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Research Article

Growth Performance and Survivability of *Gymnarchus niloticus* (Cuvier, 1892) Juveniles Fed Both Live and Formulated Diets in Earthen Ponds

Adebayo IA*, Obe BW, Jegede T

Department of Fisheries and Aquaculture Management, Faculty of Agricultural Sciences, Ekiti State University, Nigeria

ABSTRACT

A seven month feeding trial was conducted to establish the growth performance and survivability of *Gymnarchus niloticus* juveniles fed with live and formulated diets in earthen ponds under semi –intensive culture system. Four earthen ponds (10 m × 10 m × 2 m /each) arranged in two treatments (T_1 and T_2) at two ponds/treatment were stocked with six hundred and thirty (630) *Gymnarchus niloticus* juveniles at an average of 150 fish/pond with initial mean weight of 10 g/fish. Fish in T_1 were fed with young tilapia fish *Oreochromis niloticus* and live maggots while fish in T_2 were fed with locally formulated diets. Using the same feeding strategy of monthly adjusted ration based on fish growth, survivability and stocking density, at the end of the feeding trial, results indicated that the total number of fish harvested in T_1 was higher (208 pieces) with higher final mean weight of 0.53 kg/fish compared to T_2 (158 pieces, 0.22 kg) respectively. The higher mortality and poor growth recorded in T_2 (157 pieces, 0.22 kg/fish) respectively indicated poor feed utilization as reflected on the total biomass of fish. The negative gross profit margin recorded in T_2 (₦ -68,840.00) suggested that it may not be profitable raising *Gymnarchus niloticus* to grow –out on formulated diets.

Keywords: *Gymnarchus niloticus*; Growth performance; Juveniles, Earthen pond; Live feed

INTRODUCTION

Gymnarchus niloticus is a highly valued food fish in Nigeria having numerous biological characteristics that make it an excellent candidate for commercial aquaculture [1]. The market demand for *Gymnarchus niloticus* has always been high, reflecting a strong consumer preference for its sweetness compared to other freshwater fishes. Wild caught had failed to keep pace with market demands due to uncertainties which has further reduce domestic supplies thus forcing the market not to be stable all year round [2]. An alternative to this is the farming of *Gymnarchus niloticus* under controlled water environment as a way out of uncertainties associated with wild caught.

A major factor that influences the intensive cultivation of a new species like *Gymnarchus niloticus* is the nutrient requirements, especially during the 'grow –out' phase of production [2]. Nutrient requirements of *Gymnarchus niloticus* must be determined at every developmental stage as done for a number of economically important species. In the wild, *Gymnarchus niloticus* feeds on crustaceans, insects and fish but no record of formulated diets been fed to this species [3]. Falaye et al. [4] emphasized the need to discover feed that is acceptable to *Gymnarchus niloticus* at lowest cost without compromising the nutritional requirement of the fish for sustainable culture.

Except for the commonly cultured fishes such as tilapia and catfishes namely *Clarias gariepinus*, *Heterobranchus bidorsalis* and their hybrid (*Heteroclarias*), aquaculture industry in Nigeria cannot boast of other freshwater species of economic importance that is stable in the market [2]. Hence the quest for new market preference of good freshwater fish in the Nigeria aquaculture industry is a welcome development. There is high demand and high price for the table size of *Gymnarchus niloticus* in Nigeria market and the only source is wild caught which necessitates the need to have a stable cultivation [5].

Over the past decade in the riverine Areas of Nigeria, there has been a tremendous growth of interest in the feasibility of *Gymnarchus niloticus* aquaculture [6]. In recent years through trial and error, pond production at the 'grow out' stage has been experimented for the species to check Tilapia population [1]. In addition to being

Correspondence to: Adebayo IA, Department of Fisheries and Aquaculture Management, Faculty of Agricultural Sciences, Ekiti State University, Nigeria, Tel: +2348037252776; E-mail: isreal.adebayo@eksu.edu.ng

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in short supply and having an already established niche in the marketplace, research to date has demonstrated that the fish has many biological characteristics that recommend it for commercial culture [7]. *Gymnarchus niloticus* is a fast growing fish which attains 2 kg weight in a year. It can attain 15 kg weight and a length of 2 m in few years if well fed [7]. It is pscivorous and can be used to check Tilapia over population. *Gymnarchus niloticus* is tasty and rich in oil, most active at night and caught in traps and long lines in the wild [8].

As reported earlier, the major problem associated with pond culture of this species is feeding because the nutritional requirements and acceptance of artificially formulated feed has not been fine –tuned. Some authors have reported that survival rate and growth under culture conditions are directly proportional to the availability of food in the right quality and quantity [1,3,6]. In other to improve the cultivation of *Gymnarchus niloticus,* it must be trained to accept conventional formulated feed and fed the diets exclusively under a conducive rearing facility with good water management. The main objective of the research work was to determine the growth response and survivability of *Gymnarchus niloticus* raised from juvenile to 'grow out' stage in earthen ponds under semi- intensive culture system when fed with live and formulated diets. The cost of rearing and profit margin were also determined.

MATERIALS AND METHODS

Experimental set up

The experiment was carried out at the experimental station of the Department of Fisheries and Aquaculture Management, Faculty of Agricultural Sciences, Ekiti State University, Ado –Ekiti, Ekiti State, Nigeria. Four earthen ponds were used for the experiment. The size of each pond was 10 m × 10 m × 2 m, arranged in two treatments (T_1 and T_2), with two ponds assigned to each treatment under semi-intensive culture system. Prior to the start of the experiment, the ponds were de-silted, limed with hydrated lime $Ca(OH_2)$ at the rate of 1200 kg/ha and impounded with 200,000 litres of underground water (by gravity)/pond at the rate of 1,000 litres/1 m^3. Also, all the sides of the ponds including the surface were netted to prevent predators and human interference. Ponds were fertilized with fresh poultry droppings in jute bags placed in strategic locations inside the ponds.

Fish procurement and stocking

Six hundred and thirty (630) pieces of *Gymnarchus niloticus* juveniles (Av. weight of 10 g/fish) were purchased from fishermen in the riverine area of Igbokoda, Ondo State, Nigeria at the peak of the breeding season of the parent fish in the wild. Before stocking, *Gymnarchus niloticus* juveniles were treated with (5 g/L) NaCl to make sure that they were free from ectoparasites and to prevent fungal infection. Fish were stocked into four (04) already prepared earthen ponds at an average of 157 fish/pond. The size of each pond was 10 m × 10 m × 2 m.

Experimental diets and feeding procedures

The two Ponds in T_1 were earlier stocked with two thousand (2,000) pieces of young Tilapia *Oreochromis niloticus* after preparation at the rate of 1,000 pieces/pond to address the first objective of the research work (i.e., feeding the fish with live food). This was occasionally supplemented with live maggots (D_1). To address the second objective, that is, feeding *Gymnarchus niloticus* juveniles exclusively with formulated diet (D_2) in T_2, ingredients such as fishmeal, yellow maize, soybean meal, used in feed formulation were purchased from Metrovet Feed Mill, Ado-Ekiti, Ekiti State. Ingredients were analyzed for proximate composition prior to feed formulation according to AOAC (1995). The gross composition of the experimental diet is shown in Table 1 below. The calculated crude protein and caloric values of the formulated diet were 50.52% CP and 12.12 kcal/kg respectively as recommended by Faturoti et al. [8] for piscivorous fishes with high protein requirement. In preparing the diet, dry ingredients were grind to a powdery form in an improvised Willey mill fabricated in Ado Ekiti. The diet was thoroughly mixed with cod liver oil and pelleted using Hobart A–200T pelleting and mixing machine with a 2.0 mm die. After pelleting, the diet was immediately sun dried and packed in a jute bag and kept in a well-ventilated room prior to use. Gross energy in kcal/kg of diet was determined using ballistic oxygen bomb calorimeter (Gallen Kamp) as described by AOAC in 2000 (Table 1).

Feeding procedure

Gymnarchus niloticus juveniles were allowed to acclimatize to experimental conditions in a separate but smaller earthen pond (5 m ×4 m × 1.5 m) for few days before the commencement of the feeding trial. The experimental diets, live tilapia and maggots (D_1) and the formulated diet (D_2) for T_1 and T_2 respectively were fed

Table 1: Gross composition of formulated diet (D_2) (g/kg^{-1} DM).

Ingredients	(%)	(g)
Danish fish meal (72% CP)	55.0	550
Soybean meal (44% CP)	13.4	134
Ground nut cake (48% CP)	10.4	104
Yellow maize	12.1	121
Cod liver Oil	5.0	50
Vitamin premix	3.0	30
Methionine	0.3	3
Starch	0.7	7
% Crude protein (cal.)	50.5% CP	1000g/ 1 kg

kg^{-1} diet: Vit. A 1,000,000 IU; Vit. D_3 600,000 IU; Vit. E 12,000 IU, Vit. K_3 15 mg; Vit. C 12,500 mg; Vit. B_1 250 mg; Vit. B_2 1,750 mg; Vit. B_6 875; Vit. B_{12} 2,500 mg; Ca-D-pantothenate 5000 mg, Nicotinic acid 3,750 mg; Folic acid 250 mg; Co. 24,999 mg; Cu 1,999 mg; Fe 11, 249 mg; Se ($Na_2SeO_3.5H_2O$) 75 mg; I (KI) 106 mg; antioxidant 250 mg

to the fish for seven (07) months under controlled environment. Fish in T_1 were fed ad-libitum since the ponds were already stocked with young tilapia, with occasional introduction of live maggots while fish in T_2 were fed to satiation twice daily at 09:00 and 16:00 hours with locally formulated diet. The weights of fish in both treatments (T_1 and T_2) were measured monthly by randomly taken some samples with scoop net at the spot of feeding and weighed using Top Loading weighing machine (Metler PM 480, Delta range). There was a monthly adjusted ration based on fish growth and survivability.

Monitoring of water quality parameters

The adaptability of *Gymnarchus niloticus* to confinement conditions in grow–out earthen ponds was closely monitored by measuring water quality parameters for the period of the experiment. The pH values of the water during the feeding were measured directly using electronic pH meter (Jenway, 3510) by dipping the electrode into each pond. Dissolved oxygen was measured using Standardized YSI Do meter (YSI Model). Temperature was measured using thermometer.

Fish growth and survivability

The fish were reared for seven months before harvested. Average weight (g), survival (%), biomass (kg/100 m^2)· feeding ration (g/100 m^2/day), Feed ration (kg/100 m^2/30 days) and feeding rate (% body wt. /day) were calculated for the period that the experiment lasted.

Laboratory analysis of experimental diets

Samples of the formulated diet and live Tilapia (*Oreochromis niloticus*) and maggots were subjected to proximate analysis as described by the Association of Official Analytical Chemist (AOAC, 1995) to ascertain the crude protein, fat, ash, carbohydrate levels of the feeds.

Cost implication of rearing *Gymnarchus niloticus* in earthen ponds using live and formulated diets

The estimated cost and gross profit margin were calculated using appropriate indices to determine the profitability of culturing *Gymnarchus niloticus* in earthen ponds using live and formulated diets.

RESULTS

The results of the proximate analysis of experimental diets is shown in Table 2. The crude protein levels of the two diets (D_1 and D_2) ranged between 50.3% to 50.1%. The fat and ash contents were higher in D_1 (7.63% and 15.8%) respectively when compared with D_2 (6.55% and 14.1%) respectively. Fibre and Nitrogen Free Extract (N.F.E) assumed an inverse relationship with fat and ash contents in the two diets. Formulated diet had the higher fibre (2.05%) and N.F.E (16.5%) contents respectively compared to D_1 (1.27% and 15.2%) respectively. Though, there were no significant differences ($P>0.05$) among the parameters examined.

The mean values of the physico-chemical parameters of water in the two treatments (T_1 and T_2) are presented in Table 3. Mean values for dissolve oxygen (DO) were in the range of 6.76 - 6.82 mg/l in T_1 and 6.77 - 6.78 mg/l in T_2 from the onset to the end of the experiment. Similar trend was recorded for acidity (pH), Temperature (°C) and nitrate levels in the two treatments with values for pH ranging from 6.90 - 7.12 and 6.94 - 6.95 in T_1 andT_2 respectively. Temperature ranged between 25.0 - 25. 2°C in T_1 and 25.2 - 25.4°C in T_2. It was observed that the values of water parameters measured were not significantly different ($p>0.05$) in the two treatments. The earthen ponds were in the same environment with the same source of water.

This implies that changes in the final yield of fish could not be traced to the minor fluctuations in water parameters for the period the experiment lasted. Table 4 show the results of weight gain, survival rate, biomass and feed weights in the two treatments. The fish weight gain increased noticeably and higher in T_1 (fed live feeds) compared to T_2 (fed formulated feed) throughout the feeding period, leading to final mean weight gain of 530 g/fish and 220 g/fish in T_1 and T_2 respectively. Fish survival rate followed the same trend, that is, T_1 (65%) and T_2 (50%) at the end of the feeding trial. The lower weight gain and percentage survivability recorded in T_2 might be due to poor utilization of feed. The biomass weight difference was noticeably pronounced between the two treatments.

Table 5 shows that more fish were cropped in T_1 (205 pieces)

Table 2: Proximate composition of live tilapia and formulated diet as feeds for G. *niloticus*.

Variables	Proximate composition (%)					
Feeds	Protein	Fat	Ash	Moisture	Fibre	N.F.E
Tilapia (*Oreochromis niloticus*) (D_1)	50.3 ± 0.05	7.6 ± 0.62	15.8 ± 0.01	9.8 ± 0.01	1.5 ± 0.01	15.2 ± 0.50
Live maggots	60.3 ± 0.02	8.5 ± 0.45	10.6 ± 0.03	6.3 ± 0.04	3.2 ± 0.02	11.1 ± 0.32
Formulated diet (D_2)	50.1 ± 0.06	6.55 ± 0.31	14.1 ± 0.02	10.7 ± 0.05	2.05 ± 0.01	16.5 ± 0.10

Table 3: Mean values of the water quality in the earthen ponds during the culture period.

	Treatment 1 (T_1) Pond size (10 m × 10 m × 2 m/each)				Treatment (T_2) Pond size (10 m × 10 m × 2 m/each)			
Day	DO (mg/l)	pH	Temp (°C)	NO_3 (mg/l)	DO (mg/l)	pH	Temp (°C)	NO_3 (mg/l)
0	6.76	6.90	25.0	0.20	6.77	6.94	25.2	0.21
30	6.75 ± 0.01	6.98 ± 0.01	25.1 ± 0.01	0.20 ± 0.001	6.75 ± 0.01	6.93 ± 0.01	25.2 ± 0.01	0.20 ± 0.001
60	6.67 ± 0.02	7.10 ± 0.01	25.3 ± 0.00	0.21 ± 0.001	6.76 ± 0.01	6.95 ± 0.01	25.0 ± 0.01	0.21 ± 0.001
90	6.82 ± 0.02	7.12 ± 0.01	25.2 ± 0.01	0.21 ± 0.001	6.77 ± 0.01	6.94 ± 0.01	25.1 ± 0.02	0.22 ± 0.001
120	6.80 ± 0.01	7.12 ± 0.00	25.1 ± 0.01	0.20 ± 0.001	6.75 ± 0.01	6.92 ± 0.01	25.0 ± 0.01	0.22 ± 0.001
150	6.75 ± 0.02	7.10 ± 0.01	25.2 ± 0.00	0.20 ± 0.001	6.77 ± 0.01	6.92 ± 0.01	25.2 ± 0.01	0.22 ± 0.001
180	6.78 ± 0.02	7.12 ± 0.01	25.0 ± 0.01	0.22 ± 0.001	6.78 ± 0.01	6.94 ± 0.01	25.4 ± 0.02	0.21 ± 0.001
210	6.76 ± 0.01	7.12 ± 0.00	25.2 ± 0.01	0.20 ± 0.001	6.78 ± 0.01	6.95 ± 0.01	25.3 ± 0.01	0.22 ± 0.001

Table 4: Average weight, survival rate and biomass of *Gymnarchus niloticus* reared in earthen ponds for a period of seven months. Density: 630 pcs.

Treatment 1 (T_1) Pond size (10 m × 10 m × 2 m/each) Fish fed live diet (315 pieces)							Treatment 2 (T_2) Pond size (10 m × 10 m × 2 m) Fish fed formulated diet (315 pieces)						
Day	Average Weight (g)	Survival %	Biomass kg/100 m^2	Feeding ration g/100 m^2/day	Feeding ration kg/100 m^2/30 days	Feeding rate (% body wt/ day	Day	Average Weight (g)	Survival %	Biomass kg/100 m^2	Feeding ration g/100 m^2/day	Feeding ration kg/100 m^2/30 days	Feeding rate (% body wt/ day
0	10	100	10.0	157.5	4.73	5	0	10	100	10.0	157.5	4.7	5
30	45	92	41.4	445.1	13.35	5	30	30	80	24.0	378.0	11.3	5
60	120	85	102.0	1606.8	48.20	5	60	55	75	41.3	649.8	19.5	5
90	235	80	188.0	2961.0	88.83	5	90	76	68	51.7	814.0	24.4	5
120	300	77	231.0	3639.0	109.17	5	120	110	65	71.5	1126.4	33.8	5
150	380	75	285.0	4489.7	134.69	5	150	145	60	87.0	1370.3	41.1	5
180	450	68	306.0	4819.5	144.59	5	180	180	57	102.6	1616.4	48.5	5
210	530	65	344.5	Harvest	Total = 543.56 kg	Harvest	210	220	50	110.0	Harvest	Total = 183.3 kg	Harvest

Table 5: Expenditure, income and profit margin in the two treatments.

	Treatment 1 (T_1) Pond size (10 m × 10 m × 2 m/each) Fish fed live feeds	Treatment 2 (T_2) Pond size (10 m × 10 m × 2 m) Fish fed formulated diet
Cost of *G. niloticus* juveniles @ ₦ 150/one x 315 pieces	₦ 47,250.00	₦ 47,250.00
Cost of tilapia @ ₦ 10/one × 2,000 pieces (150 kg)	₦ 20,000.00	-
Cost of live maggots @ ₦50/ kg for 393.6 kg	₦ 19,680.00	-
Total cost of live feeds	₦ 39,680.00	-
Cost of locally formulated feed @ ₦ 4,250/ bag (15 kg/bag	-	₦ 51,850.00
No of bags of formulated feed consumed	-	12.2 bags @ 6.1 bags/pond
Fertilizer/liming/pond preparation/maintenance	₦ 5,000.00	₦ 5,000.00
Cost of harvesting	₦ 3,000.00	₦ 3,000.00
Number of fish harvested (cropped)	205 pieces	158 pieces
Average weight of fish at harvest (kg)	0.53 kg	0.22 kg
Total weight of fish @ harvest (kg)	108.7 kg	34.8 kg
Mortality recorded	110 pieces	157 pieces
Cost of occasional sampling and counting	₦ 3,500.00	₦ 3,500
Kilo of feed fed throughout the experiment	543.6 kg (wet)	183.3 kg (dry)
Total expenditure	₦ 98,430.00	₦ 110,600.00
Gross income (108.7 kg @1,200/kg) and 34.8 kg @ 1,200/kg)	₦ 130,440.00	₦ 41,760.00
Profit (Gross margin)	₦ +32,010.00	₦ -68,840.00

compared to T_2 (158 pieces). The higher fish mortality recorded in T_2 (157 pieces) indicated poor utilization of feed since other factors that could lead to fish mortality such as poor water quality, diseases outbreak and predators were closely monitored. Despite the higher amount (₦ 110,600.00) spent to raise the fish in T_2, the gross profit margin (₦ -68,840.00) was negative as a result of poor growth and higher mortality rate. Lesser amount was spent to raise the fish in T_1 (₦ 98,430.00) with positive gross profit margin of ₦ 32,010.00 recorded.

DISCUSSION

Sequel to the quest for domestication of more fresh water fish of economic importance in Aquaculture industry in Nigeria, this study was conducted to establish the response of *Gymnarchus niloticus* from juvenile stage to grow -out to both live and formulated diets in earthen ponds in an open culture practice. Evaluating the economic viability at the end of the feeding trial was done to know if the approach is profitable or not [9]. This study, among other things addressed the suggestion of Falaye et al. [4] that further research should be carried out to determine growth performance of *Gymnarchus niloticus* on live and formulated feeds beyond four weeks. From the growth indices such as weight gain and survivability, this study established that formulated diet was poorly utilized by *Gymnarchus niloticus*. The larvae stage of *Gymnarchus niloticus* fed live feed had the highest growth rate and survival [4]. Most cultured freshwater fish in Nigeria that share the same biological characteristics with *Gymnarchus niloticus* such as *Clarias gariepinus*, *Heterobranchus bidorsalis*, *Heterobrachus longifilis* and their hybrid, *Heteroclarias* were reported [10-12] respectively to have grown and survived better at fry and juvenile stages when fed with live feeds and thereafter recorded excellent growth performance when raised with formulated diets at grow out stage. But the results on *Gymnarchus niloticus* in this study proved otherwise. This was in agreement with the assertion of Adeyemo et al. [11] that nutrition of carnivorous fish differs in pattern common to omnivorous fish.

A major problem in intensive cultivation of carnivorous fish such as *Gymnarchus niloticus* is their poor digestibility of formulated diets leading to poor growth and mortality [4]. In this study, it was like feeding the water instead of fish in T_2 where fish were fed

with formulated diet. Abubakar et al. [13] reported that live feeds are better digested and utilized by carnivorous fish by releasing nutrients to the fish. In this study, the quantity and size of fish harvested when fish were fed with live feeds were higher, signifying better feed utilization. Knowing the feeding habit and nutritional requirement of fish in a given water body will facilitate the best culture practice to be adopted without compromising the safety of other organisms in the same ecosystem [14]. As reported in this study that *Gymnarchus niloticus* prefers live feeds to formulated diets, provision of live feeds should be factor in to achieve a successful and sustainable cultivation of this species.

The cost implications of raising *Gymnarchus niloticus* in earthen ponds with live and formulated feeds as reported in this study suggested that it is more profitable to culture the fish on live feeds, especially at commercial scale. Ayoade et al. [14] suggested culturing the fish with cichlids to prevent stunting. Profitability in grow -out fish production is dependent on final weight gain and survivability based on the knowledge and application of the technical management practices [15]. The higher weight gain and survivability recorded in this study when fish were fed with live feeds resulted in positive gross profit margin.

CONCLUSION AND RECOMMENDATIONS

In the wild *Gymnarchus niloticus* feeds on animal related materials but there is dearth of information on the nutritional preference when raised under controlled environment. This study has shown that *Gymnarchus niloticus* can only be successfully cultured when fed with live feeds, preferably of animal origin. Animal protein source as food to raise fish is expensive; it is therefore recommended that production of *Gymnarchus niloticus* to grow - out stage in ponds should be practiced under polyculture system to check the proliferation of some undesirable aquatic fauna. The use of unconventional live feeds such as maggots, tadpoles, frogs and toads would reduce the cost of production. Cultivation of this species in a controlled environment is achievable and profitable if given the right approach, to meet the yearning for its ever growing preference in the aquaculture industry.

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