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Effect of temperature rise on growth performance, feed intake, feed conversion ratio and sex ratio of the Nile Tilapia, *Oreochromis niloticus*

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ABSTRACT

This study was conducted to investigate the effect of increasing water temperature on growth performance, feed intake, feed conversion ratio, and sex ratio of *Oreochromis niloticus.* Two groups of *O. niloticus* fries (3 days post-hatching) were reared in an indoor system, at 30°C and 34°C. In the second group, the water temperature was increased to 36°C for only four hours a day, for the first 25 days of the experiment. At the end of the experiment, the values of body weight, length, specific and daily growth rates, and feed intake were comparable but slightly higher at 30°C. The feed conversion ratio was better in the control tank (30°C) than in the experimental one (36°C). Condition factor was higher than 1 at both temperatures indicating the general well-being of fries along the study period. The sex was skewed towards males under the effect of high temperature (36°C) in the experimental tank.

INTRODUCTION

Fishes, being poikilothermic organisms, they are affected by the temperature of the ambient water (Azevedo *et al*., 1998). Nile tilapia represents the basis of commercial fisheries in a lot of African countries because it is considered as the most important species in tropical and subtropical freshwater (Mohammed and Uraguchi, 2013). Food availability and water temperature are the limiting factors for *O.niloticus* growth (Kapetsky and Nath, 1997). For normal development, reproduction and growth of tilapia, the optimum temperature range is about 24-32 °C, depending on the species (Chervinski, 1982), size (Hofer and Watts, 2002) and genetic variations (Cnaani *et al*., 2000). Optimal feeding, growth, and reproduction are achieved at 22-30°C for *Oreochromis niloticus* (Caulton, 1982). Water temperature from 27°C to 32°C seemed to be the most effective range for rearing of juveniles and fries of *O.niloticus*, as the mean survival, total length, total weight, daily growth rate and food conversion ratio of fishes were significantly higher at 27 and 32°C compared to 35 and 37°C (Pandit and Nakamura, 2010). Commercial tilapia productivity generally depends on the use of male mono sex populations (Mair and Little, 1991). Mono sex male populations may be obtained by many methods; the most common are hormonal sex reversal (El-Greisy and El-Gamal, 2012) and water temperature (Azaza *et al*., 2008; Nivelle *et al*., 2019). The thermosensitive period for Nile tilapia was reported from 10 to 30 days post fertilization according to Nivelle *et al*. (2019). Azaza *et al*. (2008) reported that applying high temperature (almost 36.9°C) on fries of O.niloticus along the day though the sex differentiation period produced higher proportion of males (64.2-80%).

Hence, in this study, the effect of two different regimes of temperature application on growth performance, feeding efficiency and sex ratio of Nile tilapia was investigated.

MATERIALS AND METHODS

Fish:

Newly hatched fries were brought from Al-madina Fish Hatchery, Kafr El Sheikh, Egypt to the fish farm at Faculty of Agriculture, Menoufia University. They were obtained on the 3rd of July 2019, at the age of three days post hatching and stocked in hapa net hanged to a fiberglass tank 800 L to be acclimatized and water temperature kept constant at 30°C. After four days post hatching, when yolk sacs were completely absorbed, the average weight to the nearest gram and length to the nearest millimeter of fry were recorded. The fries were divided into two groups each consists of 200 fry and stocked into 120 L (2 fry/L) glass tanks (40×50×60) in an indoor system.

Culture management:

Aeration and water cleaning:

Each tank was provided with a Sobo aquarium air pump SB-348A for continuous aeration of the water through mechanical forcing of air into the tank. Tanks were also provided with a biomechanical sponge filter XY-380 which was hanged to its own air pump for cleaning the culture water by mechanical and biological methods.

Lighting:

The photoperiod was like the normal day in this period of study and location of the rearing system and equaled 14:10 L: D cycle.

Water exchange:

About 10% of the water was replaced manually by new freshwater supply daily.

Experimental design:

Tank (1):

Was designed to be the control tank, the temperature was kept constant at (30°C), within the normal range for Nile tilapia through the whole day and along the 61 days of the experiment. This tank was provided with a common AT- 700 glass immersion heater 300 watt, for maintaining this temperature and a floating thermometer for insuring temperature.

Tank (2):

The second tank was designed to be the experimental tank for temperature changes, where the temperature was kept constant at (34°C) through the day, but increased gradually to (36°C) for only four hours of the day between 10 AM and 2 PM, at the first twenty five days of the experiment, which are included within the thermos sensitive period of Nile tilapia, which extends from10 to 30 days post fertilization (Nivelle et al., 2019). Temperature became constant again at (34°C) through the whole day for the rest of duration of the experiment. This tank was provided with a titanium immersion heater (Hygger Titanium Tube Submersible Pinpoint Aquarium Heater with Digital Thermostat, IC Temp Controller 200 watt, U. S. A), for maintaining this temperature.

Food and feeding regime:

Fries were fed a commercial diet (40% crude protein), as powder, for the first 45 days of the experiment, as pellets 2mm in size , for the rest of experiment duration. Feeding was three times a day at 07:00, 09:00 and 15:00 h. The daily used feeding level varied, about 30% of the total body weight through the first month of the experiment and about 20% of the total body weight through the rest days of the experiment according to El-Sayed (2002).

Water quality:

The following water quality parameters were monitored twice weekly: Dissolved oxygen (DO), ammonia (NH_4-N) contents, using assay colorimetric kits (HANNA instrument, C200 multi parameter ion specific meter, Hungary) according to the manufacture's protocols. The results were expressed as mg/L. **pH:** was determined using Milwaukee MW 102 PH /Temp Meter, Romania.

Every 10 days of the experiment, a representative number of fries were taken out of each tank, weighted to the nearest grams using the analytical balance, their lengths were measured to the nearest millimeters using the digital calipers and they were returned back to the tanks. Average weight and length of fries in each tank were recorded.

Mortality of fries was recorded daily from the beginning of the experiment.

Growth:

Growth performance was studied by measuring the following parameters for both tanks according to Azaza et al. (2008):

1. Survival rate (SR) (%):

100 × (Final total fish number / Initial total fish number)

2. Specific growth rate (SGR) (%/day):

100 Ln (final body weight / initial body weight) / No. of culture days

3. Daily growth rate (DGR) (g/ day):

(Final body weight - initial body weight) / No. of culture days

4. Feed intake (FI) (g/ day):

Total weight of dry feed given / No. of culture days

5. Feed conversion ratio (FCR):

Total weight of dry feed given / body weight gain

6. Length-weight relationship:

Was computed as indicated by **Le Cren (1951)**.

$$W= a L^b$$

The log transformed equation is:

$$Log W= Log a + b Log L$$

Where:

W= fish weight in grams.

L= fish standard length in centimeters.

Regression constants= a and b.

Coefficient of condition (K):

$$(Weight / length^3) \times 100$$

After the end of the 61 days of the experiment, all fishes in both tanks were netted separately, dissected ventrally using small scissors under a dissecting microscope and their gonads which are located in contact with the ventral portion of the swim bladder were removed carefully to be sexed.

Sex ratio:

Sexing fishes was performed using the aceto-carmine squash technique, which is useful for sexing small sized fishes according to Guerrero and Shelton (1974).

A part of the gonadal tissue was cut using a pair of fine forceps, it was located on a glass slide, few drops of aceto-carmine were added, then covered and squashed by a cover slip. The mounts were examined by light microscope at 10x magnification. The ovarian tissue was more sac like due to presence of oocytes. Testicular tissue was hardly recognized, but it was identified by the early beds of developing spermatocytes of the tissue around it.

Statistical analyses were carried out using Microsoft Word16 Excell.

RESULTS

Water chemistry:

Water quality parameters were averaged ± standard deviation (SD) as follows: Dissolved oxygen 6.48 ± 0.04 mg L^{-1}, total ammonia 0.04 ± 0.01 mg L^{-1} and pH 7.33 ± 0.03, for control tank. Dissolved oxygen 6.46 ± 0.05 mg L^{-1}, total ammonia 0.04 ± 0.01 mg L^{-1} and pH 7.36 ± 0.3, for experiment tank. The average values of different water quality parameters remained within the optimum limits for *O. niloticus* growth (Table 1).

Table 1: Dissolved oxygen (DO), pH, and Total ammonia along the 61 days of the experiment for both tanks.

	Tank (1)			**Tank (2)**		
	Dissolved O_2 (mg/l)	**pH**	**Ammonia (mg/l)**	**Dissolved O2 (mg/l)**	**pH**	**Ammonia(mg/l)**
Week 1	6.49	7.29	0.05	6.42	7.33	0.04
	6.45	7.37	0.05	6.45	7.21	0.05
	6.45	7.32	0.05	6.48	7.0	0.04
	6.47	7.3	0.04	6.47	7.91	0.04
Week 2	6.44	7.3	0.04	6.44	7.12	0.05
	6.45	7.34	0.05	6.45	7.33	0.03
	6.45	7.34	0.05	6.41	7.37	0.03
	6.44	7.33	0.03	6.44	7.81	0.03
Week 3	6.48	7.33	0.03	6.43	7.03	0.05
	6.47	7.32	0.03	6.42	7.67	0.04
	6.44	7.4	0.04	6.41	7.1	0.03
	6.49	7.34	0.04	6.44	7.34	0.02
Week 4	6.5	7.33	0.04	6.6	7.33	0.05
	6.53	7.32	0.03	6.52	7.36	0.03
	6.54	7.31	0.03	6.51	7.39	0.02
	6.59	7.32	0.03	6.54	7.55	0.02
	6.48 ± 0.04	7.33 ± 0.03	0.04 ± 0.01	6.46 ± 0.05	7.36 ± 0.3	0.04 ± 0.01

Growth:

1- Growth performance:

The average final body weight (FBW), specific growth rate (SGR) and daily growth rate (DGR) of the experiment tank, which equaled to 81.6 g, 7.3 % day $^{-1}$ and 1.31g day^{-1}, respectively, were lower than that of control tank, which equal to 90.9 g, 8.21% day $^{-1}$ and 1.47g day^{-1}, respectively (Table 3).

Tables 4, 5 and Figs. 1, 2 give information about the relationship between weights (g) and lengths (mm) of fries in each tank, they are a power relationships, with good association between the two variables, r^2 = 98 and the values of b constants were comparable and more than 3 for control and experiment tanks, predicting a positive allometric growth of fries.

2- Feed intake and feed conversion:

Experiment tank that expresses temperature of 36°C, had a lower value of feed intake 7.4 and higher value of feed conversion ratio 5.66 compared to the control tank that expresses temperature of 30°C, it had a higher value of feed intake 7.71 and lower value of feed conversion ratio 5.24 (Table 3).

Condition coefficient:

Fries reared in control tank at 30°c had a higher value of condition factor (K = 2.01) than fries of the experiment tank that expresses temperature of 36°c (K = 1.83) (Table 3).

Table 2: Initial number, initial weight, and average initial length of fries of *O. niloticus* at the beginning of the experiment. Values expressed as (mean ± standard deviation).

Tank	Control	Experiment
Initial number	200	200
Initial weight (g/t)	1.2± 0.001	1.4± 0.001
Average initial length (mm/f) ± SD	9.9 ± 0.005	9.8 ± 0.01

Table 3: Total mortality, final number, final weight (FBW), average final length, survival rate (SR), specific growth rate (SGR), daily growth rate (DGR), feed intake (FI), feed conversion ratio (FCR), and condition coefficient of fries of *O. niloticus* at the end of the experiment. Values expressed as (mean ± standard deviation).

Tank	Control	Experiment
Mortality (No)	99	64
Sacrificed samples (No)	15	15
Final number of fries	101	136
final weight (g/t)	90.9± 0.2	81.6± 0.1
Average final length (mm/f) ± SD	35.5 ± 0.58	32 ± 0.55
Survival rate (SR) (%)	50.5	68
Specific growth rate (SGR) (%/t/ day)	7.09	6.66
Daily growth rate (DGR) (g/t/ day)	1.47	1.31
Total weight of dry feed given (g/t)	470.4	453.8
Feed intake (FI) (g /t/day)	7.71	7.4
Feed conversion ratio (FCR)/t	5.24	5.66
Coefficient of condition (K)	2.01	1.83

Table 4: Relationship between total length (mm) & weight (g) of fry *O. niloticus* in control tank.

Control tank (Length-weight data every 10 days)	
Average total length(mm)	**Average weight(g)**
9.9	0.006
12.2	0.02
15.5	0.06
22.2	0.18
28.1	0.41
33	0.7
35.5	0.9

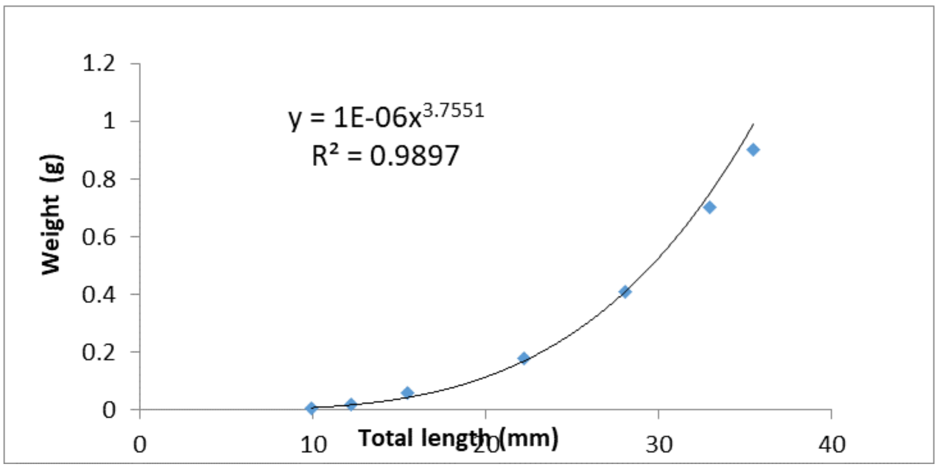

Fig. 1: Relationship between total length (mm) & weight (g) of fry *O. niloticus* in control tank.

Table 5: Relationship between total length & weight of fry *O. niloticus* in experiment tank.

Experiment tank (Length-weight data every 10 days)	
Average total length(mm)	**Average weight (g)**
9.8	0.007
11	0.01
13.8	0.04
21.2	0.17
25.1	0.31
30	0.5
32	0.6

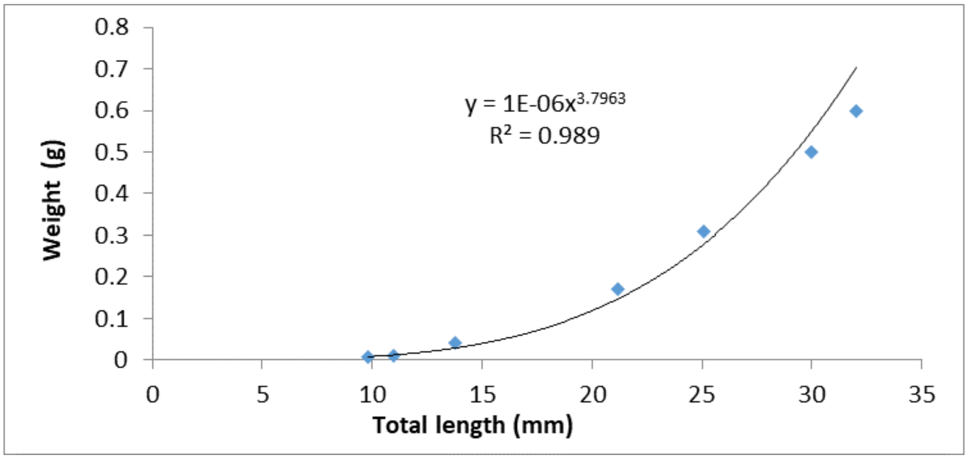

Fig. 2: Relationship between total length (mm) & weight (g) of fry *O. niloticus* in experiment tank.

Sex ratio:

Table 6 summarizes the percentage of males and females after sexing in both tanks. In control tank, where temperature kept constant at 30°c, percentage of females was higher than males (66.3% to 33.7%, respectively). In experiment tank, where temperature was increased gradually to 36°c for only four hours of the day at the first twenty five days of the experiment, percentage of females and males reached equilibrate values 50% for each.

Table 6: Sex ratio of the fries of *O. niloticus* at the end of the experiment.

Tank	Control	Experiment
Males (%)	33.7	50
Females (%)	66.3	50

DISCUSSION

There are no clear growth variations between fries of *O. niloticus* reared at 30°c and fries reared at upper suboptimal temperature of 36°c. The values of final body weight (FBW), specific growth rate (SGR), daily growth rate (DGR), and feed intake (FI) were comparable, but relatively higher in the control tank than in the experimental one (Table 3). The values of b constants were comparable and more than 3 for control and experiment tanks, predicting a positive allometric growth of fries (Figs.1, 2). Azaza *et al.* (2008) reported that growth and feed utilization of *O. niloticus* juveniles reared at 26 and 30°c were higher than those reared at 22 and 34°c, and Pandit and Nakamura (2010) concluded that water temperature from 27°C to 32°C seemed to be the most effective range for rearing of juveniles and fries of *O. niloticus*, as the mean survival, total length, total weight, daily growth rate and food conversion ratio of fishes were significantly higher at 27 and 32°C compared to 35 and 37°C. At lower and upper suboptimal temperatures, a large amount of dietary energy was used for maintaining the internal physiological functions, rather than for growth (El-Sayed *et al.*, 1996).

It is noticed, here, that survival rate (68 %) of fries in the experiment tank, where temperature kept at 34°C and increased to 36°C at certain periods was surprisingly higher than that (50.5%) of the control tank (Table 3). The total mortality of both tanks has occurred over the first ten days of the experiment. However more or less was reported by El-Sayed and Kawanna (2008) who found that survival rates of *O. niloticus* fries were not very different at temperatures between 24 and 30°C, but significantly higher than that at 32°C ($P < 0.05$).

Condition factor for the control and experiment tanks equaled 2.01 and 1.83, respectively (Table 3). The values of K factor were higher than 1 for both tanks indicating the general well-being of fries along the study period. Olurin and Aderibigbe (2006) found that K value was 1.11 for juveniles of *O. niloticus* reared as mixed sex and with mean annual temperature ranging from 22 to 32.5° C in Sanni Luba Fish Farm Ijebu-Ode, Ogun State, illustrating healthy conditions for the fishes. The difference in K values between control and experiment tanks may be due to the thermal stress applied on the experimental one.

At the end of the 61 days of the experiment, using the aceto-carmine squash technique for sexing fries, it was noticed that in control tank the ratio of females to males was 1.97 to 1.0, but was 1:1 in the experimental tank (Table 6), so the sex ratio was skewed towards males. Azaza et al. (2008) revealed that applying high temperature (almost 36.9°C) on fries of O. niloticus along the day during their sex differentiation period resulted in a higher proportion of males (64.2-80%) with lower survival (60-81%). The tendency of sex ratio in favor of males over females was reported by a number of authors, as the final sex ratio of Nile tilapia is strongly affected by the ambient water temperature during the period of sex differentiation and high ambient temperatures skewing sex towards males (Devlin and Nagahama, 2002; Ahmed et al., 2007; Nivelle et al., 2019).

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