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Growth Response of *Heteroclarias* Fingerlings Fed on Earthworm Meal in Hatchery Tanks

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KEYWORDS Earthworm Meal. Heteroclarias Fingerlings. Growth Response

ABSTRACT The study evaluated growth response of *Heteroclarias* fingerlings fed practical diet in which fish meal was substituted with graded levels of earthworm meal (E_0, E_{25}, E_{50}, E_{75} and E_{100}) in indoor tanks. Fingerlings were obtained through artificial insemination of brood stock with ovaprim in the laboratory. The resulting fries were fed with freshly harvested plankton for 4 weeks. Thereafter sixteen fingerlings weighing 4.73 g and measuring 6.512 mm standard length (on the average) were starved overnight and reared in five indoors tanks (0.8x 0.5x 0.5 m) in duplicate for eight weeks. Fingerlings were fed on graded earthworm meals containing 40% protein fed to the fingerlings twice daily at 0080 and 1600 hours. The best mean weight (6.77 g), specific growth rate (0.86) and protein efficiency ratio (0.6) was obtained with diet E_{50}. Food conversion ratio (4.47) was highest with diet E_{50} and lowest (4.07) with diet E_{00} which was significant ($p<0.05$). The profit index for diet E_{50} was the highest (1.71). Again the highest net profit ₦ 374.32 was recorded for diet E_{50}. Water quality parameters observed were within tolerable units and conducive for the growth of the fingerlings well being. Earthworm meal at 50% inclusion drastically reduced production cost which was suggestive that, the meal was an excellent alternative protein source than fish meal in feed formulation.

INTRODUCTION

Fish nutrition has always been a major aspect of research in aqua-feed operations, (Idoniboye and Ayinla 1991). For fish culture project, the optimum dietary requirement at a reduced production cost is essential, in order to achieve maximum profit. The major pre-requisite for successful fish farming is the availability of suitable artificial feeds, formulated from locally available cheap ingredients that will supply adequate nutritional requirements for the fishes cultured (Lovell 1987). One such ingredient is fish meal, which has been used extensively as a valuable source of rich protein in aqua-feed. This is because of its hitherto unrivaled properties in terms of biological value, digestible energy and excellent array of amino acid components, when compared with other commercially available protein sources (Lovell 1981; Eyo 2003). However, its protein contribution by weight (50 – 75 %) in aqua-feed formulation, is slightly lower than those contributed by poultry feather meal (60 – 84 %) and blood meal (80 – 86 %) (Adikwu 1991; N.R.C. 1993; Eyo 2001). It is believed that fish diet represent the greatest single high cost item in fish farm operations (Olomola 1990; Falaye 1992; Mohanty and Dashm 1993; Olvera-Nora 1996), and contributing between 40 to 60 % to the recurrent cost. This increased the cost of production, and reduced the profit margin and high price tag for consumers. Additionally, fish meal is scarce and expensive (Eyo 1985). Given these negative characteristics of fish meal, there is a need to find a better substitute. The aim of this study is to examine the effect of various inclusion levels of earthworm/fishmeal on the growth performance of *Heteroclarias*, its financial implications and its water quality parameters.

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MATERIALS AND METHODS

Bi-sexed brood stock of *Heteroclarias* used for the study was transported from the Faculty farm, in habitat water to the Fisheries Research Laboratory in Delta State University, Asaba Campus. They were left to acclimatize for two days in the hatchery tank, and fed twice daily on 100 % fish meal *ad-libitum*. They were then starved for 24 hours and injected with 0.5 ml ovaprim according to their body weight. Thereafter, stripping, fertilization and incubation was successfully carried out and hatching took place. The resultant fry's were fed on freshly harvested plankton. After four weeks, a total populations of 160 mixed sex fingerlings were randomly selected, and sixteen out of this number were stocked into five experimental glass tanks (measuring 0.8 x 0.5 x 0.5 m) in duplicates and left to acclimatize for three days. They were fed twice daily with uniform fishmeal diet. The fingerlings were then starved over night to em-pty their gut, thus increase their appetite for the new diet. Experimental diets consisting of rations of oven dried earthworm meal, computed in percentages thus: ($E_{00.0}$; $E_{25.0}$; $E_{50.0}$; $E_{75.0}$ and $E_{100\cdot 0\ \%}$), were introduced into each fish tank and substituted with fish meal also computed in percentages thus: (F_{100}, F_{75}, F_{50}, F_{25} and $F_{00.0}$ %). The diet without earthworm, which is diet E_{00} served as the control. The daily rations were divided into two portions and fed to the fish morning (0800 – 0900 hrs) and evening (1600 – 1700 hrs) at 5 % fish body weight. All diets were iso nitrogenous at 40-% and iso caloric at 482.11kcal/kg. Forty litres capacity constant water volume in a water flow through system (which helps in improving aeration and flushing out uneaten feed) was maintained throughout the experimental period which lasted 56 days.

At the onset of the feeding trials, two fingerlings were randomly selected from each glass tank; their standard lengths were measured in millimeters, while their body weights were batch weighed in gram, using an electronic top-loading balance. The quantity of feed was each time adjusted to each tank depending on to the new weight (Jauncey and Ross 1982).

According to Ufodike and Ekokotu (1986), growth responses such as food utilization, growth rate and general well being of the fingerlings were obtained in the form of specific growth rate (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and condition factors (K).

SGR = 100(log Wt – log Wo)/t

FCR – [(c x t) / Wt – Wo]

PER = Wt – Wo/Pf. and

K = W x 100/L^3

Where log = Natural logarithm
Wt = Final weight of fish (g)
Wo = Initial weight of fish (g)
c = Total daily food intake (g)
t = Number of day's of feeding
Pf = Crude protein fed (g)
W = Weight of fish (g)
L^3 = Length of fish in (mm)

Growth responses and data of surviving fingerlings were subjected to a two-ways analysis of variance (ANOVA) test. Mean treatments were separated using Duncan Multiple Range Test (DMRT). All statistical computations were done with Statistical Analysis System (1998).

The economic evaluation was determined by using the current market price. The profit index, incidence of cost, net profit and benefit cost ratio were evaluated according to Sogbesan et al. (2004) where,

i Profit index = Number of fish produced/ Cost of feed

ii Incidence of cost = Cost of feed/Mass of fish produced

iii Net profit = Sales minus Expenditure

iv Benefit Cost ratio (B Cr) = Total sales/Total expenditure.

Water quality parameters such as total alkalinity, temperature, dissolved oxygen and hydrogen ion concentrations, were monitored once a week in the morning before feeding commenced using standard limnology methods (APHA 1995).

RESULT AND DISCUSSION

The percentage composition (Table 1) and proximate analysis (Table 2) of the experimental diets are presented. They revealed that the diet corresponded with the set target specification of 40% crude protein and 482.11kcal/100g gross energy.

Table 1: Percentage composition of experimental diet in (g/100kg) fed to *Heteroclarias* fingerlings

Ingredients	*Experimental diets*				
	E_{00}	E_{25}	E_{50}	E_{75}	E_{100}
Earthworm meal	00.0	25.0	50.0	75.0	100.0
Fish meal	100.0	75.0	50.0	25.0	00.0
Salt	0.5	0.5	0.5	0.5	0.5
Bone meal	1.5	1.5	1.5	1.5	1.5
Vitamin premix	2.0	2.0	2.0	2.0	2.0
Starch	2.0	2.0	2.0	2.0	2.0
Vegetable oil	3.0	3.0	3.0	3.0	3.0
Ground nut cake	14.0	14.0	14.0	14.0	14.0
Rice bran	20.0	20.0	20.0	20.0	20.0
Yellow maize	32.0	32.0	32.0	32.0	32.0
% Total	100.0	100.0	100.0	100.0	100.0
% Crude protein	40.0	40.0	40.0	40.0	40.0

Table 3 shows the growth performance of the fingerlings fed on experimental diet over a study period of 56 days. Initial weight gain at the start of the experiment revealed that live organisms (plankton) aided digestion as they supplied the necessary digestible enzymes as well as in-

Table 2: Proximate analysis of earthworm

Earthworm meal	E_{00}	E_{25}	E_{50}	E_{75}	E_{100}
Total crude protein	40.47	40.58	39.92	39.85	39.79
Moisture	11.15	09.35	08.00	06.30	05.25
Crude fiber	11.10	11.21	11.03	11.04	11.15
Ether extract	08.30	09.13	09.55	07.69	06.04
Ash	08.30	0 7.20	06.05	06.20	06.65
% Nitrogen free extract	20.11	22.51	25.11	28.40	30.75
Calculated gross energy Kcal/100g	482.11	482.11	482.11	482.11	482.11

creased the conversion efficiency of artificial feeds. This observation is in line with those of Reichenbach-Klinke (1992), Wilson and Poe (1985). The table also revealed that diet E_{00} which maintained the best growth pattern in terms of weight gain from the first to the seventh week had the least weight gain (9.412^a) which was statistically similar to that of diet E_{25} (9.451^a) at the expiration of the experiment. Fish samples fed on diet E_{50} exhibited the highest weight gain (10.16^{abc}) which was significantly different from the others (Table 3). These growth performances in the fish samples show that the beneficial effect of earthworm meal increases as the fish grew in length. According to NRC (1993), the amino-acid profile of the earthworm diet in combination with the protein composition in the body tissue of the fish stimulates faster growth. This justifies the ability of earthworm meal in providing productive nitrogen and digestible amino acid needed for the metabolic activity of the fish.

The highest mean weight increase was recorded for diet E_{50} (10.16) when compared with diet E_{00} (9.412) and diet E_{100} (9.790) and was significant, because of the composition of diet E_{50} (50 % each of fish and earthworm meals). This can be explained by the synergetic effect of two crude protein sources for formulating a single more superior diet. Sigh et al. (1978), Hossain and Juancey (1989) reported that combined rations produce better single diet in aqua feed operation. The final weight gain (Table 3) were all above (9.0) and statistically significant ($P<0.05$) suggesting that even the lone earthworm diet (E_{100}) could be beneficial as it did not have an adverse effect on the final weight gain (9.790) of the fish as noted by Ogbe et al. (2004). Massumotu et al. (1996) was of the opinion that fish meal diet results to efficient weight gain, because it was adjudged the best protein source in aqua feed operations. However, this was not the situation in the present study. The nutritive value of a protein diet does not only depend on its amino acid profile but also on its level of digestibility. The fiber content of earthworm diet was known to enhance better growth performance in fish. The combined fiber content of diet E_{50} which surpassed that of diet E_{00} was the probable reason for the higher weight gain (Table 3). The lowest value in weight increment for diet E_{00} (9.412) could be attributed to insufficient amino acid present in a single fish meal diet when compared to the experimental diets (fishmeal and earthworm meal). However, Amerio (1983) and Hilton (1983) reported that there could also be a deficiency in some essential amino acid even in earthworm meal. This opinion contrasts with the findings of Sogbesan et al. (2006) who opined that the amino acid composition of earthworm meal was comparable with those of fish meal; hence earthworm meal was not only rich but nutritionally dependable for formulating fish diet. They fur-

Table 3: The summary of the analysis of variance for mean weight gain at weekly intervals

Dietary Rations (DR)	*Time in weeks*								
	0	*I*	*II*	*III*	*IV*	*V*	*VI*	*VII*	*VIII*
E_{00}	3.375a	4.007^a	4.722^a	5.573^{ab}	6.221^a	6.941^{ab}	7.740^{ab}	8.684^b	9.412^a
E_{25}	3.384^a	3.946^a	4.624^a	5.312^a	5.911^a	6.564^a	7.283^a	8.162^{ab}	9.451^a
E_{50}	3.376^a	3.964^a	4.671^a	5.441^{ab}	6.024^{ab}	6.772^a	7.544a	8.523^b	10.16^{abc}
E_{75}	3.374^a	3.972^a	4.622^a	5.233^a	5.893^a	6.511^a	7.223^a	7.914^a	9.891^{ab}
E_{100}	3.446^{ab}	4.001^a	4.633^a	5.281^a	5.874^a	6.461^a	7.142^a	7.991^a	9.790^{ab}

DR= Dietary Rations. E_{00}- E_{100} is earthworm meal inclusion, while F_{00}-F_{100} is fish meal inclusion. Means with the same superscripts are not significantly different ($P> 0.05$) using DMRT.

ther suggested that the methionine content in earthworm was higher than that found in fish meal and hence of greater benefit to man in terms of nutrition and enhanced growth. Wilson (2002) also reported that methionine was credited a growth promoting essential amino acid ingredient, highly needed in cultured fish, but which was limiting in most plant and other animal supplements. The final weight gain of diet E_{50} (10.16) above diet E_{00} (9.412) (Table 3) was an attestation of the growth enhancing capacity of methionine present in earthworm based meal. In addition, it was noted that the dietary essential amino acids must be available at levels equal to or higher than those of the non essential amino acid component of the fish (Abdullahi 2001).

Table 4 revealed that the food conversion ratio (FCR) was highest in diet E_{50} (4.471) and lowest in diet E_{00} (4.073), suggesting that diet E_{50} was a better converter of food than diet of fish meal alone (E_{00}). This observation is in line with the report by Sogbesan et al. (2006). They affirmed that since earthworm meal had higher methionine value than fish meal; it obviously would have a higher food conversion ratio (FCR) and in combination with fish meal result in higher nutrient for the fingerlings at E_{50} level. The specific growth rate (SGR) of fish samples fed E_{50} was of the highest value (0.86% day^{-1}) while the least was recorded in diet E_{00} (0.79% day^{-1}). The protein efficiency ratio (PER) equally followed this similar pattern. However, these differences were statistically significant (P>0.05) (Table 4).

It was observed that fish fed with fish meal alone were inferior in mean weight gain and cost more (in terms of production cost) than fingerlings fed earthworm based meal alone. This assertion is supported by previous results of Tacon et al. (1983); Egbe et al. (2004) and Sogbesan et al. (2006). These researchers maintained that the replacement of fish meal with earthworm meal in feed formulation was not only cheaper but resulted in higher mean weight gain than was the situation when fish meal alone was used.

The cost of earthworm and fish meal (in Naira and US Dollars) per kilogram of experimental diet is shown in Table 5. It revealed that as the costs of earthworm decreased, that of fish meal increased. Also, it was observed that diet E_{100} which was the least in terms of production cost (₦50.00 or US$0.39) was earthworm diet. On the contrary, diet E_{00} which had the highest cost of production (₦80.79 or US $0.63) was without earthworm meal. Again diet E_{100} with the least total expenditure, (₦ 500.25 or US $0.39) recorded intermediate net profit (₦356.23 or US $2.78) as compared to diet E_{00} with the highest total expenditure (₦ 631.27 or US $4.93) but which recorded the least profit (₦250.00 or US $1.95). Diet E_{50} with intermediate production cost (₦ 565.68 or US $4.42) (Table 5) recorded the highest profit (₦ 374.32 or US $2.92). This implies that the use of earthworm meal in fish hatchery at diet (E_{50}) resulted in the best returns, because it drastically reduced feed cost in the present study. Diet E_{25} recorded a condition factor of (1.536) value while diet E_{75} recorded a value of (1.849). The best condition factor was recorded for diet E_{50} (1.996).

Table 4: Analysis of variance on the growth parameters of *Heteroclarias* fingerlings fed rations of earthworm based diet for 56 days

Growth parameters	*Diet ratios*				
	E_{00}	*E_{25}*	*E_{50}*	*E_{75}*	*E_{100}*
% Fish meal formulation	100	75	50	25	00
% Earthworm meal formulation	00	25	50	75	100
Initial weight (g)	4.73	5.77	5.38	5.37	4.44
Final weight (g)	9.412^{a}	9.451^{a}	10.160^{c}	9.895^{b}	9.790^{b}
Weight gain(g)	6.041^{a}	6.084^{a}	6.776^{c}	6.522^{b}	6.348^{a}
SGR/day^{-1}	0.799^{a}	0.809^{a}	0.866^{c}	0.856^{b}	0.835^{ab}
Initial standard length(mm)	6.512^{a}	6.231^{a}	6.635^{a}	6.621^{a}	6.421^{a}
Final standard length(mm)	17.261^{c}	17.426^{c}	17.842^{ad}	15.913^{a}	16.14^{b}
FCR(Food conversion rate)	4.073^{a}	4.192^{a}	4.471^{c}	4.392^{bc}	4.311^{b}
PER (protein efficiency ratio)	0.541^{a}	0.556^{ab}	0.604^{c}	0.585^{bc}	0.568^{ab}
K (condition factors)	1.369^{a}	1.5368^{ab}	1.996^{c}	1.849^{b}	1.820^{b}
Survival rate (%)	100	100	100	100	100

Means with the same superscripts are not significantly different (P>0.05) using (DMRT

Table 5: Price per kilogram of experimental materials and other economic indices

Parameters	*Dietary rations*				
	E_{00}	*E_{25}*	*E_{50}*	*E_{75}*	*E_{100}*
Earthworm meal (₦)	₦ 00.00 ($0.00)	₦ 6.25($0.05)	₦ 12.50($0.10)	₦ 25.00($0.20)	₦ 50.00($0.39)
Fish meal (₦)	₦ 80.79 ($0.63)	₦ 60.50($0.47)	₦ 40.21($0.31)	₦ 30.30($0.24)	₦ 00.00($0.00)
Total cost of feed	₦80.79 ($0.63)	₦66.75 ($ 0.52)	₦ 52.7 ($ 0.41)	₦ 55.30($0.43)	₦50.00 ($ 0.39)
Profit indices	₦ 0.83 ($0.006)	₦ 1.05 ($0.008)	₦ 1.71($0.01)	₦ 1.11($0.008)	₦ 1.02 ($0.007)
Incidence of cost (₦)	₦ 1.20 ($0.01)	₦ 0.98($0.01)	₦ 0.95($0.01)	₦ 0.90($0.01)	₦ 0.75($0.01)
Total expenditure (₦)	₦ 631.27 ($4.93)	₦ 592.47($4.63)	₦ 565.68($4.42)	₦ 562.36($4.39)	₦ 500.25($3.91)
Sales (₦)	₦ 881.27($6.88)	₦ 894.97($6.99)	₦ 940.00($7.34)	₦ 927.39($7.25)	₦ 856.48($6.69)
Net profit	₦ 250.00($1.95)	₦ 302.50($2.36)	₦ 374.32($2.92)	₦ 365.03($2.85)	₦ 356.23($2.78)
Benefit: cost ratio (Bcr)	₦ 1.50 ($0.012)	₦ 1.56 ($0.012)	₦ 1.66 ($0.012)	₦ 1.62($0.012)	₦ 1.59 ($0.012)

128 Naira = 1Dollar. The main figures are in naira while those in parenthesis are in Dollars.

Table 6: Water quality parameters monitored weekly during the study

Parameter	*Time in weeks*							
	I	*II*	*III*	*VI*	*V*	*VI*	*VII*	*VIII*
Water temperature ^{o}C	30.30	29.40	28.90	28.80	28.50	28.40	28.20	28.85
Dissolved oxygen mgl^{-1}	7.50	7.40	7.40	6.10	6.00	5.80	5.70	5.58
Hydrogen ion concentration	7.10	7.10	7.23	7.30	7.38	7.40	7.58	7.77
Total alkalinity mgl^{-1}	20.23	20.45	21.26	22.41	22.83	23.71	24.2	25.64

It was generally observed that oxygen concentration became reduced from 7.50 in week one to 5.58 mgl^{-1} during the 8th week. Hydrogenion-concentration (pH) and total alkalinity increased from 7.10 to 7.77 units and from 20.23 to 25.64 mgl^{-1} respectively, as a result of increase in gut wastes deposits occasioned by increased feeding intensity and non- consumption of all the feed administered. These observations could be detrimental resulting in increased alkalinity (Nnaji and Okoye 2004).

A water temperature range of 28.20 - 30.30 ^{0}C; dissolved oxygen record of 5.58 – 7.50 mgl^{-1} and pH range of 7.10 -7.70 units, monitored during the experiment, were within tolerable limits for fish production (Table 6). Such water quality parameters were comparable with those recommended by Boyd and Lichtkoppler (1979).

CONCLUSION

The dietary protein requirement for fingerlings in this study was set at 40%. The 50:50 fishmeal/earthworm meal diets, which gave the best results in terms of mean weight gain, specific growth rate, and protein conversion ratio was cheaper than the other graded diets. Earthworm meal at a diet of (E_{50}) which resulted in the highest net profit was cheaper to produce in this study. Consequently, earthworm is beneficial in the formulation of fish feed for the culture of *Heteroclarias* while discouraging a total dependency on the more expensive fish meal. The diet E_{50} has its superiority because of the synergetic effect of using two sources of crude protein in the formulation of a single superior diet.

RECOMMENDATIONS

Based on the superior performance of diet E_{50} in the study especially in respect to the higher weight gain, specific growth rate and protein conversion efficiency of *Heteroclarias* fingerlings, it is recommended that the inclusion of 50 % earthworm in fish feed formulation be encouraged especially for the production of *Heteroclarias* fingerlings. Further studies are needed using other species in order to asertain if the same formulation will also lead to fast growth at a reduced feeding cost.

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