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EFFECTS OF REPLACING FISH MEAL WITH COCKROACH (*Periplaneta americana*) MEAL IN THE DIET OF AFRICAN CATFISH (*Clarias gariepinus*) FINGERLINGS

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ABSTRACT

This research investigated the growth performance of *Clarias gariepinus* fingerlings (mean weight 1.130.3g) fed cockroach meal (CM) as replacement for fish meal (FM). The fish were fed with three diets containing 45% crude protein; diet 1 (control 0% CM and 0% FM) diet 2 (10% FM, 0% CM), diet 3 (10% CM, 0% FM) for 56 days. The results showed significant differences ($p<0.05$) for the growth parameters evaluated for the treatments. Cockroach meal-based diet gave the best results in terms of mean weight gain (1.39±0.39g), food conversion ratio (2.54±0.15), specific growth rate (1.440.29%/day), protein efficiency ratio (0.87±0.20), apparent net protein utilization (16.23±7.19) and survival rate of 62%. This was followed by fish meal-based diet while the control diet gave a significantly ($p<0.05$) lower values. It can be concluded from the study that cockroach meal can substitute fish meal at 10% inclusion level. However, further study can be conducted for higher inclusion levels of cockroach meal in the diets of *C. gariepinus*.

Keywords: Insect meal, protein, catfish, feed, growth.

INTRODUCTION

Fish meal is recognized by nutritionists for its high quality nutrients (balanced amino acids, essential fatty acids, minerals and vitamins), high digestibility, palatability, large quantities of energy per unit weight and considerably low carbohydrate (Miles and Chapman, 2018). Due to large scale use of fish meal and declining harvest from the wild, keeping pace with the demand in aquaculture industry in view of its cost and availability calls for alternative protein sources (Ekelemu, 2010; Miles and Chapman, 2018). Madu *et al*. (2003) earlier stated that, fish meal constitutes 40-60% of the recurrent cost of most intensive fish farm ventures which negates the economic viability of the farm when cheaper alternatives are not available, a major constraint to aquaculture in Nigeria (Udo *et al*., 2011*)*. Much studies have been done to substitute fish meal with protein from plant sources (Fagbenro and Davies, 2002; Khan *et al.,* 2003; El-Marakby *et al*., 2006; Orire and Ozoadibe, 2015; Orire *et al*., 2015*)*. Other work considered feather meal, poultry droppings, insects, worms, garden snails and tadpoles (Devendra, 1988 and Ruth, 2017). The use of housefly maggots was reported in diets of tilapia, *C. gariepinus* and *Heterobranchus longifilis* (Madu and Ufodike, 2003).

Fish production is a key factor in food security in the developed and developing countries (Suvitha *et al*., 2014). Fish feed can be considered palatable if it is adequately accepted by fish, easily digestible, readily available and cost effective (Sogbesan and Ugwumba, 2008). In addition, adequate proportion of nutritional content should be available (Wang *et al*., 2006). American cockroach (*Periplaneta americana*) are usually found in places such as food stores, kitchen and restaurant. They have been reported to serve as food for wild and domestic birds, small reptiles as well as being source of protein in fish feed production (Rust *et al.,* 1991 and Ruth, 2017). Thus, this research was conducted to investigate the effects of cockroach meal on the growth performances of *C. gariepinus* fingerlings.

MATERIALS AND METHODS

Experimental Site and Design

The study was done at the Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Minna, Niger State (9.31 '58.8° N; 6.27 '07.7°E). One hundred and eighty (180) African catfish (*C. gariepinus)* fingerlings were purchased from Jerubbaal Fish Farm Limited, Osere, Ilorin, Kwara State. The fishes were acclimated in 1000liter plastic tank for one week before the start of the experiment. Thereafter, each fingerling was weighed using sensitive scale SF-400 (Capacity 3000gx1g/106ozx0.1oz) and the initial weights taken. The experimental design consisted of 20litre capacity rearing troughs. Each trough was stocked with 20 catfish fingerling and reared for 56 days.

Collection and Preparation of Feed Ingredients

Fishmeal (clupied) was purchased from Kure Ultra-modern market, while soybean and maize grains were purchased from Bosso market and groundnut cake (GNC) procured from Faridat Feed Mill, all in Minna, Niger State, Nigeria. Matured cockroaches used in this experiment were harvested from the aggregating site, Room 1 Block C, Kings Villa, Gidan Kwano Village, Minna, Niger State. They were aggregated by keeping rotten vegetables and left over foods in a dedicated room. The temperature of the room was kept at 28°C and relative humidity of 60% was maintained with sufficient darkness in the room. Cockroaches were attracted into the room and were harvested by placing a hot charcoal pot in the room. This raised the room temperature to between 35°C and 40°C. This high temperature made the cockroaches uncomfortable thus, trying to escape from the room. Hence, an escape route was provided. At this point, the cockroaches were physically killed with a bunch of broom. Harvested cockroaches were then sundried and ground whole for later use.

However, the use of insecticides was discouraged since it may have deleterious effect on the fish.

Feed Formulation and Fish Management

Three (3) experimental diets were compounded having 45% crude protein level. The control diet (diet 1) had soybean meal and groundnut cake (GNC) as sources of protein. Diet 2 contained soybean meal, groundnut cake (GNC) and 10% fish meal while Diet 3 had soybean meal, groundnut cake (GNC) and 10% cockroach meal. Maize meal served as main energy source of all the diets. Each diet was fed to catfish in triplicate. The proximate analysis of the formulated diets was conducted according to the standard AOAC (2005) method (Table 1). The rearing tanks were placed on an iron stand of 1.5m in height for ease of accessibility and observation. Clean freshwater was supplied into the rearing tanks from an overhead tank and dirty water was removed or drained by siphoning method daily. Dead fish, fecal matter and uneaten feed were removed daily.

Table 1: Formulated diets and proximate compositions

Ingredients	Diet 1 (Control)	Diet 2 (10% fish meal)	Diet 3 (10% Cockroach meal)
Fish meal	0.00	100.00	0.00
Groundnut cake	416.50	284.90	294.50
Soybean	416.50	284.90	294.50
Cockroach meal	0.00	0.00	100.00
Maize meal	67.000	230.30	211.10
Lipid	50.00	50.00	50.00
Vitamin mineral premix	50.00	50.00	50.00
Total	**1000.00**	**1000.00**	**1000.00**
Proximate compositions (%)			
Crude protein	45.05	45.09	45.04
Crude lipid	9.08	13.85	8.88
Crude ash	14.88	14.89	12.04
Moisture	7.81	7.18	8.20
Crude fibre	1.80	8.20	4.50
Nitrogen Free Extract	21.38		21.34

Feeding Procedure and Biological Evaluation

The experimental diets were given to each of the replicate of the treatments. The *C. gariepinus* fingerlings were fed three (3) times a day at 8:00am; 1:00pm and 4:30 pm starting with 5% body weight that was adjusted fortnightly to meet the body nutrient requirements. However, 3% body weight of feeding was adhered to till the end of the experiment because the fish tend not to finish the quantity supplied when fed at 5% rate. The uneaten diets were collected and dried for later analysis. Water quality parameters were monitored for dissolved oxygen, temperature, pH and conductivity using standard APHA (1999) method. Biological parameters were evaluated according to standard methods of: Osborne *et al*. (1919); Miller and Bender (1955); Brown (1957); Maynard *et al*. (1979) and Halver (1989) as followed:

Mean weight gain (g) = Mean final weight – mean initial weight

Specific Growth Rate (SGR %/day) = $\frac{(\text{Log}_e W_2 - \text{Log}_e W_1)}{T_2 - T_1} \times 100$

Where, W_2 and W_1 represent final and initial weights respectively, and
T_2 and T_1 represent final and initial time respectively

Feed conversion ratio (FCR)– Feed fed on dry matter/fish live weight gain

Protein efficiency ratio (PER) =Mean weight gain/protein fed

Apparent Net Protein Utilization (%) = $\frac{\text{Final carcass protein-Initial carcass protein}}{\text{Mean total protein consumed}} \times 100$

STATISTICAL ANALYSIS

Statistical package Minitab release 14 was used to analyze the data generated. The One-way analysis of variance was used to establish significant differences in the means and the new Duncan Multiple Range Test was used to separate the means.

RESULTS

The results of growth performance and nutrient utilization are presented in Table 2. From the results, the highest mean weight gain (1.39g) was recorded in fish fed Diet III (10 % cockroach meal) while fish fed Diet I (control) had a significantly lower mean weight gain (0.74g) while Diet II (10% fish meal) gave a significantly higher mean weight gain (0.98g) than the control but lower than the cockroach meal-based diet. There was significant difference in the food conversion ratio (FCR) ($p<0.05$) of the treatments. Diet I gave a significantly high FCR value (4.91) followed by Diet II (3.89) while Diet III gave a significantly lower ($p<0.05$) FCR value (2.54). The specific growth rate (SGR) values showed significant differences ($p<0.05$) among treatments. Diet I had a significantly lower SGR value (0.89%/day) followed by Diet II (1.13%/day) while Diet III gave a significantly higher ($p<0.05$) SGR value (1.44%/day).

Cockroach meal-based diet had the highest protein efficiency ratio (PER) value of 0.87 while there was no significant difference ($p>0.5$) between the control diet (0.69) and diet II (0.58). The results of apparent net protein utilization (ANPU) showed that cockroach meal-based diet gave a significantly higher value (16.23%) followed by fish meal-based diet (4.19%) while the control had a significantly lower value (1.78%). Cockroach-based diet gave a significantly higher survival rate (62%) while the control diet was significantly low (34%).

Table 2: Growth parameters of *Clarias gariepinus* fingerlings fed experimental diets for 56 days

Growth Parameters	Diet 1 (Control diet)	Diet II (10% Fish meal)	Diet III (10% Cockroach meal)	SD
Mean initial wt. (g)	1.13±0.03[a]	1.10±0.00[a]	1.10±0.00[a]	0.02
Mean final wt. (g)	1.87±0.27[c]	2.08±0.23[b]	2.49±0.39[a]	0.30
Mean wt. gain (g)	0.74±0.48[c]	0.98±0.23[b]	1.39±0.39[a]	0.38
Feed fed (g)	3.63±0.90[a]	3.81±0.29[a]	3.53±0.29[a]	0.57
FCR	4.91±0.79[c]	3.89±0.32[b]	2.54±0.15[a]	0.50
SGR (%/day)	0.89±0.30[c]	1.13±0.19[b]	1.44±0.29[a]	0.27
PER	0.69±0.15[b]	0.58±0.17[c]	0.87±0.20[a]	0.17
ANPU (%)	1.78±1.26[c]	4.19±4.87[b]	16.23±7.19[a]	5.07
Survival (%)	37.00	42.00	62.00	2.31

Means on the same column with different superscripts are significantly different (p<0.5)

The chemical composition of fish carcass (Table 3) indicated significant differences (p<0.05) for the treatments. Diet III gave a significantly higher final crude protein value (52.75%) than the initial level (51.66%) with no significant difference with that recorded in Diet I. The final tissue lipid was also significantly (p<0.05) higher for Diet III (10.75%) while the initial carcass lipid composition had a significantly lower value (8.34%). Ash content was significantly lower (p<0.05) (7.35%) for Diet III while Diet I had a significantly higher (p<0.05) ash content (14.72%) than the initial value (10.50%). The moisture content was significantly higher (p<0.05) for initial value (7.31%) and significantly lower (p<0.05) for Diet III while fibre value was significantly high (p<0.05) for Diet III (7.45%) and low for the initial value (0.05%).

Table 3: Chemical composition of fish carcass at beginning and end of experiment

Treatments	Protein	Lipid	Ash	Moisture	Fibre
Initial carcass value	51.66±0.01[c]	8.34±0.01[c]	10.50±0.06[c]	7.31±0.01[a]	0.05±0.01[d]
Final carcass value					
Diet I	51.66±0.01[c]	9.19±0.01[b]	14.72±0.01[a]	7.07±0.01[c]	4.00±0.01[c]
Diet II	52.14±0.01[b]	8.92±0.01[b]	13.70±0.01[b]	7.23±0.01[b]	6.00±0.01[b]
Diet III	52.75±0.01[a]	10.75±0.01[a]	7.35±0.01[d]	7.00±0.01[d]	7.45±0.01[a]
SD	0.01	0.01	0.03	0.01	0.01

Means on the same column with different superscripts are significantly different (p<0.5)

The results in Table 4 showed the range of physico-chemical parameters of the rearing water measured during the course of the feeding trial. Results of the water parameters indicated that temperature ranged from 23.0 to 29.80^{o}C in Diet I, 23.0 to 30.30^{o}C in Diet II and 23.15 to 30.60^{o}C in Diet III. The pH values were Diet I (6.25 to 7.64), Diet II (6.14 to 7.67) and Diet III (6.11-7.64). Dissolved oxygen ranged from (4 .0 to 6.80 ml/l) in Diet I, (4.40-6.00 ml/l) in Diet II and Diet III (4.00-6.72 ml/l).

Table 4: Water quality parameters of experimental tanks

Diets	pH	Conductivity (µs/cm)	DO (mg/l)	Temp. (°C)
Diet I	6.25-7.64	251-371	4.60-8.00	23-29.80
Diet II	6.14-7.67	257-347	4.40-6.00	23-30.30
Diet III	6.11-7.64	259-359	4.00-6.72	23.15-30.60

DISCUSSION

The water quality measured for all treatments were within acceptable range for fish rearing (David, 2019). The proximate composition of feedstuffs and experimental diets revealed high nutrient levels. This is an essential indicator for the role of nutrients in fish as reported by Shaji and Hindumathy (2013) and Ruth (2017). Sufficient nutrients in the diets will play a vital role in promoting fish growth, reproduction and survival. Protein is an indispensable nutrient which needs to be incorporated in the diet at optimum proportion to guarantee sufficient growth and health of fish (Ogunji *et al*., 2008). In this study, it was observed that growth performance of *C. gariepinus* fingerlings fed fish meal (clupeid) and cockroach meal (*Periplaneta americana*) diets were higher compared with soybean and groundnut cake-based diets. The high nutrients content in the test diets (cockroach meal-based diet) could have contributed to high growth performance of catfish fingerlings, which is in agreement with the report of Tran *et al*. (2015) that insects have high energy and crude protein contents. Dietary protein thus plays a significant role in supplying amino acids for the biosynthesis of the body proteins which are essential for growth of fish (Alam *et al*., 2016). Moreover, the amino acid profile of insect meal is comparable to that of fishmeal (PROteINSECT, 2016). The optimum dietary protein levels however depend on the fish growth rate and protein quality (Davis *et al*., 2009). This would have been responsible for the low performance of fish meal-based diet when compared with the cockroach meal-based diet in this study. Despite the high fat content of fish meal-based diet, the tissue had a low-fat deposit which is a direct reflection of its utilization for energy (Robinson and Li, 2005; Miles and Chapman, 2018). Similarly, the lipid content of cockroach meal-based diet was higher which could be due to better utilization by the fish. Fish meal lipid's high-quality fatty acid enhances its palatability and digestibility (Miles and Chapman, 2018) which could be responsible for more feed consumed as observed in this study. Furthermore, the linoleic acid in insect is not as good as that in fish but better than in vegetable oils (Tran *et al*., 2015). Ash content is a measure of the total amount of mineral elements such as calcium and phosphorous within a feed (Obeng *et al*., 2015). However, Kiriratnikom and Kiriratnikom (2012) reported that high ash content of more than 12% in feed produced better growth performance in *Clarias* species. Furthermore, Ali and Jauncey (2004) observed that growth performance of *C. gariepinus* was better on diet containing 9.3% ash content while Alam *et al*. (2012)

reported that ash content in the feed of *C. gariepinus* should not be less than 8% in order to provide sufficient mineral for the growth, survival of fish and good performance of immune system and healthy skin. The ash content of Diet III was in line with all of these findings which could be responsible for its best performance. However, most insects except for black soldier fly larvae have been reported to have low calcium and phosphorus like soybean and could affect growth and development of fish (Tran *et al*., 2015).

Fibre is very important in fish feed as it gives it the physical bulkiness, binding and passage through the alimentary canal (Ayuba, and Iorkohol, 2012; Obeng *et al*., 2015). However, fibre content of more than 8-12% in fish feed are not advisable as it lowers digestibility of nutrients and slows the growth (De Silva and Anderson, 1995 and Ruth, 2017). The fibre content observed in this study was moderate for cockroach meal-based diet compared to fish meal-based diet and could be responsible for its performance. Moreover, both fishmeal and insect meal are low in carbohydrate which makes them good alternative to plant-based protein (Makkar *et al*., 2014; PROteINSECT, 2016). The survival rate of catfish fingerlings was higher on fish fed cockroach diet which is in agreement with report of Ruth (2017) when compared to other experimental diets.

CONCLUSION

The assessment of nutrient utilization of cockroach meal in the diet of *Clarias gariepinus* fingerlings as an alternate protein source to fish meal was evaluated. The study revealed that, cockroach meal can substitute fish meal without altering the growth and survival rate of the fish species. However, further research should be conducted on higher inclusion rates.

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