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Effect of extruded and non-extruded feed types on growth performance of pure and hybrid *Clarias gariepinus*

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Abstract

Cost of feed has been the biggest challenge confronting aquaculture and efforts are geared towards reducing cost of production occasioned by feed. The standard feed used in aquaculture tanks are the extruded (floating) type which are more expensive than the non-extruded (sinking) feed types common in earthen ponds. This study aimed to evaluate the effect of feed types (extruded and non-extruded) on growth parameters in pure Clarias gariepinus and its hybrid. Two strains of 40 fishes each with an initial weight ranging from 134 to 820g due differences in breed, with an overall mean weight of 414.00± 26.4g were randomly assigned to either of the two feed types, in two replicates each in a randomized complete block design, and reared for eight weeks. Growth parameters such as Mean Growth Rate (MGR), Specific Growth Rate (SGR), Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Condition Factor (CF) were computed for all subclasses. Statistical analyses included descriptive and general linear model analysis of variance (ANOVA) using Minitab® 17 Statistical Software. Only feed type was significant ($P<0.05$) on all growth parameters except Absolute Growth Rate (AGR), while other factors studied were not significant ($P>0.05$) on all growth parameters. Similarly, feed type was significant ($P<0.05$) on weekly gain at weeks 7 and 8 whereas specie was significant ($P<0.05$) on gains at weeks 1, 4, 5 and 8, but the interaction of both factors was not significant ($P>0.05$) throughout the period of study. This study revealed that growth performance as indicated by the growth parameters and weekly gain was influenced by feed type, with the extruded feed exerting superior influence over the non-extruded feed. Also, it was observed that fish reared in plastic tanks depend solely on feed given to them and thus, the non-extruded feed clearly perform below the extruded feed in all growth parameters studied.

Keywords: African Catfish, Extruded feed, Non-Extruded feed, Growth Parameters

Effet des types d'aliments extrudés et non extrudés sur les performances de croissance de Clarias gariepinus pur et hybride

Résumé

Le coût de l'alimentation a été le plus grand défi auquel l'aquaculture est confrontée et les efforts sont axés sur la réduction des coûts de production occasionnés par l'alimentation. Les aliments standards utilisés dans les bassins d'aquaculture sont du type extrudé (flottant) qui sont plus chers que les types d'aliments non extrudés (coulants) courants dans les étangs en terre. Cette étude visait à évaluer l'effet des types d'aliments (extrudés et non extrudés) sur les paramètres de croissance chez Clarias gariepinus pur et son hybride. Deux souches de 40 poissons chacune avec un poids initial allant de 134 à 820 g en raison des différences de race, avec un poids moyen global de 414,00 ± 26,4 g ont été assignées au hasard à l'un des deux types d'aliments, en deux répétitions chacune dans un plan de bloc complet randomisé, et élevés pendant huit semaines. Les paramètres de croissance tels que le taux de croissance *moyen (MGR), le taux de croissance spécifique (SGR), le taux de croissance absolu (AGR), le taux de croissance relatif (RGR), le facteur de condition (CF) ont été calculés pour toutes les sous-classes. Les analyses statistiques comprenaient une analyse de variance descriptive et un modèle linéaire général (ANOVA) à l'aide du logiciel statistique Minitab®17. Seul le type d'aliment était significatif (P<0,05) sur tous les paramètres de croissance, à l'exception du taux de croissance absolu (AGR), tandis que les autres facteurs étudiés n'étaient pas significatifs (P>0,05) sur tous les paramètres de croissance. De même, le type d'aliment était significatif (P<0,05) sur le gain hebdomadaire aux semaines 7 et 8 alors que l'espèce était significative (P<0,05) sur les gains aux semaines 1, 4, 5 et 8, mais l'interaction des deux facteurs n'était pas significative (P>0,05) tout au long de la période d'étude. Cette étude a révélé que les performances de croissance indiquées par les paramètres de croissance et le gain hebdomadaire étaient influencées par le type d'aliment, l'aliment extrudé exerçant une influence supérieure sur l'aliment non extrudé. De plus, il a été observé que les poissons élevés dans des bacs en plastique dépendent uniquement de la nourriture qui leur est donnée et ainsi, la nourriture non extrudée performe clairement en dessous de la nourriture extrudée dans tous les paramètres de croissance étudiés.*

Mots clés : poisson-chat africain, aliments extrudés, aliments non extrudés, paramètres de croissance

Introduction

Wide range of production systems have been exploited for artificially cultured fish, which include cages, tanks and ponds, however culture in earthen ponds remains the most dominant production system in Nigeria. This preferred system of culture requires large expanse of land for intensive aquaculture in earthen pond which is becoming seemingly unavailable in many areas due to increased urbanization, diminishing land area and the attendant increase in fish demand due to population increase. Thus, for Nigeria to make significant contribution in aquaculture at global level, efforts are geared towards achieving higher production intensities by encouraging urban aquaculture system, that entails system of production which makes use of varieties of water and culture facilities that provide needed environment for the growth of the fish (Ayoola *et al.,* 2012).

Feeding is usually the largest operational cost of growing fish in aquaculture and can represent greater than 50% of the variable costs in growing fish. The choice of feeding method depends on factors such as type and age of fish, type and size of feed, size of the operation, available labor, and the type of culture system. A careful analysis of these factors is essential for successful and profitable fish culture (Tacon and Metian, 2013; Cao *et al.,* 2015). Fish reared in intensive tank systems require all nutrients in a complete pelleted diet since natural food is limited and fish cannot forage freely for natural foods (Chebbaki *et al.,* 2010). Globally, there are three production methods of fish feeds (floating, slow-sinking and sinking) to meet the nutritional requirement of fish species under artificial culture systems and the method can broadly be classified as extruded or extended method, and extrusion can be by dry or wet methods (Hematzade *et al.,*2013). The popular non-extruded feed used in Nigeria are the sinking (hard) pellets, which usually sink to the bottom of the aquacultural facilities while the extruded remain on water surface for a longer time thus, having more nutritional advantage than the non-extruded (Welker *et al.,* 2018). The floating ability depends on the degree of fineness of the grounded food components and mixing power of the machine (Hasan and Halwart, 2009). Despite this widely accepted method of feeding extruded feed to catfishes, the cost of such feed is higher compared to using non-extruded feed which is cheaper and more readily available. The sinking pellets have been mostly used in earthen ponds with comparable results which may be adduced to availability of other sources of feed in the near natural environment of the fish. The use of extruded feeds in aquaculture is known to be more environment-friendly and efficient than conventional pressed sinking pellets. Moreover, in the case of inland water aquaculture such as in lakes, such type of feeds is more appropriate to sustain fish production and minimize contribution to water quality degradation. Extruded feeds occur in floating, slow-sinking, and sinking feeds. Each type of extruded feeds is effective for specific species of fish depending on their feeding habits (Xie *et al*., 2018).There is a consensus that adopting extrusion process to make fish feed is the major means to ensure producing high quality and safe aquatic products for human health, which is also a trend for feed industry progress in the future (Abou-Zied *et al*., 2015).Growth is an important feature in fish assessment because it is related to vital characteristics such as fertility, sexual maturity, survival and body size. It is a manifestation of the net outcome of energy increases and losses within a framework of both biotic and abiotic conditions (Nwipie *et al*., 2015). As indices of growth, several parameters such as Absolute Growth Rate (AGR), Specific Growth Rate (SGR), Mean Growth Rate (MGR), Relative Growth Rate (RGR) and Condition Factor (CF) of fish have been investigated and reported by previous researchers (Abanikannda *et al*., 2019; Datta *et al,*.2013; Pepple and Ofor, 2011; Mansor, *et al.,* 2010; Varela *et al*., 2010; Bagenal, 1978; Ricker, 1975;Tesch, 1968; Brown, 1957 and Fulton, 1904). This study seeks to evaluate different growth parameters of *Clarias gariepinus* and its hybrid when fed extruded and non-extruded feed in plastic tanks where no natural feed augmentation is possible, identify the preference of the two fishes and make recommendations on the best feeding method for African catfishes, with the aim of reducing production cost and improving profit.

Materials and methods

Study site

This is a continuation of a previous study on hybridization of two species of African Catfishes involving pure *Clarias gariepinus* and the hybrid of *Clarias gariepinus* and *Heterobranchus bidorsalis* (Abanikannda *et al*., 2019), which was conducted at the Fish Hatchery of Lagos State University, Ojo – Lagos. This current research was conducted at a private fish farm along Ipaja Road, Lagos for a nine (9) week period.

Experimental units

The fishes studied were randomly selected from total of 281 fishes comprising 150 pure Clarias and 131 hybrids (Abanikannda *et al*., 2019). After random assignment into the four replicates, comparison was made between the four tanks to ensure that there was no statistical difference in the initial weights of the fish prior to commencement of the experiment.

Experimental design

The experiment was a randomized complete block design where the treatment investigated was Extruded (Floating) and Non-extruded (Sinking) feed types, blocked byspecies. The two treatment groups were further classified based on sex and two replicates of each treatment was used. In all, a total of 80, two months old fishes, comprising 40 pure and 40 hybrid fishes were investigated, in four (4) plastic tanks of equal dimension, with each tank accommodating only 20 fishes in a randomized complete block design. The fishes were reared for a period of nine weeks and fed commercially compounded two independent (floating and sinking) feed types (Aller Aqua) with the proximate analysis in Table 1. Fishes were fed twice daily with 100 grams of the respective feed type, and the water in the plastic tank was monitored for physicochemical properties and changed at three days intervals to ensure optimum rearing condition.

Measurements

Live weight of each of the fish were taken on a weekly basis in the morning using a professional digital scale sensitive to 0.00 gram, and the respective weights were recorded appropriately with the tanks ID and Weight.

Data collection and handling

Recorded data were transcribed into an excel worksheet indicating the weight, feed type and tank.

Table 1: Proximate analysis of fish feed compounded by Aller Aqua^{+}

Constituents	Floating (Extruded) Feed Proximate Content (%)	Sinking (Non-Extruded) Feed Proximate Content (%)
Crude Protein	43	45
Crude Fat	13	10
Crude Fiber	3.4	3.5
Crude Ash	6	9
Calcium	1	0.8
Sodium	0.3	0.3
Phosphorus	0.8	0.9

$^{+}$Source: Aller Aqua Fish Feed

Biological evaluation

All indices were computed using standard formula for Length-Weight Relationship (LWR), Condition Factor (CF), Absolute Growth Rate (AGR), Relative Growth Rate (RGR), Mean Growth Rate (MGR) and Specific Growth Rate (SGR) as described by Kareem-Ibrahim*et al*., (2021) with the following series of formula.

$W = aL^b$ which is transformed as $Log\ W = Log\ a + b\ Log\ L$.

$CF = \left(\frac{W.100}{L^3}\right)$ where W = Weight in gram,

L = length in (cm),

a = a constant being the initial growth index,

and b = growth coefficient.

$$AGR = \left(\frac{W_f - W_i}{t}\right)$$

$$RGR\ (\%) = \left(\frac{W_f - W_i}{W_i}\right) x\ 100$$

$$MGR\ (g/day) = \left(\frac{W_f - W_i}{0.5(W_f + W_i)t}\right) x\ 100$$

$$SGR\ (\%) = \left(\frac{Ln\ W_f - Ln\ W_i}{t}\right) x\ 100$$

Where W_f is final weight (g),

W_i is initial weight (g),

t is time (days), and Ln is natural logarithm.

Statistical analyses

All statistical tests and analysis were done using the modules for graphical box plots to check for normality, descriptive analysis, general linear model of analysis of variance and post hoc multiple comparison of means after a significant ANOVA of Minitab® 17 statistical software.

The statistical model describing the parameters for all variables studied is given as;

$Y_{ijk} = \mu + a_i + b_j + (ab)_{ij} + e_{ijk}$.

Where Y_{ijk} is the observed value of parameter on a particular fish

μ = the overall mean

a_i = the ith effect of feed type (i = 2, Floating, Sinking)

b_j is the jth effect of specie (j = 2, Pure, Hybrid)

$(ab)_{ij}$ is the interaction effect of feed type x specie, and

e_{ijk} is residual random error

Results and discussion

Pre-experimental measurement

Exploratory statistical analysis was conducted to examine the range of the measured variables and computed indices (Figure 1) to check that there was no significant difference in the initial weights of fishes assigned to the two feed types. The boxplots indicated that there were no outliers in both specie, and it had an initial weight ranging from 245g to 694g and an overall mean weight of 435.3g.

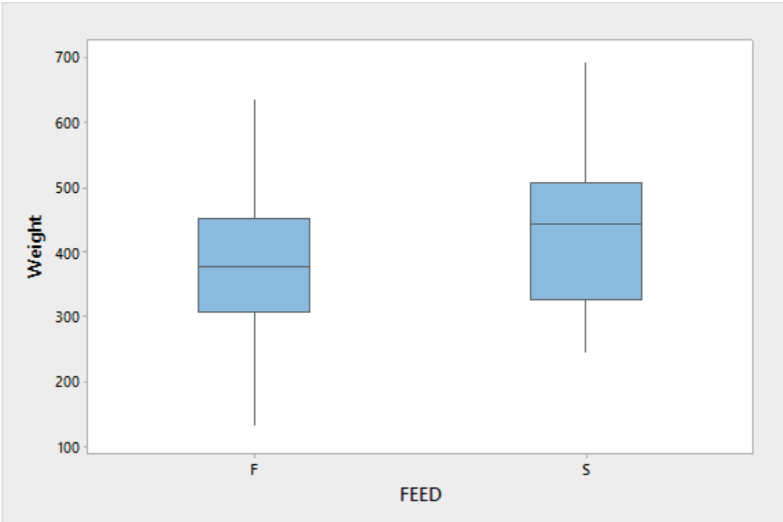

Figure 1: Boxplot of initial fish weight at the commencement of experiment by Floating (F) and Sinking (S) feed types.

Condition factor

The mean for the condition factor across both feed type was 0.68 $\pm$ 0.01 while the condition factor for extruded and non-extruded was 0.70 $\pm$ 0.01 and 0.66 $\pm$ 0.01 respectively (Table 2). Feed type was the only significant ($P<0.05$) source of variation on condition factor of all the factors studied (Table 3), while other variables (specie, feed type x species) had no statistical ($P>0.05$) influence on condition factor. There was a marginal 6% increase in the extruded feed over the non-extruded feed. This is in consonance with reports that feed type influence better growth performance in several fish species (Lee *et al.*, 2016; Hematzade *et al.*, 2013; Aba *et al.*, 2012; Chebbaki *et al*, 2010 and Ammar, 2008).

Table 2: Growth parameters by type of feed across species

Feed Type	Specie	N	SGR	AGR	MGR	RGR	CF
Extruded (Floating)	Combined	40	1.05±0.07[a]	6.35±0.72	1.01±0.06[a]	84.80±7.06[a]	0.70±0.01[a]
	Pure	20	0.99±0.10	5.71±0.76	0.96±0.09	79.30±10.1	0.69±0.01
	Hybrid	20	1.11±0.09	7.02±1.24	1.06±0.09	90.62±9.94	0.70±0.02
Non-Extruded (Sinking)	Combined	40	0.84±0.06[b]	4.75±0.43	0.81±0.06[b]	63.02±5.15[b]	0.66±0.01[b]
	Pure	20	0.74±0.09	4.26±0.68	0.72±0.09	55.54±8.40	0.66±0.02
	Hybrid	20	0.93±0.06	5.25±0.51	0.91±0.06	70.51±5.70	0.65±0.02

Means with different superscripts within the same column differs significantly ($P<0.05$)

Absolute growth rate

The mean absolute growth rate across both feed type was 5.54 ± 0.42g while the absolute growth rate for extruded and non-extruded was respectively 6.35 ± 0.72g and 4.75 ± 0.43g(Table 2). None of the factors was significant on absolute growth rate of fish (Table 3). It is noteworthy that despite the 33.7% superiority of the extruded feed over the non-extruded feed, the lack of significance can be explained by the very large difference within the pure and hybrid specie within each treatment. This observation is in consonance with Misra *et al.* (2002) and Limbu (2015) who reported no significant difference in growth for some species due to feed type.

Table 3: ANOVA of growth parameters by feed type across species

Source	df	SGR MS	AGR MS	MGR MS	RGR MS	CF MS
Feed Type	1	0.90*	51.39	0.74*	9483.27*	0.0304*
Specie	1	0.47	26.03	0.42	3418.55	0.0000
Feed x Specie	1	0.03	0.53	0.03	64.08	0.0014
Error	76	0.15	13.57	0.13	1489.27	0.0066
R-Squared (%)		10.88	7.02	10.99	10.32	5.99

* = P<0.05 ** = P<0.01 *** = P<0.001

Specific growth rate

The mean for the specific growth rate across both feed types was 0.94 ± 0.05 while extruded and non-extruded feed mean specific growth rate was 1.05 ± 0.07 and 0.84 ± 0.06 respectively (Table 2). Feed type significantly (P<0.05) influence specific growth rate (Table 3) accounting for almost 11% of total variation in specific growth rate. There was a 25% improvement in specific growth rate of extruded feed over and above the non-extruded feed.This result agrees with the study of Ammar *et al*. (2008) and Abou-Zied (2015) who both reported significantly better performance of *O. niloticus* fed extruded feed over non-extruded feed.

Mean growth rate

The mean growth rate across both feed types was 0.91 ± 0.04 while the extruded feed and non-extruded feed recorded 1.01 ± 0.06 and 0.81 ± 0.06 respectively (Table 2). Feed type accounted for almost 11% of total variation and was the only significant (P<0.05) source of variation on mean growth rate (Table 3). Other factors had no statistical (P>0.05) influence on this parameter. This observation confirms earlier reports that feed type exhibit better growth performance in several species (Lee *et al*., 2016;Hematzade *et al*., 2013; Aba *et al*., 2012; Chebbaki *et al.*, 2010 and Ammar, 2008).

Relative growth rate

The relative growth rate for extruded and non-extruded feed was respectively 84.80±7.06 and 63.02±5.15 (Table 2), whereas the overallmean across both feed type was 73.77±4.50. Feed type alone accounted for 10.32% of total variation (Table 3) in relative growth rate, which was a significant (P<0.05) source of variation on the parameter. Other factors investigated were not significant (P>0.05) on relative growth rate.This observation is due to differences in nutrient availability in the two feed types and corroborates earlier reports of Abou-Zied (2015) and Ammar *et al*. (2008).

Weekly Weight Gain: The mean weekly gain across the two feed types and species are as presented (Table 4). With the exception of Week 2 gain, where the sinking feed type had higher values than the floating feed type (Table 4), the floating feed had superior performance across the other seven weeks that the weekly gain was investigated (Figure 2).

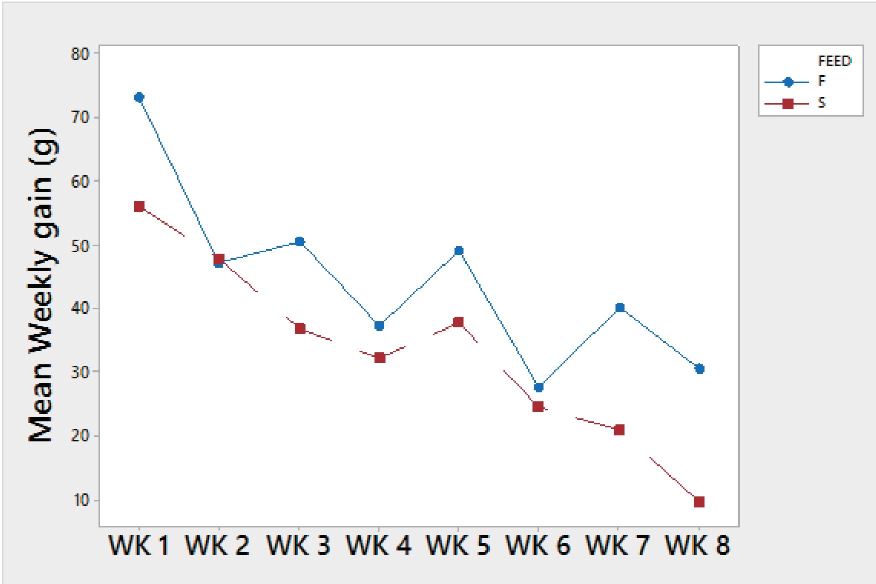

Figure 2: Weekly weight gain (g) by Floating (F) and Sinking (S) feed types.

The consistent superiority of the extruded feed over the non-extruded across the entire period of study is presented in Figure 3. The largest difference in weekly gain was recorded in Week 8, where the values for extruded feed almost triple those recorded for non-extruded (Table 4).

Effect of feed type

This factor was only statistically significant (P<0.05) on weight gain recorded in week 7 and 8 (Table 5). It respectively accounted for 11.27% and 12.68% of the total variation observed in weekly weight gain. This observation confirms earlier research reports that feed type influence better growth performance in fish (Lee *et al.*, 2016; Hematzade *et al.*, 2013; Aba *et al.*, 2012; Chebbaki *et al*, 2010 and Ammar, 2008).

Figure 3: Superiority of Extruded feed over Non-Extruded feed in weekly weight gain (g)

Table 4: Week gain (g) by type of feed across species

Feed Type	Specie	N	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Floating	Combined	40	73.13±7.45	47.17±6.09	50.42±6.36	37.40±6.76	49.15±6.53	27.69±4.44	40.13±5.44[a]	30.64±6.33[a]
	Pure	20	86.35±7.15	44.00±8.62	48.25±7.65	23.40±9.47	32.75±5.12	28.15±6.55	38.05±7.23	18.90±6.09
	Hybrid	20	59.90±12.6	50.35±8.77	52.60±10.3	51.40±8.81	65.50±11.0	27.21±6.13	42.32±8.35	43.00±10.8
Sinking	Combined	40	56.13±5.53	47.98±4.17	36.83±6.09	32.20±5.52	37.85±4.61	24.63±3.14	20.93±5.10[b]	9.70±6.05[b]
	Pure	20	65.90±8.09	47.05±6.81	32.20±8.58	25.20±8.61	33.65±7.35	18.70±4.17	12.45±9.32	3.50±10.5
	Hybrid	20	46.35±7.07	48.90±4.99	41.45±8.74	39.20±6.76	42.05±5.59	30.55±4.41	29.40±3.50	15.90±5.95

Means with different superscripts within the same column differs significantly (P<0.05)

Table 5: ANOVA of w eekly gain by feed type across species

Source	Df	Week 1	Week 2	Week 3	Week 4	Week 5	Week 6	Week 7	Week 8
Feed	1	5780.0	12.80	3699.2	540.8	2554.0	184.3	7321.0*	8914.0*
Specie	1	10580.0*	336.20	924.8	8820.0*	8487.0**	587.5	2221.3	6574.7*
Feed x Specie	1	238.0	101.25	120.0	980.0	2977.0	807.2	794.0	675.6
Error	76	1623.7	1112.33	1576.7	1434.8	1161.0	575.9	1085.0	1456.4
R-Squared (%)		11.86	0.53	3.81	8.66	13.71	3.57	11.27	12.68

* = P<0.05 ** = P<0.01 *** = P<0.001

Effect of Specie

Specie was a significant (P<0.05) source of variation in weekly gain of weeks 1, 4, 5 and 8 (Table 5). This implies that differences in four of the eight weekly weight gain was due to species of the fish, albeit at varying levels. This observation corroborates submissions of earlier researchers (Kareem-Ibrahim *et al*., 2021; Abanikannda *et al*., 2019; Akinwande *et al*., 2017; Megbowon *et al*., 2014; Martins *et al*., 2005; Nlewadim *et al*., 2004; Aluko and Ali, 2001 and Salami *et al*., 1993).

Conclusions and recommendations

The study revealed that feed type significantly affect all growth parameters studied except, Absolute Growth Rate, also hybrid outperformed pure *Clarias gariepinus* in all parameters investigated and that feed type only exerted significant influence on weekly gain at the seventh and eight weeks of study. Based on all these observations, it is recommended that the extruded (floating) feed is better in plastic tanks for maximum weight gain and consequently higher profit margin to the fishfarmer. It is also recommended that further comparative research should be conducted on the effect of both feed types in earthen ponds to evaluate the growth parameters fish reared in earthen ponds as a consequence of possible supplementation by the pond's flora and fauna.

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