aureus* [1] (Küçük et al. 2013). Yet no attempt has been made to assess effect of salinity on *O. niloticus*♀ x *O. urolepis urolepis*♂ hybrids growth performance. There is a general agreement that hybrids derived from salinity tolerant parents are salinity tolerant [9]. Also, *O. niloticus* has proven high growth and bigger size at maturity among tilapiine species while *O. urolepis urolepis* has high salinity tolerance but low growth rates at maturity. Therefore, hybrids are expected to have high growth rates and salinity tolerance than their parents. This study investigated the effect of different salinity levels on growth performance of the hybrids between *O. niloticus* females and *O. urolepis urolepis* males. The aim was to produce all male fish tolerant to varying salinity conditions for improvement of aquaculture along the Tanzanian coastline through intensive and semi intensive mariculture.

Materials and Methods

Description of the study site

This study was conducted at the Institute of Marine Sciences Mariculture Centre (IMS-MC) at Bweni village, Pangani District in Tanga Region, Tanzania (05° 26′ 0″ S and 38° 58′ 0″ E, Figure 1). Local communities' main economic activities involve fishing, seaweed aquaculture and subsistence agriculture. The site is drained by Pangani River whose basin is bordered by the Kilimanjaro and Meru Mountains and Pare and Usambara Mountain Ranges. It is well endowed with several species of terrestrial and marine ecosystems including mangroves. The Pangani River has a diversity of tilapia species including *O. pangani korogwe, O. pangani pangani*, *O. Variabilis, T. rendalli and T. zillii*. Pangani is characterized by annual rainfall of above 1000 mm with temperature varying between 25°C and 30°C. The climate is generally warm and wet annually. The *O. urolepis urolepis* and *O. niloticus* broodstocks were collected from Rufiji River in the Central Eastern Tanzania draining into Indian Ocean and Lake Victoria in Mwanza respectively.

Experimental design and hybrids stocking

An experiment with three levels of salinity was conducted. The experiment was replicated three times making a total of 12 tanks including the controls. A total of 120 fry were batch weighed prior to stocking and randomly distributed at 10 fish per tank. The initial average weights were found to be 0.29 ± 0.01g per treatment. Acclimation to different salinities was done through daily increments of 2 PSU [7] for 17 days before the start of experiment (Figure 2). Water quality parameters were measured before and after sea water addition in tanks. Furthermore, pH and temperature measured by HI8424 pH meter, salinity by Digital Hand Held Marine Tester DMT-10 and DO by a Dissolved Oxygen Meter PDO-520 were measured once a week.

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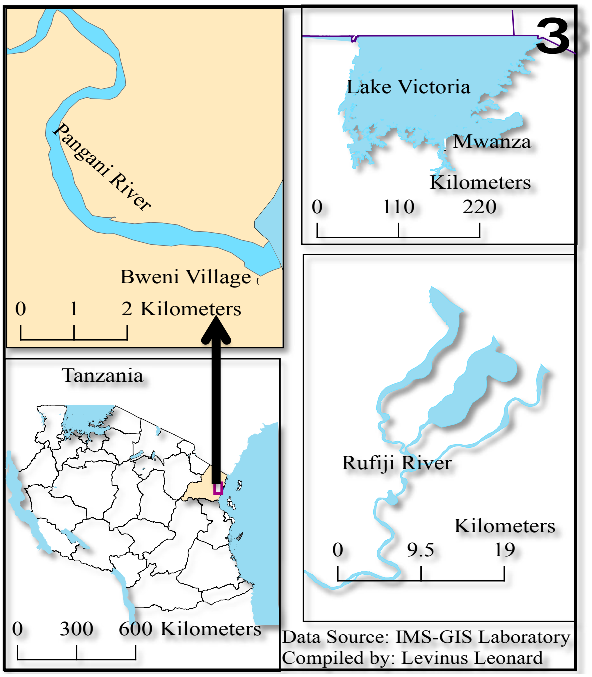

Figure 1: Maps showing of Rufiji River and Lake Victoria which are the brood stock sources and Pangani River the experimental site.

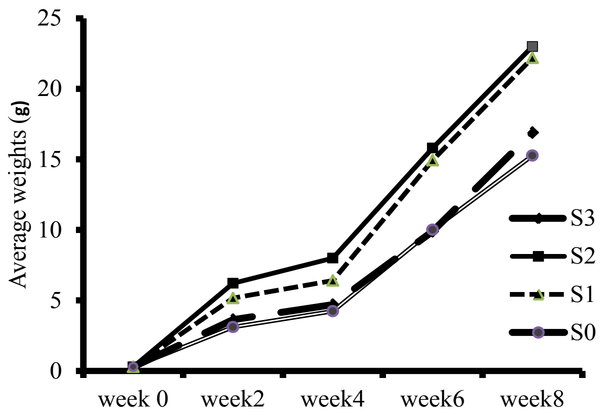

Figure 2: Changes in weight at different salinities (S0, S1, S2 and S3 = 2, 15, 25 and 35 practical salinity units respectively.

The 15 low, 25 intermediate and 35 high salinity treatments were used to determine salinity influence on fish growth (Figure 3). Fresh water at 2 PSU was used as control. A 40% crude protein basal diet composed of maize flour, cassava flour, vitamins (Premix), cotton seed cake, shrimp and fish meals was formulated and used to feed the hybrids. Fresh sardine and shrimp used as fish meal were obtained from local fisherfolk, sundried and milled. The meat mincer machine was used to prepare pelleted food. Hybrids were fed at 5% body weight twice a day. Adjustment in feeding was made subject to fish biomass increment throughout the experiment. Five individuals were sampled and their total lengths and weights measured every fortnight. Total weights were measured using a digital balance (BOECO BEB 61) while total lengths were measured using a measuring board fixed with a 30 cm ruler. However, the hybrids were not fed 24 hours prior to sampling. Water quality control was done by replacement of 20% water in tanks once a week while siphoning was done twice a week. The experiment was completed in 63 days.

Determination of hybrids' growth performance

Growth performance was determined using the following fish growth parameters;

$$\text{Specific Growth Rate (\% day}^{-1}\text{)} = \left[\frac{\ln W_f - \ln W_i}{T}\right] x100 \quad (1)$$

$$\text{Food Conversion Ratio (FCR)} = \frac{\textit{Total feed intake by fish (gram)}}{\textit{Total weight gain by fish (gram)}} \quad (2)$$

$$\text{Survival Rate (\%)} = \left[\frac{N_f}{N_i}\right] x100 \quad (3)$$

$$\text{Weight Gain (g)} = W_f - W_i \quad (4)$$

Where, T is the number of days of the experiment, W_i and W_f are the initial and final mean body weights and N_f, N_i are the numbers of harvested and stocked fish respectively.

$$\text{The coefficient of condition (K)} = \frac{W}{L^3} x100 \ [10] \quad (5)$$

Whereby W = Weight of individual fish (g), L = Total length of individual fish, K = condition factor

Length weight relationship was calculated as $W = a L^b$ [11] (6)

which was transformed into common logarithm as

$$\log W = \log a + b.\log L \quad (7)$$

W = Weight of fish in gram (g)

L = Total length of fish in centimeters (cm)

a = proportionality constant

b = the value obtained from the length-weight equation/coefficient of regression.

Statistical analysis

Data on hybrid weights and lengths were pooled for each salinity treatment (Figure 4). Kolmogorov–Smirnov normality tests and homoscedasticity Levene's test were done in Statistica 10 software. The data were normally distributed and behaved homoscedastically. Further, data analyses were done using one way ANOVA. Tukey test

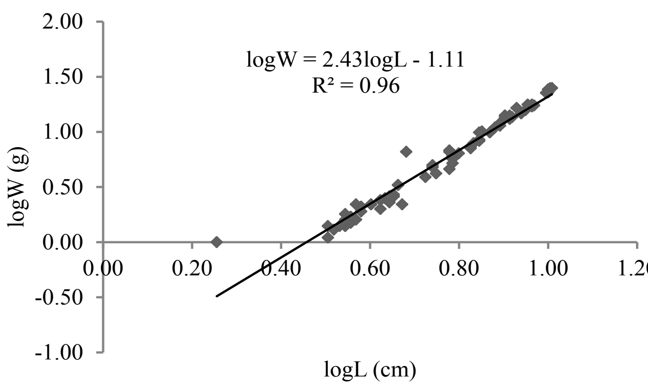

Figure 3: Hybrids L-W relationship at the salinity control.

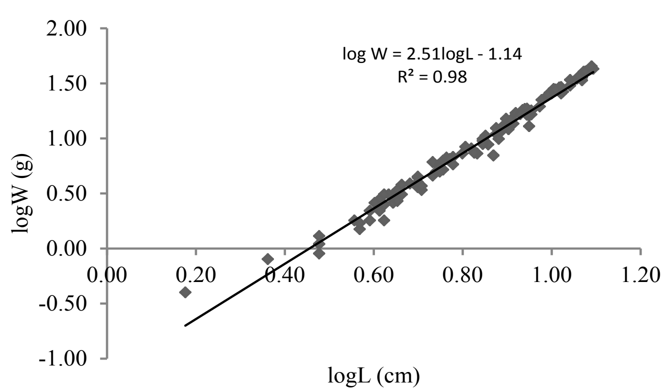

Figure 4: Hybrids L-W relationship at 15 PSU.

was used to indicate particular means that differed significantly from each other.

Results

Water quality parameters

Temperature ranged from 25-28°C across all salinity treatments. However, temperature did not vary significantly among the treatments ($p>0.05$, Table 1). Also, dissolved oxygen ranged from 6.1-6.6 mg/l but was not significantly different across the treatments ($p>0.05$, Table 1). Likewise, pH values ranged from 7-7.9 and was not significantly affected by salinity ($p>0.05$, Table 1).

Growth performance

FCR varied significantly among the treatments ($p<0.05$, Table 2). The 25 PSU recorded 1.09 FCR which was smaller compared to 3.03, 2.44, and 1.88 recorded in control, 35 and 15 PSUs respectively. However, other growth parameters SGR, survival rate and weight gain were not significantly affected among salinity treatments ($p>0.05$, Table 2). In this experiment SGR for the 25 PSU was higher than ones observe in control, 15 and 35 PSUs. The treatments recorded SGR values as 7.02, 6.35, 6.41 and 6.12 correspondingly. Meanwhile, the survival rate of 90% at 25PSU was higher than 87.16%, 85.74% and 84.63% obtained in control, 15 and 35 PSUs. Furthermore, at 25 PSU the hybrids weight gain 22.06g was slightly higher than 13.78g, 19.56g and 19.98g at the control, 15 and 35 PSUs treatments.

Length weight relationship (LWR) and condition factor

LWR studies describe fish wellbeing and effects of the environment on the fish [12]. The "b" value in regression equation indicates that fish are heavy when $b>3$, light when $b<3$ and when $b = 3$ it shows isometric fish growth [13]. Also, the authors state that fish with "b"<3 undergo negative allometric growth while ones with "b">3 undergo positive allometric growth. Furthermore, the condition factor "K" defines fish health and favourable environment for fish living [12].

In this study the coefficient of regression "b" values showed that hybrids slightly exhibited isometric growth in all salinity treatments with "b" approximately equal to 3 except the control group. The values ranged from 2.43- 2.53 (Table 3). Moreover, the determination coefficients (R^2) ranged from 0.96-0.99. The regression analyses showed strong correlation in hybrids weights and lengths at all salinity levels. Also, the correlation analyses were significant ($r = 0.96$, $p<0.001$) for control, 15 and 25 PSU whereas in the 35 PSU the analysis was significant ($r = 0.92$, $p<0.001$). On the other hand, all PSU treatments showed marginally similar condition factor (K) values ranging from 2.86-3.09. Nevertheless, the "K" values did not differ significantly among salinity treatments (Figures 5 and 6).

Discussion

Freshwater fish demonstrate high growth performance in brackish waters [14]. Besides, enhanced fish growth in brackish water was confirmed [3,5,15,16]. The studies correspond with findings of the current study whereby hybrids of *O. niloticus* and *O. urolepis urolepis* grew better at the 25 salinity than 15, 35 salinities and control. Despite using hybrids in which *O. urolepis urolepis* parents had lower growth rates than *O. niloticus* in this study, growth performance was similar to those in the previous studies. However, the present results differ from [17] who reported high growth in control than saline water for hybrids reared in concrete tanks at Pangani Tanzania. The improved growth may be due to added energy derived from osmoregulatory processes due to reduction in use of energy for osmoregulation in brackish water [1], the energy which can be spent in growth instead. Furthermore, hybrids had better survival rate in saline water where *O. niloticus* has low survival and growth rates (Personal observation). Also, increasing salinity in fresh water improves tilapia growth rate [5,18]. Meanwhile, other studies indicate that lowering salinity from marine to brackish water promotes fish growth [15,16]. However, each species has an optimum salinity at which it grows best. In this study

Parameters	Salinity treatments				
	15	25	35	2 (Control)	p
Temperature (°C)	27.22 ± 0.1^a	26.95 ± 0.2^a	26.94 ± 0.1^a	25.73 ± 0.11^a	0.51
Dissolved oxygen (mg/l)	6.26 ± 0.03^a	6.25 ± 0.07^a	6.48 ± 0.07^a	6.48 ± 0.07^a	0.84
pH	7.73 ± 0.06^a	7.72 ± 0.06^a	7.72 ± 0.06^a	7.76 ± 0.06^a	0.4

Table 1: One-way ANOVA results for water quality parameters of hybrids at different salinity treatments. Same superscripts in a row are not significantly different ($p > 0.05$) from each other.

Parameters	Salinity units				
	15	25	35	2 (Control)	p
Initial mean weight(g)	0.29 ± 0.5^a	0.29 ± 0.5^a	0.29 ± 0.5^a	0.29 ± 0.5^a	0.64
Final mean weight (g)	19.85 ± 4.4^a	22.35 ± 8.1^a	20.27 ± 7.4^a	13.78 ± 9.4^a	0.7
Yield (g)	1375	1443	1054	565	-
Weight Gain (g)	19.5 6± 5.4^a	22.06 ± 7^a	19.98 ± 7.9^a	13.59 ± 5.7^a	0.83
Survival rate (%)	85.74 ± 19.5^a	90.68 ± 11^a	84.63 ± 19.8^a	87.16 ± 8.06^a	0.39
FCR	1.88 ± 0.0^a	1.09 ± 0.02^b	2.44 ± 0.01^c	3.03 ± 0.03^d	<0.001
SGR (%/day)	6.41 ± 0.68^a	7.02 ± 0.63^a	6.12 ± 0.65^a	6.35 ± 0.98^a	0.68
Maximum weight (g)	45.2	47.2	37.6	25	-

Table 2: Average initial and final body weights, weight gain, food conversion ratio, survival and specific growth rates of hybrids at different salinities. Means with different superscripts in a row are significantly different $p<0.05$ (Tukey test) from each other.

Salinity levels	L-W Relationship			
	a	b	R^2	Mean K
Control	-1.11	2.43	0.96	3.09
15	-1.14	2.51	0.98	2.99
25	-1.14	2.50	0.99	2.86
35	-1.16	2.53	0.98	3.07

Table 3: Parameters for hybrids length-weight relationship at different salinities treatments.

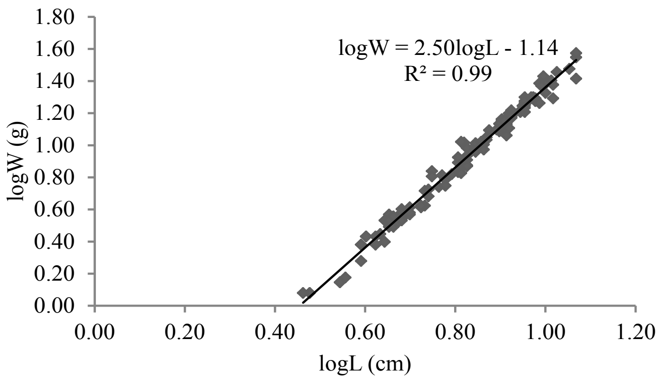

Figure 5: Hybrids L-W relationship at 25 PSU.

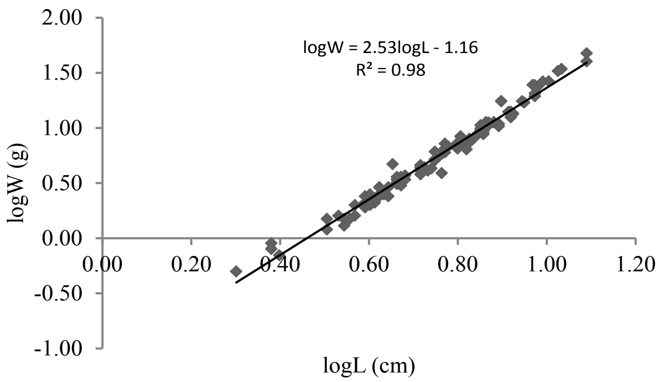

Figure 6: Hybrids L-W relationship at 35 PSU.

25 salinity was found optimum for hybrids growth based on SGR, FCR, survival, and average final weight. That salinity level is near the isosmotic between fish and the environment [19]. Similarly, observed optimal growth at 10-20 salinity range for TGGG grouper hybrids. Salt tolerance depends on species, strain, size, acclimation time and environmental factors [20]. Poor performance at 35 salinity may be due to increased osmoregulation [19] (Othman et al. 2015) and loss of appetite [21]. Furthermore, high salinity is associated with changes in blood chemistry like total protein and chloride ions [1] and increased metabolic rates [19] which may inhibit growth. Overall the hybrids growth performance was not significantly affected by salinity except FCR. This may be because salinity does not have significant influence on fish growth when temperatures are above 27°C [22] corresponding to the current study's temperature records. Additionally, lower protein demands for tilapia raised in brackish and sea water than ones rose in the fresh water [9] may also be the reason for this brackish water growth performance relative to control.

FCR results of this research are in line with FCR in Azevedo et al. and [19] Othman et al. The authors documented on a significant variation in FCR for *O. niloticus* reared at different salinities in Mexico and hybrid grouper in Malaysia respectively. In the current study lower FCR was recorded at 25 salinity units. This implies that hybrids were able to consume and convert food efficiently into biomass at 25 PSU than other salinity levels. In addition, the observed SGR were higher than ones reported in [1,19] findings. Higher SGR may be due to hybrids genetic improvement inherited from both parents. Other factors could include exposure to various salinities which alters fish water ingestion modifying intestinal contents thereby affecting the activity of digestive enzymes [23]. This may impair digestion in the alimentary canal leading to poor SGR and weight gain at high salinity in this experiment. On the other hand, survival rate behaved differently from [1,5] studies. The authors described decrease in survival with increasing salinity contrary to the current results where an intermediate salinity showed higher survival rate than other treatments.

Conclusion

In this study the LWR regression coefficients "b" are in conformity with [24] who reported 2.5-3.3 ranges for *O. niloticus* at Kisii aquaculture centre in Kenya; 2.94 and 3.3 for *Tilapia zilli*, 2.81 and 3.46 for *O. urolepis urolepis* in fresh water and FSSW respectively [7] at Pangani Tanzania. The coefficients indicate that hybrids in all salinity treatments experienced isometric growth [25] and are within suggested ranges for tropical species [26]. In isometric growth both the weight and length of fish increase concurrently. Therefore, hybrids were slightly of the same size in the 15, 25 and 35 PSU being heavier than ones in the control PSU. This indicates that the habitat was supportive in hybrids growth.

The condition factor "K" values for the hybrids in this study were slightly higher than 1.02-1-12 reported for *O. niloticus* [24]; 2.07 and 0.74 for *Tilapia zilli*, 0.86 and 0.53 for *O. urolepis urolepis* in fresh water and FSSW respectively [7]. Ayoade and Ikulala [27] report that "K" greater than one describes fish isometric growth and good fish healthy which is better for aquaculture practices. The "K" specifies that different tanks salinities were environmentally conducive for hybrids growth at better management level. Also, higher values may be due to genetic improvement of the hybrids from parents and similarity in water quality parameters in all treatments.

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