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Performance of Nile Tilapia *(Oreochromis niloticus)* Fingerlings. II. Influence of Different Water Temperatures

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ABSTRACT

Nile tilapia (*Oreochromis niloticus*) fingerlings with average weight of 19.0±1.0 g were used to study the effect of different temperatures on growth performance, survival rate and some physiological parameters. The fingerlings were stocked in 12 glass aquaria (40×70×60 cm) at 15, 20, 30 and 25°C (as control) for 60 days. Diet of 26.58% protein was offered as feed. Water was changed twice daily with 100% of water size. Growth measurements of tilapia were recorded at 15 days intervals. Blood parameters were recorded at stocking and at the end of the experiment. Results showed that growth performance for tilapia was significantly (P≤0.05) decreased at 15 and 20°C. Survival rate was high at temperature 20, 25 and 30°C but mortality occurred at 15°C. Also, the feed conversion ratio (FCR) for fish increased with increasing temperature, but the difference was not significant (P≥0.05) between high temperatures (25 & 30°C), respectively. Decreasing temperature resulted in decreasing hematocrit and hemoglobin parameters, while differences were not significant (P≥0.05) from control at temperatures 25 and 30°C, respectively. The findings revealed that water temperature 25-30°C were more suitable for culture of Nile tilapia fingerlings to obtain optimum growth performance and survival rate.

Key Words: Nile tilapia; Water temperature; Performance; Survival rate; Hematocrit; Hemoglobin

INTRODUCTION

Nile tilapia is by far the most important farmed tilapia species in the world. Tilapia is the most familiar and popular fishes in Egypt, as well as, in the Middle East and warm climate countries (Philippart & Ruwet, 1982). Gumaa and Salih (1986) showed that young *Oreochromis niloticus* prefer temperature between 30-36°C and suggested to avoid higher temperatures (about 41°C) being lethal. Also, Thomas and Michael (1999) stated that the lower lethal temperature for most species is 50 to 52°F and generally tilapia stop feeding when water temperature falls below 63°F and can reproduce well at temperature higher than 80°F. The production of tilapia fish in Egypt increased from 144.176 mt in 1995 to 349.739 mt in 2003 (FAO, 2005). Several problems face fish production in Egypt. One of the problems is that most tropical species die when temperature drops below 10°C (Weirich *et al.,* 1993). Therefore, the present study was planned to investigate the effect of different temperatures on growth performance, survival rate and some blood parameters of Nile tilapia fingerlings.

MATERIALS AND METHODS

This study was carried out at the indoor wet lab of Animal Production and Fish Resources Department, Faculty of Agriculture, Suez Canal University, Ismailia, Egypt.

Experimental fish. Nile tilapia (*Oreochromis niloticus*) fingerlings with mean average weight of 19±1 g and 10±0.3 cm of length were obtained from Fish Research Center, Suez Canal University, Ismailia, Egypt. Fish were homogenous in size, body weights and apparently healthy. They were fed on the same diet used in this study for 1 week prior to adapt them for the experimental conditions. During this adaptation period, the dead and the weak fish were eliminated daily.

Experimental aquaria. Twelve glass aquaria (40×70×60 cm) with capacity of 60 L water were used for rearing the *O. niloticus* fingerlings. De-chlorinated water in aquaria were aerated by a constant supply of compressed air pump and were exchanged twice daily (Randall, 1976) with 100% of the water volume from each aquaria and replaced with fresh water, before morning feeding.

Experimental design. The fish was stocked into glass aquaria at 15, 20, 30 and 25°C (as control). Automatic heaters with thermostat were used to obtain the high temperature. Tilapia was stocked at a rate of 14 fish per aquarium (60 L water) for 60 days with three replicates for each temperature.

Experimental diet. Commercial diet was purchased from El Bardeny Company, Egypt. The pellets size was 2 mm, which had 26.58% crude protein. The diet was stored in a refrigerator (4°C) during the experimental duration to avoid the nutrients deterioration (Jauncey & Ross, 1982).

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Feeding regime. The daily feeding rate for the 1st week was 3% of the total stocking biomass and thereafter was readjusted at the beginning of each of the next two weeks. Every two weeks, thereafter, aquaria samples provided information for the adjustment of feeding rates passed on new tilapia biomass in each aquarium. Tilapia fish were fed with the experimental diet (26.58% crude protein) three times daily. Feeding rates were assigned to a particular range of wet weight according to NRC (1993). The experimental diet was offered spreading by hand for aquaria.

Physicochemical analysis of water. Water temperature was measured using oxygen-temperature meter (YSI model L57). Water temperature of the experimental aquaria was monitored daily throughout the experimental period (Rosas *et al.,* 1986) by automatic heater with thermostat and the average was taken per 15 days. Water pH was measured using pH meter (model 56, NR 87 BB 203). The pH values of each aquarium were monitored daily in the late afternoon as suggested by Gumaa and Salih (1986). The average of pH values of water was recorded at15 days intervals throughout the experimental period. Dissolved oxygen (DO) of water was measured by using oxygen-temperature meter (YSI model L57). Concentration of dissolved oxygen (mg/L) of each aquarium was measured daily during the early morning and the average dissolved oxygen of water was recorded at 15 days intervals during the experimental period (Pullin & McConell, 1982). Salinity of water was determined using the refractometer ATAGO as described by De Silva and Perera (1985).

Blood measurements. Blood was obtained from the fish after they were immobilized by a sharp blow to the head. The caudal peduncle was severed immediately posterior to the adipose fin and blood was collected from the caudal vessels in a heparinized capillary tube (Tomasso *et al.,* 1980). Hematocrit was measured by a microhematocrit centrifuge at 1500 rpm for 15 min and hemoglobin was determined using a spectrophotometer by method described by Vankamlen (1961).

Growth parameters. The following parameters were used to evaluate tilapia growth performance according to De Silva and Anderson (1995): Body weight gain (WG)=W_1–W_0, Average daily body weight gain (ADG): ADG=(W_1–W_0)/t, Specific growth rate (%/day): SGR=(Ln W_1–Ln W_0)×100/t), Feed conversion ratio: FCR=Df/(W_1–W_0), Survival rate (%): SR=Ni×100/N0 according to (Harrell *et al.*, 1990), where: W_1=Final wet weight, W_o=Initial wet weight, t=Time interval in days, N_i=Number of fishes at the end, N_0=Number of fishes initial stocked and Df=Dry feed intake.

Statistical analysis. The data were analyzed by one-way ANOVA Procedure of Statistical Analysis System (SAS, 1988). Means were compared by Duncan's new multiple range test (Zar, 1996).

RESULTS AND DISCUSSION

Environmental conditions. The recorded values showed suitable environmental conditions for rearing Nile tilapia fingerlings during the experimental period (Table I). The water temperature ranged from 26°C to 27.3°C. These values were in the preferred range of temperature recorded for Nile tilapia. These results are in agreement with those of Lei and Li (2000) and Xu *et al.* (2005) who noted that optimal water temperature for optimum growth and feed conversion of are 21-28°C. Also, Saber *et al.* (2004) found that the optimal temperature for growth of was 26-34°C. Changes in pH values of water during the experimental period indicated that the minimum pH value was 7.2 and the maximum pH was 7.9 (Table I). This range was in the optimum values of pH recorded for Nile tilapia (Saber *et al.*, 2004). Table I further shows that the minimal and maximal values of dissolved oxygen were 6.5 and 6.7 mg L^{-1}. This range was suitable for Nile tilapia feeding and growth, which was in agreement with X*u et al.* (2005). Also, Saber *et al.* (2004) showed that Nile tilapia produced the best growth rate when DO ranged from 7 to 8.3 mg L^{-1}.

The minimal and maximal values of the salinity were 0.17 and 0.20 mg/L^{-1} (Table I). It is clear that the salinity was suitable for growth of Nile tilapia. Thomas and Michael (1999) found that Nile tilapia perform better at salinities below 5 ppt and tilapia prefer salinity <0.5-1.0 ppt. On the other hand, (Lei & Li, 2000) reported that optimal salinities for growth and feed consumption for Nile tilapia have been generally to be 14-15 mg L^{-1}.

Mean individual body weights. Mean individual final body weight (FBW) of Nile tilapia fingerlings reared in aquaria for 60 days (Table II) showed great differences among temperature treatments (15, 20, 25 & 30°C) at the end of the experimental period. The FBW was at 15 and 20°C decreased by 12.1 and 31.6 g, respectively which was attributed to a decrease in feed consumption (El-Sayed *et al.,* 1996). Temperature of 25°C showed the highest body weight (36.8 g) followed by temperature 30°C (35.4 g). From these results it could be concluded that the average individual body weight of tilapia observed in the experimental groups was found to be related to temperature. This is in agreement with the findings of De Croux *et al.* (2004) and Saber *et al.*(2004), who reported that the best growth rate at 25°C than at 30°C. The differences among the mean body weight of tilapia at 15, 20, 25 and 30°C were significant ($P \leq 0.05$), although difference was not significant between 25 and 30°C.

Mean body weight gain. Mean body weight gain at 15 days intervals at all temperature were 1.0, 2, 2.8 and 2.5 g $fish^{-1}$ in the first period (first 15 days) and then gradually reaching 2.5, 4.3, 6.2 and 5.8 g $fish^{-1}$ at the end of the experimental period for 15, 20, 25 and 30°C, respectively (Table III). The mean body weight gain sharply decreased at temperature below 20°C and 15°C, which may be attributed to decrease in feed consumption metabolic rate (Khouraiba, 1989). Also, it was clear that the optimum temperature range for growth of tilapia is between 25-30°C. Such results have been confirmed by Saber *et al.* (2004). There were

Table I. Mean values of physico-chemical characteristic of water

Rearing Period (day)	Water temperature (ºC)	pH	Dissolved oxygen (mg L^{-1})	Salinity (ppt)
0	26.1	7.2	6.5	0.18
15	26	7.5	6.7	0.20
30	26.5	7.4	6.6	0.18
45	27.1	7.9	6.7	0.17
60	27.3	7.7	6.5	0.20

Table II. Individual body weight (g) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
0	19.0 ±1.0 ^{a}	19.0 ±1.0 ^{a}	19.0 ±1.0 ^{a}	19.0 ±1.0 ^{a}
15	18.0 ±0.43 ^{c}	21.0 ±0.57 ^{b}	21.8 ±0.29 ^{a}	21.5 ±0.61^{a}
30	16.5 ±0.44 ^{c}	23.8 ±0.47 ^{b}	25.6 ±0.17 ^{a}	25.0 ±0.64^{a}
45	14.6 ±0.44 ^{c}	27.3 ±0.50 ^{b}	30.6 ±0.19 ^{a}	29.6 ±0.65^{a}
60	12.1 ± 0.46 ^{c}	31.6 ±0.46 ^{b}	36.8 ±0.19 ^{a}	35.4 ±0.65^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

Table III. Average body weight gain (g /individual fish) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	1.0 ± 0.013 ^{c}	2.0 ±0.03 ^{b}	2.8 ± 0 ^{a}	2.5 ±0.03 ^{a}
30	1.5 ± 0.006 ^{c}	2.8 ±0.09 ^{b}	3.8 ± 0.11 ^{a}	3.5 ± 0.04 ^{a}
45	1.9 ±0.009 ^{c}	3.5 ±0.05 ^{b}	5.0 ±0.02 ^{a}	4.6 ±0.03 ^{a}
60	2.5 ±0.046 ^{c}	4.3 ±0.08 ^{b}	6.2 ± 0 ^{a}	5.8 ± 0 ^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

Table IV. Average daily body weight gain (g /individual fish) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	0.06 ± 0 ^{c}	0.13 ± 0.003 ^{b}	0.19 ± 0 ^{a}	0.16± 0 ^{a}
30	0.1 ±0 ^{c}	0.18 ± 0.007 ^{b}	0.25 ± 0.005 ^{a}	0.23 ±0.003 ^{ab}
45	0.13 ± 0 ^{c}	0.23 ±0.003 ^{b}	0.33 ± 0 ^{a}	0.30 ± 0 ^{a}
60	0.16 ± 0.003 ^{c}	0.29 ± 0.006 ^{b}	0.41 ± 0 ^{a}	0.38 ± 0 ^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

significant differences (P≤0.05) among all the temperatures.

Average daily body weight gain (ADG). Table IV denotes the changes in the ADG of Nile tilapia reared in aquaria for 60 days under 15, 20, 25 & 30°C. The average body weight gain $fish^{-1}$ day^{-1} were 0.06, 0.13, 0.19 and 0.16 g for treatment 15, 20, 25 and 30°C, respectively during the first period (first 15 days) The data also indicated that, the average daily weight gain of tilapia increased gradually reaching its maximum of 0.29, 0.41 and 0.38 g at the end of the experimental period for 20, 25 and 30°C, respectively. It decreased reaching 0.16 g at 15°C. There were differences in the average daily body weight gain of tilapia at 15, 20, 25 and 30°C. The gain $fish^{-1}$ day^{-1} increased with temperature 25 then 30°C and decreased at 20°C. Similar results were obtained by Saber *et al.* (2004). There were significant differences (P≤0.05) in the average daily body weight gain at different temperatures, but the difference was not significant (P≥0.05) between 25 and 30°C.

Table V. Average feed consumption (g /individual fish) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	5.4 ±0.19 ^{c}	9.4 ±0.26 ^{b}	9.8 ±0.13 ^{a}	9.6 ±0.27 ^{a}
30	4.6 ±0.20 ^{c}	10.7 ±0.21 ^{b}	11.5 ±0.08 ^{a}	11.2 ±0.29 ^{a}
45	4.3 ±0.20 ^{c}	12.2 ±0.22 ^{b}	13.7 ±0.09 ^{a}	13.3 ±0.29 ^{a}
60	3.6 ±0.21^{c}	14.2 ±0.20 ^{b}	16.5 ±0.09 ^{a}	15.9 ±0.29 ^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

Table VI. Specific growth rate (%/day) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	0.36 ±0.014 ^{c}	0.66 ±0.031 ^{b}	0.91 ±0.005 ^{a}	0.82 ±0.026 ^{a}
30	0.94 ±0.008 ^{c}	0.83 ±0.047 ^{b}	1.07 ±0.04 ^{a}	1.01 ±0.019 ^{a}
45	0.8 ±0.003 ^{c}	0.91 ±0.012 ^{b}	1.18 ±0.003 ^{a}	1.12 ±0.020 ^{a}
60	1.25 ±0.014 ^{c}	0.97 ±0.030 ^{b}	1.23 ±0.003 ^{a}	1.19 ±0.019 ^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

Table VII. Average feed conversion ratio (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	ND	4.7 ±0.24 ^{a}	3.5 ±0.09 ^{b}	3.8 ±0.102 ^{b}
30	ND	3.8 ±0.35 ^{a}	3.0 ±0.84 ^{b}	3.2 ±0.078 ^{b}
45	ND	3.4 ±0.09 ^{a}	2.7 ±0.17 ^{b}	2.8 ±0.092 ^{b}
60	ND	3.3 ±0.24 ^{a}	2.6 ±0.11 ^{b}	2.7 ±0.102 ^{b}

Means with the same letter in each row are not significantly different (P≤0.05), ND= Not detected

Table VIII. Survival rate (%) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
15	100±0.0 ^{a}	100 ±0 ^{a}	100±0 ^{a}	100 ±0^{a}
30	98 ±0.007^{b}	100±0 ^{a}	100±0 ^{a}	100±0^{a}
45	79 ±0.005 ^{b}	100 ±0 ^{a}	100±0 ^{a}	100±0 ^{a}
60	75±0.014 ^{b}	100±0^{a}	100±0 ^{a}	100 ±0 ^{a}

Means with the same letter in each row are not significantly different (P≤0.05)

Average feed consumption. Table V shows average feed consumption of fingerlings at 2 weeks intervals for all treatments. Feed consumption (FC) at the end of the experimental period was 3.63, 14.2, 16.5 and 15.9 g feed $fish^{-1}$ at 15, 20, 25 and 30°C, respectively. The average FC g $fish^{-1}$ in the experimental groups increased with increasing temperature since feed consumption was higher at 25°C then at 30°C. It could be attributed that the fish had the best growth at 25°C (Saber *et al.*, 2004). Also, feed consumption decreased at lower temperatures, which is in full agreement

with that found by El-Sayed *et al.* (1996). Significant differences were found among temperatures at P≤0.05, but the difference was not significant between 25 and 30°C.

Specific growth rate (SGR). Changes in SGR value of (*O. niloticus*) at the end of the experimental period were 1.25, 0.97, 1.23 and 1.19% at temperature 15, 20, 25 and 30°C, respectively (Table VI). There was a decrease in SGR at 15°C and 20°C, which is in agreement with that of El-Sayed *et al.* (1996). The SGR was better at 25°C then 30°C. This was in agreement with (Saber *et al.*, 2004) who reported that SGR was better at 25°C. There was no significant difference (P≥0.05) between (25 & 30°C), although significant differences (P≤0.05) occurred among all temperatures.

Feed conversion ratio (FCR). It could be indicated from Table VII that the feed conversion ratios of tilapia at the end of the experimental period were 3.3, 2.6 and 2.7 for temperature of 20, 25 and 30°C, respectively. At low temperature (15°C), FCR was not achieved, because fish lost weight and could not take their actual requirement of food (Khouraiba, 1989). In this study, feed conversion ratio of tilapia was the best at 25°C then followed by 30 and 20°C. These results are in full agreement with the findings of De Croux *et al.* (2004) and Saber *et al*. (2004). The difference between 25 and 30°C was not significant (P≥0.05), although the differences among 20, 25 and 30°C were significant (P≤0.05).

Survival rate. The survival rates of tilapia during the experimental period were 100% at temperatures 20, 25 and 30°C (Table VIII). This is mainly due to: (a) the acclimation of tilapia prior to the start of stocking in aquaria; (b) this experiment started with Nile tilapia with an initial weight of 19±1.0 g; such size show high tolerance to the unfavorable conditions (Saber *et al.*, 2004) and (c) the ecological conditions throughout the experimental period were suitable for tilapia rearing especially the average water temperature of 20, 25 and 30°C. Saber *et al.* (2004) noted that optimal water temperature for optimum growth and survival of tilapia are 20-36°C. The survival rate of fish decreased (75%). at temperature 15°C at the end of the experimental period. The poor survival observed at 15°C was attributed to poor environmental conditions of the fish especially the prevailing low water temperature 15°C (Khouraiba, 1989). There were no significant differences (P≥0.05) in survival were recorded among the treatments (temperature 20, 25 & 30°C).

Blood measurements: hematocrit value (PCV %). Hematocrit value at the end of the experimental period was 22.0, 24.2, 25.0 and 24.5% for the groups under 15, 20, 25 and 30°C, respectively (Table IX). The average hematocrit value in the experimental groups was not different from the control. Also, it decreased at temperature 15°C as feed consumption decreased and appearance of anemia (Rodrigues *et al.*, 2003). It can be seen that at temperature 25 and 30°C there were no significant differences (P≥0.05) from control. Significant differences (P≤0.05) were found among temperatures (15, 20, 25 & 30°C), but the differences were not significant (P≥0.05) among (20, 25 & 30°C).

Table IX. Average hematocrit values (PCV %) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
0	24.5 ±1.53 [a]	25.0 ±1.40 [a]	24.5 ±1.40 [a]	24.1 ±1.40 [a]
60	22.0 ±1.53 [c]	24.2 ±1.45 [b]	24.6 ±1.76 [a]	24.2 ±1.53 [b]

Means with the same letter in each row are not significantly different (P≤0.05)

Table X. Average concentration of Hb (g 100 mL^{-1}) (mean ± SE) of Nile tilapia fingerlings under different temperatures

Rearing period (day)	Temperature (°C)			
	15	20	25	30
0	7.5 ±1.20 [a]	8.0 ±1.23 [a]	8.0 ±1.23 [a]	8.0 ±1.23 [a]
60	5.3 ±0.73 [c]	7.3 ±0.56 [b]	8.5 ±0.60 [a]	8.2 ±0.81 [a]

Means with the same letter in each row are not significantly different (P≤0.05)

Hemoglobin concentration (Hb). Average Hb concentration in the experimental groups 20 and 30°C was not different from the control (Table X). Also, the average Hb concentration decreased at 15°C. It could be attributed to decreased feed consumption and fishes were anemic (Rodrigues *et al.*, 2003). There were no significant differences (P≥0.05) among average Hb concentration in 20, 25 and 30°C, but there were significant differences (P≤0.05) in treatments of 20 and 30°C.

CONCLUSION

Nile tilapia fingerlings with average weight 19.0±1.0 g were more suitable to culture at water temperature 25°C-30°C for optimum growth performance and survival rate than other water conditions. Therefore, it can be recommended to be carried out under similar experimental conditions.

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