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Techno-Financial Study for Some Sex Reversal Methods of Nile Tilapia Fish

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ABSTRACT

The main aim of this work is a techno-financial evaluation for some sex reversal methods of Nile tilapia. To achieve that study the effect of water temperatures (25, 30 and 35 °C), hormone levels (without (0) and 60 mg 17 ᾳ-MT/ kg feed) and periods of time (1, 2, 3 and 4 weeks) on the male ratio, mortality rate, weight gain of Nile tilapia fries, energy consumption and costs of heating water and hormone were assessed. The obtained results indicated that the male ratio and mortality rate increased with the increasing of water temperature, hormone doses and rearing period. The highest value of weight gain (2.56 g) was obtained at 30 °C water temperature with 60 mg 17 ᾳ-MT/ kg feed after four weeks of rearing. The energy consumption for heating water increased with the increase of water temperature and rearing period. The costs of heating water and hormone increased with increasing water temperature, hormone doses and rearing period. The water temperature of 35°C with 60 mg 17 ᾳ-MT/ kg feed after two weeks gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after four weeks. In addition, the water temperature of 35°C with 60 mg 17 ᾳ-MT/ kg feed after one week gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after three weeks.

Keywords: Nile tilapia – temperature – Male ratio – Sex ratio - Weight gain - Specific growth rate - Feed conversion ratio

INTRODUCTION

Tilapia is the generic name of a large range of fish species of cichlids. The original distribution of this group was south-central Africa northward into Syria, where more than 70 species have been identified **(Popma and Phelps, 1998)**. **Tsadik and Bart (2007)** reported that Nile tilapia, *Oreochromis niloticus* (Linnaeus, 1758) is the main genus Oreochromis with potential for aquaculture due to its rusticity and rapid growth, reaching commercial weight in small interval of time; great capacity for adaptation to confinement and the various systems of farming, high capacity for hybridization, which allows the characters unit desired; tolerance to wide variations in salinity, temperature and concentrations of dissolved oxygen, high resistance to diseases, high quality meat with its clear color, and high acceptance by the consumer **(Tsadik and Bart, 2007)**.

Tilapia males have a higher weight gain and better-feed conversion when compared with females under same conditions. Males grow 18-25% faster than females **(Macintosh and Little, 1995 and Soto-Zarazúa *et al.,* 2011)**. There are various techniques of sex reversal, or more specifically the production of masculinization monosex culture. Among the techniques used for sex reversal in tilapia, the most widespread in the world is the use of hormone incorporated in the diet, especially the 17 -methyltestosterone **(Guerrero III and Guerrero, 1997)**.

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 **(Tessema *et al.,* 2006)**.

Production of mono-sex populations in several fish species require sex reversal, which is induced by steroid hormones **(Shelton *et al.,* 1995)**. Of these androgens and oestrogens are used as masculinizing and feminizing agents, respectively. These steroid hormones are commonly applied by oral or immersion treatments. Oral administration of the synthetic androgen 17α-methyltestosterone (MT) has been effective in producing all male populations in carps. All male population increases the efficiency and feasibility of carp aquaculture. There have been numerous published attempts to optimize the methods of sex reversal by varying parameters such as hormone dose, treatment start time, duration of treatment and stocking density **(Mubarik *et al.*, 2011)**.

Khater (1999) indicated that the male ratio found to be 67.25, 91.87 and 95.68 % for the duration treatment period of 14, 21 and 28 days, respectively, when Nile tilapia fry fed diet containing 60 mg of 17α-MT/kg feed.

Celik *et al.* (2011) tried to produce all male Nile tilapia by feeding its larvae with diet containing 17α-MT at five different doses (0, 20, 30, 40, 50 and 60 mg/kg feed) for 28 days. Since the androgens have both sex reversal and anabolic effects. The same authors also stated that, the sex reversed tilapia shows a better growth performance as compared to normal tilapia.

Temperature is one of the most commonly studied environmental factors that influence sexual determination in fish **(Devlin and Nagahama, 2002)**. The phenotypic sex in Nile tilapia is a complex trait, it is determined through interplay between major genetic and minor genetic factors and temperature. The response of the phenotypic sex to thermal treatments (>34 °C) during a 10-day period after yolk sac absorption is proven to be under genetic control **(Baroiller *et al.*, 1996)**. Former experiments using elevated temperatures (36 °C for ten days) in Nile tilapia fry, **Tessema *et al.* (2006)** showed that, differences of thermal responsiveness exist within and between Nile tilapia populations. The same authors also stated that, further increase in males was not obtained with the 38°C treatment in most of the tested progenies in both populations. Nonetheless, the low temperature treatment (18°C) was, in general, not effective in influencing the sex ratios. 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 **(Wessels and Hörstgen-Schwark, 2007)**. They mentioned that, a selection experiment revealed that selection for the male proportion in the temperature treated groups can be successful. The same authors also showed that, after two generations of divergent selection for the male proportion in temperature treated groups, male percentages of 90% and 54% were obtained in the high- and low-line, respectively.

Due to the harmful effect of the hormone used to produce monosex fish on human health due to its accumulation in fish body and it should careful to use it in order to produce monosex fish and therefore, the main aim of this work is to techno-financial evaluation for some sex reversal methods of Nile tilapia fish.

MATERIALS AND METHODS

The experiment was carried out at Agricultural and Bio-Systems Engineering Department, Faculty of Agriculture, Moshtohor, Benha University, Egypt. During the period of February to April 2018.

Materials:

System description:

The experiment was conducted in the laboratory. Seventy-two 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 liters stored with 300 new hatched tilapia fry (four days old and 0.025 g weight). 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.

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 excreted ammonia and substitute the water losses due to the evaporation. Each tank equipped with 150 W heater and thermostat to maintain the predetermined temperatures (25, 30 and 35°C).

The hormone treated feed was prepared as described by **(Killian and Kohler, 1991)**. The 17 α-methyl testosterone (MT) used in the present study was obtained from the (Sigma Chemical Ltd.). A stock solution was made by dissolving 1 g of hormone in 1 L of 95% ethanol. Treatments were made by taking the accurate amount of the hormone from stock solution and brought up to 100 ml by addition 95% ethanol. This solution was evenly sprayed over 1 kg of the diet and diet and mixed. The mixture was mixed again and this was repeated to ensure an equal distribution of the MT throughout the feed. Treated diets were fan dried in shade at 25 °C for 24 hours then kept in freezer until use.

During the experimental period, continuous monitoring and recoding of the main water quality parameters took place. Dissolved oxygen and temperature were measured by using the dissolved oxygen meter, provided with a dissolved oxygen probe (No. 81010). Total ammonia nitrogen (TAN) was measured by ion selective electrode (ORION 710). The fish weight was measured by electric digital balance (Model HG – 5000 – Range 0 - 5000 g ± 0.01 g, Japan).

Methods:

Nile Tilapia fries, which were used in the experiment, were conveyed from 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 (1989)** and the feed pellet diameter was prepared according to **Jauncey and Ross (1982)**. Feeding was stopped during weighing process.

Experimental design:

The treatments were arranged in a split split plot design in three replications. Three water temperatures are 25, 30 and 35 °C and two levels hormone (0 and 60 mg 17 α-MT /kg feed). 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 **(Guerrero and Shelton, 1974)**. Fish samples were killed by cold shock (water temperature of 0°C), weighed, measured and dissected. Fish sample were taken to determine the weight gained of the fish as following:

$$WG = W_f - W_i \tag{1}$$

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

Theoretical Approach

Figure (1) represents the energy balance described by the following mathematical expression:

$$(dq/dt) = \pm q_{rad} \pm q_{conv} \pm q_{cond} - q_{evap} + q_{in} - q_{drain} \pm q_{other} \quad (2)$$

Where:-

q is the total energy (kJ) at any given time (t) in the pond per m^2

q_{rad} is the rate of heat exchange by radiation, kW m^{-2}

q_{conv} is the rate of heat exchange with the air by convection, kW m^{-2}

q_{cond} is the rate of heat exchange with the wall, kW m^{-2}

q_{evap} is the rate of heat lost through the evaporation of water, kW m^{-2}

q_{in} is the rate of bulk energy gain from makeup water, kW m^{-2}

q_{drain} is the rate of bulk energy lost to the overflow of water, kW m^{-2}

q_{other} is the rate of energy transfer from or to other sources, kW m^{-2}

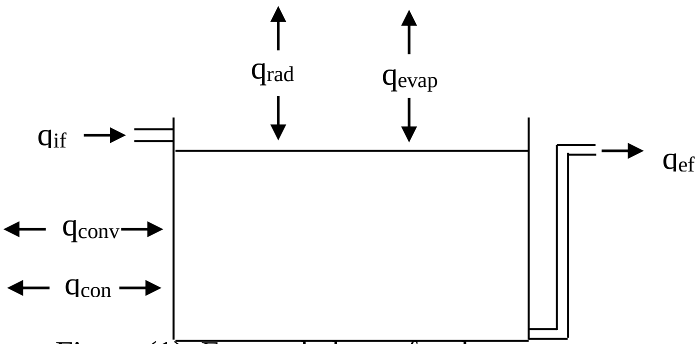

Figure (1): Energy balance for the system.

The rate of heat exchange due to pond radiation is:

$$q_{rad} = 0.97 e \sigma (T_{air})^4 \quad (3)$$

Where:-

q_{rad} is the heat exchange due to pond radiation (kW m^{-2})

σ is the Stefen-Boltzmann constant (5.67×10^{-11} kW m^{-2} K^{-4})

T_{air} is absolute air temperature 2 m above the water surface (K)

e is average emittance of the atmosphere (dimensionless)

The average emittance of the atmosphere terms can be calculated according to the following equations **(Bliss, 1961)**:

$$e = 0.398 \times 10^{-5} (T_{air})^{2.148} \quad (4)$$

The conduction of heat between the inner surface and the outer surface was calculated as:

$$q_{cond} = k(T_i - T_o)/z \quad (5)$$

Where:-

q_{cond} is the rate of heat transfer through conduction (kW m^{-2})

k is thermal conductivity coefficient (kW m^{-1} K^{-1})

T_i is temperature of the inner surface (K)

T_o is temperature of the outer surface (K)

Z is thickness of material (m)

For system, conduction occurs in two places, the bottom and the walls of pond.

Heat transferred through convection can be calculated using Newton's Law of cooling:

$$q_{conv} = h(T_{surface} - T_{fluid}) \quad (6)$$

Where

q_{conv} is the heat transferred by convection (kW m^{-2})

h is the heat transfer coefficient (kW m^{-2} K^{-1})

$T_{surface}$ is the temperature of the surface (K)

T_{fluid} is the temperature of the cooling (or heating) fluid (K).

For system, convection occurs in two places, the wall-water interface and the water-air interface.

Nusselt number (Nu) correlations are traditionally used to predict a heat transfer coefficient, depending on:

- The geometry of the surface
- The properties of the cooling fluid
- The velocity at which the cooling fluid is moving

The Nusselt number, a dimensionless number, is the ratio between the rate of convection to the rate of conduction in a fluid. Numerically, the Nusselt number (Nu) is related to the heat transfer coefficient by:

$$N_u = \frac{hL_c}{k_{air}} \quad (7)$$

Where

L_c is the characteristic length of the surface (m)

h is the heat transfer coefficient (kW m^{-2} K^{-1})

k_{air} is the thermal conductivity of the air (kW m^{-1} K^{-1})

$$k_{air} = \left(1.52E-11xT_{air}^{3} - 4.86E-08xT_{air}^{2} + 1.02E-04xT_{air} - 3.93E-04\right)/1000 \quad (8)$$

$$L_c = \frac{Area}{Perimeter} \quad (9)$$

The Rayleigh number is:

$$R_a = \frac{g\beta\left(T_{water} - T_{air}\right)L_c^3}{v_{air}^2} \quad (10)$$

Where

g is the gravitational acceleration (9.81 m s^{-2})

β is the coefficient of thermal expansion (K^{-1})

T_{water} is the temperature of water (K)

v_{air} is the kinematic viscosity of the air (m^2 s^{-1})

Estimates for the case of a flat horizontal plate where the plate (in this case, the water) is warmer than the cooling fluid (in this case, the air), the following empirical correlations apply **(Holman, 1997)**:

Nu = 0.54 $Ra^{0.25}$ if Ra is between 10^4 and 10^7.

Nu = 0.15 $Ra^{1/3}$ if Ra is between 10^7 and 10^{11}

If the plate is cooler than the fluid, and Ra is between 10^5 and 10^{10}, then

$$Nu = 0.54\ Ra^{1/4} \quad (11)$$

The rate of bulk energy moved across the system boundary can calculated with the following equation:

$$q = \dot{m}CpT_{water} \quad (12)$$

Where

$\dot{m}$ is the mass flow rate of water into (or out of) the system,

Cp is the specific heat of water and

T_{water} is the temperature of the water.

The process of evaporation requires a lot of energy. Evaporation heat losses (q_{evap}) are calculated with the following set of equations **(Anonymous, 1992)**:

$$q_{evap} = \frac{m^{\bullet}_{evap} h_{fg}}{A} = \frac{Q_e \rho_w h_{fg}}{A} \quad (13)$$

Where

$m^{\bullet}_{evap}$ is the rate of evaporation (kg s^{-1})

h_{fg} is the latent heat of vaporization (kJ kg^{-1})

A is the surface area of the pond (m^2)

Q_e is the water lost to evaporation (m^3 s^{-1})

Alternately, the following equation can used to estimate the rate of evaporation **(Piedrahita, 1991)**:

$$Q_e = 2.241 x 10^{-3} x V_2 x (e_s - e_a) \quad (15)$$

Where

Q_e is the rate of evaporation (m^3 s^{-1})

V_2 is the wind velocity 2 meters above the pond surface (m s^{-1}) (**Khater, 2012**)

e_s is the saturated vapor pressure (Pa)

e_a is the air vapor pressure (Pa)

$$e_s = 25.374 x Exp\left(17.62 - \frac{5271}{T_{water}}\right) x \left(\frac{760 mmHg}{101300 Pa}\right) \quad (16)$$

$$e_a = RH x 25.374 x Exp\left(17.62 - \frac{5271}{T_{air}}\right) x \left(\frac{760 mmHg}{101300 Pa}\right) \quad (17)$$

Where

RH is the Relative Humidity (%)

All computational procedures of the model were carried out using Excel spreadsheet. The computer program was devoted to energy balance for predicting the energy requirement for heating water.

Costs analysis

Calculation the costs for heating water to maintain the water temperature requirement and compared to costs of hormone.

Statistical analysis

The statistical analysis for the data obtained was done according to **Snedecor and Cochran (1980)** and the treatments were compared using Least Significant Differences (LSD) test at 99% confidence level **(Gomez, 1984)**.

RESULTS AND DISCUSSIONS

Male ratio:

Table (1) shows the male ratio of Nile tilapia under the two levels of hormone dose (0 and 60 mg 17 α-MT/ kg feed) as affected by water temperatures; 25, 30 and 35 °C and time periods from 1 to 4 weeks. Regarding of the effect water temperature, could be seen that the average values of the male ratio were 66.27, 83.08 and 89.04 % for Nile tilapia fries rearing at 25, 30 and 35 °C water temperature, respectively depending on the period and hormone level. The results revealed that the male ratio of Nile tilapia increased with increasing the water temperature from 25 to 35 °C. Rearing at 35 °C water temperature gave the best results of male ratio for all period of time rearing and level of hormone with significant differences. These results were in agreement with those obtained by **Tessema *et al.*, (2006)** who is found that, the high water temperature (36°C) increased the male ratio more than 80%. Nonetheless, **Bezault *et al.*, (2007)** found that, the high water temperature increased the male ratio to 91.2% at water temperature 36°C.

Table (1): Effect of water temperature, period and level of hormone on male ratio of Nile tilapia.

Hormone Dose, mg kg^{-1}	Water Temperature, °C	Time Period, week				Mean
		1	2	3	4	
		Mate Ratio, %				
0	25	50.86^{a}	56.44^{b}	64.04^{d}	68.28^{g}	**59.91^{a}**
	30	65.41^{e}	73.92^{h}	81.63^{l}	84.35^{k}	**76.33^{c}**
	35	73.00^{h}	83.18^{k}	87.78^{l}	90.65^{m}	**83.65^{d}**
	Mean	**63.09^{a}**	**71.18^{b}**	**77.82^{d}**	**81.09^{e}**	
60	25	57.68^{c}	66.82^{f}	79.78^{g}	86.19^{m}	**72.62^{b}**
	30	76.91^{i}	90.98^{n}	94.26^{o}	97.03^{p}	**89.80^{e}**
	35	86.95^{m}	94.86^{o}	96.90^{p}	98.98^{q}	**94.42^{f}**
	Mean	**73.85^{c}**	**84.22^{f}**	**90.31^{g}**	**94.07^{h}**	

$LSD_{0.05}$	A	B	C	AB	AC	BC	ABC
	0.276	0.338	0.478	0.390	0.525	0.676	0.956

Concerning the effect of period of rearing, the results indicate that the male ratio of Nile tilapia increases with increasing period of rearing. It could be seen that the average values of male ratio were significantly increased from 68.47 to 87.04 %, when the period increasing from 1 to 4 weeks depending on the water temperature and hormone level. These results agreed with those obtained by **Khater (1999)** and **Khater *et al.,* (2017)** in which the male ratio of Nile tilapia enhanced by period during rearing. The results also indicate that the male ratio of Nile tilapia ranged from 73.30 and 85.61 % for 0 and 60 mg 17 α-MT/ kg feed, respectively. These results agreed with those obtained by **Celik *et al.,* (2011)**. The statistical analysis showed that the differences between the obtained data of male ratio of Nile tilapia due to the effect of water temperature (A), time period (B) and level of hormone (C) were significant. The analysis showed also that the interaction between both AB, AC, BC and ABC were significant.

Mortality rate:

Table (2) shows the mortality rate of Nile tilapia under two levels of hormone dose (0 and 60 mg 17 α-MT/ kg feed) as affected by water temperatures from 25 to 35 °C and time periods from 1 to 4 weeks. Regarding of the effect water temperature, the results indicate that the mortality rate increases with increasing water temperature. It could see that the average values of the mortality rate significantly increased from 12.08 to 16.23 %, when the water temperature increased from 25 to 35 °C depending on the period and hormone level. Rearing at 25 °C water temperature gave the lowest results of mortality rate for all period of rearing and level of hormone with significant differences. These results are relatively in agreement with those obtained by **Baras *et al.* (2001)** and **Bezault *et al.* (2007)**.

Concerning the effect of period of rearing on the mortality rate of Nile tilapia, the results indicate that the mortality rate of Nile tilapia increases with increasing period of rearing. Since the average values of the mortality rate were 13.29, 14.63, 15.30 and 15.74 % for Nile tilapia fries rearing at 1, 2, 3 and 4 weeks of rearing period, respectively depending on the water temperature and hormone level. The highest value of the mortality rate of Nile tilapia (15.74%) obtained at period of 4 weeks.

The results also indicate that the mortality rate of Nile tilapia ranged from 14.10 and 15.38 % for 0 and 60 mg 17 α-MT/ kg feed, respectively.

The statistical analysis showed that the differences between the obtained data of male ratio of Nile tilapia due to the effect of water temperature (A), time period (B) and level of hormone (C) were significant. The analysis showed also that the interaction between AB, AC and BC was significant. On the other hand, the interaction between the effects of both ABC on the data was non-significant.

Table (2): Effect of water temperature, time period and level of hormone on mortality of Nile tilapia.

Hormone Dose, mg kg^{-1}	Water Temperature, °C	Time Period, week				**Mean**
		1	2	3	4	
		Mortality Rate, %				
0	25	10.26	11.25	12.00	12.21	**11.43^{a}**
	30	14.09	14.09	16.14	16.71	**15.26^{c}**
	35	14.27	15.74	16.01	16.43	**15.61^{c}**
	Mean	**12.87^{a}**	**13.69^{b}**	**14.72^{c}**	**15.12^{d}**	
60	25	11.17	12.79	13.23	13.70	**12.72^{b}**
	30	14.77	16.81	17.10	17.56	**16.56^{d}**
	35	15.16	17.09	17.31	17.84	**16.85^{e}**
	Mean	**13.70^{b}**	**15.56^{e}**	**15.88^{ef}**	**16.37^{g}**	

$LSD_{0.05}$	A	B	C	AB	AC	BC	ABC
	0.115	0.141	0.199	0.163	0.230	0.282	N.S

Weight gain of Nile tilapia fry:

Table (3) shows the weight gain of Nile tilapia under two levels of hormone dose (0 and 60 mg 17 α-MT/ kg feed) as affected by water temperatures from 25 to 35 °C and time periods from 1 to 4 weeks. Regarding of the effect water temperature, it could be seen that the average values of the weight gain of Nile tilapia fry were 0.78, 1.28 and 0.78 g for Nile tilapia fry rearing at 25, 30 and 35 °C water temperature, respectively depending on the period and hormone level. The highest value of the male ratio of Nile tilapia (1.28 g) was obtained at water temperature of 30 °C. The results revealed that the weight gain of Nile tilapia increased with increasing the water temperature from 25 to 30 °C. These results almost agreed with those obtained by **Khater (2012)** who mentioned that the optimum required temperature of Nile tilapia fish growth (28 ± 2 °C).

Table (3): Effect of water temperature, period and level of hormone on weight gain of Nile tilapia.

<table>
<tr><td rowspan="3">Hormone Dose, mg kg^{-1}</td><td rowspan="3">Water Temperature, °C</td><td colspan="5">Time Period, week</td><td rowspan="3">Mean</td></tr>
<tr><td>1</td><td>2</td><td colspan="2">3</td><td>4</td></tr>
<tr><td colspan="5">Weight gain, g</td></tr>
<tr><td rowspan="4">0</td><td>25</td><td>0.10</td><td>0.35</td><td colspan="2">0.93</td><td>1.63</td><td>0.75</td></tr>
<tr><td>30</td><td>0.26</td><td>0.51</td><td colspan="2">1.78</td><td>2.40</td><td>1.24</td></tr>
<tr><td>35</td><td>0.21</td><td>0.32</td><td colspan="2">0.92</td><td>1.59</td><td>0.76</td></tr>
<tr><td>Mean</td><td>0.19</td><td>0.39</td><td colspan="2">1.21</td><td>1.87</td><td></td></tr>
<tr><td rowspan="4">60</td><td>25</td><td>0.19</td><td>0.39</td><td colspan="2">1.01</td><td>1.66</td><td>0.81</td></tr>
<tr><td>30</td><td>0.28</td><td>0.55</td><td colspan="2">1.86</td><td>2.56</td><td>1.31</td></tr>
<tr><td>35</td><td>0.26</td><td>0.38</td><td colspan="2">0.96</td><td>1.61</td><td>0.81</td></tr>
<tr><td>Mean</td><td>0.24</td><td>0.44</td><td colspan="2">1.28</td><td>1.94</td><td></td></tr>
<tr><td rowspan="2">$LSD_{0.05}$</td><td>A</td><td>B</td><td>C</td><td>AB</td><td>AC</td><td>BC</td><td>ABC</td></tr>
<tr><td>0.008</td><td>0.010</td><td>0.012</td><td>N.S</td><td>N.S</td><td>0.020</td><td>N.S</td></tr>
</table>

Concerning the effect of period of rearing on the weight gain of Nile tilapia, the results indicate that the weight gain of Nile tilapia increases with increasing period of rearing. It is significantly increased from 0.22 to 1.91 g, when the rearing period increasing from 1 to 4 weeks depending on the water temperature and hormone level. The results also showed that the weight gain of Nile tilapia increased from 0.92 and 0.98 g for 0 and 60 mg 17 α̣-MT/ kg feed, respectively. The statistical analysis showed that the differences between the obtained data of male ratio of Nile tilapia due to the effect of water temperature (A), time period (B) and level of hormone (C) were significant. The analysis showed also that the interaction between both BC were significant. On the other hand, the interaction between the effect of AB, AC and ABC on the data was non-significant.

3.4. Energy Consumption for heating water:

Figure (2) shows the energy consumption for heating water to maintain of water temperature at 25, 30 and 35°C at different periods (1, 2, 3 and 4 weeks). The results indicated that the energy consumption for heating water increases with increasing water temperature and rearing period. Since, as the water temperature increased from 25 to 35 °C, the energy consumption increased from 270.00 to 326.67, 533.33 to 640.00, 820.00 to 990.00 and 1246.67 to 1286.67 kW/100000 fry after 1, 2, 3 and 4 weeks, respectively.

The results also indicate that the highest value of energy consumption for water heating (1286.67 kW/100000 fry) found at 35 °C water temperature after four weeks of period rearing. While the lowest value of energy consumption for water heating (270.00 kW/100000 fry) found at 25 °C water temperature after one week of period rearing.

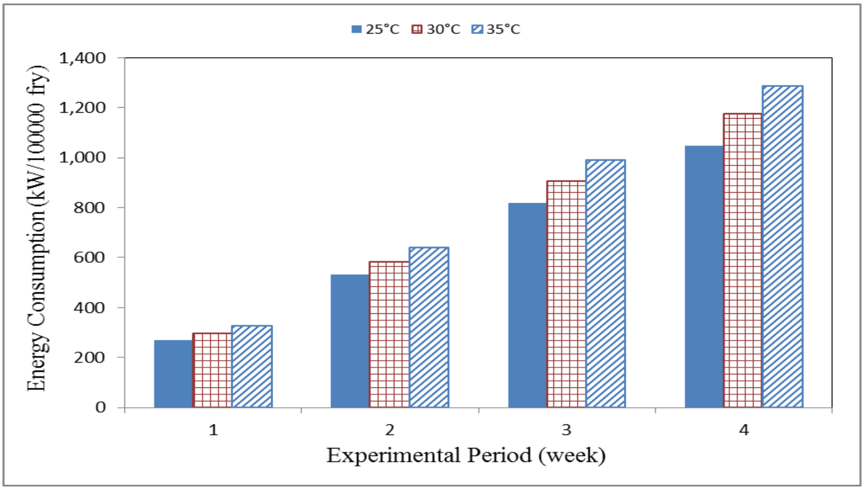

Figure (2): The energy consumption for heating water at different water temperature and different time of periods.

Multiple regression analysis was carried out to find a relation between the energy consumption for heating water and both water temperatures and periods of rearing. Equation (18) shows the most appropriate form for the relationship between the energy consumption for heating water and both water temperatures (25 - 35°C) and periods of rearing (1 – 4 week).

$$EC = -423.893 + 14.334WT + 293.222TP \qquad R^2 = 0.99 \qquad (18)$$

Where:

EC is the energy consumption for heating water, kW/100000 fry

WT is the water temperature, ^oC

TP is the time of period, week

Costs of heating water and hormone:

Table (4) shows the costs of heating water and hormone under two levels of hormone dose (0 and 60 mg 17 α-MT/ kg feed) as affected by water temperatures from 25 to 35 °C and time periods from 1 to 4 weeks. The results indicated that the costs of heating water and hormone increases with increasing hormone dose, water temperature and rearing period. It could be seen that, when the water temperature increased from 25 to 35 °C, the costs increased from 180.90 to 218.87, 357.33 to 428.80, 549.40 to 663.30 and 701.27 to 862.07 L.E/100000 fry after 1, 2, 3 and 4 weeks, respectively at 0 hormone level. At 60 mg 17 α-MT/ kg feed, the costs increased from 186.73 to 226.59, 368.58 to 439.78, 577.46 to 690.00 and 746.94 to 906.39 L.E/100000 fry after 1, 2, 3 and 4 weeks, respectively.

The results also indicate that the highest value of cost (906.39 L.E/100000 fry) was found at 35 °C water temperature with 60 mg 17 α-MT/ kg feed after four weeks of period rearing. While the lowest value of cost (180.90 L.E/100000 fry) was found at 25 °C water temperature with 0-hormone level after one week of period rearing.

Table (4): Effect of water temperature, period and level of hormone on costs production of Nile tilapia fry.

Hormone Dose, mg kg^{-1}	Water Temperature, °C	Time Period, week			
		1	2	3	4
		Cost, L.E per 100000 fry			
0	25	180.90	357.33	549.40	701.27
	30	198.77	390.83	605.23	786.13
	35	218.87	428.80	663.30	862.07
60	25	186.73	368.58	577.46	746.94
	30	207.03	406.42	656.33	856.21
	35	226.59	439.78	690.00	906.39

Price of hormone = 3 L.E g^{-1} Price of energy = 0.67 L.E kW^{-1}

The results also indicate that the water temperature of 35°C with 60 mg 17 α-MT/ kg feed after two weeks gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after four weeks. Where, the male ratio and cost production were 94.86 % and 439.48 L.E/100000 fry, respectively, at 35°C water temperature with 60 mg 17 α-MT/ kg feed after two weeks, while they were 90.65 % and 862.07 L.E/100000 fry, respectively, at 35°C water temperature with 0 hormone doses after four weeks. The cost production of Nile tilapia fry at 35°C water temperature with 0 hormone doses after four weeks was twice as high as those at 35°C water temperature with 60 mg 17 α-MT/ kg feed after two weeks.

The results also indicate that the water temperature of 35°C with 60 mg 17 ᶏ-MT/ kg feed after one week gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after three weeks. Where, the male ratio and cost production were 86.95 % and 226.59 L.E/100000 fry, respectively, at 35°C water temperature with 60 mg 17 ᶏ-MT/ kg feed after one week, while they were 87.78 % and 663.30 L.E/100000 fry, respectively, at 35°C water temperature with 0 hormone doses after three weeks. The cost production of Nile tilapia fry at 35°C water temperature with 0 hormone doses after three weeks was three times as high as those at 35°C water temperature with 60 mg 17 ᶏ-MT/ kg feed after one week.

CONCLUSIONS

The obtained results can summarized as follows:

1-The highest value of male ratio (98.98%) was obtained at 35 °C water temperature with 60 mg 17 ᶏ-MT/ kg feed after four week of rearing.

2-Otherwise, the mortality rate was significantly the highest (16.23 %) at 35 °C depending on the period of treatment and hormone level. Similarly, it was the highest also with 60 mg 17 ᶏ-MT/ kg feed (15.38 %).

3-The highest value of weight gain (2.56 g) was obtained at 30 °C water temperature with 60 mg 17 ᶏ-MT/ kg feed after four week of rearing.

4-The energy consumption for heating water increased from 270.00 to 326.67, 533.33 to 640.00, 820.00 to 990.00 and 1246.67 to 1286.67 kW/100000 fry, when the water temperature increased from 25 to 35 °C, after 1, 2, 3 and 4 weeks, respectively.

5-The water temperature of 35°C with 60 mg 17 ᶏ-MT/ kg feed after two weeks gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after four weeks. In addition, the water temperature of 35°C with 60 mg 17 ᶏ-MT/ kg feed after one week gave the best results of male ratio and costs compared to water temperature of 35°C with 0 hormone doses after three weeks.

REFERENCES

Anonymous, (1992). ASAE Standards, 1992, 39th edition. American Society of Agricultural Engineers. St. Joseph, MI. 781 pp.

Baras, E., B. Jacobs and C. Melard (2001). Effect of water temperature on survival, growth and phenotypic sex of mixed (XX-XY) progenies of Nile tilapia *Oreochromis niloticus*. Aquaculture, 192: 187-199.

Baroiller, J. F., A. Fostier, C. Cauty, X. Rognon and B. Jalabert (1996). Effects of high rearing temperatures on sex ratio of progeny from sex reversed males of Oreochromis niloticus. In: Pullin, R.S.V., Lazard, J., Legendre, M., Amon Kothias, J.B., Pauly, D. (Eds.). The Third International Symposium on Tilapia in Aquaculture. ICLARM Conference Proceedings, 41: 246–256.

Bezault, E., F. Clota, M. Derivaz, B. Chevassus and J. Baroiller (2007). Sex determination and temperature-induced sex differentiation in three natural populations of Nile tilapia (Oreochromis niloticus) adapted to extreme temperature conditions. Aquaculture 272, 3–16.

Bliss, R. W. (1961). Atmospheric Radiation near the Surface of the Ground. Solar Energy 5:103-120.

Cathcart, T. P. (1987). Heat transfer and temperature prediction in small freshwater ponds. Ph.D. dissertation, Department of Agricultural Engineering, University of Maryland, 283 PP.

Celik, I., Y. Guner and P. Celik (2011). Effect of orally – administered 17α-methyltestosterone at different doses on the sex reversal of the Nile tilapia (Oreochromis niloticus, L. 1758). J. Anim. Vet. Adv., 10 (7): 853-857.

Devlin, R. H., and Y. Nagahama (2002). Sex determination and sex differentiation in fish: an overview of genetic, physiological, and environmental influences. Aquaculture, 208: 191–364.

Gomez, K. A. (1984). Statistical Procedures for Agricultural Research, 2nd ed. John Wiely& Sons, New York, USA 680 pp.

Guerrero III, R. D. and L. A. Guerreiro (1997). Effects of Androstenedione and methyltestosterone on *Oreochromis niloticus* fry treated for sex reversal in outdoor net enclosure. In: International Symposium on Tilapia in Aquaculture, 4, 1997, Orlando, Florida. Proceedings. Orlando, 12: 772-777.

Guerrero, R. D. and W. L. Shelton (1974). An aceto-carmine squash method for sexing juvenile fishes. Prog. Fish-Cult., 36:56.

Holman, J. P. (1997). Heat Transfer, 8th edition. McGraw-Hill. 696 pp.

Jauncey, K. and B. Ross (1982). A guide to tilapia feeds and feeding. Institute of aquaculture, university of sterling, Scotland. 111 pp.

Khater, A. M. (1999). Sex reversal in tilapia nilotica. Ph. D., Thesis, Fac. Agric., Zagaaig Univ., Egypt.

Khater, E.G. (2012). Simulation model for design and management of water recirculating systems in aquaculture. Ph. D., Thesis, Fac. Agric., Moshtohor, Benha Univ., Egypt.

Khater, E.G., S.A. Ali and W. E. Mohamed (2017). Effect of water temperature on masculinization and growth of Nile tilapia fish. J. Aquac. Res. Development, 8: 507. doi: 10.4172/2155-9546.1000507

Killian, H.S. and C.C. Kohler (1991). Influence of 17 α-methyltestosterone one on Red tilapia under two thermal regime. J. World Aquac. Soc. 22 (2), 83-94.

Macintosh, D.J. and D. C. Little (1995). Nile tilapia (Oreochromis niloticus). In: Bromage, N.R. and Roberts, R.J. (Eds.). Broodstock management and egg and larval quality. Cambridge: Blackwell, pp. 277-320.

Meadmore, J. A., G. C. Mairal and R. I. Lewisb (2001). Monosex male production in finfish as exemplified by tilapia: applications, problems, and prospects. Aquaculture, 197: 283-301.

Mubarik, M. S., I. Ahmed, A. Mateen and T. Iqbal (2011). 17α-Methyltestosterone induced masculinization and its effect on growth and meat quality of Cyprinus carpio. Int. J. Agric. Biol., 13(6): 971–975.

Piedrahita, R.H. (1991). Modeling water quality in aquaculture ecosystem. In: D. E. Brune and J. R. Tomasso (Editors). Aquaculture and Water Quality. World Aquaculture Society. Baton Rouge, LA, pp. 322 – 362.

Popma, T. J. and R. P. Phelps (1998). Status report to commercial tilapia producers on monosex fingerling productions techniques. In: Aquacltura Brasil 98, 1998, Recife. Anais. Recife: SIMBRAQ, pp. 127-145.

Rakocy, J. E. (1989). Tank culture of tilapia. In the biology and culture of tilapia, ed. R. S. V. Pullin & R. H. Lowe-McConell-ICLARM conference proceedings 7. International center for living aquatic resources management, manila, the Philippines.

Shelton, W. L., V. Wanniasingham and A. E. Hiott (1995). Ovarian differentiation in common carp (Cyprinus carpio) in relation to growth rate. Aquaculture, 137: 203–211.

Snedecor, G. W. and W. G. Cochran (1980). Statistical Methods, 7th Ed., Iowa State University Press, Ames, Iowa, USA.

Soto-Zarazúa M. G., E. Rico-García and M. Toledano-Ayala (2011). Temperature effect on fish culture tank facilities inside greenhouse. Int. J. Phys. Sci., 6(5): 1039-1044.

Tessema, M., A. Müller-Belecke and G. Hörstgen-Schwark (2006). Effect of rearing temperatures on the sex ratios of Oreochromis niloticus populations. Aquaculture, 258: 270-277.

Tsadik, G. G. and A. N. Bart (2007). Effect of feeding stocking density and water-flow rate on fecundity, spawning frequency and egg quality of Nile tilapia, *Oreochromis niloticus (L.)*. Aquaculture, 272: 380–388.

Wessels, S. and G. Hörstgen-Schwark (2007). Selection experiments to increase the proportion of males in Nile Tilapia (Oreochromis niloticus) by means of temperature treatment. Aquaculture, 271: 80–87.

Wessels, S. and G. Hörstgen-Schwark (2011). Temperature dependent sex ratios in selected lines and crosses with a YY-male in Nile tilapia (*Oreochromis niloticus*). Aquaculture, 318: 79–84.

دراسة فنية مالية لبعض طرق التحول الجنسى لاسماك البلطى النيلى

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الملخص العربى

يهدف هذا البحث الى دراسة تقييم فنى ومالى لبعض طرق التحول الجنسى لاسماك البلطى النيلى. ولتحقيق هذا تم اجراء تجربة فى قسم هندسة النظم الزراعية والحيوية – كلية الزراعة بمشتهر – جامعة بنها – مصر. أجريت التجربة لدراسة تأثير درجة حرارة المياه (٢٥ و٣٠ و٣٥ °م) ومستوى الهرمون (٠ و٦٠ مجم ١٧ ألفا ميثايل تستوستيرون) ومدة التربية (١ و٢ و٣ و٤ اسابيع) على نسبة الذكور ونسبة الوفيات والزيادة في الوزن. وكانت أهم النتائج المتحصل عليها كما يلى: زادت نسبة الذكور والنسبة الوفيات بزيادة درجة الحرارة و مستوى الهرمون ومدة المعاملة. كانت أعلى قيمة للزيادة في وزن الجسم هي ٢,٥٦ جم عند درجة حرارة مياه ٣٥ °م و٦٠ مجم ١٧ ألفا ميثايل تستوستيرون بعد ٤ أسابيع. زاد استهلاك الطاقة اللازمة لتدفئة المياه بزيادة درجة الحرارة ومدة التربية. زادت تكاليف تدفئة المياه والهرمون بزيادة درجة الحرارة ومستوى الهرمون ومدة التربية. أظهرت النتائج ان استخدام درجة حرارة المياه ٣٥°م ومستوى هرمون ٦٠ مجم ١٧ ألفا ميثايل تستوستيرون بعد أسبوعين أفضل من استخدام درجة حرارة المياه ٣٥ °م ومستوى هرمون ٠ بعد ٤ أسابيع. كما أظهرت ان استخدام درجة حرارة المياه ٣٥°م ومستوى هرمون ٦٠ مجم ١٧ ألفا ميثايل تستوستيرون بعد أسبوع أفضل من استخدام درجة حرارة المياه ٣٥ °م ومستوى هرمون ٠ بعد ٣ أسابيع.