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Growth Performance, Nutrient Utilization and Survival of African Sharptooth Catfish (*Clarias gariepinus,* Burchell 1822) Fingerlings Fed Locally Formulated and Commercial Pelleted Diets Reared in Tarpaulin Tanks

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ABSTRACT

This study evaluated growth performance, nutrient utilization and survival of cultured *Clarias gariepinus* fingerlings fed locally formulated (sinking) and commercial (floating) pelleted diets in tarpaulin tanks. Fingerlings of initial mean weight (72.99 g ± 3.09) were stocked in each treatment replicated 3 times. Fish were cultured for 8 weeks. The stocking rate was 15 fish per m^2. The fish were fed three times daily at 5% body weight. Results showed that *C. gariepinus* fingerlings fed floating (commercial) diet had significantly higher ($p<0.05$) final mean weight (921.73 g ± 47.44) than sinking (locally formulated) diet (184.22 g ± 20.54). Commercial feed had higher ($p<0.05$) specific growth rate (3.29 ± 0.07) than locally formulated diet (0.97 ± 0.20). Fish fed commercial diet has significantly lower ($p<0.05$) feed conversion ratio (0.83 ± 0.03) than locally formulated diet (3.23 ± 0.40). Protein efficiency ratio was significantly ($p<0.05$) lower in fish fed locally formulated diet (0.80 ± 0.11) than commercial diet (2.69 ± 0.09). There was no significant difference ($p>0.05$) in survival rate for fish fed commercial feed (95.55 % ± 2.22) and locally formulated feed (97.78 % ± 2.22). Water quality parameters including temperature (°C), dissolved oxygen (mg/l) and pH were not significantly different ($p>0.05$) during the study and were maintained within acceptable range. Proximate analysis of the dry matter of the two experimental feeds showed that the commercial feed had higher value of crude protein (45%) and crude lipid (14%) and lower value for crude fibre (2.5%), total ash (7.5%) and carbohydrate (28.2%) when compared with the sinking diet of lower crude protein (22.75%) and crude lipid (8.06%) and higher value of crude fibre (9.66%), total ash (11.50%) and carbohydrate (48.06%). Based on these findings, commercial feed is recommended for feeding *C. gariepinus* fingerlings since it showed higher growth performance, better nutrient utilization and greater survival.
Keywords: commercial feed, locally formulated feed, floating feed, sinking feed, *Clarias gariepinus*, growth performance.

INTRODUCTION

Fish is a vital source of animal protein for many households. FAO (2007) stated that fish contributed more than 60% of the world supply

of protein, especially in the developing countries of which Nigeria is among.[1] Feeding is one of the most important inputs in aquaculture which a farmer cannot do without, mainly when fish are raised under intensive or semi-intensive system.[2] Feeding cost is the highest single cost item of most fish farm operations, accounting for over 60% of the total cost of fish production.[3]Both over and under-feeding can be detrimental to the health of the fish and may cause a marked deterioration in water quality, reduced weight gain, reduced feed utilization, and increased susceptibility to infection.[4] Therefore there is the need to obtain a balance between rapid fish growth and optimum use of the supplied feed for the operation to be economically viable and for the fish health to be maintained. In aquaculture, fish requires adequate food supply in the right proportions and with proper nutritional contents needed for growth, energy, production, movement and other activities which they carry out.[5]If growth performance and feed efficiency are increased in commercial aquaculture, the costs of production are likely to be reduced. Therefore there is the need to obtain a balance between rapid fish growth and optimum use of the supplied feed for the operation to be economically viable and for the fish health to be maintained. Commercial diet brands popular in the Nigerian market are Coppens, Multi feed, Skretting, Sarb, Vital feed, Top feed, Chi feed, Trend feed, Aqua feed, Aqua mana, Aqua mix and NIOMR feed amongst others. All these are floating diets.

Clarias gariepinus is a major fish species for aquaculture in Africa and it has also been introduced in Europe and Asia. It is cultured for its omnivorous feeding habit, high growth rate and its resistance to handling and stress.[6] *C. gariepinus* is one of the most cultured fish species in Nigeria because of the good adaptability to captivity condition, rapid growth rate, flesh tastiness, hardiness and disease resistance ability.[7][8][9]

Some studies have actually compared the growth performance, nutrient utilization and survival of *C. gariepinus* fed floating (commercial) and sinking (locally formulated) diets. Moreover, these studies have yielded varying results when floating and sinking pellets

are compared on their effect on growth performance, survival and nutrient utilization. Ajani *et al.* (2011) found similarity in mean weight gain and daily feed intake for *C. gariepinus* fed floating and sinking feeds.[10]Ekanem *et al.* (2012) found significant differences in weight gain, growth rate, specific growth rate and mean growth rate of fish *C. gariepinus* fed Coppens (floating) and Unical Aqua feed (sinking).[11]Olanipekun (2014) showed that floating and sinking feeds showed variations in growth performance with higher mean weight gain and mean growth rate in fish fed sinking diet and also, lower feed conversion ratio and higher survival rate in fish fed sinking feed.[12] Mustapha *et al.* (2014) showed significant higher weight increase, specific growth rate for *C. gariepinus* fed Coppens (floating feed) than those fed with local formulated feed (sinking).[13]Limbu (2015) showed that *C. gariepinus* fed floating or sinking diets did not significantly affect growth and survival.[14] These discrepancies call for more studies in the feeding of *C. gariepinus* to unveil the underlying causes.

Limited studies have been carried on how tobest utilize the bottom feeding habit of *C. gariepinus* in order to recommend the suitable diet between floating and sinking diets.[13]Thus, farmers are unable to decide which diet to choose for their *C. gariepinus* due to paucity and unavailability of published scientific data on growth performance, nutrient utilization and survival when the fish is fed on floating and sinking diets. The objective of the present study was to compare the growth performance, nutrient utilization and survival of *C. gariepinus* fed on floating (commercial) and sinking (locally formulated) diets.

MATERIALS AND METHODS

The study was carried out at Fulfillment Fish Farm, Obio Offot, Abak Road, Uyo Metropolis, Akwa Ibom State. The experiment was conducted for eight (8) weeks using 6 tarpaulin tanks of 1 M^3 total volume.

The fingerlings were collected from fish seed produced in Fulfillment Fish Farm through artificial propagation as described by Ngugi *et al.* (2007).[15] Ninety (90) fingerlings of similar sizes were selected from this unit stock and acclimated for two weeks. The fingerlings used for the experiment were about 9 weeks old prior to stocking and were stocked at the rate of 15 fish per M^3.

Experimental Feed

The floating (commercial) diet (Skretting feed manufactured in Israel) was purchased from a reputable feed retailer in Uyo, Nigeria. Sinking feed was locally formulated using the Pearson square method of feed formulation and continued with trial and error method for precision. Locally available feed ingredients were used in formulating the sinking feed. The ingredients used were fish meal (mainly clupeids such as *Ethmalosa fimbriata, Sardinella* marginata, etc.), soybean cake (full fat), groundnut cake, palm kernel cake, white maize (*Zea mays*), fish premix, lysine, methionine, salt, palm oil (from *Eleas guineensis*) and Vitamin C. Ingredients for the production of the experimental sinking diet was purchased from a local supplier at the popular Ariaria International market, Aba, Abia State, Nigeria, based on nutrient composition, availability and cost using market prices and available literature. All ingredients were bought in solid and dry form exception of palm oil. White maize seeds were processed by toasting mildly in order to reduce anti-nutritional factors and improve the bioavailability of the nutrients to the fish.[16] Fish meal was also toasted to remove all moisture content in order to ensure proper milling. Aside grinding, all other ingredients used in the production of the sinking diet were not introduced to any other form of processing. [14]

Bulk ingredients (fishmeal, groundnut cake, soybean cake, white maize, palm kernel cake) were sent to Biochemistry Laboratory, University of Uyo for proximate composition. Method used was the standard method of Association of Official Analytical Chemists. [17]

All dried ingredients were milled into fine particles of homogenous sizes. This was to enable proper mixing before it was weighed out according to proportion in the feed formula. Basal ingredients (palm kernel cake and white maize) and protein supplement (fish meal, groundnut cake and soybean cake) ingredients were mixed first homogenously with the help of a spade. Fish premix, lysine, methionine, vitamin C (solution), palm oil and salt were then added in the right proportion and mixed continuously to obtain a homogenous mixture. The mixture was then blended with warm water to form dough that enabled easy pelleting. The dough mixture was subjected to a locally fabricated (manual) fish feed pelletizer. The resultant 2mm fish feed pellets were sun-dried for 72 hours to eliminate all moisture that may cause the buildup of moulds during storage. These were packed in air tight polyethylene bags for storage. The high CHO content in the sinking diet which was not cooked made the sinking feed sink.

A dried sample of the experimental sinking feed was sent to Biochemistry Laboratory of University of Uyo for proximate nutrient analysis (moisture, protein, oil, fibre, ash) using standard methods.[17] The proximate analysis of the floating feed used was that of the manufacturing company's given analysis.

Experimental Procedure and Design

Ninety (90) fingerlings of *C. gariepinus* were acclimatized for two (2) weeks in 1000 litre ($1m^3$) experimental tarpaulin tanks prior to the start of the experiment. Sinking (locally formulated) and floating (commercial) pellets were used for the study as treatment. Each treatment was replicated three times. Each tarpaulin tank measuring 1m × 1m × 1m was filled to a depth of 45cm with borehole water (i.e. 0.45 M^3 total volume of water per tank). The tanks were labeled A_1, A_2 and A_3 for the floating feed trials and B_1, B_2 andB_3 for the sinking feed trials.

Fingerlings with initial mean weight 72.99 g ± 3.09were used at the start of the experiment. At the start of the feeding trial, the

acclimatized fish were starved for 24 hours to empty the gut and prepare them for the feeding trial before the mean initial average weight was taken. All fish were fed 3 times daily at 5% biomass for 56 days (8 weeks). Pellet size of 2.5 mm for both diet were used throughout the duration of the experiment. Fingerlings were weighed fortnightly and feed ration adjusted accordingly. Water was also changed bi-weekly after weight data collection.

Water Quality Analysis

The water quality parameters such as dissolved oxygen, temperature and pH were observed weekly. Dissolved oxygen and temperature was measured using DO meter (HI 9461) in mg/l and °C units respectively while pH was measured using a pen type pH meter (pH-009 III).

Growth Evaluation

Sampling of fish was done forth nightly by draining whole water from all tarpaulin tanks. Fingerlings from each tank were collected with a plastic filter basket and then weighed to nearest 0.01g using an electronic weighing balance (TD6002A). Data obtained biweekly was used to determine specific growth rate and mean weight gain. At the end of the experiment, results from weight as well as diet data were used to determine growth performance parameters such as final mean weight, mean weight gain, percentage mean weight gain, specific growth rate, feed conversion ratio, protein efficiency ratio, survival rate, mortality rate and performance index using the formulae below.

Mean weight gain (g) (MWG)

$MWG = Wt_2 - Wt_1$

Where Wt_2 = final mean weight of fish at time T_2

Wt_1 = initial mean weight of fish at time T_1

Percentage mean weight gain (%) (PWG)

$$PWG = \frac{MWG \times 100}{MIW}$$

Where MWG = Mean weight gain of the fish

MIW = Mean initial weight of fish

Specific growth rate (%/day) (SGR) [18][19]

$$SGR = \frac{100 \times [In\ (Final\ mean\ weight) - In\ (Initial\ mean\ weight)]}{Rearing\ duration\ in\ days}$$

Where In = Natural logarithm reading (Log_e)

Feed conversion ratio (FCR) [18]

$$FCR = \frac{Dry\ weight\ of\ feed\ given\ (g)}{Wet\ weight\ gain\ by\ fish\ (g)}$$

Protein efficiency ratio (PER) [20]

$$PER = \frac{Wet\ weight\ gain\ by\ fish\ (g)}{protein\ intake\ (g)}$$

Where;

$$Protein\ intake = \frac{\%\ protein\ in\ feed \times total\ weight\ (g)\ of\ diet\ consumed}{100}$$

Survival rate (%) (SR)

$$SR = \frac{Total\ no\ of\ fingerlings\ that\ survived \times 100}{Total\ no\ of\ fingerlings\ stocked}$$

Mortality rate (%) (MR)

$$MR = \frac{NT1 - NT2 \times 100}{NT1}$$

Where;

Nt_1 = Number of fingerlings stocked

Nt_2 = Number of fingerlings remaining

Performance index (PI) [21]

$$PI = \frac{SR \times (MFW - MIW)}{Rearing\ period\ in\ days}$$

Where;

SR = Survival rate

MFW = Mean final weight

MIW = Mean initial weight

Statistical Analysis

Growth parameters, nutrient utilization parameters and water quality parameters were subjected to one-way analysis of variance (ANOVA) to test for significant difference at 0.05 level. Results

with $P \leq 0.05$ were considered significantly different.[22]The statistical analysis was done using IBM SPSS Inc. (Windows version 22.0).

RESULTS

Proximate Composition of Experimental Diets

Percentage composition of feed ingredients used in formulating the sinking feed is given in Table 1 and the proximate composition of experimental feeds given in Table 2. The proximate composition of the experimental feeds revealed that there were significant differences ($P<0.05$) in the composition of crude protein, crude fibre, crude lipid, total ash and CHO. The commercial feed had higher content of crude protein (45%) and crude lipid (14%) when compared with the locally formulated feed of crude protein (22.75%) and crude lipid (8.06). The locally formulated diet had higher crude fibre (9.66%), total ash (11.50%) and CHO (48.06%) than the commercial diet of crude fibre (2.5%), total ash (7.5%) and CHO (28.2%).

Table 1: Percentage composition of feed ingredients for compounded sinking feed

Feed ingredients	Commercial	Locally formulated
Fishmeal	-	10.18%
Soybean cake	-	30.56%
Groundnut cake	-	53.93%
White maize	-	1.29%
Palm kernel cake	-	1.29%
Premix	-	0.25%
Salt	-	0.4%
Vitamin C	-	0.1%
Methionine	-	0.5%
Lysine	-	1.0%
Palm oil	-	0.5%
Total	-	100%

Table 2: Proximate composition of the experimental diets (dry matter)

Parameters (%)	Commercial	Locally formulated
Crude protein	45	22.75
Crude fibre	2.5	9.66
Total ash	7.5	11.50
Crude fat	14	8.06
CHO	28.2	48.06

Growth Performance, Survival and Mortality of *C. gariepinus* during the Study

The growth information of *C. gariepinus* fingerlings fed commercial and locally formulated diets are represented in Table 3. The biweekly mean weight (MW) for *C. gariepinus* during the study is shown in Fig. 1and specific growth rate (SGR) in Fig. 2 respectively. The biweekly MW showed increasing trend while SGR decreased biweekly for both experimental diets. At the start of the experiment, the mean weight of the fish were 70.96 g ± 5.84 and 75.01 g ± 3.10 for *C. gariepinus* fed commercial and local formulated diets respectively. Final weights were 921.73 g ± 47.44 and 184.22 g ± 20.54 for floating and sinking diets respectively. Significant differences were observed in some cases between growth parameters of *C. gariepinus* fed floating and sinking diets ($p<0.05$).

From the results on growth parameters, commercial and locally formulated diets had no significant effect ($p>0.05$) on mean initial weight (MIW), survival rate (SR), and mortality rate (MR). There were significant differences ($p<0.05$) however between growth parameters such as mean final weight (MFW), mean weight gain (MWG), percentage mean weight gain (PMWG), specific growth rate (SGR), and performance index (PI) in *C. gariepinus* fed floating (commercial) and sinking (locally formulated) diet.

C. gariepinus in tanks fed with floating (commercial) feed showed significantly ($p<0.05$) higher MFW, MWG, PMWG, SGR and PI than fish in tanks fed with sinking feed. Fish fed sinking (locally formulated) diet had SR than fish fed with floating diet; also, fish fed

floating diet had higher MR when compared to fish fed sinking diet, although no significant differences ($p>0.05$) were observed.

Table 3: Growth parameters, survival and mortality of *Clarias gariepinus* fingerlingsfed commercial and locally formulated diets during the study

Parameters	Commercial	Locally formulated	Test of significance at 0.05
Mean initial weight (g)	70.96 ± 5.84	75.01 ± 3.10	Ns
Mean final weight (g)	921.73 ± 47.44	184.22 ± 20.54	*
Mean weight gained (g)	849.77 ± 44.25	109.20 ± 17.46	*
Percentage mean weight gained (%)	1206.22 ± 67.52	144.21 ± 16.69	*
Specific growth rate(%/day)	3.29 ± 0.07	0.97 ± 0.20	*
Survival rate (%)	95.55 ± 2.22	97.78 ± 2.22	Ns
Mortality rate (%)	4.45 ± 2.22	2.22 ± 2.22	Ns
Performance index (%g/day)	1454.13 ± 101.28	191.43 ± 33.27	*

*Ns indicates no significant difference ($p>0.05$), * indicates significant difference ($p<0.05$)*

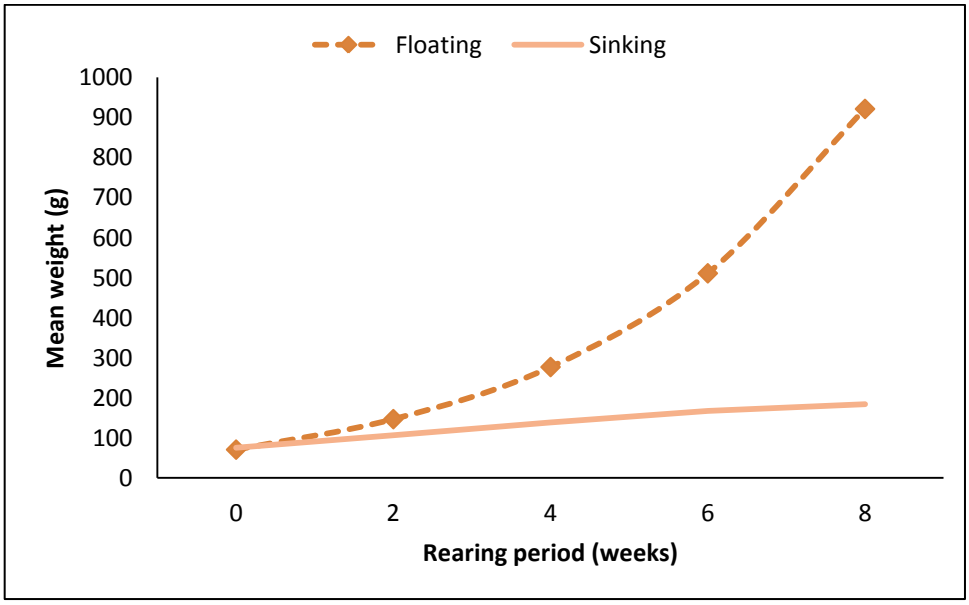

Figure 1: Growth performance of *Clarias gariepinus* fingerlings fed on Commercial and locally Formulated diets during the study

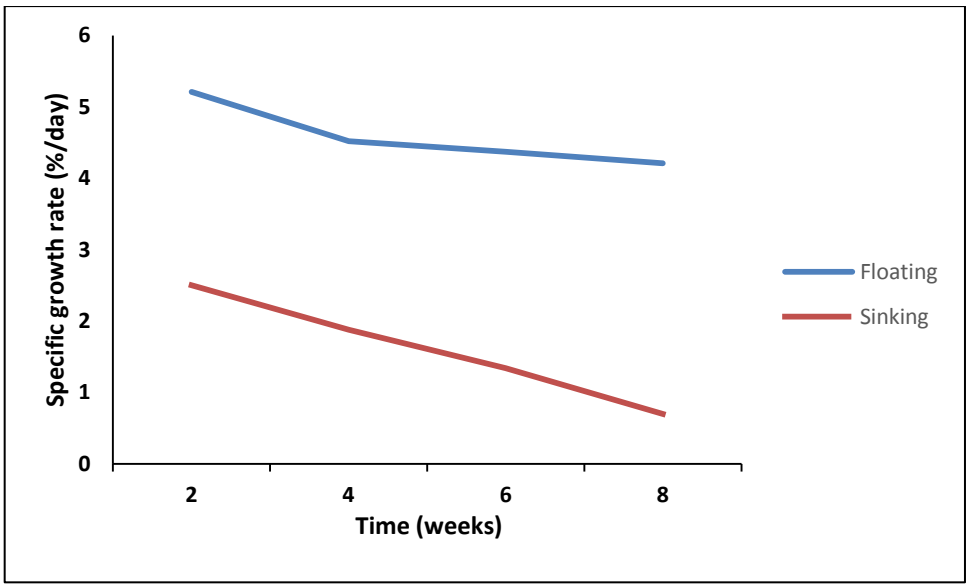

Figure 2: Specific growth rate of *Clarias gariepinus* fingerlings fed on Commercial and locally Formulated Diets during the study

Nutrient Utilization of *C. gariepinus* during the Study

Nutrient utilization data of *C. gariepinus* fed commercial and locally formulated diet during the study is presented in Table 4. From the results obtained, floating and sinking diets showed significant differences on feed conversion ratio (FCR) and protein efficiency ratio (PER). FCR was (0.83 ± 0.03) and (3.23 ± 0.40) in fish fed commercial and locally formulated diets respectively. Values obtained for PER were 2.69 ± 0.09 and 0.80 ± 0.11 for fish fed floating and sinking diets respectively.

Table 4: Nutrient utilization of *Clarias gariepinus* fingerlings fed commercial and locally formulated diet during the study

Parameters	Commercial	Locally formulated	Test of significance at 0.05
Feed conversion ratio	0.83 ± 0.03	3.23 ± 0.40	*
Protein efficiency ratio	2.69 ± 0.09	0.80 ± 0.11	*

** represent significant difference (p<0.05) between floating and sinking diets*

Water Quality Analysis

Table 5 shows the results of water quality parameters obtained during the study. There were no significant differences ($p>0.05$) in the water quality parameters of the tanks during the study. pH and water temperature were fairly stable among all treatments during the study. Temperature and dissolved oxygen were however higher in fish fed commercial diet, while higher pH values were observed in tanks fed locally formulated diet. The ranges were; water temperature (24.70 – 28.80 °C), dissolved oxygen (4.49 – 9.32 mg/l) and pH (4.70 – 8.50).

Table 5: Water quality parameters in the tanks during the study

Parameters	Commercial	Locally formulated	Test of significance at 0.05
Temperature (°C)	26.40 ± 0.21	26.21 ± 0.22	Ns
Dissolved oxygen (mg/l)	7.15 ± 0.48	6.34 ± 0.29	Ns
pH	7.57 ± 0.45	7.92 ± 0.45	Ns

Ns shows no differences ($p>0.05$) between water quality parameters of experimental diets

DISCUSSION

Fish feed is a major input in fish culture business and has remained a principal constraint to fish farmers in Nigeria and other developing countries because of high cost and availability.[23] Although, *C. gariepinus* is a bottom feeder, the fish prefer floating to sinking diet during the study. During this study, MIW, SR, MR and water quality parameters did not differ between *C. gariepinus* fed on floating (commercial) and sinking (locally formulated) diets. Results from the growth performance and water quality also indicated that fish fed the two experimental feed were optimally fed. According to Dwyer *et al.* (2002) both over-feeding and under-feeding may also affect the specific growth rates and the efficiency of feed conversion.[24] Over-and under-feeding can be detrimental to the health of the fish and may cause a marked deterioration in water quality, reduced weight, poor feed utilization, and increased susceptibility to infection.[4] According to Ng *et al.* (2000) over-feeding disrupts the water quality leading to low dissolved oxygen

levels, increased biological oxygen demand, and increased bacterial loads.[25]

The physico-chemical parameters of water used for culture of *C. gariepinus* during the experimental period were within the range recommended for African catfish culture.[26][27][28][29] The water quality parameters in the present study were not affected by the forms of the diets. All parameters measured did not differ significantly between floating and sinking diets. The physico-chemical parameters obtained in the current study were similar to those found by [30][31][10][11][13][14].These results highlight that, feeding *C. gariepinus* with floating and sinking diets does not cause significant deterioration of water quality parameters provided the diets are formulated correctly.

Growth data parameters, survival and mortality are great tools for evaluating the effect of feed and its value composition on fish species.[13]Fish like other animals; require essential nutrients for metabolic activities like growth, reproduction, repairs, etc. In this study, *C. gariepinus* responded positively to commercial and locally formulated diets as showed in their growth performance parameters (FMW, MWG, PMWG, SGR and PI). Growth performance indices evaluated in the present study showed that final mean weight (FMW), mean weight gain (MWG), percentage mean weight gain (PMWG), specific growth rate (SGR) and performance index (PI) of *Clarias gariepinus* fed floating diet significantly differed ($p<0.05$) from fish fed sinking diet. The current results have shown dissimilar growth performance between *C. gariepinus* fingerlings fed floating and sinking diets. These results agree and disagree in some areas from previous studies. Ajani *et al.* (2011) reported that there was no significant difference in the mean weight gain and daily feed intake of *C. gariepinus* fed floating and sinking diets.[10] However, they reported higher weight gain in fish fed floating diet than sinking diet. Similarly, Limbu (2015) reported that feeding *C. gariepinus* using either floating or sinking diets did not significantly affect growth and survival.[14]Olanipekun (2014) showed variations in growth performance with higher mean weight gain and mean growth rate in

fish fed sinking diet and also, lower feed conversion ratio and higher survival rate in fish fed sinking feed.[12] Meanwhile, Mustapha *et al.* (2014) and Ekanem *et al.* (2012) found higher growth performance for *C. gariepinus* fed floating diets compared to those fed sinking diets.[11][13]

From this study, results obtained agree with De Silva and Anderson (1995) who opined that the quality of a feed is a function of how well that feed meets the nutrient requirement of an animal.[32] The good growth performance, high digestibility and nutrient utilization of fish fed floating diet are an indication that the feed contained balanced nutrients as seen in the proximate composition.

The very low percentage composition of crude protein (22.75%), lipid (8.06%) and very high percentage composition of ash (11.50%), NFE or carbohydrate (48.06%) and crude fiber (9.66%) in the sinking (locally formulated) feed were responsible for the poor growth performance of *C. gariepinus* when fed with the feed with protein being most significant and limiting the growth. Researches show that fish growth is significantly influenced by the level of protein in the feed [33][34][35][36][37][38][39][40][13], with 40% dietary protein promoting maximum growth of *C. gariepinus*.[41][42]The crude protein in the sinking feed was far less than the acceptable range (30 – 45%) recommended for commercial fish culture.[43]

The poor growth response observed in tanks fed sinking diet was due to very low level of lipid (8.06%) in the diet. High amount of lipid ranging between 10-25% has been certified to produce the best growth performance in fish species.[44][45][46][47][48] Another possible cause of the slow growth performance in fish fed with the sinking diet is the high fiber content (9.66%) in the feed. This could be due to the inability of the fish to digest and utilize the high fiber content in the feed.[13] High level of fiber content in feed has been observed to slow the growth of *C. gariepinus* fingerlings.[49][50] In the results of Agokei *et al.* (2011),[47] the highest growth performance of *C. gariepinus* juveniles was found in the diet that contained <2% fiber content.

The ash content (11.50%) found in the sinking diet could also be responsible for the poor growth performance of the fish. Since necessary mineral elements such as calcium and phosphorous that promote growth in fish was lacking in the sinking diet, it might have also led to poor growth. However, high ash content of >12% in feed has been reported to produce better growth performance in *Clarias* species. [51][40]Values for the survival and mortality rate show that there was no significant difference ($p>0.05$) between *C. gariepinus* fed commercial and locally formulated diet. Survival has never been a main fear in the culture of *C. gariepinus* because of its resistance to water quality stress as well as diseases. [52][53] Likewise, survival rate was not a major concern in the present study because water quality parameters were optimum for *C. gariepinus* survival in the tank. The water quality parameters in the six tanks were within the tolerable limits for the culture of the species. Low mortality in the tanks was also due to the fish being fed optimum ration (5% biomass) as suggested by [54], and was effectively utilized by the *C. gariepinus* hence, not deteriorating the water quality.

In fish nutritional studies, the amount of feed consumed is a crucial factor for calculating feed conversion ratio (FCR).[11]Since feed is expensive, feed conversion ratio (FCR) is an important parameter for the determination of effective use of feed.[55]The proper understanding of FCR help the farmer to feed the fish to satiation, and when fish are fed exactly the quantity of feed required, they are not stressed and they provide high quality meat for human consumption.[56][57][58][59][60][61]For the present study, *C. gariepinus* fed commercial diet consumed more fed (2113.86 g) than fish fed locally formulated diet (1019.76 g). Ekanem *et al.* (2010) opined that growth and feed conversion ratio of a fish are remarkable tools to compute the acceptability of artificial feed. [62]

The present study indicates increased biweekly mean weight for *C. gariepinus* fed floating and sinking diets; this shows that the fish utilized the feed for growth. Biweekly mean weight gain increasing throughout the rearing period for *C. gariepinus* fed floating diet

indicates the fish converted the feed to flesh. The specific growth rate of *C. gariepinus* fed floating and sinking diets decreased biweekly with highest decrease in *C. gariepinus* fed sinking diet; this is a function of the poor nutrient composition of the sinking feed.

Results from the present study indicates significant difference ($p>0.05$) in feed conversion ratio (FCR) and protein efficiency ratio (PER) between *Clarias gariepinus* fed commercial and locally formulated diets. High FCR and low PER observed in fish fed locally formulated diet is traceable to the proximate composition of the feed. The low protein content in the sinking feed was responsible for the high FCR recorded in the fish. This shows that high amount of cheap sinking diet will be required to produce the fish to table size, thereby making the production of the fish more expensive as compared to expensive floating feed which requires less feed to feed fish to table size. Sawhney and Gandotra (2010) found that feed conversion efficiencies in fish increases with increasing protein in the diet.[63]

The present study showed that *C. gariepinus* does not utilize large amount of carbohydrates for growth, but protein as observed in fish fed with the commercial diet which contained a high percentage of protein (45%). Mollah and Alam (1990) reported negative effect of carbohydrate on growth of *Clarias batrachus* fry when levels were maintained at more than 15% in the diet.[64] Similarly, Tan *et al.* (2007) reported that carbohydrate in the diet of *Clarias* species should not exceed 20%, hence, FCR and PER begins to increase and reduce respectively.[65]

The inability of *Clarias gariepinus* to completely feed on the locally formulated feed could be linked to the less fishy odour of the feed since *C. gariepinus* uses olfactory senses during feeding. Agokei *et al.* (2011) as cited by Mustapha *et al.*, 2014 noted that high growth performance of *C. gariepinus* fed on coppens could be traced to fishy odour emitted by the feed.[47][13] Skretting commercial feed used in the study possessed high fishy odour thereby giving low FCR and high PER for fish in tanks fed floating diet. During feeding *C. gariepinus*

with floating feed, the fish responded more aggressively to feeding than fish fed sinking diet. This is also attributed to the fishy odour of the floating feed that makes it very inviting to the fish and also its floating and durability nature in water. More so, there was significant difference ($p<0.05$) in the quantity of feed consumed by *C. gariepinus* at the end of the feeding trial which is observed in their varying growth performance as pointed out in the present study.

CONCLUSION AND RECOMMENDATION

Farmers depend more on floating (commercial) diet which limits the development of *C. gariepinus* farming due to its being more expensive and requires specialized facilities to produce than sinking diets; moreover most farmers have no technology to produce it. The present study has shown significant difference in growth performance and nutrient utilization between *C. gariepinus* fed floating and sinking diets. FMW, MWG, PMWG, SGR, FCR, PER and PI were significantly higher in fish fed commercial diet, while there was no significant difference in SR, MR and IMW between fingerlings fed commercial and locally formulated diets.

From the present study, locally formulated diets are not good enough to enhance growth of *Clarias gariepinus*. This is due to poor balanced nutrient most especially protein and lipid being way lower than recommended values and CHO and Crude fibre being far above recommended values. The study recommends the use of commercial diet in feeding *Clarias gariepinus* since it gives better growth performance, nutrient utilization and survival.

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