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Implications of Size Heterogeneity and Food Availability on the Survival of *Heterobranchus Longifilis* Fingerlings

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ABSTRACT

This experiment was conducted for a period of 90 days to evaluate the effects of size heterogeneity and food availability on the survival rate of the fingerlings of Heterobranchuslongifilis. The experiment took place in 48 netting hap as each measuring 80cm X 250cm and 110cm deep placed in 6 concrete tanks measuring 3mx8mx1.2m with flow through. 720 fingerlings ranging from 20mm to 60mm total length were used in six size ratios of smaller to large fingerlings to give 1:1; 0.833:1; 0.667:1; 0.50:1; 0.40:1 and 0.33:1. There were 5 predators and 10 preys in each treatment set except the treatment with ratio 1:1 which had 15 (100%) predators. Four feeding regimes of 2 in a day, 1 in a day; 1 in 2 days and 1 in 4 days were taken as food availability using a 35% crude protein polluted feed. The experiment was a 6 by 4 factorial with two replications in a complete randomized design. The fish were fed at 1.5% body weight per ration based on their respective feeding regimens and adjusted accordingly bi-weekly after weight measurement. Feeding was done accordingly at 600-700 hrs (all categories) and 1800-1900hrs (for those fed twice daily). Evidence of cannibalism was monitored regularly. Water quality parameters were monitored weekly. Survival rate was determined at the end of 90 days and the data analyzed using analysis of variance for significance difference. Evidence of cannibalism was observed across all size categories. There was significant interaction between size heterogeneity and food availability. The highest survival rates were found in size ratios 0.833:1-1:1 fed twice daily and these were recommended.

INTRODUCTION

Nigeria is yet to meet her fish demand which FCWC [1] estimated at 3.32 million metric tons against total domestic production of 1.123 million metric tons as at 2014. The subsisting restriction on fish importation since 2014 [2] against the high demand for fish have stimulated private interests and investments in aquaculture. The most prominent cultured species are the two genera of clariid catfishes namely, *Clarias* and *Heterobranchus* [3] which according to [4] are very important to the sustainability of aquaculture industry in Nigeria. *Heterobranchus longifilis* is distinguished from other members of the genu: *H. bidorsalis* and *H. isopterus* by the possession of adipose fin of about the length of dorsal fin; larger premaxillary and vomerine tooth plate width; dark posterior part of adipose fin, barred caudal fin colouration and serrations on the anterior side of the pectoral spine [5-6]. The fish has tasty flesh [7], impressive growth rate [8] and tolerance to crowded conditions [9] amongst other desirable qualities.

The propitious characteristics of *H. longifilis* as a desirable culture species are however punctuated with poor survival and recovery at harvest occasioned by Cannibalism which Agnese and Oteme [10] believed to be inherent in this species. Cannibalism in *H. longifilis* had been documented by many authors including [8, 11-15]. Records of Cannibalism in other teleost fishes are also available [16-23].

Van den Bosch *et al.* [24] viewed Cannibalism as a population survival mechanism given limited resources in the environment. This could be beneficial to the predator or cannibals to ensure nutrition, minimized resources competitions, parental control and sexual selection as recorded by [25-27]. This phenomenon according to Smith and Reay [27] can be classified on the basis of the genetic relationship between the cannibal and the prey, developmental stage of the prey and/ or the age relationship of cannibal and prey. Myriads of factors have also been implicated in cannibalism by many authors [15, 28] with preponderance of

emphasis on size hetero geneity and food availability [18, 20-21, 26, 29-32]. The ultimate consequence of cannibalism in aquaculture irrespective of the purpose, benefits and basis, is often mortalities with attendant investment failure. The incidence of cannibalism among the stock of *H. longifilis* occasioned by size heterogeneity could be very debilitating and frustrating to the aquaculturist when he realizes that his hopeful investment has turned to a woeful loss. The objective of this research work was to evaluate the possible size combination of *H. longifilis* fingerlings and suitable feeding frequency that would enhance higher stock survival.

Materials and Methods

Study Area

The experiment was conducted for 90 days at the fish farm complex of Safe food M.P.C.S. Ltd Uyo, Akwa Ibom State, Nigeria.

Experimental Design and Procedures

Fingerlings of the same brood were obtained from the farm. This experiment was conducted in 48 hap as each measuring 80cm by 250cm and a depth of 110cm placed in 6 concrete tanks each measuring 3x 8m x1.2m and having flow through system. 720 fingerlings ranging from 20mm to 60mm total length were used. They were grouped approximately as 20mm, 30mm, 40mm, 50mm and 60mm. Size heterogeneity is here expressed in the total length ratio of the smaller fish (prey) to the larger fish (predator). The fingerlings of 60mm class were used as the predators relative to others to obtain the prey-predator ratio of 1:1 (100%predators); 0.833:1; 0.667:1; 0.5:1 and 0.33:1 while 0.4:1 was obtained from the 50mm class (predator) and 20mm (prey). Each prey-predator size ratio was placed in a hapa which contained 5 predators (larger fish) and 10 preys (smaller fish) except ratio 1:1 which contained 15 predators (only fish of the large size, 60mm).

There were 4 sets of each size ratio each randomly assigned only one of 4 different feeding regimens viz. 1 in 4 days, 1 in 1 day, 1 every other day, and 2 in 1 day without repeating any. Each treatment combination was replicated twice. The experiment was thus a 6 × 4 factorial complete randomized design. The fish in each treatment combination were fed with 35% crude protein pelleted diet according to the respective feeding regimen at 1.5% body weight per ration and adjusted every two weeks after weight sampling intermittent flow of water was maintained.

Water Quality Assessment

Water column in the hapas was kept at 0.5m the first month and 0.9m for the remaining 2 months. Feeding was carried out at 0600 - 0700hrs (all categories) and 1800-1900hrs (for those fed twice daily). The hap as were inspected twice daily for mortality and changed for clean ones weekly. Water temperature, pH and dissolve oxygen were monitored on weekly basis using Jen way dissolved oxygen and pH meters. The entire tanks were shaded to reduce light intensity. At the end of the three-month culture period, the fish in each replicate of the respective treatment combination were counted and survival rates determined.

Statistical Analyses

One-way analysis of variance was used to analyze the data for significant difference at $\alpha = 0.05$ using SPSS version 20 on IBM compatible computer. Mean differences were separated with Duncan Multiple Range Test.

Results

The results of the experiment were as presented in tables 1 - 4 below.

Water Quality Assessment

Table1. *Mean values of water quality parameters in the Rearing hap as*

Parameters	Mean ± SE
Temperature (°C)	27.92±1.37
pH	7. 64±0.07
Dissolved Oxygen ($mg1^{-1}$)	11.46±0.30

Effects of Size Heterogeneity and Food Availability

Table 2 highlights the effects of heterogeneous size of fingerlings and food availability on survival of *H.longifilis*. Size heterogeneity is here expressed in the total length ratio of the smaller fish (prey) to the larger fish (predator). The survival rate of the fingerlings after 90 days' culture period indicated significant interactions between size heterogeneity in the fingerlings and food availability. The general result of the interactions indicated that the more the frequencies of feeding and the higher the ratio of smaller to the larger fingerling, the better the survival rate and vice-versa.

Table2. *Effects of size heterogeneity and food availability on survival among the fingerlings of Heterobranchus Longifilis (interaction)*

Prey-predator ratio (Total length)	Reciprocal ratio	Feeding regimen	Mean survival rate (%)
1.0:1	1:1	1 in 4days	43.313
		1 in 2days	46.665
		1 in 1 day	63.364
		2 in 1 day	98.304
0.833:1	1.2:1	1 in 4days	43.317
		1 in 2days	43.317
		1 in 1 day	60.000
		2 in 1 day	93.333
0.667:1	1.5:1	1 in 4days	33.333
		1 in 2days	33.333
		1 in 1 day	50. 000
		2 in 1 day	66.666
0.5:1	2:1	1 in 4days	36.635
		1 in 2days	33. 333
		1 in 1 day	46.665
		2 in 1 day	60.093
0.4:1	2.5:1	1 in 4days	33.333
		1 in 2days	33.333
		1 in 1 day	36. 665
		2 in 1 day	56.682
0.33:1	3:1	1 in 4days	33.333
		1 in 2days	33.333
		1 in 1 day	50. 000
		2 in 1 day	53.333

Significant interaction (Fcal =8.064; Ftab =2.13; Alpha=0.05)

Effect of Prey-Predator Size on Survival

The effects of prey-predator size on survival are presented in Table 3. The survival rate of the homogeneous size fingerlings (ratio 1:1) was the highest (66.902%) followed by the heterogeneous set of prey-predator ratio 0.833:1with 62.149%. The two values however were not significantly different ($p>0.05$) but different from others. The least survival rate was recorded in prey-predator ratio 0.4:1, which did not differ significantly from the survival rates in prey-predator ratios 0.50:1 and 0.333:1. Prey-predator ratios 0.667:1 also did not exhibit significant difference from 0.50:1 and 0.333:1. ($p>0.05$).

Table3. *Effect of prey-predator size (total length) ratio on survival among the fingerlings of Heterobranclus longifilis reared for 90 days (main effect)*

Prey-predator ratio (Total length)	Reciprocal ratio	Mean survival rate (%)
1.0:1	1:1	66.902^{a}
0.833:1	1:2:1	62.149^{a}
0.667:1	1:5:1	45.757^{b}
0.5:1	2:1	44.090^{bc}
0.4:1	2.5:1	39.868^{c}
0.333:1	3:1	42.387^{bc}

Means in the same column having similar superscripts are not significantly different ($p>0.05$)

Effect of Food Availability on Survival

The effects of food availability on survival are presented in Table 4. Fish that were fed twice a day gave the highest survival rate (74.712%) which significantly differed from others ($p<0.05$). The survival rate of those fish fed once in a day also was significantly different ($p<0.05$), from all others while those on once every other day and in 4 days were not significant ($p<0.05$) but was significantly different from others.

Table4. *Effect of food availability on survival among the fingerlings of H.longifilis reared for 90 days*

Feeding regimen	Mean survival rate (%)
1 in 4 days	37.160^{c}
1 in 2 days	37.145^{c}
1 in 1 day	51.120^{b}
2 in 1 day	74.712^{a}

Means in the same column having similar superscripts are not significantly different ($p>0.005$)

Evidence of cannibalism was observed in the fish under this experiment. Occasional aggressive behavior occurred mostly at night even in those fingerlings that were about the same size (ratio 1:1). The aggression became more frequent and severe as food availability declined from twice daily to once in four days. In the fingerlings of total length ratios of 0.667:1-1:1, the attack on a particular fish continued for some time even after feed was supplied especially in the group fed once in four days. The affected fish swam more on the water surface and hung intermittently on the surface film. Dead fish discovered were variously mutilated. In the treatments containing fingerlings with length ratio between 0.33:1 and 0.50:1 each incidence of attack was not as prolonged as in the higher ratio groups. Also, very few carcasses were recovered but the number of fish remaining in each feeding regimen declined faster than in the higher ratio groups. The smaller fish were greatly depleted.

DISCUSSION

This experiment was conducted under safe conditions of handling and water quality, and suitable light condition which helped to reduce environmental stress and non-cannibalism related mortalities. The observed aggressive strikes, various degrees of mutilation of body parts and carcasses, fish engorged stomachs and communal devouring of invalid and dead members clearly indicated that cannibalism is a real issue in the culture of *Heterobranchus longifilis*. Similar observations had been recorded in other cases [19, 32-33].

The result of this research revealed significant interaction between size heterogeneity among the fingerlings and food availability. The set of homogeneous fingerlings (100% larger fingerlings or size ratio 1:1) fed once in four days and twice daily had survival rates of 43.31% and 98.30% respectively.

These however, declined to 33.33% and 53.33% respectively when the ratio of the small fish (prey) to the larger fish (predator or cannibal) was 0.33:1. The main effect of differential size marked 66.9% as the peak survival rate. The significance difference of the means revealed that the prey–predator ratios 0.833-1., 0.667-0.833, 0.5-0.667; 0.4-0.5; 0.333-0.4 could be successfully combined with their separate ranges as their respective effective prey-predator ratios become 0.833:1; 0.75:1; 0.80:1 and 0.825:1. Such combinations would narrow the size difference. This could be viewed from the reports of Baras and d'Almeida [34] on *Clarias* gariepinus and De-Angelis *et al.*[35] that initial size variation was more important than alternative feed in controlling cannibalism among large mouth base (*Micropterus salmoides*). Also Hseu [21] and Mouhamadou *et al.* [31] had observed that small in size and wide size difference are the triggers for cannibalistic behaviour in grouper and resulted in lower survival rate. Similarly, Qin and fast [19] had noted that the snake head, *Channa striatus* suffered cannibalism and other mortalities due to injuries when large size variation existed in the stock.

The result of the main effect of feeding frequencies viz-a-viz food availability in this experiment indicated that twice feeding produced a maximum of 74% survival while any lower frequency produced dismal result.This could be supported by Aluko *et al.* [36] report that food availability appeared to be a major factor affecting cannibalism in *Clarias gariepinus*. Twice daily feeding in the present work ensured more food availability than once daily feeding or once in four days. Davies *et al.* [37] Observed that fish fed once in alternate days had the highest mortality rate. While some authors [26, 29] believed that sufficient food could mitigate the incidence of cannibalism, Kasi *et al.*[38] reported that neither survival rate did improve nor cannibalism was minimized in response to increase provision of commercial feed to the African catfish (*Clarias gariepinus*).

The significant interaction between size heterogeneity and food availability obtained in the present experiment was indicative of the fact that cannibalism in *H. longifilis* cannot be sufficiently controlled by either stocking homogeneous size fingerling or providing adequate feed alone. Hecht and Appelaum [19] and Safina *et al.* [39] pointed out that cannibalism is caused mainly by size variation and lack of food. It is logical therefore that cannibalism mitigating strategies must be synergistic in addressing these two cardinal factors. This is evident from the results of interaction of these two factors in the current experiment that prey-predator ratios of 0.833:1-1:1 fed twice daily gave survival rates of 93-98%, whereas once daily feeding could give at least 60% survival. Similarly, ratios between 0.5:1 and 0.667:1 produced at least 60% survival rate when feed was applied twice daily.

In order to improve survival rate of cultured fish sorting has been applied [29, 40] which process might be cumbersome and expensive. This might only suspend cannibalism for a while as this phenomenon in the clariid catfishes seems to be continual. Baras and d' Almeida [34] noted that a once smaller individual could grow faster for a couple of days to become a cannibal and consumes a once larger individual when alternate food resources become scarce. Also as noted in the present work, the possibility of intra-cohort cannibalism can still be a challenge in later life if adequate feeding is not observed. Social dominance results from size variation whereas intra-cohort cannibalism could be a result of resource deprivation or invalid disposition of individual members of the population. Feeding fish twice daily as in this experiment would not only encourage good survival rate but also promote good growth performance [37, 41-42]. According to baras *et al.* [42] and Coulibaly *et al.* [13], cannibalism is

density dependent and could be influenced by certain environmental variables. The higher level of cannibalism activity observed at night during this experiment seems to support [42] that night time feeding or 24-hour feeding under permanent darkness could mitigate cannibalism in intensive fish culture. To reduce cannibalism in *H. longifilis* to the barest minimum therefore requires a holistic approach involving stocking homogeneous sizes or close sized combination, adequate feeding and night feeding (or feeding under darkness).

CONCLUSION

Heterobranchuslongifilis is a very popular species in the sub-Saharan African aquaculture industry due to its many favorable culture characteristics, nutritional value and high market demand. The phenomenon of cannibalism resulting from size heterogeneity with the attendant low recovery remains the greatest set back to the culturists. Size variation might not be completely avoided in the stock of this species, therefore careful combination of close size ratios or homogeneous sized stocks assured with adequate food and minimal environmental predisposing factors would enhance high survival rate. This work revealed significant interactions between heterogeneous sizes and food availability. Prey-predator ratio of 0.833:1 – 1:1 fed twice daily gave the highest survival rate. This is therefore recommended for excellent recovery of cultured *H. longifilis.*

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