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Conditions for high growth rates of Nile tilapia (*Oreochromis niloticus*) fry in Western Kenya

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Abstract
This study evaluated the effects of various temperatures on growth of 17 alpha Methyl Testosterone treated Nile tilapia (*Oreochromis niloticus*) fry in Western Kenya. Nile tilapia larvae of Lake Victoria strain which had just hatched were subjected to different temperatures and Hormone concentrations in 40L aquariums in a 4 x 3 x 3 factorial experiment set up in a complete randomized design. The fry were fed on 10% body weight rations over a period of (28, 34 or 40 days) at 0800 hours, 1100 hours, 1400 hours and 1700 hours with equal amounts of the MT treated feeds. This paper reports an increase in growth of fry with increasing temperature ($p<0.05$) whereas MT concentration did not affect growth ($p>0.05$). The study showed that 60 mg MT/kg feed for 28 days at 30 ^{0}C are the optimal conditions for growth of *Oreochromis niloticus* fry grown by hatchery farmers in western Kenya.

Keywords: Nile tilapia, specific growth rate, relative growth rate, condition factor

1. Introduction

Tilapia (*Oreochromis niloticus*) is one of the most popular fish farmed in the world, with more than 135 countries engaged in the farming of this species [1]. The worldwide commercial production of tilapia was 3.6 million tonnes in 2008, with aquaculture accounting for 78% of this value [1]. The fisheries sub sector in Kenya contributes about 0.5% of the GDP, with inland capture fisheries accounting for 134,840 metric tonnes (81%), aquaculture 24,096 metric tonnes (14%); whereas marine accounted for 8,987 metric tonnes (5%) [2]. *Oreochromis niloticus* contributes to the bulk of the fish, yielding about 3,400 tons (69.9%), followed by African catfish *Clarias gariepinus* at 1,047 tons (21%), common carp *Cyprinus carpio* at 373 tons, and trout *Oncorhynchus mykiss* at 51 tons [3]. Aquaculture has therefore been targeted by both the National and County governments as an important subsector geared towards poverty reduction and reducing pressure on capture fisheries [4]. Despite the enormous potential for fish farming in Kenya, aquaculture has been characterized by low levels of production that have stagnated at less than 1% of the country’s protein needs over the past decade [5]. More importantly, the inadequate supply of certified quality feed and seed fish has been a longstanding hurdle to the growth of aquaculture [5]. Studies have shown that there are higher risks involved in stocking smaller fry since there is reduced survival which leads to lower net returns [6]. Lower mortality of large sized fry is much favorable among farmers and has good income from the enterprise [7]. Nonetheless, studies have shown that male tilapia attains greater size at maturity compared to female [8]. The oral administration of 17 -Methyl Testosterone has gained prominence in the tilapia aquaculture industry as a way of getting male tilapia because it is more convenient and less cumbersome than other methods [9]. Feeding rate, water temperature, and fish size are 3 important factors which are synergistically affecting the growth of fish [10]. All fish species are characterized by an ideal range of temperature in which they show their maximum growth [11-13]. Temperature has further been identified to affect growth in Nile tilapia [14]. Feeding rate of Nile tilapia fry has been observed to be reduced at temperatures lower than 22 ºC [14], and therefore may affect growth.

In Western Kenya, although fish hatcheries exist, most fish farmers can only access smaller fry for stocking in their ponds [15]. The fish hatcheries also use 60mg MT/kg feed for sex reversal which has become popular and is being used commercially worldwide, with efficacy of up to 95% [16]. The appropriate temperature that can increase the growth of MT treated Nile tilapia fry is not known.

This study aimed at determining the conditions for high growth of Nile tilapia fry in Western Kenya, information will be useful to fish hatchery operatives in Western Kenya, and can help them improve on the sizes of fry that they sell to farmers.

2. Materials and methods

2.1 Study procedure

The study was conducted in Lutonyi Fish Farm laboratory in a 4 x 3 x 3 factorial experiment set up in a complete randomized design. Twelve 40 liter aquariums carrying 200 fry each were set up with sub sets of temperature (26 ^{0}C, 28 ^{0}C and 30 ^{0}C) controlled by thermostats (JAD DR-9200, manufactured by JAD Aquarium CO. LTD, China. Methyl testosterone concentration of 0 mg/Kg feed, 50 mg/Kg feed, 60 mg/Kg feed and 70 mg/Kg feed were applied at 10% body weight over a period of 28 days, 34 days and 40 days; and fed four times a day at 0800 hours, 1100 hours, 1400 hours and 1700 hours. An air pump (Resun AC-9906) was used for aquarium aeration. The experiments were performed in duplicates.

After the aquarium treatment periods i.e. 28th days, 34th days and 40st days, forty five fry in each aquarium were measured for weight (g) using Satorius CP2245 (Satorius AG Gogitten from Germany) and length (cm) using 30cm ruler, before being transferred to happa nets in open ponds. This was done in two trials.

2.2 Feed for treatment

Feed was prepared from ground and sieved fresh water shrimps whose proximate content was: Crude proteins-47.40%, Fiber-13.13%, Ash-18.94%, Fat-4.51% and Moisture-8.64%.

2.3 Brood stock sourcing

10 male Nile tilapia brooders weighing 300g each were collected from Lake Basin development Authority (Kibos Farm) in Kisumu while 30 female brooders weighing 300 g each were collected from Jafi fish farm in Kakamega. Both farms had Lake Victoria strains of Nile tilapia. The brooders were stocked in happa net measuring 3m by 5m by 1m with a surface area of 15 m^2, mounted in earthen pond. The brood stock was fed on fish pellets (Skretting feed, from France) 4.5mm pellet size, containing 45% crude proteins, 14% fat, 2.4% fiber,7.5% ash and 1% moisture at 10% body weight twice daily. After three weeks, mature eggs were collected from female fish mouths and allowed to incubate.

2.4 Fry collection

From the incubator, hatched fry swam out through the overflow of the incubation system into the happa net mounted in water. The fry which had absorbed the yolk sac were graded, 200 fry were randomly selected and stocked to each aquarium. The fry were fed with the hormone treated feed at 10% body weight four times a day at 0800 hours, 1100 hours, 1400 hours and 1700 hours for 28 days, 34 days and 40 days.

2.5 Growth parameters

At the end of the experiment, growth parameters and survival rate were measured as follows:

2.5.1 Specific growth rate (SGR,%)

The specific growth rate was calculated using the formula: 100 (ln Final weight-ln Initial weight)/period in days, where ln is the natural log as described by Effiong *et al.* [17]

2.5.2 Feed conversion ratio (FCR)

This was calculated as follows: feed offered / weight gain as described by Effiong *et al.*, [17].

2.5.3 Survival rate (SR)%

The survival rate of Nile tilapia fry was calculated as follows: Final number of fish /Initial number of fish x 100 as described by Charo-Karisa *et al.* [18]

2.5.4 Relative growth rate

The relative growth rate was calculated using the formula: (W2-W1/W1 x T) X 100 as described by Busacker [19] where;
W1: initial weight at the start of the study period
W2: final weight at the end of the study period
T: Time of study period in days

2.5.5 Condition factor (K)

This was given by: (W/L^3) X 100 as described by Busacker [19]; where;
W- Wet weight in grams
L-Total length in cm

2.6 Water quality parameters

Water quality parameters like pH, Dissolved oxygen (DO), nitrite (NO_2), nitrate (NO_3) and ammonia (NH_3-N) were monitored weekly using JBL test kit.

2.7 Statistical analysis

All data was analyzed using Minitab version 14 at $\alpha = 0.05$. Univariate ANOVA was used to compare the treated and the untreated means. Turkeys test was used to separate significant differences while differences in sex ratios were assessed by Chi square.

3. Results

3.1 Effect of temperature on growth of the MT treated Nile tilapia fry

The study shows that FCR decreased with increase in temperature as shown in table 1. The lowest FCR of 0.85 was attained at temperature of 30 ^{0}C for duration of 28 days whereas the highest FCR of 3.35 was at temperature of 26 ^{0}C for 40 days. There was a significant difference among FCR when compared among temperature and number of days the fry were reared in the aquarium ($p<0.05$).

Specific growth rate (SGR) increased with increase in temperature. Specific growth rates in this study ranged from 1.96 at temperature of 26 ^{0}C for 40 days to 5.19 at temperature of 30 ^{0}C for 28 days. There was a significant difference among SGR when compared among temperature and number of days the fry were reared in the aquarium ($p<0.05$). Condition factor ranged from 1.14 at temperature of 30 ^{0}C for 40 days to 5.83 at temperature of 26 ^{0}C for 28 days. There was a significant difference among K values when compared among temperature and number of days the fry were reared in the aquarium ($p<0.05$). Relative growth rate ranged from 2.97 at temperature of 26 ^{0}C for 40 days to 11.7 at temperature of 30 ^{0}C for 28 days. There was a significant difference among RGR when compared among temperature and number of days the fry were reared in the aquarium ($p<0.05$).

The highest mean weight was 0.819 g at temperature of 30 ^{0}C 40 days whereas the lowest mean weight was 0.0358 g at temperature of 26 ^{0}C 28 days.

The highest survival rate of 87% was observed in aquarium which was maintained at temperature of 30 ^{0}C while the lowest survival rate of 70% was observed in the aquarium which was maintained at temperature of 26 ^{0}C as shown in table 2. There was a significant difference among survival rates when compared among temperature and number of days the fry were reared in the aquarium ($p<0.05$).

3.2 Effect of MT concentration on growth of Nile tilapia fry

From this study, the lowest FCR of 0.85 was attained at concentration of 60 mg MT/kg for duration of 28 days whereas the highest FCR of 3.35 was at control for 40 days as shown in table 1. There was no significant difference among FCR when compared with respect to MT concentration and number of days the fry were reared in the aquarium ($p>0.05$).

Specific growth rates in this study ranged from 1.96 at control for 40 days to 5.19 at concentration of 60 mg MT/kg for 28 days. There was no significant difference among SGR when compared with respect to MT concentration and number of days the fry were reared in the aquarium ($p>0.05$). Condition factor ranged from 1.14 at control for 40 days to 5.83 at control for 28 days. There was no significant difference among K values when compared with respect to MT concentration and number of days the fry were reared in the aquarium ($p>0.05$).

Relative growth rate ranged from 2.97 at control for 40 days to 11.7 at 60 mg MT/kg for 28 days. There was no significant difference among RGR when compared with respect to MT concentration and number of days the fry were reared in the aquarium ($p>0.05$).

The highest mean weight was 0.819 g at concentration of 60 mg MT/kg 40 days whereas the lowest mean weight was 0.0358 g at control for 28 days.

The highest survival rate of 87% was observed in control while the lowest survival rate of 70% was observed in hormone concentration of 60 mg MT/kg as shown in table 2. There was no significant difference among survival rates when compared with respect to MT concentration and number of days the fry were reared in the aquarium ($p>0.05$)

Table 1: Effect of temperature on growth of the MT treated Nile tilapia fry

		28 DAYS				34 DAYS				40 DAYS			
CONC	**TEMP**	**RGR**	**SGR**	**K**	**FCR**	**RGR**	**SGR**	**K**	**FCR**	**RGR**	**SGR**	**K**	**FCR**
Control	26 ^{0}C	3.12	2.24	5.83	3.18	3.05	2.09	5.7	3.26	2.97	1.96	4.62	3.35
	28 ^{0}C	9.51	4.64	1.43	1.05	7.86	3.82	1.2	1.27	6.74	3.27	2.09	1.48
	30 ^{0}C	11.23	5.08	1.46	0.89	9.28	4.19	1.4	1.07	7.87	3.56	1.34	1.27
50 mg MT/Kg	26 ^{0}C	4.15	2.75	3.67	2.40	3.44	2.27	4.14	2.90	3.12	2.02	3.53	3.19
	28 ^{0}C	10.42	4.83	1.5	0.97	8.72	4.05	1.34	1.14	7.44	3.45	1.96	1.34
	30 ^{0}C	11.22	5.08	1.47	0.89	9.31	4.21	1.62	1.06	7.95	3.58	1.45	1.25
60 mg MT/Kg	26 ^{0}C	4.15	2.75	3.81	2.40	3.5	2.30	5.15	2.85	3.14	2.04	3.55	3.17
	28 ^{0}C	10.45	4.89	1.73	0.95	8.77	4.06	1.55	1.14	7.55	3.48	1.48	1.32
	30 ^{0}C	11.7	5.19	1.39	0.85	9.66	4.28	1.33	1.03	8.22	3.64	1.14	1.21
70 mg MT/Kg	26 ^{0}C	4.22	2.79	3.63	2.35	3.48	2.30	4.17	2.86	3.05	1.99	3.45	3.26
	28 ^{0}C	10.45	4.89	1.51	0.95	8.63	4.03	1.53	1.15	7.37	3.43	1.41	1.35
	30 ^{0}C	11.16	5.06	1.36	0.89	9.20	4.17	1.43	1.08	7.88	3.56	1.22	1.26

P value (Temperature)	a	a	a	a	a	a	a	a	a	a	a	a
P value (MT)	b	b	b	a	b	b	b	a	b	b	b	a
P value (days)	a	a	b	a	a	a	b	a	a	a	b	a

Key: a = $p<0.05$; b = p >

Table 2: Survival rates of Nile tilapia fry during aquarium phase

Temperature (^{0}C)	Hormone concentration (mg MT/Kg)	Survival rate (%)
26	Control	71.5
	50	75.5
	60	74.5
	70	70
28	Control	84
	50	82
	60	86
	70	80
30	Control	87
	50	80.5
	60	84.5
	70	76

4. Discussions

4.1 Effect of temperature on growth of the MT treated Nile tilapia fry

This study set to investigate the effect of temperature on growth of MT treated Nile tilapia fry in Western Kenya. The study shows that growth rates of fish increased with increasing water temperatures and performed best at 30 ^{0}C. This study also showed that the greatest feed conversion ratio (FCR) of 0.85, the highest SGR of 5.19 and the RGR of 11.7 were observed at 30 ^{0}C. These findings of better growth performance at increased temperature agrees with Martinez *et al*. [20] who observed that temperature influences food intake and food conversion. This is related to maximum feed consumption and better FCR [16]. Popma and Lovshin [21] also observed that tilapia prefer waters with temperatures between 29 and 31 ^{0}C for optimal growth, observations which agree with the performance of fry in this study. This could be attributed to higher temperature increasing the feeding rate and thereby increasing hormone dose uptake by the fish [22]. The study shows that increase of temperature lead to the decrease in condition factor (K). The condition factor (K) is very important for proper exploitation and management of the population of fish species [23]. Changes in condition factor of fishes have been used to interpret various biological features such as fatness, food availability; reproductive activities and environmental health [24]. In this study the condition factor K recorded ranged from 1.14 at 30 ^{0}C to 5.83 at 26 ^{0}C; which agrees with Stenseth *et al.* [25] who found out that the increasing sensitivity to ambient surroundings for fish may cause a decrease in their *K* values. According to Popma and Lovshin [21]; condition factor is influenced by both biotic and abiotic environmental conditions; in this study, K was affected by temperature which is an abiotic factor.

Survival rate was influenced by temperature, with the highest survival rate of 87% observed at 30 ^{0}C and the lowest of 70% at 26 ^{0}C. This finding is in line with Baras *et al.* [26] who stated that temperature of 29.7 ^{0}C is the ideal for survival and growth of Nile tilapia. It also agrees with Cristina *et al.* [27] who observed highest survival of 85.2% at 30 ^{0}C

4.2 Effect of MT concentration on growth of Nile tilapia fry

In the present study, different concentrations of 17α-MT containing feed were applied in order to observe the effect of these different doses of 17α-MT during feeding on growth. Lower K, greater FCR, higher SGR and RGR were observed in fish treated with MT than the control. This finding is in agreement with those of Ahmad *et al.* [28], who suggested that MT, being anabolic steroid may produce fish with increased weight gains and muscle deposition. The increased growth in this study could be attributed to MT being able to induce the feed digestion and absorption rate thereby causing increase in body weight [29], or possibly the MT administration may have increased the proteolytic activity of the gut as the case in mirror carp leading to increase in growth rate [30]. In this study, there was however no significant difference with the hormone concentration on weight on different day intervals. Similar results were obtained by Vera-Cruz and Mair [31] and Pechsiri and Yakupitiage [32], who found that 17α-methyl testosterone, has no effect on the growth of Nile tilapia during the hormonal treatment. According to Bombardelli and Hayashi [33], the lack of significant difference for weight, length and survival fry among treatments may be due to rapidly metabolized and excretion of hormone causing no anabolic effect. The hormone concentration of 60 mg MT/kg for a period of 28 days gave the greatest FCR, SGR and RGR. The result agrees with that of Adel *et al.* [34], who obtained better growth performance with 60 mg MT/kg with 40% protein diet compared to 40 mg MT/kg with 40% protein diet. On the contrary, Beardmore *et al.* [9] observed that male tilapia is desirable in a variety of fish species in a range of production systems because they have faster growth rates. Dan and little [35] who observed the performance of monosex and mixed sex culture of 3 different strains of Nile tilapia concluded that monosex strains of the 3 strains grew significantly faster than their corresponding mixed sex.

In this study, survival rates were not significantly affected by hormone concentrations, which agree with Vera Cruz & Mair [31], Al-Asaly [36], Nabil F. abd Al-Hakim *et al.* [37] and Chakraborty *et al.* [38], who also observed that MT treatment had no effect on survival of tilapia. Adel *et al.* [34] also observed that the survival rate did not differ significantly with MT levels. This could be because of the continuous flushing of water in the culture system which might have sustained a better general environment [38]. The results do not agree with those of Mangawaya [39] who stated that survival rates were higher in the control than the 30 mg MT/kg treatment. According to Kirankumar and Pandian [40] survival progressively decrease up-to 76% with increase in MT immersion at a dose rate of 900 µg.L-1 and 71% at the termination of experiment for fighting fish, *B. splendens*.

5. Conclusion

The results revealed that the best conditions for higher growth rate of tilapia fry were achieved at temperature of 30 ^{0}C, concentration of 60 mg MT/kg feed for a period of 28 days at It can be concluded that Temperature and hormone concentration has influence on growth of MT treated Nile tilapia fry raised in Western Kenya.

It is suggested that future studies should consider developing affordable technologies that can give fish hatcheries optimum or desirable temperatures for optimum growth and sex reversal.

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