A LEGACY OF LEADERSHIP: A SPECIAL ISSUE HONOURING THE TENURE OF OUR VICE CHANCELLOR, PROFESSOR ARMAYA'U HAMISU BICHI, *OON, FASN, FFS, FNSAP*

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EFFECT OF WATER FLOW-RATE ON GROWTH, NUTRIENT UTILIZATION, AND SURVIVAL OF AFRICAN CATFISH FINGERLINGS IN A SEMI-CLOSED SYSTEM

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ABSTRACT

The circulation of water by gravity in fish tank is a strategy to reduce the cost of energy in pumping. Thus, this study assessed different water flow-rates on growth, nutrient utilization, survival and condition factor of *Clarias gariepinus* in semi-closed system. It involved 15 PVC tanks of 120 L each stocked with first weight of 5.10 ± 0.06 g and fed with a commercial feed for 8 weeks under varied water flow rates of 0 L/m, 0.12 L/m, 0.24 L/m, 0.48 L/m and 0.96 L/m in triplicates. Weight gain was significantly ($p < 0.05$) enhanced from 26.63 ± 0.20 g in the 0 L/m to 121.40 ± 0.25 g in the 0.96 L/m. The highest survival rate of 91.67 ± 4.17 % was noticed in the 0.96 L/m. The feed conversion ratio and condition factor followed the same trend with growth responses. While, the dissolved oxygen was significantly increased from 5.56 ± 0.04 $mg.L^{-1}$ in the 0 L/m to 8.57 ± 0.03 $mg.L^{-1}$ in the 0.96 L/m. The PCA1 exhibited a positive correlation in growth responses, survival rate and condition factor, while, feed conversion ratio showed a negative correlation. The RDA recorded observed responses of 82 % reliability in the specific growth rate, condition factor and feed conversion ratio. This study established a significant specific growth rate of 5.71 ± 0.01 $\%.day^{-1}$; condition factor of 1.68 ± 0.02 $g.cm^{3-1}$ and feed conversion ratio of 1.34 ± 0.04 in the 0.96 L/m.

Keywords: Fish, Dissolved oxygen, Circulation, Tank, System

INTRODUCTION

Energy is needed to aerate the fish culture system, a method used to boost the dissolved oxygen in the rearing basin. However, dissolved oxygen is a limiting factor for successful production especially in a static tank. Fish cultured in such facility experience stress every other day as a result of poor water quality parameters (Brendan, 2017). Ammonia is an unwanted end product of fish waste in most culture units it becomes harmful to fish with a minimal accumulation of more than 0.02 $mg.L^{-1}$ (Brendan, 2017). There is an evidence that definite amount of dissolved oxygen for a given fish culture facility is require to ensure optimal food metabolism, growth and good health. Although, the oxygen is a prerequisite condition for fish production, its value varies with species of fish and the nature of water system, thus, aquaculturist must ensure that the dissolved oxygen of a system are provided (Rhatnagar & Devi, 2013). The World Health Organization (WHO) water quality parameters limits for freshwater/aquaculture include dissolved oxygen (5.0 – 10.0) $mg.L^{-1}$; hydrogen ion concentration (pH) (6.0 – 8.5) and alkalinity (>24.0) $mg.L^{-1}$ (Chapman & Kimstach, 2006).

To maintain the freshwater/aquaculture limits for hydrogen ion concentration (pH) is paramount at ensuring good health of the fish, and among the various ways to keep the pH of water in aquaculture include the addition of specific amount of slake lime (Ca_2Co_3) (Rhatnagar & Devi, 2013). Generally, extreme reduction in water pH supports increasing quantity of dissolved carbon (iv) oxide which may be harmful to fish. While, the sensitivity of fish to water temperature varies with species and its environment, warm water species including the African catfish and tilapia thrive best under temperature of 24 ℃ and above, and the amount of dissolved oxygen in water is temperature dependent, thus, higher water temperature reduces the quantity of dissolved oxygen at a given period of time (Rhatnagar & Devi, 2013).

The *Clarias gariepinus* is famous for its availability as a meal in most homes, and among the cheapest protein source for the lower class in Nigeria. The African catfish aquaculture share is huge as it comprises of over 70 % of the culture species in Nigeria (FAO, 2022). Amongst the endearing features of this species are its faster growth rate, high fecundity, possession of air breathing organ, ruggedness and adaptability to low dissolved oxygen in rearing condition.

A tank culture facility is a popular fish rearing vessel, and the water flow-rate is crucial for fish growth and nutrient utilization in most culture units. Water quality parameters are important factors to be considered in fish rearing, and the flow-through tank (semi-closed system) has proven to enhance water quality relative to the static tank (Omitoyin & Ajani, 2020). Most fish including the *C. gariepinus* produces diverse responses to water quality characteristics for instance, ammonia, nitrite, and nitrate concentrations (Brendan, 2017). Consistent water removal and supply to the fish rearing facility is a strategy of eliminating waste, and it is needed to ensure good water quality in a static system (Omitoyin & Ajani, 2020).

Semi-closed or flow-through tanks are made to improve the water flow and subsequently enhanced the water quality parameters, as proven in the study of *C. gariepinus* grown in flow-through tanks which improved the growth performance and water quality parameters compared to the static tanks (Omitoyin & Ajani, 2020). Previous work that reared this type of fish in flow-through tanks recorded enhanced feed efficiency and reduce effluent discharge from the system (Taiwo & Adebayo, 2019). Some contemporary studies on growth response of *C. gariepinus* in semi-closed and static culture tanks include works of (Omitoyin & Ajani, 2020; Taiwo & Adebayo, 2019). Therefore, this present study assessed different water flow-rates on growth responses, survival rate, condition factor, and nutrient utilization of *C. gariepinus* fingerlings in semi-closed tanks.

MATERIALS AND METHODS

Experimental fish

The fish comprises of 120 fingerlings of *Clarias gariepinus* of initial weight of 5.10 ± 0.06 g, which were bought from a reliable dealer at Almana hatchery at Dutsinma in katsina state, Nigeria. A total number of 8 fishes were reared in each of the 100 litres capacity polyvinyl chloride tank, connected to a borehole water source with 2000 litres storage overhead water delivery. The test fishes were fed to satiation twice daily in the morning at 8 – 9 hours and 18 – 19 hours with a Blue Crown a commercial feed purchased from an outlet in Katsina. At the beginning and end of the feeding experiment, fishes were subjected to Clove sedative at 100 $mg.L^{-1}$, followed by batch measurements of their weight and length by a digital scale and graduated meter rule in order to compute the weekly feeding ration.

Rearing tank system

The required materials include 1 polyvinyl (PVC) overhead tank of 2000 L capacity; one 2 horse power electric power pump made in Shanghai co. China; 15 PVC fish tanks of 100 L each; 10 PVC ½ inch pipes, 30 PVC ½ ball gauges; 43 PVC ½ elbows; 30 PVC back nuts/adaptors and a 20 grams PVC gum. The semi-closed system started by connecting the ½ inch tap from the overhead reservoir to the system, which supplied water exclusively by gravity to each of the 100 litres polyvinyl chloride fish tank sited in a column along with its 2 replicates. At the end, connect ½ inch pipe to drain water from the fish tank in order to ensure circulation. Finally, covered each of the holding tank with netting materials to forestall any jump out and loss of fish. The mean water flow-rate of each fish tank was determined by measurement of the volume of water discharged in litres at a given period in minutes (L/m).

Determination of growth, nutrient utilization, survival and condition factor

$\text{Weight gain} = \text{w2} - \text{w1}$ (Falayi, 2009)

Where w1 = mean initial weight

w2 = mean final weight

$\text{Percentage weight gain} = 100 \times \left(\frac{\text{w2}-\text{w1}}{\text{w2}}\right)$ (Wannigama *et al*., 1985)

$\text{Specific growth rate} = 100 \times \left(\frac{\text{Log e w2} - \text{Log e w1}}{\text{t}}\right)$

Where t = duration of the feeding trial in days

$\text{Condition factor} = 100 \times \frac{\text{w2}}{(\text{lf})^{\wedge}3}$ (Fulton. 1904)

Where w2 = mean final weight

lf = mean final length

$\text{Percentage survival} = 100 \times \frac{\text{final number of fish}}{\text{initial number of fish}}$

$\text{Feed conversion ratio} = \frac{\text{feed consumed}}{\text{weight gain}}$ *(*Hepher*,* 1988*)*

Feed consumed = 5 % of body weight X Feed

Water quality parameters in experimental tank

The pH and Temperature (°C) were determined in situ using Hanna digital meter SKU H199192 by inserting the probe of the digital meter into the water.

The Winkler method (Winkler, 1888), was used for the analysis of dissolved oxygen ($mg.L^{-1}$) in the water sampled.

The Salicylate method (Bower & Holm-hansen, 1980), was used to measure the total ammonia ($mg.L^{-1}$).

Statistics analysis

The mean and standard error of data were shown in Table and Figure. One-way analysis of variance was used for equality test of means that were grouped ($p < 0.05$) according to Tukey's post hoc comparison. The principal components analysis was deployed to visualize correlation among different values. While, the redundancy analysis revealed explained responses. The SPSS 23 version and Past 4.06b applications were used for these analyses.

RESULTS AND DISCUSSION

Growth, nutrient utilization, survival and condition factor

Table 1, showed the growth, nutrient utilization, survival and condition factor of *Clarias gariepinus* under different water flow-rates. The weight gain recorded a significant ($p < 0.05$) improvement from 26.63 ± 0.20 g in the 0 L/m to 121.40 ± 0.25 g in the 0.96 L/m. The improved growth responses could be attributed to the consisted increase of the water circulation, which perhaps enhanced its quality through removal of effluents from the flow-through fish tank. Similarly, the final weight; percentage weight gain; specific growth rate; condition factor; survival rate and feed consumed followed the same trend, as each exhibited water flow-rates depended enhancement across board. Moreover, the feed conversion ratio, which depicts the efficient utilization of nutrient and the quality of feed significantly ($p < 0.05$) decreased with increment in the water flow-rates. This signifies an enhancement on the part of feed quality in terms of improved digestibility, absorption and gross utilization by the experimental fish (Elaigwu *et al*., 2024). Since a small quantity of the feed could have met the nutrient need of the tested fish. Similarly, this result corroborates with the study by Omitoyin & Ajani, (2020) on *C. gariepinus* reared in flow-through tanks that led to enhanced growth responses. On the contrary this is not in line with that of Oboh, (2022) who observed that an exclusive provision of a good feed and feeding method probably do not guaranteed an additional growth performance of *C. gariepinus*. The component 1 exhibited a strong positive correlation in survival rate; percentage weight gain; final weight; weight gain; feed consumed, specific growth rate and condition factor in Figure 1 and Table 2, while, the feed conversion ratio revealed a strong negative correlation. This means that each of the response was improved with further increase of the water flow-rate, this analysis probably represents a second proof to earlier

results in Table 1 that in this experiment, the growth, nutrient utilization, survival and condition factor enhancements of the *C. gariepinus* were water flow-rates based.

Table 1: Growth, Nutrient Utilization, Survival and Condition Factor of *Clarias gariepinus* under Different Flow-rates in Semi-closed Tanks

	Control	R_1	R_2	R_3	R_4
Initial weight (g)	5.07 ± 0.03^{a}	5.13 ± 0.07^{a}	5.10 ± 0.06^{a}	5.03 ± 0.03^{a}	5.17 ± 0.03^{a}
Final weight (g)	31.70 ± 0.17^{e}	40.80 ± 0.12^{d}	58.33 ± 0.09^{c}	81.99 ± 0.30^{b}	126.57 ± 0.22^{a}
Weight gain (g)	26.63 ± 0.20^{e}	35.67 ± 0.13^{d}	53.23 ± 0.03^{c}	76.95 ± 0.33^{b}	121.40 ± 0.25^{a}
Feed consumed (g)	47.57 ± 0.12^{e}	61.00 ± 0.12^{d}	82.50 ± 0.12^{c}	110.67 ± 0.20^{b}	162.09 ± 0.16^{a}
Percentage weight gain (%)	3154.01 ± 17.50^{e}	4067.42 ± 11.58^{d}	5824.59 ± 8.74^{c}	8192.53 ± 30.09^{b}	12652.58 ± 21.89^{a}
Survival rate (%)	58.33 ± 4.17^{d}	66.67 ± 4.17^{cd}	75.00 ± 0.00^{bc}	87.50 ± 0.00^{ab}	91.67 ± 4.17^{a}
Specific growth rate (%.day^{-1})	3.27 ± 0.02^{e}	3.70 ± 0.02^{d}	4.35 ± 0.02^{c}	4.98 ± 0.02^{b}	5.71 ± 0.01^{a}
Feed conversion ratio	1.79 ± 0.02^{e}	1.71 ± 0.01^{d}	1.55 ± 0.003^{c}	1.43 ± 0.01^{b}	1.34 ± 0.004^{a}
Condition factor (g.cm$^{3-1}$)	1.10 ± 0.01^{d}	1.17 ± 0.02^{d}	1.35 ± 0.01^{c}	1.57 ± 0.05^{b}	1.68 ± 0.02^{a}

Each value is a mean + SE (n=3), the same superscript alphabets in a row are not significant ($p > 0.05$). $R_1 - R_4$ = (0.12, 0.24, 0.48, 0.96) L/m, Control = 0 L/m.

The effectiveness of some explanatory values were further tested using the redundancy analysis on growth, nutrient utilization, survival and condition factor of *C. gariepinus*, which recorded high observed responses of 82 % reliability in the specific growth rate, condition factor and feed conversion ratio that were improved with increasing water flow-rates in Figure 2. The redundancy analysis was in line with that of the result obtained in Table 1, Figure 1 and Table 2. Respectively, this is in confirmation that growth, nutrient utilization, survival and condition factor of *C. gariepinus* improved with increasing water flow-rates.

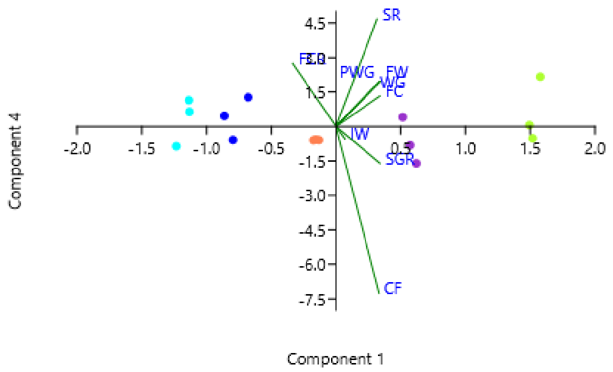

Figure 1: The Correlation among Growth, Nutrient Utilization, Survival and Condition Factor of *Clarias gariepinus* under Varied Flow Flow-rates in Semi-Closed Tanks using Principal Components Analysis

Table 2: The Correlation Eigenscores of Parameters in Components 1 and 2

	PC 1	PC 4
IW	0.20614	-0.014529
FW	0.99027	0.052623
WG	0.99032	0.052688
FC	0.99313	0.035675
PWG	0.99033	0.052407
SR	0.92658	0.12575
SGR	0.99512	-0.043074
FCR	-0.98182	0.073769
CF	0.97267	-0.19519

IW = Initial weight, FW = Final weight, WG = Weight gain, FC = Feed consumed, PWG = Percentage weight gain, SR = Survival rate, SGR = Specific growth rate, FCR = Feed conversion ratio, CF = Condition factor.

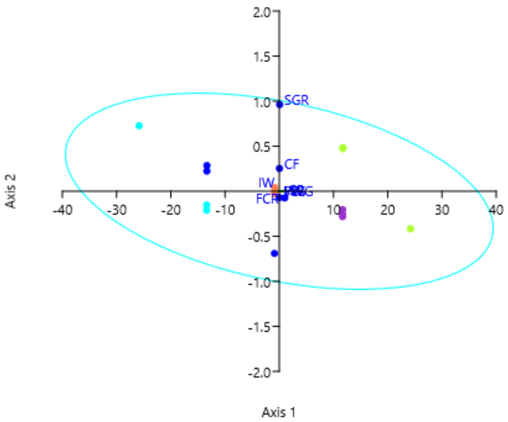

Figure 2: The Influence of Explanatory Values on Growth, Nutrient Utilization, Survival and Condition Factor of *Clarias gariepinus* under Varied Water Flow-rates in Semi-closed Tanks

Water quality parameters

The results of hydrogen ion concentration, dissolved oxygen, temperature and total ammonia are in Figure 3. The pH of the cultured tank increased significantly ($p < 0.05$) from 6.53 ± 0.76 in 0 L/m to 7.33 ± 0.33 in 0.96 L/m, similarly, dissolved oxygen improved with increasing water flow-rates and the highest value of 8.57 ± 0.33 mg.L^{-1}was obtained in 0.96 L/m. Moreover, the total ammonia followed a reversed trend as it reduced with increment in water flow-rates and the lowest significant value of 0.01 ± 0.00 mg.L^{-1} was obtained in 0.96 L/m. The enhanced water quality that improves with increase in water flow-rates in the current study could be attributed to an improved water circulation in the fish rearing tank. Contemporary studies that recorded similar improvements in water quality include that of Omitoyin & Ajani. (2020) who obtained improved water quality through consisted removal of water from the flow-through tank that was used to cultured *C. gariepinus*. Also, Elaigwu *et al*. (2024) recorded the same ranged of pH value from (6 – 7) and dissolved oxygen from (7- 8) mg.L^{-1} in static fish tank used to culture *C. gariepinus* juveniles.

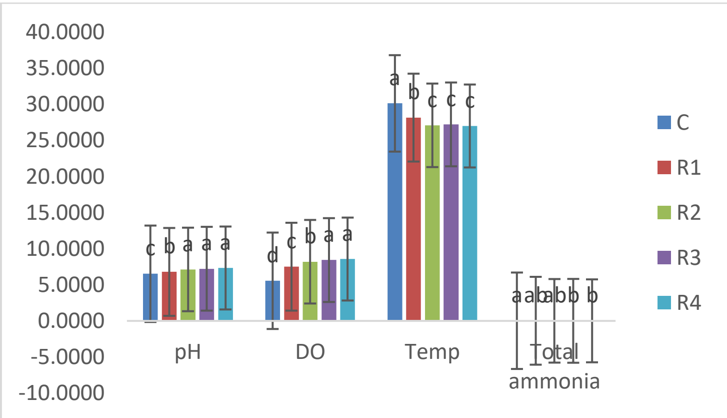

Figure 3: Water Quality Parameters of *Clarias gariepinus* Cultured Tanks in Semi-Closed System

The current work exhibited significant enhancements in growth, nutrient utilization, survival and condition factor of *C. gariepinus*. These water flow-rate depended improvements followed the same trend, including the specific growth rate, condition factor, dissolved oxygen and pH that surged with increasing water flow-rates. While, the feed conversion ratio and total ammonia improved with decreasing water flow-rates.

CONCLUSION

The water flow-rate based growth, feed conversion ratio, survival and condition factor of *C. gariepinus* were significantly enhanced, establishing the best specific growth rate of 5.71 ± 0.01 %.day^{-1}; condition factor of 1.68 ± 0.02 g.cm$^{3-1}$ and feed conversion ratio of 1.34 ± 0.04 in the 0.96 L/m. Therefore, the 0.96 L/m of water flow-rate in semi-closed system should be adopted for the rearing of *C. gariepinus* fingerlings in polyvinyl chloride tank.

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