IJABR Vol. 14(2): x - xx (2023)

Original article

Length-weight Relationships and Condition Factor of *Clarias gariepinus* post larvae fed three Diets

*[1]Anigboro, O. F., [2]Ikomi, R. B. and [3]Iloba, K. I.

[1]Department of Biological Sciences, Faculty of Science, University of Delta, Agbor, Delta State, Nigeria
[2&3]Animal and Environmental Biology (AEB), Delta State University, Abraka, Delta State, Nigeria

Submitted: July, 2023; Accepted: December, 2023; Published: December, 2023

ABSTRACT

Length/weight are veritable tools in discussing the growth performance of fish. The quality/quantity of diets and water are limiting factors that determines the wellbeing of the *C. gariepinus* larvae. This present study is to investigate the length/weight relationship and condition factor of the post larvae of *C.gariepinus* fed three different diets with the aim of optimizing larvae production in the aquaculture sector without compromising their nutritional requirements. Fifteen (15) *C. gariepinus* weighing between 0.06 and 0.07g were collected from each of the three concrete tank in a flow through system that contain 150 stocking capacity and fed Commercial feed(CF), Housefly Maggot (*Musca domestica*) (MM), Plankton(MZ) for 12 weeks. Proximate composition of the treatment diets used in this study ranged from 18.04% to 49.00% with post larvae fed commercial diets having highest value of 49.00% and highest final value of weight of (233.85g) followed by those fed with Maggot valued 42.50% and weight value of 210.04g, and plankton fed larvae the least (18.04%, 198.37g) after 12 weeks of rearing period. Post larvae fed on commercial feed performed significantly better with survival percentage of 96.67%, followed closely by post larvae fed on maggot (93.33%) and plankton the least with 86.67%. Physicochemical parameters of water in the rearing tanks through 12-weeks rearing period did not vary significantly ($p>0.05$) during the feeding trials. The tank containing post larvae fed with maggot had significantly ($p>0.05$) higher dissolved oxygen (5.80-6.78) and lower ammonia (0.01-0.59) and nitrate value of (0.01-0.03) respectively. The length/weight analysis indicate a, b, r and K values of 3.299, 0.878 and 1.853 for commercially fed post larvae, then 2.922, 0.886 and 1.094 for plankton fed post larvae and 3.109, 0.885 and 1.283 for Maggot fed post larvae respectively. PCA indicated temperature as having a weak correlation with axis 1 and associated with week 4 and 5 values of growth parameters. Length values of the different diets were strongly correlated with axis 1. This study confirmed Maggot as better alternative diet as against the high-cost Commercial feed in order to reduce cost and optimize production.

KEYWORDS: Fish feeds, Growth parameters, *Clarias gariepinus,* African catfish

Corresponding author's email: anigborofidelis@gmail.com; Phone Number: +234(0)8109910455

INTRODUCTION

Fish, although a cheap and ready source of protein, its availability in the wild has been seriously compromised due to unsustainable exploitation, over-population of dependent human species, and poor water conditions. Aquaculture; the rearing of fish in an artificial enclosure that can retain water, by simply applying biological principles [10], provides an alternate means of satisfying the pressures of demand and supply of fish and fish products.

The global aquaculture industry is a multi -billion dollar industry requiring huge capital and human investment. Nigeria has a huge potential for aquaculture [14]. The country has vast water resources; agro-ecology enriched land and presence of suitable fish species [11]. The scarcity of seed (fingerlings) and unavailability of commercial feeds has been cited as the most pressing constraints for aquaculture development in Nigeria [33]. These two crucial constraints cannot be viewed individually as they act in correlation. Successful larvae rearing depend mainly on the availability of suitable diets that are readily consumed, efficiently digested and provides the required nutrients to support good growth, survival and health [19]. Most hatchery operation in Nigeria have experienced high mortality of Fish larvae, [6]. This has affected the quality and cost of fingerlings. It was suggested that the water quality and feed quality was a major cause of the experienced high mortality of fish larvae [31]

According to, Limbu [23], African catfish farmers can reduce feed cost to about 30% by using on-farm produced feeds without affecting fish growth performance, survival and yield, providing better protein retention and healthier fish population. Generally, length-weight relationship (LWR) provides useful information on growth patterns, age determination and fishery assessment through different stages during development [35, 30].

The condition factor denoted as "K" provides information on the wellbeing of a fish; reflecting interaction between biotic and abiotic factors in the physiological conditions of fishes, and is usually influenced by the fish, sex, season, maturity stage etc. [13]. In fisheries science, It is based on the hypothesis that heavier fish of a particular length are in a better physiological condition. It is also a useful index for monitoring feeding intensity, age, and growth rates in fish [35].

C. gariepinus larvae are reared from hatching to fingerling size, either completely in extensive pond culture systems [32], solely in the hatchery [37,25] or for a 10 – 16 day period in the hatchery, followed by a nursery phase in ponds [23].

Previous research works include those of Getso *et al.* [18] who studied the growth morphology of two fish species (*Clarias gariepinus* and *Oreochromis niloticus* from Wudil River, Kano, Nigeria. Mir *et al*. [26] worked on the feed utilization and growth performance of *Claria gariepinus* reared in biofloc system and fed commercial diet. **Ujjania** *et al.* [35] investigated the dietary energy required by juvenile *Clarias gariepinus* fed fixed protein while Khatoon *et al.* [21] evaluated the growth performance of *Clarias gariepinus* fed processed offal diet. **Getso** *et al*. [18] reported the effects of feed rationing on the growth performance of *Clarias gariepinus*.

Giri *et al* [19] investigated the rearing of Zebra fish (*Danio rerio*) larvae, a freshwater specie like the African catfish without using live food: an evaluation of a commercial, a practical and a purified starter diet on larval performance using *Artemia* nauplii, commercial, Purified diet.and Practical diet for 21 days.

Fasakin *et al.,* [15] investigated the survival, growth and feed utilization of the reciprocal hybrids of *C. gariepinus* and *Heterobranchus bidorsalis* in concrete tanks reared for 14 and 35 days for larvae and post larvae. Percentage weight gain and specific growth rate was significantly ($p < 0.05$) higher in *Clarias* with the value of $2525.00+109.67^{a}$, SGR of $9.34+ 0.77^{a}$ than *Heterobranchus* with the value of $1362.07+101.95^{b}$, SGR of $7.66+ 0.79^{b}$ respectively.

However most studies worked on these food items in isolation and possibly under different conditions/environment. But the present study tried to examine these diets under the same environmental conditions and used fish from the same parent stocks to acquire the post larvae used for this study in order to reduce the impact of gene interference. This study tried to find a suitable alternative diet as against the costly commercial feed in order to optimize post larvae production of *C. gariepinus*.

The objective of this study therefore was to determine the effect of the three different diet on the growth parameters (length and weight) and condition factor of post larvae of the African catfish (*C. gariepinus*) under the same environmental conditions.

MATERIALS AND METHODS

Location of the Study

This study was carried out in the Aquaculture laboratory of Department of Animal and Environmental Biology, Delta state University, Abraka. The post larvae fishes used for the study were acquired through hypophysation technique Idahor[16], invasive techniques was adopted where sperm extraction(milt) with the aid of a sterilized syringe of 5.0ml was used. The process involves an incision made in the abdominal wall and a part of the gonad of the fish was extracted then this material was used to fertilize the female eggs. Thereafter the opened section was treated or held together with surgical thread or with polymer medical glue. Isolation of the male to complete healing of the surgeon was ensured to avoid risk of infection of the wound and to enhance survival. This was possible because the African catfish has a higher regenerative ability of gonad and in other to keep the male catfish alive. The brood stocks were selected from centrally located parent stock holding ponds at the Department of Animal and Environmental Biology, Campus II, Delta State University, Abraka. Males and females were conditioned in separate concrete ponds. The brood stocks were fed with 29% Crude Protein formulated feed, acclimatized for three weeks, then transferred into the hatchery holding tanks. During the period, the temperature of water in the tanks was maintained between 24 to 27°C to stimulate ovulation. One female catfish [29]. The eggs obtained from striped female was fertilized in a bowl with milt extracted surgically from the male catfish. The fertilized eggs was placed in incubating tanks where continuous flow of water was allowed until hatching was finished in 26hours (i.e. after 22hours, fertilized embryos start to hatch) in warm water of 25-27°C. After21 days rearing period for the fry, the post larval rearing commenced and lasted for twelve weeks at a stocking density of 150 fish per concrete tank in a flow through system. At the onset of the feeding trials, 15 fry were removed from each experimental tank and batch weighed. This was repeated weekly for 12 weeks. Three treatment diet namely Commercial feed (CF), Maggot (MM) and Plankton (MZ) were used to feed the post larvae replicated thrice in a completely randomized design. Fish growth performance parameters evaluation was conducted weekly through to the 12th week of culture. During each evaluation, weight of fifteen fishes was taken and recorded using electronic sensitive weighing balance to the nearest 0.01g and their length taken on a measuring board and recorded to the nearest 0.1cm respectively. Temperature, dissolved oxygen (D O), pH, ammonia and nitrite values of the various test tank water were recorded weekly using methods described by APHA, [5]

Length-Weight Relationship

The length-weight (log-transformed) relationships were determined by linear regression analysis and scatter diagrams of length and weight were plotted. The length-weight relationship of the experimented fish was worked out as per cube law given by Le Cren (1951).

$W = aL^b$ ....(1)

Where, W=Weight of fish (g), L is observed total length (cm), 'a' is the regression intercept and 'b' is the regression slope.

The logarithmic transformation of the above formula is-

$\text{Log } W = \log a + b \log L$ ....(2)

Fulton's Condition Factor (K)

Fulton's condition factor (K) was calculated according to Htun-Han (1978) equation as per formula given below:

$$K = \frac{W \times 100}{L^3}$$

Where, W=weight of fish (g), L=Length of fish (cm).

Data Analysis

Mean and Standard Deviation of length and weight measurements were analysed using descriptive analysis in Graph Pad software. Data on mean of lengths and weights, % survival, proximate composition of diets were analyzed using one-way and two-way analysis of variance (ANOVA) and differences in means were compared using the Tukey Honest Test at *p* = 0.05. The analysis of covariance was performed to determine variation in 'b' values for each diet following method of Datta *et al.*, [9]. In the first two cases (i.e., b<3 and b>3) fish growth is allometric (i.e., when b<3 the fish grows faster in length than in weight, and when b>3 the fish grows faster in weight than in length), whereas when b=3 growth is isometric. Statistical software GraphPad Prism 9.40 used for analysing the data.

RESULTS

Growth performance and Survival of the post larvae of African catfish fed different diets

Length Increase

The length (cm) increase in the post larvae of the African catfish fed different diets for 12 weeks period using different diets is shown in Table 1. At the start of the experiment the initial lengths of the post larvae did not vary significantly (P>0.05). The initial lengths ranged between 4.56 and 4.60cm. However, the final length varied significantly among the various treatments ranging between 31.25±0.05cm for post larvae fed Plankton (MZ) to 36.44±0.25cm for post larvae fed Commercial feed (CF). Therefore, final length was significantly affected by diet, with the post larvae fed with Commercial feed (CF) having the highest value. This was closely followed by post larvae fed maggots (MM) and the least was post larvae fed Plankton (MZ) attaining an average length of 31.25±0.05cm after 12 weeks of rearing. Post larvae fed on specific commercial diet performed better than those fed on Plankton but did not differ significantly (*P>0.05*) from those fed with maggots using Tukey Honest test for comparison of the mean length increase.

Table 1: Weekly length (cm) increase of African catfish Post larvae through 12-weeks rearing period using different diets (CF- Commercial diet, MM- Maggot, MZ- Plankton).

Diet/ Week	CF Commercial feed	MZ Plankton	MM Maggot	Probability
0	4.60±0.08^{a}	4.56±0.06^{a}	4.56±0.03^{a}	P>0.05
1	7.29±0.24^{a}	5.74±0.08^{b}	7.01±0.03^{a}	P>0.05
2	9.85±0.25^{a}	9.06±0.08^{a}	9.46±0.04^{a}	P>0.05
3	13.41±0.26^{a}	10.38±0.07^{b}	11.90±0.04^{c}	P<0.05
4	15.97±0.26^{a}	12.67±0.08^{b}	14.35±0.04^{c}	P<0.05
5	18.53±0.26^{a}	15.02±0.06^{b}	16.80±0.05^{ab}	P<0.05
6	21.09±0.26^{a}	17.34±0.05^{b}	19.25±0.05^{c}	P<0.05
7	23.64±0.26^{a}	19.66±0.05^{b}	21.70±0.05^{ab}	P<0.05
8	26.20±0.26^{a}	21.97±0.05^{b}	24.15±0.06^{c}	P<0.05
9	28.76±0.25^{a}	24.29±0.04^{b}	26.60±0.06^{ab}	P<0.05
10	31.32±0.2^{a}	26.61±0.04^{b}	29.05±0.06^{ab}	P<0.05
11	33.88±0.25^{a}	28.93±0.04^{b}	31.50±0.07^{ab}	P<0.05

12	36.44±0.25[a]	31.25±0.05[b]	33.95±0.07[ab]	P<0.05

Note: Values are Mean±SD. Superscript of the same letter present in the same row do not vary significantly (P>0.05) using Tukey Honest multiple comparison test for mean

Key: CF- Commercial diet, MM- Maggot, MZ- Plankton.

Weight Increase

The weight (g) increase in the post larvae of the African catfish fed different diets from week 0 to the 12th week rearing period using different diets is shown in Table 2. The initial weights of the larvae in the various holding tanks did not vary significantly (P>0.05). Values ranged between 0.06 and 0.07g. The final weight was significantly affected by diet, with the highest values obtained in post larvae fed commercial feed (CF) (233.85±3.34g). This was followed by larvae fed maggots (MM) attaining an average weight of 210.04g after 12 weeks of rearing. Larvae fed on Plankton performance were significantly lower (P<0.05) than those fed on maggots and commercial feed, which also differed significantly (*P<0.05*) from each other using Tukey Honest test for comparison of the mean weight increase. Obviously, Figure 2 show a steady increase in the weight of the post larvae fed on the different diets from week 0 to week 8. Spontaneous growth in weight was evident from the 9th week through to the 12th week. The post larvae fed on commercial feed had better weights from the 3rd week to the 12th week of rearing and significantly (P<0.05) from those fed on Plankton and maggots.

Table 2: Weekly mean weight (g) increase of the African catfish post larvae through 12-weeks rearing period using different diets (CF- Commercial diet, MM- Maggot, MZ- Plankton). (Values are Mean ± SD)

Diet/ Week	CF Commercial feed	MZ Plankton	MM Maggot	Stat.
0	0.07±0.00[a]	0.06±0.00[a]	0.07±0.00[a]	P>0.05
1	11.51±0.03[a]	11.37±0.06[a]	11.09±0.03[a]	P>0.05
2	24.04±0.23[a]	23.56±0.06[a]	22.71±0.08[a]	P>0.05
3	37.60±0.63[a]	36.56±0.06[a]	35.71±0.08[a]	P>0.05
4	52.32±0.88[a]	50.56±0.06[a]	49.71±0.08[a]	P>0.05
5	69.06±1.21[a]	65.89±0.52[ab]	64.71±0.08[b]	P<0.05
6	87.56±1.55[a]	81.89±0.52[b]	81.71±0.08[b]	P<0.05
7	108.26±2.12[a]	99.22±1.09[b]	100.71±0.08[b]	P<0.05
8	130.71±2.48[a]	117.21±1.09[b]	120.71±0.08[b]	P<0.05
9	155.22±2.91[a]	136.70±1.42[b]	142.04±0.59[c]	P<0.05
10	180.88±3.32[a]	156.70±1.42[b]	164.04±0.59[c]	P<0.05
11	206.85±3.33[a]	176.70±1.42[b]	187.04±0.59[c]	P<0.05
12	233.85±3.34[a]	198.37±0.23[b]	210.04±0.59[c]	P<0.05

Note: Values are Mean±SD. Superscript of the same letter present in the same row do not vary significantly (P>0.05) using Tukey Honest multiple comparison test for means

Key: CF- Commercial diet, MM- Maggot, MZ- Plankton.

Survival of the post larvae of *C. gariepinus* fed different diets

The Percentage survival of the post larvae of the African Catfish (*C. gariepinus)* fed different diets is shown in Figure 3. Generally, mortality occurred between week 0 and 7th week of rearing and thereafter there were no further mortality till the end of the 12th week of the experiment. Percentage survival was affected by the diet and this was significantly lower ($P<0.05$) for post larvae fed on plankton. Post larvae fed on commercial feed performed significantly better achieving a total survival rate of 96.67%. This was closely followed by post larvae fed on maggots with 93.3%. From the foregoing, post larvae fed on commercial feed performed better in terms of both length and weight increase as well as having the lowest mortality rate.

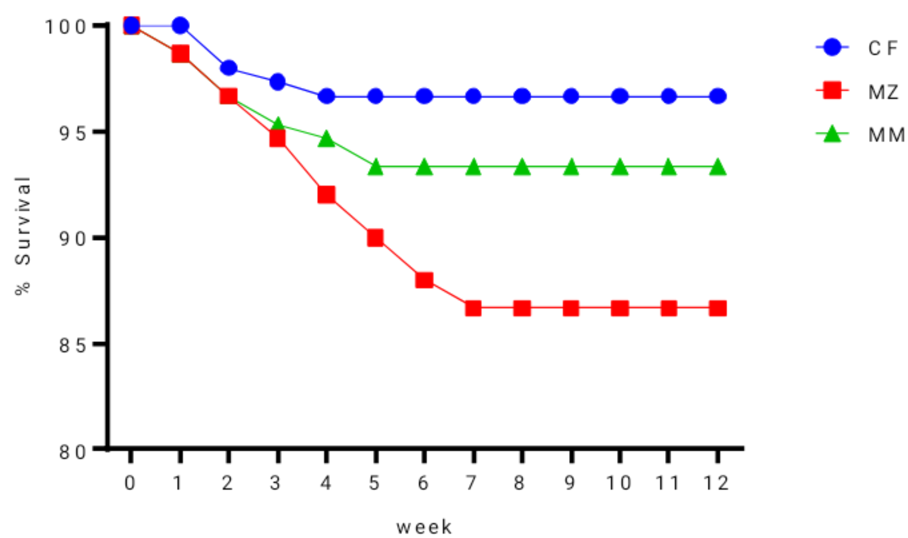

Figure 3: Percentage survival of post larvae of *Clarias gariepinus* fed different diets (***CF** = Commercial feed,* ***MM**= Maggot,* ***MZ** = Plankton*).

Table 3: Proximate Analysis of different diets used in feeding the African catfish post larvae through 12-weeks rearing period using different diets (CF- Commercial diet, MM- Maggot, MZ- Plankton).

	% Moisture	% Ash	% Crude Fibre	% Ether	% Crude Protein	% Carbohydrate (NFE)
Commercial feed (Coppens) (CF)	8.00	8.00	6.00		49.00	12.40
Maggot (MM)						

Plankton (MZ)	10.53	5.91	6.37	18.00	42.50	16.69
	12.96	3.50	2.00	5.39	18.04	58.81

Key: CF- Commercial diet, MM- Maggot, MZ- Plankton.

Physico-chemical parameters of water in the post larvae rearing tanks

The physicochemical parameters of water in the post larvae rearing tanks are given in Table 4. The range of temperature variation during the experimental period was very narrow between 26.0 and 27.0°C with a mean of 26.8°C. This was not different ($p>0.05$) among the different treatments. Dissolved oxygen levels fluctuated between 5.04 and 6.78mg/L. The value was significantly higher in tanks containing post larvae fed with maggots. The range of dissolved oxygen did not vary significantly between the water in the tanks with post larvae fed on commercial feed and Plankton respectively. Hydrogen ion concentration (pH) was slightly alkaline in all the water containing the post larvae irrespective of the feed. The values of pH fluctuated minimally from 7.4 to 8.3 in all the tanks throughout the experimental period. The value of ammonia was considerably lower in the water in tanks containing post larvae fed on maggots. Generally, the value of ammonia fluctuated widely between 0.01 to 0.94mg/L. The value did not vary significantly between the holding tanks for post larvae fed on commercial feed and on Plankton diet. Of particular interest however, is that the amount of Nitrate was significantly higher in holding tanks containing post larvae fed on Plankton as compared to the other tanks

Table 4: Physicochemical parameters of water in the rearing tanks of the post larvae of the African catfish (*C. gariepinus*) fed different diets for 12-week rearing period using different diets (Values are Mean ± SD).

	Diets			Pro
Parameters	Commercial feed CF	Plankton MZ	Maggot MM	
Temperature °C	26.76±0.12[a]	26.77±0.12[a]	26.77±0.12[a]	P>0.05
	(26.00-27.00)	(26.00-27.00)	(26.00-27.00)	
Dissolved Oxygen (mg/L)	5.89±0.07[a]	5.82±0.09[a]	6.24±0.09[b]	P<0.05
	(5.40 - 6.10)	(5.04 - 6.41)	(5.80 - 6.78)	
pH	7.88±0.08[a]	7.95±0.08[a]	7.94±0.10[a]	P>0.05
	(7.40 - 8.30)	(7.40 - 8.30)	(7.40 - 8.30)	
Ammonia (mg/L)	0.62±0.08[a]	0.61±0.08[a]	0.46±0.05[b]	P<0.05
	(0.01 - 0.90)	(0.01 - 0.94)	(0.01 - 0.59)	
Nitrate (mg/L)	0.03±0.00[a]	0.61±0.08[b]	0.02±0.00[a]	P<0.05
	(0.01 - 0.04)	(0.01 - 0.94)	(0.01 - 0.03)	

Note: Values are Mean±SD. Superscript of the same letter present in the same row do not vary significantly (P>0.05) using Tukey Honest multiple comparison test for means

The principal component analysis plot between the physicochemical variables and growth in terms of length and weight increase in the post larvae of *C. gariepinus* is shown in Fig 4 Temperature was associated with week 4 and 5 values of growth parameters, same with pH which showed high positive correlation (0.99) with PCA axis 3. Ammonia and DO were clustered at the center with almost zero (0) values, showing no correlation with any of the PCA axes. Results also indicate that length values of the different diets (CF, MM and MZ) were all significantly positively correlated with Axis 1. Length values for post larvae fed the three diets were strongly associated with week 6-8. Weights values were poorly correlated with Axis 1. The weight values for all the diets can be seen clustering more at the center very close to zero (0).

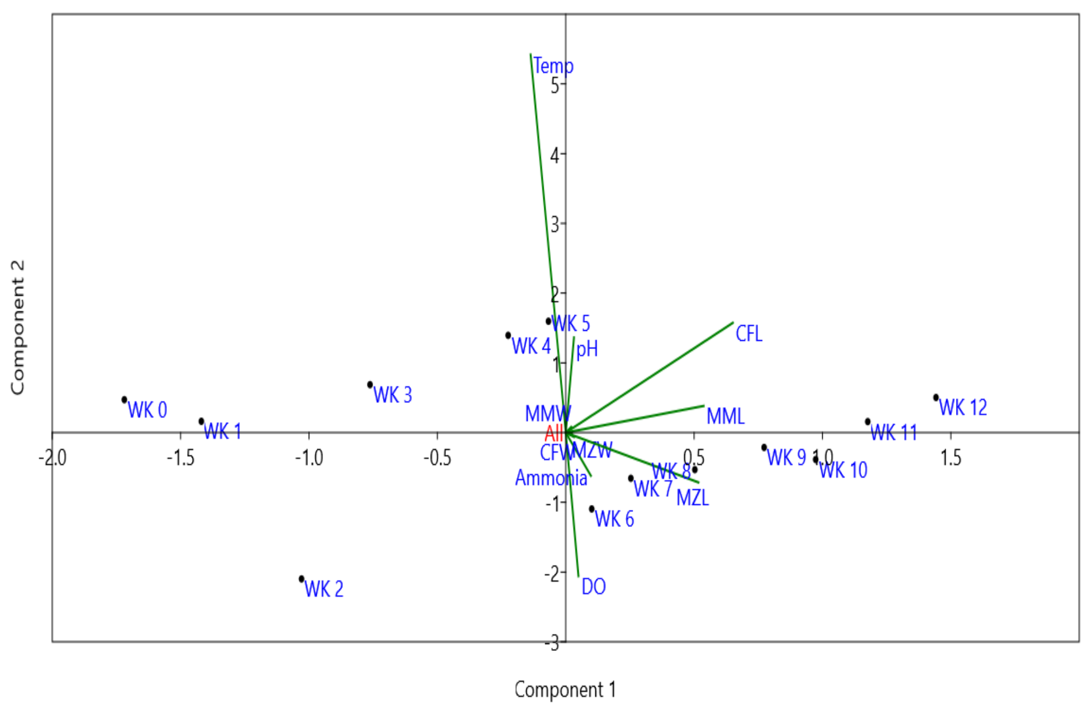

Fig 4: Principal Component Analysis (PCA) plot between the physicochemical variables (Temperature, Dissolved Oxygen-DO, pH and ammonia) and growth parameters (Length-L and weight-W increase) in the post larvae of *C. gariepinus* fed different diets (CF-commercial feed,MM-Maggots and MZ-Plankton

Length – weight relationship, co-efficient 'b' and logarithmic relationship between length and weight

Length – weight relationship, co-efficient 'b' and logarithmic relationship between length and weight with regression equation is given in Tables 6 and Figures 5 - 10. In the present study final 'b' varied only slightly between 2.024 and 2.194. Growth is said to be positive allometric when the weight of an organism increases more than length (b>3) and negative allometric when length increases more than weight (b<3) (Datta *et al.* 2013). When Length was regressed with Body Weight, the slope value was significantly higher than critical isometric value i.e. 3, in CF indicating positive allometric growth. For post larvae raised on plankton diet, the slope value (b) was approximately 3 (2.922), indicating isometric growth. Also, post larvae fed on maggots had a b- value of 3.1(∞3), indicating isometric growth. The relationship between Length and Weight in post larvae fed on commercial diet is shown in Fig 5. It is more of a curvilinear than a linear relationship. The regressed log transformed L-W relationship for post larvae raised on commercial feed (Fig 6) gave an intercept (a) value of 2.514 and a slope (b) of 3.299. On the other hand, the relationship between Length and Weight in post larvae fed on plankton feed (Fig 7) showed also a more curvilinear curve. The regressed log transformed L-W relationship for post larvae raised on plankton diet (Fig 8) gave an intercept (a) value of 1.786, a slope (b) of 2.922 and regression coefficient of 0.886. For post larvae raised on maggots, the Length-Weight relationship is more of a linear curve (Fig 9). The regressed log transformed L-W relationship for post larvae raised on maggots (Fig 10) gave an intercept (a) value of 2.163, a slope (b) of 3.109 and regression coefficient of 0.885.

Condition Factor ('K')

The values of condition factor 'K' recorded in this study for the final length and final weight of the post larvae are 0.65, 0.48, and 0.54 in CF, MZ and MM respectively. Averagely, for the 12 weeks the experiment lasted the condition factor was greater than 1 in all the experimental diets ranging between 1.09 and 1.85 with the fish fed commercial feed having the highest condition factor and those fed Plankton diet having the lowest. The correlation coefficient 'r' was similar in all the treatments (ranging between 0.878 and 0.885). Post larvae fed commercial diet had better r values and relatively higher condition factor followed by maggot and least in post larvae fed plankton.

Table 6: Final length- weight relationship of post larvae of the African catfish (*C. gariepinus*) reared in experimental tanks.

Diet	Final average Length(cm)	Final average weight (g)	Logarithmic equation Log W = log a + b log L	Correlation coefficient 'r'	Condition factor 'K'	Average condition factor through the 12 weeks	'b'
CF	36.44	233.85	Log W = log 2.514-3.299 log L	0.878	0.6500	1.853	3.299
MZ	31.25	198.37	Log W = log 1.786-2.922 log L	0.886	0.4833	1.094	2.922

MM	33.95	210.04	Log W = log 2.163-3.109 log L	0.885	0.5367	1.283	3.109

Note. *CF= Commercial Feed, MZ= Plankton, MM= Maggots*

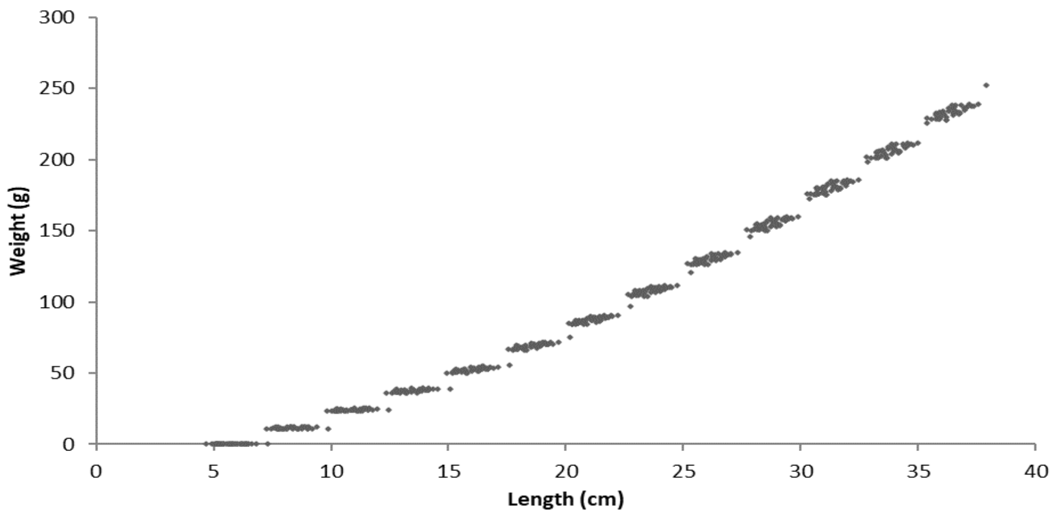

Fig 5: Length-weight relationship of post larvae fed with commercial feed through 12 weeks of culture.

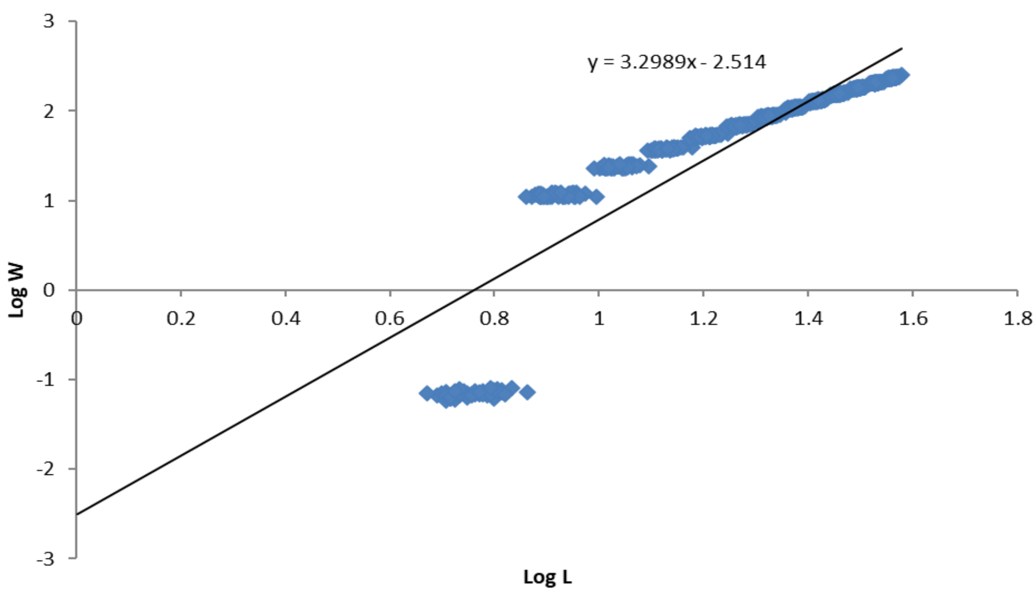

Figure 6 Logarithmic relationship between length and weight with regression equation of post larvae of *C. gariepinus* fed on commercial feed.

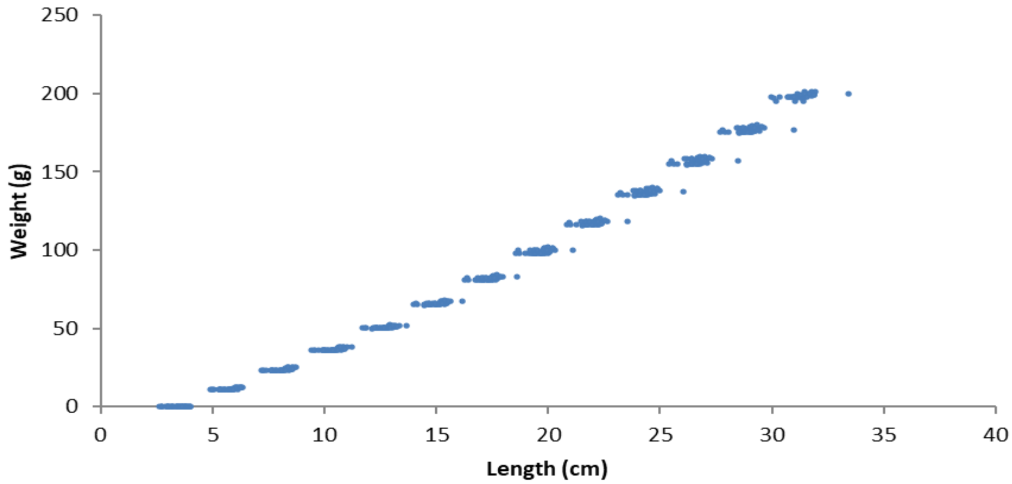

Fig 7: Length-weight relationship of post larvae fed with Plankton feed

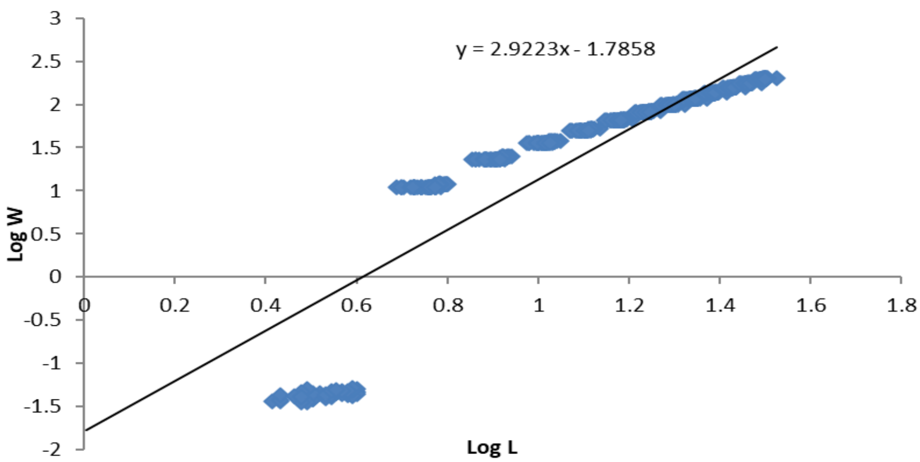

Figure 8 Logarithmic relationship between length and weight with regression equation of post larvae of *C. gariepinus* fed on Plankton diet.

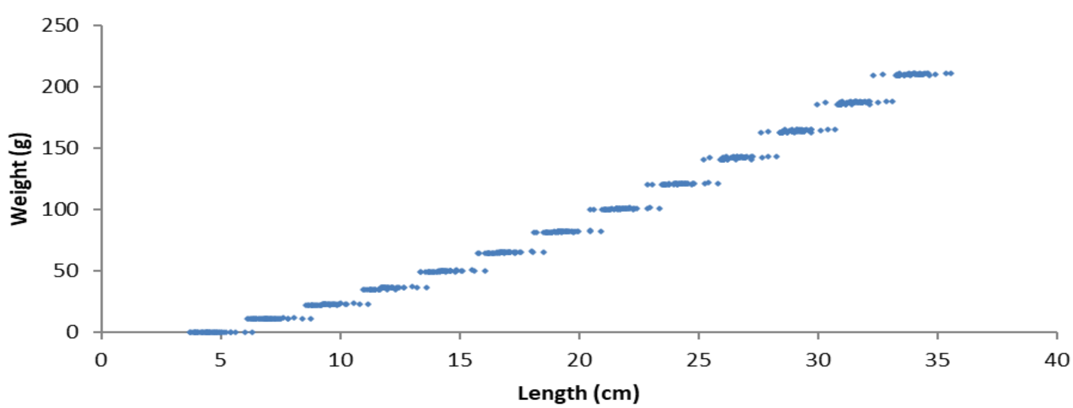

Fig 9 Length-weight relationship of post larvae fed with maggots.

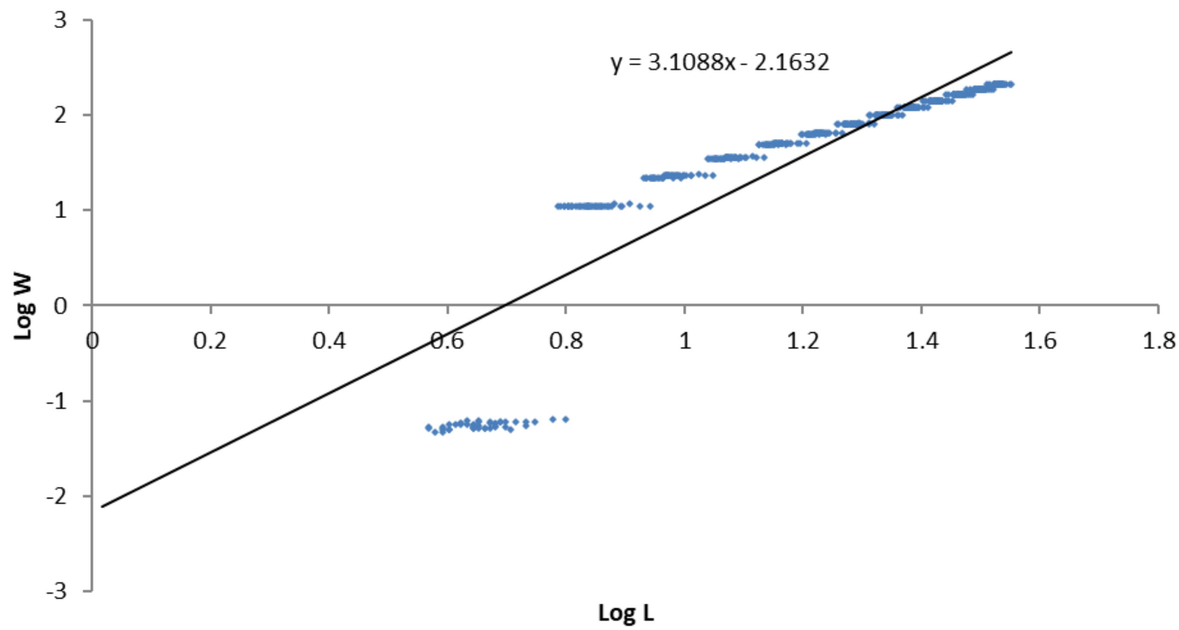

Figure 10: Logarithmic relationship between length and weight with regression equation of post larvae of *C. gariepinus* fed on maggots.

DISCUSSION

Growth Performance

Overall, in any hatchery operation, larval growth and survival are influenced by a multiplicity of factors ranging from maturation, nutritional quality, and digestive capability of larvae. Others include effective management and control of key physico-chemical water parameters, hygiene in the hatchery [7] and often genetic quality of the species [24].

According to the results obtained, post larvae feeding of the African catfish with the commercial feed (CF) diet led to a better growth rate, this was followed by larvae fed maggot (MM) with Plankton (MZ) having the least growth rate. However, it could be argued that the development of high-quality commercial larval feed, as demonstrated in this experiment (Coppens), enhanced greatly the possibility to totally replace live food by an artificial feed. In addition, higher energy content of this commercial feed combined with a good supply in micro-nutrients (amino acids, phospholipids, vitamins, carotenoids) probably explains the better growth attained in terms of length and weight increase [26].

Percentage survival was affected by the diet and this was significantly lower ($P<0.05$) for post larvae fed on plankton. Post larvae fed on commercial feed performed significantly better achieving a total survival rate of 96.67%. This was closely followed by post larvae fed on maggots with 93.3%. Similar results have previously been reported for this species and related genus by Yasmin *et al* [37, 29, 1]
Proximate composition of the three experimental diets used indicates Commercial feed crude protein (CP) as 49%, Maggot as 42.50% and least in Plankton having 18.04%.Generally, the percentage crude protein level was

highest in commercial diet (49%) and lowest in plankton (18.04%). This crude protein level reported for the cultured maggot in this study is similar to 47.1% obtained by Aniebo *et al* [4] on maggots generated from a mixture of cattle blood and bran and 45% crude protein content reported by Fasakin *et al* [15]. The crude protein content obtained in this study is therefore a proof of the high protein content of this particular maggot meal. The relatively lower level of crude protein content (18.04%) obtained from the plankton diet may be attributed to the species of algae that dominated in the composition. In this case, *Chlorella* species were the dominate algae. Khatoon *et al* [21] reported a much higher crude protein content (44.4%) in the freshwater algae belonging to *Scenesdesmus* species. Enyidi [12] obtained a crude protein content of 32% in fresh water algae. The crude protein (18.06%) content obtained in the cultured plankton is much lower than that reported for *Daphnia* (57.25%) by Riccardi and Mangoni [32] and 48.35% reported by Vollenweider (2000) for the same species and 41.65% reported for plankton by Ademu *et al* [2]. The plausible reason for the relatively lower crude protein content obtained in this study may be attributed to the dominate zooplankton in the mix culture. In this case, *Moina* and *Brachionus* species were the dominant zooplankton. Generally, giving a fish the correct amount of protein is very important in ensuring good growth and health. Protein deficiency means slower growth whereas excessive protein will put up the feeding cost. Most fish studied require a feed with 25 to 50 % crude protein [17]. Therefore, the crude protein content obtained in this study for maggots is ideal or compete favourably with that of the commercial diet as fish feed. The proximate composition of maggots cultured in this study, is a reflection of the nutritive quality and acceptance of this biomaterial. This also corroborates previous observation that maggot meal, like other animal protein sources has been accepted and utilized by fish [4, 28, 27]. Maggots are easily digested by fish owing to their relatively high crude fibre content, which plays a significant role in feed digestion. It has also been reported that the biological value of maggot meal is equal to that of fish meal [3]. This fact is strengthened by the results obtained in the present study. Utilization of maggot meal will thus pave way for cheaper and nutritionally rich aquaculture feeds.

Physico-chemical parameters tested had effect on fish diet and all parameters except nitrate were within permissible limits. Nitrate was relatively higher in post larval holding tanks with plankton as compared to the other tanks. Meck [25] recommended that its concentrations from 0 to 200mg/l are acceptable in a fish holding tank and is generally low toxic for most freshwater species although marine species are more sensitive to its presence. According to Bhatnagar and Devi [8], nitrate is relatively nontoxic to fish and do not cause any health hazard except at exceedingly high levels (above 90 mg/l). Santhosh and Singh [34] described the favourable range of 0.1 mg/l to 4.0 mg/l in fish culture water. Therefore the Nitrate range of 0.01 to 0.90mg/l obtained in this study in the post larval holding tanks is considered to be nontoxic.

Generally, length-weight relationship (LWR) provides information on growth patterns of fish, which passes through different stages during development [20]. Statistical analysis of the LWR showed that the Regression coefficients obtained from length-weight relationships (LWR) were indicative of isometric or positive allometric growths for all post larvae raised on the different diets. Growth is said to be positive allometric when the weight of an organism increases more than length (b>3) and negative allometric when length increases more than weight (b<3) (Datta *et al.* 2013). The slope value was significantly higher than critical isometric value i.e. 3, in CF indicating positive allometric growth. For post larvae raised on Plankton diet, the slope value (b) was approximately 3 (2.922), indicating isometric growth. Also, post larvae fed on maggots had a b- value of 3.1(∞3), indicating isometric growth. This finding is consistent with the reports of Getso *et al* [18]. Several factors could also be the cause of variation in b values such as water quality and food availability [35]; sample size and length range [20]. Condition coefficient is one of the standard practices in fisheries which is used as an indicator of the variability attributable to growth coefficient (b). Here, the individual fish species condition is determined based on the analysis of length weight data reflecting that the heavier fish at a given length is in better condition [20], hence indicating favourable condition. The mean condition coefficient (K) for the post larvae of *C. gariepinus* obtained in this study was 1.09, 1.26 and 1.85 for CF, MZ and MM respectively. Ujjania *et al*. [35] stated that condition factor greater or equal to one is good, indicating a good level of feeding, and proper environmental condition. Therefore all the fish fed the different experimental diets in this study could be said to be in good condition.

CONCLUSION

Optimizing the feed for post larvae catfish rearing is crucial for the growth, health and overall success of the farming venture. While Commercial feeds are readily available, exploring local feed options that are equally available and culturable at a low cost can significantly reduce costs without compromising the nutritional needs of the catfish, hence the choice of maggot as an alternative diet is recommended from this study.

This study has elucidated the fact that post larvae fed on commercial feed performed extremely well and had better growth in terms of weight, length increase survival and Specific Growth Rate (%SGR). Maggot diet performed well and compete favourably with commercial feed and Plankton the least. Therefore it could serve as possible replacement or alternative diet to be recommended for the rearing of the post larvae of the African catfish (*C. gariepinus*) as against the high cost Commercial feed in order to reduce cost and optimize post larvae production in the aquaculture sector.

Authors Contribution

AOF conceptualized the study. AOF, IRB and IKI designed the study. AOF and IRB participated in fieldwork and data collection. IKI performed the data analysis and interpreted the data. AOF prepared the first draft of the manuscript, reviewed by IRB. All authors contributed to the development of the final manuscript and approved its submission.

REFERENCES

1. **Abdulraheem, I., Otubusin, S. O., Agbebi, O. T., Olowofeso, O., Alegbeleye, W. O., Abdul, W. O., and Nathaniel, B.** (2012). The growth response of Clarias gariepinus hatchlings to different dry feeds. *Journal of Agricultural Science*, ***4*(10)**, 75.

2. **Ademu, H., Kabiru, A. Y., Abubakar, A., and Ojochenemi, E.** (2021). Evaluation of nutritional compositions and haematological effect of locally produced fish feeds in Heterobranchus Bidorsalis (catfish) Fingerings.????????

3. **Ajani, E. K., Nwanna, L. C. and Musa, B. O.** (2004). Replacement of fishmeal with maggot meal in the diets of Nile tilapia, *Oreochromis niloticus*. World Aquaculture, ????????

4. **Aniebo, A. O., Erondu, E. S., and Owen, O. J.** (2008). Proximate composition of housefly larvae (Musca domestica) meal generated from mixture of cattle blood and wheat bran. *Livestock Research for Rural Development*, ***20*(12)**, 1-5.

5. **APHA** (1989) Standard methods for the examination of water and wastewater. 17th edition

6. **Arimoro, F. O.** (2006). Culture of the freshwater rotifer, *Brachionus calyciflorus*, and its application in fish larviculture technology. *African Journal of Biotechnology*, ***5*(7)**, 536-541.

7. **Aruho, C., Walakira, J. K., Owori-Wadunde, A., Nuwamanya, E., Bugenyi, F., Sserwadda, M., and Borski, R. J.** (2020). Growth and survival of Ripon barbel (Barbus altianalis) larvae and juveniles fed five experimental diets in captivity. *Aquaculture Reports*, *18*, 100441.

8. **Bhatnagar A, and Devi P** (2013). Water quality guidelines for the management of pond fish culture. *Int. J. Environ. Sci.* **3(6)**:1980- 2009.

9. **Datta, S. N., Kaur, V. I., Dhawan, A., and Jassal, G.** (2013). Estimation of length-weight relationship and condition factor of spotted snakehead Channa punctata (Bloch) under different feeding regimes. *SpringerPlus*, ***2*(1),** 1-5.

10. **Davis, D. A., and Hardy, R. W.** (2022).

Feeding and fish husbandry. In *Fish Nutrition* (pp. 857-882). Academic Press.

11. **Dejen, E and Mintesnot, Z.** (2012). A generic GIS based site suitability analysis for pond production of Nile Tilapia (Oreochromis niloticus) in Ethiopia. In: The Role of Aquatic Resources for Food Security in Ethiopia, proceeding of The Fourth Annual Conference of the Ethiopian Fisheries and Aquatic Sciences Association (EFASA), Brook Lemma and Abebe Getahun (eds). AAU Printing Press, Addis Ababa; pp. 28-57.

12. **Enyidi, U. D.** (2017). Chlorella vulgaris as protein source in the diets of African catfish Clarias gariepinus. *Fishes*, ***2*****(4)**, 17.

13. **Famoofo, O. O., and Abdul, W. O.** (2020). Biometry, condition factors and length-weight relationships of sixteen fish species in Iwopin fresh-water ecotype of Lekki Lagoon, Ogun State, Southwest Nigeria. *Heliyon*, ***6*****(1),** e02957.

14. **FAO** (2006). *State of world aquaculture* FAO *Fisheries Technical paper,* No. 500. Rome, pp 134

15. **Fasakin, E. A., Balogun, A. M. and Ajayi, O. O**. (2003). Evaluation of full-fat and defatted maggot meals in the feeding of Clariid catfish, *Clarias gariepinus*, fingerlings. Aquaculture Research, 2003; **34**: 733–738.

16. **Idahor, K. O**. (2013). Anatomical determination of testes position in African Mudfish (C. *gariepinus*) as a guide to harvest milt using syringe without sacrificing the fish. *J Anim Prod Adv* **3(9):**265-270.

17. **Gabriel, U. U., Akinrotimi, O. A., Bekibele, O. O., Onunkuno, D. N. and Ayanwu, P. E.**(2007). Locally produced fish feed; Potential for Aquaculture Development in Sub-Saharan Africa. African Journal of Agricultural Research, **2(7):** 287-295.

18. **Getso, B. U., Abdullahi, J. M., and Yola, I. A.** (2017). Length-weight relationship and condition factor of Clarias gariepinus and Oreochromis niloticus of Wudil River, Kano, Nigeria. *Agro-Science*, ***16*****(1)**, 1-4.

19. **Giri, S.S., Sahoo, S.K., Sahu, A.K. and Meher, P.K.** (2003). Effect of dietary protein level on growth, survival, feed utilization and body composition of hybrid Clarias catfish (Clarias batrachus X Clarias gariepinus).*Journal Animal Feed Science and Technology 104: 169–178.*

20. **Ighwela, K. A., Ahmed, A. B., and Abol-Munafi, A. B.** (2011). Condition factor as an indicator of growth and feeding intensity of Nile tilapia fingerlings (*Oreochromis niloticus*) feed on different levels of maltose. *American-Eurasian Journal of Agricultural and Environmental Science*, ***11*(4)**, 559-563.

21. **Khatoon, H., Rahman, N. A., Suleiman, S. S., Banerjee, S., and Abol-Munafi, A. B.** (2019). Growth and proximate composition of Scenedesmus obliquus and Selenastrum bibraianum cultured in different media and condition. *Proceedings of the National Academy of Sciences, India Section B: Biological Sciences*, ***89*(1)**, 251-257.

22. **Le Cren, E. D.** (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (Perca fluviatilis). *The Journal of Animal Ecology*, 201-219.

23. **Limbu, S. M.** (2020). The effects of on-farm produced feeds on growth, survival, yield and feed cost of juvenile African sharptooth catfish (*Clarias gariepinus*). *Aquaculture and Fisheries*, ***5*(1)**, 58-64.

24. **Lorenzen, K., Beveridge, M. C., and Mangel, M.** (2012). Cultured fish: integrative biology and management of domestication and interactions with wild fish. *Biological Reviews*, ***87*(3)**, 639-660.

25. **Meck Norm.,** (1996), Pond water chemistry, San Diego, Koi Club, http://users.vcnet.com/rrenshaw/h2oquality.html Revised on July 31, 1996.

26. **Mir, I. N., Srivastava, P. P., Bhat, I. A., Jaffar, Y. D., Sushila, N., Sardar, P., and Jain, K. K**. (2020). Optimal dietary lipid and protein level for growth and survival of catfish Clarias magur larvae. *Aquaculture*, *520*, 734678.

27. **Obeng, A. K., Atuna, R. A., and Aihoon, S.** (2015). Proximate composition of housefly (Musca domestica) maggots cultured on different substrates as potential feed for Tilapia (Oreochromis niloticus). ????????

28. **Odesanya, B. O., Ajayi, S. O., baogun, B. K. O., and Okuneye, B.** (2011). Comparative evaluation of nutritive value of maggots. *International Journal of Scientific and Engineering Research*, ***2*(11)**, 1-5.

29. **Olurin, K. B., and Oluwo, A. B.** (2010). Growth and Survival of African Catfish (Clarias gariepinus) Larvae Fed Decapsulated Artemia, Live

Daphnia, or Commercial Starter Diet.*African Journal of Food Science and Technology*. **62(1),** 50–55

30. **Pepple, P. C. G., and Ofor, C. O.** (2011). Length–Weight relationship of Heleterobranchus longifilis reared in earthen Ponds. *Nigerian journal of Fisheries*, *8*(**2**), 315-321.

31. **Potongkam Kamthorn and Miller Jim** (2006), Manual on Catfish Hatchery and Production. A guide for small to medium scale Hatchery and farm producers in Nigeria. ????????

32. **Riccardi, N., and Mangoni, M.** (1999). Considerations on the biochemical composition of some freshwater zooplankton species. *Journal of Limnology*, ***58***(**1**), 58-65.

33. **Rothuis A.J, Duijn A.P, Kamstra .A, and Dejen E.** (2012). Growth performance of the Nile Tilapia (Orechromis niloticusl) fed different types of Diets formulated. *Journal Zoological Research* **(2)**128-137

34. **Santhosh, B. and Singh, N.P.,** (2007), Guidelines for water quality management for fish culture in Tripura, ICAR Research Complex for NEH Region, Tripura Center, Publication no.29

35. **Ujjania N.C., Kohli M.P.S. and Sharma L.L.** (2012). Length-weight relationship and condition factors of Indian major carps (*C. catla, L. rohita* and *C. mrigala*) in Mahi Bajaj Sagar, India. *Research Journal of Biology*, **2 (1),** 30-36

36. **Vollenweider, R.A.** (2000). Concerning calculation methods and limitations of proxi-estimates of proteins, carbohydrates and lipids in crustacean zooplankton from CHN analyses: some comments. J. Limnol., **59(2):** 170-178.

37. **Yasmin, A., Mollah, M. F. A., and Haylor, G. S.** (1998). Rearing of catfish (*Clarias batrachus* Lin.) larvae with live and prepared feeds. ????????

Assessing the Fish species for Insect Pest Infestation

After six weeks of storage and in order to exposed the various insect pests, the stored smoked fish were placed on a different shallow tray, each for a particular species, and there after spread. Hand lens was used to view each of the species in order and entomological forceps was used to extract any observable insect pests. Both the larval stage and adult were preserved in a labeled specimen bottles with 70% alcohol prior to identification.

Counting and identification of insect pests

The adults and larvae of insects collected from the different species of smoked fish were identified to possible taxonomic level in the laboratory. The identification was based on the morphological features of the insects; microscope was also employed for the proper view in order to clearly identify their features. The different species of insect pests found were counted and recorded. The adult and larval forms were counted separately for each species of the insect pests on the smoked fish and recorded.

Data analysis

Simple percentage was used to analyze the total number of insect pests collected from each of the three species of fish used for the research. Data was processed using Microsoft excel, 2019th version.

RESULTS

The result of the insect pest species infesting some smoked fish in the study area is presented in the Table 1. On the general note, there were three main categories of insect species associated with smoked fish, these includes *Dermestis, Necrobia* and *Tribolium* spp, respectively. Tilapia species recorded the highest (50.85 %) insect infestation followed by *Synodontis* (26.27 %) while the least insect infested fish was *Clarias* spp (22.85 %). The occurrence of the insect pest species varies among the fishes examined. While in *Clarias, Tribolium* spp recorded highest infestation (77.78%) *Necrobia* was recorded highest (70.97%) in *Synodontis* spp. Also, the insect pest that showed highest infestation on the fish was *Tribolium* spp.

The result of the adult and larva occurrence and abundance in relation to the fish species they are associated with is presented in Table 2. The adult stage of the insect pest was found to be the most encountered with the smoked fish examined. On the other hand, the *Necrobium* larva was highest abundance of insect larvae recorded. The population of *Tribolium* was highest in the Tilapia spp followed by *Clarais* spp, while the least were observed in *Synodontis* spp.

Table 1: Infestation status and insect pest species associated with smoked fishes in Bida

Fish species	*Tribolium* spp (%)	*Dermestes* spp (%)	*Necrobia* spp (%)	Total insect (%)
Clarias spp	21(77.78) *	4 (14.81)	2 (7.41)	27 (22.88)
Gynodontis spp	3 (9.68)	6 (19.35)	22 (70.97)	31(26.88)
Tilapia spp	34 (56.67)	7 (11.67)	19 (31.67)	60 (50.85)

*Values in porentesis represent the percentage occurrence of the insect species

Table 2: Occurrence and abundance of adult and larva states of insect pest association with some smoked fish species

Fish species	*Tribolium* spp		*Dermestes* spp		Necrobia spp	
	Adult	Larva	Adult	Larva	Adul t	Larva
Clarias spp	20	1	4	0	1	1
Synodontis spp	3	0	3	3	14	8
Tilapia spp	34	0	7	0	11	8

Discussion

Insect infestation on food items has been well addressing as one of the limiting factors affecting food security. Despite the immeasurable health, social and economic benefit of fish and fish product, the fauna still suffers severe losses due to pest and pathogen infestation. [1] mentioned that insect infestation is mostly with dried fish.

In the current study, the most infested by the insect pest, among the examined fish species was Tilapia. There is possibility that the smoked Tilapia fish contained more suitable for the insect pest to drop their egg and/or larva compared to other fish spp examined. It is possible that the variation in the abundance of insect pest is due to the differences in their storage time. This is very possible since the smoked fish were purchased from sellers. In most time fish sellers buy in bulk and can only restock after selling the old stock. The increase in storage period could be the contributing factor that affords the insect pest enough time to breed and multiply in the fish host body [2]. This observation is in conformity with the report of [7].

The above observation was confirmed with abundance adult stage of the insect pest compare to the larval stage. By implication, the adult stage of insect pest implication will result into higher economic loss because they infest in high abundance and feed on the tissue of the fish [1,10,12].

CONCLUSION

The study recorded three species of insect pest associated with smoked fish in Bida metropolis. Tilapia was the fish spp that is mostly susceptible to insect pest infestation in the study area. The adult stage of the insect pest caused most of the damage. There is therefore need for more attention and concentration on preventing insect pest infestation of fish during processing and preservation.

REFERENCES

1. Singh, S. M., Siddhnath, R. B., Aziz, A., Pradhan, S., Chhaba, B., and Narinder, K. (2018). Insect infestation in dried fishes. *Journal of Entomology and ZoologyStudies*, *6*(2), 2720-2725.
2. Eyo, A. A. (2001). *Fish processing technology in the tropics*. National Institute for Freshwater Fisheries Research (NIFFR).
3. Akinwumi, F. O., Fasakin, E. A., and Adedire, C. O. (2007). Toxic and repellence activities of four plant extracts to Dermestes maculatus Degeer on smoked african mud catfish, Clarias gariepinus Burchell. *Journal of Entomology*, *4*(2), 149-154.
4. Amusan, A. A. S., and Okorie, T. G. (2002). The use of Piper guineense fruit oil (PFO) as protectant of dried fish against Dermestes maculatus (Degeer) infestation. *Global journal of pure and applied Sciences*, *8*(2), 197-202.
5. Ajayi, F. A., Audu, S. B., Usman, D. M., Keke, I. R., And Omoregie, E. (2006). Effect of insect infestation on nutritional quality of some smoked fish species in Jos, Nigeria. *Cameroon Journal of Experimental Biology*, *2*(01), 26-30.
6. Ashamo, M. O., and Ajayi, O. E. (2003). Effect of processing and storage methods on the shelf life and incidence of insect pests on smoked fish. *Global Journal of Pure and Applied Sciences*, *9*(3), 319-324.

7. Wahedi, J. A., and Kefas, M. (2013). Investigation of insect pests on three species of smoked fish in mubi north-eastern Nigeria. *Global Journal of Biology, Agriculture and Health Sciences*, *2*(3), 103-105.

8. Shuaibu, T., Majeed, Q., Bandiya, H. M., Argungu, L. A., Ibrahim, J. N., and Adeniyi, K. A. Evaluation of the ovicidal efficacy of some salts against hide beetle, Dermestes maculatus De Geer, fed on smoked fish.

9. Muhammad, S., Musa, H. D., and Akanbi, M. O. (2022). Waste Generation and Trend among Households in Bida Town.

10. Oliveira, C. M., Auad, A. M., Mendes, S. M., and Frizzas, M. R. (2013). Economic impact of exotic insect pests in Brazilian agriculture. *Journal of Applied Entomology*, *137*(1-2), 1-15.

11. Nowsad, A. K. M. A. (2005). Low cost processing of fish in coastal Bangladesh. *ECFC Field Doc. Food and Agricultural Organization of the United Nations, Dhaka*, 88.

12. Johnson, C., and Esser, J. (2005). *A review of insect infestation of Traditionally Processed Fish in the tropics.* Department for International Development, London. 92pp.