GROWTH RESPONSE AND CARCASS COMPOSITION OF HYBRID CATFISH (HETEROCLARIAS) FED VARIEGATED GRASSHOPPER MEAL (*Zonocerus variegatus*) LINN MEAL

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ABSTRACT

A feeding trial was conducted to evaluate the suitability of *Zonocerus variegatus* meal (VGM) in the practical diet of hybrid catfish (Heteroclarias) fingerlings through their growth performance and carcass composition for 70 days. Six isonitrogenous diets were formulated in which VGM was included in the diet at different inclusion levels - D1 (0%), D2 (10%), D3 (20%), D4 (30%), D5 (40%) and D6 (50%). Each treatment had three replicates, eighteen net hapa (0.5 × 0.5 × 1m) were suspended in three outdoor concrete tanks (8m×5×1.5m). The concrete tanks were filled to 5/6 of its volume (40 m^3) with filtered and dechlorinated tap water, 20 fish with the initial average weight of 2.17±0.14 were stocked in each hapa. Water temperature and other water quality parameters were monitored daily. Except for the specific growth rate (SGR) where fish fed D3 and D4 were not significantly different ($P>0.05$), the result showed that fish fed with D4 (30% inclusion) had the highest value in other growth performance indices measured ($P< 0.05$), while fish fed D6 (50% inclusion) gave the lowest value. There were no significant differences among fish fed D1, D2, and D3. However, they were significantly higher ($P< 0.05$) than fish fed D5 and D6. The proximate composition result revealed that carcass lipid increased with an increase in the inclusion level of VGM in the diet. It could be concluded that 30% inclusion of VGM can improve growth performance of hybrid catfish without any adverse effect health status, suggesting that VGM could be a suitable ingredient in the diet of hybrid catfish.

Keywords: Growth performance; Zonocerus variegatus meal; Hybrid catfish

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INTRODUCTION

Fish meal constitutes the main protein source of commercial fish diets and its cost and restrictive availability have been a matter of concern to fish nutritionist for over a decade. The current world production of fishmeal is estimated at approximately 6.7 m tonnes annually, and according to New and Wijkstrom (2002), this level is expected to remain stable for the next decade. FAO (2007), reported

that the cost of feed ingredients including fishmeal is expected to be competitive due to the increasing global requirement for animal protein. The consequences of these, according to Tacon (2007), are the limited expansion and profitability of aquaculture, especially in a third-world state like Nigeria, where small-scale aquaculture contributes to over 70% of the domestic local fish production. This level of fish farming depends on readily available ingredients with less restrictive cost.

The constraint imposed by the high cost and un-predictability of fish meal has led to the consideration of alternative dietary protein sources, especially those with limited relevance in human nutrition. Some of these studies have concentrated on the evaluation of non-conventional dietary animal protein sources as a substitute for fishmeal in fish diets. These include meat bone meal, hydrolysed feather and blood meal Bureau et al (2000), dried fish and chicken viscera Giri, *et al.,* (2000). Recently, in Nigeria, there has been an increasing interest in the use of locally available animal protein ingredients with limited relevance in human nutrition; some of these are fermented shrimp head waste (Nwana, 2003) termites *Macrotermes subhyalinus*; Sogbesan and Ugwumba (2008); earthworm meal (Alegbeleye and Oresegun, 1998); Sogbesan *et al.,* (2006) garden snail meal (Sogbesan and Ugwumba, 2006); toad meal (Annune, 1990); tadpole meal (Ayinla *et al.,* 1994); maggot meal (Ugwumba *et al.,* 2001); Sogbesan *et al.,* 2005) and poultry dung meal (Fasakin *et al.,* 2000). Insects are considered to be nutritious (42% crude protein content), and have played an important role in the history of human nutrition in Africa, Asia and Latin America. However, the extensive use of various life stages of insects as dietary protein sources in culture fish feed has received very limited attention inspite of the fact that insects include some of the natural food of fish in the wild (Madu, *et al.,* 2003). The major limitation in the use of insect meal is the presence of chitin, a carbohydrate polymer that constitutes about 10% of whole dried insect (Goodman, 1989), which limits the digestibility of insects, and according to DeFoliart (1992), its removal from meal could increase the quality of insect protein.

The variegated grasshopper *Zonocerus variegatus* (Linn.) (Orthoptera: Pyrgomorphidae) is a large grasshopper with a high dry season population in the southwest and northern parts of Nigeria. It is recognized easily by the multicoloured markings on its body and the disagreeable odour. It is a polyphagus insect that feeds on and defoliates a large number of farm crops (Toye 1971; Youdeowei, 1974). According to Asoranti and Ajiboye (1993); Banjo *et al.,* (2006) their population is high enough to constitute a threat to plantations, especially cassava and maize (Ofin-Nape *et al.,* 1994). On the positive side, they provide animal dietary protein supplements for rural populations in the southwest and northern parts of Nigeria, hence, alleviating animal protein scarcity in these zones (Ojewole *et al.,* 2005). They could be found variously processed (fried, smoked, roasted, and dried) and sold to school children as snacks in markets in this part of the country (Banjo *et al.,* 2006), Information on the use of grasshopper meal in fish feed in Nigeria is still scanty (Madu *et al.,* 2003). The use of

grasshopper meal in livestock diets has been demonstrated in poultry; Ojewole, *et al.,* (2005) and Wang *et al.,* (2006) studied the nutritive value of Chinese grasshopper (*Acrida cinera*) for broilers.

Since one of the major problem militating against fish culture in Nigeria is inadequate supply and high cost of feedstuff of which fish meal is a major ingredient, thus the inclusion of grasshopper meal (VGM) as a protein source in fish diet would be imperative and a welcome development to aquaculture. Therefore the main objective of this study is to evaluate the effect of feeding concentrate containing graded inclusion levels of *Zonocerus variegated* grasshopper meal in the diet of *Heteroclarias* through their growth response, and carcass composition.

MATERIALS AND METHODS

The feeding trial experiment was carried out at the Old Research School of Agriculture and Agricultural technology Farm, Federal University of Technology, Bosso campus, Minna, Niger State. The adult variegated grasshoppers were collected from the environment of Federal University of Technology Minna, Bosso campus, Niger state. They were weighed fresh, oven dried at 80°C for 24 hours and soaked in water at 120°C for 10 mins to remove the waste and destroy harmful microorganisms in the grasshopper. The grasshoppers were sun-dried for 8 hours, milled with the aid of grinding machine. The fish meal used for the experimental diet was purchased from Sauki fish farm Km 16 MinnaZungeru road Niger state. Soybean and ground nut cake was obtained from the Kure market Minna Niger state. The Soybean was then toasted using a frying pan and allowed to cool before milling with the aid of grinding machine. All the ingredients used were separately milled and fortified with vitamin and mineral premix, each experimental diet was thoroughly mixed starting from the less quantity ingredient in a plastic bowl and later mixed with water. The moist mixed ingredients were made into dough and pelleted with manual pelleting machine at the laboratory unit of the Department of Water Resources, Aquaculture and Fisheries Technology, with 2 mm die. The pellets were sun dried and preserved in polythene bags.

Based on the nutritional requirements of African catfish fingerlings (NRC 1993), six isonitrogenous and isolipidic diets were formulated at 40 % protein and 9.5 % lipids, containing 10-50% ZVM at different levels of inclusion designated as D1 (0% inclusion), D2 (10% inclusion), D3 (20% inclusion), D4 (30% inclusion), D5 (40% inclusion)and D6 (50% inclusion).

The experimented fish, hybrid catfish (*Heteroclarias*) fingerlings (average weight of 1.38± 20.16g), were purchased from Pearl Catfish Hybridization Centre, Lagos State. The fish were transferred in a well-oxygenated water plastic container from the hatchery to the Department of Water Resources, Aquaculture and Fisheries Technology experimental fish farm, Federal University of Technology, Bosso campus, Minna where the feeding trial was conducted. Upon arrival they were acclimatized in a transitional tank in the farm for four days and were fed commercial feed (Coppens®) at 40% crude protein once a day before the experiment commenced.Fifteen hapa nets (0.5x0.5x1m) were suspended in two

outdoor concrete tanks (8mx5mx1.5m) with the aid of kuralon twine tied to plastic poles. The concrete tanks were filled to 5/6 of its volume (40m^3) with filtered and dechlorinated tap water. Twenty (20) fish were accommodated in each hapa and each treatment was randomly allocated to three hapas. Photoperiod depends on the natural light, and water temperature was monitored daily. The water quality parameters in the system were monitored weekly, the temperature ranged between 24ºC-29ºC while the concentration of dissolved oxygen ranged between 5.94-7.82 mg/L and the pH values of the treatments ranged from 7.18-7.60. No critical values were detected for nitrite and nitrate. The fish were fed three times daily at 5% of body weight at 09:00 am, 12:00pm and 16:00pm for 70 days. Feeding rate was subsequently adjusted according to their growth rates per hapa. The uneaten and faecal matters were siphoned out of the hapa every morning before feeding, and 45 minutes after the fish have been fed. The fish were denied feed 24 h prior to sampling. Five fish were randomly sampled on weekly basis, and weights were measured using a digital electronic weighing balance (*CITIZEN MP-300*) model.

About 10g initial sample and 15g of final samples from each hapa were pooled separately and then homogenized using laboratory mortar and pestle. The major ingredient used for the diet; the formulated diet and the fish body samples were subjected to chemical analysis. The proximate composition analysis was determined according to AOAC procedures (AOAC 2002). Moisture content was determined by drying samples at 105±2°C until a constant weight was obtained. Dried samples were used for determination of crude fat, protein and Ash contents. Crude fat was measured by solvent extraction method in a soxhlet system where n-hexane was used as solvent. Crude protein content was calculated by using nitrogen content obtained by Kjeldahl method. A conversion factor of 6.25 was used for calculation of protein content according to AOAC (2002).

Growth performance were analyzed in terms of weight gain (WG), specific growth rate (SGR), and feed intake (FI). The following formulas were used:

Weight gain (%) = (final weight (g) - initial weight (g)) × 100 / initial weight (g)

Survival (%) = 100 × (final number of fish/ initial number of fish).

Specific growth rate (%) = (ln final weight (g) - ln initial weight (g)) / feeding period (day) ×100

Feed intake (mg/fish/day) = dry feed (mg) fed / number of fish / feeding period (day)

The determination of the protein and lipid digestibility coefficient was done according to Jimoh *et al.,* (2010) which were calculated based on the percentage of AIA in feed and in faeces and the percentage of nutrient on diets and faeces.

Data Analysis

Data were analyzed using one-way analysis of variance (ANOVA) with Statistica 8.0 (Stat-Soft, Inc., Oklahoma, USA). Differences between treatments were compared by Tukey's test. Level of significance was tested at $P<0.05$.

RESULTS

The proximate composition of the major ingredients used for the formulation of the experimental diets is presented in .

Table 1. The result showed that, fish meal had the highest crude protein (69.34%) and 11.39% crude lipid, while variegated grasshopper meal had (44.22%) crude protein and (7.65%) crude lipid

Table 1: Proximate composition of the major ingredients used in the formulation of the experimental diet for hybrid catfishfingerlings.

Ingredients	Fishmeal	Soybean meal	Maize meal	Millet meal	GNC	ZVGM
Proximate composition						
Moisture (%)	5.79	3.09	4.66	3.22	7.19	5.28
Crude protien (% d.b.*1)	69.34	43.63	9.32	12.86	42.56	52.22
Crude lipid (% d.b.*1)	11.39	7.00	4.20	4.36	13.45	8.92
Ash (% d.b.*1)	13.34	8.45	3.22	2.33	6.35	12.34
Crude fibre (% d.b*1)	0.04	5.43	3.40	2.60	4.82	9.25

d.b = dry basis

Table 2: Formulation of the experimental diet and proximate composition of the experimental diet for hybrid catfishfingerlings (g/kg).

Ingredients	D1	D2	D3	D4	D5	D6
FM	448.80	373.50	298.20	222.80	147.50	72.30
SBM	100.00	100.00	100.00	100.00	100.00	100.00
GNC	100.00	100.00	100.00	100.00	100.00	100.00
ZVG	0.00	100.00	200.00	300.00	400.00	500.00
MM	25.00	25.00	25.00	25.00	25.00	25.00
Millet	25.00	25.00	25.00	25.00	25.00	25.00
Starch	45.00	45.00	45.00	45.00	45.00	45.00
Cellulose	189.20	164.70	140.50	116.30	91.90	67.50
Vitamin premix	20.00	20.00	20.00	20.00	20.00	20.00
SBO	27.00	26.80	26.30	25.90	25.60	25.20
Mineral	20.00	20.00	20.00	20.00	20.00	20.00
Total	1000.00	1000.00	1000.00	1000.00	1000.00	1000.00
Moisture (%)	6.25	6.56	5.82	6.45	6.74	6.85
Crude protien (% d.b.*1)	37.32	37.15	37.48	37.43	37.31	37.03
Crude lipid (% d.b.*1)	9.62	9.78	9.77	9.62	9.76	9.84
Ash (% d.b.*1)	9.27	9.87	10.45	10.65	10.76	10.84
Crude fibre (% d.b.*1)	4.14	4.25	5.26	5.43	5.43	5.43
AIA (% d.b.*1)	4.66	4.67	4.75	4.22	5.51	5.64

d.b = dry basis
AIA = Ash insoluble ash; SBM= Soybean meal; GNC= Groundnut cake meal; ZVG

Table 2 showed the ingredient profile and nutrient composition of the six experimental diets. The diets were similar in all the nutrient composition.
Table 3 showed the growth performance indices of the fish fed the experimental diets for 70 days. The result showed that fish fed with (D4 30% inclusion) had the highest final body weight and was significantly different from other fish fed other experimental diets. Fish fed D6 had the lowest final body weight although it was not significant difference fish fed D5. There was no significant difference between fish fed D1, D2 and D3 however they were significantly higher than fish fed D5 and D6. The percentage weight gain and Specific growth rate followed the same pattern as final weight gain. The survival rate of the fish fed experimental diets showed that there was no significant difference (P>0.05) among all of them.

Table 3.Growth performance indices of *hybrid catfish fed* experimental diets for 70 days.

Diet code	Body weight (g)		Weight gain (%)	Survival rate (%)	Specific growth rate (%)
	Initial	Final			
D1	2.16±0.02	20.52±1.52 b	848.68±11.00 b	98.81±1.14 a	3.21±0.11 b
D2	2.17±0.03	20.45±1.21 b	843.82±21.59 b	98.62±1.02 a	3.21±0.34 b
D3	2.16±0.04	21.52±2.22 b	872.40±21.60 b	98.90±1.03 a	3.28±0.35 ab
D4	2.17±0.03	23.26±1.23 a	973.49±21.61 a	98.65±1.04 a	3.39±0.36 a
D5	2.17±0.02	17.97±1.33 c	726.70±32.54 c	98.73±1.07 a	3.02±0.26 c
D6	2.18±0.04	17.23±1.24 c	689.43±42.11 c	98.75±1.05 a	2.96±0.18 c

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

The proximate composition analysis of whole body hybrid catfish (wet basis) fed experimental diets for 70days is given in Table 4. The whole body composition of the fish fed the experimental diets revealed that there was no significant difference in the crude protein of the fish fed experimental diets however the inclusion levels of VGM influenced the composition of moisture and carcass lipid

in the whole body of the of the experimental fish. The carcass lipid increased with an increase in the inclusion level of VGM while the moisture reduced with inclusion level of VGM.

Table 4 Proximate composition analyses of whole body hybrid catfish(wet basis) fed experimental diets for 70 days

Component (%)	Initial	Final*1											
		D1		D2		D3		D4		D5		D6	
Moisture	78.43	74.45±0.8	c	73.94±0.5	c	74.33±0.7	b	74.72±1.1	b	75.24±1.2	a	75.86±1.3	a
Protein	14.64	17.18±1.5	a	17.22±1.3	a	17.24±1.1	a	17.44±1.2	a	17.19±1.3	a	17.15±1.4	a
Lipid	2.57	5.63±0.7	a	5.28±0.5	a	4.88±0.5	b	4.48±0.4	b	3.66±0.5	c	3.37±0.2	c
Ash	2.16	2.47±0.3	a	2.39±0.4	a	2.42±0.1	a	2.36±0.3	a	2.44±0.3	a	2.40±0.3	a

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

DISCUSSION

This study reconnoiters the possibility of utilizing variegated grasshopper meal in the diet of hybrid catfish (Heteroclarias) fingerlings. Fish mortality was low and relatively uniform in all the treatments and the remaining experimental fish in the hapas were morphologically normal at the end of the feed trial. The absence of negative impact on the growth and physiology of the experimental fish indicated that inclusion of VGM will not hampered both the development and health being of fish. During the period of the experiment the water temperature ranged between 26±0.5°C - 28±04°C and the dissolved oxgen 5.8-8.2mg/L, these water quality parameters were within the acceptable range for hybrid catfish culture (Larry 1995). These values are in consistence with the means indicating that the experimental diets had no detrimental effect on the surrounding water where the experimental fish were stocked.

The proximate composition of major ingredients used for the formulation of the experimental diets in Table 1 showed that variegated grasshopper meal in the present study had 52.22% Crude protein content. In this present study the value was higher than the values reported by Ojewole *et al.,* (2005), Banjo *et al.,* (2006); Omotoso (2006) and Sogbesan and Ugwumba (2008). However was lower than the values reported by Olaofe *et al.,* (1998); Olaleye (2015) and Micheal and Kolapo (2016). The crude fiber content of the variegated grasshopper meal used was high (9.25%) this could be due to the fact that grasshopper has an exoskeleton made of chitin, this agrees with the report of Okoye and Nnaji (2004) on chemical composition of variegated grasshoppers. The differences in the proximate composition of the

variegated grasshopper meal samples could be due to season, geographical location, the age, size and method of harvesting, processing and storage. This is in agreement with the findings of Liu (2001).

The experimental fish became acclimatized to the experimental diets within 3-5 days of the start of the feeding trial. However the acceptability of the diets was not the same. This study showed that acceptability may have affected the feed intake, growth and the carcass composition of the fish fed the experimental diets.

The fish fed with Diet 4 (30% inclusion of VGM) gave better performance in all the growth parameter indices measured than even the control (fish meal based) and performed superiorly than other diets with higher inclusion levels of VGM in terms of the final mean body weight (MWG) , specific growth rate (SGR). The growth of hybrid catfish (*Heteroclarias*) fed VGM base diets increased tremendously with increase in the inclusion level of ZGM up to 30% inclusion, however a significant ($P<0.05$) decrease above 30% inclusion, in all the growth parameters measured.The measurable superior performance of the fish fed with Diet 4 compared with the group fed with the control diet is surprising judging from the comparative proximate composition profile of these feeds; however, the reasons for this could have been due to a number of factors. The presence of chitin in the diet could be a factor; the growth trends observed in the study are similar to those observed in other studies where arthropods have been fed to fish and livestock (Wang *et al.,* 2005; Olsen *et al.,* 2006; Wang *et al.,* 2006; Sogbesan & Ugwumba, 2008). Amar *et al.,* (2006) and Clarke *et al.,* (1993) had observed similar enhanced growth in white prawn (*FenneropenaeusHalian indicus*). According to Spreen *et al.,* (1984), low levels of chitin (chitinious material) as in Diet 4 (30%) could improve growth efficiency through the enhancement in bifidobacterium, thus stimulating improved growth gains. Some qualities of chitin as a pre biotic has been suggested by Olsen *et al.,* (2006) they noted a tendency for chitin to act as a pre biotic by screening out autochthonous bacteria that may have the potential to encounter the establishment of pathogenic microbes in the gastrointestinal track; although, the levels of chitin that hybrid catfish (*Heteroclarias*) can tolerate have not been evaluated in this study, but it is doubtful whether the levels in the feeds exceeded the upper tolerance limit of hybrid catfish (*Heteroclarias*). At higher inclusion levels of VGM (D5 and D6), there was a trend towards reduced growth rate. This could be related to the increased content of indigestible materials like chitin and ash. Olsen *et al.,* (2005) reported that at high levels of chitin could result in indigestibility of a diet. The digestibility of individual ingredient in feeds according to Desilva Shim and Ong (1996), Fagbenro *et al.,* (2003) and Bake *et al.* (2014) has been known to influence growth performance in fish. In this study growth rate decreased significantly ($P< 0.05$) with an increase in the inclusion level of VGM above 30% inclusion. The decrease in growth in groups fed high levels of variegated grasshopper meal agrees with the finding of Shiau and Yu (1999) and Olsen *et al.,* (2006). Chitin is a non- starch polysaccharide and is considered to be a

component of dietary fiber; according to Tharannathan and Kiltur (2003), chitin normally display the main characteristics of dietary fibre like water – binding capacity. Lindsay *et al.,* (1984) and Shiau and Yu (1999) reported that high content of chitin induced growth reduction in rainbow trout and Oreochromis hybrid respectively. Furthermore, Wang *et al.,* (2006) confirmed the presence of a high content of growth – promoting PUFA like oleic, linoleic and linolenic FAA in grasshopper thus this content in VGM could also be a booster to the growth of the fish.

The analysis from this study indicated that the crude protein content of carcass was not significantly different (P> 0.05) among all the fish fed the experimental. However, carcass lipid and moisture was greatly influenced by the inclusion levels of VGM. Carcass lipid deposited declined with an increase in the inclusion level of VGM. This result agrees with previous studies in which animal protein sources rich in chitnious material were used in fish feed (Shiau and Yu 1999; Olsen *et al.,* 2006). Moisture was inversely corresponding to the lipid this also agrees with the work of Sadiku and Oladimeji (1991); Bake *et al.,* (2012 and 2013) that in most semi fatty fresh water fishes species musclelipid content shows inverse proportionality to its water content.

This study reveals the potential of VGM as a dietary protein source that could be included in the diet of hybrid catfish (*Heteroclarias*) fingerlings. It also reveals that variegated grasshopper meal could be incorporated into the diet of hybrid catfish (*Heteroclarias*) up to 30%. From the result obtained in this study, it is concluded that hybrid catfish (*Heteroclarias*) fingerlings can make use of VGM at an inclusion level up to 30% in their diet to give an excellent growth performance, without any adverse effect on their body. However, an increase beyond this percentage would lead to depression in their growth response. This study recommends that subsequent research should be done to increase the inclusion level of variegate grasshopper meal through evaluation of other processing technique that could reduce the chitin level of variegated grasshopper meal without reducing the nutritive value.

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