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Effect of three Feeding Regimes on Growth, Condition Factor and Food Conversion rate of Pond Cultured *Parachanna obscura* (Gunther, 1861) (Channidae) in Calabar, Nigeria

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Abstract

This study was aimed at investigating the possibility of culturing *Parachanna obscura* in an artificial lentic system. The effects of three different feeding regimes on growth and survival of *P. obscura* were tested. Likewise, the species ability to act as a controlling agent to the over-population of the Nile Tilapia, *Oreochromis niloticus* was also investigated. Results indicated that the culture of *P. obscura* with *O. niloticus* was quite effective in the recruitment control of tilapia and thus, enhanced individual growth rate of both *P. obscura* and *O. niloticus* with average marketable sizes of 109.9 g and 420 g, respectively. Moreover, the growth in weight of the live tilapia experiment wherein the fry of *O. niloticus* served as food for *P. obscura* was significantly greater than that where *P. obscura* fed on both trash fish and artificially compounded feed, producing weight gains of 64.52%, 57.75% and 43.38%, respectively. The feed conversion rates for live tilapia food, trash fish food and compounded feed have been found as 1.3, 2.3 and 3.1 respectively. But, this value for compounded feed is very low according to other moisture foods (live tilapia food and fish food). Therefore, this value for compounded feed does not seem to be reliable. The live tilapia feeding treatment gave the greatest improvement in condition of this species, suggesting this as highly essential feed component for *P. obscura.*

Keywords: *Parachanna obscura,* lentic system, feeding regimes, growth, survival.

Havuzda Yetiştirilen *Parachanna obscura* (Gunther, 1861) (Channidae)'ya Uygulanan Üç Beslenme Rejiminin; Büyüme, Kondisyon Faktörü ve Yem Dönüşüm Oranına Etkisi

Özet

Bu çalışmada, *Parachanna obscura*'nın yapay lentik sistemde yetiştirme olasılığı araştırılması amaçlanmıştır. *P. obscura*'ya uygulanan üç farklı beslenme rejiminin büyüme ve yaşama oranına etkileri incelenmiştir. Aynı şekilde türün; Nil tilapyasının *Oreochromis niloticus* aşırı popülasyon artışını kontrol altına alma özelliği de incelenmiştir. Sonuç olarak; *P. obscura*'nın *O. niloticus*'ın stoka katılımının kontrolünde oldukça etkili olduğu ve böylece 109,9 g ve 420,0 g'lık ortalama pazarlanabilir boylarla sırasıyla hem *P. obscura* hem de *O. niloticus* için bireysel büyüme oranlarını arttırdığı bulunmuştur. Ayrıca *O. niloticus* yavrularının *P. obscura* türüne canlı yem olarak verilmesi sonucu ağırlık olarak büyüme, *P. obscura*'nın hem ıskartayla hem de suni karma yem ile beslendiği deneyden sırasıyla %64,52, %57,75 ve %43,38 oranlarında fazla bulunmuştur. Canlı Tilapia, ıskarta balık ve karma yem için yem dönüşüm oranları sırasıyla 1,3, 2,3 ve 3,1 olarak bulunmuştur. Fakat diğer nemli yemlere göre (canlı Tilapia yem ve balık yemi) karma yem için bu değer çok düşüktür. Böylelikle karma yem için bu değer güvenilir görünmemektedir. Canlı Tilapia ile beslemede, türün kondisyonu en yüksek değerde olmuş ve *P. obscura* için bunun son derece önemli yem bileşeni olduğu bildirilmiştir.

Anahtar Kelimeler: *Parachanna obscura,* yapay lentik sistem, beslenme rejimi, büyüme, yaşama oranı.

Introduction

The snakehead, *Parachanna obscura* that inhabits freshwaters of tropical Africa is widely distributed ranging from the Nile, Senegal to the Chad basin and extends to the Congo system. It is found in all the freshwater bodies of Nigeria and nineteen other African countries (Teugels and van der Audernaede, 1984). Teugels *et al.* (1992) listed *P. obscura* and *P. africana* as common in stagnant side channels of Cross River, Nigeria.

A total of eight species of Channa are known to be cultured worldwide and *P. obscura* is the least cultured species. However, very few attempts have been made to culture *P. obscura* one of the species that has potentials for aquaculture in Nigeria.

Gonella (2003) reported that snakeheads being the topmost predators in their habitats cannot be fed primarily on industrially manufactured fish foods but on fresh animal food especially diet of fish while Mohanty and Samantaray (1996) successfully fed *Channa striata* fry on nine isocaloric diets based on fish meal-ground nut oil cake. Jackson (1988) used *P. obscura* to effectively control the recruitment of *Tilapia* in Benin Republic; Fagbenro (1989) did same on *Tilapia guinensis* in earthen pond in Ondo State, Nigeria, Morrice (1991) in Ghana and de Graaf (2004) on *O. niloticus* in the Netherlands.

In view of the paucity of information on *Parachanna obscura*, this research is undertaken to investigate some of the culture potentials of this species, develop simple culture system for the production of table sized *P. obscura* from the fingerling stage and determine the maturation rate of the species in both polyculture and monoculture systems.

Material and Methods

Experiments on the feeding and growth of *Parachanna obscura* were conducted in the Institute of Oceanography, University of Calabar experimental ponds. The ponds are located at latitude 04°55.9' N and longitude 08°20' E along the coastal plains of Nigeria bordering the Gulf of Guinea.

A total of nine ponds, each with the dimensions of 9 m x 4 m, were used in this study. The ponds used for these experiments were drained and the pond bottoms were completely dried until the overlying mud caked and cracked. The bottom of each pond was limed by spreading evenly powdered calcium carbonate on it a week before flooding. The quantity of lime applied was dependent upon the value of the soil pH tested before liming. The lime was applied at the rate of 1000 kg/ha for the unused ponds and 278 kg/ha for the previously limed ponds. The quantity of lime applied was based on standardized methods given by Swift (1988) who indicated that lime should be applied at the rate of 200–400 kg/ha for previously limed ponds while the application should be increased to 1000 kg/ha when treating pond bottom for eradication of fish parasites or when combating conditions of low pH in the pond.

Fertilization of the ponds was carried out a week after flooding with freshwater from the reservoir. Each pond was fertilized with chicken manure at the rate of 278 kg/ha (Ajah, 1995). The weighed fertilizer was placed in a sack bag to soak in the pond water, thus filtering the manure. Each pond was flooded to a depth of 1.2 m and was maintained at that depth throughout the experimental periods.

Analysis of the physicochemical parameters was carried out after two weeks of flooding in all ponds before stocking. The water quality parameters considered were total alkalinity, temperature, dissolved oxygen, hydrogen ion concentration (pH), ammonium and nutrients like NO_3^--N, and PO_4^{3-}-P. Total alkalinity in each pond was determined by titration. The pond water sample was titrated against 0.02 N sulphuric acid using phenolphthalein and methyl orange indicators (Lagler, 1956). This parameter was monitored and corrected (by liming when it got low) to maintain the level at approximately 25-30 ppm. Concentration of hydrogen ions (pH) was measured with the help of Lectron pH 201 meter. Dissolved oxygen in the ponds was determined using Lectron 5509 DO meter. Nitrate was determined by the cadmium reduction method (Parsons *et al.*, 1984). Ammonium (NH_4^+-N) content of the water was determined by Neslerization method (Parsons *et al.*, 1984). Phosphate (PO_4^{3-}-P) was determined by molybdenum blue method (Parsons *et al.*, 1984). Chlorophyll a content was extracted by the spectrophotometer (HACH). Water temperature was measured using HACH conductivity meter and recorded once a week from the start of the experiment, June 2004 to the end, December 2004. The temperature reading was taken twice a day. Minimum temperature of the pond was taken at dawn between $07.^{00}$ a.m. and $08.^{00}$ a.m. while maximum temperature was taken between $01.^{00}$ pm and $03.^{00}$ pm. The water parameters were monitored weekly in all the ponds and appropriate action of liming was taken if pH fell below optimum level of 6.5-6.9 (Boyd, 1992).

The experiment had three feeding treatments, each in three replicates. Ponds 1 to 3 were fed with tilapia fry, ponds 4, 5 and 6 with trash fish, while ponds 7, 8 and 9 were fed with compounded feed.

Feed Preparation and Formulation

Fresh cattle blood was brought from the abattoir. The blood meal was prepared by boiling the fresh cattle blood until cooked for about one hour. The cooked blood was dried in the oven at 90°C, after which it was crushed to powder form with the Hammer mill and stored for feed formulation. The blood meal feed was composed for 40% protein content following percentage composition method (New, 1987).

The soybean flour was prepared by toasting the raw soybean for 30 minutes in the oven at 100°C to destroy the trypsin inhibitors and improve the nutritive value. The toasted soybeans were broken down into smaller particles mechanically to remove the hull and later ground into powder using the Hammer mill.

The compounded blood meal feed was produced from each of the components being mixed together. Sufficient hot water was added to each feed mixture till a paste of workable consistency was obtained. After thorough mixing of the dough, a compact shape was formed by squeezing with the hand (New, 1987).

Flat cakes of the feed were made and blanched at 100°C for two hours. To facilitate easy preservation, the feed was dried in the oven at 75°C for 15 hours and stored for later usage in feeding the fish.

Dried fish were bought from the local market and dried in the oven at 80°C for 6 hours before grinding to powder in a Hammer mill. The fish meal feed was composed from 40% protein sources made up of 20% each of soybean flour and fish meal powder, 15% each of wheat offal and palm kernel cake (PKC), 15% of cassava flour, 7% of bone meal, 4% of red palm oil, 3% of vitamin/mineral premix and 1% of salt (New, 1987). The formulated fishmeal feed was prepared and preserved in the same way like the blood meal feed.

Proximate Analysis of the Formulated Feeds

The formulated feeds were subjected to proximate analysis for the basic food ingredients. Protein content was determined by Kjeldahl method. Ether extraction (soxhlet) was used to determine the fat content. Carbohydrate content was determined by difference (AOAC, 1984).

Stocking of Ponds with *Oreochromis niloticus*

The sub adults of *O. niloticus* used in this experiment were obtained from the University of Calabar fish farm. They were sexed by differences for secondary sexual characters as stipulated by Chervinski and Rothbard (1981). Ponds 1 to 3 were stocked with *O. niloticus* two weeks after they had been fertilized. Each pond was stocked with nine females and two males after taking measurements of the total length and weight of individual fish. This gave a stocking density of 2222 sub-adults per hectare. The fish stocked were of average total length of 14.5 cm and average weight of 56.5g. Lengths were taken on a measuring board to the nearest 0.1 cm. The weighing was done with electronic weighing balance to the nearest 0.05 g. Stocking of the Nile Tilapia was done on May 4, 2004 after necessary water parameters had been checked and corrected. The fish was fed a day after stocking with the formulated blood meal feed at 3% body weight of fish biomass as stipulated by New (1987) for nine days a weekly. The Nile Tilapia was monitored on weekly basis to observe its breeding period and onset of fry production. Spawning occurred in three ponds and was first observed 30 days after stocking. Following the production of fry, all the nine-ponds were stocked with fingerlings of *P. obscura.*

Stocking with *Parachanna obscura*

The fingerlings of *Parachanna obscura* were obtained from Usung Esuk creek, Uyanga fishpond, Great Kwa River, and Idundu all in Cross River State and Ayadehe Creek, Oku Iboku and Etinan Flood-Plain in Akwa Ibom State, Nigeria through local fishers. The initial weight and total length of the fish were measured after being held in quarantine for one month before stocking. Weight measurement was taken to the nearest mm with a top loading electronic balance. Each of the nine ponds was stocked with 25 fingerlings. This gave a stocking density of 6944 fingerlings per hectare.

Feeding of the Fish

The fish were fed at 3% body weight of fish biomass per pond for six days weekly. Feeding of the fish started a day after stocking. The feed was administered at two rations, one half in the morning and the other half in the evening. The feeding was continuous for 180 days, which the experiment lasted. The experiment had three feeding treatments and each with three replicates. Ponds 1, 2 and 3 were culture of *O. niloticus* with *P. obscura* wherein the fry of *O. niloticus* served as food for *P. obscura*. Ponds 4, 5 and 6 were monoculture of *P. obscura* fed with trash fish by boiling the fresh fish, chopping them to appropriate particle size. Ponds 7, 8 and 9 were also monoculture of *P. obscura* fed with compounded fishmeal feed.

Gut Analysis of the Pond Cultured *Parachanna obscura* from Live Tilapia Feeding Treatment

Ten specimen of *P. obscura* harvested from the live Tilapia treatment were randomly selected at the end of the experiment, brought to the laboratory, dissected and their gut contents stored in 5 % formalin for analysis. The gut contents were identified using stereomicroscope for the macro food items and light microscope for the micro food components. Food items of each specimen were determined by analysis of its gut contents using the frequency of occurrence method as reviewed by Hysiop (1980).

Condition Factor

Initial condition factor was that obtained at stocking while final condition factor was that obtained at harvest. The formula used for calculating Fulton's condition factor (K) was

$$K = \frac{100\,W}{L^3} \quad \text{(Ricker, 1975)}$$

where; W and L were weight and total length of the fish, respectively.

Growth Parameters

Growth parameters analyzed were percentage weight gain, average daily weight gain and specific growth rate.

$$\text{Percentage weight gain} = \frac{\text{Weight gained}}{\text{Initial weight}} \times 100$$

Daily weight gain (DW) per gram weight of fish

$$DW = \frac{W_t - W_o}{t} \quad \text{(Hepher, 1990)}$$

where, DW was the average daily weight gain in wet weight expressed as g g^{-1}; W_t and W_o were final and initial weights after 180 days of growth (t). Specific growth rate (SGR) was calculated using the formula

$$SGR (\%) = \frac{\ell n\, W_t - \ell n\, W_o}{t} \times 100 \quad \text{(Viola et al., 1988)}$$

where, ℓn is the natural logarithm, W_t and W_o the final and initial weights, respectively, and t the 180 days interval the experiment lasted.

Feed Conversion Ratio

The feed conversion ratio (FCR) was calculated using the following formula

$$FCR = \frac{\text{Total weight of food presented (g)}}{\text{Total weight of fish produced (g)}} \quad \text{(New, 1987)}$$

Statistical Analysis

Single classification ANOVA was used for comparison of the significant difference between the means of the treatments. The least significant difference tests (LSD) was used to find where the significance lied (Sokal and Rohlf, 1994) while the Duncan Multiple Range (DMR) and Student Newman Keul (SNK) test (Duncan, 1955) were used to further reduce the significant differences (DMR) and arrive at a more conservative estimate (SNK). T-test was used to determine if there was significant difference in experiments, which involved only two treatments.

Results

Effects of Different Feed Treatments on Growth Performance of *Parachanna obscura*

A summary of results from the three different feeding treatments given to the fish is recorded in Table 1. Conditions of fish showed improvement at the end of the experiment with the different feeding treatment (Table 2). The greatest weight gain (64.52%) and daily weight gain (0.24 gg^{-1}) as well as the greatest feed conversion (1.32) and specific growth rate (0.28) were recorded for the culture with *O. niloticus* when *P. obscura* fed on the Nile Tilapia fry. The trash fish fed treatment resulted in a weight gain of 57.7%, daily weight gain of 0.114 gg^{-1}, specific growth rate of 0.25 and feed conversion rate of 2.3 which put this treatment second best on most aspects of the growth performance. The compounded feed had the least growth performance and the poorest feed conversion (3.12), indicating that *P. obscura* could not efficiently utilize the dry formulated feed. The comparative growth and the average weight gain of *P. obscura* on the three feeding regimes are as shown on Table 1.

Single classification ANOVA indicated highly significant differences ($P \leq 0.00$, $_{124}\,^{2}F_{130.429}$) amongst the three comparisons. Pair-wise comparisons using single classification ANOVA showed that *P. obscura* cultured with *O. niloticus* had significantly ($P<0.01$, $_{85}\,^{1}F_{282.599}$, $_{80}\,^{1}F_{130.895}$, respectively) higher yields than compounded feed and trash fish treatments. Whereas there was no significant difference ($P>0.05$, $_{82}\,^{1}F_{1.637}$) between the yield of *P. obscura* when fed on trash fish and compounded feed, further confirmatory tests for more conservative estimates using Duncan Multiple Range Test (DMR) and Student Newman keul Test (SNK) gave the same result as above. This indicates that the culture of *P. obscura* with *O. niloticus* had significantly ($P<0.05$) much higher yield than both *P. obscura* fed on either trash fish or

Table 1. Growth performance of *Parachanna obscura* on three feeding treatments for 180 days

Food types	Initial mean W (g)	Final mean W (g)	Mean gain W (g)	% W gain	Daily gain W (gg^{-1})	Specific growth rate	Feed conversion rate	Survival rate
Live Tilapia	66.8	109.9	43.1	64.52	0.24	0.28	1.32	84
Trash fish	35.5	56	20.5	57.75	0.11	0.25	2.3	78
Compounded Feed	35.5	50.9	15.4	43.38	0.09	0.20	3.12	88

Table 2. Condition factor (K) of *Parachanna obscura* at the end of experiment

Food Types	Initial length (cm)	Initial W (g)	K	Final length (cm)	Final W (g)	K
Live Tilapia	22.0	66.8	0.63	23.7	109.9	0.83
Trash fish	16.5	35.5	0.79	19.0	56	0.82
Compounded feed	16.5	35.5	0.79	18.5	50.9	0.80

compounded feed. Again, there was no significant difference between *P. obscura* fed on trash fish and compounded feed.

The result of the proximate analysis of compounded feeds and their composition are presented in Table 3.

Water Quality Parameters

The water quality parameters for the different feeding treatments monitored at dawn during the experiment proved that the temperature, dissolved oxygen (DO), hydrogen ion concentration (pH) and ammonium (NH_4^+- N) in all the ponds were similar throughout the study. The lowest water temperature for the period (June–December, 2004) was 26°C and this was recorded in the second week in December 2004, while the highest temperature (32.5°C) was recorded in the last week of November 2004. The mean water temperature monitored at dawn throughout the experiment remained at 28°C for the three feeding treatments. The pond water pH ranged from 6.3 to 7.4. The mean pH values for live tilapia, trash fish and compounded feed were 6.9, 6.8 and 6.8, respectively. The dissolved oxygen was between 3.0 and 6.9 with a mean of 4.8 mg/L for live tilapia treatment, 4.6 mg/L for trash fish and 4.6 mg/L for compounded feed. The mean value for ammonium was 0.2 mg/L for trash fish and the compounded feed treatments while 0.18 mg/L was recorded for live tilapia treatment. The above mean values of the water quality parameters were the best with the live tilapia treatment, an indication of a strong relationship between water quality and growth performance of the fish.

Recruitment Control of *Oreochromis niloticus* by *Parachanna obscura*

There was effective control of *O. niloticus* recruitment in the two replicates, as evident by the marketable size *O. niloticus*, though replicate 1 was more effective. The population of *O. niloticus* fingerlings harvested from the three ponds was low, 38 in replicate 1, 40 in 2 and 43 in replicate 3.

Total yield of *O. niloticus* in replicates 1, 2 and 3 were 4,518, 4,264 and 4,149.01 kg/ha/yr, respectively. Mean harvest weight of *Oreochromis niloticus* was the highest with 438.42 g at replicate 1 while the mean harvest weight of *Parachanna obscura* was the highest with 111.7 g at replicate 2. The combined yield of *O. niloticus* and *P. obscura* was the highest in replicate 1 with 5734.67 kg/ha/yr.

The average weights of the marketable size tilapia in the three replicates were 419.46 g, 395 g and 280.03 g. The presence of *Parachanna obscura* in the three ponds significantly increased the production of marketable size *Oreochromis niloticus*. Replicate 2 produced the highest yield of juvenile–size *Oreochromis niloticus* with average weight of 166.88 g and corresponding yield of 1,315.98. Replicate 1 produced the highest yield of fingerlings with average weight of 79.51 g and a corresponding yield of 1,701.8 kg/ha/yr. The *Parachanna obscura* in the three ponds did not grow to marketable size at the end of the experiment. The total yield of *Oreochromis niloticus* in replicate 1 was more than the yields in replicate 2 and 3. This is an indication of the effectiveness of the *Parachanna obscura* in replicate 1 to control the recruitment of *Oreochromis*. Hence, the production of more marketable size *Oreochromis* was realized in replicate 1 than in 2 and 3.

The survival rate of the parent stock of *Oreochromis niloticus* in the three ponds was 100%. Mortality occurred only in *Parachanna obscura* and its incidence was moderate in the three ponds. All the *O. niloticus* stocked were cropped at harvest.

The population of *Oreochromis niloticus* fingerlings spawned in the ponds was quite high and accounted for the high percentage of 37.67%, 33.4% and 22.67% by weight of total tilapia population.

Gut Analysis

The guts of *Parachanna obscura* examined for their contents were all found with ctenoid scales of tilapia, fish bones, fish eggs and Copepods. The ctenoid scales of tilapia found in the gut of *P. obscura* scored the highest by the occurrence method of the gut contents analysis. Ctenoid scales accounted for 80% of the food items in the guts of *P.obscura* while fish bones and fish eggs scored 30% each. Copepods scored 4% of the guts of fish with total lengths of 18-22 cm.

Discussion

Effects of Different Feeding Treatments on Growth of *Parachanna obscura*

The feeding treatment of *Parachanna obscura* with live *Oreochromis niloticus* gave the greatest weight increase and was the best in all aspects of growth such as mean weight gain, best specific growth rate and the highest feed conversion rate. The present work and that of Welcome (1985), Munshi

Table 3. Proximate analysis of compounded feeds

Feed	Crude protein (%)	Carbohydrate (NFE) %	Crude fibre (%)	Ether Extract (%)	Ash (%)
Blood meal	41.2	35.88	6.70	5.25	7.0
Compounded feed	52.81	15.94	8.16	8.50	12.0

and Hughes (1992), Gonella (2003) and Ajah *et al.* (2006) suggest that *P. obscura* prefers live foods like fry of fishes, insects, small crustaceans, frogs, smaller reptiles, young birds, small mammals and earthworms. The optimal growth performance of *P. obscura* in live tilapia feeding treatment was enhanced through the provision of fry from *Oreochromis niloticus*. The provision of live foods may improve the growth of *Parachanna obscura* in monoculture since the species prefer snapping after moving preys.

The mean weight gain and growth performance of the fish fed trash fish meal in the monoculture of *Parachanna obscura* was next to the highest. This is indicative of the fact that this species could be fed with any form of frozen fish food, depending on the size of the fish. The high cost involved in this feeding treatment makes the monoculture of this species quite unacceptable to any fish farmer or culturist whose main objective is to maximize growth of the fish at minimum time and minimum cost.

The compounded feed with the highest crude protein content (53.81%) failed to provide the optimal growth in *Parachanna obscura* with the poorest feed conversion rate of 3.12. The result suggests that *Parachanna obscura* being a voracious predator should not be fed primarily on industrially manufactured fish feeds. *Parachanna obscura* needs a diet of fresh animal foods, which should consist primarily of fish.

The poor feed conversion rate could be attributed to the feeding habits of the species, which may have depended largely on the mechanical ability of the fish to catch and consume prey and also upon the physiological ability to seek out their food. This voracious species might have left all that exist on the bottom or in the mud of the bottom and became interested in that which swims above the bottom and moves in the water. Another reason for the poor conversion rate may be the presence of tadpoles, which appeared in large numbers in the pond after the experiment, had started. These tadpoles may have eaten part of the fish which ought to have been utilized as food by the *P. obscura*. However, the fact that this species showed poor feed conversion in monoculture cannot be ignored.

The trash fish feed stimulated better growth in this species than the compounded feed, but the high cost of providing such feed may be out of the reach of many farmers. It therefore follows that the most economic way of culturing *Parachanna obscura*, which could be afforded by most culturists, is polyculture with tilapia species fed on either wheat offal, blood meal feed or rice bran. *Parachanna obscura* will be used as a predator fish to control the over-population of tilapia. The provision of feed (such as blood meal feed) in such a system will be for the growth and maintenance of the tilapia as was found in this work. Gonella (2003) reported that Snakeheads produce a lot of waste with their high metabolism, which pollute their environment very quickly. Such a condition could result in stress, which could be the obvious reasons for the poor condition of this fish.

Water Quality Parameters

The physico-chemical parameters of water play a significant role in the growth of fish. These parameters remained within the favourable range required for *Parachanna obscura* (Teugels and Daget, 1984). The water quality parameters were the best with the live tilapia fed treatment throughout the period of the experiment. The growth performance of *P. obscura* in the live tilapia fed treatment was significantly greater than those fed with trash fish and compounded feed. This showed the considerable effect that water quality had on the growth of the fish. The optimal levels for water quality parameters varied with species. Cyprinids for example, are satisfied with lower oxygen content and in consequence live in water with higher temperatures. The oxygen demand for carp is 6 mg/L but can withstand levels as low as 3 mg/L. Other species like Cichlids and Channids can withstand a much lower oxygen content and in consequence, higher temperatures (Swift, 1988). Fishes can only breathe normally in an environment with sufficient oxygen. The oxygen needs of fish vary with the species. Dissolved oxygen is a critical factor in fish culture and the success or failure of fish farming depends to a large extent on its availability. Alabaster and Lloyd (1980) indicated that reduction in dissolved oxygen to 50% air saturation, could depress food consumption and growth even when all other conditions are favourable. Certain species of fish are very demanding with regard to the dissolved oxygen. Salmonids in particular usually require 9 mg/L of dissolved oxygen for survival, which corresponds to a temperature of 20°C. Since snakeheads are either obligate or facultative air breathers, their survival in hypoxic water is not problematic. This situation applies very much to *Parachanna obscura* (Lee and Ng, 1991). Dissolved oxygen concentrations decrease with increasing temperature.

The water temperature as high as 32.5°C recorded in November 2004 was above the tolerance range of 26–30°C (Teugels *et al*., 1984) and 30.3°C (Liu *et al*., 1998) established for *Parachanna obscura* in the wild. Such high water temperature may have contributed to some mortality recorded during the experiment. Some Salmonids, depending on the species, die at temperature ranges of 22-25°C and above (Huet, 1986). Apart from death, high temperature may result in reduced growth and poor production. Abnormally high temperature could lead to increased food consumption accompanied by increasing assimilation efficiency; or it may cause reduction in dissolved oxygen in the water leading to inadequate oxygen uptake and hence abnormal metabolic processes and poor growth. The minimum temperature of 26°C recorded in this study falls within the favourable optimal range of *Parachanna obscura* and also within the established tolerance range (21-32°C) for warm water fishes (Huner and Dupree 1984). Huet (1986) stated that temperature manipulation could be used in tilapia culture in Europe to control their prolific breeding activities, and that if the temperature is lowered below 20°C, it can reduce the rate of reproduction in tilapias. Ita and Omorinkoba (2000) affirmed this fact in their work in which temperature below 24°C tended to depress fry production in *Oreochromis niloticus*.

The effect of pH on pond fish as illustrated by Boyd (1992) indicated that if waters were more acidic than pH 6.5 or more alkaline than pH 9-9.5 for long periods, growth of fish would diminish. Chapman (1992) also stipulated the following optimal levels for water quality in fisheries and aquaculture; pH: 6.5-9.0, DO: 4.0-6.0 and ammonium 0.04-1. The pH of the pond water was quite stable except the 7^{th} and 15^{th} weeks of culture when it was low, which were followed by appropriate application of lime (Calcium carbonate) to increase the pH and thus ensured pH stability. Huet (1986) and Swift (1988) affirmed that the best conditions for a fishpond are a stable pH with a level between neutral and alkaline.

There was generally uniform low mortality of *Parachanna obscura* in all the ponds due to good water quality conditions that persisted through out the study period. The few mortality occurrences could possibly be as a result of the fish being carried away by the flood that occurred in the last week of August 2004 following heavy rains which affected all the stocked ponds. Another possible reason for the mortality could be predation by piscivorous birds and snakes, which were observed in the ponds during the study period. Thirdly, the mortality could be as a result of the fish jumping out of the ponds during floods. Liem (1987) noted that some species of snakeheads are capable of overland migration and such species are somewhat flattened ventrally. He further noted that snakeheads could undertake overland migration during or soon after heavy rains, allowing these fishes to invade new habitats.

Recruitment Control of *Oreochromis niloticus* by *Parachanna obscura*

The marketable size of *Oreochromis niloticus* and *Parachanna obscura* was fixed as 200 and 250 g, respectively, (Elliot, 1975; Cross, 1976). There was effective control of *Oreochromis niloticus* recruitment in the three replicates as evidenced by the production of marketable *Oreochromis niloticus.* This confirms earlier findings by Jackson (1988) in Benin Republic, Morrice (1991) in Ghana and de Graaf (2004) in the Netherlands. The degree of recruitment control exhibited by *Parachanna obscura* was limited by the species inefficient hunting ability due to its size. Consequently, the population of *Oreochromis niloticus* fingerlings spawned in the three ponds was high with replicate one having the highest. The tilapia classification was based on three categories namely marketable size (≥200 g) or juvenile–size (140-199 g) and fingerlings (<140 g) (Cross, 1976). The percentage composition of marketable size *Oreochromis niloticus* of parent stock was 100%. For effective recruitment control of *Oreochromis niloticus* to be achieved, there should be simultaneous stocking of both prey and predator of similar lengths or age class. For the studies carried out, the predator fish *Parachanna obscura* should have been introduced into the tilapia ponds at an adult stage and not as fingerlings to be good match for the adult tilapia. *Parachanna obscura* should not be kept with fish smaller than 2/3 of the species size due to its high predatory rate.

A few of the pond spawned *Oreochromis niloticus* reached the stipulated marketable size as recorded by Elliot (1975) suggesting that the growth of the tilapia is fast indicating good conditions of the culture environment in the pond. The tilapia was able to reach over 200 g in nine months. This has age over the report of Huet (1986) that tilapia under cultivation can have best size of 150 g after 10 or 11 months of culture. He further indicated that the same species would not even reach to 100 g in a year when the culture conditions are poor. In the wild, tilapia can grow to be large fish reaching sizes of 1,300 g (Huet, 1986). The male generally grows faster than the female because, where there is mouth incubation, during the incubation period the female does not feed at all. The presence of *Parachanna obscura* in these ponds significantly increased the production of marketable - size *Oreochromis niloticus* although *Parachanna obscura* did not reach marketable size. The findings here prove that tilapia grows faster than *Parachanna obscura*.

Gut Analysis

The pond cultured *Parachanna obscura* was found to be a piscivore feeding predominantly on fish. Results from analyses of gut contents revealed that there were variations in the dietary composition with size of fish. As the predatory fish in the pond, the fry of *Oreochromis niloticus* became the best food leading to the recruitment control of the Nile Tilapia and resulting in production of marketable size of *Oreochromis niloticus*.

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