Available online www.unicrossjournals.com

UNICROSS JOURNAL OF SCIENCE AND TECHNOLOGY, UJOST

RESEARCH ARTICLE VOL. 3(1) MARCH 31, 2024 ISSN:2814-2233

Date Approved March 31, 2024 Pages 138 - 152

RELATIVE STUDY OF THE GONADO-SOMATIC INDEX (GSI) AND FECUNDITY OF AFRICAN CATFISH (*Clariasgariepinus*) FED VARYING INCLUSION LEVELS OF CHICKEN OFFAL BASED DIETS.

[1]Ayim, E. M. and [2]Obule, G. O

[1]Department of Animal and Environmental Biology, Faculty of Biological Sciences, University of Cross River State, Calabar, Nigeria.

[2]Department of Zoology and Environmental Biology, University of Calabar, Calabar, Nigeria

Corresponding author's E-mail address: ayimmonfung@yahoo.com

Abstract

This article centres on the study of gonado-somatic index (GSI) and fecundity of African Catfish (*Clarias gariepinus*) reared in concrete tanks and fed varying inclusion levels of Chicken offal-based diets for 22 weeks. Five experimental feeds were formulated (40% crude protein). The experimental feed was composed using locally available feed ingredients and formulated at 0 per cent (control), 25per cent, 50 per cent, 75 per cent and 100 per cent inclusion levels of Chicken offal. The experimental feeds were labelled: Feed A (0 per cent), Feed B (25 per cent), Feed C (50 per cent), Feed D (75 per cent) and Feed E (100 per cent). Proximate analysis of the experimental diets and the raw and parboiled Chicken offal was examined using standard scientific method at the Faculty of Agriculture Central Laboratory, University of Calabar, Calabar. *gariepinus* (n=300; mean length 8.12 ± 0.48cm and mean weight of 3.68±0.00g) were allotted to 15 rectangular tanks and fed experimental diets apparently at 5% body weight. Ganado-somatic indices and fecundity were studied using standard methods. The results indicated that fish fed with Diet C recorded significantly high values for mean gonad weight gain (3.66±0.21gand GSI value of 0.62±0.03% for male fish) and (21.00±6.65gand GSI value of 3.10±0.80% for female fish), mean fecundity (14700.00±4657.32in diet C) which was highest, the least mean fecundity was recorded in fish fed diet D (6066.66±617.34). Analysis of variance (ANOVA) showed that the male gonadosomatic indices such as; male gonad weight was not significantly different ($P>0.05$), but GSI values were observed to be significantly different ($P<0.05$) between the treatments. Male *C. gariepinus* gonadal maturation (development of genital papilla and spermatozoa) was visible at 16-18 weeks of culture, while for female *C. gariepinus*; ANOVA showed that the female gonad weight and GSI value were not significantly different ($P>0.05$) between the fish fed with the five experimental diets, fecundity was also not significantly different ($P>0.05$), between the fish fed with the experimental diets. The exceptional performance recorded at 50% inclusion level (Diet C) of chicken offal showed that the chicken offal could be favourably incorporated into the diet of *C. gariepinus* to boost gonad development and increase in fecundity.

Keywords: Chicken offal, African catfish, Gonads, Fecundity.

1.0 Introduction

Global prices of feed commodities have increased significantly during recent years. Secondly, the cost implication of establishing a standard commercial fish feed mill is very high. According to Ajang *et al.,* (2018) and Food and Agricultural Organization (FAO, 2018) a large amount of capital is required for setting up the initial infrastructure, machinery and subsequent operation of the mill. Over the years, aquaculture has taken over the use of fish meal as the best source of protein in aquafeed. But fish meal usage has faced serious competition with humans and livestock resulting in extremely high price for fish meal. (Ekanem *et al* 2010); In aquaculture, replacement of fish meal with plant protein or other animal protein sources such as; shrimp meal, maggot meal and chicken offal reduce the cost of production of the feed and the cost per kilogram of produced fish weight (Ajang *et al.,* 2018). Also, a comparative study on growth and gonad development of *C. gariepinus* fed on plant diet, *Moringa oleifera*, and animal-based ingredients in concrete tank produced positive effect (Ekanem *et al;* 2012). Currently, the use of invertebrate meal such as earthworm meal, maggot meal as protein source in fish feed is gaining world interest, especially as these insects face a reduced competition with humans as food, however, there are still very difficult to gather a reasonable quantity of the invertebrate meal for utilization in the formulation of fish feed. Chcken offal is another source of animal protein which has proven to boost growth in fish because of its high mineral contents (Ayim *et al.,* 2018). Chicken offal can be obtained from poultry slaughter houses in the local markets, however, there are highly sort for by humans as food. Research findings have shown that chicken offal protein can successfully replace fishmeal as alternative protein sources in fish and livestock feed without any negative impact on fish growth (Akwari and Ayim, 2023).

2.0 Materials and methods

2.1 Study area

The fish farm (Andem and Sons Fish Farm Limited) is located in Ca1abar South Local Government Area, Cross River State at (latitude 4.9340699, 4o56’ 2.6514’’N and longitude 8.3282381, 8o19’ 41.65716oE, Akwari and Ayim, 2023).

This is a privately owned farm with a capacity of 20 concrete tanks, 5 plastic tanks and 3 collapsible tanks). Calabar-South is a city in Cross River State, South-South, Nigeria. Calabar is situated at an elevation of 98 meters above sea level. It is the biggest city in Cross River, with an area of 406 km^2. Administratively, the city is divided into Calabar Municipal and Calabar South Local Government Areas. The state shares a common border with Cameroon to the East, Benue State to the north, Ebonyi and Abia States to the west and to the South by Akwa-Ibom State and the Atlantic Ocean.

2.2 Collection of chicken offal and other feed ingredients

Watt Market Chicken slaughter and Marian market broiler slaughter in Calabar, Cross River State, provided the chicken offal used in this study. To extract as much faecal material as possible, the freshly collected offal was thoroughly washed in water. After that, the chicken offal was par boiled for 20 minutes. It was allowed to cool before being oven-dried until it was required. The dried chicken offal was then weighed and ground to powder using an electrically driven grinder.

The feed ingredients for this research were bought from aquaculture feed stores and from Bogobri in Calabar. These ingredients include; fish meal (FM), wheat offal, soybean meal (SBM), bone meal, lysine, methionine, wheat flour, vitamin premix, sodium chloride (NaCl), and Chicken offal.

2.3 Preparation of experimental diets

Five isonitrogenous experimental feed were formulated using Pearson square method at 40 per cent crude protein level. The experimental feed was composed of fish meal (FM), wheat offal, soybean meal (SBM), bone meal, lysine, methionine, wheat flour, vitamin premix, sodium chloride (NaCl), palm oil and Chicken offal (Table 1).

The five experimental diets were formulated at 0 per cent (control), 25per cent, 50 per cent, 75 per cent and 100 per cent inclusion levels of Chicken offal. A control diet of fish meal, with fish meal serving as the only protein source was equally formulated. The five experimental feeds were labelled: Feed A (0 per cent), Feed B (25 per cent), Feed C (50 per cent), Feed D (75 per cent) and Feed E (100 per cent).

TABLE 1

Composition of experimental diets in percentages and in Grams Per Kilograms

Ingredients	Diet A (0%) Amount in g/kg	(%)	Diet B (25%) Amount in g/kg	(%)	Diet C (50%) Amount in g/kg	(%)	Diet D (75%) Amount in g/kg	(%)	Diet E (100%) Amount in g/kg	(%)
Chicken Offal (CO)	----------	----------	136	13.61	272	27.22	408	40.83	302	30.17
Fish meal (FM)	283	28.3	204	20.41	136	13.61	68	6.80	----------	----------
Soyabeans Meal (SBM)	283	28.3	204	20.41	136	13.61	68	6.80	302	30.17
Wheat Offal (WO)	192	19.9	203	20.27	203	20.27	203	20.27	173	17.32
Wheat Flour (WF)	192	19.9	203	20.27	203	20.27	203	20.27	173	17.32
Lysine	6	0.50	6	0.50	6	0.50	6	0.50	6	0.50
Methionine	6	0.50	6	0.50	6	0.50	6	0.50	6	0.50
Vitamin Premix	20	1.50	20	1.50	20	1.50	20	1.50	20	1.50
Bone ash/Calcium	8	0.50	8	0.50	8	0.50	8	0.50	8	0.50
NaCl	5	0.25	5	0.25	5	0.25	5	0.25	5	0.25
Palm Oil	5	0.35	5	0.35	5	0.35	5	0.35	5	0.35
Total		**100**		**100**		**100**		**100**		**100**

Experimental ingredients in g/kg and their per cent inclusion levels (Akwari and Ayim, 2023)

2.4 Proximate analysis of the experimental feed

Proximate analysis of the test diets, and that of the raw and parboiled chicken offal were performed according to AOAC (2000), in the Faculty of Agriculture Central Laboratory, University of Calabar, Calabar. The moisture content, crude protein, lipids content, ash and carbohydrate contents were analyzed by the following methods:

2.4.1 Determination of moisture level

A neat crucible was subjected to drying in an oven to a constant weight (a) before introducing a quantity of sample into a beaker, then weighed (b). Next, the sample was dried inside a ventilated heated oven that was powered electrically at 75^{o}C for 24 hours, then allowed to cool in a desiccator, then weighed. The procedure was repeated until a constant weight (c) was reached. Same procedure was repeated three times for each sample. The percentage moisture level was mathematically calculated using the formula:

% moisture content = $\frac{b-c}{b-a} x\ 100\%$

2.4.2 Ash content

The crucible was ignited at 550^{o}C for 3 hours, cooled and weighed. Five grams (5g) of the sample was placed in the crucible and weighed. And burnt at 550^{o}C for a day, cooled then weighed. Same procedure was carried out over and over again until a constant weight was obtained. The calculation of percentage ash content followed the formula as shown below:

% Ash content = $\frac{wtofash}{wtofsample} x\ 100$

2.4.3 Crude fat or ether extract

About five grams (5g) of the sample was weighed and put in a thimble. 120 ml of petroleum ether was emptied into an earlier dried and weighed round bottom flask. An extractor known as the Soxhlet extractor into which the thimbles and its content had been introduced, sooner became fitted into the spherical bottom flask and the condenser together with the extraction apparatus was set up with the flask sitting on the spaces provided on the hot plate. The hot plate was set to gentle heat. With tap on, the ether evaporated and as it condensed, dropping into a thimble from where it extracted the soluble ether contents into a round bottom flask. The process continued for 10 hours, the thimble was removed and dried in the air (later the fat from the extract was utilize for the determination of fibre). Then, petroleum ether present in the flask was distilled off and received in the Soxhlet extractor tube. Drying of the flask was carried out in an air circulating desiccator for two days. The circular bottom flask with the lipid extract inside was then weighed. The content inside the flask was dried and weighed to a constant weight. The lipid quantity that was obtained from the difference between the flask weight previously measured and later-on was obtained as shown below:

% Ether Extract = $\frac{wtofextract}{wtofsample} x\ 100$

2.4.4 Crude fibre

For acid digestion, the fat free material (8-10g) was weighed and transferred into a 400ml beaker that has previously been marked at 200 ml level. 50 ml

sulphuric acid i: e (1.25 per cent) was added and the mixture rose to 200 ml marked. The beaker together with the content was heated to a boiling point for half an hour. The content of the beaker was then filtered through a Buchner funnel with the aid of a suction pump. The residue was washed with hot water until it was acid free. For base digestion, the residue left after acid digestion was transferred into 400 ml beaker. The mixture was again heated for 30 minutes with constant stirring. The content of the beaker was filtered through the Buchner funnel and washed several times with hot water until it was free from sodium hydroxide. Finally, the residue was washed twice with 95 per cent methanol, quantitatively transferred into a porcelain crucible and dried at 100^{o}C. The weight of the dry residue was noted, and the residue ignited in a furnace at 550^{o}C. The weight of the ash left after ignition was also noted. The crude fibre content was determined from the loss in weight of crucible and its content after ignition

2.4.5 Crude protein estimation (6.25 x N) micro kheljahl method

1g of the sample powder was measured for weight into 50 ml digestive Kjeldahl flask. About 20 ml conc. H_2SO_4, 1 tablet of Kjeldahl catalyst and a pinch of anti bumbing chips included. Same mixture sample was incinerated into a slowly boiling digestion rock, it was then subjected to strong heating till the digest appeared clear, then heated for a further 3 hours. The digest at this point was removed and allowed to get cooled, then certain amount of a known quantity was transferred into 100 ml volumetric flask up to a required point. The Erlenmeyer flask with 100 ml of boric acid solution indicator was placed on the tip of the condenser unit of the distillation apparatus (which had been steam washed) so that the condenser tip extended below the upper layer of the solution. Then 10 ml of the digest sample was put into the dums sample tube and made to undergo steam heating. 10 ml NaOH solution at 40 per cent was included in the digest and steam distilled into the Erlenmeyer flask till the content increased more than double its original quantity. As the ammonia distilled into the boric acid indicator solution, it transformed into green. A black determination was conducted in a same manner as highlighted above, exception that here, the digestion sample was substituted by 0.1 ml of distilled H_2O. The sample inside the Erlenmeyer flask was subjected to titration with 0.1 NH_4Cl to arrive at pink end. Percentage protein was calculated as shown below:

% protein = (MI HCI (test) – MI HCI (BLANK)) X normality of acid x $\frac{1.4}{1000} x \frac{100}{10}$x 6.25 x $\frac{100}{0.1}$

2.5 Experimental set up

This research was carried out using 15 square shaped concrete tanks of equal size measuring 120 by 90 by 120 cm. It consisted of five (5) treatments (done in triplicates): Treatment 1, served as the control with the test organisms fed with a diet formulated without chicken offal, while the other sets of fish were fed with feeds formulated with local ingredients

using chicken offal at varying levels, formed treatments 2, 3, 4 and 5. To aid replication of treatments, the tanks were labeled A_1, A_2, A_3, B_1, B_2, B_3, C_1, C_2, C_3, D_1, D_2, D_3, E_1, E_2 and E_3. A sum of 300 *C. gariepinus* fingerlings, ranging in age from 5 to 6 weeks, were purchased from the University of Calabar fish farm and stocked in each of the 15 experimental units (20 in each unit). Prior to the start of the feeding trials, the stocked fish were acclimated for fourteen days. The fish were fed twice daily to satiation during the acclimation time. The acclimated fish were starved for 24 hours before the feeding trial began, during which the average initial wet body weight of the fish in each experimental unit was measured using a METLAR MT-5000D electronic balance to the nearest gram (Eyo and Ekanem, 2011). Biweekly measurements of body parameters including total length (TL) and total weight (TW) were taken. Total length was measured using a measuring board from the snout to the base of the caudal fin rays, to the nearest 0.1 cm, and fish bulk weight was measured to the nearest 0.1g**.**

2.6 Feeding of experimental fish

The experimental fish were fed to satiation at the rate of 5 per cent of their body weight in 2 rations. The quantity of feed per day was determined using the formula:

$$F= \frac{W \times S \times P \quad Kg/tank/day}{1000\ X\ 100}$$

Where, F= weight of feed to be applied per tank daily

W= Average weight of fish obtained by random sampling

S= Stocking density (Total number of fish stock per tank)

P=Percentage of body weight (5 per cent).

The total quantity of feed per tank was determined by multiplying the quantity of feed/day by the number of days fish were fed that quantity and then adding up the result, (quantity of feed changed every 14 days as the fish in each tank attained new body weights).

2.7 Examination of fish gonads and fecundity estimation

2.7.1 Gonadosomatic index and gonad gross morphology of fish fed the experimental diets

At the end of the experiment, the fish was harvested and sorted according to sex and treatment to avoid mix up. External features (elongated genital papilla for males, round serrated opening for females) and internal features (gonad) were used to differentiate the sexes. For each specimen, the following body parameters were measured: total length (TL), total weight (TW), and gonad weight (GW). The gonadosomatic index (GSI) was used to assess gonadal development, and it was computed as follows according to Bolger and Connolly (1989):

$$GSI=\frac{g1}{g2} X\ 100$$ ……Bolger and Connolly (1989)

Where: GSI = Gonadosomatic index

g1 = Gonad weight (g)

g2 = Whole fish weight (g))

2.7.2 Fecundity estimation

Fecundity was estimated according to Viveen *et al.,* (1985) by multiplying the

weight of the egg mass by number of eggs per gram of egg mass.

2.8 Statistical analysis

Data obtained from the experiments was subjected to Analysis of Variance to test for significant difference in fish fed the five experimental diets using Predictive Analytical Software (PASW) windows software program for statistical analysis (version 18.0). This analysis was conducted at 95% confidence level ($P<0.05$).

3.0 Results

3.1 Proximate composition of raw chicken offal, parboiled chicken offal and the experimental diets.

Results obtained for the proximate composition of the chicken offal (in raw and parboiled forms) and the experimental diets analyzed included crude protein, crude lipid, crude fat, moisture content, ash and nitrogen free extract (NFE) as shown in Table 2 and 3. For the proximate composition of the Chicken offal, the raw offal contained a mean crude protein of 57.89 ± 0.62 per cent, mean fat was 5.11 ± 0.07, mean crude fibre was 0.00 ± 0.00 per cent, mean ash 12.223 ± 0.27 per cent, mean moisture was 8.38±0.35 per cent, mean NFE was 14.47 ± 0.28 per cent. The parboiled offal contained a mean crude protein of 61.80 ± 0.93 per cent), mean fat 7.83 ± 0.88, mean crude fibre 0.16 ± 0.12 per cent, mean ash 13.09 ± 0.10 per cent, mean moisture 7.20±0.11 per cent, mean NFE 7.84 ± 0.10 per cent.

The proximate composition of the experimental diets was as follows; mean crude protein was higher in diet A with a value of 38.05 ± 0.29 per cent and lowest crude protein level was recorded in diet D with a mean value of 36.75±0.82. Ether extract was also higher in diet A (10.03±0.13) and the lowest was recorded in diet E (7.82±0.13), others fell between these extremes respectively. Fibre was higher in diet A and lower in diet E. Ash was higher in diet A (6.99±0.06per cent) and lower in diet E (4.98±0.07), others fell between these extremes respectively. Mean moisture was higher in diet D (12.41±0.20per cent), and lower in diet C (7.59±0.28). mean NFE was higher in diet C (34.56±0.96 per cent), the lowest NFE value was recorded in diet A (31.03±0.72), others fell between these two extremes respectively. Statistical analysis revealed that the difference in mean crude protein (per cent) and NFE (per cent) between the experimental diets were not statistically significant (ANOVA, $P > 0.05$), but there was a significant difference statistically in ether extract, crude fibre, crude ash and crude moisture content between the experimental diets (ANOVA, $P<0.05$).

TABLE 2

Mean proximate indices of raw and parboiled offal (%)

Indices	Raw Offal	Parboiled Offal
Protein	57.89±0.62	61.80±0.93
Fat	5.11±0.07	7.83±0.88
Fibre	0.00±0.00	0.16±0.12
Ash	12.23±0.27	13.09±0.10
Moisture	8.38±0.35	7.20±0.11
NFE	14.47±0.28	7.84±0.10

Values represent the mean and standard error for three determinations

TABLE 3

Mean proximate composition of experimental diets (%)

Indices	Diet A	Diet B	Diet C	Diet D	Diet E	P-values
Crude protein	38.05±0.29^{a}	37.35±0.57^{a}	37.49±0.47^{a}	36.75±0.82^{a}	37.80±0.08^{a}	0.490
Ether extract	10.03±0.13^{a}	9.60±0.37^{b}	9.25±0.28^{c}	8.26±0.12^{d}	7.82±0.13^{e}	0.000
Fibre	5.08±0.04^{a}	4.99±0.07^{b}	4.83±0.09^{c}	4.53±0.19^{d}	4.36±0.15^{e}	0.010
Ash	6.99±0.06^{a}	6.23±0.18^{b}	6.26±0.09^{c}	5.24±0.19^{d}	4.98±0.07^{e}	0.00
Moisture	8.80±0.37^{a}	8.12±0.07^{b}	7.59±0.28^{c}	12.41±0.20^{d}	12.02±0.45^{e}	0.00
NFE	31.03±0.72^{a}	33.69±0.93^{a}	34.56±0.96^{a}	32.78±1.04^{a}	32.99±0.54^{a}	0.130

Values represent the mean and standard error for three determinations and mean with the same superscript are not significantly different (P>0.05)

3.2 Mean gonadosomatic indices (GSI) and fecundity of *C. gariepinus* fed experimental diets

Mean gonadosomatic indices (Table 4) of C. *gariepinus* administered the study diets showed that male *C. gariepinus* fed diet A recorded the highest mean length of 44.71±0.97 cm, weight of 708.83±21.07 g, the lowest mean total length and weight was recorded in fish fed diet D to be 41.70±1.18cm and 525.83±53.70g. The mean weight of male fish gonad was higher in fish fed diet C 3.66±0.21 g and a GSI mean value of 0.62±0.03 per cent, the lowest gonad weight and GSI value was recorded in male fish fed diet A and B 3.16±0.47 g and 3.16±0.30 g

respectively for gonad weight, GSI of 0.44±0.06% and 0.47±0.04% respectively were recorded.Analysis of Variance (ANOVA) showed that the male gonadosomatic indices such as; male total length and male gonad weight were not significantly different ((P>0.05), but, male total weight and GSI value were observed to be significantly different (P<0.05).

Female *C. gariepinus* fed diet A had the highest mean total length of 44.70 ± 1.38 cm, the least mean length was recorded in female fish fed diet E(37.20±1.90g). Female fish fed diet B had a mean weight of 722.50 ± 19.98 g, the lowest mean weight was recorded in fish fed diet E(464.83±32.83 g), others fell between this extremes respectively. Female fish fed diet C recorded weight of gonad to be 21.00 ± 6.65 g and a GSI value of 3.10 ± 0.80 per cent. The lowest gonad weight and GSI value was observed in female fish fed diet D with a mean gonad weight of 8.66 ± 0.88 g and a GSI value of 1.82 ± 0.16 per cent, others fell between these extremes respectively. Analysis of Variance (ANOVA) showed that the female gonadosomatic indices (GSI) such as; female gonad weight and GSI value were observed to be significantly different (P<0.05) between the fish fed with the five experimental diets. Fecundity of fish reared with the experimental diets (Table, 4) was highest (14700.00±4657.32 eggs) in fish fed diet C (50 per cent inclusion level), followed by fish fed feed A (0 per cent inclusion level) with a mean and standard error figure of 12716.66±1218.03 eggs, and least in fish fed Feed D with a value of 6066.66±617.34 eggs. ANOVA indicated that the fecundity was not significantly different ((P>0.05), between the fish fed with the experimental diet.

TABLE 4

Mean gonadosomatic indices and fecundity of C. gariepinus fed experimental diets

Gonad Indices	Diet A (0%)	Diet B (25%)	Diet C (50%)	Diet D (75%)	Diet E (100%)	P-values
Male Total Length (cm)	44.71± 0.97a	43.58±1. 47a	42.76± 1.24a	41.70± 1.18a	42.30± 1.17a	0.464
Male Total Weight (g)	708.83 ±21.07 a	669.16± 20.10b	588.66 ±30.84 c	525.83 ±53.70 d	597.66 ±23.29 e	0.005
Male Gonad Weight (g)	3.16±0. 47a	3.16±0.3 0a	3.66±0. 21a	3.50±0. 42a	3.50±0. 22a	0.795
Male GSI (%)	0.44±0. 06a	0.47±0.0 4b	0.62±0. 03c	0.66±0. 04d	0.59±0. 04e	0.007
Female Total Length (cm)	44.70± 1.38a	43.66±1. 03b	42.45± 1.23c	39.23± 1.55d	37.20± 1.90e	0.006

Female Total Weight (g)	643.66 ±34.37 a	722.50± 19.98b	643.66 ±27.29 c	478.33 ±31.10 d	464.83 ±32.83 e	0.000
Female Gonad Weight (g)	18.16± 1.74a	15.16±1. 66a	21.00± 6.65a	8.66±0. 88a	11.50± 1.23a	0.082
Female GSI (%)	2.81±0. 19a	2.07±0.1 8a	3.10±0. 80a	1.82±0. 16a	2.46±0. 20a	0.174
Mean Fecundity	12716. 66±121 8.03a	10616.6 6±1163. 16a	14700. 00±465 7.32a	6066.6 6±617. 34a	8050.0 0±862. 07a	0.082

* Values represents the mean of the triplicate experimental units and mean with the same superscript are not significantly different (P>0.05)

4.0 DISCUSSION

In this research, the discoveries proved that the use of high-quality feeds is critical for *C. gariepinus* gonad growth and development. The germ cell can divide into ripe male and female gametes because of the microenvironment created by gonads. Adult fish spermatogonia and oogonia differentiate into mature spermatozoa and sperm cells, according to Guraya (1994). The undifferentiated gonad in fish includes all of the cell types necessary for it to grow into either a testis or an ovary before sex differentiation (Francis, 1992). *C. gariepinus* formed gonads (matured) between 6 and 8 months in a standard outdoor square-like concrete tank with normal phyicochemical characteristics such as pH, dissolved oxygen, and water temperature, as suggested by Boyd (1975) for fresh water fish culture. Temperature, photoperiod, food supply, dissolved oxygen, disease (parasites), and other environmental factors have been found to affect gametogenesis (the mechanism by which gametes (sperm and eggs) are formed from the gonia of matured gonads during the reproductive cycle) in fish (Maitra, 1997). As a result, effective management is critical for long-term aquaculture, especially in terms of broodstock egg and larval quality management (Bromage and Roberts, 1995).

In the present study, Mean gonadosomatic indices of C. *gariepinus* administered the study diets showed that male fish administered diet C had the highest mean weight of gonad 3.66±0.21 g and a GS1 mean va1ue of 0.62±0.03 %. Analysis of Variance (ANOVA) showed that the male gonadosomatic indices such as; male gonad weight was not significantly different ((P>0.05), but GSI value were observed to be significantly different (P<0.05) between the treatments. Male *C. gariepinus* gonadal maturation (development of genital papilla and spermatozoa) was visible at 16-18 weeks of culture. Early maturation in fish can be accomplished primarily by better nutrition or genetic selection, according to Le Bail (1996), this implies that the experimental diets were balanced in composition and supported all round growth and development of the experimental fish.

Fema1e *C. gariepinus* fed diet C also had a better mean gonad weight of 21.00 ± 6.65 g and a GSI value of 3.10 ± 0.80 per cent. Analysis of Variance (ANOVA) showed that the female gonadosomatic indices such as; female gonad weight and GSI value were significantly different (P<0.05) between the fish fed with the five experimental diets.

It was observed in both male and female fish fed the five experimental diets that body size had no effect on gonad development; these results are alike to those of Schulz *et al.*, (1994), who stated that maturity is linked to age in *C.gariepinus*, on the other hand, disagrees with Cek and Yilmaz (2005), who found the opposite (i.e maturity is linked to size rather than age).

Sotolu and Kigbu (2011) suggested that the dietary protein level in catfish diets be increased to 40% for good gonadal growth, adding that dietary protein level can influence catfish broodstock output. According to Ajang *et al*., (2018), rising dietary crude protein content resulted in higher fish egg weight values. The five isonitrogenous (40 percent crude protein)

experimental diets used by the experimental fish are shown in the (FCR) and (FCE). The experimental fish's consumption of these experimental feeds induced early maturation, as evidenced by their gonadal growth. This is in line with the assertion of Sotolu and Kigbu (2011), Eyo and Ekanem (2011), who in their studies stated that nutrients are a cornerstone for growth and should be digested and ingested in a way that allows them to be used for energy production, growth and development. Fecundity which is the number of eggs carried by a female gravid fish, is an important aspect of fish farming that focuses on their reproductive capacity. The amount of eggs of *C. gariepinus* fed with the experimental diets was found to be the maximum in the current study (14700.00±4657.32 eggs) in fish fed diet C (50 per cent inclusion level), followed by fish fed feed A (0 per cent inclusion level) with a mean and standard error figure of 12716.66±1218.03 eggs and 1east in fish fed Feed D with a value of 6066.66±617.34 eggs, ANOVA showed that the fecundity was not significantly different ((P>0.05), between the fish fed with the experimental diets, this is attributed to the balance nature of the experimental diets and the sufficient quantity of feed fed to the experimental fish which ensured rapid growth and early maturity of the fish.

It is well documented that assessing fecundity and fish gonad growth aids in determining the reproductive capacity of individual fish species (Shalloof and Salama, 2008).

5.0 Conclusion and recommendation

The cultivation of certain species of fish, including *Clarias gariepinus* has been found to be a safe and easy way of meeting the protein demands of the world's teeming population. Though this practice in Africa is at a minimal level of production, it is becoming popular in Nigeria. And one of the major constraints to aquaculture is feed, which can take up to 60-70% of the overall cost of fish production (Ajang *et al*., 2018).

This research has shown that using locally available agricultural raw materials with varying inclusion levels of chicken offal, to formulate fish feed can reduce the cost of aquaculture production and still give a very good result in terms of growth of the fish. The feeds formulated from these ingredients at varying levels of inclusion of Chicken offal and fish meal was found to compete favourably with each other in their GR and SGR respectively.

The formulated feeds with locally available ingredients were iso-nitogeous (at about 40 per cent protein content) and therefore suitable for feeding juveniles as well as adult fish, and the economic analysis shows that it is more economically beneficial feeding fish with locally formulated feeds using chicken offal at varying inclusion levels. And feeding the fish with locally formulated feeds was without negative influence on fish well-being.

Considering the large size of the chicken market within Calabar metropolis and its immediate environment and the high demand for chicken by consumers supported by an all-year-round availability of raw materials for fish feed formulation, farmers can willingly and freely collect offal from the local markets, and from individuals who slaughter and supply chicken to hotels within Calabar metropolis and use them at varying inclusion rates in the formulation of feeds for fish as this will assist to reduce cost of fish production and offer employment to the teeming Nigerian population.

References

Akwari, A. A., & Ayim, E. M. (2023). Haematological responses of replacement levels of fish meal with chicken offal in catfish (Clarias gariepinus) diets. Journal of *Animal Science and Veterinary Medicine*, 8(4), 125-130.

Ajang, R. O., Joseph, A. P., Ivon, E. A. & Ayim, E. M., (2018). Comparative Evaluation of the Reproductive Indices and Gonadal Development of *Clarias* gariepinus Fed Chicken Offal and Shrimp Based Diets. *Asian Journal of Biology*, 7(2), 1-13

AOAC (2000). Association of Official Analytical Chemist Official Methods of analysis. 15th edition, Washington, DC.

Ayim, E. M., Ivon, E. A., Ajang, R. O., & Joseph, A. P., (2018). Comparative Assessment of Growth Performance and Nutrients Utilization of African Catfish (*Clarias gariepinus*, Burchell 1882) Fed Chicken Offal and Shrimp-Based Diets. Annual *Research and Review in Biology*.30(5), 1-11, 201

Bolger, J. & Connolly, P. L. (1989). The selection of suitable indices for the measurement and analysis of fish condition. *Journal of Fish Biology, 34, 171-182.*

Boyd, C. E. (1979). Water Quality in Warmwater Fish Ponds.Auburn University Agriculture Experiment Station, Auburn, Alabama.

Bromage, N. (1975). Broodstock Management and Seed Quality-General Considerations In: Bromage, N.R, Roberts, R.J. (Editor), Broodstock Management and Egg and Larval Quality University Press, Cambridge, UK, 1-24.

Cek, S. & Yilmaz E. (2007) Gonad Development and sex ratio of sharptooth catfish (*Clarias gariepinus* Burchell, 1822) cultured under laboratory conditions. *Turkey Journal of Zoology*,31, 35-46

Ekanem, A. P., Victor, O. E., Austin, I. O., Udeme, I. E. & Udo, P. J. (2012). Growth performance and food utilization of the African catfish (*Clarias gariepinus*) fed Unical. Aqua feed and coppens commercial feed. *Journal of Marine Biology and Oceanography.* 1, 2 – 5.

Ekanem, A.P., Eyo, V. O. & Ndome, C. B. (2010) The effect of diet with different inclusion level of cassava leaf meal (CLM) *Manihot utilissima* on the growth performance of Heteroclarias fingerlings. *Journal of Science and Multidisciplinary Research, 2(1),* 58-67

Eyo, V. O. & Ekanem, A. P. (2011). Effect of feeding frequency on the growth, food utilization and survival of African catfish (*Clarias gariepinus*) using locally formulated diet. *African Journal of Environmental Pollution and Health 9* (2), 11-17.

FAO (2018). Food and Agriculture – The state of world fisheries and aquaculture. Meeting the sustainable development goals. 227pp. Rome, Italy.

Guraya, S.S., (1994). Gonadal development and production of gametes in fish; Proceedings of *Indian National Science Academy*, 60, 15-32

Le Bail, P. Y., (1996). Growth-reproduction interaction in salmonids. In: (Eds. Y. Zohar and B. Breton) *Reproduction in fish, basic and applied aspects in endocrinology and genetics*. Paris, *Les Colloques de IOINRA*, pp91-107

Maitra, S. K. (1997). Frontiers in Environmental and Metabolic Endocrinology (Burdwan, West Bengal: The University of Burdwan).

Schulz, R.W., Van der Corput, L., Janssen-Dommerholt, J. & Goos, H.J.Th. (1994) Sexual steroids during puberty in male African catfish (*Clarias gariepinus*): serum levels and gonadotropin stimulated testicular secretion in vitro. *Journal of Comparative Physiology* 164, 195-205.

Shalloof, K.A.S & Salama, H. M. M. (2008). Investigation on some aspects of reproductive biology in *Oreochromis niloticus* (Linnaeus, 1757) inhabited Abu-zabal Lake, Egypt. *Global Veterinaria*, 2 (6), 351-359.

Sotolu, A. O. & Kigbu, A. A. (2011). Growth and Gonad Quality of *Clarias gariepinus* (Burchell, 1822) Broodstock Fed Varying Dietary Protein Levels. *Pakistan Journal of Aquaculture*, *7* (2), 61-67.

Viveen, W. J., Richter, A R., Van-Oordt, P. G. Jansen, J. A. & Huisman Z. A. (1985). Practical manual for the culture of African catfish *Ciarias gariepinus*- The Netherlands ministry for development co-operation, section for research and technology. The Hague, 122.