

Effect of Water Temperature on Masculinization and Growth of Nile Tilapia Fish

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Abstract

The main aim of this work is to study the effect of water temperature on masculinization, growth and survival of Nile tilapia. To achieve that two experiments were carried out to study the effect of water temperatures (25°C, 30°C and 35°C) and periods of time (1, 2, 3 and 4 weeks) on the male ratio, mortality rate and weight of Nile tilapia fry in the first experiment. While the second experiment aimed to evaluate the growth and survival rate of sex reversed tilapia fry which obtained from the first experiment. The obtained results indicated that the male ratio and mortality rate increased with increasing the water temperature and period of time rearing. The highest value of male ratio and mortality rate (91.50% and 17.13%) was obtained at 35°C water temperature and four weeks of rearing. The weight of Nile tilapia fry significantly increased from 0.16 to 1.51 g, 0.30 to 2.67 g and 0.27 to 2.05 g at 25°C, 30°C and 35°C, respectively after 1, 2, 3 and 4 weeks of rearing. The Nile tilapia fry previously treated by water temperature and period of time rearing increased each of body weight, weight gain and specific growth rate, while the feed conversion ratio decreased with increasing the water temperature and period of time rearing.

Keywords: Nile tilapia; Temperature; Male ratio; Sex ratio; Weight gain; Specific growth rate; Feed conversion ratio

Introduction

Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is likely to be the most important cultured fish in the 21st century [1]. It grows and reproduces in a wide range of environmental conditions and tolerates stress induced by handling [2]. With the purpose of achieving more productivity in growing tilapia, *Oreochromis niloticus*, at the unit time, it is important to produce monosex culture that constitutes totally of males [3]. The majority of species in which monosex culture is practiced, the male is more economically attractive than the female because of faster growth rate. In addition to the males, the metabolic energy is channeled towards growth. They benefit from anabolism enhancing androgens [4,5]. In females, there is a greater reallocation of metabolic energy towards reproduction.

Male Tilapia production has an economic importance to its producers and sellers. The increase in employment in the sector outpacing world population growth and employment in traditional agriculture is a crucial source of income and livelihood for hundreds of millions of people around the world [6]. It could play an important role to provide food security for the general population as an excellent source of high-quality protein [7,8].

Monosex males may be obtained by (1) manual sorting of fingerlings based on anatomy is extremely laborious and does not have high resolution, (2) hybridization, (3) hormonal sex reversal used to produce larger numbers and (4) water temperature [9].

Temperature is one of the most commonly studied environmental factors that influence sexual determination in fish [10]. Particularly, in fish exposure to high water temperatures 35°C during early development or sex differentiation period [11] was described to induce a male-biased sex ratio. Nevertheless, it has been suggested that thermal effects in zebrafish are secondary to genetic, since sex ratio only changes at extreme water temperatures [12]. Several studies have reported that increases or decreases in water temperatures also modify the phenotypic sex and shift the sex ratio in other teleost species, such as blue tilapia (*Oreochromis aureus*) [13]. However, in fish the impact of temperature

in sexual determination remains unclear since few studies have been carried out [11,14,15], and to our knowledge, there are no studies on sexual development of fish at low water temperatures.

Tessema et al. [9] studied the effect of different temperature regimes (18°C for 20 days, 36°C for 10 days or 38°C for 10 days starting on day 10 post fertilization) on sex ratios in two different Nile tilapia populations (Lake Manzala-Egypt, Lake Rudolph-Kenya). The author's show that, compared to the 36°C treatment, a further increase in males was not obtained with a treatment of 38°C in the majority of the tested progenies in both populations. The low temperature treatment (18°C) was, in general, not effective in influencing the sex ratios. Significant differences between populations to high temperature responsiveness were observed with regard to the degree and the range of response. In the Lake Manzala population, 66% of the temperature-treated progenies (36°C) showed sex ratios with more than 80% males, while in the Lake Rudolph population, no temperature-treated progeny (36°C) showed such a corresponding surplus of males.

Bezault et al. [16] studied the effect of temperature on sex reversal on three populations of Nile tilapia and he concluded that, 91.2% of progenies exhibited an excess of males at high temperature and 71.9% a significant increase of this proportion in comparison with the control temperature.

The long-term exposure of Nile tilapia to high temperature during a masculinizing treatment may decrease their survival and depress

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their growth substantially. Additionally, the early rearing of tilapia at very high temperature may impose an acclimation process when fish are returned at standard rearing temperature (28°C). It is thus uncertain whether the production of male monosex population would compensate for the growth deficit incurred during the masculinizing treatment. Due to the harmful effect of the hormone used to produce monosex fish on human health because of accumulation in fish body and it should not be used to produce monosex fish, therefore, the main aim of this work is to study the effect of water temperature on masculinization, growth and survival of Nile tilapia.

Materials and Methods

The experiment was carried out at the hatchery unit at the experimental station of the World Fish Center (WFC), Abbassa, Abou-Hammad Sharkia, Egypt. During the period of March to May, 2017 season.

Materials

System description

(a) **First experiment:** The experiment was conducted in the laboratory. Thirty-six glass tanks were used for tilapia fry culture, dimensions of each tank are 50 cm long, 25 cm wide and 30 cm high. The water volume used in each tank was 30 L. Each tank equipped with 15 W air blower of flow rate 850 L h⁻¹ at 1.5 m head to increase dissolved oxygen concentrations. 300 new hatched tilapia fry (four days old and 0.025 g weight) were reared.

The effluent water of the glass rearing tanks was passing through the filter unit, after that water passes through heater before it was returned to the fish tank by pump. The use of new water by the system was low. Daily partial water was added per day to reduce the accumulation of nitrate and substitute the water losses due to the evaporation. Heaters and thermostat were used to maintain the predetermined temperatures (25°C, 30°C and 35°C).

(b) **Second experiment:** Twenty-five fry from each replicate of all treatments of the sex reversal experiment after four weeks were kept in the same tank in order to test their growth performance for two months.

Methods

Tilapia nilotica fry, which were used in the experiment, were hatchery unit of the World Fish Center (WFC), Abbassa, Abou-Hammad Sharkia, Egypt. The daily feed rates at different fish sizes were applied according to the recommendations of Rakocy [17] and the feed pellet diameter was prepared according to Jauncey and Ross [18]. Feeding was stopped during weighing process.

Experimental design: The treatments were arranged in a split plot design in three replications. Three water temperatures are 25°C, 30°C and 35°C. Four periods of time are 1, 2, 3 and 4 weeks.

All treatments tanks were placed in a lab where a water recycling unit used to supply the tank with temperature controlled water.

Measurements: After each mentioned period of time for each treatment, a sample of 100 fry was collected from each tank to undergo sex ratio check using the Squash Technique [19]. Fish samples were killed by cold shock (water temperature of 0°C), weighed, measured and dissected.

During the experimental period continuous monitoring and recoding of the main water quality parameters was taken place.

Dissolved oxygen and temperature were measured by using the dissolved oxygen meter (Model HI9143 – Range 0 - 45 mg L⁻¹ ± 0.01 mg L⁻¹, Italy), provided with a dissolved oxygen probe (No. 81010). Total ammonia nitrogen (TAN) was measured by ion selective electrode (Model ORION 710 – Range 0 - 1000 mg L⁻¹ ± 0.01 mg L⁻¹, UK). The fish weight was measured by electric digital balance (Model HG – 5000 – Range 0 - 5000 g ± 0.01 g, Japan).

Fish growth calculations: Fish samples were taken to determine the biological parameters (weight gain, specific growth rate and feed conversion rate) of the fish as follows:

$$WG = W_f - W_i$$

$$SGR = \frac{\ln W_f - \ln W_i}{t} \times 100$$

$$FCR = \frac{FI}{WG.Nt}$$

Where: WG is the weight gained, g

W_f is the mean final fish weight, g

W_i is the mean initial fish weight, g

SGR is the specific growth rate, (% or g day⁻¹)

t is the time, day

FCR is the feed conversion rate, g feed g⁻¹ fish weight

FI is the feed intake, g

Nt is the final number of fish in the tank

Statistical analysis

The statistical analysis for the data obtained was done according to Snedecor and Cochran [20] and the treatments were compared using Least Significant Differences (LSD) test at 99% confidence level [21].

Results and Discussion

First experiment

Male ratio: Figure 1 shows the male ratio of Nile tilapia as affected by different water temperatures (25°C, 30°C and 35°C) and after different periods of time (1, 2, 3 and 4 weeks). The results indicate that the male ratio increases with increasing water temperature and time period under study. It could be seen that when the water temperature increasing from 25°C to 35°C, the male ratio significantly increased from 52.47% to 75.91% after one week of rearing, while it significantly increased from 56.92% to 85.05%, 63.12% to 88.21% and 66.94% to

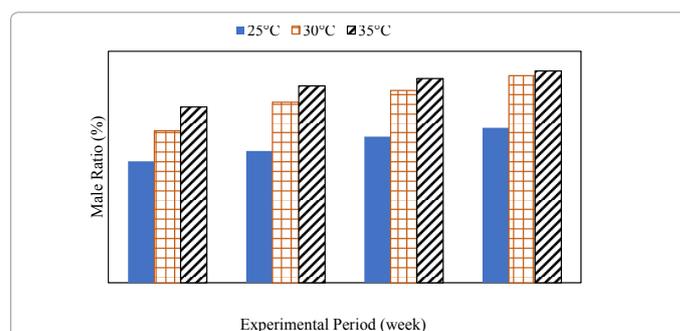


Figure 1: The male ratio of Nile tilapia at different water temperatures and periods of time.

91.50% after two, three and four weeks of rearing, respectively. These results agreed with those obtained by Tessema et al. [9] who's found the low temperature treatment (18°C) was not effective in influencing the sex ratios, while the high temperature (36°C) increased the male ratio more than 80% and Bezault et al. [16] who's found the high-water temperature increased the male ratio to 91.2% at water temperature of 36°C.

Concerning the effect of period of time rearing on the male ratio, the results indicate that the male ratio of Nile tilapia increases with increasing the period of time. It indicates that when the period of time increased from 1 to 4 weeks, the male ratio significantly increased from 52.47% to 66.94%, 65.65% to 89.47% and 75.91% to 91.50% at 25°C, 30°C and 35°C water temperature, respectively.

Mortality rate: Figure 2 shows the mortality rate of Nile tilapia as affected by different water temperatures (25°C, 30°C and 35°C) and different periods of time (1, 2, 3 and 4 weeks). The results indicate that the mortality rates of Nile tilapia were 10.27%, 14.09% and 14.28% at 25°C, 30°C and 35°C water temperature, respectively, after one week of rearing. After two weeks of rearing, the mortality rates were found to be 11.34, 15.01 and 15.09% at 25°C, 30°C and 35°C water temperature, respectively. After three weeks of rearing, the mortality rates were 11.41, 15.83 and 15.98% and reached to 11.62, 15.89 and 17.13% after four weeks under the previous mentioned temperature treatments for Nile tilapia, respectively. The lowest value of the mortality rate (10.27%) was obtained at 25°C water temperature and one week of rearing, while the highest value of mortality rate (17.13%) was obtained at 35°C water temperature and four weeks of rearing. These results are relatively in agreement with those obtained by Bezault et al. [16,22] who's found the mortality rate ranged from 21.4 to 21.2% at 27°C and 36°C water temperature.

Weight of Nile tilapia fry: Figure 3 shows the weight of Nile

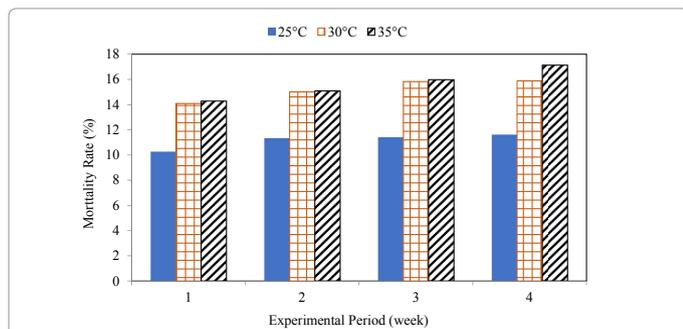


Figure 2: The mortality rate of Nile tilapia at different water temperatures and periods of time.

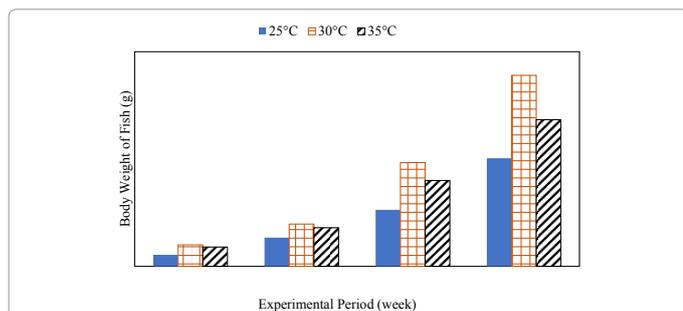


Figure 3: The weight of Nile tilapia fry at different water temperatures and periods of time.

Water Temperature (°C)	Body Weight of Nile Tilapia Fish, g							
	One Week		Two Weeks		Three Weeks		Four Weeks	
	Initial BW	Final BW	Initial BW	Final BW	Initial BW	Final BW	Initial BW	Final BW
25	4.16	46.67	4.20	48.64	4.27	50.19	4.28	56.83
30	4.24	49.91	4.31	54.73	4.33	59.00	4.26	62.46
35	4.21	54.96	4.22	61.06	4.28	72.61	4.25	78.25

Table 1: The weight of Nile tilapia fish.

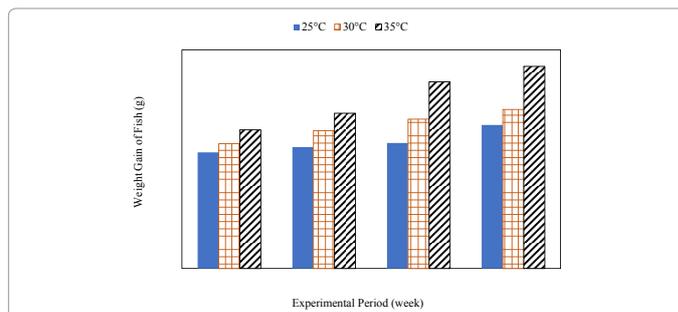


Figure 4: The weight gain of Nile tilapia fish after growth period.

tilapia fry as affected by different water temperatures (25°C, 30°C and 35°C) and different periods of time (1, 2, 3 and 4 weeks). The results indicate that the weights of Nile tilapia fry were 0.16, 0.30 and 0.27 g at 25°C, 30°C and 35°C water temperature, respectively, after one week of rearing. After two weeks of rearing, the weight of Nile tilapia fry was found to be 0.40, 0.59 and 0.54 g at 25°C, 30°C and 35°C water temperature, respectively. After three weeks of rearing, the weights of Nile tilapia fry were found to be 0.79, 1.45 and 1.20 g and reached to 1.51, 2.67 and 2.05 g after four weeks, at the same pervious mentioned water temperature, respectively. The highest value of the weight of Nile tilapia fry was obtained at water temperature of 30°C. These results agreed with those obtained by Khater [23] who mentioned that the optimum required temperature of Nile tilapia fish growth (28 ± 2°C).

The results also indicate that the weight of Nile tilapia fry increases with increasing time period. It could be seen that when the period of time increasing from 1 to 4 weeks, the weight of Nile tilapia fry significantly increased from 0.16 to 1.51, 0.30 to 2.67 and 0.27 to 2.05 g at 25°C, 30°C and 35°C, respectively.

Second experiment

Weight of fish: Table 1 shows the weight of fish previously treated by each water temperatures (25°C, 30°C and 35°C) and different periods (1, 2, 3 and 4 weeks) after growth period (two months). The results indicated that the weight of Nile tilapia fish increased from 4.16 to 46.67, 4.24 to 49.91 and 4.21 to 54.96 g for fry treated by water temperature 25°C, 30°C and 35°C for one week. The weight of Nile tilapia fish increased from 4.20 to 48.64, 4.31 to 54.73 and 4.22 to 61.06 g for fry treated by water temperature 25°C, 30°C and 35°C for two weeks. The results also indicated that the weight of Nile tilapia fish increased from 4.27 to 50.19, 4.33 to 59.00 and 4.28 to 72.61 g for fry treated by water temperature 25°C, 30°C and 35°C for three weeks, while it increased from 4.28 to 56.83, 4.26 to 62.46 and 4.25 to 78.25 g for fry treated by water temperature 25°C, 30°C and 35°C for four weeks.

Weight gain of Nile tilapia fish: Figure 4 shows the weight gain of Nile tilapia fish previously treated by each water temperature (25°C, 30°C and 35°C) and different periods (1, 2, 3 and 4 weeks) after growth period (two months). The results indicate that the weight gain of

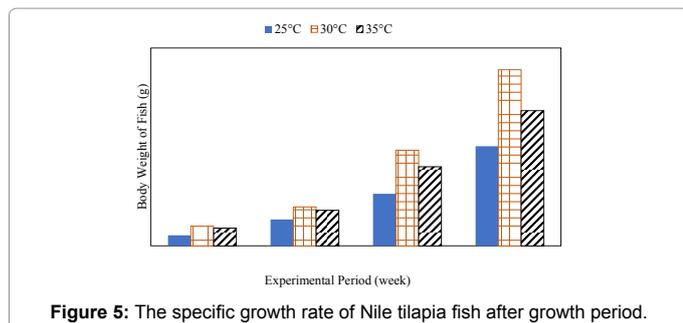


Figure 5: The specific growth rate of Nile tilapia fish after growth period.

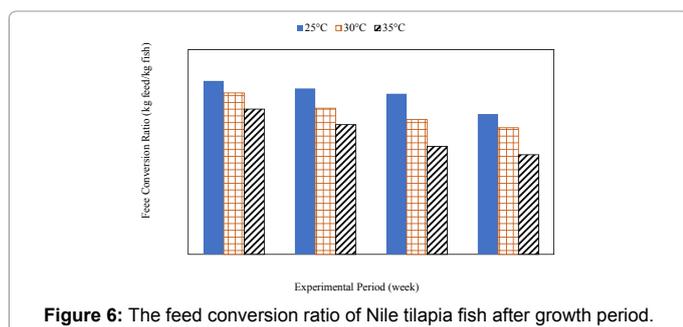


Figure 6: The feed conversion ratio of Nile tilapia fish after growth period.

Nile tilapia fish was 42.51, 45.67 and 50.75 g for fry treated by water temperature 25°C, 30°C and 35°C for one week, respectively. The weight gain of Nile tilapia fish found to be 44.44, 50.42 and 56.84 g for fry treated by water temperature 25°C, 30°C and 35°C for two weeks, respectively. The weight gain of Nile tilapia fish found to be 45.92, 54.67 and 68.33 g for fry treated by water temperature 25°C, 30°C and 35°C for three weeks, respectively, and reached to 52.55, 58.20 and 74.00 g for fry treated four weeks of temperature treatment for Nile tilapia, respectively.

The results indicate that, when the Nile tilapia fry treated by different water temperature (25 to 35°C) the weight gain of Nile tilapia fish significantly increased from 42.51 to 50.75, 44.44 to 56.84, 45.92 to 68.33 and 52.55 to 74.00 g for 1, 2, 3 and 4-week period of time rearing. The results also indicate that, when the Nile tilapia fry treated by different period (1 to 4 weeks) the weight gain of Nile tilapia fish significantly increased from 42.51 to 52.55, 45.67 to 58.20 and 50.75 to 74.00 g at 25°C, 30°C and 35°C water temperature, respectively. Increasing weight gain of Nile tilapia fish with increasing water temperature and period of time may be due to increasing in male ratio, where, the growth rate of fish is increased in male over those of female.

Specific growth rate (SGR) of Nile tilapia fish: Figure 5 shows the specific growth rate of Nile tilapia fish previously treated by each water temperature (25°C, 30°C and 35°C) and different periods (1, 2, 3 and 4 weeks) after growth period (two months). The results indicate that the specific growth rate increases with increasing water temperature and period of time. It could be seen that when the water temperature increasing from 25 to 35°C, the specific growth rate significantly increased from 4.03% to 4.28% or g day⁻¹ after one week of rearing, while it significantly increased from 4.08% to 4.45%, 4.11% to 4.72% and 4.31% to 4.86% after two, three and four weeks of rearing, respectively. The results also indicate that when the period of time increased from 1 to 4 weeks, the specific growth rate significantly increased from 4.03% to 4.31%, 4.11% to 4.48% and 4.28% to 4.86% at 25°C, 30°C and 35°C water temperature, respectively. These results agreed with those obtained by [23] who found the specific growth rate ranged from 1.18% to 4.83%.

Feed conversion ratio (FCR) of Nile tilapia fish: Figure 6 shows the feed conversion ratio of Nile tilapia fish previously treated by each water temperature (25°C, 30°C and 35°C) and different periods (1, 2, 3 and 4 weeks) after growth period (two months). The results indicate that the feed conversion ratio decreases with increasing water temperature and period of time. It could be seen that when the water temperature increasing from 25 to 35°C, the feed conversion ratio non-significantly decreased from 2.12 to 1.77 kg feed/kg fish after one week of rearing, while it non-significantly decreased from 2.03 to 1.58, 1.96 to 1.32 and 1.71 to 1.22 kg feed/kg fish after two, three and four weeks of rearing, respectively. The results also indicate that when the period of time increased from 1 to 4 weeks, the feed conversion ratio non-significantly decreased from 2.12 to 1.71, 1.97 to 1.55 and 1.77 to 1.22 kg feed/kg fish at 25°C, 30°C and 35°C water temperature, respectively. Decreasing feed conversion ratio of Nile tilapia fish with increasing water temperature and period of time may be due to increasing in male ratio, where, the growth rate of fish is increased in male over those of female.

Conclusion

Two experiments were carried out to study the effect of water temperature on masculinization, growth and survival of Nile tilapia. The treatments under study the first experiment is: Water temperatures (25°C, 30°C and 35°C) and periods of time (1, 2, 3 and 4 weeks). While the second experiment aimed to evaluate the growth and survival rate of sex reversal tilapia fry which obtained from the first experiment. The obtained results can be summarized as follows: The lowest value of the male ratio and mortality rate (75.91% and 10.27%) were obtained at 25°C water temperature and one week of rearing, while the highest value of male ratio and mortality rate (91.50% and 17.13%) was obtained at 35°C water temperature and four weeks of rearing. The weight of Nile tilapia fry significantly increased from 0.16 to 1.51, 0.30 to 2.67 and 0.27 to 2.05 g at 25°C, 30°C and 35°C, respectively after 1, 2, 3 and 4 weeks of rearing. The highest value of weight gain fish and specific growth rate (74.00 g and 4.86%) was obtained at 35°C water temperature and four weeks of rearing. The feed conversion ratio decreased from 2.12 to 1.77, 2.03 to 1.58, 1.96 to 1.32 and 1.71 to 1.22 kg feed/kg fish after 1, 2, 3 and 4 weeks of rearing, respectively with increasing water temperature from 25°C to 35°C.

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