Nutrient composition and growth performance of *Clarias gariepinus* cultured in Concrete and Cage enclosures

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Abstract
A 62-day experiment was conducted at the Teaching and Research Farm, Ekiti State University, Ado – Ekiti to compare the nutrient and growth performance of *Clarias gariepinus* juvenile cultured in Cage and concrete enclosures. *Clarias gariepinus* juveniles were reared in a concrete tank of 2 ×1.2 × 1m dimension. There were three (3) different stocking spaces of twenty (20) fish per replicate for both culturing systems. The Fish were fed at 4% body weight with water quality of pH 6.88±0.007, Temperature 26.54±0.16, Dissolved Oxygen 6.01 ±0.13 in cage enclosure and pH 6.63 ±0.05, Temperature 25.74 ±0.09, Dissolved Oxygen 5.64± 0.15 in a concrete enclosure. The best growth performance was recorded in the fish cultured in cage enclosure with weight gain of 1.50 ± 0.26, specific growth rate (SGR) of 8.31 ± 1.59, feed efficiency ratio (FER) of 1.56 ± 0.28, and protein efficiency ratio (PER) of 1.40 ± 0.26. The results from the study showed that *Clarias gariepinus* juvenile had the best performance in the cage culture system.
Keywords: Cage, *Clarias gariepinus,* concrete tanks, culture, nutrient

Introduction

Fish is an important and the cheapest source of animal protein and account for about 37% of Nigeria's total protein requirement (Krishna and Prabhavathi, 2019). Over the last decade, spectacular growth has taken place in aquaculture in Nigeria, the culture of fish is receiving much attention with the introduction and adoption of new cultivation techniques (Ojutiku, 2008). About 50 years ago, fish farming techniques started in Nigeria, and as at now, aquaculture in the country is in the developing stage, because it has not been able to meet the demand of the ever-increasing population (Olagunju *et al.*, 2007). The most popular fish species that has proved desirable for culture in Nigeria are the *clariid* fish; *Clarias gariepinus* (Burchell, 1822)*, 'Heteroclarias'* and *Heterobranchus spp.* (Adekoya *et al.*, 2006). African catfish is an essential species in the aquaculture industry throughout the world. The species have several advantages that include; good taste, fast growth, resistance to low oxygen and considerable ease in farming (Van *et al.*, 2009).

Currently, fish can be cultured in any of the four culture systems; ponds, raceways, recirculating systems or cages. A cage or net pen is a system that confines the fish or shellfish in a mesh enclosure. By Strict definition, a cage has a completely rigid frame (on all sides), and a net pen has a rigid frame around the top. Cage culture uses existing water resources but confines the fish inside some mesh enclosures. The mesh retains the fish, and guarantees their feeding, observation and harvesting.. The mesh also allows water to pass freely between the fish, thus maintaining good water quality. Cage culture also offers the farmer a chance to utilize existing water resource in which most cases have only limited use for other purposes. Factors such as increasing consumption of fish, declining stock of wild fishes and weak farm economy have increased interest in fish production in cages; many small or limited resource farmers are looking for alternatives to traditional agriculture crops. Aquaculture appears to be a rapidly expanding industry, and it offers opportunity even on a small scale.

Given the high production attainable in cage culture, it can play a significant role in increasing the overall fish production in Nigeria; this farming method is ideal for small scale fishers as an alternative income source (FAO, 2003). The specific objectives of this work are to; compare the nutrient composition of *Clarias gariepinus* raised in concrete and cage enclosures, and determine the effect on proximate composition of *Clarias gariepinus* carcass, compare the growth performance of *Clarias gariepinus* raised in concrete and cage enclosures. One of the significant challenges confronting the fisheries sector in this nation is low aquaculture production as compared to demand, high cost of production and narrow profit margins for fish farmers due to sickness and in ineffective aquaculture practices. Thus, there is a need to reduce the problems encountered in the practice of Concrete tanks. Currently, many fish species are cultivated in various designs and sizes of cages in Asia, Europe and other parts of the world. Tilapia and carp predominate in freshwater cage culture in Asia, while salmon are commonly farmed in Europe and the Americas. The rapid growth of the industry in most countries may be attributed to the availability of suitable offshore sites for cage culture, well-established breeding techniques that yield a sufficient quantity of various marine and freshwater fish juveniles, availability of supporting industries such as feed, net manufactures, and fish processors. Other reasons include Intense research and development initiatives from institutions, governments and universities and the private sector ensuring refinement and improvement of techniques/ culture systems, thereby further development of the industry. (FAO, 2007)

Cage culture operations

The stocking density of fish depends on the carrying capacity of the cages and feeding habits of the cultured species. For those species which are low in the food chain, stocking will also depend on the primary and secondary productivity of the sites. The optimal stocking density varies with species and size of fish and ensures optimum yield and low disease prevalence. Many biological, climatic, environmental and economic factors affect the feeding of fish in the cages. The growth rate is affected by feeding intensity and feeding time. Each species varies in maximum food intake, feeding frequency, digestibility and conversion efficiency. These, in turn, affect the net yield, survival rates, size of fish and overall production form the Cage. Trash fish is the main feed for yellowtail, grouper, bream, snapper and other carnivorous fish species cultured in marine cages. The shortage of trash fish is a significant problem in many countries with large scale cage farm. Farm management must optimize production at minimum cost. Efficient management depends heavily on the competence and efficiency of the farm operator concerning feeding, stocking, minimizing loss due to diseases and predators, monitoring environmental parameters and maintaining efficiency in technical facilities (Hengsawat *et al*., 1997). Maintenance works are also very vital in cage culture. (Gopakumar, 2009). The advantages and disadvantages of Cage culture are adjudged by its comparative performance with other land-based culture systems in terms of the level of technology required for construction, ease of management, adaptability, quality of the fish reared, resource use, social implications, and economic performance (Hengsawat *et al*., 1997).. Construction of Cage is comparatively easy, be it artisanal type or modern, sophisticated ones. Observation of the stock is easy in cages. Therefore feeding and routine management is easy, Cage reared fish are superior in quality in terms of condition factor, appearance and taste (Njiru *et al.*, 2019). Cages make use of existing water bodies, and thus it can be given to non-land owned people of the community (fishermen) whose income is affected by many reasons in the fishing sector. It, therefore, acts as an alternative income for such groups.

Pond fish can make use of naturally occurring food, while Cage grown fish only have limited access to natural food since they cannot forage on their own. Cage grown fish, therefore, needs to be fed by the farmer to a much greater extent. The food that is given to the Cage grown fish also has to be nutritionally complete. When fish grow in cages instead of ponds, most farmers opt for a high stocking density. However, a high stocking density creates a stressful environment for the fish and stress damages the immune system. The risk of diseases is, therefore, high. The risks will be increased further if the farmer fails to provide the fish with optimal water conditions and an adequate diet. Cage culture can introduce or disrupt disease and parasite cycles, change the aquatic flora and fauna and alter the behaviour and distribution of local fauna.

Although no official statistical information exists concerning the total global production of farmed aquatic species within cage culture systems or concerning the overall growth of the sector, there is some information on the number of cage rearing units and production statistics being reported to FAO by some member countries. In total, 62 countries provided data on cage aquaculture for the year 2015. The cage aquaculture sector has proliferated during the past 20 years and is presently undergoing rapid changes in response to pressures from globalization and growing demand for aquatic products. The move within aquaculture toward the development and use of intensive cage farming systems was driven by a combination of factors, including the increasing competition faced by the sector for available resources, the need for economies of scale and the drive for increased productivity per unit area particularly the need for suitable sites resulted in the sector accessing and expanding into new untapped open water culture areas such as lakes, reservoirs, rivers and coastal brackish and marine offshore waters for cage culture.

Materials and Methods

Cage construction

Materials used for the cage construction were; redwood, protection nets and knotted nets. The Cage was constructed following the dimension of 2 x 1.2 x 1m of the concrete tank used for the experiment to ensure equal sizes in both enclosures. The Cage has three replicates with an equal dimension of 2 x 1.2 x 1 m per replicates, with suspended floating edges. The suspension system was constructed by attaching a rope with knotted nets to the redwood at each edge to form a distinct rectangular shape.

Pond construction

Already constructed concrete tank with the dimension 2 x 2 x 1 m was used for his experiment. The pond also had three replicates with an equal dimension of 2 x 1.2 x 1 m per replicates.

Study Location

The Practical aspect of this work was carried out at the Department of Fisheries and Aquaculture Management Research Laboratory / Research Farm, Faculty of Agricultural Sciences, Ekiti State University, Ado- Ekiti, Nigeria with the coordinates; 7.6656^{0}N, 5.3103^{0}E.

Experimental Fish

African Catfish was selected for the experimental days that lasted for sixty-two (62) days. *Clarias gariepinus* belong to the family *Clariidae*, Order *Siluriformes*, Class Actinopterygii, Phylum *Chordata* and Kingdom Animalia. One hundred and twenty (120) fingerlings of *Clarias gariepinus* were used for the experiment, which was purchased from MM Agro-allied enterprise Farm, Ibadan, and transported to Fisheries and Aquaculture Management, Teaching and Research Farm, Ekiti State University. The fish was weighed and allowed to acclimatize for 72 hours before the commencement of the experiment.

Experimental Procedure

The experiment was carried out using the concrete department pond which was divided into three sections of dimension two by 1.2 by 1m, and a cage enclosure of the same size was used and also divided into three replicates, respectively. Twenty (20) fish was kept in each replicate. The experiment lasted for 62 days, and the fish was fed with Vital Fish feed at 4% Bodyweight daily. The fish was fed at 09:00 – 09:20 am and 4:00 - 4:20 pm. The growth rate was recorded, and data collected were used to evaluate the growth rate of each culture system used. Water was changed every two weeks in the concrete tank to allow the freshness of the water and to maintain a suitable water quality parameter throughout the time of the experiment.

Water Quality Assessments

The pH: The pH was measured directly by an electronic pH meter (Metler Toledo 320 model) by dipping the electrode into each section of the ponds.

Dissolved Oxygen: The dissolved oxygen of the water in the experimental tank was measured using Standard YSI dissolved oxygen meter (YSI Model 57).

Water Temperature: The water temperature was measured using a mercury thermometer calibrated from 0^{0}C – 100^{0}C. Measurements were carried out by gently immersing the thermometer into the water at a vertical position for about 2-3 minutes. It was quickly moved near the surface of the water and read.

Biological Evaluation

Growth performance was determined as follows:

Weight gain = Final weight gain $W_2 - W_1$ Initial Weight

$$\text{Specific Growth rate (SGR)} = \frac{100(\log_e W_2 - \log_e W_1)}{T_2 - T_1}$$

Where W_2 and W_1 represents the final and initial weight of fish respectively;

T_2 and T_1 represents final and initial time (days) respectively;

$\log_e$ represent – natural log to base$_e$ (Adewolu *et al*. 2008).

$$\text{Feed Conversion ratio (FCR)} = \frac{\text{Weight of feed (g)}}{\text{Fish weight gain (g)}}$$

$$\text{Protein efficiency ratio (PER)} = \frac{\text{Fish weight gain (g)}}{\text{Protein consumed (g)}}$$

Proximate Analysis

The Proximate analysis of fish after the experiment was determined using the method of AOAC (2016) as follows:

Moisture Content: The moisture content was determined by taking the weight of samples before oven drying at 80^0C and taking the weight after oven drying. The moisture content was derived by subtracting weight after oven drying from weight before oven drying.

Crude Protein: The crude Protein of the sample was determined using the micro Kjeldahl method of AOAC (2016). The percentage of protein was calculated by multiplying the amount of nitrogen content by a factor of 6.25.

$$\text{Total Nitrogen (N)} = \frac{\text{Volume of the acid X Dilution factor}}{\text{Weight of sample used}}$$

% Crude protein = N x 6.25

Lipid: The fat content was determined by subjecting the sample to a continuous extraction with petroleum using soxhlet extraction as described by AOAC (2016). The ether residue was obtained from the evaporation of the solvent.

Crude Fibre: The crude Fibre was determined as a loss on ignition of dried lipid-free residue after digestion with 1.25 % H_2SO_4 acid and 1.25% NaOH.

$$\text{\% crude fibre} = \frac{\text{weight of residue X weight of ash X 100}}{\text{Weight of sample}}$$

Ash Content: The ash content was determined method, by charring the already roasted samples by combustion as described by AOAC (2016) in a muffle furnace at 50^0C for 1hour. These samples were later cooled ion desiccators and weighed.

$$\text{\% ash} = \frac{\text{weight of ash}}{\text{Weight of samples after roasting}} \quad \text{X} \quad 100$$

Statistical Analysis: The data collected was analyzed using the Turkey test.

Results

Nutritive composition and Growth of *Clarias gariepinus*

Table 3 shows the mean weight, the mean weight gain of *Clarias gariepinus* and the specific growth rate. The initial mean weight of fish cultured in the cage was 4.25± 0.61, and the final mean weight recorded from the cage enclosures was 5.74± 0.82 while the initial mean weight and final mean weight recorded from the concrete tank were 3.70±0.50 and 4.90± 0.67 respectively. There was a general increase in weight gain from the first week to the last week of the experiment.

The highest weight gain was found in fish reared in Cage enclosure while there was lower value recorded from the fish reared in concrete tank. Weight gain in Cage enclosure and concrete tank were not significantly different (P $\geq$0.05). Also, the highest specific growth rate was recorded in the fish *Clarias gariepinus* cultured in Cage enclosure compared to fish cultured in Concrete tank.

Nutrients Utilization of *Clarias gariepinus*

The nutrient utilization is based on the protein efficiency ratio given in Table 3. The highest Protein efficiency ratio was found in fish cultured in Cage enclosure compared to the fish cultured in Concrete tank. Fish cultured in Cage enclosure had the highest feed conversion ratio (FCR) 1.56 ± 0.28 compared to the one reared under concrete tank 1.55 ± 0.28. However there were no significant differences (P $\leq$ 0.05) (t-test = 0.96). There were significant differences in (P $\geq$ 0.05) (t-test = 0.55) in the weight gain in cage and concrete enclosures. There were significant differences (P $\geq$ 0.05) (t = 0.55) in specific growth rate and protein efficiency ratio for both

Table 3: Growth Performance Evaluation of Clarias gariepinus cultured in Cage enclosure and Concrete Tank.

Parameters	Cage Enclosure	Concrete Tank
Initial Weight(g)	4.25± 0.61a	3.70 ± 0.50a
Final Weight (g)	5.74 ± 0.82a	4.98 ± 0.67a
Weight Gain(g)	1.50 ± 0.26a	1.29 ± 0.23b
Specific Growth Rate(g)	8.31 ± 1.59a	7.07 ± 1.30b
Feed Conversion Ratio	1.56 ± 0.28a	1.55 ± 0.28b
Protein Efficiency Ratio	1.40 ± 0.26a	1.19 ± 0.22b

The means with the same letters are not significantly different (P > 0.05) using the Turkey test.

Proximate Composition of the Experimental Fish (*Clarias gariepinus)*

The carcass composition of the experimental fish used (*Clarias gariepinu*is given in Table 4). Fish reared under concrete tank had the highest protein value while fish reared under cage enclosure had a lower protein value. The crude protein level of all the fish reared under the two culture systems increase generally compared to their initial protein level. Ash content in the final carcass composition was higher in the concrete tank compared to Cage enclosure. There was a higher level of Fat in *Clarias gariepinus* reared under Cage enclosure compared to the fish reared under Concrete tank. There were significant differences (p $\geq$ 0.05) (t = 0.05) in the Nitrogen free extract (NFE) for the two culture systems. There were also significant differences (p $\geq$ 0.05) (t test= 0.01) in the crude protein of fish reared in cage enclosure and concrete tanks.

Table 4: Nutritive Composition of *Clarias gariepinus* cultured in Cage enclosure and Concrete tank.

Parameters	Cage Enclosure	Concrete Tank
Moisture	0.80 ± 0.02^{a}	1.30 ± 0.06^{b}
Ash	16.72 ± 0.05^{a}	19.80 ± 0.07^{a}
Fat	25.61 ± 0.06^{a}	14.19 ± 0.06^{a}
Crude Protein	52.96 ± 0.35^{a}	57.95 ± 0.20^{b}
Crude fiber	-	-
Nitrogen Free Extract	3.90 ± 0.44^{a}	6.76 ± 0.28^{b}

The mean with the same letter is not significantly different (P $\geq$ 0.05) using the Turkey test.

Water Quality Parameters

Table 5 shows the result of water quality parameters recorded during the period of the experiment. The temperature values ranged between 26.00^{o}C to 27.32^{O}C for the cage enclosure while it ranged from 26.00^{O}C to 27.00^{O}C for the concrete tank. The dissolved oxygen ranged from 5.35 mg/l to 6.50mg/l for the cage culture while it ranged from 4.89 mg/l to 6.20 mg/l for the concrete tank. The pH value ranged from 6.65 to 7.30 for cage culture while it ranged from 6.40 to 6.90 for the concrete tank. There were significant differences ($P \geq 0.05$) (t = 0.09) in the pH of both the Cage and concrete tanks. Also, there were significant differences ($P \geq 0.05$) (t = 0.85, 0.86) in the Dissolved Oxygen of both Cage and concrete tanks, respectively. There were no significant difference ($P \leq 0.05$) (t = 0.00) in temperature for both cage culture and concrete tank respectively.

Table 5: Water Quality Parameters Recorded During the Experimental Period

Parameters	Cage Enclosure	Concrete Tank
Ph	6.88 ± 0.07^{a}	6.63 ± 0.05^{b}
Temperature (^{o}C)	26.54 ± 0.16^{a}	25.74 ± 0.09^{a}
Dissolved Oxygen (mg/l)	6.01 ± 0.13^{a}	5.64 ± 0.15^{b}

The mean with the same letter are not significantly different ($P \geq 0.05$) using Turkey test.

Analysis of Feed

Vital fish feed was used to feed the fish during the experimental period at varying pellet size. However, proximate analysis of the feed is found in Table 6.

Table 6: Proximate Analysis of feed

Nutrients	Analysis
Crude protein	45%
Crude fiber	3%
Crude Fat	14%
Calcium	1.5%
Ash	7%
Sodium	0.3%
Phosphorus	0.5%
E672 Vitamin A	5000 UI.
E67` Vitamin D3	750 UI.

Discussion

The results prove that cage culture is a better system of rearing Catfish than Concrete tank. The highest weight gain was found in fish reared in Cage enclosure 5.74±0.82 while lower value was recorded from the fish reared in concrete tank 4.90±0.67. This result reflects the findings of Okunsebor *et al.* (2013), who reported that *Clarias gariepinus* reared in Hapa-in- tank exhibited significantly superior growth when compared to those reared in concrete tanks.

Ahmed et al. (1997) also reported comparatively higher growth performance in hapa tank (5.99g) than the glass tank (3.74g). Highest specific growth rate was recorded in *Clarias gariepinus* cultured in cage enclosure 8.31 ± 1.59 compared to the fish (*Clarias gariepinus)* cultured in concrete tank 7.07 ± 1.30, this is similar to Agbebi *et al.* (2009) who successfully raised *Clariobranchus* fry in Hapa-in-tank and observed better growth performance. The protein efficiency ratio recorded from both culture system followed the same way with the highest value from

Cage culturing system and the lesser value from the concrete tank. The values of Feed conversion ratio also followed the same way with the highest value recorded from cage culture to the least value from the concrete tank, within the standard value for feed conversion ratio (Adebayo *et al*., 2013; Akin-Obasola and Ajewole, 2018). Other studies have relatively recorded higher feed conversion ratio with no significant difference (Gabriel, 2009; Hildalgo *et al.,* 2006). Fish cultured in cage enclosures which had the best growth response for all the parameters considered were significantly different from the other culture system. There were significant differences in the Specific growth rate and the protein efficiency ratio. The percentage of survival was best recorded throughout the experimental period from the fish cultured in cage enclosure compared to a concrete tank. It is due to proper water quality management, a constant flow of water, easy access to supplementary food by the Fish (*Clarias gariepinus)*. The observation agrees with the work of Olanrewaju *et al.* (2009) that studied the growth performance of Dutch *clarias* fry /fingerlings in indoor concrete tank and reported higher survival rate. The high survival validates the report of Otunbusin (2000) and Osofero *et al.*, (2007) that survival range of 98.5 – 99.5% is attainable in the cage culture system.

There was a good carcass composition result from the Fish (*Clarias gariepinus)* reared under cage enclosure. There was a higher level of Fat (25.61 ± 0.06) in the experimental Fish (*Clarias gariepinus)* reared under cage enclosure compared to the fish reared under the concrete tank (14. 19 ± 0.06). There were significant differences ($p \geq 0.05$) ($t = 0.08$) in the Nitrogen free extract (NFE) for fish reared under cage and concrete tanks respectively. There were no significant differences ($p \leq 0.05$) in the crude protein reared in Cage and concrete tank, which agrees with Geoffroy *et* al. (2018), who recorded no significant difference in the African Catfish cultured.

Conclusion

Based on the results obtained in this study, cage enclosure is a better culturing system compared to concrete tanks rearing as the growth performance and nutrient composition was better.

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