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Growth performance: A comparative analysis of African catfish, *Clarias gariepinus* fingerlings reared in a cage, concrete pond and earthen pond systems

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Abstract

A comparative study between fingerlings reared in a cage, concrete pond, and earthen pond systems was conducted between March and August 2019. The fish net cage was constructed with ½ netting materials (210 D/9), nylon twine (210 D/9 and 210 D/8), and ropes (10mm PE and 4mm PE, as a house in which the fish fingerlings were stocked. The stocked fish were held captive in the fishnet while water flows through it. This is Treatment 1 (T_1). A concrete pond of 10 m x 10 m x 15 m was constructed, as Treatment II (T_{11}). Simultaneously an earthen pond measuring 10m x 10mx 15m was constructed entirely from soil materials both manually and mechanically in a site with excess water retention potential near Otamiri River beside the Fisheries Department of the University of Agriculture. This is Treatment III (T_{111}). Each of the treatments was stocked with 1,500 *Clarias gariepinus* fingerlings of 10gms average weight and managed simultaneously for the 6 months. Data were analysed by simple descriptive statistics. The result showed 83.3%, 93.3%, and 96.7% survival rates in a cage, concrete pond, and earthen pond systems. Average weight at harvest (gm) and total weight at harvest (gm) of 332.6 gm and 415.7 gm for cage fish farming, 250.6gm and 350.8gm for concrete pond systems, and 250.6 gm and 280.65 gm for earthen pond system. The survival rate in cage culture (83.3%) was low due to high water depth, as the cage was floated; hence fingerlings could not maximize feed intake at the initial stage. The 96.7% suggest that the earthen point system has the highest production rate. Adequate care should be taken to ensure maximal utilization of feed given to the fish in cage floater in water.

Keywords: Fingerlings; Growth Performance; Survival rate; *Clarias gariepinus*

1. Introduction

In Nigeria, Government is focusing great attention on strategies for food security. Notably amongst these strategies is fish farming which is increasingly becoming very popular as a major source of accelerated fish production. [1] And [2] reported that the fisheries development and its sub-sector projected a contribution of only 2.5% of national GDP in 2015. The authors also report that the supply of fish within the period was 671.492t whereas demand was 2,650.000t, leaving a deficit of 1,978.500t.) [3] Present a critical review of fisheries and aquaculture production and management in Nigeria and state that it is essential to follow improved agricultural management practices to ensure enhanced yield. Aquaculture is a major fish farming strategy, which has become a very popular and major source of accelerated fish production. [4] Explain that fish farming in ponds is a fast-developing food-producing sector in the world and a major source of food security. [5]; [6] explain that with the increased human population, urbanization, and increase in the demand for fish, the improvement in all methods of accelerated fish production cannot be over-emphasized [7] reported that the farming of African catfish *Clarias gariepinus* has become popular in Africa, and quoting [8] explained that this popularity is attributable to the catfish's rapid growth, disease resistance, hardiness, excellent taste, and high market

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demand. In the same vein, [9] explained that the Nile *Tilapia* is an easily cultivable species, and as a tropical species, easily survives in the culture system. According to [10, 11, 12, 13], the Nile *Tilapia* cultured in ponds and cages has a unique quality of surviving at reducing dissolved oxygen, tolerance to a large change in salinity, fast growth, and management conditions. As a result of these characteristics, the fish is greatly cultured all over the world [14 15, 16]. In the same vein, [17] made a comparison between cage and pond production of Perch (*Anabas testudineus*) and Tilapia (*Oreochromis niloticus*) under three management systems and opted for an integrated cage-pond system with high-value production, and the authors suggested that fish farming in cages and ponds in an integrated system will be the better option for rural aquaculture, considering the production and economic benefits. Comparatively, [18] showed a great preference for catfish farming in cages, where artificial feeds were used to monitor the growth of fish in different compartments. However, the culture and production of fish in cages has been a relatively recent aquaculture innovation [19]. [20] explained and demonstrated that cage/pond culture of fish is the raising of fish from fingerings to harvestable size in containers (cages) enclosed on all sides and bottom by wooden stalls, hard wire cloth, net, or other materials that allow free circulation of water in/and out of the cage. Fish cage culture allows intensive production of fish without conventional preparation for aquaculture. [21, 22] explains that fish farming cages and ponds are fast developing in the fish production sector in the world and are a major source of food security. Perhaps, the earliest type of aquaculture was the earthen pond system practised in pre-historic times, [23], which described the earthen pond as a synthetic dam, reservoir, or lake constructed entirely from soil materials, manually or mechanically in a site with excessive water retention potentials. Thus, can simply be described as a water body that is enclosed by the earth. Considering the importance and prospects of aquaculture for accelerated production of fish using the cage, concrete pond, and earthen pond systems, especially in developing countries like Nigeria, and recognising the potential of fish farming in underutilized water bodies such as Otamiri River in South- East, Nigeria, the present research Is undertaken to show a comparative study of growth performance and production potential of *Clarias gariepinus* fingerlings reared in a cage, concrete pond and earthen pond systems respectively with specific objectives to show the effect of stocking density on growth performance and production potential of *Clarias gariepinus* under these culture conditions, and to develop a method of catfish cage culture in Inland open water body like Otamiri River.

2. Material and methods

2.1. The Study Area and Duration

The study was carried out at the University of Agriculture and Environmental Sciences, Umuagwo, Imo State at the axis of Otamiri River between 1st March and August 31st 2019, a period of 184 days. It was done using a cage, pond, and earthen pond culture systems.

2.2. Construction of Cage and Predator Barrier Net

The fish net cage measured 2.5m by 2.5m x 2m. The following materials were used to construct the fish net cage.

- ½ "netting material (210D/9)
- Nylon twine (210 D/9)
- Nylon twine (210 D/8)
- Rope (10, mm PE)
- Rope (4mm PE)
- Weaver's stick

The predator barrier net measuring 2.5 x 2.5 x2m was constructed with the view of preventing the entrance of predators into the cage. The net was constructed with the following materials;

- Galvanized angle rods,
- Copper ½ wire mesh
- Copper binding wire,
- Black paint for coating the net against rusting while in water.

The predator barrier net houses the fish net cage. Thereafter the cage was transported in a carriage truck from the construction site to the research site (Otamiri River) after clearing the site. A cross-bridge was also constructed after lowering the cage to float on the water.

2.3. Stocking, Feeding, and Management

Four thousand five hundred (4,500) pieces of fingerlings of catfish *Clarias gariepinus* were purchased from Barnabas Fish and hatchery Farm at Mgburuchi, Owerri. The 4,500 pieces of fingerlings were transported in 9 pieces of 50-litre plastic containers filled with native pond water. Each of the 50-litre containers contained 500 pieces of fingerlings. Upon transportation to the experimental site, the 4,500 fingerlings were divided into three equal parts of 1,500 each and weighted with mettle weighing machine. An average weight of 10gram was obtained.

The cage was stocked with 1,500 pieces of fingerlings of *Clarias species* of 10gms average weight. A concrete pond of 10m x 10m x 10m, was also stocked with 1,500 *Clarias fingerlings* of 10gms average weight and the third group of 1,500 fingerlings was stocked in the earthen pond. The three culture systems were simultaneously managed. The researchers were responsible for the feeding and regular maintenance of the fishes in a cage, concrete pond, and earthen pond systems respectively. The fish were fed in the morning (9.00 am) and evening (4.00 pm).

2.4. Records and Data Collation

The cage culture system is described as Treatment 1 (T1) and the concrete pond system is described as Treatment II (T 11) while the earthen pond is described as Treatment III (T III). The data collated include the following parameters:

- Initial number of fingerlings stocked
- Average weight of fish at stocking
- Total weight at stocking
- Number of fish at harvest
- Percentage survival
- The average weight of fish at harvest
- Total weight of fish at harvest

The details of data collated are for fish production, stocking, and harvesting; Weight frequency of harvested fish, Average weight of harvested fish. The table shows the weighted frequency of harvested fish in all the culture systems.

3. Result

The result in table 1 shows three experimental treatments ($T_{1,}$ $T_{II,}$ and $T_{III)}$ for a cage, concrete pond, and earthen pond cultures. The initial stocking densities of the fingerlings were 1,500 pieces each. The survival samples at the end were 1,250 for the cage culture system, 1,450 for the concrete pond culture system, and 1,440 for the earthen pond culture system respectively. The survival rate was higher in the earthen pond culture system (96%) followed by the concrete pond culture system (93%) while the least was recorded in the cage culture system (83.3%) respectively. The average weight of harvested fish was highest in the cage culture system (332.6 g), followed by the concrete pond culture system (352 g) and the least was recorded in the earthen pond culture system (250.6g). The highest weight at harvests was observed in the earthen pond culture system (420g) followed by the cage culture system which was 415.7g, and the least was recorded in the concrete pond culture system (350.8g) respectively (Figure 1).

Table 1 Record of Fish Production, Stocking, and Harvest

S/N	Item	Treatment I, Cage Culture System	Treatment II, Concrete Pond culture system	Treatment III, Earthen Pond culture system
1.	Number stocked	1500	1500	1500
2.	Average initial weight at stocking	15g	15g	15g
3.	Number harvested	1250	1450	1450
4.	Percentage survival (%)	83.3%	93%	96%
5.	Average weight at Harvest (g)	332.6	250.6	352
6.	Total weight at harvest (g)	415.7g	350.8g	420g

Results from table 2 show the weighted frequency of harvested fish at the end of the experiment. The wight frequency of the cage and pond culture system displayed below shows varying degrees of importance for the cage culture the percentage weight varies between 12% to 21.6% while in pond culture it varies between 3.45 to 41.38%, and in the earthen pond, between 4.9% - 41.6% with total percentage survival of 83.30%, 93.3%, and 96% for the cage, concrete pond and earthen pond culture systems respectively.

Table 2 Weight Frequency of Harvested fish

	Treatment I: Cage Culture System		**Treatment II: Concrete Pond Culture System**		**Treatment III: Earthen Pond Culture System**	
Group(g)	**Number**	**%**	**Number**	**%**	**Number**	**%**
201-250	180	14.4	600	42.8	600	41.6
251-300	150	12	500	34.48	500	34.7
301-350	150	12	100	6.90	100	6.9
351-400	200	16	100	6.90	100	6.9
401-451	270	21.6	50	3.45	70	4.9
451-500	200	16	100	6.90	70	4.9
	1,250		1,450		1,440	
	Percentage survival = $\frac{1250}{1500}$ x $\frac{100}{1}$ = 83.3%		Percentage survival = $\frac{1450}{1500}$ x $\frac{100}{1}$ = 96.67%		Percentage survival = $\frac{1440}{1500}$ x $\frac{100}{1}$ = 96%	

From table 3 below, the following values were obtained: 332.6gm, 264.3gm, and 276.2gm.

Table 3 The Sum of the weight in each group of the harvested fish

X group (gms)	**Treatment I: Cage Culture System**			**Treatment II: Concrete Pond Culture System**			**Treatment III: Earthen Pond Culture System**		
	Midpoint x	**F**	**Fx**	**Midpoint x**	**F**	**Fx**	**Midpoint x**	**F**	**Fx**
201-250	225.5	180	40590	225.5	600	135300	225.5	600	135300
251-300	275.5	150	41325	275.5	500	137750	275.5	500	137750
301-350	325.5	150	48825	325.5	100	32550	325.5	100	32550
351-400	375.5	200	75100	375.5	100	32550	375.5	100	32550
401-451	425.5	270	114885	425.5	50	21275	425.5	70	29785
451-500	475.5	200	95100	475.5	100	23775	475.5	70	29785
		Ɛ F	**Ɛ Fx**		Ɛf	Ɛfx		Ɛf	Ɛfx
		1,250	415825		1450	383200		1,440	397720
	$\bar{X}$	**Ɛ fx** / **Ɛ f**	**332.6** (gm)	$\bar{X}$	**Ɛfx** / **Ɛf**	**264.3** (gm)	$\bar{X}$	**Ɛfx** / **Ɛf**	**276.** (gm)**2**

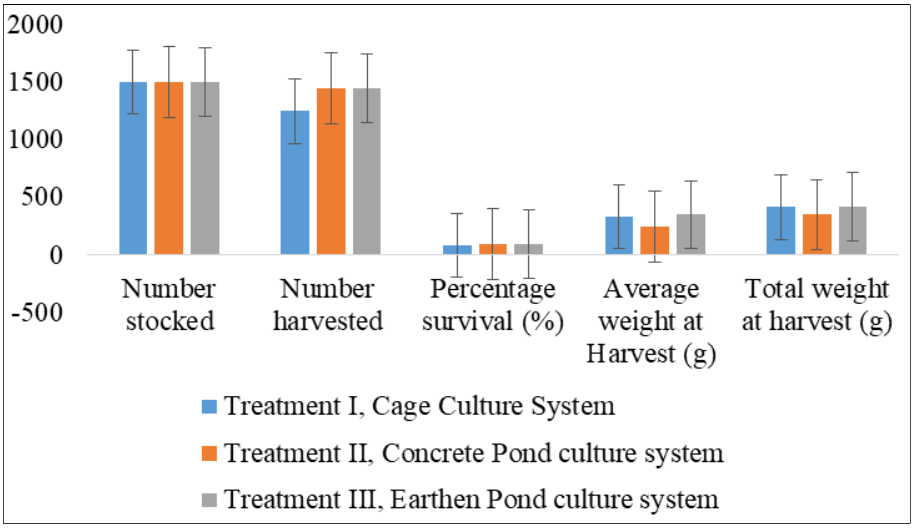

Figure 1 Experimental treatments (T_1, T_{II}, and T_{III}) for cage, concrete, and earthen pond)

4. Discussion

4.1. Survival Rate

The number of fishes harvested for the three experimental trials is T_1 1250, T_{11} 1400, and T_{111} 1450 with a corresponding average weight of 332.6gm, 250.6gm, and 280.65gm. The result also reveals that total also revealed that the weighted total of the fish at harvest was T_1 415.7gm, T_{11} 350.8gm, T_{III} 420gm, and percentage survival rates of T_1 83.3%, T_{11}93.3%, and T_{III} 96.6%. The transcend is that the earthen pond system has the highest performance in comparison to the cage and concrete system. T_{III} 96.6% had the highest production rate, with a lower average weight, 250gm. [21] explain that production rate is correlated with stocking density on growth performance and the production potential of tilapia *(Oreochromis niloticus)*. The researchers observed a higher production for 150 fish m^{-3} for a $T\text{-}_{150}$ cage, whereas a lower production rate was recorded for $T\text{-}_{150}$ in 200 fish m^{-3}. In the same vein, [24] suggested that in studies on the production and biomass of fish in cages and ponds, stocking density is of great importance; for optimum productivity. They also showed that the highest production of tilapia *(Oreochromis niloticus)* at the stocking of the density of 200 fish m^{-3} was most ideal. In contrast to this, [25] with hybrid red Tilapia stocked at a density of 200, 300, and 400 fish m^{-3} in replicated cages, obtained the highest production at the density of 400 fish m^{-3}. However, [26] conducted a study in Ghana with the stocking density of 50, 100, and 150 fish m^{-3} and the highest gross production was obtained in 150 fish m^{-3} in a cage culture system. Closely, [27] reported the highest stocking density of 7000 fish in 48 m^{-3}. This research resulted in less gross and net yields compared to the research mentioned above on cage culture systems. From all these accounts, it can be said that stocking density affects the growth performance and production potential of fish under c conditions. Apart from [26] who showed that stocking density of 150 fish m^{-3} guarantees the highest gross production in 150 fish m^{-3} in a cage culture system, information is lacking on the effect of stocking density on mean final individual body weight (gm), mean individual weight gain (gm), average daily gain (gm), percentage (%) weight gain, specific growth rate and production rate (g m^{-3} day^{-1}).

In the present research, the low percentage survival of T_1 (83%) is attributable to the high-water depth where the cage was floated, thereby making it fairly difficult for the fingerlings to maximise feed in-take at the initial stage. T_{III} has the highest performance due to the nutrient-rich environment, hence it could be said to be the best alternative aquaculture system.

The survival rate of the fingerlings 1,250 and 1,450, was 83.3% and 96.66% for T_1 and T_{11}, compares with the range of survival rates obtained by [5], and also in line with Odin et al. (2009) [28, 29, 30]. However, [31] reported a survival rate of 44% and 49% after 80 days of feeding *Oreochromis niloticus* fingerlings with a testosterone (40mg/g) diet. Consequent to these observations, a correlation between survival rate, weight gain, and stocking density of fish fingerlings has been postulated by several authors. A production rate of 1,250 and 1,450 T_I and T_{II} was observed in the present research. [21] Showed that the highest production rate was observed in T-150 for the stocking density of 150 fish $m^{-.}$ The lower production rate was recorded at a lower stocking density (100 fish m^{-3}) and higher stocking density (200 fish m^{-3}). [27] Found the highest production (28560g m^{-3}) of *Oreochromis niloticus* fingerlings at the stocking density of 400 fish $m^{-3.}$ [26] conducted a study in Ghana with stocking densities of 50, 100, and 150 fish $m^{-3,}$ and the highest gross production was obtained in 150 fish m^{-3}in a cage culture system. [27] Reported the highest stocking density (7000 fish 48 m^{-3}) which resulted in less gross and net yields compared to others in cage culture conditions. [32] Concluded that integrated cage-cum-pond system culture with high-valued fingerlings is a more suitable option than the conventional mixed culture system, due to its high yield, maximum feed efficiency, and more economic return. From the result of the research under reference, stocking density, and the culture medium, the cage, and pond system play major roles in the production capacity of fingerlings in culture.

5. Conclusion

The result of this study shows that the average weight of the fish at harvest in the earthen pond system was 420g, which was better than that reported in the cage and concrete pond systems which were 250.6gm and 350.8gm. Hence, the earthen pond system is a more viable aquaculture production system with a higher return on investment and a lower cost of production. The potentials of Otarniri River are grossly unexploited. Therefore, diversifying the resources of the river through cage and earthen pond fish farming will make for the bridge gap in the improvement and accelerate fish production in the river. It is therefore recommended that earthen pond and cage systems be promoted and practiced in riverine communities in Nigeria, especially where there is a vast stretch of rivers as seen in the Otamini River. Government agencies are encouraged to provide financial assistance, and fishing materials, especially cages and nets to support the fishers to argue their needs, especially in the purchase of fishing materials.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declared that for this research article, they have no actual, potential, or perceived conflict of interest.

Author contribution

The contribution of the authors to the present study is equal. All the authors read and approved the final manuscript. All the authors verify that the Text and Tables are original and that they have not been published before.

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Data availability

The authors confirm that the data that supports the findings of this study are available within the article.

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