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EFFECT OF TEMPERATURE ON GROWTH PARAMETERS OF NILE TILAPIA

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ABSTRACT

Aims: To analyze the effect of temperature on the growth performance of Nile tilapia (*Oreochromis niloticus*)

Study design: Experimental study to improve production strategies in a context of climate change

Place and Duration of Study: A 2-month trial (from 15th April to 15th June, 2024) was conducted at the ISMA Aquaculture Experimental Unit.

Methodology: Therefore, after a 10-day habituation period, the Nile tilapia fry were distributed in triplicate into aquariums containing 35 liters of water at a density of 20 fry weighing 3.3 g per aquarium. The fish were subjected to three treatments: T0: ambient water temperature, T1: 32°C, and T2: 34°C. They were manually fed 3 times a day with a commercial feed containing 33% crude protein.

Results: At the end of the trial, the results show that the overall growth of tilapias is better at T0 and T1, with a significant increase in the average weight of the fish compared to T2. The survival rate is also higher at these temperatures reaching 100%, while it decreases to 85% for T2. The feed conversion ratio is better at T0 and T1, with respectively a TCA of 2.01 and 2.10 indicating optimal nutrient utilization at these temperatures; and less favorable at T2 with a TCA of 2.75. The daily weight gain (DWG) of tilapias is better in T0 and T1, with a DWG of 0.14 and 0.12 g/day respectively but drops at T2 to 0.10 g/day.

Conclusion: This study highlights the importance of maintaining a maximum temperature of 32°C to optimize the growth performance of Nile tilapia and thus improve the productivity and efficiency of culture systems for this species.

Keywords: Nile Tilapia, Temperature, Aquarium, Growth Performance.

1 INTRODUCTION

With the rapid growth of the world's population, the demand for animal protein, particularly from fishery products, has increased considerably. However, natural resources from traditional fishing remain insufficient to meet the growing needs of populations. In this context, aquaculture, defined as the controlled breeding of aquatic organisms, has emerged as a sustainable alternative and is experiencing significant growth worldwide [1].

Fish production in Africa, dominated by small-scale fisheries, reaches around 10 million tons per year, but this resource is increasingly threatened by overfishing and climate change [2]. African aquaculture produces around 2.5 million tons of fish per year, mainly concentrated in Egypt, which is the largest producer on the continent, followed by Nigeria and Ghana. These countries specialize in the cultivation of tilapia and catfish, which are well adapted to local conditions and in high demand on the market [3].

In Togo, the population's demand for fish continues to grow year after year. National fish production, estimated at around 25,000 tons per year, is far from meeting the needs of this population, estimated at nearly 98,000 tons per year based on 13 kg/person/year [4]. To fill this gap, Togo imports approximately 78,000 tons of fish each year from countries such as Ghana and Mauritania [5]. Among the most popular fish in Togo is Nile tilapia, which thrives in a temperature range of 25 to 30 degrees Celsius [6]. Temperature variations can influence the growth parameters of this species [7].

Climate change is a current issue that also affects fish farmers because environmental conditions affect growth parameters and fish metabolism [8], but data on Nile tilapia farming at high temperatures are scarce, which led to the implementation of this study. The main objective of this study is to improve Nile tilapia production techniques and specifically to evaluate the impact of temperature on water parameters and growth parameters in this species.

2 MATERIALS AND METHODS

2.1 Materials

2.1.1 Study area

The experiment was conducted in Pya, in the Kozah 2 commune of the Kara region (Togo), more precisely at the Higher Institute of Agricultural Professions (ISMA) aquaculture experimental unit of the University of Kara.

2.1.2 Biological Material

The study involved monosex male Nile tilapia fry, with an average weight of 3.3 g, from the Shalom farm, located in Kovie in the Zio prefecture (Maritime region).

2.1.3 Experimental Material

Heating elements (Aquarium Heater, Lansenfish, 100W) with a temperature range of 20 to 38°C were used to obtain the target temperatures for the water contained in 40-liter glass aquariums.

2.1.4 Technical Equipment

To conduct the experiment, an air pump (Jngye air pump) coupled with bubblers was used to supply oxygen, an oximeter (Dissolved Oxygen Analyzer, DO. 9100) to measure dissolved oxygen levels, and a multimeter (Multifunction) to measure pH and water temperature. A commercial tilapia feed containing 33% crude protein, and an electronic scale (Camry. 5 kg, 1 g) for weighing were used.

2.2 Methods

2.2.1 Experimental procedure

After receiving, the monosex male Nile tilapia fry with an average weight of 3.3 g were accustomed to the new rearing conditions for 10 days. Then the fry were distributed in aquariums containing 35 liters of water at a density of 20 fry per aquarium [6] in triplicate. The fish were subjected to three treatments namely T0: ambient water temperature, T1: 32 °C, T2: 34 °C. They were fed 3 times a day with a commercial fish feed containing 33% crude protein at the rate of 10 and 8% of the biomass, respectively, the first and second months of the trial. Water renewals were carried out twice a week. The physicochemical parameters of the water were regularly recorded; temperature and oxygen 3 times a day

while pH, twice a week. A control fishing was conducted weekly to collect essential data for calculating analytical parameters and readjusting the ration based on fish biomass.

2.2.2 Analytical Parameters

To estimate fish growth during the trial and characterize the utilization efficiency of the different experimental diets, the following parameters were calculated (Table 1).

Table 1: Formulas for production parameters

Production Parameters	Formulas
WG: Weight Gain (g)	$WG = Fmw - Imw$
DWG: Daily Weight Gain (g/d)	$DWG = WG/\text{ test duration (d)}$
FCR: Feed Conversion Ratio	$FCR = Q / (Bf + Bd - Bi)$
S: Survival Rate (%)	$S = 100 \times (Nf / Ni)$

Imw: Initial mean weight; Fmw: Final mean weight; Q: Quantity of feed distributed; Bi: Initial biomass; Bd: Biomass of dead fish; Bf: Final biomass; Ni: Initial number of fish; Nf: Final number of fish.

2.3 Statistical Analysis

The effect of temperature on Nile tilapia (*Oreochromis niloticus*) fry was assessed by comparing different growth parameters using a one-way analysis of variance (ANOVA). Fisher's LSD test was used to identify significant differences at the 5% level between the different treatments. Statistical analyses were performed using STATISTICA 5.0 software.

3 RESULTS

3.1 Physicochemical parameters

3.1.1 Temperature

The temperature ranged from 27.49 to 31.29°C with an average of 29.75 ± 1.58°C for treatment T0; 31.57 to 32.24°C with an average of 32.07 ± 0.11°C for treatment T1, and 33.67 to 34.18°C with an average of 34.06 ± 0.41°C for treatment T2.

3.1.2 Oxygen

The dissolved oxygen level in the water ranged from 1.78 to 6.25 mg/L with an average of 3.96 ± 1.30 mg/L for treatment T0; 1.02 to 5.43 mg/l with an average of 3.43 ± 1.33 mg/l for treatment T1 and 0.43 to 5.80 mg/l with an average of 3.28 ± 1.38 mg/l for treatment T2.

3.1.3 pH

A pH variation was noted from 5.16 to 7.13, with an average of 6.2 ± 0.7 for treatment T0; 5.43 to 7.16, with an average of 6.5 ± 0.6 for treatment T1; and 5.13 to 7.03, with an average of 6.4 ± 0.6 for treatment T2.

3.2 Growth parameters

Table 1: Average growth parameters of the different batches of fish subjected to the different treatments.

Treatments	Imw (g)	Fmw (g)	Ni	Nf	S (%)	WG (g)	DWG (g)	FCR
T0	3.35 ± 0.01	15.10 ± 0.18^{a}	20.00	20.00 ± 0.00^{a}	100.00 ± 0.00^{a}	11.75 ± 0.16^{a}	0.14 ± 0.00^{a}	2.01 ± 0.03^{b}
T1	3.32 ± 0.07	13.77 ± 0.10^{b}	20.00	20.00 ± 0.00^{a}	100.00 ± 0.00^{a}	10.45 ± 0.11^{b}	0.12 ± 0.00^{b}	2.10 ± 0.03^{b}
T2	3.28 ± 0.15	11.47 ± 0.43^{c}	20.00	17.00 ± 2.60^{b}	85.00 ± 12.90^{b}	8.18 ± 0.57^{c}	0.10 ± 0.01^{c}	2.75 ± 0.05^{a}

T0, T1 and T2: batches subjected to ambient temperature, 32°C and 34°C. Imw: Initial mean weight; Fmw: Final mean weight; S: Survival rate; WG: Weight gain; DWG: Daily Weight Gain; FCR: Food conversion ratio; Ni: Initial number of fish; Nf: Final number of fish. In each column, numbers with different superscript letters are statistically different ($P < 0.05$).

Table 1 shows the average growth parameters according to the heat treatments.

3.2.1 Survival Rates

Survival rates recorded at the end of the experiment were 100% for groups T0 and T1, and 85% for group T2. No statistical difference was found between groups T0 and T1 ($P > 0.05$), but there was a significant difference between them and group T2 ($P < 0.05$).

3.2.2 Daily Weight Gain

The daily weight gain recorded at the end of this experiment were 0.14 g/d for group T0, 0.12 g/d for group T1, and 0.10 g/d for group T2. There was a significant difference between the different groups of fish ($P < 0.05$).

3.2.3 Weight growth

Figure 1 shows the evolution of the average weight of fish batches according to the treatments during the experiment.

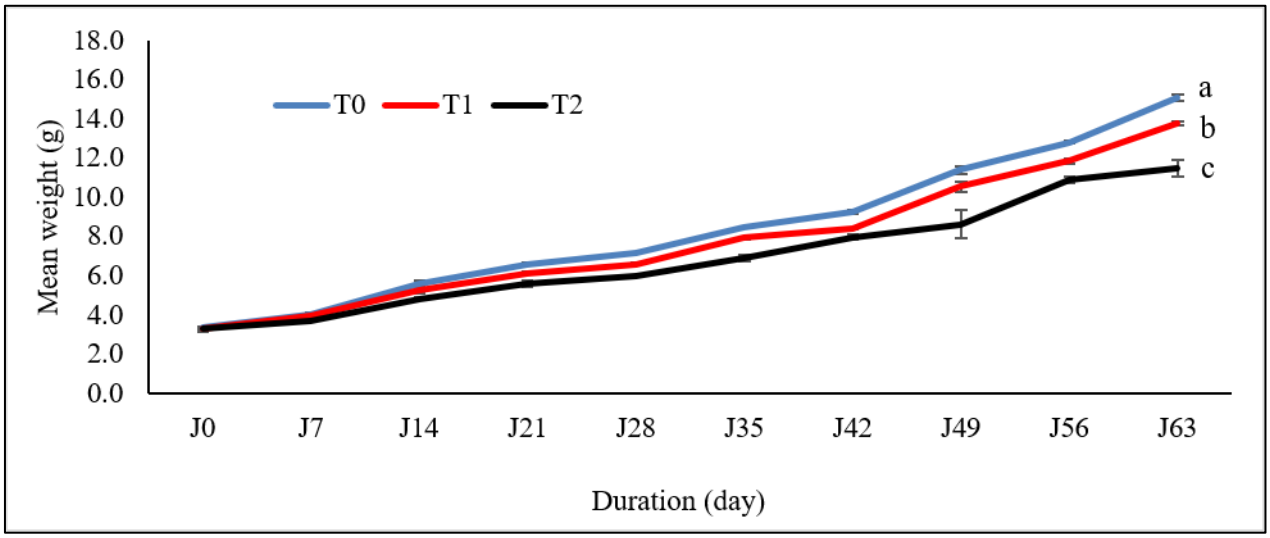

Figure 1: Weight changes in fish batches according to treatments during the trial.

T0, T1, and T2: batches subjected to ambient water temperature, 32°C, and 34°C. Curves with different letters are statistically different ($P < 0.05$).

Growth was effective throughout the trial. Thus, from Day 0 to Day 7, growth was similar across the different batches. However, from Day 7 until the end of the trial, growth was higher for batch T0, followed by batch T1, and finally batch T2. A significant difference was noted between the different batches of fish at the end of the trial ($P < 0.05$).

3.2.4 Food conversion ratio

The FCR was relatively high for batch T2 and low but similar between batches T0 and T2 ($P > 0.05$). There was a significant difference between these three batches ($P < 0.05$).

4 DISCUSSION

The mean values of the water pH recorded during the trial did not have a negative effect on tilapia growth and survival, as they were within the range recommended by [6]. Variations in pH values were thought to be due to CO2 released by the fish. Dissolved oxygen levels, negatively affected the growth and survival of Nile tilapia, as some values were below the range required for tilapia culture, according to [6]. The increase in oxygen levels could be attributed to activities such as water renewal and siphoning carried out during the trial. The decrease in oxygen levels could be due to the presence of feces and food debris in the water, as well as the lack of oxygen supply due to power outages.

At the end of the trial, the survival rate varied between 85 and 100% depending on the treatments. These values are similar to those obtained by [9]. The mortalities recorded during the experiment appear to be due to thermal stress, lack of oxygen and stress related to handling during control fishing. Fish survival was therefore affected by temperature [8].

DWG is correlated with the increase in temperature which explains the growth differences observed between the different batches at the end of the trial. Our values obtained are similar to those obtained by [10]. The decrease in DWG would therefore be due to heat stress. Generally, the best growth performances were obtained by fish submitted to ambient temperature and 32°C and the lowest by fish submitted to 34°C. The growth difference observed between the different batches could be due to metabolic activities. Indeed, instead of using the feed to grow, the fish use the feed to combat the temperature. Temperature also affects metabolism, which is faster at high temperatures, increasing food demand; however, extreme temperatures can cause heat stress, reducing growth and increasing susceptibility to disease [11]. These observations are consistent with the work of [10] on Nile tilapia.

The recorded FCR values increased with temperature. This observation is confirmed by the work of [9]. Temperature therefore impairs the efficiency of feed utilization by fish. The differences observed between the different treatments may be due to the influence of temperature [12]. Nile tilapia thrives at optimal temperatures between 25 and 30°C.

The sudden temperature changes linked to climate change will certainly have an impact on fish farms [12, 13]. Proper water renewal combined with increasing the depth of farming structures like ponds will allow fish farms to become more resilient [6].

5 CONCLUSION

This study demonstrated the importance of temperature on the zootechnical performance of Nile tilapia. Ambient water temperatures or 32°C were found to be the most favorable for growth, survival, and feed efficiency of the fish. On the other hand, a higher temperature of 34°C led to a decrease in these parameters. Smart adjustments will be needed to reduce the impact of climate change on fish farming.

STATEMENTS ON COMPLIANCE WITH ETHICAL STANDARDS

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Disclosure of conflict of interest

The authors declare that they have no conflict of interest related to this article.

Authors' contributions

Amakoé ADJANKE is the principal researcher and has been involved in all phases of the work of this study, including the design of the subject, the conduct of the experiment, the analysis and interpretation of data, the analysis of results and food samples, as well as the writing of the article. Hilaire Nimombé DJALA contributed to the monitoring of the experiment; Ali Kpatcha KADANGA and Atti TCHABI contributed to the revision of the article.

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