EFFECT OF PARTIALLY SUBSTITUTING FISHMEAL WITH EARTHWORM MEAL ON GROWTH PERFORMANCE AND BODY COMPOSITION OF *Clarias gariepinus*

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Abstract
A study was undertaken to assess the effect of partially replacing fishmeal with earthworm on the growth and proximate composition analysis of *Clarias gariepinus* fingerlings. Six iso-nitrogenous diets of 40% crude protein were used. Diet1 1 has no earthworm inclusion; diet 2, 3, 4, and 5 had 20%, 40%, 60%, and 80% substitution of fishmeal with earthworm in the diets, respectively, while diet 6 had 100% replacement. The diets were formulated using fishmeal, earthworm, soybean, maize, salt, oil, bonemeal and premix. Groups of ten *C. gariepinus* were stocked into 70-litre plastic bowls which were filled up to the 40 litre mark and they were fed with the test diets. The diets were assigned in duplicate in a completely randomized design to the fish. The diets were fed at the rate of 5% fresh body weight divided twice daily. The experiment lasted for 88 days. The fish were weighed every two weeks for determination of weight gain, specific growth rate (SGR), feed conversion ratio (FCR), condition factor, feed conversion efficiency (FCE) and final weight. Growth and fish flesh proximate analysis indices were analyzed for significant differences between the treatments using the ANOVA at 5% level of significance. Treatment 1 had the best FCR, FCE, and SGR which were significantly different ($p<0.05$) from all the other treatments. There were no significant differences ($p>0.05$) in the condition factor and percentage survival amongst the whole treatment. Treatments 2 and 3 showed to have performed the same in all the parameters studied. The result of the experiment shows that earthworm can be used to substitute for fishmeal up to 60% above which the performance declines.

Keywords: Capture fishery, Feed substitution, Earthworm, Clarias.

Introduction

Fish can be obtained from the wild, a practice referred to as capture fishery, but this has dwindled due to overexploitation, resulting from the ever increasing human population. Aquaculture of recent has been found necessary as one approach to increase fish production to make enough fish protein (FAO, 1995). However, increasing demand, high cost, scarcity of fish meal (Nyorenda *et al.,* 2000) as well as its rare availability, consumption by man and competition from other livestock industry have resulted in nutritionist seeking alternative sources of protein other than fishmeal (Missa *et al.,* 2003). Plant protein on the other hand lacks at least one of the essential amino acids needed by the body. Animal protein therefore, is the best form of protein source. One of such substitutes that need to be investigated is earthworm (*Lumbricus terristis*). *L. terristis* is readily available during the rainy seasons. Earthworm meal has been reported to be rich in protein. Tacon (1983) reported that earthworm contains about 56% crude protein. Unfortunately, in the immediate past it was considered to have little or no value until now when it has been discovered otherwise, and this led to its massive culture in some countries like Japan and China.

There is dearth of information on the substitution level on the use of earthworm meal in fish diets and the replacement value for fish meal has necessitated this work to assess growth performance and proximate composition of *Clarias gariepinus*-fed earthworm meal as replacement for fish meal and to determine what percentage substitution is most ideal for farmers and for growth.

Materials and Methods

This research work was carried out in the Departmental Laboratory of Fisheries and Aquatic Resources Management, Michael Okpara University of Agriculture, Umudike, Umuahia, Abia State, Nigeria. Large collection specimens of earthworms (*L. terrestis*) were obtained during the rainy season when they range freely. They were rinsed with water and kept in a bowl for 30 minutes to evacuate the residual undigested contents in the guts (Akpodiete and Okagbare, 1999). The worms were then blanched in hot water and oven dried (60 – 80%) for 3hours, milled and assayed according to AOAC (1990), and then used to formulate diets.

The *C. gariepinus* fingerlings were used for this experiment. The experiment consisted of 12 round 70 litres capacity plastic containers which were filled to the 40 litre mark each time it was changed. Water was partially replaced once in three days and completely changed on the 6th day. Such practice has been found to enhance survival of cultured organisms (Peters, 1989). The experiment was carried out in a completely randomised design.

Feed was formulated using fishmeal, soyabean, maize, earthworm, premix, oyster shell, salt and oil. These feedstuffs were subjected to proximate analysis; and the feed was formulated using the Persons square method. Six (6) diets were used for the experiment. They were represented as follows: Treatment 1 was 0% of earthworm and 100%

fishmeal, Treatment 2 was 20% substitution of fishmeal with earthworm meal, Treatment 3 was 40% substitution of fishmeal with earthworm meal, Treatment 4 was 60% substitution of fishmeal with earthworm meal, Treatment 5 was 80% substitution of fishmeal with earthworm meal and Treatment 6 was 100% earthworm meal no fishmeal

Each treatment had two (2) replicates with a stocking rate of 10 fish in a 70 litres basin.. The initial length (cm) of each individual fish in each replicate was measured with a calibrated measuring board and the batch weight (g) of each replicate was taken with a sensitive scale (Acculab 333) before placing them in the bowl. The fish was not fed for 2 days prior to the commencement of the experiment so as to empty their guts to aid increase in their appetite and reception for new diets. Fish was fed 5% of their body weight per day. Each day's ration was divided into two equal parts and each part was dispensed at 8:00 hrs and 18:00 hrs, respectively. Sampling of fish was carried out every two weeks to obtain data for growth analysis. The experimental fish as well as the feed were subjected to proximate composition analysis according to the method of AOAC (1990).

The feed and growth data for each parameter were subjected to one way Analysis of Variance (ANOVA) and the means for the various treatments were compared for significant differences ($P<0.05$) using Least Significant Difference (LSD).

The data collected during the experimental period were analysed for the following:

Mean body weight gain = $W_2 - W_1$
Where W_2= mean final body weight
W_1 = mean initial body weight.

Mean increase in standard length (cm) = L2 – L1
Where L2 = Final standard length
L_1 = initial standard length

Specific Growth Rate (S.G.R.)

$$S.G.R. = \frac{(LnW2 - LnW1)}{T} \times \frac{100}{1}$$

where W2 = Final weight
W_1 = Initial weight.
T = Period of Experiment (days)
L_n =Natural Log

Feed Conversion Rate (FCR)

$$FCR = \frac{\text{Amount of feed fed}}{\text{Weight gain}}$$

Percentage Survival =

$$\frac{\text{Initial No. stocked} - \text{No. of Mortality}}{\text{Initial Number Stocked}} \times \frac{100}{1}$$

Feed Conversion Efficiency (FCE)

$$FCE = \frac{\text{Weight gain}}{\text{Amount of Feed Fed}} \times \frac{100}{1}$$

Condition Factor (CF) = $\frac{W}{L^3} \times \frac{100}{1}$

Where, w = final weight of fish.
L = standard length.

Table 1. Proximate analysis of feed ingredients used in the formulation the experimental feed.

	PROXIMATE COMPOSITION				
FEEDSTUFFS	**MC**	**CP**	**EE**	**CF**	**ASH**
Fishmeal	8.5	58	6.59	1.12	15.11
Soyabean	8.6	46	16.90	4.80	3.87
Maize	9.65	10	3.81	2.54	1.98
Earthworm	7.6	56	7.7	1.4	7.99

Key
CP = Crude Protein
EE = Ether Extract
CF = Crude Fiber
MC = Moisture Content

Table 2. Percentage ingredient composition of the test diet.

FEED INGREDIENTS	**PERCENTAGE COMPOSITION**					
	TRT1 0%	**TRT2 20%**	**TRT3 40%**	**TRT4 60%**	**TRT 5 80%**	**TRT6 100%**
Fishmeal	25.34	20.27	15.20	10.14	5.07	-
Earthworm	-	5.07	10.14	15.20	20.27	25.77
Soyabean	50.67	50.67	50.67	50.67	50.67	51.54
Maize	19.99	19.99	19.99	19.99	19.99	18.70
Salt	0.5	0.5	0.5	0.5	0.5	0.5
Oil	0.5	0.5	0.5	0.5	0.5	0.5
Bonemeal	1	1	1	1	1	1
remix	2	2	2	2	2	2

Results and Discussion

The physico-chemical parameters of the culture water during the experiment are shown in Table 3. There were no significant differences ($P>0.05$) amongst the treatments for dissolved oxygen, pH and temperature. The range of value for temperature (25.27°C – 25.43°C), for pH (6.75 – 6.81) and for dissolved oxygen (3.77 – 3.93 mg/l) in the various treatments fall within the range recommended by Boyd and Lichtopher (1990) for warm water fishes. Water monitoring revealed that the differences in the yield between the six treatments were not influenced by differences in the physico-chemical parameters amongst the treatments.

Table 3: Mean Water Quality Data for the Different Treatments over the Culture Period

Variables	Treatments					
	1	**2**	**3**	**4**	**5**	**6**
Temperature (°C)	25.39±3.67 [a]	25.33±3.65[a]	25.30±3.62[a]	25.30±0.06[a]	25.43±0.39[a]	25.43±0.12
pH	6.80±0.14[a]	6.78±0.17[a]	6.80±0.15[a]	6.79±0.10[a]	6.81±0.02[a]	6.75±0.02
DO (mg/l)	3.93±0.42[a]	3.86±0.40[a]	3.93±0.40[a]	3.77±0.12[a]	3.90±0.10[a]	3.77±0.12[a]

Mean values with the same superscript letters in the same row were not significantly different (P>0.05).
Data are mean values of the duplicate of the treatments ± standard error.

The performance and nutrient utilization of earthworm meal as replacement for fishmeal in the diets of *C. gariepinus* is presented in Table 5. The mean initial weight of fish fed the experimental diets showed no significant difference (P>0.05). Treatment 1 had the highest percentage mean weight gain of 383.0g which were significantly different (P<0.05) from the other treatments. Treatment 5 had the lowest percentage mean weight gain of 155.0g followed by treatment 6 (230.0g). This could be attributable to imbalance of essential amino acid in earthworm meal. Amerio (1983) and Hilton (1983) reported that earthworm meal contains most of the amino acids needed for fish growth, however, that there is amino acid deficiency in earthworm meal. There were significant differences (P<0.05) amongst the treatments in FCR. Treatment 1 (2.33) had the best feed conversion ratio followed by treatment 2 and 3 with (2.78 and 2.79), respectively. Treatment 1 had the highest SGR of 2.22 which were all significantly different (P<0.05) from the other treatments. It also recorded the highest increase in standard length 6.99 cm which is significantly different from other treatments. There were no significant differences (P>0.05) in the condition factor as well as percentage survival.

Table 4 Proximate Analysis of the fish flesh.

Parameters	Treatments						
	1	2	3	4	5	6	LSD
Ash	7.805	8.225	8.290	7.820	8.030	8.765	0.868
Crude Protein	43.050	42.525	41.825	43.925	42.525	41.650	0.697
Fat	5.690	6.010	6.120	6.190	6.460	6.010	0.346
Moisture	71.16	69.78	75.74	64.76	69.80	69.36	8.28

The utilization of earthworm meal as a protein source in aquaculture feeds is poorly studied. Tuan and Focken (2009) reported that fish fed diets contained 30%, 70% and 100% of fish meal protein, replaced by earthworm meal had similar or higher growth rate, protein efficiency and energy retention than those fed the fish meal based control diet

The results of this study showed that fish fed fishmeal had no much comparative advantage over that fed earthworm based meal. These findings are supported by that of Hilton (1983). Tacon *et al.* (1983); Stafford and Tacon (1984) who reported the inclusion of earthworm meal as protein source in fish. Treatment 4 (60% earthworm meal and 40% fishmeal) achieved the second best percentage weight gain (275.0g) and SGR. This could be utilized for better economic returns. This is in disagreement with Sogbensan and Madu (2008) who on

Evaluation of earthworm (*Hyperiodrilus euryaulis*) meal as a protein source in diets for *Heterobranchus longifilis* under laboratory conditions revealed that 25% replacement of fish meal by earthworm meal supported higher net gain in weight and specific growth rate than fish fed 0% (control), 50%, 75% or 100% earthworm meal. The result from this study can be compared to that of Hilton (1983) who reported that juveniles of *Clarias anguilaris* stocked in outdoor hapas achieved greatest increase in body weight (99.7 g) when fed a mixture of live earthworm and 40% fishmeal feed at 3% body weight of their biomass for 10 weeks.

The reason for performance of treatments 2 – 4, in terms of growth was not obvious from the experiment, but the combination of earthworm with fishmeal might have formed a better balanced diet for the fingerlings. After all, it is a known fact that the protein quality of fish, livestock and poultry diet as influenced by amino acids were also contained in earthworm (Aluko, and Olufegba, 1998) although Fetuga (1977) confirmed that they were lesser in amount than those contained in fishmeal. If the amino acid in earthworm is combined with those in fishmeal feed, it could probably result in a more balanced diet. Similarly, the findings of this study is in agreement with the findings as reported by Tacon (1984) who reported that fishmeal could be replaced with earthworm meal in fish feed without any adverse effect on the growth performance of *C. gariepinus*. There were no significant differences (P>0.05) in all the parameters amongst treatments 2 and 3. This shows that the replacement of fishmeal with earthworm up to 40% had no differences amongst themselves in growth, nutrient utilization and the well being of the fish.

Treatment 4 had the best carcass crude protein percentage, moisture content and second best in lipid content as shown in table 4, while treatment 5 have the highest lipid content. Langer and Rewa (2011) also reported high protein and lipid content with the diet containing earthworm meal in Macrobrachium when fed with diets where fishmeal where partially replaced with silk worm pupae, earthworm, soyabean meal.

Table 5. Growth Performance of *Clarias gariepinus* fingerlings fed fishmeal based diets supplemented with earthworm meal diets.

Parameters	Treatments						
	1	2	3	4	5	6	LSD
Mean initial weight (g)	12.90 [a]	12.70[a]	14.00[a]	11.70[a]	14.50[a]	12.10[a]	10.25
Mean final weight (g)	58.70[a]	44.30[a]	50.10[a]	44.00[a]	35.40[b]	40.00[b]	16.67
Mean weight gain (g)	45.80	31.60	36.10	32.30	20.90	27.80	10.47
Percentage Mean weight gain (g)	383.0[a]	259.0[ab]	261.0[ab]	275.0[ab]	155.0[b]	230.0[ab]	206.3
Feed Conversion Ratio (FCR)	2.330[c]	2.775[bc]	2.795[bc]	2.940[b]	3.950[a]	3.125[b]	0.595
Specific Growth Rate (SGR % Day)	2.215[a]	1.810[ab]	1.835[ab]	1.890[ab]	1.320[b]	1.705[ab]	0.733
Feed Conversion Efficiency (FCE)	42.95[a]	36.16[b]	35.77[b]	34.05[b]	25.50[c]	31.99[b]	5.73
Initial Standard Length (cm)	12.20a	11.76[a]	12.41[a]	12.44[a]	12.31[a]	12.75[a]	1.09
Final Standard Length (cm	58.70[a]	44.30[a]	50.10[a]	44.00[a]	35.40[b]	40.00[b]	1.90
Mean Increase in Standard Length (cm)	6.99[a]	5.47[a]	5.24[b]	4.83[b]	3.90[c]	3.92[c]	1.03
Condition Factor	0.835[a]	0.865[a]	0.865[a]	0.845[a]	0.815[a]	0.860[a]	0.170
% Survival	100.0[a]	100.0[a]	100.0[a]	100.0[a]	100.0[a]	100.0[a]	Not significant

Conclusion and Recommendations

It could be concluded from this study that earthworm meal could be used to replace fish meal without any adverse effect on the growth performance, bearing in mind that the aim of aquaculture business is profit maximization. More effective results were obtained up to the 60% inclusion of the earthworm with fish meal. Earthworm meal based diets are relatively a cheap source of protein that could be used in aquaculture. It is readily available during the rainy season and could be harvested in large quantities during the rains and stored for use later in the year.

For a better performance the use of earthworm meal to supplement fish meal is highly recommended based on the result of this experiment. However, more research should be done on the commercial production of earthworm so that easier methods of making it more available to fish farmers could be discovered.

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