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Efficacy of *Zonocercus Variegatus* (Grasshopper) Meal on *Clarias Gariepinus* Juveniles – Growth Rate in Lafia, Nasarawa State, Nigeria.

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Abstract

The residents of the north-eastern part of Nigeria like eating edible grasshoppers, which have an amino acid profile that is comparable to fish meal. In terms of amino acid composition, these grasshoppers are just as rich as fish meal. This study investigated the effects of feeding juveniles *Clarias gariepinus* different amounts of Grasshopper meal (GM) in their diet. Twenty-four (24) *Clarias gariepinus* juveniles were bought, acclimated for seven days and divided into five treatments groups (Control, T1, T2, T3, and T4). The grasshopper was ground into powder form after being oven-dried to a uniform weight. Five diets were created, each with a different inclusion level of 0%, 30%, 40%,50% and 60 % respectively. The proximate analysis showed that GM contained 60.90% Crude protein, 12.0% Ether extract, 1.0% Ash content and 17.0% crude fibre accordingly. Diet T3 had the lowest survival rate at 60%, while diets T1, T4, TC and T2 all had survival rate of 75%. However, there was significant difference (P<0.05) between the two diets. In all of the treatments that were looked at, the feed conversion ratio (FCR) revealed significant variations (p<0.05). Increase mean Length (IML) varied significantly(p<0.05) with T4 gaining the most length (12.67cm) and T3 gaining the least (5.58cm). With the exception of T2 and T3, the physico-chemical parameters of water in the experimental tank were within the acceptable range for *C. gariepinus* optimum growth. It is recommended that Grasshopper meal (GM) be added to the feed of *C. gariepinus* for optimum growth performance and lower production costs.

Keywords: *Clarias gariepinus*, Feed conversion ratio (FCR), Grasshopper meal (GM), Increase mean length (IML), Juveniles

Introduction

Protein, an essential macronutrient that performs numerous bodily activities is primarily found in fish, It containsomega-3 fatty acids as well as vitamin D and B2(riboflavin). Protein is typically composed of carbon (50%), nitrogen (16%), oxygen (21.5%) and hydrogen (6.5%), with certain protein also containing small amount of sulfur (2.12%) (Halver and Hardy, 2002). One of the distinguishing species in the subclass *Actinopterygii,* order *Siluriformes*, and family *Clariidae* is the African catfish, *Clarias gariepinus*. The habitat needs of the African catfish species are quite common and pervasive. Although, it is predatory and omnivorous, it has a relatively high dietary protein requirement of between 40 and 50 percent of crude protein on a daily weight basis (Balogun and Dabrowski, 1992). There is a rising demand for seafood as a result of the human rapid growth in human population and rising level of life (Daniel, 2018; Stankus, 2021). Fish feed is presently very expensive both imported and locally produced ones (Falaye, 2003). The use of other sustainable sources as alternatives for fish meal in relation to the production of formulated feed has reduced the dependence on fish meal. The rise in global population has increased the demand for protein source, which has inevitably impacted the aquaculture industry to produce high yielding fish with lower cost (Barroso *et al.,*2014; Henry *et al.*, 2015). The global aquaculture production of farmed food fish in 2018 reached 82 million tons with a value of USD 400 billion, representing around half of the total world fish production for human consumption (FAO, 2020).

Insects have gained a lot of interest recently as a source of protein for both humans and livestock. Insects are capable of rapid growth and reproduction, high feed conversion efficiency, and bio-waste rearing (Van Huis *et al.,* 2013; Makkar *et al.,* 2014). An average of 2 kg of feed biomass may be converted into 1 kg of insect biomass (Collavo *et al.,* 2005). Insects are one of the sustainable and promising alternatives to fishmeal for use in aqua diets (Henry *et al.,* 2015). The utilization of insect meals as a substitute for fish meal has been successfully evaluated for different number of fish species such as the European sea bass (Gasco *et al.,* 2016) trout *Oncorhynchus mykiss* (Walbaum) (Renna *et al.,* 2017); Nile tilapia; *Oreochromis niloticus* by (Sanchez muros *et al.,* 2016) gilthead seabream (Karapanagiotidis *et al.,* 2014); the Siberian sturgeon, *Acipenser baerii* Brandt (Zarantoniello *et al.,* 2021); the clownfish, *Amphiprion ocellaris* Cuvier (Vargas-Abúndez, *et al.,* 2019) or the zebrafish, *Danio rerio* (Hamilton) (Zarantoniello *et al.,* 2019) and shrimps (Motte *et al.,* 2019). There are several reports on the use of some alternative animal protein feedstuffs to fish meal such as: Black soldier fly larvae with about 40-44% crude protein (Makkar *et al*., 2014; Tran *et al.,* 2015), Locust with high level of protein, minerals and vitamins, and contain 50-65% crude protein (Makkar *et al.,* 2014), Sliver cyprinid (*Rastrioneobola argentea)* with protein values range from 19.1-21.8% (Bille and Shemkai, 2006). The similarity in the quality of the amino acid profiles of fish and grasshopper meal encourages the conclusion that these grasshoppers are as rich in amino acids as fishmeal. When they fall into a fish pond, according to Madu *et al*., 2003, fish eat them while they are still alive. Therefore, it is important that insects be used as the primary protein source to increase the growth rate of juvenile *Clarias gariepinus.*

2.0 Materials and methods

2.1 Study site

The research was conducted in Lafia, Nasarawa State at the College of Agriculture, Science and Technology Experimental farm of the Department of Fisheries Technology, Lafia, Nasarawa State. Lafia is a town in North Central Nigeria; it is the capital of Nasarawa State with its current metro area population of 361,000 by 2022 which is about 3.74% increase from 2021 (NIMET, 2021).

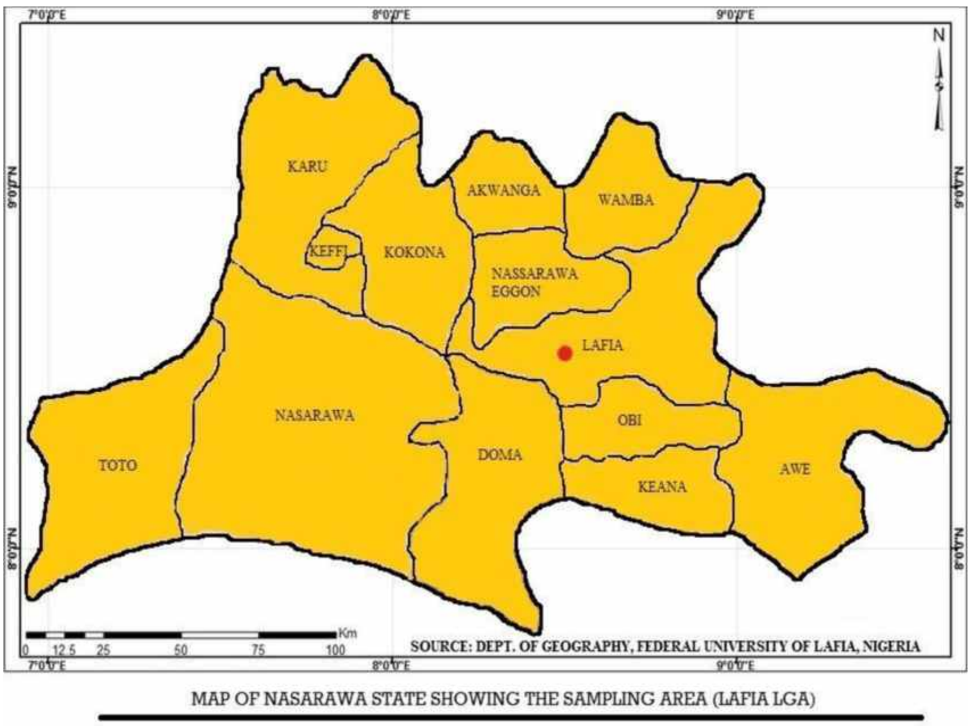

Figure 1: **Map of Nasarawa state showing the study site**

2.2 Grasshopper collection and processing

A sample of a grasshopper that are edible was purchased from a market in Maiduguri, Borno state, Nigeria. Prior to proximate analysis, the sample was maintained in a cold chamber after being oven dried at 55°C for 24 hours to generate grasshopper meal, which was then crushed to a fine powder using a mortar and pestle. The moisture content, total ash, crude fat, crude fiber, and crude protein of the target insect powder were then calculated utilizing control laboratory techniques (AOAC, 2005).

2.3 Preparation of the experimental diet

The food composition and concentration for each treatment, which was carried out using the technique outlined by Olurin *et al*. (2006), are shown on Tables 1. Fishmeal (FM), maize meal, soybeans, vitamin, bone meal, cassava starch, salt mineral, and dicalcium phosphate (DCP) were all purchased as raw materials from a nearby livestock feed plant. The feedstuffs received the necessary processing, were individually ground using a home hammer milling machine, packaged, and kept for use. Grasshopper meal was thoroughly combined with cassava starch as a binder and added at 0g (control), 30g, 40g, 50g, and 60g. Using a local small pelleting machine (KCM, Y132m-4), the resulting dough was formed into pellets with a 2mm diameter. The wet pellet was air-dried for 24 hours in the shade before being stored for later usage in the laboratory in a new airtight polythene bag.

2.4 Experimental design

The experiment was created using a modified version of the methodology of Akinrotimi *et al.* (2011). One hundred and twenty (120) *Clarias gariepinus* juveniles were obtained from the College of Agriculture, a recognized fish farm in Lafia, acclimated for seven days and then randomly placed in a concrete tank that measured 148 cm in length and 81 cm in width. Each tank received 24 fish, representing the five treatments of 0g (control), 30g, 40g, 50g, and 60g, which were referred to as T1, T2, T3, and T4 correspondingly. Weekly fish weigh-ins were used to modify the feeding rate. The investigation lasted for eight weeks. Fish growth response to diet was assessed using weekly weight of fish and feed provided. The system's water quality was observed and maintained within acceptable bounds at that time.

2.5 Statistical analysis

($P < 0.05$) was regarded as statistically significant, and one-way analysis of variance (ANOVA) was performed on all data using SPSS version 21.0 (SPSS Inc., Chicago IL, USA) to determine the specific growth rate (SGR), feed conversion ratio (FCR), percentage mean weight gain (PMWG), percentage survival rate (PSR), and survival rate (SR) across treatment groups.

3.0 Results

3.1 Experimental Diet composition and Proximate analysis of Grasshopper meal

All treatment groups received the following percentages of the experimental diet: fish meal 32%, soya beans 33%, maize 30%, vitamin premixes 1%, bone meal 0.5%, lysine 0.5%, methionine 0.5%, palm oil 1%, cassava starch 1%, and salt 0.5%. Grasshopper meal was added at various inclusion levels of 30%, 40%, 50%, and 60% (Table 1). According to the proximate composition (Table 2), grasshopper meal contains 4.00% dry matter, 5.1% moisture, 60.90% crude protein, 12.0% ether extract, 1.0% ash, and 17.0% crude fiber.

Table 1: The Composition of the Experimental diet

Ingredient	Composition (%dry matter)	Control	T_1(30%)	T_2(40%)	T_3(50%)	T_4(60%)
Fish meal	32.00	32.00	31.7	31.6	31.5	31.4
Grasshopper	64.00	0	0.3	0.4	0.5	0.6
Soya bean	33.00	33.0	33.0	33.0	33.0	33.0
Maize	30.00	30.0	30.0	30.0	30.0	30.0
Vitamin premixes	1.0	1.0	1.0	1.0	1.0	1.0
Bone meal	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	0.5	0.5	0.5	0.5	0.5	0.5
Methionine	0.5	0.5	0.5	0.5	0.5	0.5
Palm oil	1.0	1.0	1.0	1.0	1.0	1.0
Cassava starch	1.0	1.0	1.0	1.0	1.0	1.0
Common salt	0.5	0.5	0.5	0.5	0.5	0.5
Total	**100.0**					

Table 2: Proximate composition of Grasshopper meal

Sample	%Dry matter	%Moisture content	%Crude Protein	%ether extract	%Ash content	%Crude fibre
Grasshopper meal	4.00	5.1	60.90	12.0	1.0	17.0

3.2 Feed Conversion Ratio (FCR)

T3 had the highest Feed Conversion Ratio (68.71), followed by T2 (32.44), Control (18.76), and T4 (14.51), while T1 had the lowest Feed Conversion Ratio (11.86). The Feed Conversion Ratio between T1, T2, and T3, however, differed significantly (P 0.05) from T1, T2, and T3. Control and T4 don't, however, display any statistical significance (P>0.05).

The specific growth rate (SGR) was highest in T1 (37.35) and lowest in T3 (6.47), followed by T4 (30.54), Control (23.62), T2 (13.66) and T3. However, there was a significant difference (P0.05) between T2, T3, and Control but not between T1 and T4, T1, T2, or T4.

The survival rate in T1 was high at 87.5%, with a significant difference (P0.05) between T1, T3, and T4. However, there was no change between control and T2 that was statistically significant (P 0.05). PSR, or Percentage Survival Rate. The fish fed with T1 had the best survival rate (87.5%), while the fish fed with T2 and T3 had the worst survival rate (66.66%). With the exception of T2 and T3, where there was a significant difference (P0.005), none of the experimental diets had an impact on the fish's survival rate (P>0.05) (Table 3)

Table 3: Feed conversion ratio (FCR) and other parameters:

Parameters	Feed Conversion ratio (FCR)	Specific growth rate (SGR)	Survival rate (SR)	Percentage survival rate (PSR)
Control	18.76^{c}	23.62^{b}	16^{c}	66.66^{c}
T1	11.86^{d}	37.35^{a}	21^{a}	87.5^{a}
T2	32.44^{b}	13.66^{c}	16^{c}	66.66^{c}
T3	68.71^{a}	6.47^{d}	15^{d}	62.5^{c}
T4	14.51^{c}	30.54^{a}	17^{b}	70.83^{b}

*SGR- Specific Growth rate, PMWG- Percentage mean weight gain, FCR- Feed Conversion Ratio and PSR- percentage Survival Rate.
*Mean values with the same superscript along rows are not significantly different (p>0.005)
*Mean Values with Different superscripts along rows are significantly different (P<0.005).

3.3 Growth performance of *Clarias gariepinus* Juveniles

After 62 days, the results of *Clarias gariepinus* given the experimental diet were displayed in Table 4. Before the trial, the initial weights of every fish given with every experimental diet were the same. After 62 days of the experiment, fish with a 30% inclusion had the highest mean weight gain (23.25g) and weight gain (27.25g). However, T4 had the largest increase in length, followed by T1, Control, T2, and T3, which had the smallest increase at 5.58 cm. Nevertheless, there was a significant difference in the lengthening of T1 between the experimental group and the control group. The experimental fish were fed diets containing various amounts of grasshopper meal, and weight gain revealed that T1 had the fastest growth trend, followed by T4, then TC. T2 and T3 showed sluggish growth. The experimental fish's growth rate varied significantly (P0.005) between T1, Control, and T4 (Figure 1).

Table 4: Morphometric indices of the fishes at different treatment groups.

Parameters	Number of fish stocked	Weight gained				Length gained		
		Initial Weight	Final Weight	Mean Weight Gained	% Mean Weight Gained	Initial Length	Final Length	Increased Mean Length (IML)
Control	24	4.09	18.70^{b}	14.65^{c}	358.19^{c}	6.46	15.36^{b}	8.90^{a}
T1	24	4.00	27.25^{a}	23.16^{a}	566.25^{a}	6.72	18.30^{a}	11.28^{c}
T2	24	4.10	12.56^{c}	8.47^{d}	207.09^{c}	6.80	15.26^{b}	8.46^{d}
T3	24	4.00	8.09^{d}	4.00^{d}	97.79^{d}	6.72	12.3^{c}	5.58^{d}
T4	24	4.08	23.03^{a}	18.94^{b}	463.08^{b}	6.66	19.33^{a}	12.67^{b}
Total	**120**							

*MWG-Mean Weight gain, IML- Increase in mean length.
*Mean values with the same superscript along rows are not significantly different (p>0.005)
*Mean Values with Different superscripts along rows are significantly different (P<0.005)

Table 5: Water Quality Parameter Range During the Experimental Period

Parameter	Control Min -Max	T1 (30%) Min -Max	T2 (40%) Min -Max	T3 (50%) Min -Max	T4 (60%) Min-Max	Normal Range for fish culture
Temperature	24^0C -26^0C	23^0C -29^0C	22^0C -25^0C	23^0C -26^0C	24^0C- 28^0C	25^0C -31^0C
pH	6.5-7.0	7.0-8.0	5.5 -6.8	6.0 -7.5	6.5 -7.5	6.5 -8.5
D.P (mg/l)	6.8 -6.9	5.0 – 9.5	4.0 -4.5	3.2 -4.8	3.2 – 7.8	5mg/l

4.0 Discussion

One cannot overstate the importance of fish eating as a source of protein for people. The impact of grasshopper feedd on the juvenile *C. gariepinus* growth rate was examined in this study. According to the results of the nutritional analysis, grasshopper meal has a high crude protein content of 60.90%. This value is extremely high and could entirely replace fishmeal in fish diet. The amount is consistent with the findings of Njidda *et al*. (2010) who found that the diet of *C. gariepinus* fingerlings contained 64.32% crude protein. Contrarily, Subhachae *et al.* (2010) report stated that the crude protein level was 18.39%. This figure is also comparable to fishmeal made from clupeids by Okoye *et al*. (2003) which had a crude protein content of 68.47%. Crude protein, ether extract, ash content, and crude fiber are all present in grasshopper meal in that order. The importance of these components makes it an excellent nutritional feed for the manufacturing of fish feed.

The feed conversion ratio (FCR) for T1 was high at 11.86, which is consistent with the findings of Haruna, 2003, who found a 2.32 FCR with 20% inclusion of grasshopper meal. This might be due to the experiment's high grasshopper meal inclusion level, 100% feed conversion, and therefore the animals' quick growth. Similar to this, Adikwu (2003) noted that fish use feed more effectively the lower the FCR. According to Finke, 2015 research, T1 had the highest specific growth rate (SGR), which is in contrast to Okoye *et al.* 2004 findings that claimed 10% grasshopper meal produced higher growth results. This may be due to protein utilization as the protein level was 30% more appropriate than the other treatments. Fishes require specific amounts of protein, and once the body has met those needs, the remaining protein is wasted. According to Omeru and Solomon (2014), the greater the SGR value, the higher the feed quality. T1 had a high percentage survival rate (PSR) of 87.5%. This is consistent with the results of Ogunji *et al*. (2007), who observed a comparable percentage survival rate of 73-80% in tilapia O. niloticus fingerlings fed on diets made with inclusion levels of *M. domestica* maggot meal of 45% and 68%. This can be because the water quality is good and the inclusion level is 30%, which is optimal for growth. The percentage mean weight gain (PMWG) in T1 was high at 566.25%, which is consistent with Abanikannda (2012) findings of 801.35%.

The findings of Gbadamosi *et al.* (2007), who indicated that 30% grasshopper feed exhibited decreased weight gain in *C. gariepinus,* are in contradiction. The outcome of the current study could be attributed to the protein content and feed's quality as well as the fact that grasshoppers contain a growth-promoting metabolite that enhances the function of the intestinal flora, improving digestion and enhancing energy utilization, which in turn led to better fish growth. (Abdel-Tawwab *et al* 2010).

T4 had the largest length, with 12.67 cm, according to the Increased Mean Length (IML). This result contrasts with those of Okoye *et al.* (2004) and is in agreement with Madu *et al.* (2003) which found an increase in the mean length of Tilapia fish to 8.65 cm. This might be a result of the low water quality, which impairs their food intake and causes the fish to become emaciated and grow longer rather than gaining weight. The surviving fish would degrade the water quality since they would only consume what they needed for protein. It would slow their growth, prevent them from gaining weight, and lengthen them. Factors as a result of high ammonia, high hydrogen sulphide and high carbon dioxide in the water. Except for T2 and T3, which exhibited a drop in pH (5.5, 5.0), temperature (22°C, 23°C), and D.O. (4.0, 3.2).

The physico-chemical parameters seen in the various treatment groups were within the permissible range for fish growing. This could be explained by the delayed development being caused by low feed use. Dissolved oxygen, pH, and temperature are some of the most significant physico-chemical factors that might affect fish growth (Chukwuma and Henry, 2012). Since dissolved oxygen has an impact on fish and the growth of other organism, survival,distribution, behavior, physiology, oxygen depletion in water can result in poor fish nutrition, hunger, stunted growth, and increased fish mortality either directly or indirectly (Bhatnager, 2000). When the pH falls below 4, catfish will perish from the acidity of the water. An acceptable pH value is between (6.5 and 7.5).

4.1 Conclusion

The experimental fish in this study avidly ingested grasshopper meal, which significantly accelerated their growth. The T1 with 30% inclusion and T4 with 60% inclusion groups showed the best overall results. The amount of crude protein in grasshopper meal is high (60.90%), and it also contains other nutrients in variable amounts, including dry matter, moisture content, crude protein, ether extract, ash content, and crude fiber. The percentage survival rate (PSR) in T1 was high at 87.5%, a high Feed Conversion Ratio (FCR) of 11.86, and a high Specific Growth Rate (SGR) of 37.35g. T1 had a high percentage mean weight gain (PMWG) of 566.25%, while T4 had the greatest IML (12.67 cm) of all then the diet of C. gariepinus without sacrificing growth performance, feed utilization, or fish health. 30% of grasshopper meal has the capacity to replace fish meal in the diet of *C. gariepinus*. Additionally, compared to imported fish meal, these indigenous protein sources are far more affordable.

4.2 Recommendation

Based on the findings of this study, it is advised that 30% grasshopper meal be added to *Clarias gariepinus* feed to promote optimal growth and lower production costs. It is advised that field experiments employing the semi-intensive system frequently used in earthen ponds be investigated as this work was conducted under experimental settings in a concrete pond.

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