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Growth and aquaculture potential of Tilapia jipe, *Oreochromis jipe* and Nile tilapia, *Oreochromis niloticus*

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Abstract
Aquaculture growth needs to be accelerated in order to bridge the gap in fish demand occasioned by the dwindling stocks in the inland fisheries in Kenya. The 84 days experiment was conducted to compare the growth performance of Jipe tilapia and Nile tilapia, using 180 fingerlings of each species stocked in 9m^2 wooden backyard ponds. Feeding was administered daily between 11.00hr and 15.00hr using floating pellets (30% CP) at 10% body weight. Total length and body weight were measured biweekly using measuring board (readability=0.01cm) and electronic balance (readability= 0.001 g) respectively, while the survivals were counted during each sampling. All statistical analyses were performed using R software and observed differences considered statistically significant at $p<0.05$. Water temperature, pH and dissolved oxygen levels were significantly different ($p<0.05$) between the two treatments. The final mean weight (12.16±0.34) of *O. jipe* was significantly ($p<0.05$) lower than the final mean weight (29.79±0.91) of *O. niloticus*. Similarly, *O. jipe* exhibited a significantly ($p<0.05$) lower specific growth rate, weight gain and growth rate compared to *O. niloticus*. The study demonstrated that Nile tilapia outperformed Jipe tilapia, therefore we recommend further growth trials to be conducted in a controlled culture environment to establish optimal growth conditions for *O. jipe* growth.

Keywords: *Oreochromis jipe*, *Oreochromis niloticus*, fish growth, culture potential

1. Introduction

The global capture fishery has declined tremendously over the years; hence, aquaculture growth needs to be embraced to reduce the fishing pressure on declining wild stocks. Aquaculture has shown great potential to bridge the gap in fish demand in efforts geared towards promoting food and nutrition security among the vulnerable groups in the Kenyan population, which grows at the rate of 3% annually [1]. Aquaculture has become one of the fastest growing food production sectors in the world [2], which accounts for more than half of the fish consumed globally [3]. Tilapias are the most preferred species for aquaculture because they grow to market demand driven sizes [4]. According to [5], Tilapia contributed 9.3% (3.5 million MT) to global aquaculture. Over 112 Tilapia species are documented but Nile tilapia, *Oreochromis niloticus*, is the most important commercial aquaculture species globally. The widespread introduction and culture of *O. niloticus* over the past decades [6] is largely attributed to a wide range of ecological and feeding adaptations exhibited, high food conversion ratio, and the ease of captive breeding [7, 8]. According to [9], freshwater aquaculture accounts for 98% (24,096 MT) of aquaculture production, which only represents 15% of total fish production nationally. Kenya is endowed with a large biodiversity of over 180 freshwater fish including native Tilapia which form the basis of inland fisheries [10]. However, fish farmers distributed across the five major drainage basins in Kenya prefer the production of Nile tilapia under semi-intensive pond culture systems because of their presumed moderate operational costs [11]. At present, Nile tilapia is the dominant species in Kenya's freshwater aquaculture contributing to 80% in the total aquaculture production [12]. Despite these unlimited resources, the potential for aquaculture growth in Kenya remains largely underexploited with aquaculture contributing to only 7% (12,000 MT) of the total annual fish production [10]. This could be due diversity limitations in Tilapia farming which is still a major hindrance to aquaculture growth and development in Kenya. Most native species are highly preferred by consumers but have not been fully tested as potential candidates for aquaculture [13]. *Oreochromis jipe* has several characteristics in common with *O. niloticus* [14]. The species is however limited in its distribution to the Pangani catchment, where the wild fishery has reportedly declined to an extent that *O. jipe* is currently red-listed among the IUCN critically endangered species [15] but has not been successfully cultured due to limited information on its culture potential, growth and general biology [16]. Thus, the study was conducted to assess the growth and culture potential of *O. jipe* in comparison with *O. niloticus* under similar culture conditions.

2. Materials and Methods

2.1 Study area

The 84 days study was conducted between September and December 2019, at Kenya Marine and Fisheries Research Institute, Kegati Aquaculture Research Centre, located at latitude 0042’ 50.44S and longitude 0344 47’ 59.4 E’, at an altitude of 1974m above sea level (Figure 1).

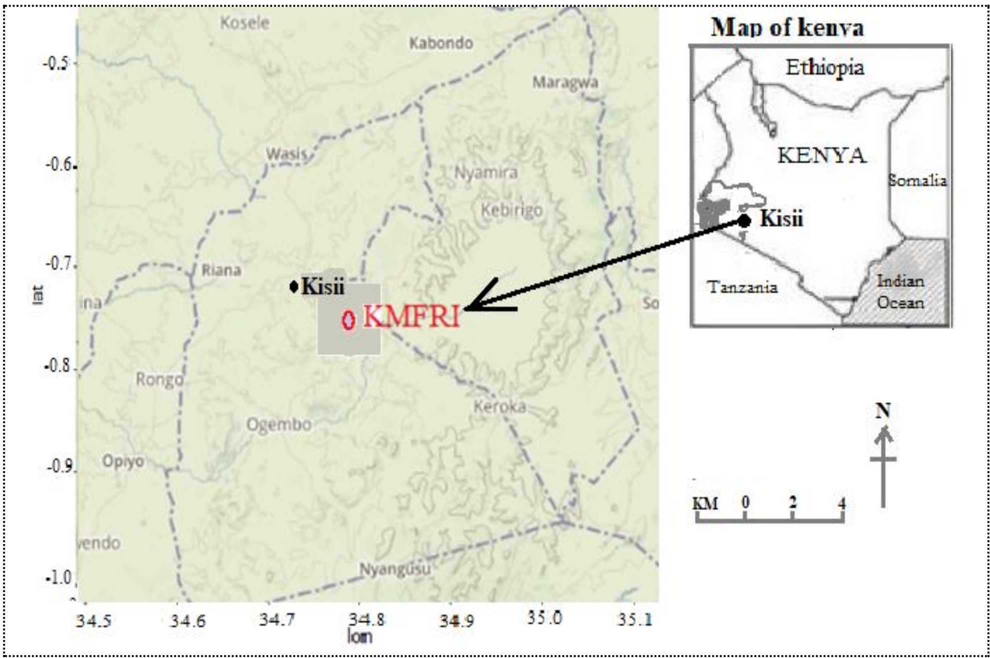

Fig 1: Map of Kisii County in Kenya, showing the geographical location of KMFRI-Kegati Aquaculture Centre (Drawn using R-software)

2.2 Study design and data collection

The mixed-sex Nile tilapia and Jipe tilapia fingerlings with initial mean weight of 2.93±0.12g and 2.69±0.10 respectively, were randomly stocked in 8 wooden backyard ponds measuring 3m long, 3m wide by 1 meter deep at the stocking density of 5 fish per m^2. The fingerlings were acclimatized to backyard ponds for one week, before feeding was resumed. Feeding was performed twice a day at 1100h and 300h GMT time using floating pellets with 30% crude protein at the rate of 10% body weight during the experiment and water was changed twice a week. Water level was maintained at 0.6m and all previous feed remains were removed before feeds were administered. Water quality parameters were determined twice a week using a YSI multi-parameter meter (Professional series) and 30 fish per pond were sampled biweekly using a scoop net .The fish were starved for 24 hours after which body weight and fish total length were measured using an electronic balance and a graduated measuring board respectively.

2.3 Data analysis

Collected data was tested for normality using Shapiro-Wilk test [18], and homogeneity of variances using Levene’s test and analyzed using R version 3.6.2 [17].

The Fulton’s condition factor was calculated from fish weight in grams (W) and total length measured in centimeters (L) using the formula; $K = 100\ W/\ L^b$, Where b = is the intercept of weight-length regression fitted on log transformed data. The growth parameters determined were Weight Gain (W_1-W_0), Growth Rate (W1 -W0)/t and Specific Growth Rate ((In W1 -InW0)/t*100), where W_0 and W_1 are initial weight and final weight respectively and t, the growth interval in days. All descriptive statistics performed on the data were expressed as mean ±standard error. Mean comparisons were done using a two sample t-test and the observed differences were considered statistically significant at a predetermined significance level of $p<0.05$.

3. Results

3.1 Growth parameters

Both species recoded high survival rates ranging between 92% and 100% in all replicates, and low number of mortalities was recorded towards the end of the experiment. However, the mean survival rate of *O. jipe* (96±1.19%) was not significantly different ($p>0.05$) from the mean survival rate (98.28±0.65%) of *O. niloticus*. There was a significant growth difference between *O. jipe* and *O. niloticus* treatments, with *O. niloticus* exhibiting higher length and weight gain compared to *O. jipe* over the growth period (Figure 2).

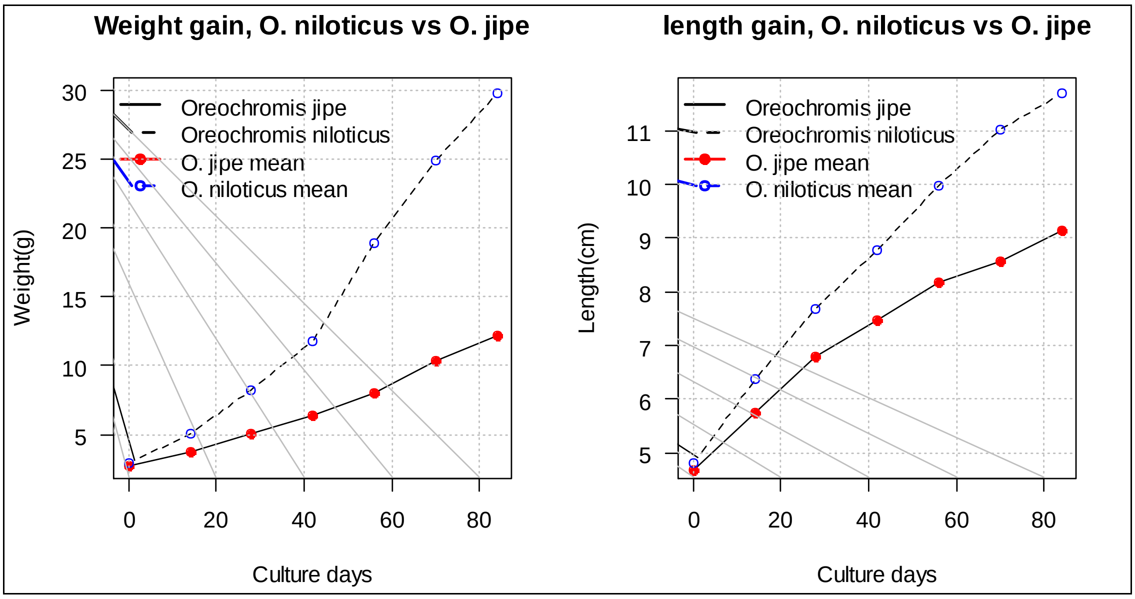

Fig 2: Length and weight gain comparison between *O. jipe* and *O. niloticus*

The final mean weight (29.79±0.91g) of *O. niloticus* was significantly ($p<0.05$) higher than final mean weight (12.18±34g) of *O. jipe* (Figure 2). Similarly, there was a significant difference ($p<0.05$) in the specific growth rates between the two species, whereby, *O. jipe* had a significantly ($p<.05$) lower mean specific growth rate (1.84±0.14 g/fish^{-1} day^{-1}) in comparison with the specific growth (2.79±0.26 g/fish^{-1} day^{-1}) rate *O. niloticus.* In addition, the daily weight gain of *O. niloticus* was significantly ($p<0.05$) higher than the daily weight gain in *O. jipe*. The values of all the growth indices are presented in the Table 1.

Table 1: Mean growth parameters and survival rates of mixed-sex *O. jipe* and *O. niloticus* fingerings. The asterisk * indicate significant difference between means

Parameters	***O. niloticus***	***O. jipe***
Initial length (cm)	4.80±0.09	4.67±0.07
Final length (cm)	11.51±0.13	9.11±0.12
Initial weight(g)	2.93±0.12	2.69±0.10
Final weight (g)	29.79±0.91*	12.16±0.34*
Specific growth rate (gfish^{-1}day^{-1})	2.78±0.16*	1.84±0.14*
Weight Gain (g fish^{-1}).	1.58 ± 0.35*	4.32±0.32*
Daily weight gain (gfish^{-1}day^{-1})	0.113g±0.01*	0.32±0.17*
b- exponent	2.63±0.09	1.79±0.10
Survival rates (%)	98.28±0.65%	96±1.19%
Fulton's condition factor (K)	2.14±0.08	1.97±0.05

There was no significant difference ($p<0.05$) in the values for Fulton's condition factor (K) computed for *O. jipe* and *O. niloticus*. The mean condition factors for Nile tilapia and Jipe tilapia were 2.14±0.08 and 1.96±0.05 respectively.

3.2 Water quality parameters

Water temperature was significantly higher ($P<0.05$) in *O. jipe* treatment with an average of 1.82-2.82 ^{0}C above the temperature of *O. niloticus* treatment. The highest mean temperature recorded was 24.3±0.58 in *O. jipe* treatment while temperature in *O. niloticus* treatment ranged between 18.5 ^{0}C and 23.8 ^{0}C, with a mean of 22.54±0.39 ^{0}C. With the exception of temperature, pH and dissolved Oxygen, other water quality variables showed no significant ($p>0.05$) difference between the treatments. Notably, the dissolved oxygen level was significantly higher ($p<0.05$) in the *O. niloticus* treatment, whereas the pH significantly ($p<0.05$) higher in *O. jipe* treatment. The mean pH in all the treatments ranged from 7.39± 0.09 – 8.57 ± 0.14 in all culture ponds while the mean dissolved oxygen ranged between 4.9±0.20 mg/l and 5.75±0.14mg/l as shown in Table 2.

Table 2: Comparison of water quality parameters in *O. jipe* and *O. niloticus* treatments

Treatment	***O. niloticus***	***O. jipe***	**Significance**
Temp (^{0}C)	22.54±0.39	23.93±0.31	significant
range	18.5-24.8	20.9-26.5	-
D.O (mg/l)	4.94±0.10	5.64±0.11	significant
pH	7.54±0.09	8.01±0.13	significant
Range	6.88-8.69	6.99-9.37	-
TDS	41.39±3.51	40.42±3.53	Not significant
Salinity	0.03±0.003	0.03±0.003	Not significant
Conductivity	57.92±4.61	57.2±4.55	Not significant

4. Discussion

The high survival rates in the fingerlings of both species indicated that fish survival in this experiment was not affected by species treatment and intervening environmental variables. The result of fish survival of *O. jipe* and *O. niloticus* agree with the study by [19] who reported the survival rates of 95.8% in *O. jipe* and 100% survival in *O. niloticus*, suggesting that both species can have exceptionally high survival rates regardless of the culture system. This result also concurs with [20] who reported 100% survival of *O. niloticus* in a polyculture experiment with *Labeo rohita* and *Cirrhinus mrigala*. These findings on survival however differ with the findings of [16], who reported the low survival rate of 25.8% for *O. jipe*. Ogada *et al*. attributed the low survival rates of *O. jipe* to decomposing uneaten feed which settled at the bottom of the hapas in which the growth trial was conducted. In the present study, the use of wooden backyard ponds enhanced easy removal of feed remnants before they settled at the pond bottom. The fish growth was initially slow immediately after stocking but eventually a consistent increase in total length and weight was recorded throughout the experiment. The growth was steady in the second and third month of culture before it began decelerating towards the last week. Generally, the transition of brooders from the wild environment to captivity might have caused low genetic adaptability of the F1 generation to captive conditions (Christie *et al*., 2012). This might have contributed to slow initial growth in *O. jipe* because fish have been reported not to easily adapt to changes in the environment [21]. Lack of adaptability to the culture environment has been associated with poor growth in captivity of the wild fish species. Orina *et al*. [22] attributed the poor growth of *Labeo victorianus* to accumulation of unconsumed feed resulting to prolonged low dissolved oxygen levels in the ponds which stressed the fish. However, the study by [19] confirms previous reports that Nile tilapia which is already adapted to aquaculture conditions performs better than native tilapia under such conditions. Chenyambuga *et al*. found that the species attained the mean final weight of 67.6±2.4g and specific growth rate of 2.2±0.14g/fishday^{-1} outperformed Jipe tilapia which attained the mean final weight of 16.3±2.0 and had a specific growth rate of 1.5 g/fish/day. This study reported lower values of mean final weight and SGR in *O. jipe* and *O. niloticus* probably due to temperature difference between the two regions. Whereas, Chenyambuga *et al*. reported a mean temperature of 25.2 ± 2.0 ^{0}C, the present study recorded lower mean temperature of 22.93±0.31 ^{0}C. This temperature is far much below the optimal range of 28-30 given recommended for *O. niloticus* by [23, 11]. Water quality was mainly affected by fluctuations in ambient conditions which the study did not control and poor feeding in Jipe tilapia was observed during cloudy and rainy days, which led to deterioration of water quality, consequently affecting the survival rates and growth. Weight gain has been observed to decline during cold seasons characterized by ambient temperatures as low as 18^{0}C which have been reported to directly affect feed intake [20, 24]. However, this was not established by the study since water temperature was not controlled. Generally the pH and dissolved oxygen levels were within the recommended range for tilapia growth [25] and the growth observed in fish was comparable to what has been previously reported in other studies.

5. Conclusion
The study found that Jipe tilapia (*Oreochromis jipe*) cultured in wooden backyard ponds can give better performance comparable to *O. niloticus* . However, the species did not realize its full growth potential because of stress factors imposed by the new environment due to its present introduction to captivity, unlike *O. niloticus* which has a long history in aquaculture. However, despite lack of acclimatization, the F1 generation fingerlings of *O. jipe* which was used for the study showed potential growth, hence can be introduced to aquaculture for commercial purposes and conservation. Production of *O. jipe* from aquaculture can produce fish to target the market segment that consumes fish directly from the lake as an immediate solution to declining wild stocks.

6. Recommendations
In order to culture the species successfully, it is important to delineate optimal culture conditions for the species. The study therefore recommends a further study of *O. jipe* under controlled culture conditions to determine optimum conditions for the growth of *O. jipe*.

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