EFFECT OF TEMPERATURE ON HATCHING AND SURVIVAL RATES OF NILE TILAPIA,*OREOCHROMIS NILOTICUS* (LINNAEUS, 1758)

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Abstract

Experiments were conducted to assess the effect of temperatures on hatching and survival rates of Nile tilapia, (*Oreochromis niloticus*). The present study was carried out at the Laboratory of Aquatic Bioscience Laboratory, Department of Zoology, University of Yangon from June 2017 to March 2018. The fertilized eggs were collected from the mouth of brood stock female tilapia and incubated at three different temperature treatments; 28ºC, 30ºC and 32ºC, each experiment was carried out with duplicate. For control, (ambient temperature, 26ºC) was used to compare with other temperature effects. The present results show that the longest incubation period was 39:02 hours at 26ºC and the shortest 21:51 hours at 30ºC. Incubation period decreased with increasing in incubation temperature. The optimum percentage of hatching rate was 75% at 30ºC, followed by 72% at 32ºC, 68.50% at 28ºC and 70.25% at 26ºC.Similarly, the survival rates were 98% at 26ºC, 97.2%at 28ºC and 97% at 30ºC and 32ºC respectively. The survival rates of fry decreased with the increasing of water temperature. The highest body weight fry (fish) was (4.6 ± 0.28) g at 32ºC and (3.03 ± 0.53) g at 26ºC (ambient) during the study period. Results of the present study showed that water temperature had significant ($P<0.000$) effect on hatching period. The temperature also has shown that it was significant ($P<0.03$) effect on growth. According to the present study, most suitable temperature for hatching the egg was 30ºC, while survivals rate was better at 26ºC. On the other hand, high body weight was recorded in fry maintained at 32ºC. The results of the present study found that temperature played an important role on the hatching and survival rates of Nile tilapia.

Keywords: Temperature, Hatching, Survival, Nile Tilapia

Introduction

Temperature is very essential for the egg formation, production and growth of fry in hatchery system. The effects of water temperature on growth

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and development of fish have been well documented in Nile tilapia, shortnose sturgeon (*Acuoebser brevirastrum*), Atlantic sturgeon (*Acuoebser oxyrhynchus*) (Van Ham *et al*., 2003; Chatterjee *et al.,* 2004; Larsson and Berglund, 2005). Temperature is the main environmental factor governing the development of fish eggs (Nwosu and Holzlohnev, 2000). It determines certain morphological feature, hatching rate and the behaviour of larvae (Bagenal and Braun, 1978).

Physical and chemical parameters are known to affect the egg development. For example, temperature affects certain morphological features, hatching rate and larval behavior. In earlier studies, temperature influenced egg development and hatching in *Oreochromis niloticus* (Bhujel *et al*., 2000), *Tilapia zillii* (Omotosho, 1988), common carp, *Cyprinus carpio* (El-Gamal, 2009), and cod, *Gadus morhual* (Page and Frank, 1989; Geffen *et al*., 2006).

Optimal environmental conditions are essential to gain the best growth temperature. But due to excessive temperature on egg production and growth of fry hampered and the hatchery operator cannot produce in its optimal production. Thus, at higher or lower temperatures, feeding and growth rates are reduced, and at 20°C or less, feeding and growth are completely stopped (Caluton, 1982).

The climate models referenced by the Intergovernmental Panel on Climate Change (IPCC, 2001) predicted that global temperatures are likely to increase by 1.4 to 6.4°C in this century. So, the present study has been conducted to forecast the optimal temperature on hatching, growth and survival of Nile tilapia.

The world's total tilapia production in 2010 was 3.49 million tons (FAO, 2012).Culture of this species has expanded rapidly under a wide range of farming environments from extensive to intensive scale in both fresh and brackish water in Asia and many other countries of the world. They can also feed on locally available foods since they are herbivorous and omnivorous, and are resistant to diseases (Beveridge and McAndrew, 2000).

The "Miracle Fish" *Oreochromis niloticus*, is one of 77 tilapia species described by Thys in 1968 and belongs to the Family Cichlidae of the Tribe *Tilapiine* (Thys, 1968 and George, 1955). It is indigenous to Sudan among other tilapia species namely, *Tilipia zillii* and *Sarotherodon galilaeus* (George, 1955 and Sandon, 1950). Tilapia is a worldwide fish of great commercial importance and it is recognized as one of the most important aquaculture species of the 21st century. Tilapia is currently ranked second only to carps in global production (Ridha, 2006).

The tilapia species are preferred species for aquaculture because they exhibit tolerance to harsh water conditions such as temperature changes, high salinity and low water quality (Maluwa and Brood, 1996).Tilapia was first introduced to Malawi in 1999 in order to develop the enormous geothermal water resources in the south of the country. Their tropical and subtropical origins are clearly reflected in their thermal preference these fish do not grow well at temperature below 16°C and cannot usually survive for more than a few days below 10°C (Chervinski, 1982), but they are remarkably tolerant to high temperature, up to 40°C (Azaza, 2004).

The Nile tilapia is a mouth-brooder. Mouth brooding is an advanced reproductive tactic, a form of intensive care by mother whereby the seed can be protected from the outside world until their development is more advanced. The male establishes a territory and builds a round nest in the pond bottom. (Usually the diameter of a nest is 30-60 cm. The size of the nest is correlated to the size of the male.) The female enters the nest and lays the eggs. The eggs are fertilized by male. The female then collects and incubates the eggs in her mouth. The eggs are yellow in color. Eggs hatch after about five to seven days. After hatching the fry remain in the mouth of the female for another 4-7days. Female spawns every four to six weeks interval, but may spawn sooner if the eggs are removed. The number of eggs per spawning is related to the size of the female. A female of about 100 grams may produce approximately 100 eggs per spawning while a female weighting 100-600 g can produce 1,000-1,500 or more per spawning (Hepher and Prugunin, 1981).

Brummett, (1995) found that Nile tilapia did not lay eggs when water temperatures went down below 19°C. The most productive period coincided with the rise in water temperature to 2-27°C where spawning rate averaged 40 and 73% of total females under dark and natural photoperiod conditions, respectively. Nile tilapia, *Oreochromis niloticus* (Linnaeus 1758), is one of the most commonly farmed species in freshwater aquaculture. The species is cultured extensively by small holder farmers and commercial intensive operators in Myanmar.

Tilapia species are favored by consumers for white meat good flavor, shiny appearance and bigger size. The species that has been overfished from the major water quantities is necessary to meet both market demand for consumption and restocking purposes (Kaunda *et al*., 2005).So, the present study was chosen the tilapia fish species to test the temperature effect on hatching, survival and growth rate.

Due to above mentioned reasons; the present study has been carried out with the following objectives:

- to determine hatching period and hatching rates at different temperatures
- to find out the survival rates at different temperatures
- to carry out the optimum temperature for hatching and survival rates

Materials and Methods

Study site

Fertilized eggs of female tilapia were collected at the Hlaw-ga fish farm, Htauk Kyant Township, Yangon (Plate 1. A). After collecting the eggs from the mouth of fish from Hlaw-ga Fish Farm. The following experiments were conducted in the Aquatic Bioscience Laboratory, Department of Zoology, University of Yangon.

Study period

Study period lasted from June 2017 to March 2018. Laboratory experimental period was conducted for duration of six months from August 2017 to January 2018.

Materials

The following materials were used in the present study.

1. Aquarium jar tanks (120cm×60cm×45cm)
2. Handmade incubation jar (1.5Litre)
3. Thermostat for controlling temperatures (SOBO AC-220V 50/60Hz 200W)
4. DO meter
5. pH meter
6. SOBO aquarium top filter (WP-1800F, AC220-240V 50/60Hz, 25W)

Methods

This experiment was conducted using the following methods.

Identification and classification of the studied fish species

The studied species was identified and classified according to Fish Base, (2013).

Preparation of the tanks, incubation jars and installation the thermostat

Glass aquaria were cleaned with the sodium chloride and filled with water (12inches depth). A total of four glass aquaria (120cm×60cm×45cm) were prepared to observe the effect of different temperatures on hatching duration of fish (Plate 3.A). To imitate the McDonald jar, the incubation jars were prepared with Coca Cola plastic bottle (1.5L), piece of net, PVC pipe and SOBO aquarium top filter (WP-1800F, AC220-240V 50/60Hz, 25W) (Plate 3. B).Water entered each incubation jar through a vertical tube that caused an up-welling effect to maintain the eggs suspended. This effect imitates similar to the natural process in the buccal cavity of a female during

the incubation process. Tilapia eggs are negatively buoyant. And then, thermostat (SOBO AC-220V 50/60Hz 200W) was installed into each aquarium to control the water temperature.

Sample collection

Fertilized eggs were directly collected from the mouth of brood stock female tilapia and the eggs were counted with plastic siphon pipe in small size of beakers (Plate 1.B and C).

Incubation of eggs at different temperatures

The eggs were transferred into the incubation jars (round plastic container) (1.5L). The jar stocked with 200 eggs were set up in the aquarium tanks. Four set of aquaria tanks were prepared, replicated twice (Plate 2) and incubated the eggs (Plate 3. F). Four different water temperatures; 26°C (ambient), 28°C, 30°C and 32°C were set up in the aquarium to assess the effect of temperature on hatching and survival rates using thermostat(Plate 3. C). Thermometer was installed in the aquarium and checked the temperatures twice a day to maintain the constant temperature. Water parameter such pH and DO were taken and recorded (Plate 3. D and E). Stability of four different water temperature of respective aquarium was checked twice a day 8:00am and 11:00pm in separate tank.

Data analysis

The hatching, survival and growth rates of the studied species were determined using the following formulae according to (El-gamal, 2009 and Naeem *et al*., 2011).

$$\text{(i) Hatching rate (\%)} = \frac{\text{No. of hatched larvae}}{\text{Fertilized eggs}} \times 100$$

$$\text{(ii) Survival rate (\%)} = \frac{\text{Survived hatchling after 3 days}}{\text{Total no. of hatched eggs}} \times 100$$

Significant difference of incubation period, hatching rate, survival rate and body weight among the various water temperatures were tested using one-way analysis of various (ANOVA), SPSS version 2.5. Multiple comparison test (HSD) was also performed.

A. Hlaw ga Fish Farm (Department of Fisheries)

B. Maintaining brood stocks in controlled tanks

C. Collecting the fertilized eggs from mouth of brood stock female

Plate 1. Hlaw-ga Fish Farm and taking the fertilized eggs from brood stocks female

A.Temperature at 26°C (ambient) B. Expt. Temperature at 28°C

C. Expt. Temperature at 30°C

D. Expt. Temperature at 32°C

Plate 2. Experimental aquarium with different water temperatures

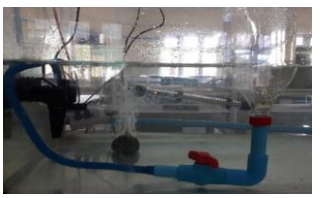
A. Preparation of the tanks

B. Handmade incubation jar

C. Thermostat

D. DO meter

E. pH meter



F. Incubating of the eggs

Plate 3.Setting up the Equipment

Results

Systematic position

The systematic position of the species was identified according to FishBase, (2013). (Plate 4)

Phylum - Chordata
Class - Vertebrata
Sub-phylum - Actinopterigii
Order - Cichliformes
Family - Cichlidae
Genus - *Oreochromis*
Species - *niloticus*

Morphological characters

Body shape generally laterally compressed to oval and deep, through variable depending on the environment. D XVI-XVIII, 12-14, A III, 9-11. Lateral line interrupted with 30-34 cycloid scales. Mouth terminal. Gill rakers on lower limb of first gill arch 20-26. Vertebrate 30-32. Caudal fin has 7-12 distinct vertical stripes. Breeding males with red flush to head, lower body, dorsal and caudal fins. Caudal fin truncate. The most diagnostic features are the regular and definitive stripes on the caudal fin, the red flush of the breeding male and the dark margin of the dorsal fin. Body coloration varies depending on environmental, physiological and dietary factors (Plate 4).

There were clear differences between the sexes and tilapia species particularly in a round of the urogenital opening. The tilapia of the male tends to be elongated with one opening. The papilla of the female tends to be wider and has to opening, one of which is a transverse slit (Plate 5)

Incubation period and hatching rate of Nile tilapia at different temperatures

The influence of temperature on incubation period and hatching rates of *Oreochromis niloticus* was shown in Fig. 1 and 2 respectively. The mean values of incubation period were also described in Table 5. The longest incubation period was 39:02:30 (hours) at 26°C (ambient) (Table 1).The shortest incubation period was 21:51 (hours) at 30°C (Table 3). The results of this study also revealed that incubation period was38:48:30 (hours) at 28°C

(Table 2) while it was 22:05 (hours) at 32°C (Table4).In the present study, the incubation period was significant at 26°C(ambient) and28°Ccompared with 30°C and 32°C($p<0.000$). It is also significant at 30°C and 32°C compared with 26°C and 28°C ($p<0.000$). There was significant different between incubation period and temperatures ($p<0.000$) (Appendix II).

The highest hatching rate was highest75% at 30°C (Table 3) and lowest68.5% at 28°C (Table 2). The hatching rates were 70.25% at 26°C (ambient) and 72% at 32°C (Table 1 and 4).

Variation in Survival rate of Nile tilapia at different temperature

In the present study, the mean values of survival rates were recorded in Table 5. The effect of different temperatures on survival rates was shown in Fig.3. The temperature treatment of 26°C (ambient) showed the highest survival rate of 98% (Table 1).The survival rates were also recorded 97.20 % at 28°C(Table 2) and 97% at 30°C and 32°C (Table 3and 4).

Variation in Body weight of Nile tilapia at different temperatures

After one month of experimental period, wet body weights of Tilapia were measured from each experimental tank. Among different temperatures treatments, the mean values of body weight were varied (Table 5). The effect of different temperatures on body weights was shown in Fig. 4. The highest fish body weight was observed; (4.6 ± 0.28) g at 32°C (Table. 4) and the lowest; (3.03 ± 0.53) g at 26°C (Table 1). The fish body weight was also recorded (3.38 ± 0.46) g at 28°Cand (4.1 ± 0.28) g at 30°C (Table 2 and 3).In the present study, the body weight was significant effect at 26°C compared with 32°C ($p<0.037$).

Plate 4. External features of Nile tilapia (*Oreochromis niloticus*)

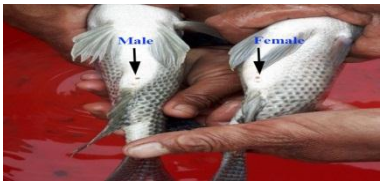


Plate 5. Male and female of Nile tilapia (*Oreochromis niloticus*)

Table 1. Biological parameter of Nile tilapia at 26°C (control)

Sr. No	**Biological parameter**	**Replication**		**Mean±SD**
		1st	2nd	
1	Fertilized eggs	200	200	
2	Incubation Period(hours)	39:20	38:30	38:55±0.025
3	Hatching rate%	53.50	87	70.25±0.237
4	Fry Survival rate%	98	97.7	98±0.002
5	Body weight	3.4	2.65	3.03±0.53

Table 2. Biological parameter of Nile tilapia at 28°C

Sr. No	**Biological parameter**	**Replication**		**Mean±SD**
		1st	2nd	
1	Fertilized eggs	200	200	
2	Incubation Period(hours)	39:07	38:30	38:48±0.018
3	Hatching rate (%)	62.5	74.5	68.5±0.085
4	Fry Survival rate (%)	98.4	96	97.2±0.017
5	Body weight	3.7	3.05	3.38±0.46

Table 3. Biological parameter of Nile tilapia at 30°C

Sr.No	Biological parameter	Replication		Mean±SD
		1st	2nd	
1	Fertilized eggs	200	200	
2	Incubation Period(hours)	21:30	21:12	21:51±0.04
3	Hatching rate (%)	62	88	75±0.184
4	Fry Survival rate (%)	96.8	96.6	96.7±0.001
5	Body weight	4.3	3.9	4.1±0.28

Table 4. Biological parameter of Nile tilapia at 32°C

Sr.No	Biological parameter	Replication		Mean±SD
		1st	2nd	
1	Fertilized eggs	200	200	
2	Incubation Period(hours)	21:18	22:53	22:05±0.05
3	Hatching rate (%)	52	92	72±0.283
4	Fry Survival rate (%)	96.2	97.3	96.75±0.008
5	Body weight	4.8	4.4	4.6 ±0.28

Table 5. Mean values of biological parameter in Nile tilapia at different temperatures

	Temperature 26°C	**Temperature 28°C**	**Temperature 30°C**	**Temperature 32°C**
Incubation Period(hours)	38:55±0.025	38:48±0.018	21:51±0.04	22:05±0.05
Hatching rate (%)	70.25±0.237	68.5±0.085	75±0.184	72±0.283
Fry survival rate (%)	98±0.002	97.2±0.017	96.7±0.001	96.75±0.008
Body weight	3.03±0.53	3.38±0.46	4.1±0.28	4.6 ±0.28

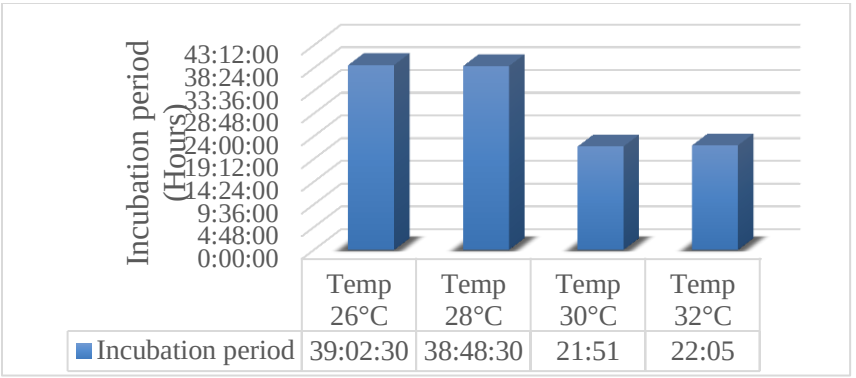


Figure 1. Variation of the incubation period of *Oreochromis niloticus* at different temperatures

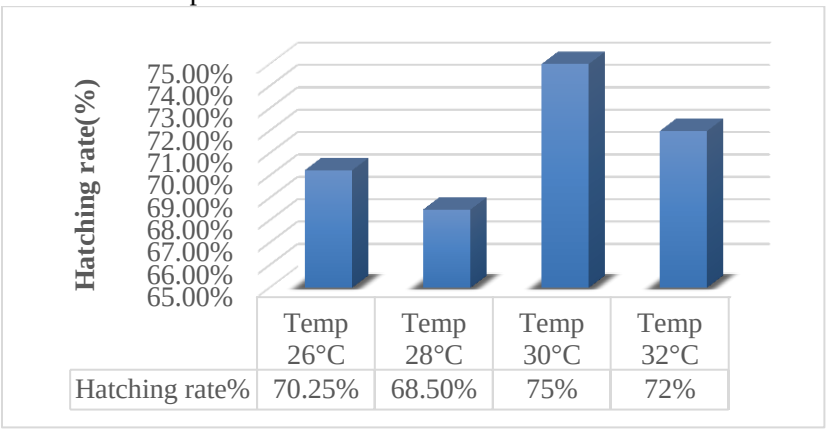


Figure 2. Variation of the hatching rate of *Oreochromis niloticus* at different temperatures

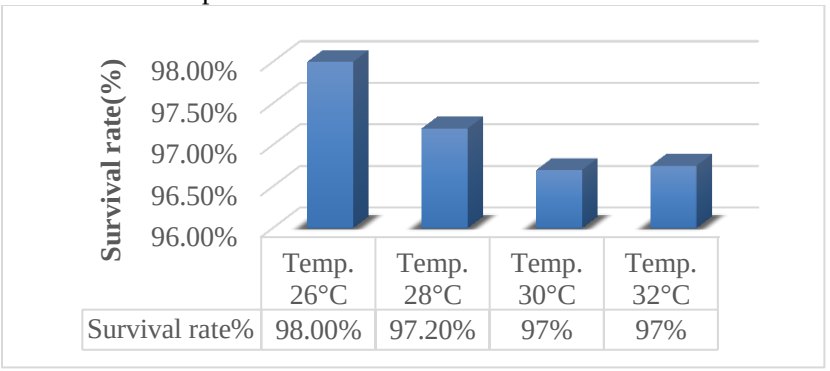


Figure 3. Variation of the survival rate of *Oreochromis niloticus* at different temperatures

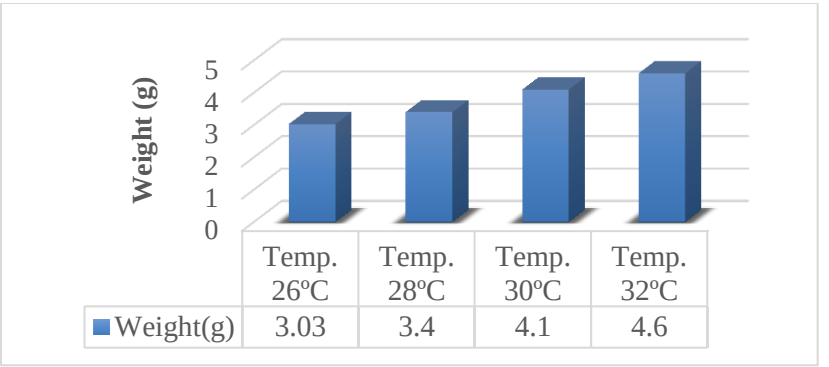


Figure 4. Final body weight of *Oreochromis niloticus* at different temperatures

Discussion

Temperature exerts a major influence on the biological activity and growth for aquatic organisms. It has also effect on the incubation and hatching rates of eggs. Incubation temperature rather than pond water temperature. It is important in hatching success. Development and hatching of fish is delayed at low temperatures and accelerated at high temperatures (Peters, 1983). Tilapia eggs tend to sink in water and when in permanent contact with a substrate, the embryo suffers and will eventually die. So, air diffuser was placed directly below the incubation jars to create an up-welling effect. During incubation, continuous water flow is essential for preventing accumulation of waste products and allowing gas exchange between the egg and the surrounding water. Continuous motion also appears to be necessary for successful hatching for some species of fish. Proper water flow also reduces mechanical abrasion (Green, 2006).

Oreochromis niloticus is known to tolerate high water temperatures. It can tolerate for a long period low water temperature between 10°C and 15°C (Ballarin and Hatton, 1979), and does not survive below 10°C (Caulton, 1982). Thus, at higher or lower temperatures, feeding and growth rates are reduced, and at 20°C or less, feeding and growth are stopped (Caulton, 1982).

The fertilized eggs of tilapia were incubated in an experimental hatchery system at different temperature in the present study. The embryonic

development of eggs, hatchability, survival and wet body weight of studied species were investigated in this study. The present results show that the incubation period was (38:55) hours at 26°C (ambient temperature), (38:48) hours at 28°C,(21:51) hours at 30°C, and (22:05) hours at 32°C respectively. The incubation period increase with decreasing in incubation temperatures in the present study. There was a significant difference between incubation period and temperatures ($p<0.000$). Similar results were observed in Common carp, *Cyprinus carpio* (El-Gamal, 2009) and *Oreochromis niloticus* (Bhujel *et al*., 2000) where hatching period decrease with increase in incubation temperature. Peng and Tang (1988) also indicated that a lower temperature could longer the time of hatching of *O. barbatulum.* Korwin-Kossakowski (2008) proposed that lower water temperature delay embryo growth, resulting in a decreased hatching rate, and fry postponed foraging. The present finding was in agreement with the results obtained from *Cyprinus carpio* (El-Gamal, 2009).

In the present work, the maximum percentage of hatching rates was (75 ± 0.18) % at 30°C. The minimum percentage of hatching was (68.5 ± 0.09) % at 28°C. The results in this study found that the optimum temperature for hatching rate of fertilized eggs was at 30°C. This finding was in agreement with the results obtained by in other fish species, Nwosu and Holzlohnev, 2000. Similar results were also observed in *O. niloticus.* It has an optimum temperature of growth at 30°C and *Tilapia zilli* has an optimum feeding temperature at 31.4°C (Stickney, 1986).

In case of a proper increase in the water temperature usually enhances the metabolism, respiration, and growth rate, shortens sex maturation period. It also reduces the high mortality of fry in the planktonic stage, and increases the fry survival rate (Pankhurst and Munday, 2011). Pandit and Nakamura (2010) reported that high water temperature above 32°C significantly reduced the survival, growth and feeding efficiency of Nile tilapia. *O. niloticus* is known to tolerate high temperatures, up to 40 - 42°C (Philippart and Ruwet, 1982). However, the optimum temperature for feeding, growth and reproduction is between 26°C and 30°C (Hauser, 1977). The survival

rate was 98% at 26°C, 97.2% at 28°C, 97% at 30°C and 97% at 32°C respectively in the present study. The present study showed that the survival rate decreases with increases in water temperature. The cannibalism was found among unequal sizes of fishes in experimental tanks. The mortality in fish is considered due to cannibalism. Similar result Dynamics of pond aquaculture found that at the age of 10-30 days was cannibalism (Hillary and Claude, 1997).

In fish biology, temperature influence is the single most important factor that determines growth rates in fish (Brett *et al.*, 1975). Studies on several fish species have revealed that in the temperature ranges tolerated by fish, growth rates increase with increasing temperature, showing a parabolic pattern (Xiao-jun and Ruyung, 1992; Larsson and Berglund, 2005). When experimental temperature reached the upper extreme limit of the tolerance range, performance of growth decreased. This depression of growth is due to the higher energy cost for maintenance metabolism and seems to be related mainly to a loss of appetite (Azaza *et al.*, 2008). Results of our study showed that performance of body weight is better at 32°C (4.6 ± 0.28) g than at 26°C (ambient) (3.03 ± 0.53) g, which confirms the thermophilic character of *O. niloticus.* Water temperature also found to have a significant ($P<0.03$) effect on body weight of fry. El-gamal (2009) reported that growth of larvae increased at the optimum temperature rate of 27°C-30°C and no eggs hatched at 20°C and 38°C for *Cyprinus carpio*.

The optimum temperature for incubation period and hatching rate was found at 30°C, while the survival rate at 26°C and body weight at 32°C. So, this study provided an insight into the thermal effect on developmental stages, hatching rates, survival rates and body weight of Tilapia fish species.

Conclusion

The experiments were conducted to find out the hatching, survival and growth of Nile tilapia at different temperatures of 28°C, 30°C, 32°C and ambient water temperature with 26°C. It was found that the water temperature increase, the incubation period will increase. Significant difference was

detected among the temperatures and incubation periods (P<0.000) and also between temperatures and growth (body weight), (P<0.03). Incubation period was significantly different at the temperatures of 26°C versus 30°C and 32°C. It was also significant between the temperature of 28°C versus 30°C and 32°C. In the case of growth (body weight), it was significant only between the temperature of 26°C and 30°C. Hatching rate and survival rate were not significantly difference at the temperature tested at ambient temperature of 26°C.

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