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Combination of Black Soldier Fly Larvae (*Hermetia Illucens L.)* with Commercial Feed on Growth Performance of African Catfish (*Clarias Gariepinus*) in Port Harcourt, Nigeria

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Abstract:- The aim of this study was to determine the growth performance, proximate composition of commercial feed and Black Soldier Fly Larvae (BSFL) as feed components and the proximate composition of African catfish (*Clarias gariepinus*). Four groups A, B, C, and D of catfish were used in this experiment. Group A were fed with 100 commercial feed, group B; 60% commercial feed and 40% black soldier fly larvae (BSFL)}, group C; 55% commercial feed and 45% BSFL, and group D; 50% commercial feed and 50% BSFL. The results revealed fish weight gain as follows: group C recorded the highest weight gain 895.59%; followed by group D with 889.88%. For the growth rate; group C recorded 9.95%, being the highest; followed by group D with 9.88%. Feed conversion ratio was lowest in group C (0.281), followed by group D (0.283). Analysis of variance however, showed no significant differences in the weight gain of all the groups (A, B, C and D). The proximate analysis of the fish fed with the different formulations of A, B, C and D revealed that ash content in group D (2.23%) was the highest followed by group B (1.94%). Group A recorded the highest fat content (8.07%), followed by group B (7.635%) while the lowest was recorded in group C (4.51%). Interestingly, group D recorded the highest protein content (16.705%), followed by group A (15.295%). Group C recorded the highest crude fibre (11.57%) followed by group A (6.795%), while the lowest was recorded in group B (4.785). Lastly, group C recorded the highest carbohydrate (2.735%) followed by group A (2.67%) while the lowest was recorded in group B (2.015%). Based on this study, it is recommended that BSFL of up to 50% can be combined with commercial feed to feed African catfish from melange stage to table size.

Keywords:- *Black Soldier Fly Larvae (BSFL), African Catfish, Proximate Composition, Growth Performance.*

I. INTRODUCTION

Aquaculture involves the cultivation of many fish species of either fresh or brackish water origin and among the important freshwater fish species is the North African catfish which is also called African catfish (*Clarias gariepinus*). Its production is increasing in line with the increase in the global aquaculture industry, with Nigeria reported as producing the highest annual amount of the catfish [1]. Despite this commendation, Nigeria's annual demand for fish is about 3.6 million metric tons, while domestic production is about 1.12 million metric tonnes implying that the deficit is being bridged through importation. To fill the demand supply gap, Nigeria needs to produce at least 2.48 million metric tons of fish annually to feed its population and to enhance economic growth [2]. One of the ways to sustain increased aquaculture production is through the combination of feed that will enhance both the growth performance and the nutritional quality of the fish. The rearing of *Clarias gariepinus* started in the early 70s in Central and Western African countries. It received wide acceptance on the realization that it is a very suitable species for aquaculture with high economic value [3]. To reduce the dependency on the relatively scarce fishmeal (FM) and imported plant-based proteins, some farmers started using insects to enhance the quantity of FM in fish feed. Insect meals have gained significant attention in recent years due to their potential to meet the increasing demand for feed raw materials [4]. These next generation feed ingredients have the potential to meet the proximate composition requirement of catfish as well as lowe environmental and carbon footprints, making them promising solutions for the aquaculture industry to uphold environmental sustainability [5]. In this regard, the Black soldier fly larvae (*Hermetia illucens*) stand out due to its dual ability of recycling organic waste materials into useful biomass for feed [6]. Therefore, the main aim of this research was to study the growth performance and proximate composition of including BSFL as feed component for the production of *Clarias gariepinus*.

II. LITERATURE REVIEW

A. Success of Black Soldier Fly as Aquafeed Ingredient

In many parts of the world Black soldier fly larvae have been used to partially replace Fish Meal [1,4,6,7]. BSFL have been reported as one of the renewable ingredients that could replace fish meal in the aquafeed production. For instance, about 22.5% of BSFL has been used to feed European seabass (*Dicentrsrchus labrax)* as dietary protein with positive growth performance [7]. Also, up to 40% of BSFL with 60% commercial feed have been used to feed Rainbow trout (*Oncorhynchus mykiss*) with remarkable success [8]. In terms of easy digestibility 13% of BSFL was recommended for Rainbow trout (*Oncorhynchus mykiss*) [9]. However, it was advised to be cautious when 50% of BSFL is combined with

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commercial feed in Rainbow trout (*Oncorhynchus mykiss*). [10]. For Eurasian perch (*Perca fluviatilis*), about 40% of BSFL can be used as parts of its diet [11]. For the Siberian sturgeon fingerlings (*Acipenser baerii*), up to 10% of BSFL has been utilized with promises for further increase [12]. In the African Catfish (*Clarias gariepinus*), 75% of partially defatted BSFL successfully replace FM in the commercial feed [13]. Furthermore, the oil from BSFL can be used to replace 100% Soybean in Juvenile Jian Carp (*Cyprinus carpio var. Jian*) feed with no negative effect on them [14].

B. *Proximate Composition of Black Soldier Fly Larvae and Fish*

The major factors limiting inclusion of insects in aquafeed are: reduction in protein digestibility, imbalance amino acid profile and increase in levels of saturated fatty acid [15]. Identifying and utilizing insect-specific substrates suitable for digestibility as aquafeed has been recommended [16]. In a study to determine proximate composition of BSFL, it was found that crude protein was 35.20% while ash content was 11.80% [5]. Another study found proximate composition of fish fed with BSFL 50 % and 50% Commercial feed with crude protein content of 35.37%, crude fat 10.97%, ash content 12.5%, crude fibre 6.8% and moisture content of 8.5%. [6]. A study that included 10 to 30% of BSFL, used to feed hybrid tilapia (*Oreochromis spp*.) revealed high crude protein of 80.3% DM, and fat of 2.9% DM. [17]. Trial of 50% BSFL have been reported to replace fishmeal in African catfish [6]. The proximate analysis of fish with 50% replacement of BSFL in fishmeal revealed crude protein of 66.24%, crude fat of 13.5%, ash content of 6.23% [6].

III. MATERIALS AND METHODS

This research employed explorative design as it was a field trial with African Catfish (*Clarias gariepinus*). The field trial included control and treatment applications in Plastic tanks of 1m^3 to enable comparison. Melange sized catfish with average weight of 113-315g were purchased from a private fish hatchery in Port Harcourt, Rivers State, Nigeria. The fish were acclimatized to the ambient temperature of the experimental tanks for 1 week before the experiment commenced. The 600 Melange size catfishes were thereafter placed in four treatment groups, each with three replicates fed with the experimental nonconventional feed. The schools of fish were labelled as Group A (the control group), Groups B, C, and D (treatment groups). Each replicate contained 50melange in the tank measuring 1 m^3 (1 × 1 × 1 m) and filled with 500-700 L of water. The field trial was carried out for 90 days; recording their weights and lengths bi-monthly. Three sample each from the control and treatment groups were taken to the laboratory for composite sample analyses; at the department of food science and technology laboratory, faculty of agriculture, Rivers State University. BSFL and conventional feed utilized for this study were also analysed in line with the Association of Official Analytical Chemist (AOAC) 16th edition (AOAC, 1998). For analysis of moisture content, model No. AE 223 was used for weighing balance while model No. DHG 9140A was used for pre-heated oven. Data were analysed with Statistical Package for Social Science (SPSS Version 21) as well as Microsoft Excel 2019. Fish growth performance was determine based on the following derivatives:

$$Weight\ gain\ (WG\%) = \left(\frac{final\ mean\ weight - initial\ mean\ weight}{initial\ mean\ weight}\right)$$

$$Growth\ rate\ (GR\%) = \left(\frac{final\ mean\ weight - initial\ mean\ weight}{number\ of\ feeding\ days}\right)$$

$$Feed\ conversion\ ratio\ (FCR) = \left(\frac{feed\ intake}{weight\ gain}\right)$$

IV. RESULTS

A. *Commercial Feed Components and Fish Growth Performance*

The commercial feed components used for this field trial had the information on its label as well as the findings of the laboratory analyses shown in Table 1.

Table 1: Information Provided on Commercial Feed and Laboratory Analyses

Nutrient	Supplier's Analyses		Laboratory Analyses	
	Minimum	Maximum	Commercial al feed (Mean)	BSFL (Mean)
Crude Protein (%)	40		39.81	11.69
Fat (%)		12	4.485	1.455
Ash (%)		8	8.335	3.835
Crude Fibre (%)		4.5	26.33	18.49
Moisture (%)		10	7.67	60.605
Calcium (mg/100g)	1	1.5		
Phosphorus (mg/100g)	1	8		
Sodium (mg/100g)	0.3			
Carbohydrate (%)			13.48	4.165

The fish growth performance is shown in Table 2.

Table 2: Fish growth performance

Parameter	WG	GR	FCR
Group A	780.3751	8.670835	0.322922
Group B	732.8011	8.142234	0.343886
Group C	895.5806	9.950895	0.281382
Group D	889.8833	9.887592	0.283183

B. Proximate Composition of Feeds

Results of the proximate composition between the commercial and the black soldier fly larvae feeds before consumption by fish shown in Figure 1.

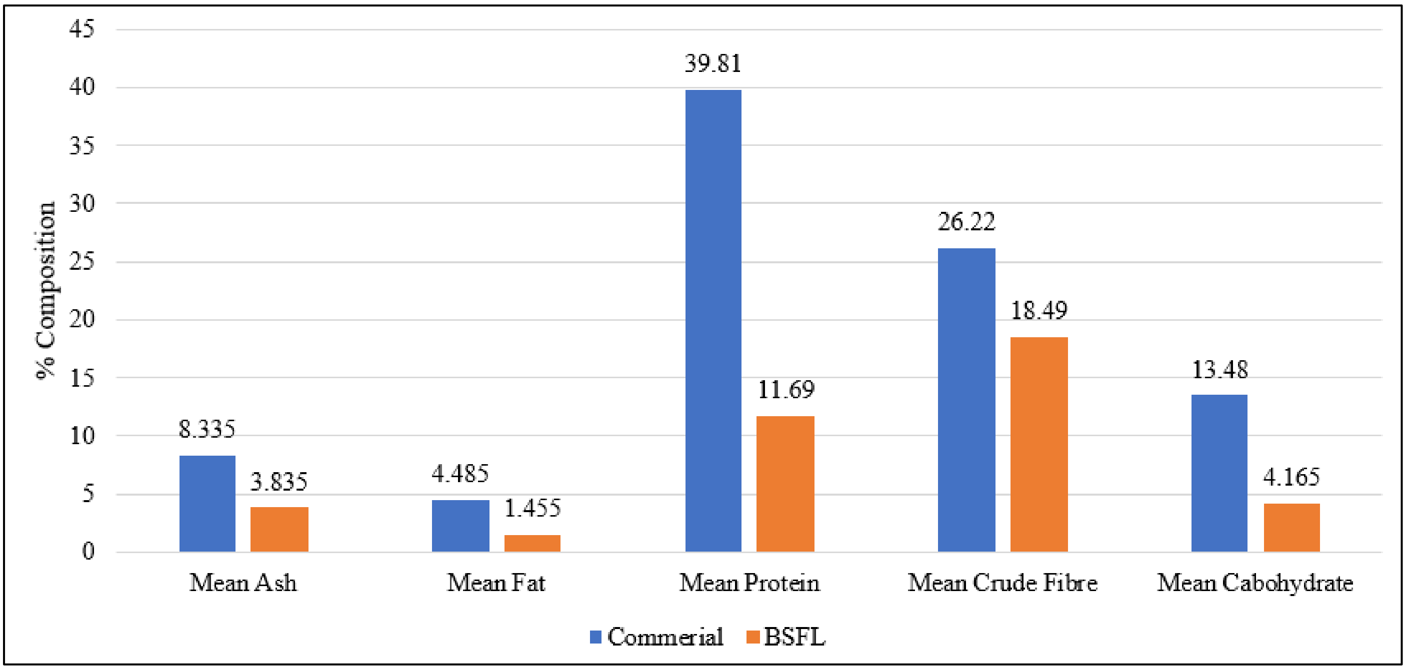

Fig 1: Proximate Composition of Commercial and BSFL Feeds

C. Proximate Composition of Fish Fed with Commercial and BSFL Feeds

Results of the proximate composition of fish fed with the combination of commercial and BSFL feeds are shown in Figures 2-6.

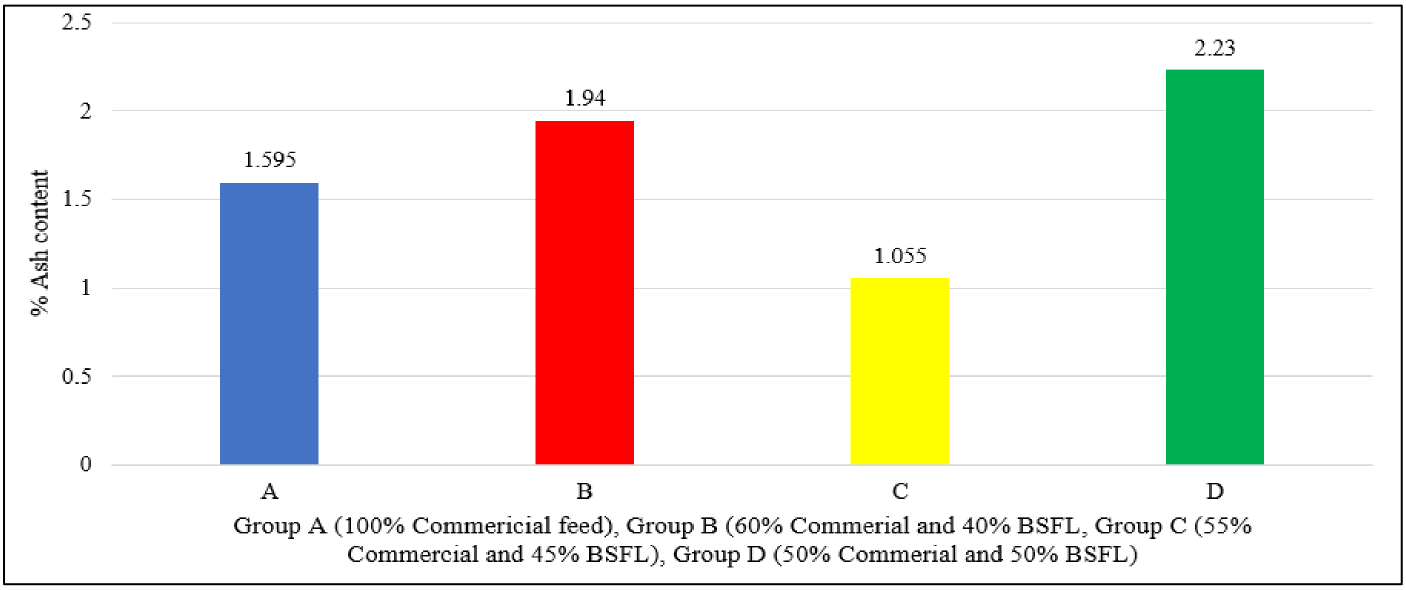

Fig 2: Mean Ash Content of Fish from Commercial and BSFL Feeds

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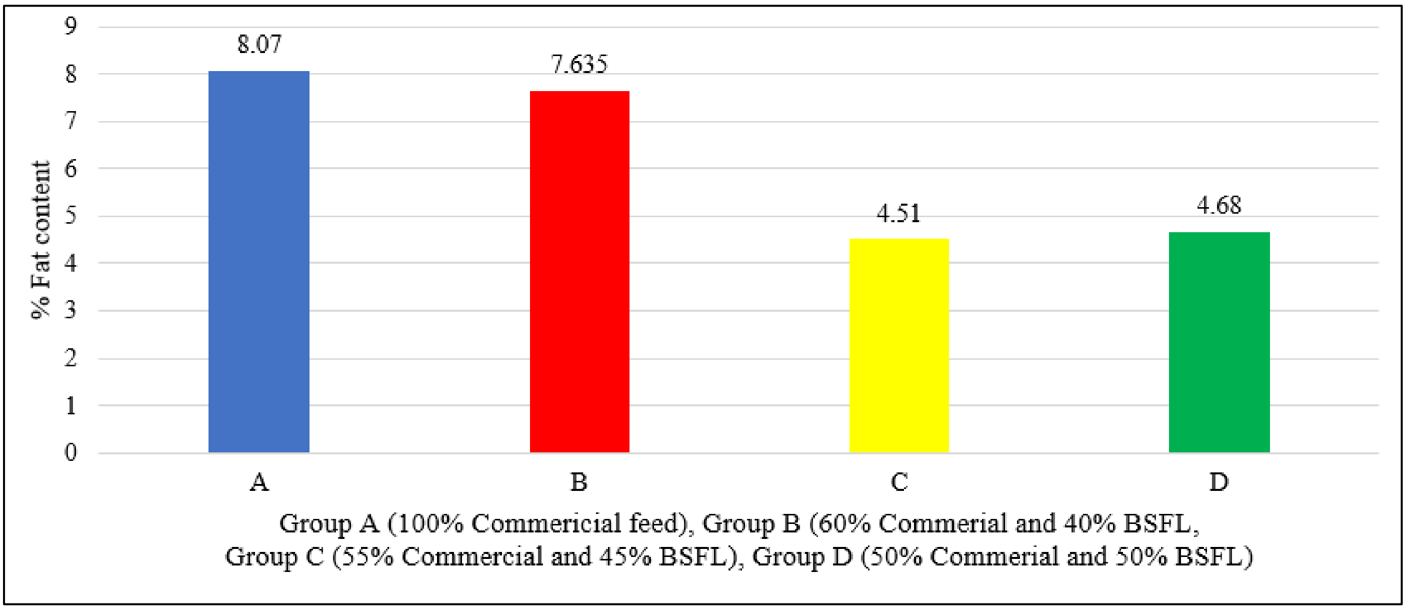

Fig 3: Mean Fat Content of Fish from Commercial and BSFL Feeds

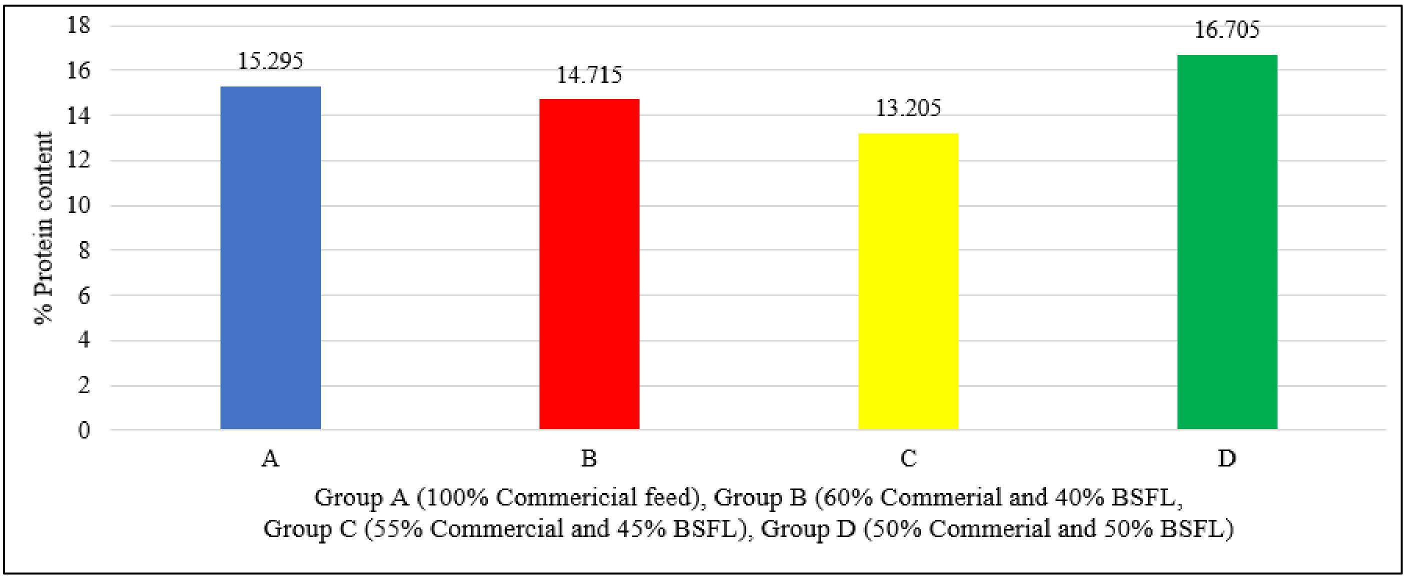

Fig 4: Mean Fat Content of Fish from Commercial and BSFL Feeds

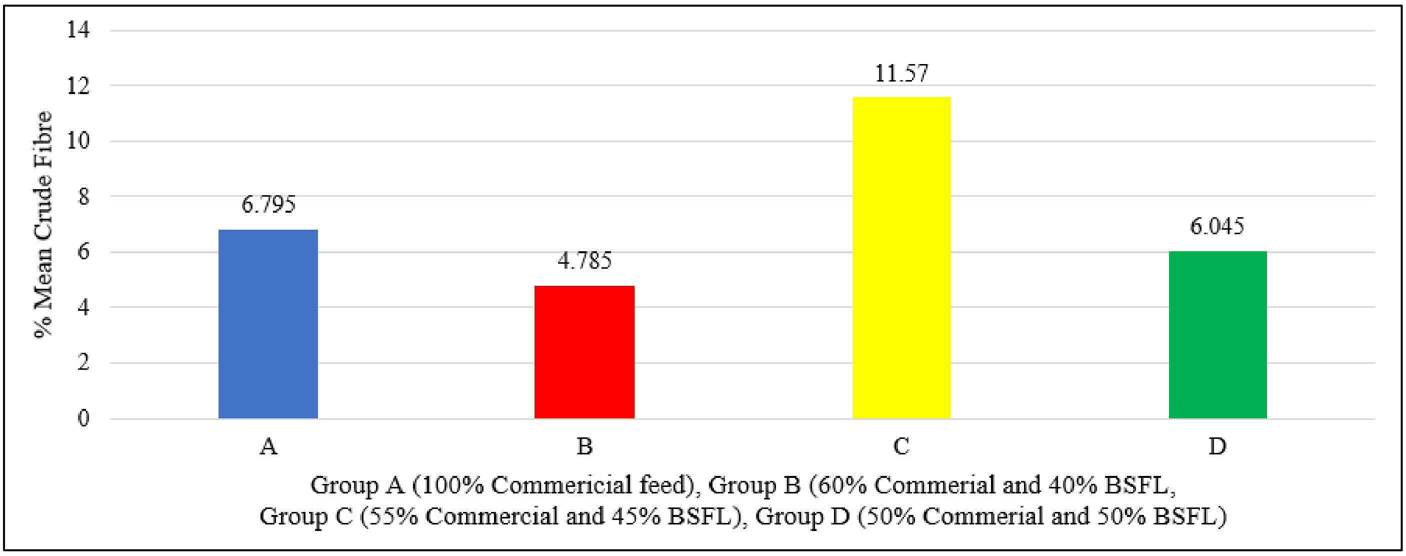

Fig 5: Mean Crude Fibre Content of Fish from Commercial and BSFL Feeds

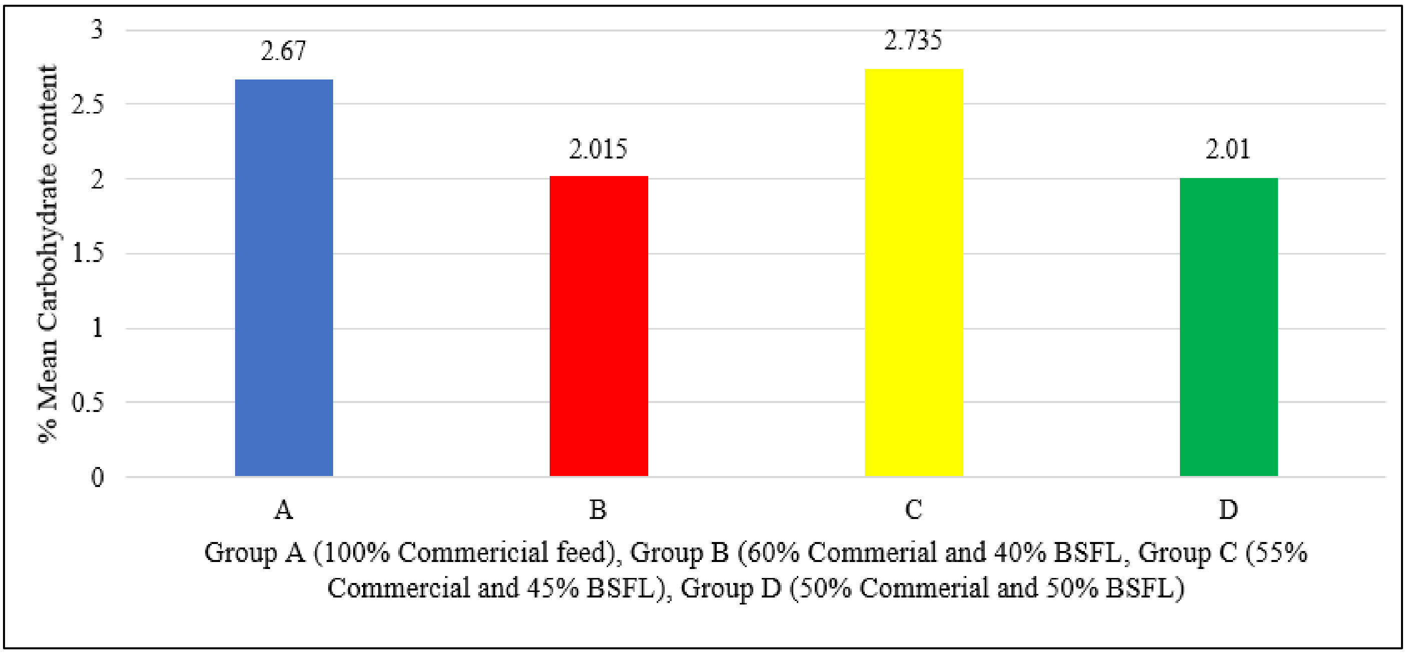

Fig 6: Mean Carbohydrate Content of Fish from Commercial and BSFL feeds

The above results showed no significant differences in weight with respect to all the field trial in groups A, B, C and D. (Table 3). Similarly, there were no significant differences in carbohydrate content with respect to all thre field trial in groups A, B, C and D. However, significant differences were recorded in ash p = 0.02, fat p = 0.000, protein p = 0.000 and crude fibre p = 0.000. Where these differences occurred, would be seen on Table 4. For value with *, the mean difference is significant at the 0.05 level.

Table 3: Analysis of Variance

		Sum of Squares	**df**	**Mean Square**	**F**	**Sig.**
Weight	Between Groups	2674.844	3	891.615	.022	.995
	Within Groups	158712.625	4	39678.156		
	Total	161387.469	7			
Moisture	Between Groups	17.478	3	5.826	144.167	.000
	Within Groups	.162	4	.040		
	Total	17.640	7			
Ash	Between Groups	.479	3	.160	44.667	.002
	Within Groups	.014	4	.004		
	Total	.493	7			
Fat	Between Groups	13.610	3	4.537	1531.346	.000
	Within Groups	.012	4	.003		
	Total	13.622	7			
Protein	Between Groups	29.693	3	9.898	65983.444	.000
	Within Groups	.001	4	.000		
	Total	29.693	7			
Crude_Fibre	Between Groups	12.911	3	4.304	28692.000	.000
	Within Groups	.001	4	.000		
	Total	12.912	7			
Carbonhydrates	Between Groups	.592	3	.197	3.961	.108
	Within Groups	.199	4	.050		
	Total	.791	7			

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Table 4: Multiple Comparisons Test

Bonferroni							
Dependent Variable	(I) Sample	(J) Sample	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Weight	1.00	2.00	38.00000	199.19377	1.000	-928.2906	1004.2906
		3.00	-7.75000	199.19377	1.000	-974.0406	958.5406
		4.00	-3.50000	199.19377	1.000	-969.7906	962.7906
	2.00	1.00	-38.00000	199.19377	1.000	-1004.2906	928.2906
		3.00	-45.75000	199.19377	1.000	-1012.0406	920.5406
		4.00	-41.50000	199.19377	1.000	-1007.7906	924.7906
	3.00	1.00	7.75000	199.19377	1.000	-958.5406	974.0406
		2.00	45.75000	199.19377	1.000	-920.5406	1012.0406
		4.00	4.25000	199.19377	1.000	-962.0406	970.5406
	4.00	1.00	3.50000	199.19377	1.000	-962.7906	969.7906
		2.00	41.50000	199.19377	1.000	-924.7906	1007.7906
		3.00	-4.25000	199.19377	1.000	-970.5406	962.0406
Moisture	1.00	2.00	-3.33500*	.20103	.000	-4.3102	-2.3598
		3.00	-.24500	.20103	1.000	-1.2202	.7302
		4.00	-2.75500*	.20103	.001	-3.7302	-1.7798
	2.00	1.00	3.33500*	.20103	.000	2.3598	4.3102
		3.00	3.09000*	.20103	.001	2.1148	4.0652
		4.00	.58000	.20103	.269	-.3952	1.5552
	3.00	1.00	.24500	.20103	1.000	-.7302	1.2202
		2.00	-3.09000*	.20103	.001	-4.0652	-2.1148
		4.00	-2.51000*	.20103	.001	-3.4852	-1.5348
	4.00	1.00	2.75500*	.20103	.001	1.7798	3.7302
		2.00	-.58000	.20103	.269	-1.5552	.3952
		3.00	2.51000*	.20103	.001	1.5348	3.4852
Ash	1.00	2.00	-.34500*	.05979	.027	-.6350	-.0550
		3.00	-.55000*	.05979	.005	-.8400	-.2600
		4.00	-.63500*	.05979	.003	-.9250	-.3450
	2.00	1.00	.34500*	.05979	.027	.0550	.6350
		3.00	-.20500	.05979	.159	-.4950	.0850
		4.00	-.29000	.05979	.050	-.5800	.0000
	3.00	1.00	.55000*	.05979	.005	.2600	.8400
		2.00	.20500	.05979	.159	-.0850	.4950
		4.00	-.08500	.05979	1.000	-.3750	.2050
	4.00	1.00	.63500*	.05979	.003	.3450	.9250
		2.00	.29000	.05979	.050	.0000	.5800
		3.00	.08500	.05979	1.000	-.2050	.3750
Fat	1.00	2.00	.43500*	.05443	.008	.1710	.6990
		3.00	1.30000*	.05443	.000	1.0360	1.5640
		4.00	3.39000*	.05443	.000	3.1260	3.6540
	2.00	1.00	-.43500*	.05443	.008	-.6990	-.1710
		3.00	.86500*	.05443	.001	.6010	1.1290
		4.00	2.95500*	.05443	.000	2.6910	3.2190
	3.00	1.00	-1.30000*	.05443	.000	-1.5640	-1.0360
		2.00	-.86500*	.05443	.001	-1.1290	-.6010
		4.00	2.09000*	.05443	.000	1.8260	2.3540
	4.00	1.00	-3.39000*	.05443	.000	-3.6540	-3.1260
		2.00	-2.95500*	.05443	.000	-3.2190	-2.6910
		3.00	-2.09000*	.05443	.000	-2.3540	-1.8260
Protein	1.00	2.00	.58000*	.01225	.000	.5206	.6394
		3.00	-4.40000*	.01225	.000	-4.4594	-4.3406
		4.00	-1.41000*	.01225	.000	-1.4694	-1.3506
	2.00	1.00	-.58000*	.01225	.000	-.6394	-.5206
		3.00	-4.98000*	.01225	.000	-5.0394	-4.9206
		4.00	-1.99000*	.01225	.000	-2.0494	-1.9306
	3.00	1.00	4.40000*	.01225	.000	4.3406	4.4594

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		2.00	4.98000*	.01225	.000	4.9206	5.0394
		4.00	2.99000*	.01225	.000	2.9306	3.0494
	4.00	1.00	1.41000*	.01225	.000	1.3506	1.4694
		2.00	1.99000*	.01225	.000	1.9306	2.0494
		3.00	-2.99000*	.01225	.000	-3.0494	-2.9306
Crude_Fibre	1.00	2.00	2.01000*	.01225	.000	1.9506	2.0694
		3.00	3.34000*	.01225	.000	3.2806	3.3994
		4.00	.75000*	.01225	.000	.6906	.8094
	2.00	1.00	-2.01000*	.01225	.000	-2.0694	-1.9506
		3.00	1.33000*	.01225	.000	1.2706	1.3894
		4.00	-1.26000*	.01225	.000	-1.3194	-1.2006
	3.00	1.00	-3.34000*	.01225	.000	-3.3994	-3.2806
		2.00	-1.33000*	.01225	.000	-1.3894	-1.2706
		4.00	-2.59000*	.01225	.000	-2.6494	-2.5306
	4.00	1.00	-.75000*	.01225	.000	-.8094	-.6906
		2.00	1.26000*	.01225	.000	1.2006	1.3194
		3.00	2.59000*	.01225	.000	2.5306	2.6494
Carbonhydrates	1.00	2.00	.65500	.22319	.256	-.4277	1.7377
		3.00	.54000	.22319	.437	-.5427	1.6227
		4.00	.66000	.22319	.250	-.4227	1.7427
	2.00	1.00	-.65500	.22319	.256	-1.7377	.4277
		3.00	-.11500	.22319	1.000	-1.1977	.9677
		4.00	.00500	.22319	1.000	-1.0777	1.0877
	3.00	1.00	-.54000	.22319	.437	-1.6227	.5427
		2.00	.11500	.22319	1.000	-.9677	1.1977
		4.00	.12000	.22319	1.000	-.9627	1.2027
	4.00	1.00	-.66000	.22319	.250	-1.7427	.4227
		2.00	-.00500	.22319	1.000	-1.0877	1.0777
		3.00	-.12000	.22319	1.000	-1.2027	.9627
*. The mean difference is significant at the 0.05 level.							

V. DISCUSSION

This study revealed mean weight gain of 780.3% for group A (commercial feed only), 732.8% for group B (60% commercial feed with 40% BSFL), 895.6% for group C (55% commercial feed with 45% BSFL) and 889.9% for group D (50% commercial feed with 50% BSFL). Growth rate revealed for group A (8.67%), group B (8.14%), group C (9.95%) and group D (9.88%). In addition, this study revealed ash content of 3.835%. This study contradicted an earlier study whose range of weight gain fell between 201.9% and 213%; the growth rate ranged from 1.70% to 1.75% and ash content of 11.80% [4]. The differences could be because the said experiments used different species of fish (Atlantic salmon).

In the case of proximate analysis of BSFL, this study recorded a lower mean ash content of 3.835% when compared with the commercial feed of 8.335%. The mean fat content in the commercial feed (4.485%) was higher than that of the BSFL (1.455%). Similarly, the mean protein content of commercial feed (39.81%) was higher than the one in BSFL (11.69%) while reported values of ash, fat and protein contents of 15%, 20%, and 40.27% respectively were higher compared to this study [6]. Furthermore, this study found the mean crude fibre and mean carbohydrate (26.22% and 13.48%) were all higher in commercial feed than in BSFL (18.49% and 4.165%) respectively. In the proximate analysis of fish, the ash content in fish in group D revealed the highest (2.23%), which was not in agreement with ash of 12.50% (50% BSFL and 50% fish meal) [6], closely followed by group B with 1.94%; group A with 1.595% while group C recorded the lowest with 1.055%. Furthermore, Group D protein content of 16.705% was equally not in agreement with 35.37% protein content from 50% BSFL with 50% fish meal [6]. The above results showed no significant difference in weight with respect to all the field trials. Similarly, no significant difference in carbohydrate content with respect to all three feed trials. However, significant differences were recorded in ash $p = 0.02$, fat $p = 0.000$, protein $p = 0.000$ and crude fibre $p = 0.000$.

VI. CONCLUSION AND RECOMMENDATION

This study considered proximate parameters of commercial feed with that of BSFL and found all the parameters' values of the commercial feed were higher than those for BSFL. However, in comparison with fish growth performance, no significant weight gain was found between using commercial feed only and the combination of commercial with BSFL at 45-50% inclusion level. Also, we found that the performance of fish with respect to weight gain in using BSFL depends on the fish species.

It is therefore recommended that BSFL of up to 50% can be substituted for fish meal to feed the African catfish from melange to table size.

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