GROWTH PERFORMANCE, BODY COMPOSITION, AND APPARENT NUTRIENT DIGESTIBILITY OF HYBRID CATFISH FINGERLINGS FED WITH BLENDED INSECT MEAL

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ABSTRACT:

This study was carried out to evaluate the growth response, nutrient utilisation, and body composition of hybrid catfish fingerlings fed varying inclusion levels of two blended insect meals [dung beetle larvae meal (DBLM) and grasshopper meal (GHM)] for 56 days. Five isonitrogenous diets of 40% CP and 9.5% Lipid were formulated with 0-60% inclusion of the two blended insect meals at the same ratio but different graded levels to replace Clupeid fishmeal. Diets were designated as D1 (0%), D2 (5%DBM and 5%GHM), D3 (10%DBM and 10%GHM), D4 (20%DBM and 20%GHM) and D5 (30%DBM and 30%GHM). A total of 300 fingerlings with average initial weights of 2.55±0.14g were distributed into fifteen hapas nets in three concrete tanks (8m×5m×1.5m). Water quality parameters were monitored daily. The results showed that fish fed D4 had the highest value in all the growth parameters and were significantly different (P<0.05) from other fish fed experimental diets, while fish fed D5 had the lowest value but were not significantly different (P>0.05) from fish fed D1, D2, and D3. The nutrient utilization parameters followed the same pattern as the growth parameter indices. It could be concluded that the inclusion of both insect meals can improve the growth performance of the fish without any adverse effects, suggesting that the blended meals could be suitable for a hybrid catfish diet.

Keywords: Hybrid-catfish; Grasshopper meal (GHM); Dung beetle larvae meal (DBLM); Blended insect meal;

INTRODUCTION

Over the last three decades, Clariid species have been considered to hold great interest in fish farming in Africa and Nigeria. A recent trend is the culture of intergenetic and intraspecific hybrids. Clarias gariepinus, Heterobranchus longifilis, and their hybrids are of high aquaculture importance in aquaculture in Nigeria. They are popularly grown because of their high market value, quick growth rate, and ability to withstand unfavourable conditions, especially low oxygen content in confinement (Fagbenro et al., 2002). The hybrids of Heterobranchus sp. and Clarias sp. exhibit the fast-growing quality of Heterobranchus sp., reaching up to 1kg under five months in ponds and are resistant to diseases of Clarias sp. (Hogendoorn, et al, 1980; Ajana and Anyanwu, 1995; Hecht et al., 1996; Anibeze and Eze 2000; Eyo and Ezechie, 2004).

In fish farming, aquafeed production is critical because it represents 40-60% of the production costs (Barlow, 2000; Craig and Helfrich, 2009). Aquafeed has witnessed tremendous progress in recent years, most importantly the commercial diets meeting the optimal growth and health of the cultured fish species. Protein is one of the most expensive and integral components of aquaculture diets (Nawalade, 2014). Animal protein sources are of the biological preference for most culturable fish species owing to their high digestibility and excellent amino acid profile (Ogunji et al., 2006; Aniebo et al., 2009). Of all the animal protein sources, FM is the most commonly used animal protein source; however, some factors are militating its efficient use in diets, such as relatively high cost, limited supply, and variable quality. Because of the ever-increasing cost of high-quality fish meal for aqua feed production and the declining stocks of fish from capture fisheries and competition for feed-in animal husbandry, dependency on the fish meal for aquafeed production is unsustainable; hence there is a need to search for alternative sources of animal protein for fish feeds, especially in developing countries such as Nigeria (Sales and Janssens, 2003).

There are some valuable research attempts available on the possible use of animal protein sources as an alternative to a fish meal, such as earthworm meal (Sogbesan and Ugwumba, 2006; Tacon, 2007); tadpole meal (Ayinla et al., 1994; Hindatu and Solomon, 2017; Ndako et al., 2019), fermented fish silage (Ugwumba et al., 2001), Maggot meal (Fasakin et al., 2000), and poultry meal (Sogbesan and Ugwumba, 2006). St Hillaire (2007) reported that black soldier pre-pupae fly contains 42% protein and 18% lipid on a dry matter basis. Prepupae larvae meal as a component of a complete diet has been found to support good growth in chicks (Pieterse, 2018), rainbow trout (Oncorhynchus mykiss) (St-Hilaire et al., 2007), channel catfish (Ictalurus punctatus) (Pimentel et al., 2004) and Nile tilapia (Oreochromis niloticus) (Ogunji et al., 2008; Devic et al., 2018). However, deficient or excessive availability of one or more important nutrients often reduces the overall cultured animal productivity when a single ingredient is used alone as the sole protein in fish farming feeds (Fasakin et al., 2003).

Variegated grasshopper Zonocerus variegatus (Linn.) (Order: Orthoptera; Family: Pyrgomorphidae) is a large grasshopper with a high dry season population in the southwest and northern parts of Nigeria. It is a polyphagous insect that feeds on and defoliates a large number of farm crops (Modder, 1994) and is used mostly in West Africa as feed for animals when there is grasshopper infestation on crops (Okoye and Nnaji, 2005). Grasshopper meal (GHM) has been reported to have a crude protein content between 29% and 61.50% (Okoye and Nnaji, 2005; Ojewola et al., 2005; Adeyemo et al., 2008; Alegbeleye et al., 2012). The use of grasshopper meal as a quality animal-based protein has been demonstrated in fish and livestock diets. Ojewole et al. (2005) evaluated variegated grasshopper as a dietary protein source in broiler chicken diets, and Wang et al. (2007) studied the nutritive value of Chinese grasshopper (Acrida cinera) for broilers and some freshwater fishes. However, one of the major factors that limit the use of grasshopper as an ingredient in animal feed production is that it has a very low lipid content and high chitin content.

Beetles (Coleoptera) are taxonomically diverse and differ widely in size. Larvae from the family Scarabaeidae (dung-beetles) are found buried in cow dung in natural savannahs and grasslands used for cattle grazing (e.g. in Africa). Edible dung beetle species that consume cow dung have been reported to contain high levels of protein and other nutritional elements (Alamu et al., 2013). Partial replacement of FM with dung beetle larvae (DBLM) is possible; however, high lipid content limits its inclusion in the diet (Bake et al., 2019). Feeding nutritionally balanced feed to fish is of utmost importance because of its effect on growth and efficient feed utilization (Hixson, 2014). Furthermore, avoidance of essential amino acid (EAA) deficiency is one of the most critical issues for the successful utilisation of inexpensive alternative proteins in fish feed. A blend of several protein sources could be a promising way to replace a higher level of dietary fish meal. Hence, the combination or blending of different alternative protein sources for partial or complete replacement of FM in practical diets of fish has often been suggested as a solution to reduce the cost of the diets without compromising on the growth and nutritive value of the fish (Erick et al., 2014; Al-Thobaiti et al., 2018). Such a strategy can provide a more nutritionally balanced and cost-effective diet to meet the needs of cultured fish. It is in this view that this research work was carried out. Therefore, the main objective of this study was to evaluate the growth response, nutrient utilization, and haematological indices of hybrid catfish fingerlings fed with graded levels of a blended meal of two insects: dung beetle larvae and grasshopper meal.

MATERIALS AND METHODS

Study Area

The experiment was carried out at the old teaching and research fish farm of Department of Water Resources, Aquaculture and Fisheries Technology, School of Agriculture and Agriculture Technology, Federal University of Technology Bosso campus Minna (9°39'17.4"N 6°31'39.3"E) Niger state Nigeria.

Preparation of DBLM and GHM: Dung beetle larvae were collected during the onset of the rainy season from a cattle farm settlement, near Police Secondary School, Shanu village Bosso, Minna, and Niger State (9°38'3"N 6°30'44"E). The larvae were degutted using a dissecting blade, according to the modified method described by Siame et al. (1996). This was achieved by forcibly squeezing the gut contents from the body after making a deep cut in the anal region of the larvae. The degutted larvae were then washed with 9% salt-water solution and thereafter, warm water at 60 °C was added to remove any impurities (Siame et al. 1996). This was followed by sun-drying for 8 days, after which it was ground into powder form using a hammer mill and sieved. The powder was then analyzed for proximate composition.

Adult variegated grasshoppers were collected from the environment of the Federal University of Technology Minna, Bosso Campus, Niger State with the aid of nets. They were weighed fresh, and then soaked in warm water at 120oC for 10 mins to kill them and also to remove any form of impurities on the body of the grasshopper, the grasshoppers were then later oven-dried at 80oC for 24 hours and allow to cool off at room temperature for 8 hours before milled with the hammer mill into powder form and then sieved. The powdered meal was then analyzed for proximate composition.

Fishmeal and soybean meal: The fishmeal used was obtained from Sauki Fish Farm, Maikunkele, Minna, and Niger State. Dry soybean seeds were purchased from Engr. A. A Kure Market Minna, Niger State. The soybeans were toasted in a frying pan at 80 °C for 60 min to a golden brown and then ground with a hammer mill.

Based on the nutritional requirements of catfish fingerlings (NRC, 2011), five experimental diets were prepared to contain 40% crude protein and 10% lipid using soybean meal, maize meal, fish meal, grasshopper meal, and dung beetle larva meal as the main ingredients (Table 2). All formulated feeds were fortified with mineral and vitamin premix. Warm distilled water was used to thoroughly mix the measured ingredients in a plastic bowl to form a dough before pelleting. The diets were pelleted using a manual laboratory pelletizer to 2 mm in diameter. The pellets were sundried, ground into smaller particles, packaged in polythene bags, and kept at room temperature.

Experimental conditions and fish rearing

Heteroclarias fingerlings with a mean weight of 2.5 ± 0.30 g were obtained from Pearl Farms (hybrid catfish multiplication Centre, Ikotun, Lagos). Lagos state. The fish were transported in a well-oxygenated water plastic container to the old University Departmental Fish Farm Bosso campus. The fish were acclimatized for a week before the commencement of the experiment and were fed a conditioning diet (Eco-feed) at 40% crude protein once a day. 20 fish with an initial average weight of 2.55±0.14 g was stocked in each hapa and were distributed into 15 hapas net (0.5 m × 0.5 m × 1 m) hanged in two outdoor concrete tanks (8 m×5 m×1.5 m) with the aid of a kuralon twine tied to plastic poles. The concrete tanks were filled to 5/6 of their volume (40 m3) with filtered and dechlorinated tap water, and the water temperature and other water quality parameters were monitored daily and 10 L of dechlorinated water was added weekly to compensate for evaporation. The fish were subsequently fed the experimental diets containing different inclusion of the two blended insect meals at the same ratio but at different graded levels, and the diets were designated as D1 (0%), D2 (5% DBM and 5% GHM), D3 (10% DBM and 10% GHM), D4 (20% DBM and 20% GHM) and D5 (30% DBM and 30% GHM) for 56 days. The Photoperiod was dependent on natural light and the water quality parameters in the system were monitored weekly. The feed was manually administered until apparent satiation three times daily at 09:00 am, 12:00 pm, and 4:00 pm. The unconsumed feed and waste materials were removed out of the hapas every morning before feeding, and 45 min after the fish had been fed. Faecal samples were collected for digestibility analysis from each hapa daily for 7 days (8 h after feeding) by siphoning with a rubber tube and oven-dried at 60°C. The fish were denied feed 24 h before sampling. Weekly, five fish were individually weighed using a digital electronic balance (CITIZEN MP-300 model).

Biochemical Analysis

The major ingredients, experimental diets, and fish samples were subjected to chemical analysis with proximate composition determined according to the AOAC (2000) procedures. A total of 10 initial fish and 5 fish of final samples from each hapa were pooled separately and then homogenised using a laboratory mortar and pestle. Moisture content was determined by drying the samples at 105±2°C until a constant weight was obtained. Dried samples were used to determine the crude fat, protein, and ash contents. Crude fat was measured using a solvent extraction method in a Soxhlet system using n-hexane. Crude protein content was calculated by measuring the nitrogen content, as determined by the Kjeldahl method. A conversion factor of 6.25 was used for the calculation of crude protein content according to AOAC (2000).

Acid insoluble ash (AIA) analysis

AIA analysis was carried out on the diets and faeces to estimate nutrient digestibility. AIA was obtained by adding 25 ml of 10% HCl to the weighed ash content of each sample. The sample was covered with a water glass and boiled gently over a low flame for 5 min. Then the sample was then filtered using ashless filters and washed with hot distilled water. The residue from the filter was returned to the crucible and ignited until it was carbon-free, after which it was weighed. The Percentage AIA was calculated as follows:

$$\% \text{ AIA} = \frac{\text{Weight of AIA}}{\text{Weight of Ash}} \times 100$$

Determination of digestibility coefficients

The protein and lipid digestibility coefficients were determined according to Jimoh et al. (2010), which was calculated based on the percentage of AIA in feed and faeces relative to the percentages of nutrients in diets and faeces.

Apparent protein digestibility (%) =

$$100 - \left(\left(\frac{\text{AIA in diet (\%)}}{\text{AIA in faeces (\%)}}\right) \times \left(\frac{\text{N in faeces (\%)}}{\text{N in diet (\%)}}\right) \times 100\right)$$

Blood collection and haematological analysis

Blood samples were collected in triplicate from fish in each net pen trial termination, by bleeding the fish from the caudal fin using a dissecting blade and subsequently taken to the Laboratory of Department of Biochemistry, Federal University of Technology, Minna for haematological analysis. The clear plasma sample was pipetted into a clean and sterilised bottle for haematological parameter analysis (Ogbu and Okechukwu, 2001). The direct measurement of erythrocyte values (packed cell volume PCV, haemoglobin Hb, and red blood cell RBC) and absolute erythrocyte indices (MCH, MCV, and MCHC) were calculated. The white blood cell count and differential count (neutrophils and lymphocytes) were analysed as described by Dacie and Lewis (2001).

$$\text{MCV}= \frac{\text{PCV}}{\text{Erythrocytes count}} \times 10$$

$$\text{MCH}= \frac{\text{Haemoglobin}}{\text{Erythrocytes count}} \times 10$$

$$\text{MCHC} = \frac{Haemoglobin}{\text{PCV}} \times 100$$

Evaluation of Growth and Nutrient Utilization Parameters

Growth and nutrient utilisation were evaluated using weight gain (WG), feed efficiency (FE), feed intake (FI), protein efficiency ratio (PER), and protein retention (PR). The following formulas were used:

$$\text{Weight gain (\%)} = \frac{\text{(Final weight (g) – initial weight (g))}}{\text{initial weight (g)}} \times 100$$

$$\text{Feed efficiency (\%)} = \left(\frac{\text{weight gained (g)}}{\text{feed fed (g)}}\right) \times 100$$

$$\text{Specific growth rate (\%)} = \left(\frac{\text{In final weight (g) – In initial weight (g)}}{\text{feeding period (day)}}\right) \times 100$$

$$\text{Feed intake (mg/fish/day)} = \frac{\text{dry feed (mg) given / number of fish}}{\text{feeding period (day)}}$$

$$\text{Protein efficiency ratio} = \frac{\text{weight gain}}{\text{protein intake (g)}}$$

$$\text{Protein retention (\%)} = \frac{\text{protein gain}}{\text{protein fed}} \times 100$$

STATISTICAL ANALYSES

Data were analysed using one-way analysis of variance (ANOVA) using Minitab, version 17.0 (Minitab, LLC., Pennsylvania, USA). Differences between treatments were compared using Tukey's multiple comparison test. The level of significance was set at *P*<0.05.

RESULTS

Over the 8-week feeding period, no significant differences were observed in the water quality indices between the experimental treatments. The Photoperiod was dependent on natural light, while the water quality parameters in the system were monitored weekly. The temperature ranged between 24.6-29.4ºC while the concentrations of dissolved oxygen ranged between 5.74-7.68 mg/*l*, the pH between 6.15 -7.86, and ammonia from 0.22-0.27 mg/l. No critical values were detected for nitrite and nitrate concentrations.

The major ingredients used in the formulation of the experimental diets are shown in Table 1. The fish meal had the highest crude protein content (65.34%), followed by *Zonocerus variegatus* meal (GHM) (44.22%), followed by soybean meal (43.63%), whereas Dung beetle larvae meal (DBLM) had the lowest crude protein value (34.41%). However, DBLM had the highest crude lipid content (12.2%), followed by a fish meal (11.36%) and soybean meal (7.00%), whereas GHM had the lowest crude lipid content (4.2%).

The ingredient profiles and nutrient compositions of the formulated experimental diets used in this study are shown in Table 2. The diets were isonitrogenous and all experimental diets were similar in terms of nutrient profile.

Table 3 shows the relationship between the inclusion levels of the blended meals and the dependent variables: growth parameter indices (final weight gain (FWG), weight gain (WG)) and nutrient utilisation parameters (feed intake (FI), survival, feed efficiency (FE), protein efficiency ratio (PER) and protein retention (PR). Among the formulated experimental diets, heteroclarias fingerlings fed D4 treatment diet had the highest value in all the growth parameters measured and was significantly different (*P*<0.05) from all the other fish-fed experimental diets. Fish fed D5 had the lowest value, but there was no significant difference (*P*>0.05) between fish fed D1, D2, and D3. The nutrient utilization parameters measured (FE, PER, and PR) followed the same pattern as the growth parameter indices measured; hence fish fed D4 had the highest value and were significantly different from other fish fed other experimental diets, and fish fed D5 had the lowest value recorded; however, there was no significant difference between fish D1, D2, D3, and D5.

In table 4, the results of the body composition revealed that except for moisture heteroclarias fingerlings fed experimental diet display a marginal increase in carcass protein, lipid, and ash, at the end of the experiment and were significantly higher than the initial body composition at the beginning of the feeding trial. In the context of this experiment, there was no significant difference in the carcass crude protein and ash contents among all the fish-fed experimental diets (*P*>0.05). The proximate composition results also revealed that carcass lipid increased with the proportional increase in the inclusion level of the two blended insect meals in the diet. Fish fed D5 had the highest significant lipid carcass composition (*P*<0.05) while D1 had the lowest value but was not significantly different from fish fed D2, fish fed D1 show the highest moisture among experimental diets although not significantly different from D2 (*P*<0.05) but were significantly different from D3, D4, and D5.

Table 5 shows the apparent diet digestibility of the heteroclarias fingerlings fed the experimental diets. Fish fed Diet D4 had the highest value of ADC value of crude protein and was significantly (*P*<0.05) different from diets D1, D2, D3, and D5. There was no significant (*P*>0.05) difference in the ADC of crude lipids measured among all the experimental diets. Diet D4 had the highest value in ADC value of fibre, which was significantly different (*P*<0.05) from diets D1, D2, D3, and D5; however, there was no significant difference (*P*>0.05) between diets D1, D2, D3 and D5.

Table 6 shows the haematological parameters of the experimental fish after the feeding trial. Fish fed the experimental diet had a higher value in all the haematological parameters measured at the end of the experiment as compared to the initial values. The fish fed D4 had the highest packed cell volume, while fish fed D5 had the lowest PCV value; however, there was no significant difference ($P>0.05$) among all the fish fed the experimental diets. WBC values showed that fish fed D5 had the highest value, while fish fed D1 had the lowest WBC value; however, there was no significant ($P> 0.05$) difference among all the fish fed the experimental diets. RBCs and Hb followed the same pattern as PCV. LYMPH showed that D3 was higher and not significantly different from other fish fed the other experimental diets. While MCH followed the same pattern as WBC, there was no significant difference in MCHC and MCV among all fish fed the experimental diets($P>0.05$).

DISCUSSION

The present study investigates the suitability and utilization of blended insect meal; (Dung beetle larvae meal (DBLM) and Grasshopper meal (GHM)) on growth performance, body composition, and apparent nutrient digestibility of hybrid catfish fingerlings.

The weekly water quality indices measured during this study were all within the recommended range for catfish culture and were in line with the report by Ekubo and Abowei (2011).

The proximate composition of the grasshopper meal (GHM) used in this study was higher than the value reported by Ojewola *et al.* (2005) and lower than those reported by Njidda and Isidahomen (2010) and Alegbeleye (2011); however, the crude protein content was within the range reported by Moreki *et al*. (2012), who reported that the crude protein content of grasshopper meal varies widely (28.13 to 53.38%). These differences in the proximate composition of GHM could be due to differences in their developmental phase, variations in dietary habits between population, geographical location, season, method of harvesting, processing, and storage (Banjo *et al*., 2006; Ssepuuya *et al.,* 2017). DBLM crude protein value, however, was within the range of 26-37% reported by Alamu *et al*. (2013), while crude lipid falls within the range reported by Bophimai and Srii (2010).

At the end of the feeding trial, all the experimental fish were found to be in good condition in terms of morphological appearance and their response to experimental diets in terms of their feed intake, although acceptability varied significantly among the experimental fishes. This indicates that the blended insect meal was well utilised by the experimental fish, resulting in excellent performance among all the growth and nutrient utilisation indicators measured.

Weight gain and specific growth rate are usually assigned as the most important tools for measuring the productivity of diets (Omitoyin and Faturoti, 2000). There was a significant increase in weight gain recorded for all the treatments in this study, indicating that the fish responded positively to all the diets, which also reaffirms that the protein contents in the experimental diets adequately supported the growth of the experimental fish. In the present study, the fish fed D4 treatment diet showed better growth performance and nutrient utilisation compared to the control diet and other experimental diets. The Feed utilisation parameters obtained in this study suggest favourable utilisation of the blended insect meal-based feed for growth which was evident in their body weight gain. In the present study, growth and nutrient utilisation were observed to increase with the level of inclusion of the blended meal from (0%), (5% DBM and 5% GHM), (10% DBM and 10% GHM), (20% DBM and 20% GHM) and a significant decline ($P< 0.05$) at (30% DBM and 30% GHM). This could be attributed to some factors; the synergy of various dietary protein sources, especially the blended insect meals used in this study, maybe the major contributing factor, which is in line with the findings of Ugwumba *et al.,* 2001; Sogbesan *et al.,* 2005; Sogbesan and Ugwumba, 2006a; 2006b. Secondly, the lipid composition of the two insect meals used could have boosted the growth of experimental fish, although this study did not investigate the lipid composition of the two insects used in this study, Wang *et al.* (2007) reported that insect meals are rich in growth-promoting polyunsaturated fatty acids (PUFAs) such as linoleic, linolenic, and oleic acids, these dietary lipids have been reported to be well digested by fish and serve as a better energy source for protein than carbohydrates (Okoye *et al.,* 2001; Orire and Sadiku, 2011). The decline in the growth performance of fish fed D5 treated diet could be attributed to the high presence of chitin and fibre content in the diet, which according to Marleen (2013), increases the viscosity in the intestines as a result of low digestibility. Furthermore, it was observed that the blended meal inclusion in the diet of the experimental fish may have resulted in the high survival recorded in this study, which could be linked to the high acceptability of the diets as indicated by the FI and PER of the experimental diets. The few mortalities observed could be more likely related to stress caused by sampling and handling, which would have more profound effects on smaller fish (Devic *et al.,* 2018). This can be an indicator that the formulated diets fed to the fish in this experiment are of excellent quality as well as optimum rearing conditions. Ono *et al*. (2008) reported that the determination of apparent digestibility coefficients of diets or ingredients is an essential tool used in the development of diets to promote good fish nutrition and consequently obtain a better growth response and nutrient utilisation as well lower environmental impacts. In the present study, at higher inclusion levels of the two blended insect meals (D5), there was a significant reduction in the ADC of protein and crude fibre. This could be related to the increased content of indigestible materials such as chitin, fibre, and ash, which usually show low ADC values at high inclusions (Olsen *et al*., 2006). These indigestible materials are responsible for nutrient dilution, inconsistencies, and low digestibility. The High chitin content in the feed may affect the feed conversion ratio (Olsen *et al.,* 2006). Some studies on insect-based protein sources in fish nutrition have always established a link between chitin levels and the apparent digestibility coefficient of nutrients in the feed (Alegbeleye *et al.,* 2012; Barroso *et al*., 2014; Henry *et al.,* 2015; Fontes *et al.,* 2019). The lower apparent digestibility of diet D5 may be attributed to the high levels of inclusion of DBLM and GHM meals in the diet. This agrees with the findings of Longvah *et al.* (2011), who reported that high chitin and fibre might interfere with the dietary utilisation of protein, hence a reduction in protein and other nutrient digestibility in a diet. In the present study, chitin and fibre in all the experimental diets did not seem to influence lipid digestibility, since the lipid ADC for the diets did not differ significantly.

In the context of this study, except for moisture, there was a significant increase in the final carcass body composition (crude protein, lipid, and ash content) of fish fed experimental diets compared to the initial composition. This observation shows that the inclusion of blended insect meal in the diets might have influenced the carcass composition of the experimental fish. A similar trend was reported in previous studies that induced insects in fish diets (Alegbeleye *et al.,* 2012; Kroeckel *et al.,* 2012). At the end of the experiment, the crude protein and ash contents did not differ significantly among all the fish fed the experimental diets (P>0.05). However, there was a significant (P<0.05) variation in the carcass moisture and lipid content among the fish fed the experimental diets, and the moisture content showed a decline with an increase in the blended insect meal inclusion, while lipid deposition showed an increase in the carcass of the experimental fish with an increase in the blended insect meal inclusion in the diets. The increase in carcass lipid content with an increase in the blended insect meal inclusion is in contrast to the findings of some researchers that work on other insects, such as grasshopper meal Alegbeleye *et al.* (2012); however, this was in line with the findings of Mathis *et al.* (2003) and Xu *et al.* (2001), who reported that moisture and lipid content tend to show more significant fluctuations than other carcass components.

Haematological parameters are good indicators of the physiological, nutritional, and pathological status of animals, and can also be used in monitor feed toxicity Olafedehan *et al.* (2010); Nse-Abasi *et al.* (2014). In the context of the present study, there was a significant increase in the final haematological profile composition of fish fed experimental diets as compared to the initial composition. The mean values of the haematological indices measured in this study were not significantly different (P>0.05) among all the fish fed the blended insect meal diets to those fed the control diet, indicating that the formulated experimental diets were free from any cytotoxic effect on fish. Furthermore, no physiological stressful conditions were introduced to the fish by the inclusion of blended insect diets fed to the experimental fish. All the haematological parameters measured in this study were within the recommended physiological ranges and were similar to those reported by various researchers for clariid catfish (Ogunji *et al.,* 2008); however, they were higher than the values reported by Diyaware *et al.* (2013).

CONCLUSION

Hence, it can be concluded that the two blended insect meals can be a suitable feed ingredient in the hybrid catfish fingerling diet. An optimal combination of the two blended insect meals at 60% inclusion in the diet of hybrid catfish fingerlings was achieved. It can also be concluded that the haematological parameters of hybrid catfish were not significantly (p>0.05) influenced by the increase in the dietary inclusion level of the two blended insect meals. Therefore, not much stress was placed on the health and well-being of the hybrid catfish even when fed at a higher inclusion level (60%). A complete inclusion of the blended meal as the only protein source in the diet should be investigated, and the amino acid and fatty acid profile of the blended insect meal should also be evaluated in other fish species.

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Table 1 Proximate composition (expressed on a dry-matter basis) of the major ingredients used for the experimental diets including grasshopper meal (GHM) and dung beetle larvae meal (DBLM)

Ingredients	Fishmeal	Soybean meal	Maize meal	Millet meal	GHM	DBLM
Proximate composition						
Moisture (%)	5.79	3.09	4.66	3.22	5.69	6.34
Crude protein (% d.b.*1)	65.34	43.63	9.32	12.86	44.22	34.41
Crude lipid (% d.b.*1)	11.36	7.00	4.20	4.36	4.15	12.15
Ash (% d.b.*1)	14.34	8.15	3.22	2.33	13.46	11.58
Crude fibre (% d.b.*1)	0.06	5.00	3.40	2.60	2.31	1.68

[a] Means of two replicate analyse

Table 2 Formulation profile and proximate composition of experimental diets (g/kg)

Ingredients	D1	D2	D3	D4	D5
Fishmeal (Clupeid)*1	512.2	455.5	398.8	285.4	172.0
Soybean meal	100.0	100.0	100.0	100.0	100.0
Grasshopper meal	0.0	50.0	100.0	200.0	300.0
Yellow Maize	25.0	25.0	25.0	25.0	25.0
Dung beetle larvae meal	0.0	50.0	100.0	200.0	300.0
Starch	30.0	30.0	30.0	30.0	30.0
Cellulose	258.1	218.3	178.6	99.1	19.6
Vitamin premix	20.0	20.0	20.0	20.0	20.0
Shea butter oil	34.7	31.2	27.6	20.5	13.4
Mineral	20.0	20.0	20.0	20.0	20.0
Total	1000.00	1000.00	1000.00	1000.00	1000.00
Moisture (%)	5.7	5.4	5.3	5.7	5.6
Crude protein (% d.b.*1)	38.3	38.5	38.6	38.7	38.2
Crude lipid (% d.b.*1)	9.7	9.7	9.6	9.7	9.6
Ash (% d.b.*1)	10.2	10.3	10.5	10.5	10.8
AIA (% d.b.*1)	4.3	4.5	4.3	4.1	4.5
Crude fiber (% d.b.*1)	3.0	3.1	3.2	3.1	3.2

***FM**= Fishmeal: **SBM**= Soybean meal: **GHM** = Grasshopper meal **DBLM**= Dung beetle Larvae meal
MM= Yellow Maize**: SBO=** Shea butter oil

*d.b.= dry bases

AIA = Ash insoluble ash

***: Premix composition: vitamin and mineral premix (IU or mg / kg of premix). Vitamin A: 4800 IU; cholecalciferol (vitamin D): 2400 IU; Vitamin E: 4000 mg; Vitamin K: 800 mg; Vitamin B1: 400mg; Riboflavin: 1600 mg; Vitamin B6: 600 mg; Vitamin B12: 4 mg; Pantothenic acid: 4000 mg; Nicotinic acid: 8000mg; Folic acid: 400 mg; Biotin: 20 mg, Manganese: 22000 mg; zinc: 22000 mg; iron: 12000 mg; copper: 4000 mg; iodine: 400 mg; selenium: 400mg; cobalt: 4.8 mg.*

Table 3. Growth performances and nutrient utilization of hetero-clarias hybrid fingerling catfish fed experimental diets for 56 days.

Diet code	Body weight (g) Initial	Body weight (g) Final	Weight gain %	Survival rate (%)	Total feed intake (g)	Feed efficiency	Protein efficiency ratio	Protein retention (%)
D1	2.56±0.14	24.42±1.45[b]	854.0±18.0[b]	98.72±1.38[a]	25.42±1.46[b]	0.86±0.53[b]	2.25±0.86[b]	40.28±1.53[b]
D2	2.55±0.22	24.85±1.38[b]	873.1±13.4[b]	98.63±1.35[a]	25.79±1.68[b]	0.86±0.42[b]	2.25±0.52[b]	40.34±1.46[b]
D3	2.55±0.18	25.31±0.85[b]	891.4±11.3[b]	98.52±1.41[a]	26.22±1.32[b]	0.87±0.31[b]	2.25±0.68[b]	40.50±1.28[b]
D4	2.54±0.28	26.86±0.24[a]	957.4±16.2[a]	98.86±1.54[a]	27.23±0.21[a]	0.89±0.15[a]	2.31±0.12[a]	41.74±0.17[a]
D5	2.55±0.10	24.23±1.62[b]	848.8±15.4[b]	98.55±1.26[a]	25.33±1.53[b]	0.86±0.69[b]	2.24±0.44[b]	40.04±1.66[b]

Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other.

Table 4. Apparent diet digestibility coefficients of experimental diets fed to hetero-clarias hybrid fingerlings for 56 days.

Diet code	ADC of crude protein (%)	ADC of crude lipid (%)	ADC of crude fibre (%)
D1	88.58±1.72[b]	85.66±1.91[a]	55.28±0.32[b]
D2	88.50±1.48[b]	85.05±1.33[a]	55.35±1.64[b]
D3	88.64±0.88[b]	85.70±0.39[a]	55.39±1.52[b]
D4	90.11±0.15[a]	85.64±0.22[a]	57.22±1.13[a]
D5	88.28±1.69[b]	85.00±1.58[a]	55.26±1.43[b]

Values in the same column with different superscript letters are significantly different ($p<0.05$) from each other.

Table 5 Proximate composition analyses of whole-body hybrid fingerlings (fresh-weight basis) fed experimental diet for 56 days.

Component (%)	Initial	Final*1 D1	D2	D3	D4	D5
Moisture	76.78	74.18±0.6[a]	73.81±0.2[b]	73.23±0.5[b]	72.51±0.8[c]	72.12±1.1[c]
Protein	14.25	17.53±1.4[a]	17.58±1.0[a]	17.62±1.3[a]	17.74±1.6[a]	17.50±1.5[a]
Lipid	3.66	5.12±0.2[c]	5.22±0.7[c]	5.92±0.1[b]	6.42±0.4[b]	7.22±0.5[a]
Ash	2.87	3.15±0.4[a]	3.21±0.5[a]	3.18±0.2[a]	3.22±0.1[a]	3.14±0.3[a]

*1 Values in the same row with different superscript letters are significantly different ($p<0.05$) from each other (n=3).

Table 6 Haematological parameters of hybrid catfish fingerling fed experimental diets for 56 days.

Blood Parameter	Initial	Final*1 D1	D2	D3	D4	D5
PCV (%)	30.04	34.58±1.52[a]	34.64±1.25[a]	34.78±1.48[a]	34.85±0.36[a]	34.48±1.27[a]
WBC (10^3 mm^{-3})	5.15	5.55±0.34[a]	5.58±0.62[a]	5.65±0.22[a]	5.73±0.44[a]	5.97±0.68[a]
RBC (10^6 mm^{-3})	2.92	3.36±0.28[a]	3.37±0.31[a]	3.40±0.53[a]	3.39±0.42[a]	3.35±0.55[a]
Hb (g/100 ml)	8.98	10.56±0.23[a]	10.52±0.55[a]	10.64±0.38[a]	10.68±0.37[a]	10.47±0.84[a]
LYMPH (100)	60.62	61.44±0.54[a]	61.66±0.45[a]	62.38±0.66[a]	61.45±0.44[a]	61.32±0.63[a]
MCHC (%)	29.89	30.54±0.22[a]	30.37±0.34[a]	30.59±0.74[a]	30.65±0.59[a]	30.37±0.36[a]
MCH (pg)	30.75	31.43±0.42[a]	31.22±1.08[a]	31.29±0.37[a]	31.50±0.63[a]	31.25±1.75[a]
MCV (fl)	102.88	102.92±1.33[a]	102.79±1.43[a]	102.29±1.32[a]	102.80±1.24[a]	102.93±1.37[a]

PCV, packed cell volume; WBC, white blood cell; RBC, red blood cell; Hb, haemoglobin; LYMPH, lymphocyte; MCHC, mean corpuscular haemoglobin concentration; MCH, mean corpuscular haemoglobin concentration; MCH, mean corpuscular haemoglobin; MCV, mean corpuscular volume.

*1 Values in the same row with different superscript letters are significantly different ($p<0.05$) from each other (n=3).