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Full Length Research Paper

Effect of stocking size of the predatory African catfish (*Heterobranchus longifilis* V.) on the growth performance of Nile Tilapia (*Oreochromis niloticus* L.) in pond culture

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Overpopulation of tilapia in confined ponds is a major problem, which causes stunted growth due to shortage of space and natural food. African catfish *Heterobranchus longifilis,* one of the common piscivore to control tilapia reproduction, has been faulted as having a low predatory efficiency in certain stocks. A study was therefore conducted, in which nine ponds with large *H. longifilis* + tilapia, small *H. longifilis* + tilapia at ratio of 1: 4 (catfish: tilapia) and mixed sex tilapia (1: 3 male: female sex ratio) breeders were stocked in monoculture to investigate the influence of the different size groups of catfish within spawns, on tilapia reproduction. Three replicate rearing ponds (0.02 ha) were assigned to each treatment. Final mean weight (Wf), Specific Growth Rate (SGR), average net and gross yields of the Nile tilapia indicated higher values for tilapia in polyculture with large and small *H. longifilis* than those stocked in monoculture. Marketable size tilapia constituted highest percentage in ponds stocked with large *H. longifilis* while tilapia in monoculture had the highest percentage of sub-marketable fish. We therefore suggest that controlled use of large *H. longifilis* could be of immense advantage in terms of the percent of marketable size tilapia in polyculture.

Key words: Effect of growth variation, African catfish, Nile tilapia, growth performance, marketable tilapia.

INTRODUCTION

It has been established that high production cost is the limiting factor to the expansion of aquaculture industry in the world (Carlberg et al., 2000). Development of growth-enhancing strategies is one of the major priorities for aquaculture research, not only to increase fish yield but also to reduce the risk culture system failure. The aquaculture of species at lower trophic levels, such as tilapia, presents the greatest potential for production efficiency (Welcomme, 1996). However, the precocious breeding habit of tilapia causes overpopulation of this species in confined ponds and limits growth rate and size. This has brought about the serious problem of stunted growth and unmarketable fish sizes due to the shortage of natural food, particularly in semi-intensive culture. Various expensive methods of population control have been applied, such as culture in cages, intermittent harvesting, hybridization, hormone-induced sex reversal, induction of sterility and production of super male fish (Mair and Little, 1991).

The use of proper predatory fish is considered as a safe biological method for checking tilapia's overpopulation in ponds without affecting the big size prey (Tawwab, 2005). Tilapia culture with predators has been practiced worldwide and different predatory fish species have been used with varying degrees of success in combination with different tilapia species depending on their availability. Fortes (1980) used tarpon (*Megalops cyprinoides*) as a predator to control population of Java tilapia (*Tilapia mossambica*) fingerlings in brackish water ponds. Similarly, McGinty (1983) used peacock bass

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(*Cichla ocellaris*) as a predator for controlling *Tilapia nilotica* in fertilized ponds. Fischer and Grant (1994) used tucunare (*Cichla monoculus*) as a native predator for controlling overcrowdiness of *Oreochromis niloticus (*Linnaeus, 1958). El Gamel (1992) and El Gamel et al. (1998) used Nile perch (*Lates niloticus*) and African sharp tooth catfish (*Clarias gariepinus)* in controlling Nile tilapia recruitment. Yi et al. (2004) used snake head (*Channa striata*) as a predator in polyculture with Nile tilapia to control its recruitment. Wysujack and Mehner (2005) reported that European catfish (*Sirulus glanis*) was stocked in a lake to reduce unwanted roach and bream population.

Piscivores of optimum predatory potential can produce more marketable tilapia sizes when stocked in polyculture because tilapia population will be efficiently controlled to allow adequate food and space for higher growth rate (Fagbenro and Syndenham, 1990). However, the difficulty in obtaining predators of optimum predation efficiency often resulted in limited application of biological control methods (Balarin and Hatton, 1979; Penman and McAndrew, 2000). Swingle (1960) recommended the use of local predatory species for this purpose. Huet (1970) pointed out varying degrees of success when using predators for the control of tilapia overpopulation. African catfish, particularly, *Heterobranchus longifilis* and *C. gariepinus* are the most abundant predators and widely distributed catfish species in South-east Asia, South Africa and West Africa. They also possess very good aquaculture attributes, the most important being: high tolerance to changes in temperature, dissolved oxygen and pH; easy spawning under captivity, excellent quality flesh, good commercial value (Micha, 1973; Legendre, 1983; Nwadukwe, 1995; Ewa-Oboho and Enyenihi, 1998) further more it plays an important role in the trophic chain, where tilapia, especially the young ones are the preferred food item (Adebisi, 1981; Babiker, 1984; Khallaf and Gaber, 1991). The polyculture of *H. longifilis* and *O. niloticus* are well documented (Pastastico et al., 1982; Welcome, 1981; Balayat, 1983). In most of this culture, catfish is used as predators to control tilapia prolific breeding and improve fish yields. However, experiments revealed low predatory performance in certain stocks of catfish and the total yields from such polycultures have not proved significantly higher than those in monoculture (Nwadike, 1995).

Furthermore, it has been shown that catfish under captivity develops offsprings that show highly aggressive intra-specific cannibalism and growth superiority over individuals within spawns (Ewa-Oboho and Enyenihi, 1998). No research had been carried out to ascertain the influence of these fast-growing (large cat-fish) cohort members in polyculture with tilapia. This study will examine growth performance and percent of marketable tilapia, after 168 days of polyculture with the different size groups of *H. longifilis*, to evaluate their influence on tilapia reproduction.

MATERIALS AND METHODS

Facility and breeding

The study was carried out in the fish farm complex of the Institute of Oceanography, University of Calabar (IOC), Cross River State located at the South-Eastern part of Nigeria (Latitude 4°25´-7°00´N; Longitude 7°15´-9°30´). The water source was a perennial water reservoir recycled through a network of pipes, filter tanks, blowers at the rate of 2000 m^3/day into an indoor and outdoor hatchery system. Matured breeders of *H. longifilis* (35.4 ± 1.8 g) were collected from the brood stock earthen ponds and transferred into the indoor hatchery where they were sexed and tested for ripeness according to methods described by Daget and Iitis (1965) and Teugels (1982, 1990). Selection of sexually mature females for the experiment was based on the ability to release ovulated eggs or on a swelling of the abdomen indicating enlarged gonads. Males do not have enlarged abdomen but semen could be expressed when the abdomen was gently squeezed. Experiments were conducted twice in 2006 and twice in 2007.

Homoplastic pituitary gland suspension was used to induce spawning according to the method described by Britz (1991). 1-2 kg gravid females were stripped 12 h after receiving a single dose at a temperature of 28°C. Fertilisation was effected by mixing sperm and eggs in a physiological saline solution. Fertilized eggs were spread onto mosquito screens suspended in hatching troughs during incubation period. Larval rearing was restricted to a 12-18 day period during which the fish was kept indoors in rearing tanks fed *ad libitum* on sun-dried brewery waste or wheat bran supplemented with artemia nauplii every two hours from 8.00am.

Production of catfish with varying sizes

18- day- old catfish fingerlings were measured for length to the nearest mm and weight to the nearest mg and distributed into two 200-litre glass tank at density of 18 fish/ L (Ewa- Oboho and Enyenihi, 1998). They were fed at 5% body weight with dried food in the form of crumbled non-pelletised feeds formulated according to Balogun and Ologhobo (1989) with 38% protein. Faster growers of catfish of a cohort were identified and separated from slow growers every seven days. The darting event was registered when a fish grew abruptly over three times the mean total length of the rest of the spawn (Ewa-Oboho and Enyennihi, 1998).

The large and small *H. longifilis* were transferred separately into out-door tanks at 15 fingerlings l^{-1} and hand-fed three times daily to apparent satiation (that is, until feeding activity ceased in the tank to avoid feed restriction) with diet of 45% crude protein at 5% body weight supplemented with zooplankton diet (Wang et al., 1998). Fingerlings were harvested six weeks later at average weight; 60.3 ± 1.7 g and 35.4 ± 1.8 g for large and small catfish respectively. The difference in weight was significant ($p<0.05$).

Experiment on polyculture

A 168-d, follow-on study was conducted in out-door earthen ponds to determine the impact of size variation in the African catfish (predator) on tilapia reproduction (prey) in polyculture. Two weeks prior to stocking, nine 0.02-ha ponds were filled with water from the reservoir and fertilized with organic manure to stimulate algal growth. Ponds were managed without water exchange. Aeration was provided by a 2-hp paddle wheel mechanical aerator when necessary. Three replicates rearing ponds were assigned per treatment. Large (60.3 ± 1.7 g) and small catfish (35.4 ± 1.8 g) were separately stocked in polyculture with mixed-sex Nile tilapia (1:3 male: female sex ratio) breeders of stocking weights 50.4 ± 1.9 and 52.1 ± 2.1 g respectively at 5000 catfish ha^{-1} and 20,000 tilapia $ha.^{-1}$

Table 1. Means ± SD[3] of initial and final weights and growth rate (SGR) for *O. niloticus* in polyculture with large and small sizes *H. longifilis* and those in monoculture in which the three groups of tilapia were separately evaluated.

Ponds	Pond type	Species stocked	Initial weight Wi (g)	Final weight Wf (g)	SGR[l] (gd^{-1})
1	Polyculture	*O. niloticus*[L]	50.4 ± 1.9[a]	355.8 ± 12.7[a]	3.4 ± 0.8[a]
2	Polyculture	*H. longifilis*[L]	60.3 ± 1.7[a]	532.4 ± 6.8[a]	4.3 ± 0.2[a]
3	Monoculture	*O. niloticus*[S]	52.1 ± 2.1[a]	300.2 ± 4.1[b]	2.2 ± 0.7[b]
		H. longifilis[S]	35.4 ± 1.8[b]	410.8 ± 3.2[b]	3.0 ± 0.1[b]
		O. niloticus	50.3 ± 0.7[a]	246.9 ± 2.4[c]	1.2 ± 0.4[c]

Within columns, values with different superscript are significantly different (P < 0.05) within species. [1] Growth rates (GR) calculated from the formula (ln [BWf] – ln[Wi] / (T – t) × 100, BWi and BWf are initial and final weights (g), respectively, and T and t initial and final times (d), respectively. [L]tilapia stocked with large *H. longifilis*, [S]tilapia stocked with Small *H. longifilis*). [3] SD is the pooled standard deviation of the mean.

Three replicate ponds with mixed sex tilapia breeders of stocking weight 50.3 ± 0.7 g and 1:3 male: female sex ratio at 20,000 tilapia ha^{-1} was used as control. Fish were twice daily fed at 5% biomass with crumbled non- pelletized food (40% crude protein). Fish growing in each pond was measured biweekly (0900-1100 h) by weighing 100 randomly sampled fish. Fish were gravity harvested after 168 days by draining the ponds into collection bags attached at the pond outfall drain. Mean fish harvest weight was determined to the nearest 0.1 g by weighing 100 randomly selected fish from each pond.

At harvest fish were graded into marketable and sub-marketable fish. Production was given as total harvest weight of Tilapia/ha (yield). The net yield of tilapia was determined by subtracting the stocking weight of tilapia from the total harvest weight of tilapia. Specific Growth Rates (SGR) were calculated from the formula (ln [BWf] – ln[Wi] / (T – t) × 100), where BWi and BWf are initial and final weights (g), respectively, and T and t initial and final times (d), respectively. Marketable and sub-marketable yields were determined by the weight of all Nile tilapia = or > 300 g, < 300 g, respectively. Mean tilapia yield, survival and Specific Growth rate were calculated for each treatment for all the ponds.

Statistical analysis

Data collected were collated and analyzed using descriptive statistics (mean, standard deviation). Statistical comparison of data (Mean tilapia yield, Specific Growth Rate and survival between and within treatments) were carried out using analysis of variance (ANOVA) at 5% significant level. Bar graphs and line graphs were generated using excel statistical package (2007). Differences between initial and final weights of a species were tested for significance using t-test at 95% confidence level.

RESULTS

Growth performance

The final mean weight of the Nile tilapia showed a significant difference (F = 0.478, P < 0.05) occurring between tilapia stocked with large and small catfish and those in monoculture (Table 1). Among the final mean weights of tilapia from each treatment, the weights of tilapia stocked with large catfish were 54% higher than those in monoculture and 30% higher than those in culture with small catfish.

Growth trajectory (Figure 1) of the Nile tilapia stocked with the large catfish far exceeded those in monoculture, although the three groups of Nile tilapia (tilapia stocked with large and small catfish and those in monoculture) appeared to reach their final mean weight at 140 and 28 days before terminating the experiment.

Fish production

Yields and percent marketable size tilapia in polyculture with large catfish were significantly higher (F = 0.56, P < 0.05) than those in monoculture and the ones stocked with small catfish (Table 2). Yields of marketable tilapia (> 300g) differ significantly (P < 0.05) as a result of stocking combination and culture system (Figure 2). Highest percentage (71.4) of sub-marketable fish was recorded for Nile tilapia in monoculture followed by Nile tilapia (48.7) stocked with small catfish and large catfish (6.8).

Fish survival rates were high (88.3 ± 6.4 to 99.1± 0.2%) and were not significantly different (P > 0.05) between treatments.

DISCUSSION

The present 168-d study demonstrates that weight gained by Nile tilapia stocked with large catfish was 44.6% greater compared to tilapia in monoculture. Similarly, Nile tilapia in polyculture with small catfish" gained 21.9% more weight than those in monoculture and 30% less than tilapia in culture with large small catfish. Therefore, the interaction between catfish predators and their tilapia prey in this study was not actually related to morphological constraints (that is, size) during the feeding process. Predator size, which has been found (Hambright et al., 1991) to be directly related to gape size, may therefore not cause substantial differences in relative survival of different prey as shown in this study. Limited gape size of the predator has been given (Hambright et al., 1991; Rice et al., 1993; Nilsson and

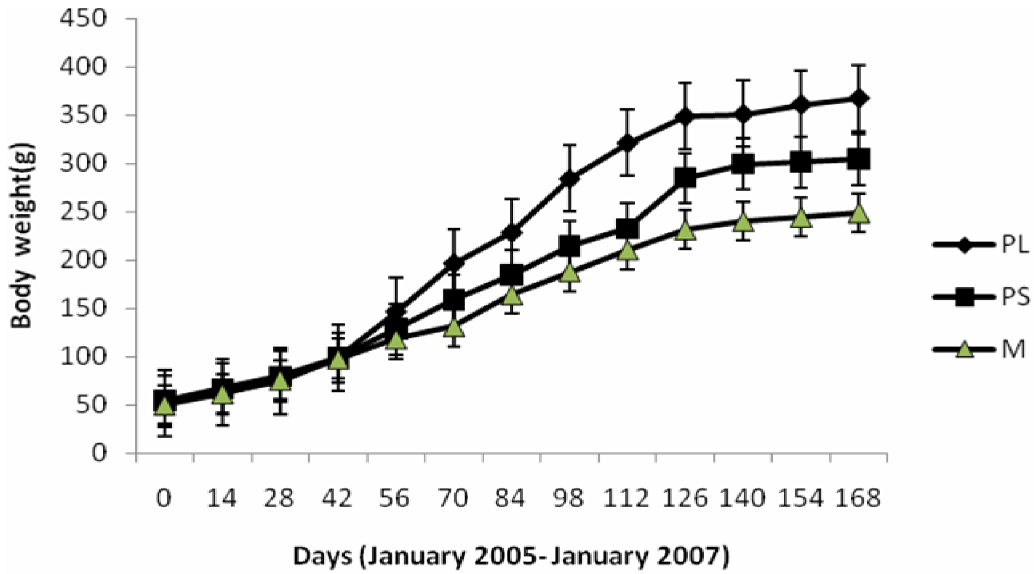

Figure 1. Mean body weight (g) of fish over time at stocking, harvest and 11 different sampling periods during the 168-d growing season of each year. PL = tilapia in polyculture with large *H. longifilis*, PS = tilapia in polyculture with small *H. longifilis*, M = tilapia in monoculture.

Table 2. Mean ± SD of Yield, survival of individually held *O. niloticus* in polyculture with large and small *H. longifilis* and in monoculture in which the three groups of tilapia were separately evaluated.

Pond	Pond type	Species	Survival	Yield (Kg/ha)	
			(%)	Net	Gross
1	Polyculture	*O. niloticus*[L]	88.3 ± 6.4^a	6110.0 ± 2110.4^a	7116.0 ± 3003.6^a
2	Polyculture	*H.* longifilis[L]	93.5 ± 2.4^a	2360.5 ± 477.2^a	2662.5 ± 477.6^a
3	Monoculture	*O. niloticus*[S]	98.2 ± 0.8^b	4996.0 ± 1772.0^b	6004.0 ± 2110.3^b
		H. longifilis[S]	93.5 ± 2.3^a	1877.6 ± 110.8^b	2054.0 ± 344.5^b
		O. niloticus	98.2 ± 0.8^a	3930.0 ± 1882.1^c	4936.0 ± 1554.5^c

Values of the same superscript in a column are not significantly different (P> 0.05) within the same species. [L]tilapia stocked with large catfish, [S]tilapia stocked with small catfish. Gross yield = Sum of marketable and sub-marketable fish, Net yield = Gross yield minus sub-marketable fish.

Bromark, 2000; Claessen et al., 2002; Wysujack and Mehner, 2005) as major factor affecting predation efficiency. Also predator length to prey length ratio has been established (Hambright, 1991; Lunvail et al., 1999) to be a good predictor of predation success and the lengths are said (Mittelbach and Person, 1998; Wysujack et al., 2002) to be positively correlated. However, results of this study did not support the findings above, as the predatory rate of African catfish, *H. longifilis* did not necessary increase when its size increased. The large catfish affected the size structure of the tilapia populations (prey) but had little influence on the growth capacity. We suspect that the higher tilapia growth in culture with large catfish than those in monoculture may not be due to the increase in the mouth gape of larger catfish but rather the increased aggressive behavior exhibited by these fast-growers (Ewa-Oboho and Enyenihi, 1998), or was probably due to complete absence of predator in monoculture to reduce tilapia reproduction and increase growth. Bio-manipulation (top-down control), by stocking small catfish (predator) with tilapia, was of limited success probably because of established co-existence of African catfish and tilapia above the critical size or because these small catfish was not aggressive enough to effectively prey upon tilapia reproduction and reduce densities. In a similar experiment, Hulata and Wohlfarth, (1982) using European and Chi-nese races of common carp established that highest densities gave least body weights as a result of competition for space and food. Production parameters were affected more by the stocking combinations of individual sizes of fish and the culture system. African catfish has been used in polyculture with other tilapine species, particularly with *Tilapia guineensis* (Salami et al., 1993), *Tilapia rendalli* and *Oreochromis karangae* (Brooks, 1994) and *O. niloticus* (Lazard, 1986; Copin and Oswald, 1993). In most of

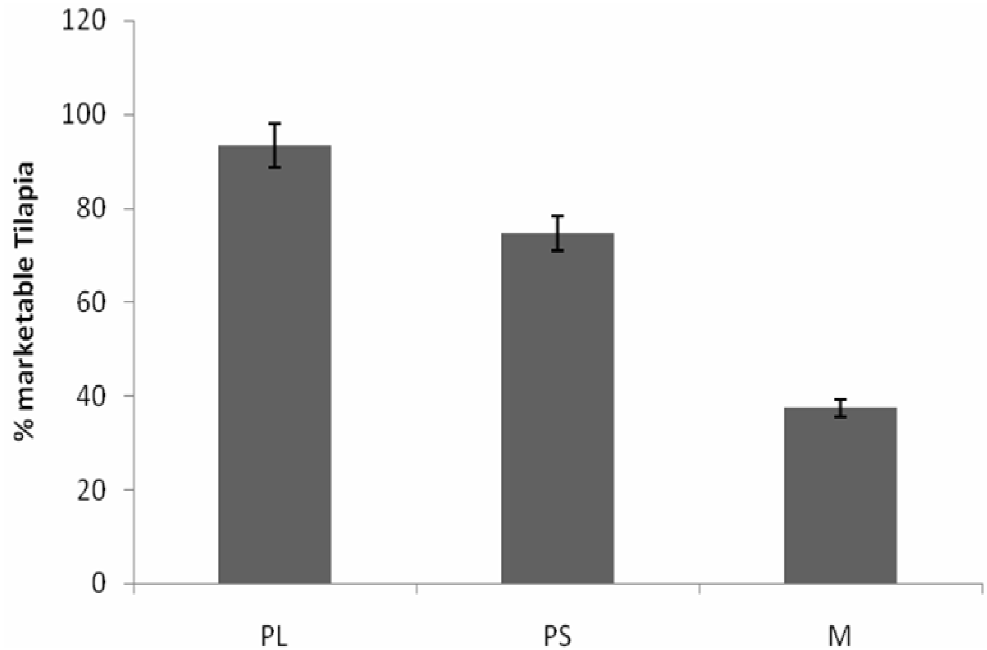

Figure 2. Percent Marketable yields of tilapia at different treatments. Different letters within the axis label describes the characteristics of the fish. PL = marketable yield of tilapia in polyculture with large catfish, PS = marketable yield of tilapia in polyculture with small catfish and M = marketable yield of tilapia in monoculture.

these studies, African catfish is used as a predator to control tilapia densities to prevent precociousness and stunting. However, in all these studies, growth performance of tilapia had been less than the obtained values in this study, likely due to the size effect in the later experiments.

The lowest percentage of marketable fish obtained in tilapia monoculture was probably due to overpopulation, and agrees with results of Penning et al. (1977). Hulata et al. (1982) using European and Chinese common carp and Primavera and Eldoni (1981) using milk fish *Chanos chanos*; both noticed significant decrease in the percentage of harvestable fish in increasing densities probably due to competition for food and available space.

The high survival of fish in all the treatments in this study indicates that the experimental conditions were conducive for fish health (Hulata and Wohlfarth, 1982; Nilsson and Bronmark, 2000). The more accentuated growth capacity of tilapia in polyculture with large catfish versus their monoculture individuals has not been known and holds important implications for selecting an appropriate catfish that will grow rapidly to required food-market size (>300 g) and at the same time provide conducive environment (optimal predation efficiency) for the rapid rearing of food-market-size Nile tilapia.

We suggest that more effective systems for producing large, food-market Nile tilapia will involve rearing with groups of predominantly large catfish (predators) to take advantage of tilapia prolific breeding (prey) and increase the marketable size.

Conclusions

The results of this study are useful to tilapia culturist in semi-intensive farms. There are obvious benefits of using local predatory species to control excess tilapia production. Two groups of catfish within spawns exhibited significantly different growth patterns. The different size groups when stocked in polyculture with tilapia succeeded in influencing tilapia reproduction and the larger catfish maintained their size advantage during the growth period. The final weight of each tilapia group was significantly affected by stocking combinations when compared with tilapia in monoculture. However, higher percent marketable tilapia yields were obtained from polyculture with large catfish than small catfish and both yields were higher than those in monoculture. Field experiments will further be done particularly on the prey-predator relationships in fish ponds particularly as are affected by factors such as fish stocking density, size, food and temperature in eutrophic fish ponds.

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