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Growth and economic performance of African catfish, *Clarias gariepinus* (Burchell, 1822) Juveniles to imported and local feeds in floating bamboo cages

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Abstract
A six months study was carried out to evaluate the effects of three commercial floating feeds (Coppens, Chi, and Dizengoff) on growth parameters and economic profitability of *Clarias gariepinus* juveniles in six floating bamboo cages (1m^3). *Clarias gariepinus* juveniles with average mean weight of 135.5g were randomly stocked at 50 fish per cage/treatment. The feeding treatments were replicated twice. In each cage, 10% of the fish were sampled and weight monthly to determine growth. On termination of the experiment at 185 days, growth performance, feed utilization and economy of feed and weight gain (EWG) were evaluated. Physico-chemical parameters were within suitable range for *Clarias gariepinus* culture. There were no significant differences (P>0.05) in initial weight, mean/percentage weight gain, and specific growth rate (SGR). There was significant differences (P<0.05) in growth per fish per day, food conversion ratio (FCR), protein efficiency ratio (PER) and final weight. Fish fed Chi, had final individual average weight of 898.76g, FCR of 0.79, 81% and gross fish production of 72.8kg, was considered best on the basis of cost benefit analysis which showed that it gave the least and thus best EWG of 0.52, and highest profit index of 2.57. Economically, Chi feed is recommended for production of *Clarias gariepinus* in cages.

Keywords: Growth performance; Clarias gariepinus, commercial feeds, Bamboo cages

1. Introduction
Aquaculture is the controlled cultivation of freshwater and saltwater animals or plants. It is an important approach in the global fight against hunger, malnutrition and poverty, particularly in the developing nations like Nigeria. Fish farming provide much needed high quality animal protein and other essential micronutrients because of its affordability to the poorer segments of the community in addition to the provision of employment opportunities and cash income. The Food and Agriculture Organization of the United Nations (FAO 2000)[1] classified aquaculture as the World's fastest growing food production sector for nearly two decades globally; the sector has shown an overall average growth rate of 11.0% per year since 1984, compared with 3.1% for terrestrial farm animal meat production.
Nigeria has a land area of 923,768Km2 with a continental shelf area of 47,934Km2 and a length of coast line of 853Km. It also has a vast network of inland waters like rivers, flood plains, natural and man-made lakes and reservoirs (Shimang, 2005) [2]. The inland water mass was estimated as 12.5 million hectares, capable of producing 512,000 metric tons of fish annually (Ita and Sado, 1985; and Shimang, 2005) [3].
Despite these considerably high potentials, local fish production has failed to meet the country's domestic demand (FAO, 1995) [4]. Nigerians consume an estimated 1.3 million tonnes of fish annually. Meanwhile, national productions from both capture fisheries and aquaculture stands at 450,000 tonnes annually. Over 800,000 tonnes of fish are imported to meet the annual demand (AIFP, 2004) [5]. Nigeria is the largest importer of frozen fish in the world with annual fish import bills exceeding N27 billion in the year 2000 (Falaye, 2008) [6], and over N100 billion in 2010 (Akinwumi, 2014) [7]. A sure means of substantially solving the demand-supply gap is by embarking on widespread homestead/small scale fish production particularly in central and northern Nigeria with limited water resources relative to the southern part.
Cage culture is a system of fish production that is massive in terms of capacity, reasonable in terms of capital intensiveness, and workable in terms of the ecology and governance of a target

Location. Otubusin (1993) [8] had noted that Cage, pen and enclosure systems which utilize existing water bodies should be popularized for intensive fish production using existing technology. Cage culture is relatively new in north central and northern Nigeria compared to southern Nigeria where it has been practiced over the years. For optimal growth, fish like other vertebrates require complete ration containing all nutrients necessary for normal growth and metabolism. These include; protein, fats and oil, carbohydrates, vitamins, energy and minerals Eyo (2003) [9]. Fish require diets relatively high in protein content because of their poor utilization of carbohydrates as energy source, thus sufficient supply of dietary protein is needed for rapid growth. Lack of nutritionally adequate and low cost feed has always been one of the constraints to the successful practice of cage fish culture in many developing countries (Otubusin 1987) [10]. Jamu and Ayinla (2003) [11] have reported that feed accounts for at least 60% of the total cost of fish production in Africa, which to a large extent determines the viability and profitability of fish farming enterprise. Most farmers in Africa depend largely on imported fish feed from European countries for the productivity and sustainability of the industry. In Nigeria, an estimated 4,000 tons of quality fish feeds are imported into the country each year (AIFP, 2004). There is paucity of information on the nutrient content of fish feed produced by different feed companies in Nigeria. Also, lack of legal legislation and control over the feed components and feed quality, leave farmers with no option but to depend solely on the existing information about the feed composition and growth performance that is given by the feed company which need to be authenticated. Therefore, the present study investigated performance indices of Clarias gariepinus juveniles fed two locally produced commercial floating feeds: B and C, with an imported commercial floating feed A.

2. Materials and methods

2.1 Experimental Design

Six (6) floating bamboo cages (L x B x H: 1m x 1m x 1m) were placed in Kubanni reservoir Ahmadu Bello University, Zaria, located approximately within latitude N 11o 11" and longitude E 07o 38" at an elevation of 2,200m above sea level. Each cage was made up of a wooden frame lined with net (210/9, 12.7mm mesh size) and bamboo lattices walls with lockable lids. Fastened to the upper side of each cage were two well-sealed plastic kegs (20 litres) which served as floats. Two units of floating bamboo poles (11m in length) were used as the raft (framework) for the cages. The raft was anchored to site with six 9-inch (2286mm) blocks at the four corners and the middle (5.5m) with the aid of polypropylene anchor ropes, to secure the cages and protect them from being carried away by wind or flood. Depths at the cage site varied from 6-7 m. Three hundred juveniles of Clarias gariepinus with mean weight of 135.5g were procured from Mairuwa farms hatchery Funtua, and randomly stocked at 50 fish per cage. The cages were labelled 1 to 6 for identification. Three commercial pelleted floating feeds, namely Coppens, Chi, and Dizengoff with crude protein 42%, 45% and 42% respectively, were fed to the fish at 3% of their body weight twice daily, morning (8:00am -9.00am) and evening (5:00pm-6:00pm). Each feeding trial was replicated twice and randomized as: Coppens, cages 2(T1) and 5 (T2); Chi, cages 3(TI) and 6(T2) and Dizengoff, cages1 (T1) and 4(T2), Coppens and Dizengoff are imported commercial fish feed, Chi is locally produced in Nigeria. In each cage, 10% of fish stocked was sampled fortnightly using a scoop net, and a top weighing balance was used to weigh the fish between 7: 00am, and 9:00am to determine growth. The water pH, temperature, electrical conductivity and total dissolved solids (TDS) were taken weekly using HANNA instruments (HI 98129. HI 987130 meters), while Dissolved oxygen (DO), was analyzed weekly using Dissolved oxygen test kit (HANNA instruments model: HI 3810). The experimental feeds were analyzed for crude protein, lipids, crude fibre, ash, moisture and carbohydrate as described by AOAC (1990) [12]. On termination of the research at the end of 185 days, the cages were dragged ashore and the fish harvested with a scoop-net.

2.2.1Growth performance

Growth performance of the fish was determined using the following parameters;

2.2.2 Mean Weight Gain (g) (MWG) (Adikwu, 2003) [13]

MWG = Wt2 –Wt1

Where

Wt1 = initial mean weight of fish at time T1

Wt2 = final mean weight of fish at time T2

2.2.3 Feed Conversion Ratio (g) (FCR) (Adikwu, 2003)

$$FCR = \frac{\text{weight of feed given (g)}}{\text{Fish weight gain (g)}}$$

2.2.4 Relative Growth Rate (RGR) (Wannigamma *et al.*, 1985) [14]

$$RGR (\%) = \frac{(Wf - Wi) \times 100}{Wi}$$

Wf = final average weight at the end of the experiment

Wi = initial average weight at the beginning of the experiment

2.2.5 Protein Efficiency Ratio (PER) (Mohsen, 2012)15

$$PER = \frac{\text{fish Weight Gain (g)}}{\text{Protein intake (g)}}$$

2.2.6 Specific Growth Rate (SGR) (Auta *et al.*, 20013)16

$$SGR = SGR = \frac{\log_e W2 - \log_e W1 \times 100\%}{t}$$

Wf = final average weight at the end of the experiment

Wi = initial average weight at the beginning of the experiment

Loge = e = the base of Natural Logarithm (10).

t = Number of days for the experiment

2.2.7 Survival rate (%):

$$= \frac{\text{Number of fish that survived} \times 100}{\text{Total number of fish stocked}}$$

2.3 Profitability analysis

A simple economic analysis was developed to estimate the profitability in each treatment using the following indices:

2.3.1 Economic weight gain (EWG)

$$= \frac{\text{Cost of feed (N)}}{\text{Weight gain}}$$

(Ita and Okeoye 1998) [17]

2.3.2 Profit index

$$= \frac{\text{Value of fish crop}}{\text{Cost of feed}}$$

(Ita and Okeoye 1998)

3. Proximate analysis of feed

The feed/experimental diets were analyzed for proximate composition according to A.O.A.C (1999) [18].

4. Data Analysis

Mean values of the water quality parameters measured was calculated. Mean values of weight measurements were subjected to Analysis of variance (ANOVA) and tested for significance difference at P=0.05(5% probability level). Duncan Multiple Range Test (DMRT) was used to rank the means.

5. Result

Mean weight and feed utilization of Clarias gariepinus juveniles fed with different commercial floating feeds over a period of 185 days, is given in Table 1. Coppens had the highest total final biomass and percentage weight gain of 7654.0g and 456.3g respectively. Followed by Chi and the lowest was Dizengoff. However, statistical analysis showed that there was no significant difference (*P*>0.05). Chi had the highest SGR of 1.02, that was not significantly different (*P*>0.05) from Coppens and Dizengoff with SGR of 1.00 and 0.88 respectively. The results of the nutrient utilization clearly showed that, the best diet was Coppens with FCR 1.69 and PER1.25. There was no significant difference (*P*>0.05) in FCR between Coppens with FCR of 1.69 and Chi FCR 1.78. However, both diets were significantly different from Dizengoff with FCR of 1.98. Furthermore, Chi and Dizengoff with PER of 1.10 and 1, 06 respectively, were not significantly different (*P*>0.05), but both diets showed significant difference from Coppens with PER 1.25.

Table 1: Summary of mean weight and feed utilization of Clarias gariepinus juveniles fed different commercial floating feeds over 185 days trials.

	Treatments			
Mean Value	**Coppens**	**Chi**	**Dizengoff**	**S.E**
Initial No. of fish	100	100	100	--
Final No. of fish (% Survival)	87^a	81^a	99^a	18.33
Dept. of water (6m)	6	6	6	--
Initial individual weight (g)	137.6^a	135.6^a	133.2^a	1.24
Total initial biomass (g)	6880.0^a	6780.0^{ab}	6660.0^b	63.60
Total final biomass (g)	76540.0^a	72800.0^a	66700.0^a	4966.94
% Weight Gain (g)	456.3^a	436.9^a	400.8^a	28.165
Growth per fish per day (g)	4.01^a	4.13^a	2.92^b	0.38
Specific growth rate (SGR)	1.00^a	1.02^a	0.88^a	0.08
Food conversion ratio (FCR)	1.69^b	1.79^b	1.98^a	0.09
Protein efficiency ratio (PER)	1.25^a	1.10^b	1.06^b	0.06

S.E= Standard error calculated from the difference within mean squares.

Figures with the same superscripts horizontally are not significantly different (*p*>000.05) The economic profitability of using the three commercial fish diet for the cage culture of the Clarias gariepinus is presented in Table 2. Total cost of production was N27, 960.00, N26, 370.00 and N27, 430.00 for Coppens, Chi and Dizengoff respectively. Dizengoff had the least gross profit of N5, 920.00; and also high EWG (0.61) that resulted in the lowest profit index (2.03). The highest gross profit of N10, 310.00 was recorded with Coppens, while Chi had the highest profit index of 2.37.

Table 2: Summary of cost benefit evaluation of the three commercial feeds

TREATMENTS			
	Coppens	**Chi**	**Dizengoff**
Production period (days)	185	185	185
Stocking density	100	100	100
Net production (kg/cage/days)	76.54	72.8	66.7
Value of fish crop @ =N=500.00 kg	38,270.00	36,400.00	33,350.00
Feed input (kg)	53	53	53
Cost of feeds per kg (=N=)	320.00	290.00	310.00
Cost of feeds used =(N=)	16,960.00	15,370.00	16,430.00
Cost of cages (=N=)	6000.00	6000.00	6000.00
Cost of juveniles (=N=50 per fish)	5000.00	5000.00	5000.00
Total Cost of production (=N=)	27960.00	26370.00	27430.00
Gross profit (=N=)	10,310.00	10,030.00	5,920.00
Economic weight gain (EWG)	0.54	0.52	0.61
Profit index	2.26	2.37	2.03

Water quality parameters during the culture period as presented in Table 3, were within the suitable ranges for Clarias gariepinus culture. Water temperature ranged from 20.0 to 33.7 °C, with an average of 26.9 °C. Water pH ranged from 6.88 to 8.51, with an average of 7.70. Dissolved oxygen ranged from 4.2 to 7.76 mg/l, with an average of 5.90 mg/1. Conductivity ranged from 108–197 mmho/cm, with an average of 151.83 mmho/cm. The total dissolve solute (TDS) for the three treatments ranged between 54-98. The mean TDS was 76 mg/l for Coppens and Dizengoff and 75.5mg/l for Chi. There was no significant difference (P>0.05) in water quality parameters in all the treatments (Table 3).

Table 3: Summary of some water quality parameters during the culture period

Parameters	Treatments	Ranges	Mean	S.E
Temperature ºC	Coppens	20.1 - 33.3	26.7	6.6
	Chi	20.0 -33.2	26.6	6.6
	Dizengoff	21.0 – 33.7	27.35	6.35
PH	Coppens	6.98 - 8.51	7.75	0.77
	Chi	6.88 -8.4 0	7.64	0.76
	Dizengoff	6.89 – 8.49	7.69	0.8
Dissolved Oxygen	Coppens	4.3 - 7.75	6.03	1.73
	Chi	4.2 -7.76	5.98	1.78
	Dizengoff	4.2 – 7.10	5.65	1.45
Conductivity	Coppens	109 – 198	153.5	62.93
	Chi	108 – 190	149	41
	Dizengoff	109 – 197	153	44
Total dissolved solute (TDS)	Coppens	54 – 98	76	22
	Chi	54 - 97	75.5	21.5
	Dizengoff	54 – 98	76	22

The proximate composition of the three feeds given by the manufacturers is presented in Table 4. Chi had the highest crude protein of 45%, while both Coppens and Dizengoff contain 42% each. For ash, Chi had 8.5%, closely followed by Coppens 7.2%, and lastly Dizengoff 6.7%. Also Coppens and Dizengoff contain 13% and 14% crude fat respectively, while Chi has 8%. For crude fibre, Chi had the highest; 8%, Coppens 7.4%, while Dizengoff had 6.2%.

Table 4: Proximate composition of experimental feeds

Nutrients	Coppens	Chi	Dizengoff
Moisture%	3.0	5.0	4.0
Crude protein%	42.0	45.0	42.0
Crude Lipid%	13.0	8.0	14.0
Crude fiber%	7.4	8.0	6.2
Ash%	7.2	8.5	6.7
Nitrogen-free extracts%	30.8	25.5	27.3

The proximate composition of the feeds from the manufacturers (Table 4) did not show remarkable difference from that obtained after the proximate analysis (Table 5). Chi had the highest crude protein of 43%, while both Coppens and Dizengoff contain 41% and 40% respectively. For ash, Chi had 9.5%, closely followed by Coppens 8%, and lastly Dizengoff 7.3%. Dizengoff had the highest crude fiber content of 12%, followed by Chi with 10% and Coppens 5% respectively.

Table 5: Result of proximate analysis of experimental feeds

Nutrients	Coppens	Chi	Dizengoff
Moisture%	3.0	4.8	3.0
Crude protein%	41.0	43.0	40.0
Crude Lipid%	11.9.0	9.3	13.0
Crude fiber%	5.0	10.0	12.0
Ash%	8.0	9.5	7.3
Nitrogen-free extracts%	29.8	22.5	26.3

6. Discussion

The physico-chemical parameters of Ahmadu Bello University reservoir were optimal for fish growth. This result corroborates that of Boyd and Lichtkoppler (1979) [19] who Recorded that fish require moderate temperature of between 25–32 °C and pH range of 6.7 - 8.6 for optimal growth. Labon (1993) [20] had also reported an optimal temperature range for the growth of warm water fish as 23.9-32.2 °C, and pH range of 6.5-9.0. Higher ranges of Dissolved oxygen (DO) recorded during the rainy season were due to the churning of water by heavy wind action and mixing. Furthermore, the arrangement of the cages in a row perpendicular to the wind direction at a depth of 6-7m provided maximum quantity of oxygenated water to all the cages and also flushed out organic waste. Dissolved oxygen has been attributed a great significance as an indicator of water quality especially the magnitude of eutrophication. Dissolve oxygen concentration in water is mainly dependent upon temperature, dissolved salts, velocity of wind, pollution load photosynthetic activity and respiration rate (Zuitshi *et al*., 1990) [21]. The high survival rate recorded in all the treatments could be attributed to the favorable physico-chemical parameters of the water body, the good health condition of the fish stocked, the quality and quantity of the feeds used and also, the fish acceptance of the feeds. The high survival validates the report of Otubusin (2000) [22] and Osofero *et al*., (2007) [23] that survival range of 98.5–99.5% is attainable in cage culture system.

The quality and quantity of the protein in the three commercial diets in this study could be a factor responsible for the high yields obtained. Similar results were recorded by Faturoti *et al*. (1986) [24], and Fagbenro *et al*. (1992) [25], who reported that the African catfish Clarias gariepinus and Heterobranchus bidorsalis tend to require at least 40% crude protein for normal growth. Also, Otubusin *et al*., (2004) [26], recorded a harvest of 103.5kg per m3 of C. gariepinus juveniles in floating bamboo cages in Ajanla farms at stocking density of 308 juveniles per m3.Tacon (1987) [27] reported that dietary protein levels of 42% for fry and 35% for growing adult fish appeared to be the best.

Growth response was more in the rainy season compared to the dry season. This could be due to favourable environmental conditions leading to food abundance in the rainy season. Also the relatively cold temperatures of about 20 °C in the month of February and part of March probably reduced the metabolic activities of the fish because it was below the optimum required for warm water fishes, thus

resulting in poor growth of Clarias gariepinus in the study.
Production estimates based on gross and net yield for growth gain were the basis for estimating the economic revenue from the fish culture operation. The high gross profit, low EWG and good profit index for fishes fed with Coppens and Chi, could be attributed to good feed quality, acceptance of fed by fish, and suitable water quality parameters, results in better growth performance and relatively high survival rate.
The total cost of feed fed, coupled with the high price of feed per kilo, increased the cost of production and affected the profit index from the revenue generated from the sale of fish.

7. Conclusion

The high yield (average: 67kg/m3) from this feeding trial suggest that with the necessary technical and financial assistance, Cage culture system could be successfully used for intensive table size catfish production on small scale involving local fishermen in Northern Nigeria. These small scale farmers are in the best position to utilize the vast unpolluted water bodies in the country for catfish cage farming which could be a practical solution to the problem of inadequate protein for the country's growing population.
The result has also shown that, research on fish nutrition by Nigerian scientists spanning several decades, is beginning to yield dividends as the locally manufactured Chi feed which is cheaper and accessible competed favourably with the imported feeds (Coppens and Dizengoff) which apart from being more expensive are often hardly available.
Chi feed, is strongly recommended for catfish production.

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