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Effect of temperature variation on food intake and growth of *Oreochromis niloticus*

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ABSTRACT

This study was conducted to investigate the effect of temperature variation on food intake and growth performance of Nile tilapia (*Oreochromis niloticus*, Linnaeus, 1758). Nile tilapia with an average weight of 13.52 ± 0.23 g was used in this study. Three hundred (300) juveniles were randomly selected and stored in 15 aquariums of 50 L capacity. Five (5) treatments were tested in triplicate. Thermostats were used to maintain temperatures at 20, 23, 26, 29 and 32°C respectively. The experiment lasted for 6 weeks. The juveniles were weighted each two weeks and growth parameters were calculated. Juveniles were fed twice a day at (8:30 am and 3:30 pm) with commercial feed containing 32% protein. Water quality parameters were measured daily and readjusted whenever necessary. The results of this study showed a significant growth difference in fish reared at 29 and 32°C compared to those reared at 20 and 23°C.The feed conversion rate increases with temperature. The feed conversion rate is obtained with the batch raised at 29°C. No significant difference was observed between the feed conversion rate of treatments raised in waters at 29 and 32°C. With respect to survival rates, statistical analyses showed no significant difference between the different treatments. In conclusion, water temperatures at or above 29°C seem to be more appropriate for *Oreochromis niloticus*. The juveniles at 33°C were very eager during feeding while the others were less active. In conclusion, water temperatures ranging from 29-32 °C seem to be the most efficient for the culture of *Oreochromis niloticus.*

INTRODUCTION

Fisheries and aquaculture remain a key resource for hundreds of millions of people around the world for food, nutrition, income and livelihoods. Senegal has the highest per capita consumption of fish in Africa (37kg/person/year). Unfortunately, fisheries production has been declining. This justifies the decrease in fish consumption to 28kg/person/year. Fish farming remains an alternative to this situation, especially since Senegal has an enormous potential that has not yet been exploited. Fish farming in Senegal is largely dominated by Tilapia, particularly the *Oreochromis niloticus* species, thanks to its great adaptability. Tilapia is one of the most widely farmed fish in the world and its aquaculture production has been increasing at a high rate since the 1990s.

Originating from Africa, tilapias constitute the foundation and the first resource of an African aquaculture. Its hardiness of breeding, its wide ecological valence and its flexibility of adaptation to extremely varied environments, encouraged its introduction in several countries of the world. As a result, *Oreochromis niloticus* is considered by far the most interesting fish farming species and the basis of freshwater fish farming in the intertropical belt of the globe (Arrignon, 1998). Indeed, according to the statistics of the world production of freshwater fishes (FAO, 2005), tilapias occupy the third rank after Cyprinidae and Salmonidae, with a production increasing from 1.25 million tons in 2002 to 2.37 million tons in 2005, of which 87.6% of the total production is represented by the species *Oreochromis niloticus*.

It is known that fish are poikilothermic and that each species is adapted to a thermal zone with a

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vital optimum and limits outside of which the temperature has harmful effects that can lead to death. Furthermore, temperature has a direct effect on several metabolic processes, notably growth and reproduction. Since each environment and each site has its own characteristics, it is important to deal with the problems related to the lack of knowledge of the precise biological characteristics of each species, and even of each strain in relation to its biotope. The notion of tolerance to fluctuations in environmental factors (temperature, oxygen, salinity), is of practical interest only if it is associated with the knowledge of tolerable limits in breeding.

Temperature has a wide range of effects on food intake, locomotor activity, metabolism, growth and survival of fish (Abucay and Mair, 2004; Chatterjee et al., 2004; Manush et al., 2004; Azaza and Kraïem, 2005; Das et al., 2005; Perry et al., 2005; Mora and Maya, 2006; Resley et al., 2006; Kikuchi and Furuta, 2007; Azaza et al., 2007).

As a cold blooded animal, fish is affected by the temperature of the surrounding water which influences the body temperature, growth rate, food consumption, feed conversion and other body functions (Britz et al., 1997; Azevedo et al., 1998). The effects of water temperature on growth and development of fish have been well documented for many species (Anelli et al., 2004; Chatterjee et al., 2004; Larsson and Berglund, 2005). Nile Tilapia fish do not grow well at temperature below 16°C and can not usually survive for more than a few days below 10°C (Chervinski, 1982), but they are remarkably tolerant of high temperatures, up to 40-42°C (Philippart and Ruwet, 1982).

However, the determination of optimal temperature is essential for optimizing aquaculture production. The overall objective of this paper is to contribute to the improvement of knowledge on aquaculture farming in northern Senegal through the study on effect of optimal temperature for maximum growth of Nile tilapia (*Oreochromis niloticus*).

MATERIALS AND METHODS

Animal material

The fish species chosen for this experiment is Tilapia (*Oreochromis niloticus*) because of the scarcity of catches in recent years due to climatic variations.

Experimental design

The experiments were carried out at the Agricultural Farm of the Gaston Berger University of Saint-Louis. A group of 1000 juveniles of *O. niloticus* of 10 to 15 g were purchased and stocked in a pond of the fish farm of Richard-Toll.

The juveniles were fed a commercial food for one week for acclimatization purposes at a rate of 2 feedings per day. At the end of this acclimatization phase, 300 juveniles were randomly selected and distributed in 15 aquariums of 50 L at random.

Five treatments were tested in triplicate. Thermostats were used to maintain temperatures at 20; 23; 26; 29 and 32°C respectively. The dead subjects were counted daily, removed and weighed. At the end of the experiments, all juveniles were weighed.

The inner sides of the aquaria were cleaned daily 1 hour before the first meal of the day to control possible algal growth. During the experiments, the fish were subjected to natural photoperiod. Temperature, pH and conductivity measurements of the rearing water were performed daily with devices purchased for this purpose.

Feed and feeding

A commercial NMA feed with a protein content of 32% was used during the experiment. Prior to distribution, the feed was stored in a refrigerator at 4˚C. After daily weighing, the pellets were manually fed until apparent satiety, twice a day (8:30 am and 3:30 pm), in two passes on each occasion.

Sampling and analysis

The physico-chemical parameters were measured daily and readjusted whenever necessary, and the fish in each aquarium were weighed once every two weeks.

Growth evaluation

From the results obtained, several parameters were calculated to evaluate growth and feed efficiency respectively. These parameters are Specific Growth Rate (SGR), Weight Gain (WG) expressed as a percentage, Nutrient Quotient (NQ), and Survival Rate expressed as a percentage.

The data obtained and the parameters calculated were subjected to a one or two criteria analysis of variance (ANOVA) in order to compare the different treatments after prior verification of the homogeneity of the variances and the normality of the data to be analyzed. Significant probability thresholds of 5% were used. When the treatment effect in ANOVA was significant, the multiple comparison of means by Duncan's test was applied. All statistical analyses were performed using SAS software (Version 5.0.1.0., SAS Institute Inc.) and the graphs with Microsoft Office Excel 2010.

RESULTS

Feed acceptance

Feed acceptance varied with temperature. Fish reared in aquaria at 22 and 23 °C fed slowly compared to those reared in high temperatures. Fish at 33 °C were very active during feeding.

Water quality parameters

The water quality parameters during the experiment are recorded in Table 1. During the experiment, the water temperature for each treatment was constant, the pH of the water in the different aquaria varied from 7.80 to 7.89 and ammonium concentration varied from 0.043 to 0.072(mg/l).

Table 1: Average temperatures, pH and total ammonia in the different treatments

Temperature (°C)	pH	NH3-NH4 (mg/l)
20 ± 0,15	7,82 ± 0,03	0,043 ± 0,01
23 ± 0,23	7,84 ± 0,01	0,045 ± 0,03
26 ± 0,09	7,81 ± 0,07	0,049 ± 0,02
29 ± 0,19	7,89 ± 0,12	0,061 ± 0,01
32 ± 0,27	7,80 ± 0,04	0,072 ± 0,05

Growth

The results of the zootechnical parameters in *Oreochromis niloticus* during the experiment are recorded in Table 2. The best growth and feed efficiency performances were obtained with the batches reared in the aquaria at 29 and 32 °C, followed in order by the batches reared in the waters at temperatures 26 then 23 and 20 °C.

The results showed that the specific growth rates (SGR) varied between 3.31% and 2.79% in fish reared in water temperatures ranging from 20 to 32°C. There was a significant difference between the different treatments ($P< 0.05$). Statistical results showed that the best SGR was obtained with batches reared at temperatures of 29 and 31°C ($P< 0.05$) and the lowest with batches reared at temperatures of 20 and 23°C.

The highest FCR is obtained with the batch reared at 20°C water, while the best nutrient quotient is obtained with the batch reared at 29°C. No significant difference was observed between the nutrient quotients of the treatments reared in 29 and 32°C water ($P>0.05$).

Regarding survival rates, statistical analyses showed no significant difference between the different treatments ($P> 0.05$).

DISCUSSION

Numerous studies have been conducted to evaluate the effect of temperature on the growth of fishes such as juvenile *Cichlasoma urophthalus* (Palacios et al., 1996), *Ctenopharyngodon idella* (Bettoly et al. 1985), *Oreochromis niloticus* (Azaza and Kraiem, 2005, 2007; Azaza et al., 2007), *Barbusbarbus* (Kraiem and Patee, 1980, *Cyclopterus lumpus L*. (Nytro, 2013), *Labeo rohuta* (Kausar and Salim, 2006), *Oncorhynchus mykiss* (Alanara, 1994), and *Gadus morhau* (Otterlei et al., 1994).

The results of the present study revealed that tilapia *Oreochromis niloticus* maintained at low temperature (20-23°C) did not grow rapidly compared to the other treatment groups. Weight gain increased with increasing water temperature. These results confirm previous findings that fish growth and survival are optimal at a defined temperature (Gadowaski and Caddell, 1991).

The highest weight gain was observed in fish maintained on 29-32°C. Fish are strongly influenced by the temperature of the water in which they live (Houlihan et al. 1993, Britz et al., 1997 and Azevedo et al., 1998). Increased growth has also been reported in *Labeo rohita* reared in polyethylene greenhouses at an average temperature of 19 °C compared to those in outdoor tanks at an average temperature of 14.8 °C (Khan et al., 2004). An increase in temperature increases the activity of digestive enzymes, which can accelerate the digestion of nutrients, resulting in better growth (Shcherbina and Kazlauskene, 1971).

Table 2: Zootechnical performance of different batches of *Oreochromis niloticus* as a function of rearing temperature during 6 weeks of experimentation

	Temperature (˚C)				
	20	23	26	29	32
Mean initial Weight (g)	13.36 ± 0.15	13.50 ± 0.1	13.30 ± 0.26	13.70 ± 0.15	13.70 ± 0.2
Mean finalweight(g)	43.80 ± 0.8[c]	43.70 ± 1.3[c]	44.70 ± 0.9[b]	55.08 ± 0.3[a]	54.53 ± 2.9[a]
Weight gain (%)	227.90 ± 6[c]	223.70 ± 10.9[c]	236.70 ± 9.8[b]	301.10 ± 6.9[a]	298.10 ± 4[a]
Specific growth rate	2.83 ± 0.04[c]	2.79 ± 0.08[c]	2.89 ± 0.06[b]	3.31 ± 0.04[a]	3.28 ± 0.15[a]
FCR	1.52 ± 0.05[a]	1.41 ± 0.03[b]	1.53 ± 0.06[a]	1.19 ± 0.01[c]	1.31 ± 0.14[bc]
Survival (%)	82.20 ± 7	84.40 ± 10	86.70 ± 11.5	93.30 ± 6.67	95.20 ± 6.5

Results are expressed as: Mean ± MSE of three replicates (n = 3). In each row, the means ± MSE, assigned by different letters, are significantly different ($P < 0.05$).

The low average final weight of *Labeo rohita* maintained at low water temperature (20-22°C) may be due to the low acceptance of feed compared to fish maintained at higher water temperatures (24-26°C).

Therefore, better growth of fish maintained at water temperature between 24-26 °C in *Labeo rohita* can be attributed to the higher water temperature, which increases the amount of feed consumed and the metabolism of the fish.

The best FCR was observed in fish maintained at 29°C followed by 32°C. These results are consistent with those of Andrews and Stickney (1972), who reported a better nutrient quotient at 30°C, in juvenile *Ictalurus punctatus* reared in a temperature range of 18-34°C.

Osborne and Riddle (1999) observed better feeding efficiency in fish reared at high temperature compared to those kept at low temperature (17-27 °C).

However, the study by Azevedo et al. (1998) found that water temperature had very little effect on the feeding efficiency of rainbow trout (*Oncorhynchus mykiss*). A likely explanation for the improved feeding efficiency of fish maintained at high temperature may be due to the increased amount of feed consumed as rearing water temperature increases, resulting in better fish growth, leading to a higher feed conversion ratio. Another explanation may be the low energy requirement for the thermoregulatory process of fish kept at this temperature.

Increased temperature leads to better feed utilization compared to fish reared in water temperatures between 20.9 and 24.3°C (Goolish and Adelman, 1984).

The better FCR of the fish maintained between 29-32°C observed in this study can be attributed to the increase in the amount of feed consumed compared to other treatments, which saved more nutrients for fish growth after ensuring their maintenance needs.

CONCLUSION

Water temperatures ranging from 29-32 °C seem to be the most efficient for the culture of *Oreochromis niloticus*. However, the effect of water temperature on the digestibility of diet nutrients in *Oreochromis niloticus* remains an important factor, which could play an important role in understanding fish growth performance.

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