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Investigation on Food Source to Substitute Commercial Feed in Aquaculture

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Abstract

Man's unquenchable need for food, combined with his limited financial means, fuels the never-ending hunt for a low-cost, acceptable feed that promotes good fish growth. This search inspired the research of the growth parameters of *Clarias gariepinus* (Burchell, 1822) fingerlings in static aquaria for 11 weeks on a commercial diet, cockroach feed, and fowl droppings. With the exception of temperature (p>0.05), all water variables were within acceptable ranges throughout the research. Regardless of protein level, no treatment had a significant effect on fish development (p>0.05). The lack of substantial fish growth (p>0.05) demonstrates the importance of additional growth factors in the cockroach diet, such as lipids, fibre, and carbohydrates. On the other side, commercial feed had the highest mean weight gain (18.42±13.12 g), average length (11.83±7.71 cm), average weight (17.00±13.92 g), and specific growth rate (0.360.15). Following that is the fish-fed cockroach (mean gain of 13.70±9.78 g, mean length of 9.87±5.94 cm, mean weight of 12.77±10.31 g, and specific growth rate of 0.34±0.14). On the other hand, fish-fed chicken droppings grew at the slowest pace (mean length (11.8±3.71 g), mean weight (17.00±13.92 g), and specific growth rate (0.360.15%). Additionally, cockroach feed had the highest survival rate (90 %), followed by commercial feed (83.33 %) and fowl droppings (66.33 %). Because the cockroach scores locally and readily available and is less expensive, it can take advantage of pricey commercial feed without significant growth. Without a doubt, cockroach feed is a feasible meal substitute for commercially produced feeds for low-income people.

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Introduction

Global consumption and demand for fish protein and fish products have increased at an unprecedented rate in recent years. Demand for fish is increasing as a result of the widespread publicity surrounding the health advantages linked with its nutritional components (Ayeloja *et al*., 2013). Additionally, meat protein is prohibitively expensive for the typical person, not to mention scarce in developing countries. Due to the paucity of cow protein, the value of the fish business has increased, attracting a variety of fish species for culture (Arlene *et al*., 2019). Besides its nutritive benefits, fish is a cheap source of protein and some essential nutrients required by the body (Iloba *et al*., 2020).

C. gariepinus is a popular and well-cultured fish in a number of African and other countries (Oke *et al*., 2016; Opiyo *et al*., 2017). Additionally, millions of artisanal fish farmers have raised *C. gariepinus* successfully without any formal training or professionalism. *C. gariepinus* farming's success is contingent upon its uniqueness. They reproduce rapidly, are omnivorous, and can withstand harsh climatic conditions (Onuoha *et al*., 2018). However, aquaculture's apparent solution to low fish supply is jeopardised by insufficient supplies and excessive feed prices. In Nigeria, the need for feed quality enhancement has been complicated by the country's economic recession and financial climate (Adeoye *et al*., 2012), which have damaged fish productivity and profitability.

The scarcity of feed, particularly high-protein fish feed, has slowed global aquaculture development, particularly in low-income nations such as Nigeria (Oke *et al*., 2016). The ever-increasing price trend and inconsistency of fish meal supply have encouraged extensive research into alternative plant and animal feed sources in aquaculture (Arlene *et al*., 2019; David and Afia, 2017; Muin *et al*., 2016; Oke *et al*., 2016). The use of farm and food wastes, agro-industrial byproducts, or household wastes as food or feed components has been touted as a viable technique for reducing fish feed costs (Arlene *et al*., 2019). Apart from plant-based feeds, which have been proven to retard growth and increase mortality in fish (Achi *et al*., 2018), animal-based fish meals have also been shown to be superior feed substitutes (Musa *et al*., 2012). One of the key success factors for fish farmers is supplying fish meals with an ideal amount of nutrients that are inexpensive or readily available, well-accepted (palatable), and easily replenished in order to promote rapid development, a high survival rate, and hence higher profit (Arlene *et al*., 2019; Jewel *et al*., 2018; Yakubu *et al*., 2015). In other words, the success of fish culture is contingent upon the composition of fish feed meeting the majority, if not all, of the characteristics given above. The current study examines the growth responses of catfish fed cockroach meal, commercial feed, and fowl droppings in order to identify a low-cost, acceptable diet that promotes healthy fish growth, reduces feed costs, and boosts profit.

Materials and methods

This experiment was conducted from February to May 2019 at Delta State University's Department of Animal and Environmental Biology in Abraka, Delta, Nigeria. The experiment was conducted in 24 × 47 × 33 cm plastic aquaria. Every two weeks, the culture water was changed, and physicochemical characteristics were determined. The water quality indicators dissolved oxygen, pH, temperature, and biological oxygen demand were all assessed during the experiment using standard methods.

Experimental design

Ninety *C. gariepinus* fingerlings ranging in length from 3.4 to 4.0 cm and in weight from 1.28 to 1.82 g were used in the experiment. The fish from the same broodstock were bought from Songhai Farm, Sapele, Delta State, Nigeria and were acclimatised for 14 days. Three plastic aquaria were labeled A, B, and C to denote unique treatments, with each label being duplicated three times. Each plastic aquarium was randomly assigned ten fish, and the three plastic aquariums labeled A were fed dry grounded cockroaches. Those assigned to group B received commercial feed, whereas those assigned to group C received fowl droppings. The cockroaches were dried in a low-heat frying pan to remove excess moisture. The dried cockroaches had been pulverised and were made suitable for consumption by fish. The fowl droppings were sun-dried to remove excess moisture. It was then sieved to obtain the right size for fingerling feed. Throughout the study, the fish were fed at a rate of 5% of their body weight every day between 8:00 AM and 4:00 PM.

Growth rate

The growth rate of *C. gariepinus* in terms of weight gain and the growth rate of each meal were investigated. Weight gain and the specific growth rate of each feed were used to determine the specific growth rate of *C. gariepinus* fingerlings. The fish were scooped from the plastic aquaria and carried to the weighing scale using a hand scoop net. A digital weighing scale was calibrated to 0.00 prior to placing the fish on the scale.

The formula (W1 – W0) / T was used to compute the growth rate.

Where W1 is the mean final body weight.

The starting mean body weight is denoted by W_0

T = The number of days in a calendar year

The mean weight gain (g) was determined as the sum of the fish's total weight divided by their total number in the tank.

The mean length (cm) of the fish in the aquarium was computed as the sum of the total length of the fish in the aquarium divided by the total number of fish in the aquarium.

The mortality rate (%) was estimated as (number of fish that died throughout the experiment divided by the total number of fish at the start of the experiment).

The survival rate (percentage) was computed as (Number of fish at the conclusion of the experiment divided by the number of fish at the start of the experiment).

The Specific growth rate (SGR) was determined as follows: (Final mean weight growth – initial mean weight gain) /Number of experimental days.

Statistical analysis

The means and standard deviations of the parameters are presented. To determine the treatment differences, data on growth parameters were analysed using One-way Analysis of Variance (ANOVA). All statistical computations were performed using Past 325 (2000) and all statistical significance was at the probability level of 0.05.

Results

A total of 90 *Clarias gariepinus* fingerlings used in this study measured between 3.40 and 4.40 cm in length and weighed between 1.28 and 1.82 g. Table 1 contains the nutritional makeup of the feeds employed in this investigation.

Table 1. The nutritional makeup of cockroach feed, commercial feed, and fowl droppings.

Nutritional Composition	Cockroach (%)	Commercial feed (%)	Fowl droppings (%)
Crude Protein	9.26	58.20	30
Fat	21.21	15.00	N/P
Fiber	7.52	2.00	N/P
Moisture	13.85	11.24	3.63
Carbohydrate	41.33	13	30.20

N/P = Not Provided.

The growth performance of fish fed various diets is shown in Table 2. The largest mean weight rise (18.42±13.12 g) was observed in fish-fed commercial feed, followed by fish-fed cockroaches (13.70±9.78 g) and fish-fed fowl droppings (9.51±5.69 g) (Table 2). The fish fed a commercial feed had the highest specific growth rate (0.36±0.15). In comparison, the lowest value (0.25±0.12) was obtained from fish-fed fowl droppings, whilst the highest value (0.34±0.14) was obtained from a fish-fed cockroach. None of these growth metrics was found to be significant (p>0.05) among the feeds (Table 2). The highest survival rate (90%) was observed in the fish given cockroach, followed by fish fed commercial feed (83.33 percent).

Throughout the research period, the fish fed with fowl droppings had the lowest survival rate (66.33 percent).

Table 2. Mean and standard deviation of growth parameters over the course of the study.

Growth Parameters	Cockroach	Zeigler	Fowl droppings	F-value	*p*-value
Feed intake	8.82±2.50	10.73±5.08	13.93±8.01	1.24	0.3167
Mean weight gain (g)	13.70±9.78	18.42±13.12	9.51±5.69	0.73	0.4981
Standard Growth rate	0.34±0.14	0.36±0.15	0.25±0.12	0.13	0.8785
Survival rate (%)	90.00	83.33	66.33	0.30	0.7482
Mortality rate (%)	10.00	16.67	33.33		

The temperature values ranged between 28.87±3.83 and 31.8±03.74°C, as indicated by the mean values of the water quality indicators tested during the study (Table 3). Additionally, dissolved oxygen concentrations were between 3.55±1.78 and 4.66±2.20 mg-1, pH values ranged between 6.35±0.50 and 6.65±0.54, while BOD concentrations ranged between 2.01±0.57 and 3.40±0.74 mg-1 during the study period. The one-way analyses of variance indicated no statistically significant variation in any of the water quality measures across the three experimental setups (p>0.05). The mean length and weight of the fish at the conclusion of the experiment indicated that fish-fed commercial food had the greatest length and weight, while that fed cockroach exhibited a reasonable size increment.

At the conclusion of the investigation, the fish-fed chicken droppings had the lowest length and weight rates (Fig. 1 A and B).

Table 3. The mean and standard deviation of the water quality metrics determined during the experiment.

Water Quality Parameters	Cockroach	Zeigler	Fowl droppings	F value	*p*-value
Temperature °C	30.68±4.78	28.87±3.83	31.80±3.74	0.77	0.4825
Dissolved Oxygen mgl^{-1}	4.66±2.20	3.55±1.78	4.13±1.62	0.04	0.9656
pH	6.65±0.54	6.35±0.50	6.51±0.40	0.782	0.4753
BOD mgl^{-1}	2.07±0.52	2.01±0.57	3.40±0.74	0.04	0.9656

Discussion

The differences in the growth parameter magnitudes in all treatments in the study demonstrated a non-significant difference (p>0.05). The non-substantiality in the fish growth is revealed in the similar biweekly progressive growth parameters of the *C. gariepinus* in renewable static culture. The lack of statistically significant fish growth (p>0.05) amongst the treatments demonstrates that the higher fish growth in commercial feed fed fish could be due to insignificant factors, probably not from the feed. This study, like previous ones, established the reliance on fish growth on biochemical components of feed diets. Thus, the lack of substantial fish growth (p > 0.05) demonstrates the importance of additional growth factors in the cockroach diet, such as lipids, fibre, and carbohydrates and not solely crude protein, which is regarded as a critical growth factor in fish farming. Simhachalam *et al.* (2015) also demonstrated the importance of feed biochemical composition on the growth and proximate composition of *Carassius auratua*, a freshwater ornamental fish culture, using zooplankton (animal feed) and commercial pellets. In the present study, crude protein amongst the experimental feeds was least in the Cockroach feed. Yet, the growth induced by the cockroach diet performed almost in parallel to the commercial feed. Ukoroije and Bawo (2020) demonstrated a similar effect on fish growth using 8.72 % crude protein as opposed to the 9.26 % crude protein in the Cockroach diet used in this study. This is also consistent with Iloba's (2020) study, which discovered the highest growth rate in feeds with the lowest crude protein content when analysing *C. gariepinus* growth performance induced by commercial feeds in a concrete tank. The One-Way Anova found no difference between the growth achieved by both the commercial and the cockroach diet. The non-significant difference in fish growth despite the overriding protein composition in the commercial feed suggests other contributory growth factors in the cockroach feed. This comparable growth induction is attributed to the other growth biochemicals such as fats, fibre, and carbohydrates. These additional nutritional contents of cockroaches exceeded those of commercial feed and thus may contribute to the excellent yield of fish-fed cockroaches.

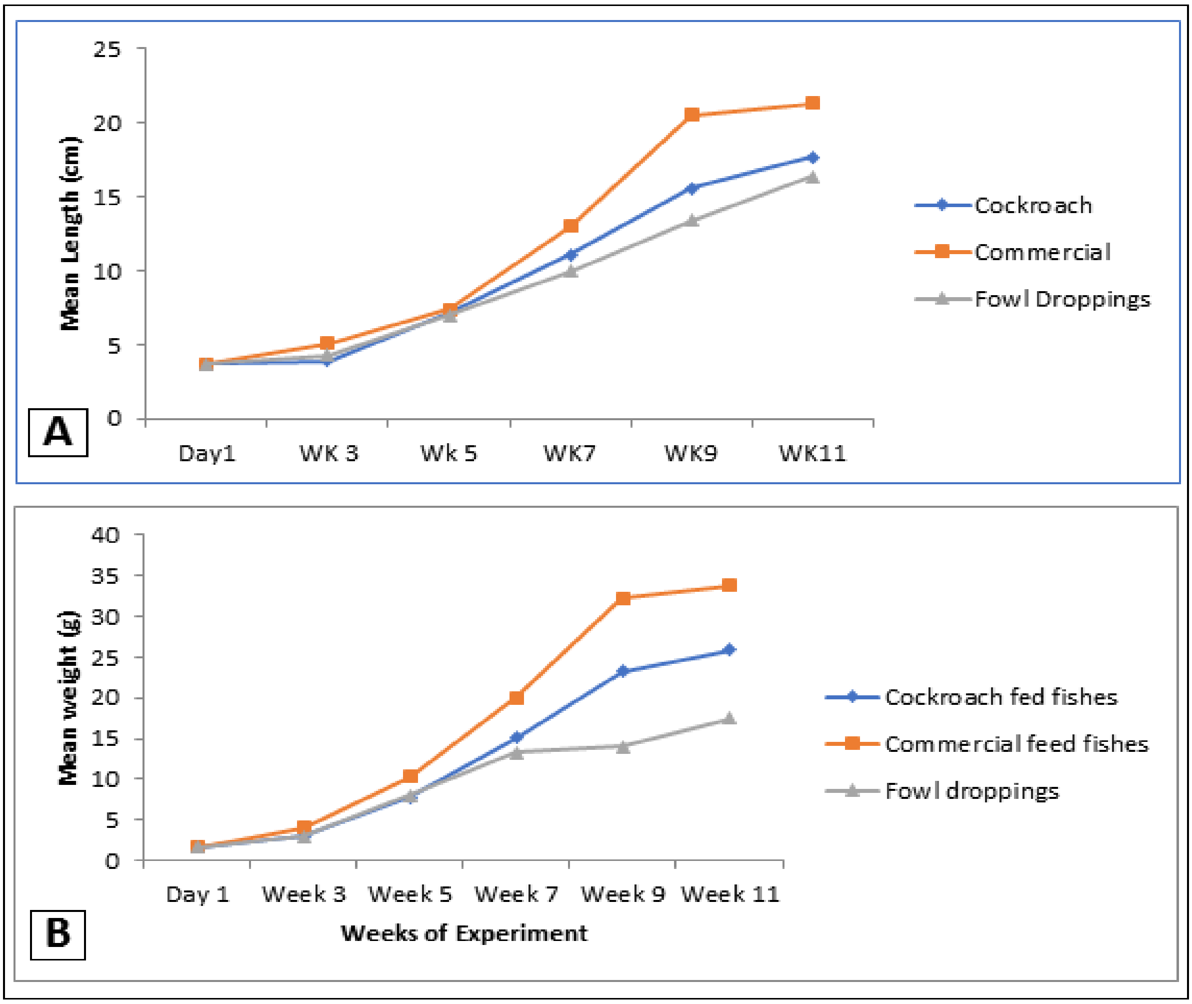

Fig. 1. A: Mean length and B: Mean weight of experimental fish fed feed Cockroach, Commercial feed, Fowl droppings over the course of the experiment.

The fish fed commercial feed gained the most weight, while the fish fed fowl droppings gained the least weight. The mean weight gain of the fish in the three treatments was not significantly different (p=0.4981), nor were the other growth parameters. Again, the disparity in growth indices might be explained by the nutrient makeup of the various feed diets provided. Kwikiriza *et al.* (2017) identified variances in feed content as one of the factors influencing weight increase discrepancies. However, the observation was made in the fish's natural environment.

Fish-fed commercial foods had the highest specific growth rate (0.36±0.15), while fish-fed fowl droppings had the lowest specific growth rate (0.25±0.12). The specific growth rate follows a similar pattern to the mean weight gain of fish, implying that cockroach-produced feed can be used in place of commercial feed in aquaculture. This is consistent with the findings of Babalola *et al.* (2018), who observed a similar pattern of specific growth rate and weight gain while evaluating the impact of dietary cassava dough (Fufu) kitchen waste as a maize substitute on the growth performance of *C. gariapinus* fingerlings.

On the other hand, feeding (intake) had no discernible effect on weight gain or other growth parameters. Weight gain's insignificant effect on other growth metrics may be related to nutritional status or underutilization of food. The weight gain's insignificant effect on other growth metrics could indicate that the duo's metabolizable energy is within the same range. This is consistent with Babalola *et al.* (2018)'s observation that similarities in fish weight gain and feed intake may indicate that the metabolizable energy values of fufu waste and maize are within the same range; However, in the current study, fish fed cockroaches had the lowest feed consumption but gained weight at a pace comparable to fish given poultry droppings and practically identical to fish fed commercial feed. This indicates that fish fed on cockroaches had a higher metabolizable value than fish fed on commercial feed or poultry droppings. According to El-Haroun (2007), feed consumption has a considerable effect on weight increase and other growth indices. However, the current research discovered no statistically significant difference in the standard growth rate of fish in the three treatments, as well as between feed intake and mean weight in the three treatments. The present study's minor difference in growth metrics contradicted Babalola *et al.* (2018) 's findings. When maize was substituted for cassava dough (Fufu) in a fish meal, the researchers observed a significant change in feed consumption and mean weight ($P<0.05$).

The fish mortality seen in all treatments could be a result of the higher water temperature towards the end of this research. Since all other physicochemical parameters except temperature were within the normal range for cultured fish during the entire study period. Iloba *et al.* (2016) reported a similar condition in their study on hydrogen ion (pH), ammonia, dissolved oxygen, and nitrite concentrations in catfish water recirculatory and semi-intensive static-water systems, and they hypothesised that the increase in temperature was caused by increased fish activity as growth progressed, waste generated, and the heat retained by the conservable-plastic natatorium.

The mortality rate in this study is in contrast to Arlene *et al.* (2019)'s research on the production of low-cost feeds for native catfish fattening, which showed 100 percent survival in one of their three treatments. Nonetheless, in this study, the fish-fed cockroach had the highest survival rate. The trial demonstrated a 90% survival rate throughout the research period. Fish fed commercial feed had an 83.33 percent survival rate, whereas fish fed fowl droppings had the worst mortality rate (63.33 %), which was attributed to the restricted area available to manage the biologically laden droppings and exacerbated by the culture's static nature. This finding corroborates the findings of Anyadike and Ugwuishiwu (2013), which evaluated water quality in waste-fed catfish and discovered that fish-fed poultry droppings had the greatest fatality rate of the three treatments utilised. The high mortality rate could be attributed to a large amount of ammonia formed during the hydrolysis of the fowl droppings, which facilitates the reaction of hydrogen ions released by water molecules with the organic nitrogen present in the fowl droppings. This is supported by Zeng-Guang *et al.* (2019)'s report, which noted that ammonia is toxic to fish by damaging their gills, reducing blood oxygen-carrying capacity, and interfering with metabolic activities, wreaking havoc on the liver and kidney. The fish's low cockroach consumption resulted in a considerable increase in growth rate and survival rate when compared to food intake, fowl droppings, and commercial pellets.

The outstanding performance of fish-fed cockroaches shows that cockroaches can be used in place of commercial feed due to their availability. There are several advantages to feed diets in aquaculture, all of which are anchored on finance. The cockroach is a low-cost, nutrient-dense food source that is readily available in Nigeria. Musa *et al.* (2012) demonstrated a similar observation while using Artemia nauplii, rotifers with fish meal, and rotifers with maize meal as starter feed on the growth performance of African catfish fry. However, the study recommended rotifers due to their availability and Artemia's cost implications. As a result, less expensive, locally and readily available cockroach feed can take advantage of more expensive feed that elicits a negligible growth response. Because no statistically significant difference exists between the standard growth rate and mean weight of fish in the three treatments, this also suggests that cockroaches can overcome the high cost of feed and financial constraints faced by catfish farmers, which were ranked as the most severe constraints.

This study demonstrated that cockroaches could be used in commercial feed to produce comparable growth yields at a higher profit margin than commercial feed, which discourages many people from fish farming. In addition to the benefits mentioned previously, cockroach feed can be used to eliminate the unsightly cockroaches that live in and around our homes by converting them to fish food. Cockroaches are readily available in Nigeria, with little reward other than collection input.

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