IJEN

International Journal of Entomology and Nematology
Vol. 3(1), pp. 042-050, January, 2017. © www.premierpublishers.org. **ISSN**: XXXX-XXXX

Research Article

Evaluation of house fly (*Musca domestica*) maggot meal and termite (*Macrotermes subhyalinus*) meal as supplementary feed for African catfish *Clarias gariepinus* (Burchell, 1822)

[1]Arong, Gabriel A. and [2]Eyo, Victor Oscar

[1*] Department of Zoology and Environmental Biology, University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria.
[2] Department of Fisheries and Aquaculture, Institute of Oceanography, University of Calabar, P.M.B. 1115, Calabar, Cross River State, Nigeria.
***Corresponding email address:** gabrielarong@yahoo.com

A 56-day feeding trial was conducted to investigate the effects of the combination of maggot and termite meal with Coppens commercial feed on the growth performance, food utilization and survival of the African catfish (*C. gariepinus*). A total of 150 fingerlings were stocked in fifteen glass aquaria, 10 each in triplicate. Fish in aquarium A_1, A_2 and A_3 were fed maggot meal (100 %-MM), B_1, B_2 and B_3 with termite meal (100 % - TM), C_1, C_2 and C_3 with equal combination of maggot meal and Coppens feed (50:50), D_1, D_2, and D_3 with equal combination of termite meal and Coppens feed (50:50) and E_1, E_2 and E_3 with Coppens feed (100 %). Growth performance including length gain, weight gain, growth rate, specific growth rate and mean growth rate and food utilization indices including food consumed (g), food conversion ratio and food conversion ratio showed significant variation (P<0.05) in fish fed Coppens feed compared to other treatments. Physico-chemical parameters and ammonia (mg/l) were within the acceptable range for optimal growth of freshwater fishes. Although Coppens was the best result for growth and food utilization, the combination of maggot/termite meal with Coppens as supplementary feed will reduce the cost of fish production exposing farmers to a higher profit margin. In conclusion, feeding fish with only termite meal or maggot meal can lead to poor growth because these insect meals do not provide all the nutrients required for optimal growth in fish. However, maggot meal and termite meal should be used as only as a supplementary food in fish culture or as a replacement for highly priced fishmeal in fish feed formulation because they are rich in protein.

Keywords: *Clarias gariepinus*, Supplementary feed, Maggot meal, Termite meal, Coppens feed, Growth performance, Food utilization.

INTRODUCTION

As aquaculture continues to gain popularity in Nigeria, its growth rate is significantly influenced by unavailability of high quality feed especially in the rural areas. According to Eyo *et al.,* (2014), this has led to importation of different feed such as Aqua Aller, Coppens, Podder feed etc. These imported feed are very expensive and sometimes, their supply is inconsistent especially for farmers who locate their farms in rural areas (Eyo *et al.,* 2014). Therefore, farmers are searching for supplementary feed that can be combined with these imported feed or that can completely replace these imported feed with compromising with fish growth and health. Recent high demand and consequent high prices for conventional feed ingredients such as fishmeal, soybean meal, groundnut meal etc., has led to the development of insect protein for aquaculture as a new area of research (FAO, 2013).

Insect meals are nutritious and healthy alternatives to fishmeal because of its rich nutritional values especially protein, fat and minerals. Termite (*Macrotermes subhyalinus*) are winged insect that emerge from holes near termite nests after the first rainfall at the end of the dry season (Sogbesan and Ugwumba, 2008; FAO, 2013). In Africa, heavy rain can be stimulated through local beat on the ground around termite hills which will provoke the termites to emerge (van Huis, 2003). According to Nkouka (1987), termites are rich in protein and other micronutrients. *M. subhyalinus* has been reported by Santos Oliveira *et al.,* (1976) to be rich in essential fatty acids such as linoleic acid (43 %).

Fly maggot (*Musca domestica*) is the larva of a housefly which grows extensively on animal dung including cow, goat, sheep and poultry droppings under favorable conditions. Nigeria, being a tropical country provides a suitable environment and climate for maggot development. According to Omotugba *et al.,* (2005), maggot is a potential alternative protein source for fish and livestock as reflected in its proximate composition. Also, the ease of maggot production and processing, storage and acceptability by fish qualifies it as a suitable supplementary feed for fish. Proximate composition of maggot flour published by Atse *et al.,* (2014) shows that it is composed crude protein (42 %), lipid (28.95 %), ash (8.10 %), fibre (5.89 %) and nitrogen free extract (15.06 %). Magmeal is also known to be rich in B complex vitamins, phosphorus and trace elements and (Teotia and Miller, 1973).

The African catfish (*Clarias gariepinus*) which belongs to the family Clariidae is the most dominant farmed fish in Nigeria (Eyo *et al.,* 2014). The dominance of this species in Nigeria is attributed to its fast growth rate, disease resistance, ability to tolerate harsh environmental conditions, high fecundity, high stocking densities under culture conditions, ease of artificial breeding, acceptability of formulated feed, high market value, good taste, high meat quality and consumer's preference compared to other species (Eyo et al*.,* 2014).

Several studies have been reported on the use of insect protein as alternative protein sources in fish and livestock feed to partially or completely replace conventional feedstuff such as fish meal and soybean meal. Fishmeal was replaced by maggot meal in the diets *Oreochromis niloticus* (Fashina-Bombata and Balogun, 1997; Ajani *et al.,* 2004). Ogbe *et al.,* (2005) and Michael and Sogbesan (2015) assessed if earthworms and maggots cultivated in agricultural and industrial waste products of origin are source of protein for Tilapia and *Clarias.* Studies on the harvesting techniques of maggot and evaluation of maggot meal as dietary animal protein source for Catfish have been documented (Sogbesan *et al*., 2005; Sogbesan, *et al.,* 2006; Sogbesan, *et al.,* 2006). However, none of these studies have presented findings on the effects of the combination of these insect meals with foreign and imported feed such as Coppens.

Therefore, this study aims to investigate the effects of the combination of maggot and termite meal with Coppens commercial feed on the growth performance, food utilization and survival of the African catfish (*C. gariepinus*).

MATERIALS AND METHODS

Study area

This study was conducted out at the Institute of Oceanography Fish Farm Hatchery complex, University of Calabar, Cross River State, Nigeria. This farm has a total surface area of three hectares (3Ha) and is located within latitude of 04°55.9″N and longitude of 08°26″E. This farm occupies the peninsula between the Great Kwa River and Calabar River with elevation of 41 meters above sea level (Eyo *et al.,* 2014).

Experimental design

This research was conducted in triplicate for 56 days using 15 aquaria measuring 1.0m x 0.5m x 0.5m, in the Hatchery complex of the Institute of Oceanography, University of Calabar. The aquaria were labeled A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3, D_1, D_2, D_3, E_1, E_2 and E_3. A total of 150 fingerlings of *C. gariepinus* (10 fingerling in each aquarium) were stocked in the 15 aquaria filled with dechlorinated water from the hatchery borehole. The fingerlings were acclimated for seven days prior to the start of the experiment. During acclimation, the fish were fed to satiation twice daily. At the end of the seven days acclimatization period, the fish were starved for 24 hours to empty their guts, thus increase their appetite for the new diet. Thereafter, the initial wet body weight (bulk) of the fish in each aquarium was measured to the nearest gram using a METLAR MT-5000D electronic balance (Eyo and Ekanem, 2011). Also, the initial total length of the fingerlings was measured to the nearest 0.1 cm using measuring board (Eyo *et al.,* 2013). Fish in aquarium A_1, A_2 and A_3 were fed feed 1 (100 % maggot meal), fish in aquarium B_1, B_2 and B_3 were fed feed 2 (100 % termite meal), fish in aquarium C_1, C_2 and C_3 were fed feed 3 (equal combination of maggot meal and Coppens feed - 50:50), fish in aquarium D_1, D_2, and D_3 were fed feed 4 (equal combination of termite meal and Coppens feed - 50:50), while fish in aquarium E_1, E_2 and E_3 were fed feed 5 (100 % Coppens feed). The fishes were fed twice daily (08.00-09.00h and 17.00-18.00h) at 5% of their body weight. The morphometric measurements (bulk wet body weight in grams and individual total length in cm) were repeated after every two weeks for eight weeks (Ekanem *et al.,* 2012).

Maggot production and Preparation of Maggot Meal (MM)

Maggot were produced from poultry droppings by placing them in plastic sacs and soaked with water and the sacs were kept outside in a shade as a substrate for maggot development. The sacs were exposed for house flies to lay egg. The sacs were watered twice daily morning and evening to maintain the constant moisture required for maggot development (Nuov *et al.,* 1995). Maggots were noticed to appear on the second day with a peak on the fourth and fifth day. The maggot were harvested from the sac by washing and sieved through a metal screen of 3mm mesh size. The maggots harvested were weighed, blanched in hot water, thereafter oven dried at 70 °C for 24 h before crushing into powder to obtain maggot meal. The maggot meal was packed in an air tight container and stored in a refrigerator at 8°C (Sogbesan and Ugwumba, 2008).

Collection of Termites and Preparation of Termite Meal (TM)

Termites (*M. subhyalinus*) were collected during swarm activities from a termitarium in the University of Calabar. The collected termites were weighed fresh and oven-dried at 80°C for 3 hours according to Sogbesan and Ugwumba (2008). Thereafter, the wings were blown off and dried termites were milled and re-weighed to ascertain the amount of termite meal prepared. The termite meal was packed in an air tight container and stored in a refrigerator at 8°C (Sogbesan and Ugwumba, 2008).

Growth Performance indices

Growth performance indices of fish fed the experimental diets including wet weight gain, length increment, growth rate, specific growth rate, mean growth rate and survival (%) were calculated according to standard formulas (De Silva and Anderson, 1995; Eyo and Ekanem (2011) as shown below:

i. Wet weight gain: Final weight (W_2) – initial weight (W_1)
ii. Length increment: Final length (L_2) – initial length (L_1)
iii. Growth rate: (Final weight, W_2 – initial weight, W_1) / (Number of days)
iv. Specific growth rate: SGR (% per day) = $[(\text{Loge } W_2 - \text{Loge } W_1) / T_2 - T_1]*100$

Where W_1 = Initial weight (g)
W_1 = Final weight (g)
T_1 = Initial day
T_2 = Final day

v. Mean Growth Rate (MGR) was calculated as the average weight gain in million gram per day.

$$MGR = [(W_2 - W_1)/ 0.5 (W_2 + W_1)t] \quad x\ 1000$$

Where W_2 = final weight (g)
W_1 = initial weight (g)
t = experimental period in days

vi. Survival Rate (%): Survival rate (%) was calculated as total fish number harvested and divided by total fish number stocked, expressed in percentage as follows:

$$\text{Survival (\%)} = \frac{\text{Total fish number harvested}}{\text{Total fish number stocked}} \text{ X } 100$$

Food Utilization Indices

Food utilization indices of fish fed the experimental diets including include food consumed (g), food conversion ratio (FCR) and feed conversion efficiency (FCE) were calculated according to standard formulas (De Silva and Anderson, 1995; Eyo and Ekanem (2011) as shown below:

Food Consumed (g): This is given as 5 % of fish bulk body weight X No. of days (Eyo and Ekanem, 2011)
Food Conversion Ratio: This is given as: Feed consumed (g)/ Weight gain (g) (De Silva and Anderson, 1995).
Food Conversion Efficiency This is given as: [Weight gain (g) / Feed consumed (g)]* 100 (De Silva and Anderson, 1995).
Protein Intake: This is given as Protein (%) in feed × total weight (g) of diet consumed / 100.
Protein Efficiency Ratio: This is given as wet weight gain by fish (g) / protein intake (g).

Proximate Composition of Experimental Diets

Maggot meal, Termite meal and Coppens feed were analyzed for proximate indices including crude protein, lipid, crude fiber, ash, moisture and carbohydrate contents in the Biochemistry Department of the University of Calabar, Nigeria, following standard procedures provided by AOAC (2000). Moisture was determined

Table 1. Proximate Composition of Maggot Meal (MM), Termite Meal (TM) and Coppens Feed

Proximate Indices	Maggot Meal (MM)	Termite Meal (TM)	Coppens Feed	P-Value
Moisture (%)	16.53 ± 0.01[a]	10.78 ± 0.02[b]	8.15 ± 0.03[c]	0.00000015
Ash (%)	4.50 ± 0.01 [a]	7.60 ± 0.33 [b]	9.32 ± 0.03 [c]	0.00000069
Protein (%)	33.29 ± 0.01 [a]	20.94 ± 0.08 [b]	42.24 ± 0.05 [c]	0.000000015
Fat (%)	37.78 ± 0.01 [a]	34.23 ± 0.83 [b]	11.35 ± 0.08 [c]	0.000000062
Fibre (%)	3.14 ± 0.01 [a]	5.71 ± 0.01 [b]	3.47 ± 0.10 [c]	0.00000044
Carbohydrate (%)	4.70 ± 0.02 [a]	20.74 ± 0.00 [b]	25.47 ± 0.16 [c]	0.00000028

* Each value represents the mean of three determination and means with different superscript are significantly different (P<0.05)

using the oven drying method, crude protein content was determined using the micro-Kjeldahl method, lipid content was determined by the Sohxlet extraction method, ash content was determined by incinerating at 550 ^{0}C and carbohydrate was calculated by difference.

Monitoring of Physico-chemical parameters

Physico-chemical parameters measured include pH, dissolved oxygen (mg/l), temperature (°C) and ammonia (mg/l). The common calibrated mercury in glass thermometer was used for measuring water temperature while the pH and dissolved oxygen concentration were measured using the Jenway meters (models 3050, England for DO and model 9070 for the pH). Ammonia was be measured colorimetrically using ammonia test kit (David *et al.,* 2010).

Statistical analysis

Growth performance and food utilization indices including weight gain, length gain, growth rate (g/day), mean growth rate, specific growth rate, food consumed, food conversion ratio (FCR),food conversion efficiency (FCE) and survival (%) were subjected to one way analysis of variance (ANOVA) to test for significance using Predictive Analytical Software window (PASW), version 18.0. Effects with a probability of (P< 0.05) were considered significant. Least Significance differences (LSD) was used to determine the level of significance among the various treatments.

RESULTS

Growth Performance Indices of *C. gariepinus* fed the Experimental Diets

Results of the growth performance of *C. gariepinus* fed the five experimental diets showed that length gain (cm) was significantly highest in fish fed Coppens feed (23.53 ± 0.29 cm), followed by fish fed Maggot Meal + Coppens feed (19.73 ± 0.18 cm), followed by fish fed Termite Meal + Coppens feed (17.80 ± 0.30 cm), followed by fish fed Maggot Meal (15.77 ± 0.20 cm) and least in fish fed Termite Meal (14.73 ± 0.22 cm). Weight gain (g) was also significantly highest in fish fed Coppens feed (195.87 ± 4.19 g), followed by fish fed Maggot Meal + Coppens feed (171.57 ± 2.87 g), followed by fish fed Termite Meal + Coppens feed (162.80 ± 195 g), followed by fish fed Maggot Meal (115.03 ± 1.07 g) and least in fish fed Termite Meal (107.57 ± 1.55 g). Growth rate was also significantly highest in fish fed Coppens feed (3.50 ± 0.08 g/day), followed by fish fed Maggot Meal + Coppens feed (3.06 ± 0.05 g/day), followed by fish fed Termite Meal + Coppens feed (2.91 ± 0.03 g/day), followed by fish fed Maggot Meal (2.06 ± 0.02 g/day) and least in fish fed Termite Meal (1.92 ± 0.03 g/day). Specific growth rate (SGR) was also followed the same trend with highest value in fish fed Coppens feed (3.91 ± 0.03 %g/day), followed by fish fed Maggot Meal + Coppens feed (3.67 ± 0.02 %/day), followed by fish fed Termite Meal + Coppens feed (3.59 ± 0.02 %/day), followed by fish fed Maggot Meal (3.07 ± 0.02 %/day) and least in fish fed Termite Meal (2.96 ± 0.02 %/day).

Mean growth rate (MGR) was also followed the same trend with highest value in fish fed Coppens feed (28.53 ± 0.10 mg/day), followed by fish fed Maggot Meal + Coppens feed (27.58 ± 0.08 mg/day), followed by fish fed Termite Meal + Coppens feed (27.63 ± 0.11 mg/day), followed by fish fed Maggot Meal (24.87 ± 0.10 mg/day) and least in fish fed Termite Meal (24.28 ± 0.08 mg/day). Percentage survival (%) was highest value in fish fed Coppens feed, Termite Meal + Coppens feed and Termite Meal (100.00 ± 0.00), followed by fish fed Maggot Meal 96.67 ± 3.33 (96.67 ± 3.33 %) and least in fish fed Termite Meal (93.33 ± 3.33 %).

Table 2. Growth Performance Indices of *C. gariepinus* fed the Experimental Diets

Growth Indices	Maggot Meal (MM)	Termite Meal (TM)	Maggot Meal + Coppens	Termite Meal + Coppens	Coppens Feed	P-Value
Initial Length (cm)	7.47 ± 0.03	7.33 ± 0.09	7.40 ± 0.06	7.43 ± 0.09	7.40 ± 0.06	-
Final Length (cm)	23.23 ± 0.23	22.07 ± 0.26	27.13 ± 0.20	25.23 ± 0.45	30.93 ± 0.24	-
Length Gain (cm)	15.77 ± 0.20 [a]	14.73 ± 0.22[b]	19.73 ± 0.18[c]	17.80 ± 0.30[d]	23.53 ± 0.29[e]	0.0000000043
Initial Weight (g)	25.07 ± 0.15	25.33 ± 0.56	25.26 ± 0.16	25.23 ± 0.23	24.63 ± 0.20	-
Final Weight (g)	140.10 ± 1.00	132.90 ± 2.06	196.83 ± 3.00	188.03 ± 1.92	220.50 ± 4.33	-
Weight Gain (g)	115.03 ± 1.07[a]	107.57 ± 1.55[a]	171.57 ± 2.87[b]	162.80 ± 1.95[c]	195.87 ± 4.19[d]	0.0000000114
Growth Rate (g/day)	2.06 ± 0.02[a]	1.92 ± 0.03[a]	3.06 ± 0.05[b]	2.91 ± 0.03[c]	3.50 ± 0.08[d]	0.0000000012
SGR (%/day)	3.07 ± 0.02[a]	2.96 ± 0.02[b]	3.67 ± 0.02[c]	3.59 ± 0.02[d]	3.91 ± 0.03[e]	0.0000000066
MGR (mg/day)	24.87 ± 0.10 [a]	24.28 ± 0.08[b]	27.58 ± 0.08[c]	27.63 ± 0.11[c]	28.53 ± 0.10[d]	0.0000000072
% Survival	96.67 ± 3.33[a]	100.00 ± 0.00 [a]	93.33 ± 3.33 [a]	100.00 ± 0.00 [a]	100.00 ± 0.00 [a]	0.171

*Each value represents the mean of triplicate experimental units and means with different superscript are significantly different (P<0.05)

Table 3. Food Utilization Indices of *C. gariepinus* fed the Experimental Diets

Food Utilization Indices	Maggot Meal (MM)	Termite Meal (TM)	Maggot Meal + Coppens	Termite Meal + Coppens	Coppens Feed	P-Value
Food Consumed (g)	171.70 ± 1.96[a]	164.59 ± 1.49[b]	225.91 ± 2.27[c]	211.03 ± 3.01[d]	237.23 ± 2.82[e]	0.000000023
Food Conversion Ratio	1.49 ± 0.17[a]	1.53 ± 0.01[b]	1.32 ± 0.01[c]	1.30 ± 0.01[c]	1.21 ± 0.01[d]	0.000000018
Food Conversion Efficiency	67.21 ± 0.73 [a]	65.35 ± 0.46[b]	75.93 ± 0.53[c]	77.16 ± 0.70[c]	82.54 ± 0.80[d]	0.000000021
Protein Intake (g)	56.49 ± 0.65[a]	32.92 ± 0.30[b]	85.85 ± 0.86[c]	65.42 ± 0.93[d]	99.64 ± 1.15[e]	0.000000073
Protein Efficiency Ratio	2.04 ± 0.02[a]	3.27 ± 0.02[b]	2.00 ± 0.02[c]	2.49 ± 0.02[c]	1.96 ± 0.02[d]	0.000000025

* Each value represents the mean of triplicate experimental units and means with different superscript are significantly different (P<0.05)

Table 4. Physico-chemical Parameters of the Experimental Aquaria

Parameters	Maggot Meal (MM)	Termite Meal (TM)	Maggot Meal + Coppens	Termite Meal + Coppens	Coppens Feed	P-Value
pH	6.9 ± 0.06[a]	6.9 ± 0.03[a]	7.0 ± 0.10[a]	6.9 ± 0.02[a]	7.0 ± 0.05[a]	0.925
Water Temperature (°C)	28.5 ± 0.05[a]	28.5 ± 0.05[a]	28.5 ± 0.05[a]	28.5 ± 0.05[a]	28.5 ± 0.05[a]	0.982
Dissolved Oxygen (mg/l)	4.7 ± 0.2 [a]	4.8 ± 0.1[a]	4.9 ± 0.2[a]	4.7 ± 0.3[a]	4.8 ± 0.1[a]	0.626
Ammonia (mg/l)9g	0.02 ± 0.01 [a]	0.01 ± 0.02 [a]	0.02 ± 0.02 [a]	0.03 ± 0.01 [a]	0.01 ± 0.01 [a]	0.974

* Each value represents the mean of triplicate experimental units and means with different superscript are significantly different (P<0.05)

Food Utilization Indices of *C. gariepinus* fed the Experimental Diets

Feed utilization indices of *C. gariepinus* fed the five experimental diets (Table 3) showed that feed consumed (g) was highest in fish fed Coppens feed (237.23 ± 2.82 g), followed by fish fed Maggot Meal + Coppens feed (225.91 ± 2.27 g), followed by fish fed Termite Meal + Coppens feed (211.03 ± 3.01 g), followed by fish fed Maggot Meal (171.70 ± 1.96 g) and least in fish fed Termite Meal (164.59 ± 1.49). Feed conversion ratio (FCR) was highest in fish fed Termite meal (1.53 ± 0.01), followed by fish fed Maggot Meal (1.49 ± 0.17), followed by fish fed Maggot Meal + Coppens feed (1.32 ± 0.01 g), followed by fish fed Termite Meal (1.30 ± 0.01) and least in fish fed Coppens (1.21 ± 0.01). Feed conversion efficiency (FCE) was highest in fish fed Coppens feed (82.54 ± 0.80 %), followed by fish fed Maggot Meal + Coppens feed (75.93 ± 0.53 %), followed by fish fed Termite Meal + Coppens feed (77.16 ± 0.70 %), followed by fish fed Maggot Meal (67.21 ± 0.73 %) and least in fish fed Termite Meal (65.35 ± 0.46 %). Protein intake (g) was highest in fish fed Coppens feed (99.64 ± 1.15 g), followed by fish fed Maggot Meal + Coppens feed (85.85 ± 0.86 g), followed by fish fed Termite Meal + Coppens feed (65.42 ± 0.93 g), followed by fish fed Maggot Meal (56.49 ± 0.65 g) and least in fish fed Termite Meal (32.92 ± 0.30 g). Protein efficiency ratio was highest in fish fed Termite Meal (3.27 ± 0.02), followed by fish fed Termite M eal + Coppens feed (2.49 ± 0.02 g), followed by fish fed Maggot Meal (2.04 ± 0.02), followed by fish fed Maggot Meal + Coppens feed (56.49 ± 0.65 g) and least in fish fed Coppens feed (1.96 ± 0.02).

Physico-chemical Parameters of the Experimental Aquaria

Results of Physico-chemical parameters showed that in aquaria fed Maggot meal, mean pH was 6.9 ± 0.06, mean water temperature (28.5 ± 0.05°C), mean dissolved oxygen (4.7 ± 0.2 mg/l) and mean ammonia (0.02 ± 0.01 mg/l). in aquaria fed Termite meal, mean pH was 6.9 ± 0.03, mean water temperature (28.5 ± 0.05°C), mean dissolved oxygen (4.8 ± 0.1 mg/l) and mean ammonia (0.001 ± 0.02 mg/l). in aquaria fed Maggot meal + Coppens feed, mean pH was 7.0 ± 0.10, mean water temperature (28.5 ± 0.05°C), mean dissolved oxygen (4.9 ± 0.2 mg/l) and mean ammonia (0.002 ± 0.02 mg/l). in aquaria fed Termite meal + Coppens feed, mean pH was 6.9 ± 0.02, mean water temperature (28.5 ± 0.05°C), mean dissolved oxygen (4.7 ± 0.3 mg/l) and mean ammonia (0.003 ± 0.01 mg/l). in aquaria fed Coppens feed, mean pH was 7.0 ± 0.05, mean water temperature (28.5 ± 0.05°C), mean dissolved oxygen (4.8 ± 0.1 mg/l) and mean ammonia (0.001 ± 0.01 mg/l).

DISCUSSION

Growth performance indices evaluated in this study showed that weight gain was significantly highest (P<0.05) in fish fed Coppens feed, followed by fish fed a combination of maggot meal and Coppens feed, followed by fish fed a combination of termite meal and Coppens feed, followed by fish fed maggot meal and least in fish fed termite meal. Results obtained for growth performance indices of fish in this study such as weight gain, length gain, growth rate, specific growth rate and mean growth rate showed that there was a significant influence (P<0.05) of experimental diets on the experimental fish with fish fed only Coppens feed recording the best performance. The difference obtained in the growth performance of fish fed only termite and maggot meal when compared to Coppens feed and the combination of Coppens feed with termite and maggot meal may be attributed to the fact that termite and maggot meal are only rich in proximate composition but are very poor in mineral or elemental composition (Barker *et al.,* 1998; Sogbesan and Ugwumba, 2008). Proximate analysis of maggot meal (MM) and termite meal (TM) revealed that these two insects are rich in protein, moisture, carbohydrate, fat, lipid and fibre, required by fish for optimal growth under culture condition. In this study, Termite meal had crude protein of 20.94 ± 0.08 %. This result is lower than 37 % reported by Aduku (1993) for for *Macrotermes spp*, 44.12 % reported by Oyarzum *et al.,* (1996) for *Nasutitermes* spp, 48.80 % reported by Fadiyimu *et al.,* (2003) for *Macrotermes* spp. and 43.5 % reported by Sogbesan and Ugwumba (2008) for *Macrotermes subhyalinus.* Moreover, maggot meal had crude protein of 33.29 ± 0.01 % which is higher 22.97 % reported by Omoyinmi and Olaoye (2012) and lower than 42.00 ± 1.40 % reported by Atse *et al.,* (2014) for *Musca domestica*. These variations observed in the proximate composition of maggot and termite meal in this study with other studies may be attributed to the methods used in processing of these insect meals. Response to feed was more aggressive in Coppens than other feed during the feeding experiment and this is similar to findings of Ekanem *et al.,* (2012). This may be attributed to the fact that Coppens feed is very palatable with a more fishy odour attracting fish during feeding (Ekanem *et al.,* 2012). Comparatively, the growth performance of fish fed maggot meal and Coppens feed reported in this study fall within the ranges reported by Sogbesan (2006) for *Heterobranchus longifilis*, Sogbesan *et al.,* (2006) for *Heterclarias,* Madu and Ufodike (2003) for *Clarias anguillaris* and Fagbenro *et al.,* (1992) for *Heterobranchus* bidorsalis, when fly maggots were used in Combination with other feed types in feeding their experimental fishes. The mean crude protein level in maggot meal (33.29 ± 0.01 %) agrees with 30 – 45 % recommended by Omoyinmi and Fafioye (2005) for the African catfish (*C. gariepinus*) whereas 20.94 ± 0.08 % obtained for termite meal is below recommended levels. The growth performance of a fish species or any organism has been reported to hinged on the biological index value of protein source (Sogbesan, 2006; Lovell, 1994). Fly maggots are known for their positive high biological index value of 3.33 (Hoffman *et al.,* 2004). Again, fibre content of feed has been documented to enhance growth performance in fish especially when the Biological Index Value (BIV) is in the same range as the fibre content (Lovell, 1994; Steffen, 1989; Hoffman *et al., 2004).* In this study the fibre content in the fly maggot (3.14%) was in the same value range of 3.33 of the fly maggot Biological index value, and this gave the reason for the observed growth performance of *Clarias gariepinus* fingerlings fed maggot meal and Coppens feed. Additionally, the combination was highly acceptable by the fish. A result similar to those of Faturoti (1991), and Sogbesan (2006) when respectively working on the fish nutrition on feeding in freshwater catfishes, and performance of *Heterobranchus longifilis* fingerlings fed maggot meal-based diets in miniflow through systems. From the result of the study, the use of maggot meal and termite meal in combination with Coppens feed to raise *C. gariepinus* appear to be advantageous especially as it produced higher growth indices when compared to the use of only maggot meal and termite meal in feeding. In fish nutrition studies, amount of feed consumed, food conversion ratios (FCRs) and food conversion efficiency are very useful indices that are used to evaluate feed acceptability, production economics and fish performance in terms of growth. In this study, feed consumed and food conversion efficiency was highest in fish fed Coppens feed (237.23 ± 2.82 g and 82.54 ± 0.80 %) and least in fish fed only termite meal (164.59 ± 1.49 g and 65.35 ± 0.46 %). These results explain the trend obtained in the growth performance indices of *C. gariepinus* fed the five experimental diets. This indicates that food utilization is a function of fish growth. In the present study, the best food conversion ratio was obtained in fish fed Coppens feed (1.21 ± 0.01) while fish fed only termite meal gave the highest FCR value 1.53 ± 0.01. However, FCR and FCE values obtained for fish fed all the experimental diets were within the range reported by several authors to be optimal for better growth performance in fishes (Ndome *et al.,* 2011; Eyo and Ekanem, 2011; Ekanem *et al.,* 2012; Ekanem *et al.,* 2013; and Eyo *et al.,* 2014). This clearly indicates that all the invertebrates (termite and maggot) used in this study as supplementary feed could be consumed and utilized efficiently by fish in the absence of commercial fish feed. This fact confirms the suitability of termite and maggot meal as supplementary diets for *C. gariepinus*. Percentage survival was not influenced by experimental feed as fish fed Coppens feed, Termite Meal + Coppens feed and Termite Meal showed highest survival of 100.00 ± 0.00%, followed by fish fed Maggot Meal (96.67 ± 3.33 %) and least in fish fed Termite Meal (93.33 ± 3.33 %). This observation supports findings of several other authors such as Eyo and Ekanem (2011), Ekanem *et al.,* (2012) and Eyo *et al.,* (2014). Results of physico-chemical parameters (pH, DO and temperature) obtained in this study for all the experimental units were within the range recommended for optimal growth of freshwater fishes (Boyd, 1990). Also, the absence of negative effect of the fish growth and physico-chemical parameters are also factors that place the combination of maggot and termite meal with Commercial Pellet feed as a suitable feed combination to be used in culturing *C. gariepinus.*

SUMMARY AND CONCLUSION

Findings of this study has shown that food utilization indices and growth performance was significantly better (P<0.05) in fish fed Coppens feed, followed by fish fed the combination of Coppens feed and maggot meal, followed by fish fed Coppens feed and termite meal, followed by fish fed only maggot meal and least in fish fed only termite meal. Although Coppens feed gave the best result in terms of growth and food utilization, its availability especially in rural areas where fish farming is practiced is inconsistent. Moreover, the use of only termite meal or maggot meal for the culture of *C. gariepinus* is not advocated because these insect meals is only rich in proximate indices but very poor in minerals which are also required by *C. gariepinus* for optimal growth. It is recommended that maggot and termite meal could therefore be used a whole or partial replacement for fishmeal in fish feed formulation.

REFERENCES

Aduku AO. (1993). Tropical feedstuff analysis table. Department of Animal science, Faculty of Agriculture, Ahmadu Bello University, Zaria, Nigeria.

Ajani EK, Nwanna LC, Musa BO. (2004).Replacement of fishmeal with maggot meal in the diets of Nile tilapia, *Oreochromis niloticus. World aquaculture,* 35: 52 – 54.

AOAC (2000) Association of Official Analytical Chemists Official Method of Analysis 16th edition, Arlinton, Virginia.

Atse BC, Ossey Y B, Koffi KM, Kouame PL. (2014). Effects of Feeding by-Products; Maggot Meal, Fish Meal, Soybean Meal, Blood Meal and Beef Brain on Growth, Survival and Carcass Composition of African Catfish, *Heterobranchus Longifilis* Valenciennes, 1840 Larvae under Recirculating Conditions. International Journal of Agriculture Innovations and Research, 2(4): 530 – 535.

Barker D, Fitzpatrick MP, Dicrenfeld ES. (1998). Nutrient composition of selected whole invertebrates. Zoo. Biology, 17(2):123-134.

Boyd CE. (1990). Water quality in ponds for aquaculture. Alabama Agric. Exptn. Stn Auburn University, Alabama, 120 pp.

David DL, Edward A, Addass PA, Jesse C. (2010). Some aspects of water quality and the biology of *Clarias gariepinus* in Vimtim stream, Mubi Adamawa State, Nigeria. World Journal of Fish and marine Sciences 2(2): 129 – 133.

De Silva SS, Anderson TA. (1995). Fish Nutrition in Aquaculture. Ghapman and Hall. London. 319pp.

Ekanem AP, Eteng SU, Nwosu FM, Eyo VO. (2012). Comparative Study of the Growth and Gonad Development of *Clarias gariepinus* (Burchell 1822) Fed Diets with Plant and Animal-based Ingredients in Concrete Tanks. Journal of Agricultural Science and Technology, 2, 1203-1210.

Ekanem AP, Eyo VO, James PU, Udo NE. (2013). Effects of Unical Feed on Fecundity and Gonad Development of *Clarias gariepinus*; a Comparative Study with Coppens Commercial Feed in Earthen Pond. International Journal of Science and research, 2 (10): 8-14.

Eyo VO, Ekanem AP. (2011): Effect of feeding frequency on the growth, food utilization and survival of African catfish (*Clarias gariepinus)* using locally formulated diet. African Journal of Environmental Pollution and Health, (9): 2, 11-17.

Eyo VO, Ekanem AP, Jimmy UU. (2014). A comparative study of the gonado-somatic index (GSI) and gonad gross morphology of African Catfish (*Clarias gariepinus)* fed Unical Aqua feed and Coppens commercial feed. Croatian Journal of Fisheries, 72: 63 – 69.

Eyo VO, Ekanem AP, Eni GE, Asikpo PE, Jimmy U. (2013). Comparative study of growth performance, food utilization and survival of hatchery bred and wild collected fingerlings of African catfish *Clarias gariepinus*. Greener Journal of Oceanography, 1(1): 1-10.

Fadiyimu AA, Ayodele AO, Olowu PA, Folorunso OR. (2003). Performance of finishing broilers fed graded levels of termites meal as replacement for fish meal. Proceeding of the 28th Annual Conference of Nigeran society for Animal Production, 28: 211 -212.

Fagbenro OA, Balogun AM, Anyanwu CN. (1992). Optimum dietary protein level for *heterobranhus bidorsalis* finglings fed compounded diets. Nigerian Journal of Applied Fisheries and Hydrobiology, 1:41-45.

FAO (2013). Edible insects: future prospects for food and feed security. pp 97 – 101.

Fasakin EA, Balogun AM, Ajayi OO, (2003).Evaluation of full fat and defatted maggot meals in the feeding of clariid catfish, *Clarias gariepinus* fingerlings. Aquaculture Research, 34: 733 – 738.

Fashina-Bombata HA, Balogun O. (1997).The effect of partial or total replacement of fish meal with maggot meal in the diet of tilapia (*Oreochromis niloticus*) fry. Journal of prospects in science, 1: 178 – 181.

Faturoti EO. (1991). Fish nutrition and feeding. University of Ibadan Press, Ibadan, Nigeria. 366p.

Hoffman J, Falvo R, Michael J, (2004). “Protein-which is best”. Journal of Sports Science and Medicine, 3(3):118130.

Hwangbo J, Hong EC, Jang A, Kang HK, Oh JS, Kim BW, Park BS, (2009). Utilization of house fly-maggots, a feed supplement in the production of broiler chickens. J. Environ Biol., 30(4): 609–614.

Lovell RT. (1994). Compensatory gain in fish-Aquacultural Management, 20(1): 91-93.

Madu CT, Ufodike, B. C. (2003). Growth and survival of catfish *Clarias anguillaris* juveniles fed Tilapia and maggot as unconventional diets. Journal of Aquatic Sciences, 18 (1): 47-51.
Madu CT, Sogbesan OA, Ibiyo LMO (2003). Some Non-conventional fish feed resources in Nigeria. In: A.A. Eyo (Ed.), Proceeding Joint FISON/ NIFFR/SPFS National workshop on Fish feed and Feeding Practices in Aquaculture held. National Institute for Freshwater Fisheries Research, 15th -19th September, 2003. New-Bussa: 73-82.
Michael KG, Sogbesan OA (2015) Evaluation of Maggot Meal (Muscadomestica) and Single Cell Protein (Mushroom) in the Diet of *Clarias gariepinus* Fingerlings (Burchell, 1822). Fish Aquac J 6:133. doi::10.4172/2150-3508.1000133
Ndome CB, Ekwu AO, Ateb AA (2011). Effect of Feeding Frequency on Feed Consumption, Growth and Feed Conversion of *Clarias gariepinus* X *Heterobranchus longifilis* Hybrids*.* American-Eurasian Journal of Scientific Research 6 (1): 06-12, 2011
Nkouka, E. (1987). Les insectes comestibles dans les societes d'Afrique Centrale. Revue Scientifique et Culturelle du CICIBAASC LEIDEN, 6(1): 171–178.
Nouv S, Little K, Yakupitiyage A, (1995). Nutrient flows in an integrated pig, maggot and fish production system. Aquaculture Research 26:601-604.
Ogbe FG, Tiamiyu LO, Eze PN (2005). *Growth performance of Clarias gariepinus fingerlings fed earthworm meal (Lumbricus terrestis).* In: 19th Annual Conference of the Fisheries Society of Nigeria (FISON) , 29 Nov - 03 Dec 2004 ,Ilorin, Nigeria, pp. 214-218.
Omotugba SK, Meduna AJ, Ugege PE, Ogundun NJ. (2005). Growth response of *Clarias gariepinus* (Burchell 1822) fingerlings fed with varying levels of maggot meal. Federal College of Wildlife Management, New Bussa, Niger State. J. Agric. Res and Dev*.* 2005 Vol. 4(2): 170-175.
Omoyinmi GAK, Olaoye OJ, (2012). Growth Performance of Nile Tilapia-*Oreochromis niloticus* fed Diets Containing Different Sources of Animal Protein. Libyan Agriculture Research Center Journal International 3 (1): 18-23.
Omoyinmi GAK, Fafioye OO, (2005). Cultured Invertebrates as alternative sources of animal protein in the diet of African catfish-Clarias gariepinus (Burchell, 1822) Aquafield Journal of Field Aquatic Studies, 2(1): 32-38.
Oyarzum SE, Grawshaw GJ, Valdes EV. (1996). Nutrition of the Tamandua: I. Nutrient composition of termites (Nasutitermes spp.) and stomach content from wild Tamandua (Tamandua tetradactyl) Zoo. Biology, 15: 509-524.
Santos Oliveira JF, Passos de Carvalho J, Bruno de Sousa RFX, Madalena Simao M. (1976). The nutritional value of four species of insects consumed in Angola. Ecology of Food and Nutrition, 5: 91–97.
Sogbesan, A. O. (2006). Performance of *Heterobranchus longifilis* fingerlins fed maggot meal-based diets in miniflow through system. *Proceedings of 21st of Annual conference of the Fisheries society of Nigeria (FISON), Calabar, 13th 17th November, 2006, Pp. 216-223.*
Sogbesan AO, Ajuonu DN, Musa BO, Adewolele AM. (2006). Harvesting techniques and evaluation of maggot meal as dietary animal protein source for "Heteroclarias" fingerlings in outdoor concrete tanks. World Journal of Agricultural sciences, 2(3): 115-120.
Sogbesan OA, Ugwumba AA. (2006). Bionomics evaluation of garden snail (Limicolaria aurora, Jay, 1937; Gastropoda: Limicolaria)meat meal in the diet of Clarias gariepinusfingerlings (Burchell, 1822). Nigerian Journal of Fisheries, 2(3): 358-371.
Sogbesan OA, Ajuonu ND, Ugwumba A A, Madu CT. (2005). Cost benefits of maggot meal as supplemented feed in the diets of Heterobranchus longifilis x Clarias gariepinus(Pisces-Clariidae) hybrid fingerlings in outdoor concrete tanks. Journal of Industrial and Scientific Research, 3(2): 51-55.
Steffens W. (1989). Principles of fish nutrition. Ellis Horwood Limited Uk. Pp 384. Tilapia and Maggot as unconventional diets. *Journal of Aquatic Sciences*, 18(1):47-51.
Téguia A, Mpoame M, Okourou MJA. (2002). The production performance of broiler birds as affected by the replacement of fish meal by maggot meal in the starter and finisher diets. Tropicultura, 20(4): 187–192.
Teotia JS, Miller BF. (1973). Fly pupae as a dietary ingredient for starting chicks. Poultry Science 52: 1830-1835.
van Huis, A. (2003). Insects as food in sub-Saharan Africa. Insect Science and its Application, 23(3): 163–185.

Accepted November 12, 2015

Citation: Arong GA, Eyo VO (2015). Evaluation of house fly (*Musca domestica*) maggot meal and termite (*Macrotermes subhyalinus*) meal as supplementary feed for African catfish *Clarias gariepinus* (Burchell, 1822). International Journal of Entomology and Nematology, 3(1): 042-050.