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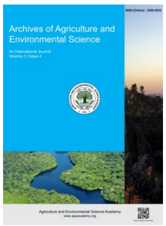

ORIGINAL RESEARCH ARTICLE

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Culture suitability of stinging catfish *Heteropneustes fossilis* in homestead tank: Selection of suitable stocking size

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ABSTRACT

The present experiment was conducted for a period of 150 days to assess the effects of different stocking size on growth and production of stinging catfish (*Heteropneustes fossilis)* in three homestead cemented tanks (12×10×4 ft). Three different size groups of fish viz., 3.79±0.11, 3.09±0.13 and 2.53±0.18 cm was stocked at treatment T_1, T_2 and T_3, respectively at a stocking density of 5000 individuals/tank each with three replications. Fish were feed twice daily with floating feed containing 35-40% protein at the rate of 15-10% for 1st 60 days, 8-6% for 2nd 60 days and 5-2.50% for rest of the culture period. The water quality parameters were within the suitable ranges for the fish culture. Mean weight gain (g) of stinging catfish was 49.03 ± 1.04, 36.72 ± 1.59 and 28.09 ± 0.41g, specific growth rate was 1.76 ± 0.02, 1.70 ± 0.04 and 1.66 ± 0.05 %/day in T_1, T_2 and T_3, respectively. Food conversion ratio was 3.45 ± 0.82, 3.31 ± 0.10 and 3.30 ± 0.06 and survival rate were 90.67 ± 1.51, 88.20 ± 2.62 and 87.56 ± 1.26% in T_1, T_2 and T_3, respectively. Higher stocking size also resulted in a significantly higher economic output in the form of benefit cost ratio (BCR) at T_1 (2.13 ± 0.05) and the lowest at T_3 (1.21 ± 0.03). The findings of the present study revealed that the highest weight gain and BCR was found in T_1 which dictates that larger stocking size has a significant impact on better production.

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INTRODUCTION

Intensification of aquaculture, in the present scenario of increasing population, has utmost importance to the nutritional security and economic well-being of Bangladesh. Although some intensive aquaculture practices (biofloc system, in pond raceway system, bottom clean raceway system) are now practiced in several locations of the country, their sustainability is not insured yet. Several studies have figured out some technical issues such as skilled manpower, selection of quality fish seed, stocking density, market access and profitability analysis which are hindering adoption and sustainability of intensive aquaculture in Bangladesh (Ali *et al*., 2022; Rashid and Ashab, 2022). Therefore, tanks prepared for biofloc culture are sometimes remained in unused condition. However, fish culture in these abandoned household tank can insure technical ease and lower capital investment for fish culture. It can also ensure increased women's participation in the fisheries sector. Sometimes, malnutrition in female is caused by their lower percentage of participation in aquaculture or similar industries. According to Ahmed *et al.* (2012), 36% of children under the age of five in Bangladesh are underweight, and almost one-third of women in Bangladesh are malnourished. Women spend a significant part of the day doing household chores; their involvement in tank fish culture can supplement the family income, enabling their male counterparts to work elsewhere.

The stinging catfish, *Heteropneustes fossilis* (Bloch, 1974), belonging to the family Heteropneustidae, is a commercially vital freshwater fish species (Ali *et al*., 2016; Rahman *et al*., 2019), and commonly known as shing or 'singhi' in Bangladesh and India (Khan *et al*., 2003; Samad *et al*., 2017). Moreover, this fish has already become favorable worldwide because of its medicinal value, highly digestible protein, edible and palatable meat, and less fat (Rahman *et al*., 2017; Kohinoor *et al*., 2013; Zafar and Khan, 2019). Very few studies has been conducted on the culture of shing in the cemented tank, which estimated the optimum stocking density fed with formulated pelleted feed in the cemented cistern. However, no published information is available on the effect of stocking size on water quality, growth performance, survival rate, economic feasibility, and business development strategy of stinging catfish culture in cemented tank. Therefore, we set the specific objectives as follows: (1) to quantify the impact of stocking size on water quality and growth performance, (2) to evaluate the cost and return, (3) to estimate the business feasibility and prospective of tank culture of stinging catfish in Bangladesh. Finally, the outcome of this study will exclusively benefit the local, national, and global fish farmers, entrepreneurs, extension workers, aquaculturists, and policymakers. The present effort is aimed at studying comparative production performances of stinging catfish in tank environment with low water circulation. However, the specific objectives of the work are to compare growth and production in tanks; to determine appropriate stocking size of the fish in tank and to identify the problem in tank culture of stinging catfish for further improvement of culture technology using tanks.

MATERIALS AND METHODS

Duration and study location

The research work was conducted in homestead tanks located in fish seed multiplication farm at Natore district of Bangladesh for a period of 150 days from March to August 2019 (Figure 1).

Experimental design

A randomized block design (RBD) was followed for carrying out the present experiment (Table 1). Three homestead tanks of 12×10×4 ft. with three replicates were used for the present study. The fingerlings of Stinging catfish used in this experiment were collected from a private hatchery of Rajshahi district, Bangladesh. The sizes of fingerlings were 3.79±0.11, 3.09±0.13 and 2.53±0.18 cm in T_1, T_2 and T_3 respectively.

Supplementary feeding

After stocking, to meet up the increasing dietary demand, fish were feed twice (morning and afternoon) daily with floating feed containing 35-40% protein at the rate of 15-10% for 1st 60 days, 8-6% for 2nd 60 days and was reduced to 5-2.50% for rest of the culture period.

Water quality parameters

Throughout the experimental period, four major water quality parameters were recorded after every 15 days. Water quality measurements and sample collection were made between 9.00 and 10.00am on each sampling day. Using a Multi-Parameter Water Quality Meter (HANNA, HI 98194, pH/EC/DO multi-parameter), temperature (°C), pH, DO of the water were measured. Ammonia-Nitrogen (mg/l) was determined by ammonia measuring kit (HANNA instrument Test Kit).

Growth parameters

Growth performance of stinging catfish read in cemented tank was evaluated after Brett and Groves (1979) as follows:

Total weight gain (g) = Mean final weight (g) - Mean initial weight (g)

$$\text{Specific growth rate (SGR, \%/day} = \frac{\ln \text{final weight} - \ln \text{initial weight}}{\text{Culture period}} \times 100$$

$$\text{Survival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

$$\text{Fee Conversion Ratio (FCR)} = \frac{\text{Feed fed dry weight}}{\text{Total weight gain}}$$

Fish yield (kg) = Fish biomass at harvest

The following simple equation was used to find out the net return after Hossain *et al*. (2022):

R = I - (FC+VC+Ii)

Where, R = net return, I = income from fish sale, FC = fixed/common costs (costs which are similar for all the treatments), VC = variable costs and Ii = interest on inputs.

The benefit-cost ratio was determined as:

Benefit-cost ratio (BCR) = Income from fish sale/Total input cost.

Figure 1. *Study location at Natore Sadar Upazila of Natore district, Bangladesh.*

Table 1. *Experimental layout for tank culture of Stinging catfish.*

	T_1	T_2	T_3
TS (ft)	12×10×4	12×10×4	12×10×4
WV (l)	10000	10000	10000
SS (cm)	3.79±0.11	3.09±0.13	2.53±0.18
SD (nos.)	5000	5000	5000
CP (days)	150	150	150

TS = Tank size, WV = Water volume, SS = Stocking size, SD = Stocking density, CP = Culture period.

Statistical analysis

All the analysis were done using SPSS version 20.0. ANOVA and DMRT were performed to observe whether treatments had any significant variation among them. One-way analysis of variance (ANOVA) was performed for the statistical analysis of growth and production. Finally, the data were processed and analyzed statistically by using Microsoft Excel program and statistical software.

RESULTS AND DISCUSSION

Water quality parameters

Figure 2 illustrates the trends of changes in different water quality parameters in the tanks during the study. Water temperature increased gradually with the progress of culture period. However, no major changes were observed among the treatments. Inverse to the temperature, DO has fluctuated most during the study period with the marked lower values recorded during 105 days of culture. After that a gradual increment was observed on to the end of the culture period. Water pH was peaked during the 105 days of cultured period, except that, no major fluctuation was recorded over the culture period. With sudden ups and downs, NH_3 concentration was almost stable during the sampling period. Mean values of all water quality parameters were not varied significantly ($P < 0.05$) among the treatments (Table 2). Water temperature ranged from 17.02 to 34.00 ˚C with mean values between 29.42 ± 0.13 (T_2) to 30.12 ± 0.13 ˚C (T_1). DO ranged from 2.83 to 5.06 with mean values between 3.75 ± 0.11 (T_1) to 3.83 ± 0.10 (T_3). Water pH ranged from 7.19 to 8.11 with the highest value recorded at T_1 (7.63 ± 0.04) and the lowest in T_2 (7.60 ± 0.03). The value of NH_3 was observed at T_2 (0.43 ± 0.03 mg/l) and the lowest in T_3 (0.42 ± 0.01 mg/l), whereas the range was 0.37 to 0.49 over the culture period. Fish culture in tank is mainly limited by the factors that adversely affect the culture system such as quantity of uneaten feed and fecal materials generated by fish. Metabolic by products generated by uneaten feed and fecal materials are known to release excessive NH_3, reduced DO and finally reduced the fish growth. Deterioration in water quality due to increased stocking biomass and subsequent reduction in fish somatic growth have been reported in several studies (Mramba and Kahindi, 2023; Ni *et al*., 2016). In the present study, water quality of the different treatments did not differ significantly, indicating that tank culture with programmed water exchanging had no adverse impact on the tank environment regardless of different stocking biomass. Similar observation was also made by Obirikorang *et al.* (2019), whereas they reported that water exchanging was most effective for tilapia reared in recirculating aquaculture system and reported reduced growth compromised welfare in poor water exchange. Although, literature search revealed little information on the water quality requirement for tank culture of stinging catfish, the prevailed water quality parameters in all tanks were within the tolerance limit reported in the study of Roy *et al.* (2019) and Narejo *et al.* (2005).

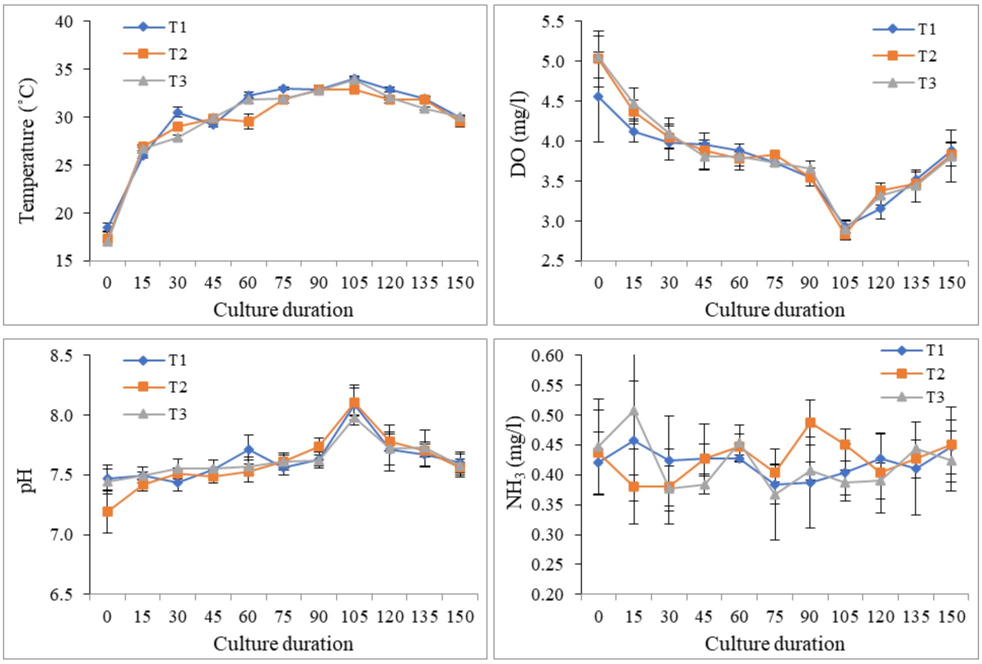

Figure 2. Fortnightly variations in water quality parameters.

Table 2. Water quality parameters of the experimental tanks.

Parameters	T_1	T_2	T_3	F-value	P-value
Temperature (˚C)	30.12 ± 0.13 (18.50 – 34.00)	29.42 ± 0.13 (17.36 – 32.90)	29.57 ± 0.06 (17.02 – 33.89)	32.47	> 0.05
Dissolved oxygen (mg/l)	3.75 ± 0.11 (2.93 – 4.55)	3.82 ± 0.04 (2.83 – 5.03)	3.83 ± 0.10 (2.89 – 5.06)	6.66	> 0.05
pH	7.63 ± 0.04 (7.44 – 8.08)	7.60 ± 0.03 (7.19 – 8.11)	7.62 ± 0.01 (7.44 – 7.98)	9.62	> 0.05
NH_3 (mg/l)	0.42 ± 0.03 (0.38 – 0.45)	0.43 ± 0.03 (0.38 – 0.49)	0.42 ± 0.01 (0.37 – 0.51)	7.19	> 0.05

Table 3. Growth parameters (Mean±SD) of stinging catfish for the tank culture.

Parameters	T_1	T_2	T_3	F-value	P-value
IW (g)	3.79 ± 0.11	3.09 ± 0.13	2.53 ± 0.18	99.35	< 0.01
FW (g)	52.81 ± 1.10^a	39.82 ± 1.58^b	30.61 ± 0.39^c	484.73	< 0.01
CV_{FW} (%)	2.08 ± 0.04^b	3.97 ± 0.15^a	1.27 ± 0.02^c	1127.89	< 0.01
WG (g)	49.03 ± 1.04^a	36.72 ± 1.59^b	28.09 ± 0.41^c	438.19	< 0.01
SGR (%/day)	1.76 ± 0.02^a	1.70 ± 0.04^b	1.66 ± 0.05^c	8.31	< 0.05
SR (%)	90.67 ± 1.51^a	88.20 ± 2.62^b	87.56 ± 1.26^b	3.78	< 0.05
FCR	3.45 ± 0.82^a	3.31 ± 0.10^b	3.30 ± 0.06^b	5.55	< 0.05

Values in the same row with different superscript letters were significantly different (P < 0.05). IW, Initial weight; FW, Final weight; WG, weight gain, SGR, specific growth rate, SR, survival rate, FCR, feed conversion ratio.

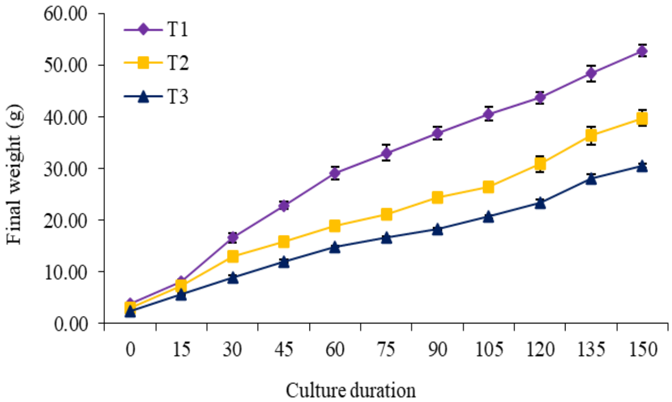

Figure 3. *Fortnightly growth performances (final weight) of stinging catfish in tank culture.*

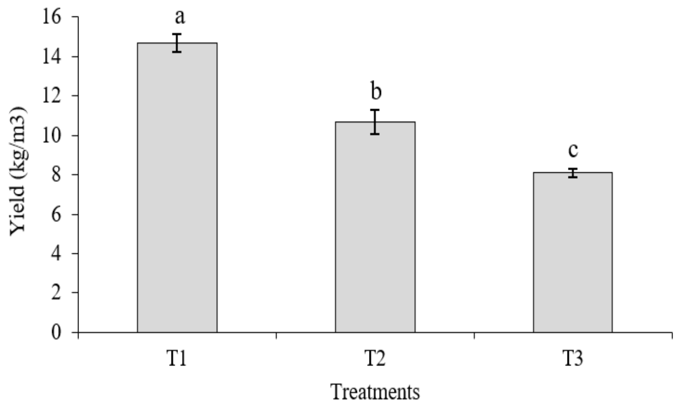

Figure 4. *Gross yields of stinging catfish in tank culture.*

Growth performance and survival

Figure 3 depicted the size-dependent growth response of stinging catfish at different culture duration. Fish with larger stocking size at treatment T_1 showed higher increasing trend in final weight compared to the smaller sized groups at treatment T_2 and T_3. Mean final weight, weight gain, specific growth rate, survival and feed conversion ratio were described in Table 3. Mean FW was significantly (P < 0.05) higher at treatment T_1 compared to treatment T_2 and T_3. Therefore, increasing initial size of 18.47 and 33.25% in treatment T_1 resulted in 24.60 and 41.04% increment in FW compared to T_2 and T_3, respectively. Size heterogeneity as a function of stocking size showed significant difference (P < 0.05) in CV_{FW} among the treatments which ranged from 1.27 ± 0.02 (T_3) to 3.97 ± 0.15% (T_2). WG was 25.11 and 42.71% higher in treatment T_1 compared to treatment T_2 and T_3, respectively. SGR was also significantly higher at treatment T_1 and the lowest at treatment T_3. Stocking size also had a significant effect on fish survival, whereas fish at treatment T_1 showed higher survival rate compared to treatment T_2 and T_3. Increment in FCR in treatment T_2 and T_3 compared to T_1 were also ascribed to the increase in initial stocking size of stinging catfish. However, FCR was not affected in any case by the size of the stinging catfish at treatment T_2 and T_3 (P > 0.05). The gross biomass yield in treatment T_1 (14.70 ± 0.45 kg/m^3) was also significantly (P < 0.05) higher than those of the treatment T_2 (10.68 ± 0.64 kg/m^3) and T_3 (8.09 ± 0.21 kg/m^3) (Figure 4). Under the experimental conditions, the growth performance of stinging catfish was attributed to the increase in stocking size or biomass, which was depicted by the significantly higher FW, WG and SGR in treatment T_1. FW recorded in the present experiment are comparable with the finding of Kohinoor *et al.* (2012) who reported the final weight ranged between 49.50 ± 4.52 to 69.42 ± 6.20 g in pond culture of stinging catfish after 180 days of culture period. WG in the present was also comparable with the findings of Roy *et al.* (2019) whereas they stocked stinging catfish with initial weight 1.25 to 1.50 g and recorded weight gain ranged between 39.10 to 40.48 g after 150 days of culture period. In terms of heterogeneity of the fish groups, fish in treatment T_2 showed most heterogeneity in FW compared to the other treatments. However, fish in treatment T_3 showed more homogeneity among them might be due to similar growth pattern. Collaborated with the FW and WG, significantly higher SGR was recorded in treatment T_1 followed by T_2 and T_3 which contradicts with the findings of Akbulut *et al.* (2002) who reported that specific growth rate decreased with the increasing body size due to the faster growth rate of larger fish. SGR recorded in the present experiment was slightly lower than the findings of Kohinoor *et al.* (2012) who also used the fish with similar initial weight (3.24 to 3.26 g) of our study. However, much higher SGR of stinging catfish was reported by Monir and Rahman (2015) with much lower stocking size (0.0007 g). In the present study, larger fish at treatment T_1 survived most compared to treatment T_2 and T_3. However, overall survivability in all the treatments were comparable with Chakraborty and Nur (2012) and Kohinoor *et al.* (2012) which was supported by the suitability of prevailing water quality parameters in tank culture system. The FCR values of different treatments were acceptable and indicated better food utilization, which is agreed by Kohinoor *et al.* (2012) who reported the FCR value ranged between 2.78 to 3.59. However, significantly higher FCR in treatment T_1 indicated active feeding by larger sized fish.

Table 4. Economic performance (mean ± standard deviation) of stinging catfish in tank culture (considering 1 m^3 tank area).

Variables	T_1	T_2	T_3	F-value	P-value
Tank preparation	1000	1000	1000	-	-
Electricity	50	50	50	-	-
Seed cost	920	880	830	-	-
Feed cost	693.38 ± 8.30^a	475.99 ± 5.53^b	363.66 ± 3.06^c	3868.65	< 0.01
Total cost	2626.71 ± 8.88^a	2375.99 ± 6.36^b	2213.66 ± 3.45^c	5962.22	< 0.01
Total income	5587.03 ± 156.87^a	3746.94 ± 210.14^b	2680.32 ± 54.48^c	452.11	< 0.01
Net income	2960.32 ± 151.95^a	1370.95 ± 205.66^b	466.65 ± 54.78^c	349.57	< 0.01
BCR	2.13 ± 0.05^a	1.57 ± 0.08^b	1.21 ± 0.03^c	301.55	< 0.01

Values in each same row having different superscripts are significantly different (P < 0.01).

Table 5. Correlation analysis of growth, yield and economics parameters.

Parameters	IW	FW	SR	FCR	Yield	TC	TI
FW	0.968**						
SR	0.587*	0.621*					
FCR	0.651**	0.572*	0.228				
Yield	0.963**	0.997**	0.682**	0.557*			
TC	0.972**	0.995**	0.617*	0.641*	0.992**		
TI	0.963**	0.997**	0.671**	0.584*	0.999**	0.995**	
BCR	0.962**	0.997**	0.681**	0.557*	1.000**	0.992**	0.999**

**Correlation is significant at the 0.01 level (2-tailed). * Correlation is significant at the 0.05 level (2-tailed). SR = Survival rate, FCR = Feed conversion efficiency, TC = Total cost, TI = Total income, BCR = Benefit cost ratio.

During the present experiment, significantly higher gross yield was recorded in treatment T_1 (14.70 ± 0.45 kg/m^3) which was 26.64 and 44.03% higher than T_2 (10.68 ± 0.64 kg/m^3) and T_3 (8.09 ± 0.21 kg/m^3), respectively. The present yield was much higher than the pond production of stinging catfish recorded in the study of Kohinoor *et al.* (2012) whereas they reported the gross production ranged between 0.75 to 0.90 kg/m^3 for 180 days of culture period. Again, study conducted by Roy *et al.* (2019) in concrete tank for 150 days also reported much lower yield (0.45 to 0.51 kg/m^3) than the present findings. These huge differences might be due to the lower stocking density (12 to 25 nos./m^3) used by the above-mentioned authors. The above comparison indicated that higher stocking density and favorable environmental condition could increase the production of stinging catfish in tank culture.

Economic performance

Economic performance of stinging catfish in tank culture is shown in Table 4. Cost items such as tank preparation, electricity and seed cost were fixed for each treatment. Feed cost was significantly (P < 0.01) higher in treatment T_1 and the lowest in treatment T_3. Consequently, total cost was significantly higher at treatment T_1. However, despite the higher total cost in treatment T_1, significantly higher total and net income were incurred from treatment T_1. Therefore, treatment T_1 was found to show higher benefit-cost ratio (BCR) compared to the other treatments. During the study period, consistently higher net benefits (BDT 2960.32 ± 151.95/ m^3 of tank) were obtained from treatment T_1 than those of treatment T_4, T_3. As there are no previous studies conducting on evaluating the effect of stocking biomass on the economics of stinging catfish in tank culture, no comparison is made. However, studies conducted by Roy *et al.* (2019) and Kohinoor *et al.* (2012) reported that higher stocking density was beneficial for higher production. Furthermore, the present study reported significantly higher BCR in treatment T_1, compared to T_2 and T_3. Correlation analysis also reported positive influence of stocking size on the growth, yield, and economics of stinging catfish in tank culture system.

Correlation analysis

Correlation matrix of growth and economic variables are shown in Table 5. IW has highly significant positive correlation (P < 0.01) with FW, FCR, Yield, TC, TI and BCR, while significant positive correlation (P < 0.05) with SR. Yield, TC and TI also has highly significant positive correlation (P < 0.01) with BCR, which indicated that although tank culture of stinging catfish with larger sized fry needs high investment cost, better yield, net income and BCR can be obtained.

Conclusion

In conclusion, based on the present findings of highest growth, survival, yield and BCR, the present study concluded that stocking size is a major criterion determining the success of tank culture of stinging catfish. Significantly higher FW and BCR recorded were 52.81 ± 1.10g and 2.13 ± 0.05 at treatment T_1. Therefore, a stocking biomass of 1.25 kg/m^3 with an initial size of 3.79±0.11 cm stinging catfish can be cultured for 150 days for higher growth and economic performance. Furthermore, physiological mechanism in terms of blood parameters and proximate analysis needs to be further investigated to provide insight into the growth response of stinging catfish in tank culture.

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