Original Research Article

Some Physiological Parameters of African Catfish,Clariasgariepinus (BURCHELLS, 1822) Juveniles fed Composite Insect Meal and Phyto-additives in Cage Culture System

ABSTRACT

A 70 days experiment was conducted to examine the effect of fishmeal substitution with defatted African palm weevil larvae supplemented with phyto-additives on the growth performance and nutrient utilization of *Clarias gariepinus*juveniles. Seven diets were formulated containing 45% crude protein: control diet was formulated using fishmeal as the principal protein source, three individual diets were prepared using 17% each of fish meal and defatted African palm weevil larvae supplemented with *Telfaria occidentalis, Corchorus olitorious* and *Cymbopogon citratus* as phyto-additives. Another three individual diets were prepared using 17% each of fish meal and defatted African palm weevil larvae supplemented with a mixture of *Telfaria occidentalis* and *Corchorus olitorious*, Telfaria occidentalis and *Cymbopogoncitratus*, and *Corchorus olitorious* and *Cymbopogon citratus* as phyto-additives making it a total of seven diets. A total of 450 juveniles of African catfish (Clarias gariepinus) was used for the experiment and distributed into 21 baskets embedded in a pond each containing 20(7.50±0.00-7.53±0.00 g/fish) fish. At the end of the feeding trial, the mean weight gain was significantly different (P>0.05) across the fish fed experimental diets. The fish fed with African palm weevil and *Telfaria occidentalis* as phyto-additives recorded the highest mean weight gain(95.66±25.64) percentage weight gain(91.77±2.14) compared to the other groups. The nutrient utilization indices such as feed conversion ratio, feed efficiency ratio were found to be better in fish fed African palm weevil compared with the CONTROL group. A significantly higher whole-body protein was recorded in fish fed African palm weevil and phyto-additives. From this study, it was concluded that processed African palm weevil larvae with phyto-additives can effectively replace fishmeal in the diet of *Clarias gariepinus*juveniles.

KEYWORDS: African catfish; African palm weevil larvae; Phyto-additives; Growth and nutrient utilization

INTRODUCTION

Fish is vital to humans due to its high quality protein as well as the essential amino acids required by the body for growth and maintenance of muscle tissue. Fish is a common protein source globally, with Nigeria leading in its consumption in the African continent (Bradley *et al*., 2020). African catfish is an economically important fish species extensively cultured in various parts of the world especially in the tropics due to its ability to accepta wide variety of feed, breed in captivity, grow fast, tolerate high stocking density and resist common diseases (Musa *et al*., 2021). Fishmeal is a major component of commercial fish feeds

(Allam *et al*., 2020). Aquaculture relies heavily on the consistent supply of fish feed. Fish feed accounts for more than half of the operating costs in intensive fish farming systems (Abdel-Latif *et al*., 2022). In intensive fish farming, improving profits requires access to cheap and sustainable feed ingredients that maintain the growth and welfare of the fish (Allam *et al.*, 2020). The conventional use of fishmeal has led to an increase in demand and subsequently in the price. Scarcity of fishmeal has led to the search for cheap, sustainable and locally available protein sources as alternatives. Extensive efforts are being made to search for alternative protein sources to minimize dependency on the scarce and costly fishmeal that would provide adequate nutrition for fish growth. In order to make a balanced fish protein diet, the ingredients to be used should be sustainable, affordable and locally available. Ingredients such as insect meal and plant proteins should be included in the Diet or substituted for expensive animals and plant protein sources (Adeparusi and Agbede, 2005). Insects are the most diverse group of animals, and a natural food source for fish, especially for carnivorous and omnivorous fish, as these fish species need relatively high amounts of protein in their diets (Van Huis, 2020). Insect meals nutritional components are similar to fish meal. Insect culture is considered sustainable as insects do not need large areas or much water and they contribute to waste recycling.

The African palm weevil, *Rhychophorusphoenicis*, known as edible worm is a species of beetles belonging to the family *Curculionidae*. It is distributed throughout tropical Africa and its plant hosts are mainly oil palm (*Elaeisguineensis* Jacq), date palm (*Phoenix dactylifera*), raffia palm (*Raphia*spp) and coconut palm (*Cocos nucifera*) (Bong *et al*., 2008). The nutritional composition of Africa palm weevil (*Rhychophorusphoenicis*) shows that it has a protein content ranging between 32-66% (Alamu *et al.*, 2013).The study of Agbanimu and Adeparusi (2020) and Fakayode and Ugwumba (2013) showed that African palm weevil can be used to replace the diet of Clariidae at 25% inclusion level.

The need for plant protein in fish feed is essential because it is sustainable, available and affordable. The search for protein-rich plant source is an ongoing process, leaf meal inclusion in fish feed is fast gaining global attention over the years due to its availability, protein and mineral/vitamin contents and economic feasibility (Ali et al., 2003). Phyto-additives has been used in fish as immunomodulators, immunostimulants, antioxidants, antimicrobials (Gabor *et al*., 2010). Thus the essence of this study is to use African palm weevil larvae at lower inclusion level(17%) with some phyto-additives as (growth promoters) in the diet of *Clarias gariepinus* thereby reducing associated cost of production of using African palm weevil at higher inclusion level. Hence the need for this study.

MATERIALS AND METHOD

Study Area

The study was carried out at the Teaching and Research farm of the Department of Fisheries and Aquaculture Technology, Akure, Ondo state, Nigeria.

Samples Collection

African palm weevil larvae (*Rhynchophorusphoenicis*) were obtained from Igbokoda, Ondo state. The larvae was rinsed thoroughly with water to remove dirts and it was oven dried at 80^{O}C for 19-20hours as recommended by Banjo *et al*., (2006). Freshly collected Ugwu leaf (*Telfairia occidentalis*), Jute leaf (*Corchorus olitorius*) and Lemon grass leaf (*Cymbopogon citratus*) was gotten from markets within Akure metropolis and taken to the Crop Soil and Pest Department for proper Identification. Leaves from the stems of this plants were plucked out of their stem and air-dried at room temperature. They were milled separately into a fine powder using Binatone electric blender (Model BLG 402) and sieved to obtain a fine powder. It was stored in a Ziploc bag and stored at room temperature prior to its usage for feed formulation.

Preparation of Experimental Diets

Seven iso-nitrogenous diets were formulated to contain 45% crude protein with single and composite phyto-additives as Diet A, Diet B, Diet C, Diet AB, Diet AC and Diet BC with the CONTROL diet containing fishmeal using trial and error method. The feed ingrediets include Palm weevil larvae, fishmeal, soyabean meal, groundnut cake, yellow maize, cassava flour(as binder), Vitamin-mineral premix, Vitamin C, bone meal, groundnut oil, lysine, methionine, dicalcium phosphate, baker’s yeast and phyto-additives(Table 1). Each of the listed ingredients was weighed and poured in a plastic container and thoroughly mixed together to obtain a homogenous mixture, this mixture was extruded using an extruder (Henan Lima Machinery Manufacture Co. Ltd.) with a 2mm die

Table 1: Ingredients composition of the Experimental Diets (g/100g) for *Clarias gariepinus*

Ingredients	Control	Diet A	Diet B	Diet C	Diet AB	Diet AC	Diet BC
Fishmeal(72%)	34	17	17	17	17	17	17
Palm weevil(65%)	0	17	17	17	17	17	17
Soybean(42%)	20	20	20	20	20	20	20
Groundnut cake(45%)	20	20	20	20	20	20	20
Yellow maize(10%)	11	11	11	11	11	11	11
Cassava flour	3	3	3	3	3	3	3
Yeast(48%)	5	5	5	5	5	5	5
Dicalcium phosphate	1	0.5	0.5	0.5	0.5	0.5	0.5
Lysine	1	1	1	1	1	1	1
Methionine	1	1	1	1	1	1	1
Vitamin-mineral premix	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Vitamin C	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Bone meal	1	1	1	1	1	1	1
Groundnut oil	2	2	2	2	2	2	2
Phyto-additives	0	0.5	0.5	0.5	0.5	0.5	0.5
Total	100	100	100	100	100	100	100
FEED PROXIMATE COMPOSITION (%)							
Moisture Content	7.65	7.52	7.29	7.81	7.28	7.96	7.22
Crude protein	44.83	45.05	44.12	44.89	45.37	44.75	44.85
Crude lipid	5.56	4.90	5.42	5.61	5.74	5.57	5.29
Crude fibre	10.66	10.69	10.45	10.88	10.95	10.86	10.95
Ash	12.02	12.19	12.47	12.56	12.12	12.36	12.23
NFE	18.97	19.58	19.23	18.24	18.52	18.45	18.83

Premix: Vitamin A; 10,000,000.00I.U, Vitamin D3; 2,000,000.00 I.U, Vitamins E; 23.000.00mg, Vitamin K3; 2,000.00mg, Vitamin B1; 3,000.00mg, Vitamins B2; 6,000.00mg, Niacin; 50,000.00mg, Calcium Pantothenate; 10,000.00; Vitamin B6; 5,000.00mg, Vitamin B12; 25.00mg; Folic Acid; 1,000,00mg, Biotin; 50.00mg, Choline Chloride; 400,000.00mg, Manganese; 120,000.00mg, Iron; 100,000.00mg, Zinc; 80,000.00mg, Iodine; 1,500.00mg, Cobalt; 300.00mg, Selenium; 120.00mg, Anti-oxidant; 120,000.00mg.(Source: Chemiconsult International Limited, Ikeji, Lagos, Nigeria). Recommended Inclusion Rate is 2.5kg per tonne of final feed. NFE: Nitrogen Free Extract

Diet A: *Telfairia occidentalis*, Diet B:*Corchorus olitorius*Diet C: *Cymbopogon citratus*, Diet AB:*Telfairia occidentalis* and *Corchorus olitorius*Diet BC: *Corchorus olitorius*and*Cymbopogon citratus* Diet AC:*Telfairia occidentalis* and *Cymbopogon citratus

Experimental Setup

Completely Randomized Design (CRD) was used for the study. Four hundred and fifty *Clarias gariepinus* juveniles (average mean weight 7.50±0.00-7.53±0.00) was obtained from the teaching and Research Farm of the Department of Fisheries and Aquaculture Technology, Federal University of Technology, Akure, Ondo State. These obtained fish was acclimatized for 14 days and fed with 2mm commercial feed twice a day before the experiment was commenced properly. Fish was starved for 24hours prior to being placed on experimental diets. Twenty-one circular baskets with a dimension of (49.00x71.50) cm^2 was covered with a mesh net and each of the baskets was placed in the pond. Three baskets per experimental diet represented replicates for each experimental diet. Twenty *Clarias gariepinus* juveniles was kept in each of the twenty-one baskets and fed to satiation twice daily between 08:00-09:00GMT and 16:00-17:00GMT hours for a period of 70days. The water quality variables were observed fortnightly (pH 7.01±0.05 -7.30±0.03, dissolved oxygen 4.05±0.05-5.15±0.05mg/L, and temperature 25.55^{O}C±0.05 - 26.70^{O}C±0.10.)

Growth Indices

Weighing of the fish was done using an electric weighing balance (Model no: XY15KMB) before the experiment commenced and fortnightly during the period of the experiment to adjust feeding level. Also at the end of the experiment, individual weights of all surviving fish from all the groups was weighed to obtain their final mean weight after evacuation of feed by starving for 24hours.

Calculations.

The formulas below were used for the evaluation of growth performance and nutrient utilization among experimental groups.

$$Weight\ gain\ (WG) = Final\ body\ weight - Initial\ body\ weight$$

$$Percentage\ weight\ gain = \frac{Weight\ gain}{Final\ body\ weight}\ X\ 100$$

$$Specific\ Growth\ Rate\ (SGR) = \frac{In\ final\ body\ weight - In\ initial\ body\ weight}{Duration\ of\ feeding}\ X\ 100$$

$$Feed\ Intake\ (FI) = Total\ amount\ of\ feed\ given\ (g)\ X\ number\ of\ days$$

$$Feed\ Conversion\ Ratio\ (FCR) = \frac{Feed\ intake}{Weight\ gain}$$

$$Feed\ Efficiency\ Ratio = \frac{Weight\ gain}{Feed\ Intake}$$

$$Protein\ Efficiency\ Ratio\ (PER) = \frac{Weight\ of\ fish}{Protein\ fed}$$

$$Protein\ Intake = Feed\ intake\ \ X\ \ \%crude\ protein\ in\ diet$$

$$Survival\ \% = \frac{Number\ of\ fish\ at\ the\ end\ of\ the\ experiment}{Number\ of\ fish\ at\ the\ start\ of\ the\ experiment}\ X\ 100$$

Proximate analysis and Statistical analysis

Proximate analysis of the diets and experimental fish was done using the methods described by the Association of Official Analytical Chemist (AOAC, 2000). All data collected were checked for normality using one-way analysis of variance (ANOVA) and homogeneity of variance using Levene's test to test for significant difference in the means using Statistical Package for Social Sciences (SPSS 22.0 for windows). The means was separated using Duncan's multiple range test where there is significant difference. Mean difference was considered statistically significant with a 95% confidence level and all data was presented as means ± standard errors.

RESULTS

Proximate composition of whole body of *Clarias gariepinus* juveniles fed experimental diets

The result of the proximate composition of the whole body of *Clarias gariepinus* fed experimental diets is presented in Table 1. The crude protein, ash, moisture content, nitrogen free extract and lipid was significantly different (p<0.05). The highest moisture content was recorded in the control and the lowest in the diet B (6.79±0.07-5.08±0.04). The highest ash content was recorded in Diet B and the lowest in the control (13.19±0.04-12.20±0.08). The highest value of crude lipid was recorded in the diet C and the lowest was recorded in diet AC (14.27±0.54-9.52±0.23). The crude protein ranged between 58.69±1.09 to 65.01±0.03, with the highest value of (65.01±0.03) in diet AB and the lowest value of (58.69±1.09) was recorded in the control, the nitrogen free extract (NFE) were between (2.42±0.36-11.64±0.94).

Growth Performance, nutrient utilization and Survival of *Clarias gariepinus* fed Experimental Diets

The growth performance mutrient utilization and survival of *Clarias gariepinus* fed experimental diets are presented in table 2. Mean weight gain, Final weight gain, specific growth rate and survival were significantly different (p<0.05) amongst the diets. The initial mean weight of juveniles ranged between 7.50±0.00-7.53±0.00, and no significant difference (p>0.05) was observed in the initial weight. Final mean weight (FMW) ranged between 63.05±17.90 and 98.31±25.64, the highest weight gain was observed in diet A (98.31±25.64) and the lowest was observed in the control (63.05±17.90). Mean weight gain (MWG) ranged between 55.53±17.91 and 90.78±25.63, the highest weight gain was observed in diet A (90.78±25.63) and the lowest was observed in the control (55.53±17.91). Specific growth rate (SGR) recorded ranged between 2.97±0.42 and 3.61±0.38, diet A had the highest SGR (3.61±0.38) and control had the lowest SGR (2.97±0.42). Percentage weight gain ranged between 87.03±3.70 and 91.77±2.14, diet A recorded the highest PWG (91.77±2.14) while lower PWG (87.03±3.70) was recorded in the control. Survival amongst the diet were significantly different (p<0.05), the highest was recorded in diet AB (92.50±2.50) and the lowest was recorded in the control (65.00±5.00). The nutrient utilization parameters (Feed Intake, Protein intake, Feed Conversion Ratio, Feed Efficiency Ratio and Protein Efficiency Ratio) of *Clarias gariepinus* fed experimental diets are presented in table 2. There was significant difference (p<0.05) among the different treatments in Feed Intake, Feed Conversion Ratio, Feed Efficiency Ratio and Protein intake. Diet A has the highest Feed Intake and Protein Intake (98.48±18.96 and 43.57±7.58) respectively while the lowest value of Feed Intake and Protein intake was recorded in diet AB (75.65±2.10 and 34.04±0.84) respectively. The FCR recorded indicated that diet AC and diet BC has the lowest value (1.11±0.01) and highest value in the control (1.83±0.68). The FER recorded shows highest values in diet AC and BC (0.90±0.01 and 0.90±0.02) and lowest value in the control (0.63±0.24). The PER recorded indicated that diet A (1.82±0.23) and diet BC (1.82±0.06) has the highest value and the control recorded the lowest value (1.32±0.50).

Table 2: Proximate composition of whole body of *Clarias gariepinus* juveniles fed experimental diets

Composition (%)	Dietary Treatment						
	CONTROL	A	B	C	AB	AC	BC
MoistureContent	6.79±0.07^{d}	5.97±0.03^{ab}	5.08±0.04^{a}	6.20±0.05^{bc}	5.90±0.03^{a}	6.66±0.05^{d}	6.21±0.13^{c}
Crude protein	58.69±1.09^{a}	64.00±0.71^{de}	64.97±0.30^{e}	59.81±0.45^{ab}	65.01±0.03^{e}	60.92±0.74^{bc}	62.83±0.01^{cd}
Crude lipid	10.67±0.15^{ab}	13.81±0.44^{d}	13.02±0.50^{cd}	14.27±0.54^{d}	13.57±0.39^{d}	9.52±0.23^{a}	11.83±0.62^{bc}
Ash	12.20±0.08^{a}	13.02±0.03^{cd}	13.19±0.04^{d}	12.80±0.05^{bc}	13.09±0.03^{d}	12.33±0.05^{a}	12.78±0.13^{b}
NFE	11.64±0.94^{c}	3.18±0.27^{a}	3.00±0.20^{a}	6.92±0.99^{b}	2.42±0.36^{a}	10.56±0.52^{c}	6.34±0.63^{b}

Means in a given row with the same superscript letter were not significantly different at $p<0.05$ NFE = Nitrogen free extract

Table 3: Growth Performance, nutrient utilization and Survival of *Clarias gariepinus* fed Experimental Diets

Parameters	CONTROL	A	B	C	AB	AC	BC
IMW (g)	7.51±0.01^{a}	7.53±0.00^{a}	7.52±0.02^{a}	7.50±0.00^{a}	7.53±0.00^{a}	7.50±0.00^{a}	7.52±0.01^{a}
FMW (g)	63.05±17.90^{a}	95.66±25.64^{c}	83.37±5.35^{bc}	74.14±4.21^{ab}	65.66±1.90^{a}	81.54±0.87^{bc}	87.25±9.00^{bc}
MWG (g)	55.53±17.91^{a}	88.17±25.63^{c}	75.85±5.34^{bc}	66.64±4.21^{ab}	58.12±1.91^{a}	74.03±0.86^{bc}	79.73±9.00^{bc}
PWG (%)	87.03±3.70^{a}	91.77±2.14^{b}	90.94±0.56^{b}	89.84±0.57^{ab}	88.51±0.344^{a}	90.79±0.09^{b}	91.29±0.90^{b}
SGR(g/day)	2.97±0.42^{a}	3.61±0.38^{c}	3.43±0.09^{bc}	3.27±0.08^{ab}	3.09±0.04^{a}	3.40±0.01^{ab}	3.50±0.14^{bc}
PER	1.32±0.50^{a}	1.82±0.23^{c}	1.80±0.07^{bc}	1.67±0.09^{b}	1.70±0.01^{b}	1.81±0.02^{bc}	1.82±0.06^{c}
PI	42.10±0.69^{ab}	43.57±7.58^{b}	42.13±1.41^{ab}	40.34±3.93^{ab}	34.04±0.84^{a}	40.43±0.09^{ab}	43.54±3.33^{b}
FI (g)	93.57±1.74^{b}	98.48±18.96^{ab}	93.62±3.53^{b}	89.09±9.83^{ab}	75.65±2.10^{a}	90.61±0.21^{ab}	96.76±8.33^{bc}
FCR	1.83±0.68^{b}	1.13±0.10^{a}	1.12±0.03^{a}	1.20±0.06^{ab}	1.15±0.00^{ab}	1.11±0.01^{a}	1.11±0.01^{a}
FER	0.63±0.24^{a}	0.89±0.08^{bc}	0.89±0.02^{bc}	0.84±0.05^{b}	0.87±0.00^{b}	0.90±0.01^{c}	0.90±0.02^{c}
S	65.00±5.00^{a}	72.50±7.50^{a}	90.00±0.00^{b}	75.00±0.00^{ab}	92.50±2.50^{c}	87.50±2.50^{bc}	75.00±0.00^{ab}

Means in a given row with the same superscript letter were not significantly different at $p<0.05$. IMW= Initial mean weight, FMW= final mean weight, MWG= Mean weight gain, PWG= Percentage weight gain, SGR= Specific growth rate

DISCUSSION

In 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 Control group. This observation shows that the inclusion of insect meal and phyto addictive 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, moisture content, crude lipid, NFE, crude fibre and ash contents differ significantly among all the fish fed the experimental diets ($P<0.05$). The increase in carcass lipid content with the inclusion of insect meal was in line with the findings of Mathis *et al.* (2003) and Xu *et al.* (2001), who reported that lipid content tends to show more significant fluctuations than other carcass components. This result further demonstrates that protein synthesis and increased tissue production in *C. gariepinus* occurred which resulted in growth. The chemical composition of fish carcass reflects quality of feed which eventually affects the final quality of the product, and its processing properties.

Also the experimental fish within all the treatments showed great increase in weight, which indicates that the fishes were able to convert feed protein to extra muscles. Weight gain and species growth rate are usually considered as the most important measurement of productivity of Diets (Adesina *et al*., 2013).The result of the current study showed an increase in the body weight of the experimental fish. This is similar to the observation made by Agbanimu and Adeparusi, (2020) when *Clarias gariepinus* juveniles was fed insect (Palm Weevils) meal. This experiment showed that there was a general increase in weight gain in all the treatment which indicates that the experimental fish were able to convert feed protein to flesh. It also indicates 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. It was observed from the study that the mean weight gain of the fish showed that fish fed diet A, B, C, AB, AC and BC had significant difference ($P<0.05$) with the value of 90.78±25.63, 75.85±5.34, 66.64±4.21, 58.12±1.91, 74.03±0.86 and 79.73±9.00 respectively. In the present study, the fish fed Diet A showed better growth performance compared to the control diet and other experimental diets. At the end of the feeding trial, all the experimental fish were found to be in good condition in terms of their feed intake, although acceptability varied significantly among the experimental fishes. This indicates that the experimental meals were well utilized by the fish, resulting in excellent performance among all the growth and nutrient utilization indicators measured.

In the present study, growth and nutrient utilization parameters were observed to be high in Diets AB, AC and BC. This could be attributed to the synergy of various dietary protein sources used and this also is in line with the findings of Ugwumba*et al.*, 2001; Sogbesan*et al.*, 2005; Sogbesan and Ugwumba, 2006a; 2006b. The protein composition of the insect and fish meal in combination with the phyto-additive used could have boosted the growth of experimental fish. Furthermore, it was observed that the inclusion of insect meal and phyto-additive 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.

Feed utilization expressed as FCR is known to be affected by body weight, ration size and temperature (Keremah and Beregha, 2014). The feed conversion ratio of Diet A, B, C, AB, AC and BC obtained are lower in comparison with the control, this is an indication that the Diets (A, B, C, AB, AC and BC) is of better quality than the control. This finding corroborates with that of Olele*et al.* (2013) who stated that lower food conversion ratio indicates higher protein conversion efficiency thereby resulting in better growth. Adikwu (2003) documented that the lower the FCR, the better the feed utilization by the fish. The lowest FCR of fish obtained in this present study indicated better feed utilization by the fish and this obviously accounted for better growth performance of *C. gariepinus* Diet A, B, C, AB, AC and BC.

Protein Efficiency Ratio (PER) is known to be regulated by the non-protein energy input of the Diet and is a good measure of the protein-sparing effect of lipid and/or carbohydrate (Tibbets *et al.,* 2005). The

PER of the experimental fish obtained in this study exhibited significant differences p≤0.05 in all treatments. Similar observations were made by Sotolu (2008). The significant difference p≤0.05 in PER value obtained in Diet A, B, C, AB, AC and BC indicated maximum utilization of inherent nutrients in the Diet.

CONCLUSION

In this study, it was observed that water quality parameters during the period of the experiment were within the recommended range and has no negative effect on the growth of *Clarias gariepinus*juveniles. The carcass composition of the fish (crude protein, lipid, moisture, ash and nitrogen free extract) were within the range for *Clarias gariepinus*. It was established that feeding *Clarias gariepinus* with processed African palm weevil with phyto-additives is a good substitute for fish meal.

The growth performance and survival indicated that the fish fed diet containing African palm weevil meal and phyto-additives had the best performance compared to the CONTROL group fed fishmeal. The highest growth indices was recorded in Diet A among the experimental groups. This shows that the diet has good nutritional value without negatively affecting the nutritional profile of the fish.

REFERENCES

Abdel-Latif, H. M. R., Soliman, A. A., Khaled, A. A., Kord, M., Abdel-Tawwab, M., Darwish, S., Grana, Y.S., Zaki, M., Nour, A., Ali, E., Khalil, R. H. and Khalil, H. S., (2022). Growth performance, antioxidant activities, and immunological responses of hapa-reared thin lip mullet (Liza ramada) juveniles fed on diets supplemented with spirulina (*Arthrospira platensis*). *Fish Shellfish Immunology*.

Adeparusi, E. O. and Agbede, J. O. (2005). Evaluation of leucaena and gliricidia leaf protein concentrate as supplements to Bambara groundnut (Vignas subterranean (l. verdc) in the Diet of *Oreochromis niloticus*. Aquaculture Nutrition, 12(2): 335 - 342.s

Adesina, S. A, Falaye, A. E, Olusola, S.E. and Ajani, E. K. (2013). Growth performance and nutrient utilisation of Clarias gariepinus juveniles fed graded levels of boiled sunflower (Helianthus annus L) seed meal-based Diets. Wudpecker*Journal of Agricultural Research*, (12): 342 – 351.

Adikwu, I.A. (2003). A review of aquaculture nutritional in aquaculture development in Nigeria. In: Proceeding of the Joint Fisheries Society of Nigeria, National Institute for Freshwater Fisheries Research, FAO-National Special Programme for Food Security and National Workshop on Fish Feed Development and Feeding Practices in Aquaculture held at National Institute for Freshwater Fisheries

Research, New-Bussa. (Eyo, A. A. Ed): 34 – 42.

Agbanimu, A.B and Adeparusi, E.O (2020). Growth Performance and Nutrient Utilization of African Catfish (Clarias gariepinus) Juveniles Fed Varying Inclusions of Defatted African Palm Weevils (Rhynchophorusphoenicis) Meal. *Aquaculture Studies*, 20(2), 73-79

Alegbeleye, W. O., Obasa, S. O., Olude, O. O., Otubu, K. and Jimoh, W., (2012). Preliminary evaluation of the nutritive value of the variegated grasshopper (Zonocerus variegatus L.) for African catfish Clarias gariepinus (Burchell. 1822) fingerlings. Aquaculture Research, 43(3): 412-420

Ali, A., Al-Asgah, N.A., Al-Ogaily, S.M. and Ali, S. (2003). Effect of feeding different levels of Alfalfa meal on the growth performance and body composition of Nile Tilapia (*Oreochromis niloticus*) fingerlings. Asian Fisheries Sciences, 16: 59-67.

Allam, B. W., Khalil, H. S., Mansour, A. T., Srour, T. M., Omar, E. A. and Nour, A. M. (2020). Impact of substitution of fish meal by high protein distillers dried grains on growth performance, plasma protein and economic benefit of striped catfish (*Pangasianodonhypophthalmus*). Aquaculture 517, 734792.

Allam, B. W., Khalil, H. S., Mansour, A. T., Srour, T. M., Omar, E. A. and Nour, A. M. (2020). Impact of substitution of fish meal by high protein distillers dried grains on growth performance, plasma protein and economic benefit of striped catfish (*Pangasianodonhypophthalmus*). Aquaculture 517, 734792.

AOAC (2000). Association of Official Analytical Chemists. Official Methods of Analysis, (17th ed.) Gaithersburg,MD, USA.

Banjo, A.D., Lawa, O.A. and Songonuga, E.A. (2006). The Nutritional Value of Fifteen Species of Edible Insects in Southwestern Nigeria. *African Journal of Biotechnology*, 5: 298-301.

Bong C. J., ER C YIU P., RAJAN A., 2008., Growth performance of red stripe weevil Rhynchophorusschach Olive.(Insecta: Coleptera: Curculiondae) on meridic diets. American *Journal of Agriculture and Biological Sciences*, 3(1): 403-409

Bradley, B., Byrd, K. A. and Atkins, M. (2020). Fish in food systems in Nigeria: A review. Penang, Malaysia: WorldFish. Program Report: 2020-06

Devic, E., Leschen, W., Murray, F., and Little, D. C. (2018). Growth performance, feed utilization, and body composition of advanced nursing Nile tilapia (*Oreochromis niloticus*) fed diets containing Black Soldier Fly (*Hermetiaillucens*) larvae meal. *Aquaculture Nutrition*, 24(1): 416–423.

Gabor E.F., Sara, A., Barbu A. (2010): The effects of some Phyto-additives on growth, health and meat quality on different species of fish. Scientific Papers: *Animal Sciences and Biotechnologies* 43(1): 61-65

Keremah, R. I. and Beregha, O. (2014).Effect of Varying Dietary Protein Levels on Growth and Nutrient Utilization of African Catfish Clarias gariepinus Fingerlings *Journal of Experimental Biology and Agricultural Sciences*, 2(1): 13-18.

Kroeckel, S., Harjes, A.-G. E., Roth, I., Katz, H., Wuertz, S., Susenbeth, A., and Schulz, C. (2012). When a turbot catches a fly: Evaluation of a pre-pupae meal of the Black Soldier Fly (*Hermetiaillucens*) as fish meal substitute – Growth performance and chitin degradation in juvenile turbot (*Psetta maxima*). *Aquaculture*, 345–365.

Mathis, N., Feidt, C., and Brun-Bellut, J. (2003). Influence of protein/energy ratio on carcass quality during the growing period of Eurasian perch (Percafluviatilis). *Aquaculture*, 217(1–4): 453–464.

Musa, B. O., Hernández- Flores, A., Adeogun, O. A. and Oresegun, A. (2021). Determination of a predictive growth model for cultivated African catfish Clarias gariepinus (Burchell, 1882). *Aquaculture Research*, *52*(9), 4434-4444.

Olele, N.F., Onyema, M. I, and Odiko, A.E., (2013). Growth Performance, Survival Rate and Nutrient Profile of Clarias gariepinus Fingerlings Fed Rations of Soybean as Alternative Protein Source *Academic Journal of Interdisciplinary Studies*, 2(10):58-66.

Sogbesan, O. A., Ajuonu, N. D., Ugwumba, A. A. A. and Madu, C. T. (2005). Cost benefits of maggot meal as supplemented feed in the diets of Heterobranchuslongifilis × Clarias gariepinus (Pisces-Clariidae) hybrid fingerlings in outdoor concrete tanks. *Journal of Industrial and Scientific Research*, 3(2): 51-55.

Sogbesan, O. A., Ugwumba, A. A. A. and Ibiwoye, T. I. I. (2006b). Growth performance and nutritional of semi-arid zone earthworm (Hyperiodriluseuryaulos; Clausen, 1967) cultured in some organic wastes as fish meal supplement. *Nigeria Journal of Tropical Agriculture*, 8(3): 255 - 262.

Sogbesan, O. A., Ugwumba, A. A. A. and Madu, C. T. (2006a). Nutritive potentials and utilization of Garden snail (Limicolaria aurora, Jay, 1937; Gastropoda: Limicolaria) meat meal in the diet in the diet of Clarias gariepinus fingerlings (Burchell, 1822). *African Journal of Biotechnology*, 5(1): 1999-2003.

Sotolu, A. O. (2008). Nutrient Potential of Water Hyacinth as a Feed Supplement in Sustainable Aquaculture. Obeche. 26 (1): 45-51.

Tibbets, S.M., Lall, S.P. and Milley, J.E. (2005). Effect of Dietary protein and lipid levels and Dietary protein/Dietary energy ratio on growth, feed utilization and 75 hepatosomatic index of juvenile haddock, Melanogrammsaeglefonus. Aquaculture Nutrition 11: 67-78.

Ugwumba, A. A. A., Ugwumba, A.O. and Okunola, A.O. (2001). Utilization of Live maggot as supplementary feed on the growth of Clarias gariepinus (Burchell) fingerlings. *Nigerian Journal of Science*, 35(1): 1-7.

Xu, X. L., Fontaine, P., Mélard, C., and Kestemont, P. (2001). Effects of dietary fat levels on growth, feed efficiency, and biochemical compositions of Eurasian perch Percafluviatilis. Aquaculture International, 9(5): 437–449.