Nigerian Journal of Science and Engineering Infrastructure (NJSEI)

Volume 1, Issue 1 (2023), 85-105. Idris et al.

Utilisation of Maggots and Earthworms as Protein Supplement in the Feed of *Clarias Gariepinus* (Burchell, 1822).

ABDULRAHMAN, H. I*, IDOWU, R. T. & OGUNLADE-ANIBASA, G. O.

Department of Biology, University of Abuja, Abuja.

*Corresponding author: **Idrishabibatu@gmail.com**

ABSTRACT

Six months feeding trial was conducted to determine the growth performances of juvenile of *Clarias gariepinus* fed with varying replacement levels of Earthworm and Maggot meals. Proximate analysis was conducted using the procedure of Association of Official Analytical Chemist (AOAC) to ascertain the proximate compositions of Earthworm and Maggot. It was found that both Earthworm and Maggots have high protein content (42.95% and 40.33% respectively). Twenty-five (25) fingerlings of *Clarias gariepinus* were subjected to five different dietary treatments in replicate of 0%, 25%, 50%, 75% and 100%. Feedings were done twice a day (8am in the morning and 5pm in the evening) at 3% of their body weight, and the quantity of feeds was adjusted based on new weight gain. The morphometric measurements were carried out biweekly. At six months, the highest standard length (40.40 ± 0.50cm), total length (43.30 ± 1.00cm), and weight gain (485.10 ± 13.00g) was observed in 100% Earthworm and maggot meal, while the least standard length (32.60 ± 0.80cm), total length (35.90 ± 1.60cm) and weight gain (428.60 ± 4.50g) was observed in 0% Earthworm and Maggot meal. However, in all other growth performances and nutrient utilization parameters measured such as Relative growth rate, Specific growth rate, Feed intake, Protein efficiency ratio and Feed conversion ratio, 100% Earthworm and maggot had the best performance more than other treatments. There are no significant differences ($P<0.05$) in survival rates in all the five different treatments. The results gotten from the water quality parameters showed no significant difference among all the treatment. Therefore, it can be concluded that combination of Earthworm and Maggot meal as a substitute to fish meal at 100% replacement level, in the diet of *Clarias gariepinus* could enhance growth without any adverse

DOI.org/10.61352/2023AT09

negative effect on the health, growth and development of juvenile of African catfish (*Clarias gariepinus*).
Keyword: *Clarias gariepinus*, Maggots, Earthworm, fishmeal, protein supplement.

INTRODUCTION

Fish is a highly nutritious food, and large production of it at a lower price could also benefit many of our people (Allumma and Idowu, 2011). The cost of feeding is a significant factor affecting the development of the aquaculture industries in Nigeria (Omitoyin, 2007). The growth of aquaculture industry depends on the availability of suitable and less expensive feeds. Fagbenro *et al.* (2003) reported that commercial pellets and supplementary fish feeds account for about 60% and 40% respectively, of the recurrent cost of fish farming ventures in Nigeria. In 1989, the Presidential Task Force on Alternative feed Formulation noted that the major problem of aquaculture in Nigeria is feeding of fishes and gave solutions with a view to increasing fish production from this sector (FDF, 2003). One suggestion was the use non-conventional protein supplements of both animal and plant origin in experimental fish diets. The primary prerequisite for successful fish farming is the availability of suitable artificial feeds formulated from locally available cheap ingredients that will supply adequate nutritional requirements for culturing fishes (Olele and Okonkwo, 2012). Non-Conventional Feed Resources (NCFRs) are credited for being non-competitive to human consumption; they are a very cheap by-product or waste from agriculture, farm-made feeds, and processing industries. Finally, they can serve as a form of waste management in enhancing good sanitation. NCFRs include all types of feedstuffs from animals (e.g. silkworm, maggot, termite, grub, earthworm, snail and tadpoles; plant wastes (jack bean seeds, kunnu waste, cottonseed meal, soybean meal, pigeon pea, chaya, duckweed, maize bran, brewers waste, rice bran, palm kernel cake, and groundnut cake) as well as wastes from animal sources and processing of food for human consumption such as animal dung, offal, shrimp head, feathers, fish silage, bone and blood) (Fasakin *et al*., 2000; Alegbeleye, 2005, Omitoyin 2007, Faturoti and Akinbote, 2015). Many studies have been carried out on the possibility of the inclusion of some of these NCFRs in fish feed by Fasakin *et al.* (2000), Otubusin and Ifili (2000), Ugwumba *et al*. (2001), Akinwande *et al*. (2002), Fagbenro *et al.* (2003), Dankishiya *et al*., (2017) and Sogbesan *et al.* (2005).

Nigerian farmers' most cultured and economically desired fish species is *Clarias gariepinus* (Adekoya *et al.,* 2001). *Clarias gariepinus* is widely distributed, thrives in diverse environments, hardy, fast-growing, efficient in nutrient utilisation and has a high yield of tasteful flesh (Ebonwu *et al.,* 2011). It is highly fecund and easily spawned under captive condition (FAO, 2006). However, local production has not been able to meet the demand for the species. Hence, there is a need to boost this fast-growing and suitable aquaculture species for food sustainability in Nigeria. Earthworm and maggot are animal protein sources with highly nutritive values (Sogbesan *et al*., 2006; Sogbesan and Ugwumba, 2008). They have high digestibility (NRC, 2011) and contains essential amino acids (Adesina, 2012). These animal proteins are cheap and also easy to produce using dungs from animal or agro-alimentary wastes (Sogbesan *et al*., 2006; Djissou *et al*., 2015). To satisfy the essential amino acids required for the growth of *Clarias gariepinus* fingerlings, the experimental diets based on a mixture of earthworm and maggots (at the ratio of 50:50) were tested in order to replace fishmeal which is the major protein source in the fish feed and also very expensive, with a view to determining the growth performances and feed utilization of the cultured *Clarias gariepinus* fingerlings.

MATERIALS AND METHODS

Study Area

This study was carried out at the Aquaculture Unit of the National Biotechnology Development Agency (NABDA) which is located at Umaru Musa Yar'Adua way, Airport Road Lugbe, FCT, Abuja.

Experimental Design

This research was conducted for six months (24 weeks), which commenced in November, 2021 and ends in May, 2022. The experimental design adopted was Randomised Complete Block Design. The treatment groups were fed diets T^0, T^1, T^2, T^3, T^4, which contains 0% earthworm and maggot meal, 25% earthworm and maggot meal, 50% earthworm and maggot meal, 75% earthworm and maggot meal, 100% earthworm and maggot meal respectively. Fifteen (15) plastic tanks (1000 litres respectively) at the NABDA Complex Research Farm were used for the feeding trial and stocked with twenty-five fingerlings of *Clarias gariepinus* respectively, with an average total weight of 4g and average total length of 8.2cm.

Experimental Fish

Three hundred and Seventy-five fingerlings of *Clarias gariepinus* were purchased from Chiody Agro allied farms, Zuba FCT, Abuja. They were harvested in a jerry can and transported to the experimental site. Upon arrival at NABDA, Abuja, the fingerlings were acclimatised in a plastic tank for three days and fed with a commercial diet. At the end of the acclimatisation period, they were randomly selected and stocked at the rate of 24 fingerlings per tank and fed twice a day (8am in the morning and 5pm in the evening) at 3% body weight. Hence the quantity of feeds was increased based on new weight gain. They were starved for 24hrs before stocking to prepare their appetite for the new feed.

Sources of Ingredients.

The ingredients for the formulation of the feed such as Earthworm, maggot, Fishmeal, vitamin and mineral premix, soyabean, groundnut cake, maize and binder were obtained from FCT, Abuja.

Collection and Processing of Earthworm and Maggots.

Collection of earthworms

Large amounts of fully grown earthworms, *Lumbricus terrestis* were obtained at the NABDA dumpsites and gardens during the rainy season. The earthworms were blanched with hot water and cleaned using blotting paper. They were dried in an electric oven for 50 mins at 80^{o}C, crushed using mechanical grinder, and stored in a container (Sogbesan, 2014).

Production and Collection of maggots.

Maggots were produced from Abattoir waste, which were collected directly from the pouch of the cattle into a basin at the abattoir in Kutunku, Gwagwalada – Abuja, and transported to the laboratory at NABDA. The collected Abattoir waste was dried to a constant weight and weighed. One litre of water was added to each of the dried 1kg Abattoir waste and packed in a jute bag. The substrate was exposed to housefly Musca domestica for feeding between 8:00 am – 10:00 pm within premises of the fish farm of NABDA, Abuja. They laid eggs while feeding on the Abattoir waste. Maggot production was monitored, and collections were made after the full production period (Sogbesan et al., 2006). The maggots collected were washed, dried in an electric oven for 50 mins at 80^{o}C, crushed using mechanical grinder and stored in a container.

Experimental diets and feed formulation.

Experimental diets with crude protein of 40% was formulated according to Pearson's Square Method as described by Olokor et al. (2007). All the ingredients were grounded into a fine powder using a hammer mill and sieved using a 0.25mm sieve. The experimental diets were prepared by measuring appropriate quantities of the ingredients using weighing balance, and then fishmeal was gradually replaced by Earthworm and Maggot meal (EMM) in the following proportions;

0% EMM: 100% fishmeal and 0% Earthworm and Maggot meal.

25% EMM: 75% fishmeal and 25% Earthworm and Maggot meal.

50% EMM: 50% fishmeal and 50% Earthworm and Maggot meal.

75% EMM: 25% fishmeal and 75% Earthworm and Maggot meal.

100% EMM: 0% fishmeal and 100% Earthworm and Maggot meal.

Moreover, the ingredients were mixed thoroughly to form a slurry before pelletising using a locally fabricated industrial pelleting machine and sun dried for 24 hours to ensure constant dry weight (Babale, 2016). The pelletised feeds were stored in polythene bags before proximate analysis.

Proximate Analysis of Ingredients and Experimental Diets.

The proximate composition of the ingredients and the experimental feeds, such as Moisture content, Crude Protein, Crude lipid, Ash content and Carbohydrates were determined, in the research laboratory of Jagaba Analytical and Consultancy Service (JACS), Minna, Niger State, using the AOAC (2000) methods.

Feeding and Morphometric measurement.

Feeding of the fish was done twice a day based on percentage body weight, in the morning at 7:00-8:00 and evening at 5:00-6:00 pm in all the fifteen experimental ponds as described by (Kataki et al., 2010).

A sampling of the fish was carried out biweekly using scoop nets to determine the growth performances and nutrient utilization. The quantity of feeds were adjusted according to changes in the weight gain of the fish

Water Quality Parameters.

Water quality parameters such as temperature, pH, conductivity and Dissolved oxygen was measured in situ throughout the research period (Dankishiya and Ekpenwa, 2020).

Statistical Analysis

The data obtained from growth performance, feed utilisation parameters, and survival rates was expressed as the Mean of the duplicate ± standard deviation. The data were presented in Tables and figures. The values were further analysed using a two-way variance (ANOVA) analysis at a

0.05% significant level. Mean separation was done using Duncan Multiple Range Test (DMRT) to separate mean values at $p<0.05$ level of significance.

RESULTS

Proximate Composition of Earthworm and Maggots.

Proximate analysis was conducted to ascertain the proximate compositions of Earthworm and maggot respectively. The proximate percentage compositions were shown in table 1.

Table 1: Proximate compositions of Earthworm and Maggots.

Proximate Composition	Earthworm	Maggot
Moisture content	7.23%	9.92%
Crude protein	42.95%	40.33%
Fat content	10.39%	22.65%
Ash content	33.80%	10.43%
Crude fibre	2.22%	10.25%
Carbohydrate content	3.43%	6.42%
Total	100%	100%

Experimental diets composition

Experimental diets with 40% crude protein were formulated using Pearson's Square Method. The compositions of each of the diets were shown in Table 2. The quantity of fishmeal, earthworm and maggots varies across different diets, in the sense that, as the quantity of fishmeal in the diets is decreasing, the quantity of Earthworm and Maggot is increasing, while other ingredients like groundnut cake, soybean, maize, vitamins and mineral premix, binder and groundnut oil remains constant across the whole diets.

Table 2: Compositions of different experimental diets.

Ingredients	0% EMM	25% EMM	50% EMM	75% EMM	100% EMM
Fishmeal	20.30	15.20	10.15	5.10	0.00
EMM	0.00	5.10	10.15	15.20	20.30
GNC	31.20	31.20	31.20	31.20	31.20
Maize	30.50	30.50	30.50	30.50	30.50

Soybean	8.00	8.00	8.00	8.00	8.00
Premix	1.50	1.50	1.50	1.50	1.50
G. Oil	0.50	0.50	0.50	0.50	0.50
Binder	8.00	8.00	8.00	8.00	8.00
Total	100.00	100.00	100.00	100.00	100.00

Legend: EMM = Earthworm and Maggot Meal, GNC = Groundnut cake, G.Oil = Groundnut oil.

Proximate composition of the Experimental diets

The proximate analysis was conducted according to the procedure of Association of Official Analytical Chemists (2000). The proximate compositions of the experimental diets were shown in figure 1.

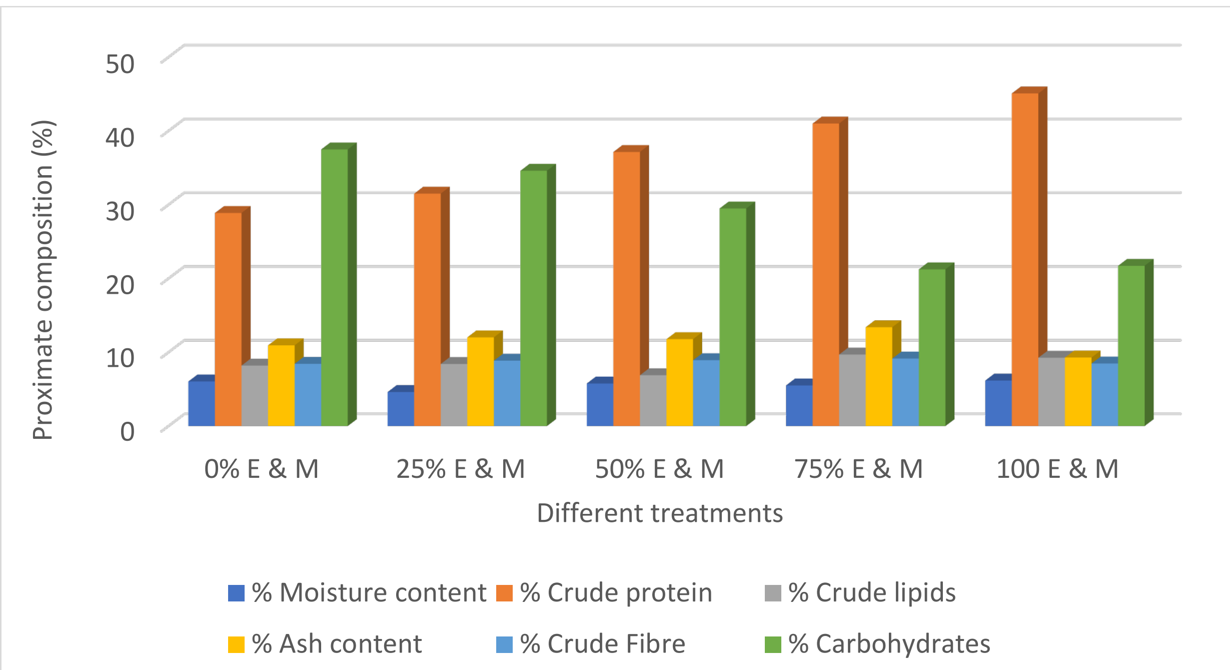

Fig 1: Proximate Compositions of Experimental diets

The highest moisture content was found in 100% Earthworm and Maggot meal (6.17%) while the least was found in 25% Earthworm and Maggot meal (4.61%). The highest Crude protein content was found in 100% Earthworm and Maggot meal (45.08%) while the least was found in 25% Earthworm and Maggot meal (28.88%). The highest fat content was found in 75% Earthworm and Maggot meal (9.70%) while the least was found in 50% Earthworm and Maggot meal (6.89%). The highest ash content was found in 75% Earthworm and Maggot meal (13.40%) while the least was found in 100% Earthworm and Maggot meal (9.29%). The highest fibre was found in 75%

Earthworm and Maggot meal (9.15%) while the least was found in 0% Earthworm and Maggot meal (8.44%). The highest carbohydrate content was found in 0% Earthworm and Maggot meal (37.49%) while the least was found in 75% Earthworm and Maggot meal (21.24%).

Growth performances and Nutrient Utilization

The growth performances and survival rates of juveniles of African catfish, *Clarias gariepinus* fed with different percentages of Earthworm and Maggot Meal (EMM) were shown in Table 3.

Table 3: Growth performance and feed utilisation of *Clarias gariepinus* fed with different inclusion levels of Earthworm and Maggot Meal.

Parameter	0% EMM	25%EMM	50%EMM	75%EMM	100%EMM
MISL	7.60 ± 0.30^{a}	7.20 ± 0.10^{ab}	7.00 ± 0.10^{b}	7.20 ± 0.20^{ab}	7.20 ± 0.10^{ab}
MFSL	32.60 ± 0.80^{a}	35.80 ± 0.90^{ab}	36.90 ± 0.60^{b}	37.10 ± 2.70^{b}	40.40 ± 0.50^{c}
MITL	8.60 ± 0.30^{a}	8.20 ± 0.10^{a}	8.00 ± 0.10^{a}	8.00 ± 0.20^{a}	8.20 ± 0.04^{a}
MFTL	35.90 ± 1.60^{a}	37.70 ± 0.60^{ab}	38.50 ± 0.90^{ab}	40.30 ± 2.60^{b}	43.30 ± 1.00^{c}
MIW	4.40 ± 0.20^{a}	4.00 ± 0.20^{a}	3.90 ± 0.10^{a}	3.80 ± 0.20^{a}	3.90 ± 0.10^{a}
MFW	433.00 ± 4.50^{a}	446.00 ± 2.90^{ab}	458.90 ± 7.20^{b}	473.10 ± 11.60^{c}	489.00 ± 13.10^{d}
MWG	428.60 ± 4.50^{a}	442.00 ± 2.90^{ab}	455.00 ± 7.30^{b}	469.30 ± 11.80^{c}	485.10 ± 13.00^{d}
RGR	9753.03 ± 337.90^{a}	11053.17 ± 156.80^{ab}	11742.10 ± 514.60^{b}	12075.00 ± 17.20^{c}	12340.97 ± 1040.20^{d}
SGR	1.446 ± 0.02^{a}	1.453 ± 0.01^{ab}	1.460 ± 0.03^{c}	1.470 ± 0.01^{d}	1.478 ± 0.01^{e}
FI	253.30 ± 3.00^{a}	258.60 ± 1.20^{ab}	273.70 ± 5.40^{b}	284.30 ± 3.00^{c}	298.60 ± 3.00^{d}
PER	10.80 ± 0.10^{a}	11.03 ± 0.05^{ab}	11.40 ± 0.20^{b}	11.70 ± 0.30^{c}	12.10 ± 0.30^{d}
SR	80.00 ± 3.30^{a}	81.30 ± 6.80^{ab}	82.60 ± 5.00^{b}	80.00 ± 6.50^{a}	83.00 ± 3.80^{c}

FCR	3.20 ± 0.10[a]	3.10 ± 0.20[ab]	3.04 ± 0.20[b]	3.02 ± 0.10[b]	2.90 ± 0.10[c]

Legend: EMM = Earthworm and Maggot Meal; MISL = Mean Initial Standard Length; MFSL = Mean Final Standard Length; MITL = Mean Initial Total Length; MFTL = Mean Final Total Length; MIW = Mean Initial Weight; MFW = Mean Final Weight; MWG = Mean Weight gain; RGR = Relative Growth Rate; SGR = Specific Growth Rate; FI = Feed Intake; PER = Protein Efficiency Ratio; SR = survival rate; FCR = Feed Conversion Ratio.

Mean values followed by the same letter(s) within same row are not significantly different ($P \geq 0.05$).

The highest initial Standard and Total length was found in 0% EMM (7.6 ± 0.30, 8.60 ± 0.30), while the least was found in 50% EMM (7.00 ± 0.10cm, 8.10 ± 0.10cm) and 75% EMM (7.00 ± 0.20cm, 8.00 ± 0.20cm) respectively. There is no significant difference ($P>0.05$) in initial Standard length and Total length of the fishes fed with 25% EMM (7.20 ± 0.10cm and 8.20 ± 010cm respectively) and 100% EMM (7.20 ± 0. 10cm and 8.20 ± 0.04cm respectively).

However, at 24 weeks (6 months), it was observed that the highest mean standard and total length were noticed in the fishes fed with 100% EMM (40.40 ± 0.50cm and 43.30 ± 1.00cm respectively), followed by 75% EMM (37.10 ± 2.70cm and 40.30 ± 2.60cm respectively) while the least was found in fishes fed with 0% EMM (32.60 ± 0.80cm and 35.90 ± 1.60cm respectively). There is no significant difference ($P>0.05$) between the fishes fed with 25% EMM (35.80 ± 0.90cm and 37.70 ± 0.60cm respectively) 50% EMM (36.90 ± 0.60cm and 38.50 ± 0.90cm respectively).

The highest initial weight was observed in fishes fed 0% EMM (4.40 ± 0.20g), While the least was observed in 75% EMM (3.80 ± 0.20g). There is no significant difference ($P>0.05$) in initial weight of the fishes fed 25% EMM (4.0 ± 0.20g), 50% EMM (3.90 ± 0.10g) and 100% EMM (3.90 ± 0.10g).

However, at 24 weeks (6 months), the highest mean weight gain was recorded in the fishes fed with 100% EMM (485.10 ± 13.00g) followed by 75% EMM (469.30 ± 11.80g) while the lowest monthly weight gain was recorded in fish fed with 0% EMM (428.60 ± 4.50g). There is significant difference ($P \leq 0.05$) in the mean weight gain of fishes fed with 25% EMM (442.00 ± 2.90g) and 50% EMM (455.00 ± 7.30g).

The highest Relative growth rate (RGR) was recorded in the fishes fed with 100% EMM (12340.97 ± 1040.20) followed by 75% EMM (12075.00 ± 17.20) while the lowest monthly weight gain was recorded in fish fed with 0% EMM (9753.03 ± 337.90). There is a significant difference ($P \leq 0.05$) in the Relative Growth Rate (RGR) of fishes fed with 25% EMM (11053.17 ± 156.80) and 50% EMM (11742.10 ± 514.60).

The highest specific growth rate was recorded among fishes fed with 100% EMM (1.478 ± 0.01%), followed by 75% EMM (1.470 ± 0.01%), While the lowest specific growth rate was recorded among fishes fed with 0% EMM (1.446 ± 0.02%). There is no significant difference in specific growth rate between fishes fed with 25% EMM (1.453 ± 0.01%) and 50% EMM (1.460 ± 0.03%).

The highest Feed intake was recorded in fishes fed with 100% EMM (298.60 ± 3.00) followed by 75% EMM (284.30 ± 3.00) while the lowest was found in fish fed with 0% EMM (253.30 ± 3.00). There is a significant difference in feed intake between the fishes fed with 25% EMM (258.60 ± 1.20). and 50% EMM (273.70 ± 5.40).

The highest Protein efficiency ratio was recorded in fishes fed with 100% EMM (12.10 ± 0.30), followed by 75% EMM (11.70 ± 0.30) while the lowest was found in fish fed with 0% EMM (10.80 ± 0.10). There is no significant difference in the Protein Efficiency ratio between the fishes fed with 25% EMM (11.03 ± 0.05) and 50% EMM (11.40 ± 0.20).

The highest Survival rate was found in the fishes fed with 100% EMM (83.00 ± 3.80), followed by 50% EMM (82.60 ± 5.00), while the least was found in fish fed with 0% EMM and 75% EMM (80.00 ± 3.30 and 80.00 ± 6.50). However, there were no significant differences ($P>0.05$) in survival rate between the fish fed with 25% EMM (81.30 ± 6.80) and other inclusion levels.

The best feed Conversion ratio was found in the diets containing 100% EMM (2.90 ± 0.10), followed by 75% EMM (3.02 ± 0.10), while the poorest was found in the 0% EMM (3.20 ± 0.10). There are no significant differences ($p>0.05$) between the fish fed with 25% EMM (3.10 ± 0.20) and 75% EMM (3.04 ± 0.20). The lower the FCR, the better the performance in weight gain.

Growth curve of *Clarias gariepinus*

The growth curve of *Clarias gariepinus* fed with different percentages of Earthworm and Maggot meal is shown in figure 2. At the commencement of the feeding trials (Initial measurement), there is no significant differences in the weight of the fishes in all levels (Percentages) of Earthworm and Maggot meal, but from the fourth week (Month 1), there is observable differences in weight gain in all different treatment levels with the highest weight obtained in 100% Earthworm and Maggot meal.

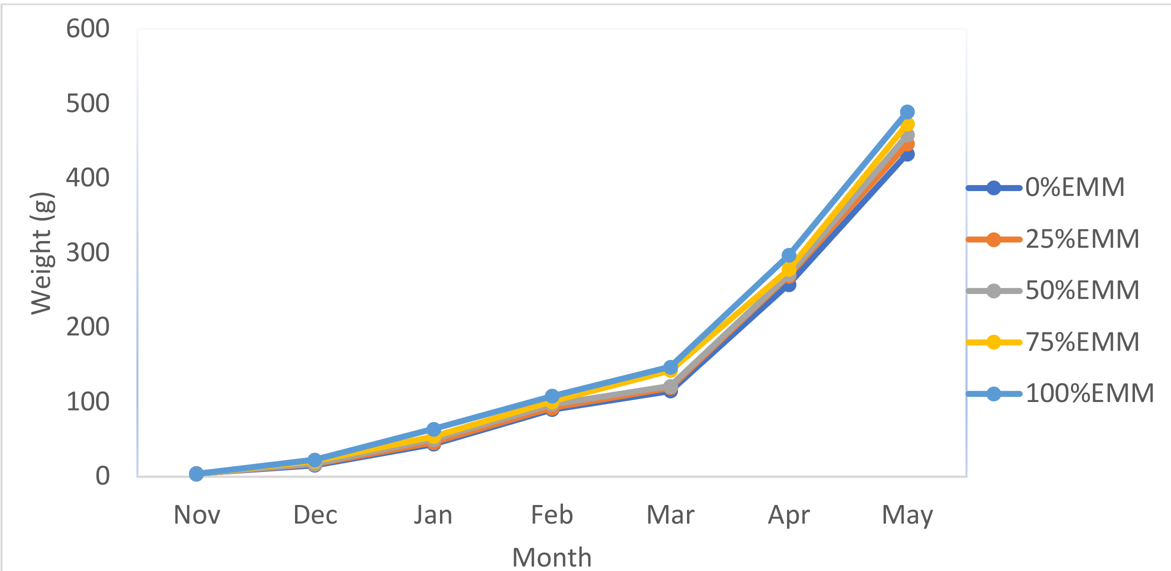

Fig 2: Growth curve of *Clarias gariepinus* fed with different percentages of Earthworm and Maggot Meal November 2021 to May 2022.

Physico-chemical Parameters of Water.

The result of the Physico-chemical Parameters of water is shown in Table 4

Table 4: Physico-chemical parameters of water

Parameter	0% EMM	25%EMM	50%EMM	75%EMM	100%EMM
Temp (^{O}C)	26.80 ± 0.90^{a}	27.50 ±0.90^{ab}	26.60±0.40^{a}	26.80 ± 0.40^{a}	26.70 ± 0.40^{a}
pH	6.60 ± 0.20^{a}	6.80 ± 0.60^{ab}	6.70 ± 0.20^{b}	6.70 ± 0.10^{b}	6.60 ± 0.10^{a}
D.O (Mg/l)	4.70 ± 0.20^{a}	4.40 ± 0.10^{ab}	4.60 ± 0.20^{a}	4.80 ± 0.40^{a}	4.50 ± 0.20^{ab}
Conductivity (µm/cm)	168.00 ± 2.90^{a}	171.00 ± 0.80^{ab}	169.00 ± 1.60^{a}	173.00 ± 2.90^{b}	170.00 ± 0.80^{ab}

The highest mean temperature was recorded in 25% EMM (27.50 ± 0.90), followed by 0% EMM and 75% EMM (26.80 ± 0.90 and 26.80 ± 0.40) while the least was found in 50% EMM (26.60 ±

0.40). The mean temperature recorded in all the diets are not significantly different (P<0.05) with value recorded in 100% EMM (26.70 ± 0.40).

The highest pH was recorded in 25% EMM (6.80 ± 0.60), followed by 50% EEM and 75% EMM (6.70 ± 0.20 and 6.70 ± 0.10 respectively) while the least was found in 0% EMM and 100% EMM (6.60 ± 0.20 and 6.60 ± 0.10). The mean monthly pH recorded in all the treatments are not significantly different (P<0.05) from others.

The highest Dissolved Oxygen was found in 75% EMM (4.80 ± 0.40mg/l), followed by 0% EMM (4.70 ± 0.20mg/l) while the least was recorded in 25% EMM (4.40 ± 0.10). The mean Dissolved Oxygen recorded in 50% EMM (4.60 ± 0.20mg/l) and 100% EMM (4.50 ± 0.20mg/l) are not significantly different (P<0.05).

The highest water Conductivity was observed in 75% EMM (173.00 ± 2.90), followed by 25% EMM (171.00 ± 0.80) while the lowest was found in 0% EMM (168.00 ± 2.90). However, the mean water Conductivity recorded in 50% EMM (169.00 ± 1.60) and 100% EMM (170.00 ± 0.80) are not significantly different (P<0.05).

DISCUSSION

Fish meal is the major protein source in the diets of African catfish because it contains all the essential amino acid required for the growth of fishes, but its high cost and its competitive value has necessitated a search for an alternative source of protein. Animal protein is always preferable as a substitute because they contain all the essential amino acids unlike plant protein that has many antinutritional qualities. The use of either earthworm and maggots respectively as a single protein source in the diet of African catfish has been recorded by many researchers but there is scanty information on the combination of both as a replacement to fish meal. Protein requirement is prerequisite in the study of fish nutrition because it is a single nutrient that is required in a higher quantity to ensure growth and development and it is also regarded as the most expensive ingredients in feed formulation. Nutritional quality of fish diets depends on the quality of the protein ingredients used in formulating the diets (Glen cross *et al*., 2007, Li *et al*., 2009).

Proximate analysis was conducted using the procedure of Association of Official Analytical Chemist (AOAC, 2000) to ascertain the proximate compositions of Earthworm and Maggot meal. The crude protein of earthworm and maggot recorded in this research work is significantly high and within the recommended range for the growth of *Clarias gariepinus*. Similar result was obtained by Gbai *et al* (2018) which shows that earthworm and maggot has a crude protein of 41.7% and 40.34% respectively. Some other studies showed some little variations in the crude protein contents of Earthworm (Beg *et al*., 2016, Dedeke *et al*., 2010, Sogbesan *et al*., 2007, Dong *et al*., 2010) and maggot meal (Ugwumba *et al*., 2001, Ogunji *et al*.,2006, Okah and Onwujiariri 2012, Ezewudo *et al.,* 2015). The differences between the crude protein of Earthworm and Maggots recorded in this present research work and other previous research work may be attributed to the method of harvesting, method of processing, differences in age when harvesting, method of drying and some environmental factors.

The growth performances and nutrient utilization of *Clarias gariepinus* increases as the quantity of Earthworm and maggot meal increases across the diets. The result gotten from this research work shows that the growth performance (Weight gain, Standard and Total length, Relative growth rate and Specific growth rate) of the juvenile of African catfish, *Clarias gariepinus* increases with the increasing levels of Earthworm and Maggot meal in the diet. This could be due to the fact that both earthworm and maggots have high nutritional values, high digestibility and contains essential amino acids that are similar to that of fish. This agrees with the findings of Collins *et al*. (2013), who reported that a mixture of two proteic sources in the replacement of fish meal improves the growth performances of fishes. However, Djissou *et al. (*2016) in their findings reported that the combination of unconventional animal protein such as earthworms and maggot meal in the diet of fingerlings of *Clarias gariepinus* improves their growth and feed utilization. Combination of different ingredients in production of a single fish feed improves fish better growth performance (Sogbesan *et al*., 2006, Khan *et al*., 2013, Makkar *et al*., 2014)

Fish fed with 100% earthworm and maggot meals had the highest feed intake. This has a direct link with palatability and nutritive value of the feed. Palatability is one of the factors affecting feed intake of fish. Meena (2015) reported palatability of the diets as among the factors that affects acceptance of feed to fish. Coelomic fluid in earthworm which could have caused low palatability was properly taken care of by properly soaking the earthworms in hot water and drying using an oven. Lysenin, which is a component of the coelomic fluid, was said to produce toxic effects by binding to sphingomyelin (Kobayashi *et al.,* 2001, Kobayashi *et al.,* 2004), but heat-treatment of coelomic fluid removes its toxic effects, and this shows that lysenin and other haemolytic factors may be heat labile (Kauschke *et al.,* 2007). Preservation and processing methods used when some species of earthworms are incorporated into fish feed can greatly affect its palatability (Pucher *et al*., 2014). Tacon *et al.* (1983) suggested pre-treatment of earthworm by removal of coelomic fluid, heat treatment in the course of drying, or blanching with hot water.

The highest Protein efficiency ratio (PER) was found in 100% earthworm and maggot meal. This result could have a direct link with the palatability and nutritional quality of the feed which causes increase in the feed intake. This also has to do with the digestibility of the feed. It is an indication of good protein digestibility and bioavailability for optimum body protein increase and growth. This agrees with findings of Adesina (2012). He noted that the good Protein efficiency ratio values obtained for *Clarias gariepinus* fingerlings fed diets devoid of fish meal are enabled by the unconventional animal protein sources used (earthworms and maggots) which are rich in essential amino acids. Jabir *et al*. (2012), recorded that Protein efficiency ratio has to do with digestibility of nutrients.

There was a decrease in the feed conversion ratio (FCR) as the quantity of earthworm and maggot meal increases across the diet. The decrease in feed conversion ratio shows good feed utilization. The lower the feed conversion ratio, the better the conversion efficiency, that is, the better utilization of the feed by the fish. However, the best Feed conversion ratio was recorded on the fish fed with 100% earthworm and maggot meal. This implies that fishes fed with 100% earthworm and maggot meals consumes much feeds and these feeds consumed were able to convert to body flesh. This agrees with the findings of Aniebo *et al* (2009), in their research, they recorded that the non-significant differences in the values of Feed conversion ratio (FCR) is an indication that both protein sources compared favourably in feed to flesh conversion.

Earthworm and maggot meal are generally accepted by the fishes. This accounts for the high survival rates recorded in all the different treatment levels, which are not significantly different. The death recorded in the different experimental tanks could be due to some environmental factors. This agrees with the finding of Djissou et al (2016), which showed that earthworm and maggot meal does not lead to mortality, hence it could enhance fish survivorship.

The mean physico-chemical parameters of water recorded throughout the period of the research work are within the acceptable range for the culture of *Clarias gariepinus*. This also attributed to high survival rates gotten from all the treatments. Mean Temperature values ranges from 26.60^{o}C to 27.50^{o}C, pH values range from 6.60 to 6.80, Dissolved oxygen values ranges from 4.40mg/l to 4.80 mg/l, while Conductivity values ranges from 168µm/cm to 173µm/cm. The results gotten from the water parameters showed no significant difference. This agrees with the findings of Nneji and Dankishiya, (2018), that the good growth and survival rates for the juvenile of *Clarias gariepinus* could be as a result of maintenance of good water quality.

CONCLUSION

From the result obtained from this research work, it can be shown that combination of earthworm and maggot meal as a substitute to fish meal at 100% replacement level, in the diet of *Clarias gariepinus* could enhance growth without any adverse negative effect on the health, growth and development of juvenile of African catfish (*Clarias gariepinus*).

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