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Productivity Potentials and Nutritional Values of Semi-arid Zone Earthworm (*Hyperiodrilus euryaulos*; Clausen, 1967) Cultured in Organic Wastes as Fish Meal Supplement

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Abstract: In the present study 60 Adult Earthworms (*H. euryaulos*) of weight and length range 1.7-3.0 g (mean-2.34±0.91 g) and 13.0-28.0 cm (mean-21.5±5.8 cm), respectively were cultured for 12 weeks. The productivity potential and nutrient composition of earthworm (*H. euryaulos*) cultured in two rearing substrata (Cellulose Substrate (Control) - Coded Hs1 and Dry Neem and leaves and soil Substrate - Coded Hs2) were assessed using six wooden boxes stocked in triplicates at the rate of 92.7 g earthworms per box. The higher total final weight, weekly weight gain, relative growth rate, specific growth rate and survival of 400.6 g kg^{-1} of substrate, 25.7 g/week/substrate, 332.5, 0.76/day and 99.0% while the lower of 367.5 g kg^{-1} of substrate, 22.9 g/week, 296.4, 0.71/day and 98.0% were recorded in earthworm cultured in cellulose substrate and the soil substrate respectively. The proximate analyses, mineral compositions and amino acids indices were comparable to those of conventional fish meal. Based on the results of this study, the utilization of cellulose substrate is recommended for the culture of earthworm and the inclusion of the earthworm meal is guarantee as a reliable and nutritional dependable fish meal supplement.

Key words: Vermiculture, substrates, growth, nutrient value, *H. euryaulos*

INTRODUCTION

Recycling of organic waste products to fauna of high nutritive value through biodegradation process is a global growing field. The benefits derived from these finished products in the provision of animal proteins at low cost has immensely contributed to the development of aquaculture in Nigeria by reducing the cost of feeding which has been report has about 40-60% of the total recurrent cost in aquaculture industry (Olomola, 1990; Falaye, 1992). This cost reported has been as a result of hike in prices of some of the fish feed ingredients which are as well competed for by man. Hence there is a need to urgently research into the other animal proteins sources of non-conventional origin faced by little or no competition from man. Belewu and Banjo (1999) and Sowande *et al*. (2002) have reported on various treatments used in converting sawdust into useable products and its nutritive value. This waste forms the major constituents of the cellulose substrate used for earthworm culture in this study.

In Nigeria about 42 genera of Oligocheates have been documented from the family Eudrilidae (Segun, 1976). These worms are separated from all other worms by their specialized spermathecal systems, which are found posterior to the testis segments (Segun, 1978) and possession of single or paired ventral oesophageal sacs on IX, X, XI and paired calciferous glands on the XII or XIII segments (Segun, 1989). Earthworms are also dynamic bioreactors (Jameson and Venkataramarujam, 2002), decomposing wastes into bio fertilizers/organic matters (vermicompost) which has been reported to be richer in nutrient composition than other organic manure (Lee, 1985). Vermiculture practice which is about a century old is now being revived world wide with divers' objectives such as waste management, sustainable agriculture and aquaculture (Sinha *et al*., 2002). The natural process and other biodegradation activities of organic wastes are aimed at increasing food supply for man's need (Jakusko *et al*., 2001).

The need to meet up the demand for and also have a basis for commercial and all-year round production of *Hyperiodrilus euryaulos* (Clausen, 1967) by the artisanal fish farmers in the semi arid zone of Nigerian and also to investigate into its nutritional potential in serving as fish meal supplement in other to enhance sustainable aquaculture system through least-cost feed production form the major bases for this study.

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MATERIALS AND METHODS

Culture of Earthworm (*Hyperiodrilus euryaulos*)

Composition and preparation of culture media: Two different culturing substrata Cellulose Substrate (Control) and dry Neem leaves and soil Substrate) were investigated for their vermicompost efficiency and production capacity in culturing the earthworm (*H. euryaulos*). The substrata used were as follow:

Cellulose substrate: The composition and preparation of this substrate was carried out following Sogbesan *et al.* (2006) method. The composition of this substrate is also shown in Table 1. The materials were allowed to ferment for four weeks. At the end of the fourth week, the compost was separately sun dried and chunks formed were crushed into powdery form using pestle and mortar.

Dry Neem leaves and soil substrate: This substrate was prepared following Jameson and Ventakaramanujam (2002) method. The substrate was composed of red soil, loamy soil and Neem leaves (*Azadirachta indica*) as shown in Table 1.

Experimental design of the earthworm culture: One hundred and sixty adult earthworms (*H. euryaulos*) of weight and length range 1.8-3.3 g (mean-2.65±1.01 g) and 15.0-30.0 cm (mean- 22.5±7.5 cm), respectively were collected from the wild at Awuru village of Borgu Local government area of Niger-State. The earthworms were collected from moist muddy loamy soil by digging with spade and hand sorting of the worms. They were sorted into sampling plastic bottles and transported to the experimental site.

Six wooden boxes of dimension 0.9×0.6×0.3 m were used for the culture experiment. The lids of the boxes were screened with 3 mm mesh size wire in other to protect the culture animals from predators. Each substrate was packed into the boxes separately to two-third of their depth. Adult earthworms of total weight 92.7 g of different lengths were introduced into each box. The worms were fed 10% of their body weight twice a week with fermented poultry dung (Dynes, 2003). They were sampled fortnightly. Wetting was done by sprinkling of water twice a day during the dry season to maintain the moist medium. The boxes were placed outdoor of the hatchery complex of NIFFR. The culture lasted for 12 weeks.

At the end of the experimental period (84th day) the total harvest of the earthworm was done. Harvesting of earthworms was done following the methods of Jameson and Ventakaramanujam (2002).

Table 1: Percentage composition of *Hyperiodrilus euryaulos* culture substrates

Materials	Cellulose substrate	Dry neem leaves and soil substrate
Loamy soil	-	40.0
Red soil	-	40.0
Saw dust	30.0	-
Rice bran	20.0	-
Mushroom (*Termitomyces* sp.)	20.0	-
Centro-leaves (*Centrosema* sp.)	15.0	-
Poultry droppings	15.0	-
Azadirachta indica (Neem)	-	20.0
Total	100.0	100.0

Growth performances and productivity indices: The total earthworm number and mass was computed and other growth, feed utilization and biomass productivity were evaluated following the method of Sogbesan *et al.* (2006).

Processing of the earthworm meal and fish meal: After harvesting the worms, they were thoroughly washed and left in water for them to evacuate the residual undigested contents in their guts (Akpodiete and Okagbare, 1999). The worms free of wastes were weighed fresh and oven dried at 80°C for 2-4 h. After drying, the worms were milled with hammer milling machine into powdered form, weighed and packed as dried worm meal in an airtight container prior to analysis.

Clupeids used for this experiment were purchased from a fish market at New-Bussa, Niger-state Nigeria. Sorting was done to remove every strange item from the fish then sun-dried and milled with hammer milling machine into powdered form. The milled fish meal was weighed and packed in airtight container prior to analysis.

Biochemical analysis: The processed earthworm meal and fish meal were analyzed for crude protein, crude fibre, crude lipid, ash, Nitrogen free extracts, mineral salts, gross energy and amino acids according to Association of Official Analytical Chemist Methods (AOAC, 2000). The minerals in the ash was brought into solution by wet digestion using Conc. HNO_3 (63%), Perchloric acid (60%) and Sulphuric acid (98%) in the ratio of 4:1:1 (Harris, 1974). Potassium and Sodium was determined using flame photometer (Allen, 1974). Phosphorus was determined using spectronic 20 E, while Magnesium by Perkin Elmer Atomic Absorption Spectrophotometer Model 2900.

The essential amino acids indices were calculated according to Abdullah (2001) and the whole egg amino acids composition in FAO/WHO (1973) was used as the reference diet. The amino acids indices determined were: chemical score value, ratio of the chemical score to that of the protein score and essential amino acids to protein value computation.

Statistical analysis: All data collected were subjected to single analysis of variance (ANOVA). Least Significance Differences (LSD) was used to determine the level of significance among treatments. Correlation and regression analysis was carried out to determine the relationship between the treatments and some of the parameters using SPSS 10.0 Windows 2000.

RESULTS

Earthworms cultured in the cellulose substrate recorded the higher final total weight of 400.6 g kg^{-1} of substrate while the lower final total weight of 367.5 g kg^{-1} of substrate was recorded in earthworm cultured in the dry Neem leaves and soil substrate (Fig. 1 and 2). This higher final total weight recorded in earthworm cultured from the cellulose substrate is insignificantly difference $p>0.05$ to 367.5 g kg^{-1} substrate recorded from dry Neem leaves and soil substrate. Significantly high positive correlation ($p<0.05$) of $r = 0.9893$ and 0.9743 were computed from the bi-monthly weight of earthworm cultured in dry Neem leaves and soil substrate and cellulose substrate, respectively.

Higher total weight gain of 307.9 g kg^{-1} of substrate was recorded from earthworm cultured in cellulose substrate while the lower value of 274.8 g kg^{-1} of substrate was recorded for Earthworm cultured in dry leaves and soil substrate. There is insignificant difference $p>0.05$ between the weight gain of earthworm cultured in cellulose substrate and dry Neem leaves and soil substrate (Table 2). Higher biomass production of earthworm 25.7 g of recorded of worms/week was recorded in cellulose substrate raised earthworm while the lower biomass production of 22.9 g of worms/week was recorded in dry Neem leaves and soil substrate culture earthworm (Table 2). There is insignificance difference ($p>0.05$) between the means of the biomass production of earthworm cultured in cellulose substrate and dry leaves and soil substrate.

The lower feed conversion ratio of 1.43 was recorded in earthworms cultured in cellulose substrate while the higher value of 1.64 was recorded in earthworm cultured in dry Neem leaves and soil substrate. The protein efficiency rates recorded during this study are 2.87 and 2.51 for cellulose substrate and dry Neem leaves and soil substrate which means are not significantly difference $p>0.05$ (Table 2).

Fishmeal has a better crude protein of 71.64% and earthworm meal 63.04%. There was no significant difference $p>0.05$ between the crude protein compositions of the two animal protein sources. Table 3 shows the proximate composition of the two animal protein sources. The percentage ratio of the chemical score to the crude protein of the animal protein was higher in fish meal with 48.8% and lower in earthworm meal 36.1% as shown in Table 4. There is significant difference $p<0.05$ between the essential amino acid ratio index recorded in earthworm meal and fish meal.

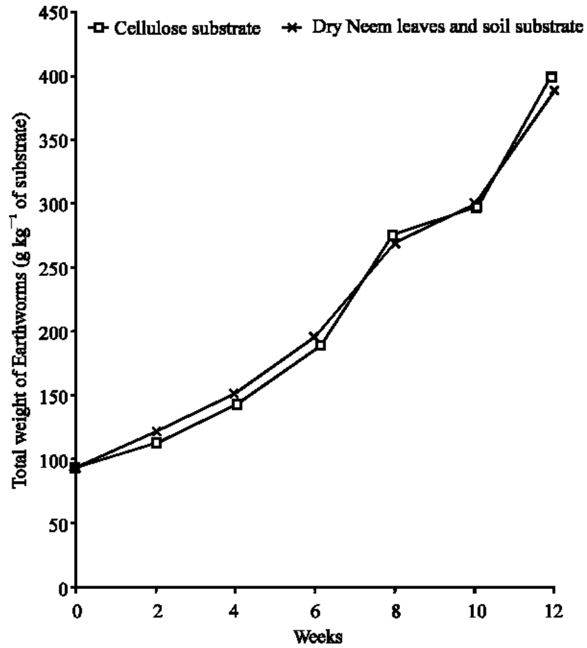

Fig. 1: Bi-Monthly growth pattern of *Hyperiodrilus euryaulos* cultured in two different organic wastes

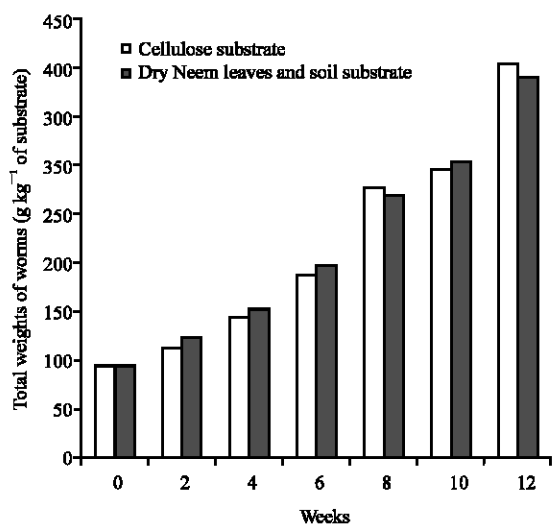

Fig. 2: Bi-Monthly biomass production of *Hyeriodrilus euryaulos* cultured in two different organic wastes

Table 2: Productivity potentials of earthworm using two different organic wastes

Parameters	Cellulose substrate	Dry neem leaves and soil substrate
Initial total weight of worms (g)	92.70	92.70
Final total weight of worms (g)	400.60[a]	367.50[a]
Total weight of worms gain (g)	307.90[a]	274.80[a]
Weekly weight gain (g/week)	25.70	22.90
Relative growth rate (%)	332.15	296.40
Specific growth rate (%/day)	0.76	0.71
Daily growth index (g/day)	3.39[a]	3.14[a]
Biomass production (worms/week)	25.70[a]	22.90[a]
Total feed intake	441.36	450.08
Feed conversion ratio	1.43[a]	1.64[a]
Gross feed conversion efficiency (%)	69.93	60.98
Protein efficiency rate	2.87[a]	2.51[a]
Survival rate %	98.00	99.00

All values on the same row with similar superscripts are not significantly difference ($p>0.05$)

Table 3: Proximate and mineral composition (DM %) of the tested animal protein sources

Composition	Earthworm meal	Fish meal (Clupeid)
Crude protein %	63.04[b]	71.46[a]
Ether extract %	5.90[d]	7.97[c]
Crude fibre %	1.90[d]	1.18[d]
Ash %	8.90[c]	18.22[b]
Nitrogen free extract %	13.76[b]	3.17[e]
Moisture %	8.60	8.89
Dry matter %	91.40	90.21
Gross Energy kJ/100 g	1968.24[c]	2074.09[b]
Sodium (g/100 g)	0.43[d]	0.91[b]
Calcium (g/100 g)	0.53[d]	3.53[a]
Potassium (g/100 g)	0.62[c]	0.96[b]
Phosphorus (g/100 g)	0.94[b]	2.40[a]
Magnesium (g/100 g)	NA	0.08

All values on the same row with different superscripts are significantly difference $p<0.05$

Table 4: Essential amino acids composition (g/16N g) dry matter and amino acids indices of the earthworm meal and Fish meal

Essential amino acids composition/animal protein sources	Earthworm meal	Fish meal (Clupeids)
Arginine	2.83[a]	5.34[b]
Histidine	1.47[a]	4.19[b]
Isoleucine	2.04[a]	2.62[a]
Leucine	4.11[a]	8.31[b]
Lysine	6.35[a]	10.96[b]
Methionine	5.30[a]	2.26[b]
Phenylalanine	6.26[a]	5.52[a]
Threonine	4.43[a]	5.28[a]
Valine	4.43[a]	5.88[b]
Tryptophan	0.88[a]	0.97[a]
Total essential amino acids	37.99[a]	51.33[b]
Crude protein %	63.04[a]	71.64[a]
EAAI (%)	71.50[b]	96.70[v]
Cs/Ps (%)	36.10[a]	48.80[b]
E:P	0.60	0.72

All values on the same row with different superscripts are significantly difference $p<0.05$

DISCUSSION

The results from this study show that cellulose substrate has better potential for earthworm culture than dry neem leaves and soil substrate which had been reported by Jameson and Venkataramanujam (2002) for *Eisenia foetida*. The weekly weight gain of 17.5 g/week reported in this study for earthworm cultured in cellulose substrate for *H. euryaulos* is higher than 1.4 g/week reported by Omoyinmi (2004) for *Eudrilus eugeniae* cultured in substrate containing an equal ratio of sand and cellulose. The increase in the biomass production of earthworm is an indication that cellulose substrate favours cocoons development and hatching because this biomass production would have originated from cocoon production and its hatchling. This report agreed with that of Omoyinmi (2004) that earthworm cultured in substrate containing sawdust and sand had the best final biomass The most likely explanation for the variation in weight recorded from the cellulose substrate was that the production of the bacteria involved in the breaking down of cellulose and possibly biochemical by-products was activated by the presence of cellulase in cellulose substrate. These bacteria were the basic food supply for worms and are need during decomposition of organic materials. Bacteria have been reported in the diet of tubificid worms (Aston, 1984) while Suzuki and Kurihara (1981) demonstrated that *Aelosoma hemprichi* could feed exclusively on bacteria, showing remarkably rapid population growth on this diet. The high reproductive rate and biomass production of *H. euryaulos* makes it ideally suited for worm meal production. This similar report was made by Dynes (2003) on *Perionyx excavatus* when he compared its biomass production to that of *Eisenia foetida*, *Eudrilus eugeniae* and *Dendrobaena veneta* and found that *P. excavatus* has the best biomass productivity. The biomass productivity reported in this study was not better than what Dynes (2003) reported for *P. excavatus* rather higher than the values for *Eisenia foetida*, *Eudrilus eugeniae* and *Dendrobaena veneta*. The fact that the two culture substrates supported the growth of earthworm indicates that they could be considered as good culture media for worm. The four months culture period used in this study is justified by the reports of Nguyen *et al.* (2000) and Nop *et al.* (2002) that earthworm population growth is slow in the first month but increases in the second month and reaches the maximum after three months.

Earthworm has been reported to help in digesting decayed plant materials in the soil for their food and produce a number of earthworm casts (Calvert, 1976). Earthworm reproductive capacity and nutritive value play important role in the possibility of its utilization as non-conventional feed for fish. Anglers also demand for this worm during sport fishing activity (Bankole *et al.*, 1985). Tacon (1987) emphasized on the ability of oligochaete worms to utilize waste streams (i.e., animal manures, domestic sewage, agricultural wastes) and upgrade waste nutrients into palatable and potentially valuable source of dietary nutrients for farmed fish and shrimp. Sogbesan *et al.* (2006) reported that with cellulose substrate culture medium about 2000 young earthworms can be collected from one set containing 50 adult worms and this was estimated at 963 worms m^{-2} which is not too far to 800 worms m^{-2} reported by Jameson and Venkataramanujam (2002) for *Eisenia foetida* cultured in dry neem leaves and soil substrates. The utilization of the cellulose substrate will go along way in recycling sawdust waste and poultry dung which are the major composition of this substrate, hence cleaning the environment off these wastes and solving pollution problems encountered as a result of their inappropriate disposal and also convert them to worm tissue solving the problems of unavailability especially during the dry season.

The fact that the crude protein content of the earthworm meal is closer to that of fish meal indicated that feeding fish with this animal supplement will not pose the problem of malnutrition to the fish. A basic principle of amino acid nutrition is the constant relationship of the amino acid requirement with protein intake up to the level that is required for growth and other metabolic performances (Petril *et al.*, 2004). The result of the essential amino acids indicated that this animal supplement could be a replacement for fishmeal. Methionine which has been reported in this study to be higher in earthworm meal than fish meal, has been credited as growth promoting essential amino acid which is highly needed by cultured fish and limiting in most plant and animal supplements (Wilson, 2002). Eyo (1999) and Fagbenro *et al.* (2000) have documented the essential amino acid compositions of *Heterobranchus longifilis* and other relatives of Clariidae family. The report of Wilson and Poe (1985) suggested that amino acid test diet for fish may be improved by formulating them to simulate the amino acid profile of the whole body tissues of the fish being studied. The nutritive value of a protein depends upon its capacity to produce nitrogen and amino acids in adequate amounts to meet the requirements of an organism (Wilson, 1989) and the value of the amino acid, have been scored with the provisional pattern as reported by National Research Council (1993) which justify the capacity of earthworm meal to produce productive nitrogen needed for metabolic activity by fish which inclusion in fish feed will be able to reduce the production cost of fish feed.

This result has provided baseline information on the culture of *H. euryaulos* and the nutrient potential which could be tried on large scale production especially for adequate supply of the worm for fishermen and anglers as bait or for the high methionine composition. There is a need for further study on the fatty acid composition of the fish so as to ascertain this important nutrient especially if the worm will be fed to either breeders or fry as live food.

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