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Original Research Article

Impact of Water Change Frequency on the Growth of *Clarias gariepinus* (Burchell, 1822) Fingerlings

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KEYWORDS
Clarias,
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ABSTRACT
This study evaluated the impact of water change frequency on the growth of *Clarias gariepinus* fingerlings. Fingerlings with an initial mean weight of 3.99g to 5.20g were stocked (10 fish per tank) across eight tanks and subjected to four treatments: T1 (water change every two days), T2 (every four days), T3 (every seven days), and T4 (every fourteen days). Physicochemical parameters (temperature, pH, dissolved oxygen, turbidity, electrical conductivity, total dissolved solid, phosphorous- phosphate and nitrate-nitrogen) and growth Parameters (weight gain and length gain) were monitored using standard methods over 28 days. Results showed T2 and T3 gave the best growth with highest values for specific growth rate, relative growth rate, average daily growth and condition factor with significant differences ($p<0.05$). Water quality parameters were within ideal ranges, except for dissolved oxygen, which varied different from the standard. Correlation analysis revealed that dissolved oxygen ($r = 0.11$ for weight gain, $r = 0.62$ for length gain) and turbidity ($r = 0.38$ for weight gain, $r = 0.78$ for length gain) had positive relationships with growth parameters. Other parameters showed varying negative correlations, suggesting that higher level of these parameters might not favour growth under the experimental conditions. The findings suggests that water changes every 4-7 days may provide optimal conditions for growth in *Clarias gariepinus* fingerlings, highlighting the importance of balanced water quality management for sustainable aquaculture practices.

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INTRODUCTION

Aquaculture has become an essential part of food production with *Clarias gariepinus* (catfish) being one of the most farmed species due to its rapid growth and resilience. The practice of aquaculture in Nigeria has been successful due to cat fish propagation, this consequently leads to an increase in the cultivation of catfish in the country (Awoke, *et al.,* 2020). Optimal growth and health of aquaculture species are linked to water quality management, with water change frequency being a critical factor. Water change frequency directly influences the physico-chemical parameters of aquatic environments, including dissolved oxygen levels, ammonia concentrations, and overall water quality stability. These parameters, in turn impact the growth, development, and survival rates of fish species like *Clarias gariepinus* during their fingerling stage. The health and subsequent growth of fish is directly related to the quality of water in which they are raised (Anwa-udondiah, 2023). Water quality is one of the most critical factors besides good feed/feeding in fish

farming (Nindum *et al.,* 2023). Maintaining and monitoring water quality parameters are essential practices in aquaculture and therefore deserves special attention. Water quality parameter is the physical, chemical and biological support in which aquatic organisms carry out their daily processes (Verma *et al.,* 2022). Good water quality benefit fish to increase the quality of plankton as food, and low water quality quickly results in decreased fish yield and Lower production. Growth and productivity of *Clarias gariepinus* fingerlings in aquaculture are influenced by various environmental factors, with water quality management being paramount (Caesar *et al.,* 2021). Water quality parameters such as temperature, PH, dissolved oxygen must be monitored at optimal levels to enhance growth of micro-organism under intensive aquaculture (Maranga *et al.,* 2022).

Regular water changes significantly reduce harmful compounds such as ammonia and nitrites, which can impair fish health and growth (FAO, 2020). Additionally, maintaining optimal water conditions minimizes stress, promoting better physiological responses and feeding behaviors essential for growth (Sanau *et al.,* 2022).

MATERIALS AND METHODS

Study Area

The research was conducted at the Fisheries Laboratory in the Biological Sciences Department of Ahmadu Bello University, Zaria, Nigeria. The university is located in northern Nigeria at latitude 11.1512° N and longitude 7.6546° E. The region experiences a tropical savanna climate, with an average annual temperature ranging from 20°C to 32°C and annual rainfall of approximately 1000 mm between April to October.

Source of Fingerlings

Fingerlings of pure breed *Clarias gariepinus* were collected from Gugson Agrovet fish farm in Zaria, Kaduna State. Fish were transported early in the morning from the farm in a 25 - litres jar can containing about 10 litres of water.

Fingerlings Selection

The fingerlings were selected after sorting the bigger ones from the smaller ones to have a uniform size. Initial weights and lengths were recorded using a weighing scale and measuring rule.

Experimental Setup

The experiment setup consisted of eight plastic tanks of size 30cm by 40cm and 25L capacity in the Fisheries laboratory, Biological Sciences Department, Ahmadu Bello University. Before stocking, parasites and other predators were eliminated by washing the plastic tanks with sodium chloride (NaCl) and rinsed with fresh water. Eighty (80) seven weeks old fingerlings of *Clarias gariepinus* were used. Borehole water for this research was collected and carried to the Hydro-biology laboratory for physico-chemical analysis (Temperature, electrical conductivity, Total dissolved solid, Dissolved oxygen, Turbidity, phosphate-phosphorous, Nitrate-Nittogen and PH). A Litre of water was sampled in each treatment tank at regular interval to be examined (10) fingerlings were randomly distributed into four(4) different tanks with their replicate labelled all having 100% water changes. Each tank contains about 20 Litres water for the research. Four experimental groups based on water change frequency were employed:

T1: Water change every two days
T2: Water change every four days
T3: Water change every seven days
T4: Water change every fourteen days

Feeding Trial

Fish were fed with commercial feed twice daily at 5% of the body weight. The feed for each day was divided into two parts and given in the morning and evening for a period of Twenty-eight(28) days. The mean weight(g) and total length(cm) of the fish from each treatment and its replicate were measured weekly. The feeding rate was recalculated every week to accommodate weight changes that would have occurred.

Fish Growth Analysis

Growth was assessed in terms of weight and size. An electronic compact scale was used to determine the weight gain of fish . A ruler calibrated in cm was used to measure the total length of the fish (Richard *et al.,* 2023). Measurements were taken weekly, growth parameters and condition factor which was determined by the formular recommended by Froese (2006) was calculated.

Weight Gain (WTG) = W2 - W1
Where W1 = Initial weight , W2=final weight
Percentage Weight Gain (%) (RGR) = 100 (Y-X)/X
Where X = Initial Body Weight , Y= Final Body Weight
Specific Growth Rate (SGR) =LnWT-LaWt/ Tx 100
Where Ln=Natural log , WT = final weight , Wt= Initial weight , T =Time interval
Daily Growth (DG) = W2-W1/T
Where W2= Final Weight , W1= Initial Weight , T=Rearing Period
Length Increment = L2-L1, L1=initial length, L2=Final length
Condition factor (K)=100x W/L^3
Where W= Weight , L^3=Final length

Determination of Physico-chemical Parameters

The Dissolved oxygen in each treatment tank was determined using titration method, Electrical conductivity and Total dissolved solid (TDS) were measured using an Ec 214 conductivity meter, PH 210 microprocessor PH and Temperature metre was used to measure Temperature

and PH, Phosphorous-phosphate, Nitrate-Nitrogen and Turbidity were measured using Calorimeter 257 (APHA, 2005)

Data Analyses

Descriptive statistics (mean and standard deviation) were calculated for fish weight and length using SPSS. One way ANOVA was used to analyze the differences in water quality parameters between treatment groups over time. post-hoc tests were conducted to identify specific differences between groups ($p<0.05$). Correlation was employed to examine the relationship between water quality and growth Parameters of *Clarias gariepinus* fingerlings.

RESULTS AND DISCUSSION

Growth Analysis

The results of the mean initial and final weights and lengths of *Clarias gariepinus* fingerlings subjected to different frequencies of water change are presented in Table 1. The mean initial weights of the fish ranged from 3.99 g in T1 to 5.20 g in T4. The mean final weights varied from 8.49 g in T1 to 12.21 g in T2. Mean weight gain was highest in T2 (7.41 g) and lowest in T1 (4.50 g). The initial lengths of the fish were relatively consistent across treatments, ranging from 8.20 cm to 8.80 cm. The final lengths also showed variation, with T2 achieving the highest final length of 10.50 cm and T1 having the lowest at 10.24 cm. Length gain was greatest in T2 (2.20 cm) and least in T4 (1.60 cm).

Table 1: Mean initial, final and weight/length of Clarias gariepinus subjected to different frequency of water change

Treatment	Mean initial weight (g)	Mean final weight (g)	Mean weight gain (g)	Initial length (cm)	Final length (cm)	Length gain (cm)
T1	3.99	8.49	4.50	8.30	10.24	1.91
T2	4.80	12.21	7.41	8.30	10.50	2.20
T3	4.50	11.40	6.90	8.20	10.36	2.16
T4	5.20	10.10	4.90	8.80	10.40	1.60

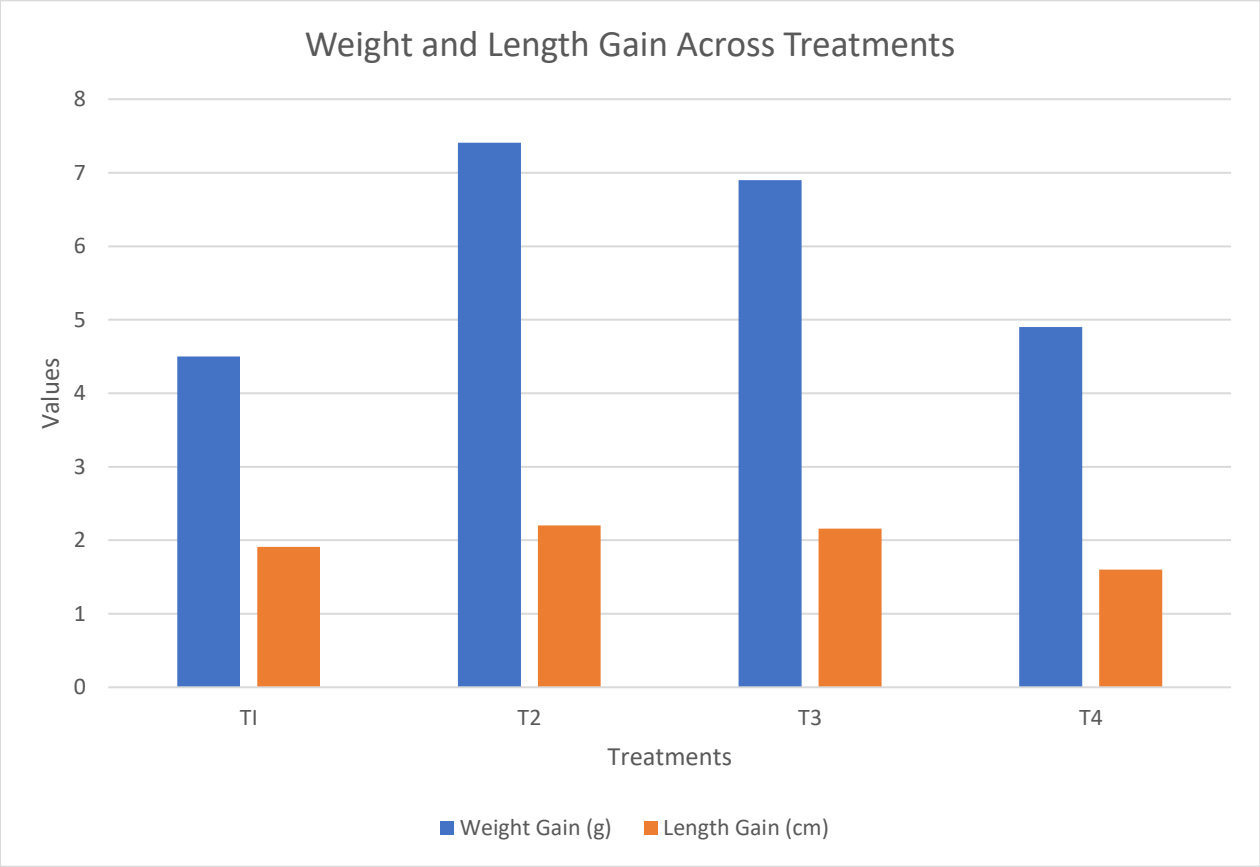

Figure 1: Effect of treatments on the weight and Length Gain of *Clarias gariepinus*

The summary of growth indices and condition factors of *Clarias gariepinus* subjected to different frequency of water changes is presented in Table 2. Condition factor was highest in fish subjected to water changes every four days (T2, 1.05) and lowest in those with water changes every two days (T1, 0.79). The relative growth rate (RGR)

was highest in T2 (154.3%), while fish subjected to water changes every 14 days (T4) had the lowest RGR (94.23%). The specific growth rate (SGR) was highest in T2 (3.33%/day) and lowest in T4 (2.37%/day). Average daily growth (ADG) followed a similar trend, with fish in T2 (0.26 g/day) showing the highest growth, while T1 had the lowest at 0.16 g/day.

Table 2: Growth indices and condition factor of Clarias gariepinus subjected to different frequency of water change

Treatment	Condition Factor	Relative Growth rate	Specific Growth rate	Average Daily Growth
T1	0.79	112.7	2.69	0.16
T2	1.05	154.3	3.33	0.26
T3	1.02	153.3	3.32	0.25
T4	0.89	94.23	2.37	0.18

Physico-chemical Analysis

The water quality parameters for the different treatments (T1, T2, T3, and T4) are summarized in Table 4.3. The physicochemical Parameters measured ranged as follows: Temperature (24.93°C to 25.27°C), PH (7.88 to 8.22), Electrical conductivity (204.72 to 480.33 µS), Total dissolved solids (102.36 to 240.17 ppm), Dissolved oxygen (1.43 to 5.97 mg/L), Phosphorous-phosphate (0.01 to 0.12 mg/L), Nitrate-nitrogen (0.13 to 0.18 mg/L), and turbidity (23.82 to 70.00 NTU).

Growth Parameters and Physico-chemical Parameters Analysis

The relationships between various water quality parameters (temperature, dissolved oxygen, phosphate, and turbidity) as well growth indicators (weight gain and length gain) for *Clarias gariepinus* fingerlings are represented in Figure 2. Positive correlations were observed between Turbidity with growth parameters (r = 0.38 with weight gain and r = 0.78 with length gain) as well as for dissolved oxygen (r = 0.11 with weight gain and r = 0.62 with length gain) while other physicochemical Parameters shows negative correlation with growth. Temperature (r= -0.54 with weight gain and r= 0.03 with length gain), PH (0.46 with weight gain and r= -0.06 with length gain), Electrical conductivity (r=-0.12 with weight gain and r= -0. 60 with length gain), Total dissolved solid (r= -0.12 with weight gain and r= -0.60 with length gain), phosphorous-phosphate (r= 0.08 with weight gain and r= -0.48 with length gain) and Nitrate-nitrogen (r= 0.39 with weight gain and r= -0.15 with length gain). The positive relationship of turbidity and dissolved oxygen with both growth indicators (weight gain and length gain) suggests that increasing levels of these parameters support better growth in *Clarias gariepinus* fingerlings. On the other hand, the negative correlations with other parameters such as temperature, pH, and electrical conductivity indicate that higher values of these factors might not be conducive to optimal growth, potentially hindering the fish's development.

Table 3: Mean physio-chemical water parameters across different treatment

Treatment	TEMP (°C)	PH	EC (µS)	TDS (ppm)	DO (mg/L)	PO_4^{-2} (mg/L)	NO_3^{-2} (mg/L)	TURBIDITY (NTU)
T1	25.27 ± 0.40 [a]	7.88 ± 0.42 [a]	223.00 ± 19.00 [a]	111.50 ± 9.50 [a]	5.97 ± 0.21 [a]	0.01 ± 0.00 [a]	0.13 ± 0.11 [a]	68.77 ± 16.48 [a]
T2	24.97 ± 0.15 [a]	8.13 ± 0.30 [a]	270.33 ± 42.16 [a]	135.17 ± 21.08 [a]	4.87 ± 0.15 [b]	0.12 ± 0.07 [a b]	0.18 ± 0.11 [a]	70.00 ± 18.73 [a]
T3	25.00 ± 0.20 [a]	8.22 ± 0.28 [a]	363.33 ± 47.54 [a]	181.67 ± 23.77 [a]	3.80 ± 0.10 [b]	0.12 ± 0.01 [a b]	0.20 ± 0.13 [a]	63.87 ± 21.46 [a]
T4	24.93 ± 0.12 [a]	8.24 ± 0.43 [a]	480.33 ± 204.72 [a]	240.17 ± 102.36 [a]	1.43 ± 0.15 [b]	0.24 ± 0.14 [b]	0.21 ± 0.13 [a]	55.03 ± 23.82 [a]

Different superscript indicates significance difference ($p<0.05$) n=2

TEMP = Temperature, EC=Electrical conductivity, TDS=Total Dissolved Solid, DO= Dissolved Oxygen.

Mean ± Standard deviation of two replicates

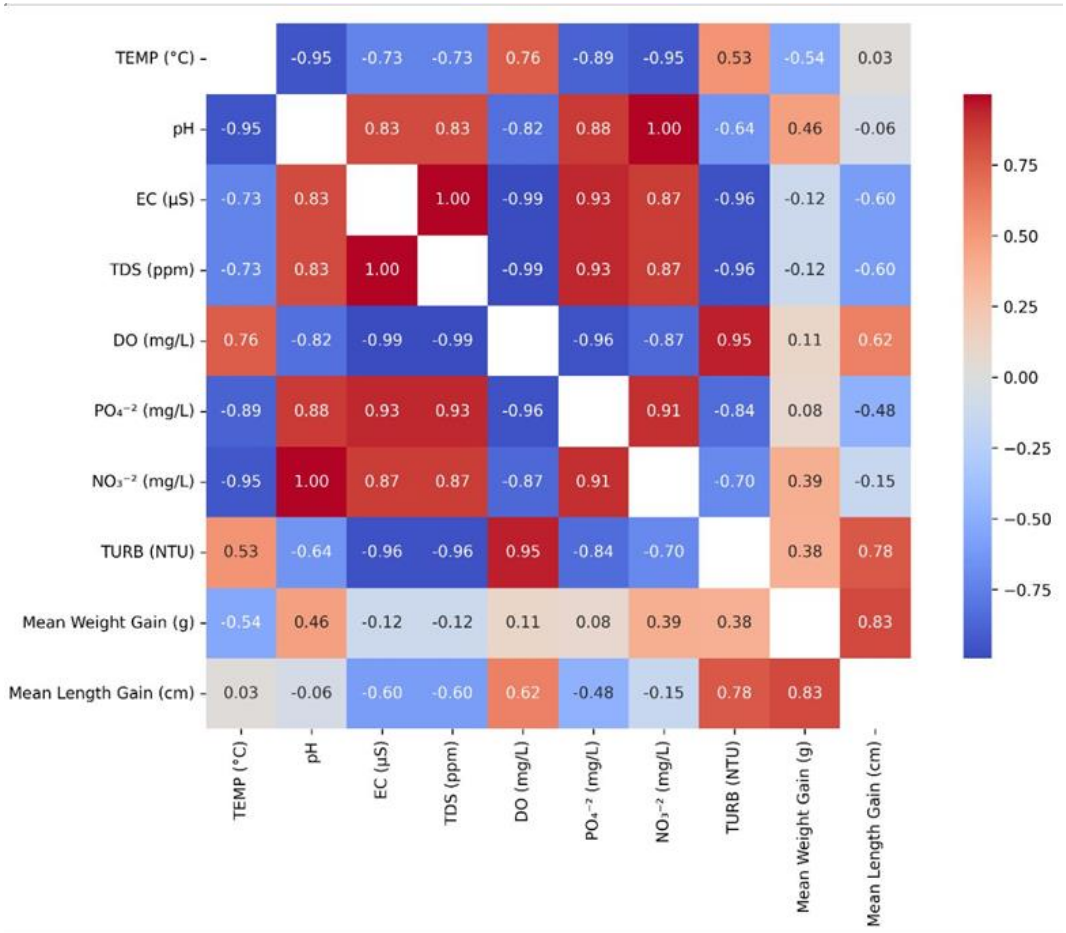

Figure 2: Pearson correlation matrix of Water quality and Growth Parameters

Discussion

The study revealed that the frequency of water change affect the growth performance of *Clarias gariepinus* fingerlings. Fish subjected to water changes every four days (T2) exhibited the highest relative growth rate, specific growth rate and condition factor. According to Froese (2006), the condition factor provides insight into how well fish are thriving in their environment, reflecting their overall growth conditions and energy reserves. The water physicochemical Parameters observed in this study were within the acceptable range for Catfish farming, except for Dissolve oxygen which differ significantly accross treatments. T1 had the highest level of dissolved oxygen, followed by T2, T3 and T4 had the least oxygen concentration. The low level of DO in T4 was the reason for poor growth. According to Rachmawati *et al.,* (2015), The right oxygen concentration for Catfish should not be less than 3mg/L. T1, T2 and T3 had dissolved oxygen level above the recommended value. Aquatic organisms need oxygen for burning their fuel (food) to produce activities, such as swimming, growth and reproduction (Caesar *et al.,* 2021), hence the observation of higher percentage of uneaten feed in the tank with water changes every fourteen days (T4). Maintaining higher DO levels promote metabolic activity and enhance growth rates in fish. Although water changes every two days leads to best water quality recorded in the study, it was not translated in performance which is the main essence of fish culture. Excessive handling or environmental changes even with high-quality water can lead to stress, reducing growth performance. Fish are affected by frequent stress (Okomoda *et al.,* 2016) . Frequent water changes could have disrupted the fish's feeding behaviour or caused mild stress, which can negatively impact growth. Fish may need time to adapt to stable environmental conditions for optimal growth. The superior performance in T2 and T3 could be attributed to the balance between maintaining water quality and minimizing stress from frequent handling, similar findings have been reported by Okomoda *et al.,* (2016) where intermediate water change frequencies were found to optimise growth of *Clarias gariepinus* fingerlings. The relationship between water quality parameters and growth Parameters indicated by the correlation matrix shows that water quality affect the growth of *Clarias gariepinus* fingerlings because dissolved Oxygen and turbidity show positive correlations with Growth Parameters (weight gain and length gain). This suggests that higher levels of dissolved oxygen are associated with better growth. Fish die when the dissolved oxygen level drops to 1mg/L (Shetaia *et al.,* 2020). Also the positive correlation of turbidity and growth parameters indicates that higher turbidity is linked to better growth. Zweig *et al.,* (1999) stated that in a production system where fish derive a majority of their nutrition from feed inputs, high turbidity content does not pose a problem. Turbidity in this study could be acting as indirect indicator of feeding activity or the presence of organic matter that promotes growth. Slight turbidity can provide shade or reduce excessive light penetration in water, which may reduce stress for fish . This is in line with the findings of Nindum *et al.,* (2023) where turbidity exhibited a strong positive correlation with growth.

CONCLUSION

The growth performance of *Clarias gariepinus* fingerlings was highest in the treatment with water changes every four days, with a weight gain of 7.41g and length gain of 2.20cm. The optimal water conditions for maximizing the growth of *Clarias gariepinus* fingerlings were associated with positive correlations between growth and water quality parameters, specifically dissolved oxygen (r = 0.11 with weight gain, r = 0.62 with length gain) and turbidity (r = 0.38 with weight gain, r = 0.78 with length gain).

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