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Effects of Weevil Infested Feed on the Fecundity and Gonadal Development of the African Catfish *Clarias gariepinus* (BURCHELL 1822)

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Abstract

This study was carried out for 126 days to evaluate the effects of weevil infested feed on the fecundity and gonadal development of the African Catfish *Clarias gariepinus*. Six (6) tarpaulin tanks (100 by 80 by 100 cm^3) were stocked randomly with twenty (20) healthy post fingerlings of *C. gariepinus* with a mean initial bulk body weight 320.58 ± 1.24 g and total length 11.62 ± 0.36 cm. Coppens feed (42% crude protein) was divided into two groups including group A (control feed) and group B (weevil infested feed) and fed to the experimental fishes in triplicate group twice daily at 8.00 am and 4.00 pm at 3% of their body weight. Results showed a significant deterioration (P<0.05) in the proximate composition of weevil infested feed compared to the control feed. Mean fecundity of fish fed the control diet (27,440 ± 670.03 eggs) was significantly higher (P<0.05) than fish fed weevil infested feed (19,100 ± 650.00 eggs). A linear relationship and positive significant correlation (P>0.05) were obtained between fecundity of *C. gariepinus* fed the two diets and body parameters (total length, body weight, ovary weight, and mean egg diameter) except total length and total weight of fish fed weevil infested feed which showed a negative significant (P<0.05) relationship. Mean female gonad weight, female GSI and male gonad weight of fish fed the control was significantly better (P < 0.05) than fish fed weevil infested feed whereas male GSI showed no significant (P > 0.05) variation. Histological examination showed that the interstitial cells of the testes and oocytes were fully matured and normally distributed Based on these findings, infestation of weevil in fish feed may lead to loss or deterioration of feed condition, quality, palatability, odor, and taste which may affect feed acceptability. It is concluded that to obtain high fecundity and a better gonad development, weevil infested feed should be avoided. Feed should be stored in a good hygienic and sanitary conditions and infested feed should be destroyed with a serious implementation of sanitation and prevention practices to prevent the infestation from recurrence.

Keywords: Weevil Infested Feed; Fecundity; Gonadal Development; *Clarias gariepinus*; Oocytes; Testes.

1. Introduction

Fish and fisheries products are highly rich in essential micronutrients [1] and serves globally as a useful supplement in diets lacking essential protein, vitamins, and minerals. The global demand for fish protein is driven by an increasing global population, increasing awareness of the health benefits of consumption of fish and other aquatic products and steady decline in capture fisheries. Majority of fish farmers in Nigeria cultivate the African catfish (*Clarias gariepinus*) which is a member of the family Clariidae compared to other species. This preference is attributed to its speedy growth and gonad formation in artificial culture environment, excessive fecundity, ability to tolerate a fluctuation in environmental conditions, high immunity and disease resistance, acceptability of artificially compounded feed, good taste, flavour and meat quality, ease of artificial seed production and excellent market value [2]. Fecundity which describes the number of eggs in the ovary of a gravid fish is useful in the assessment of fish stock, size of standing stock, exploited stock prediction, eggs and early life stages study, recruitment of back shell and fin fish species [3].]. Information of fecundity is carefully considered during selection of fish species for aquaculture purpose [4]. Gonad is the reproductive organ where germ cells differentiate into female and male gamete [5].

Gonad development in fish which could be assessed by and gonad gross morphology is useful in evaluation

values of gonadosomatic index, gonad weight of fish maturity, reproductive capacity, and success of fish. Aquaculture feed being a major input in fish production accounts for about 70 % of the gross production cost [2], [6], [7], [8] and [9]. One of the threats undermining the growth of aquaculture in Nigeria is ineffective management of aquaculture feed such as poor storage and unhygienic conditions leading to insect infestation on the feed. Presently, the impact of global pandemic (Covid-19), unstable and fragile Nigerian economy has resulted on importation restriction of goods and services such as foreign feed. However, fish feed importers that have clearance to import undergo strict and difficult screening and highly expensive procedures for their goods. Upon arrival of these foreign feeds, farmers already facing feed scarcity prefer to buy and store large quantity of that could be used for more than one production cycle. The presence of feeding pest species such as insects and rodents in feed storage area is often overlooked by many farmers but could pose a very serious health and financial risk to the cultured fish and fish farmer. The feeding activities of these pests could result in contamination and deterioration in the nutrient quality of infested feed. Warehouse beetles and grain weevil can bore through feed sacks, providing an entry point for other insect and may also expose the feed to air penetration. According to [3], harmful compounds and allergens are produced by these pests during feeding which contaminate the grains. Apart from consuming feed, these pests also create suitable environmental storage condition that could promote the growth of mold. Moreover, these pests could serve as potential vectors for transmission of diseases to fish and human. Fecundity and gonad formation in different fish species has been documented to be negatively or positively impacted by feed quality [2], [6], [10], [11], [12], [13] and [15]. Presently, literature review shows paucity of information on the effects of weevil infested fish feed on fish reproductive biology such as fecundity and gonad development. Therefore, the aim of this study is to evaluate the effects of weevil infested feed on the fecundity and gonad development of the African Catfish (*C. gariepinus*).

2. Materials and Methods

2.1. Experimental Feed

In this study, 2 mm size of Coppens feed containing 42% crude protein was used as the experimental feed. The experimental feed was purchased from a fish feed outlet in Calabar, Cross River State, Nigeria. The feed was divided into two groups, group A and group B. Group A was the control feed and group B was exposed to weevil infestation.

2.2. Collection and Introduction of Weevil into the Experimental Feed

Adult unsexed weevils of between one and fifteen days were collected from infested grains such as maize and cultured in the laboratory and in a plastic bucket containing 3 kg of Coppens feed. A total of 150 weevils were introduced into the plastic bucket containing the feed. Thereafter, muslin cloth and rubber band was used in covering the bucket to prevent the weevils from escaping. The weevils were allowed to infest the feed for 7 days.

2.3. Proximate Analysis of Experimental Diets

Proximate analysis of the two experimental diets was performed according to [15], in the Faculty of Agriculture Central Laboratory, University of Calabar. The moisture content, crude protein, lipids content, ash and carbohydrate contents was analyzed as shown in **(table 1)**.

Table 1: Proximate Analysis of the dry matter (mg/100 g) of the experimental feed

Proximate Indices	Feed A (Control)	Feed B (Weevil Infested Feed)
Crude Protein	41.18 ± 0.02[a]	34.26 ± 0.03[b]
Crude Fat	7.82 ± 0.01[a]	6.41 ± 0.01[b]
Moisture	5.60 ± 0.03[a]	5.02 ± 0.02[b]
Ash	1.64 ± 0.02[a]	1.75 ± 0.02[b]
Lipid	2.63 ± 0.01[a]	2.44 ± 0.03[b]
NFE	41.13 ± 0.02[a]	50.12 ± 0.02[b]

WIF = Weevil infested feed, NFE = Nitrogen free extract. Mean with different superscript are significantly different ($P<0.05$)

2.4. Experimental Design

This study was carried out for 126 days using 6 tarpaulin units measuring 100 by 80 by 100 cm. The 6 tarpaulin units were labelled A_1, A_2, A_3, B_1, B_2 and B_3 to aid triplication of the experiment. A total of 120 healthy post fingerlings of *C. gariepinus* was purchased from the University of Calabar fish farm and stocked in each of the 6 experimental units (15 in each unit). The stocked fish were acclimated for 14 days before the start of the feeding experiment. During the acclimation period the fish were fed twice daily to satiation with Coppens feed. At the start of the experiment, the acclimated fish were starved for 24 hours. Thereafter, 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 [8]. Fish in units A_1, A_2 and A_3 were fed Feed A (control) and fish in units B_1, B_2 and B_3 were fed Feed B (weevil infested feed).The experimental fishes were fed twice daily 9.00 am and 5.00 pm at 3 % of their body weight. Total length (TL-cm) and total weight (TW-g) were measured fortnightly. Total length was measured from snout to the base of the caudal fin rays to the nearest 0.1 cm using measuring board while fish bulk weight was measured to the nearest 0.1 g using Metlar-2000D electronic weighing balance.

2.5. Estimation of Fecundity

Fecundity was estimated according to [16] by multiplying the weight of the egg mass by number of egg per gram of egg mass. All the females fed the different experimental diets were collected and used for fecundity estimation. Before counting the eggs, the total length (TL-cm), total weight (TW-g) and Ovary weight (OW-g) were measured. The fishes were carefully dissected to remove the ovary for measurement of the ovary weight using Metlar-2000D electronic balance. Sub-samples of the ovary (1 g) was cut off from different parts of the ovary (posterior, middle and anterior part) and preserved in Gilson fluid to harden the tissues for easy separation and counting of the eggs. Forty (40) fresh eggs were randomly collected from the ovaries of each fish for measurement of egg diameter using a stereo microscope with ocular eye piece. For the pear-shaped eggs, the mean diameters of the long and short axes was taken as the diameter of the oocyte.

2.6. Gonadosomatic Index Calculation (GSI-%)

Gonasomatic index (GSI) and was calculated according to [17] as follows:

GSI = (Gonad weight (g)/ Whole fish weight (g))*100

2.7. Gonad Gross Morphology of Fish Fed the Experimental Diets

For gonad gross morphology, the male testis and female ovary of fish from the two experimental units were subjected to histological analysis. The gonad were fixed in Bouin's fluid for 48 hours, manually processed and sectioned at 10 µ with a rotary microtome, dewaxed in xylene, stained with haematoxylin and eosin standard method [18] for microscopic examinations.

2.8. Measurement of Physico-Chemical Parameters in Tarpaulin Units

Water quality parameters of the fish tanks were measured bi-weekly throughout the experimental period. The parameters include dissolved oxygen (mg/L), pH, temperature (˚C) and ammonia (mg/L). Dissolved oxygen was measured using oxygen meter, pH was measured with pH meter and temperature was measured with mercury in glass thermometer.

2.9. Statistical Analysis

Student's T-test was used to test the experimental data for significance using Predictive Analytical Software (PASW) windows software program for statistical analysis (version 18.0). Effects with a probability of ($P<0.05$) was considered significant. Correlation and regression analyses was used to determine the relationship between fecundity and body parameters of fish fed the two experimental diets using Microsoft excel program (2013).

3. Results

3.1. Fecundity of *C. gariepinus* Fed the Experimental Diet

Fecundity of *C. gariepinus* fedthe experimental diets **(Table 2)** showed that in fish fed Feed A (control), fecundity ranged between 22,400 eggs for fish with body weight of 365 g, total length (34.4 cm), ovary weight (32 g) and mean egg diameter (1.23 mm) to 31,500 eggs for fish with body weight of 441 g, total length (40.0 cm), ovary weight (45 g) and mean egg diameter (1.30 mm) with a mean of 27,440 ± 670.03 eggs. In fish fed Feed B (weevil infested feed), fecundity ranged between 14,700 eggs for fish with body weight of 342 g, total length (35.0 cm), ovary weight (21 g) and mean egg diameter (1.27 mm) to 23,100 eggs for fish with body weight of 345 g, total length (35.1 cm), ovary weight (33 g) and mean egg diameter (1.29 mm) with a mean of 19,100 ± 654eggs.

3.2. Relationship Between Fecundity and Body Parameters of *C. gariepinus* Fed the Experimental Diets

Fecundity of *C. gariepinus* fed the two experimental feeds showed a linear relationship with body parameters (total length, body weight, ovary weight, and mean egg diameter). Correlation co-efficient (r) showed a positive significant ($P<0.05$) relationship between fecundity of *C. gariepinus* fed feed A (control) with all the body parameters (total length, body weight, ovary weight, and mean egg diameter). For fish fed feed B (weevil infested feed), correlation co-efficient (r) showed a positive significant ($P<0.05$) relationship between fecundity of with ovary weight and mean egg diameter and negative relationship withtotal length and total weight. **(Table 3)** and Figure 1 – 8

Table 2: Fecundity of *C. gariepinus* fed the experimental diets

Parameters	Feed A (Control)	Feed B (Weevil infested feed)
Mean Weight (g)	418.53 ± 10.45^{a}	338.00 ± 3.42^{b}
Mean Length (cm)	38.52 ± 0.58^{a}	34.57 ± 0.31^{b}
Mean Ovary Weight (g)	39.20 ± 0.96^{a}	27.29 ± 0.94^{b}
Mean Egg Diameter (mm)	1.30 ± 0.05^{a}	1.20 ± 0.04^{a}
Mean Fecundity	27440 ±670.03^{a}	19100 ± 654.00^{b}

#WIF = Weevil infested feed, mean with the same superscript are not significantly different ($P>0.05$)

Table 3: Values of regression coefficient 'b' intercept 'a' and coefficient of correlation 'r' in relationship between fecundity and total length (F/TL) for female *C. gariepinus* fed the Control diet. Equation; y = a+ bx.

Relationship								
Feed	**Ordinate**	**Abscissa**	**N**	**a**	**b**	**R**	**r2**	**Significance of r at 5% level**
Control feed	Fecundity (F)	TW (g)	15	266.01	0.7678	0.7599	0.5775	Significant
	Fecundity (F)	TL (cm)	15	517.29	1.0689	0.6406	0.4104	Significant
	Fecundity (F)	OW (g)	15	700	1	1	1	Significant
	Fecundity (F)	MED (mm)	15	30451	0.414	0.6505	0.4232	Significant
Weevil infested feed	Fecundity (F)	TW (g)	14	26763	-0.059	0.0548	0.003	Not Significant
	Fecundity (F)	TL (cm)	14	239113	0.716	0.0583	0.0034	Not Significant
	Fecundity (F)	OW (g)	14	700	1	1	1	Significant
	Fecundity (F)	MED (mm)	14	22270	0.0255	0.8031	0.645	Significant

#TW = Total Weight in g, TL = Total length in cm, OW = Ovary Weight in g and MED = Mean Egg Diameter in mm. Pearson's product moment correlation value for df for14 is 0.532and 13 is 0.553 at P = 0.05.

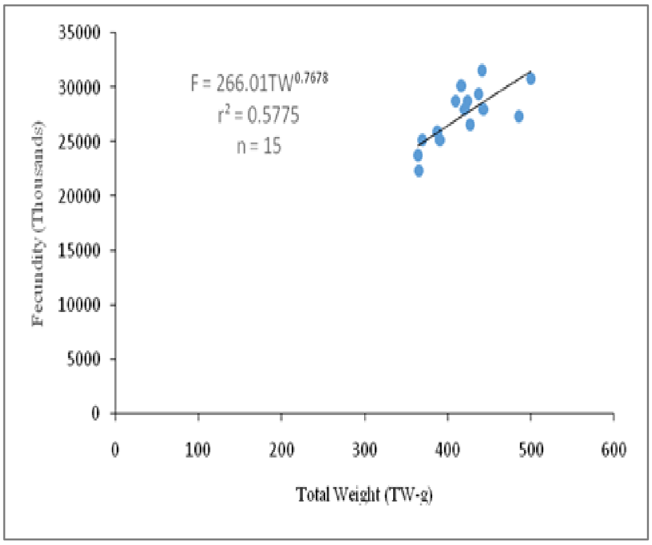

Figure 1: Relationship between fecundity and total weight (TW-g) of *C. gariepinus* fed Control feed

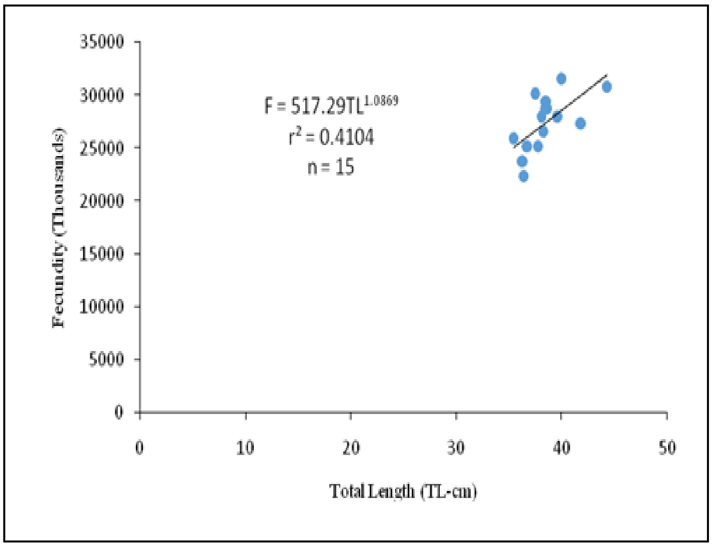

Figure 2: Relationship between fecundity and total length (TL-cm) of *C. gariepinus* fed Control feed

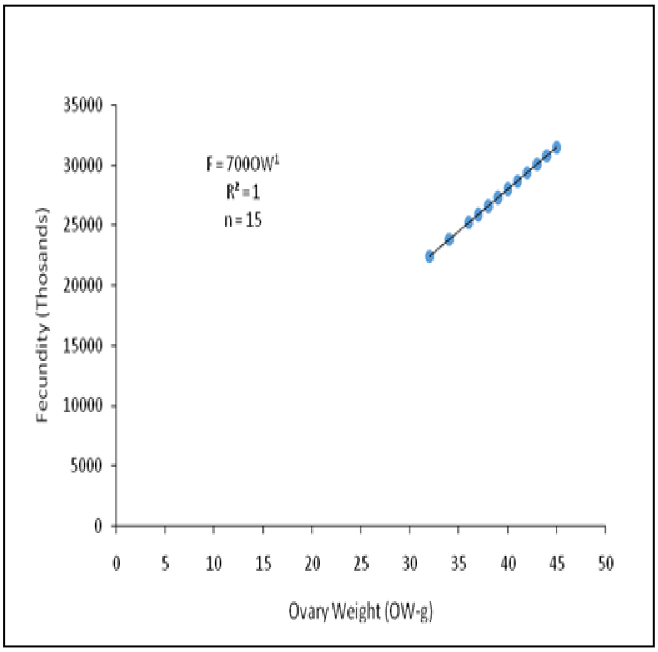

Figure 3: Relationship between fecundity and ovary weight (OW-g) of *C. gariepinus* fed Control feed

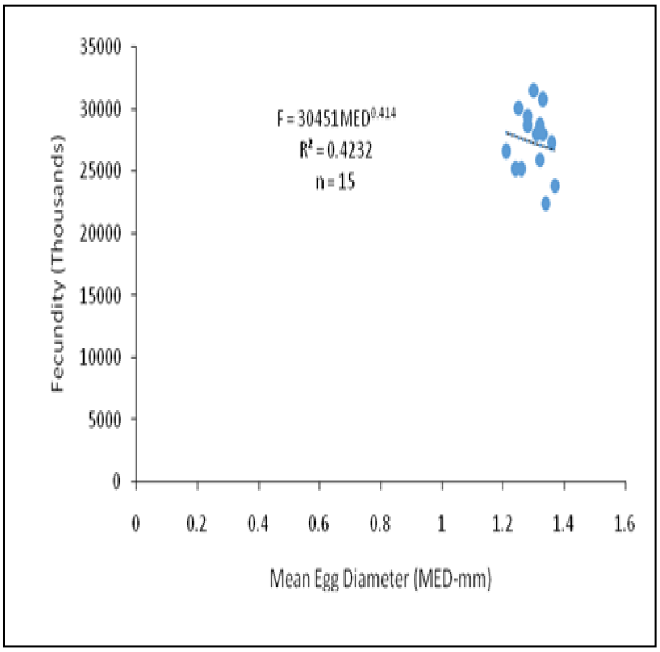

Figure 4: Relationship between fecundity and mean egg diameter (MED-mm) of *C. gariepinus* fed Control feed

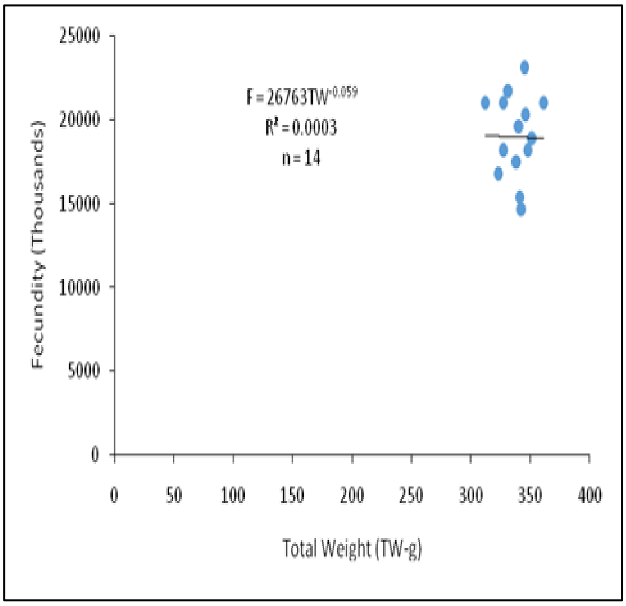

Figure 5: Relationship between fecundity and total weight (TW-g) of *C. gariepinus* fed Weevil Infested feed (WIF)

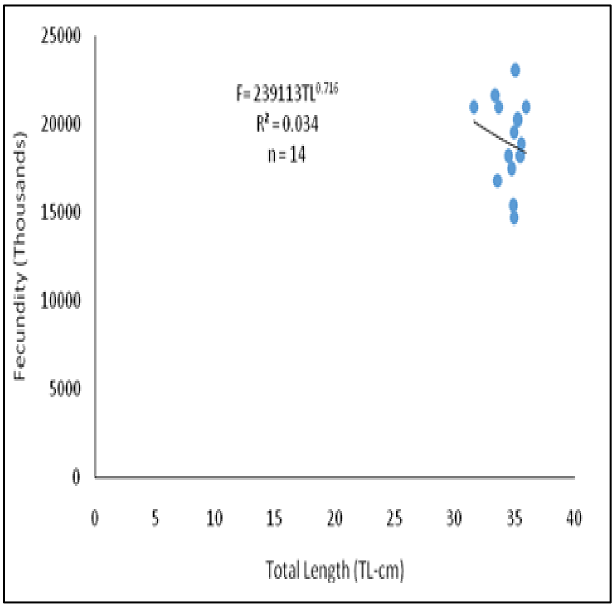

Figure 6: Relationship between fecundity and total length (TL-cm) of *C. gariepinus* fed Weevil Infested feed (WIF)

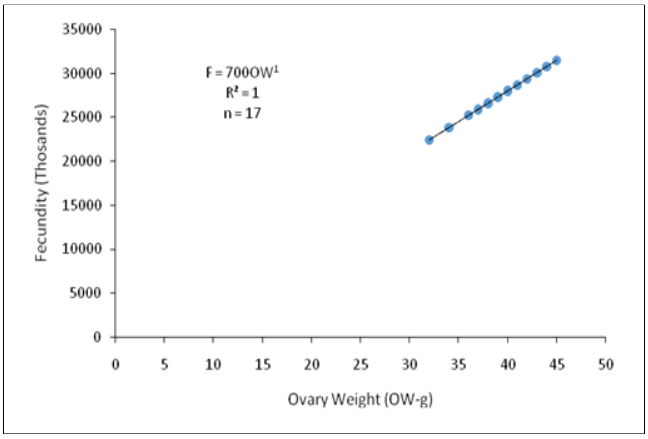

Figure 7: Relationship between fecundity and ovary weight (OW-g) of *C. gariepinus* fed Weevil Infested feed (WIF)

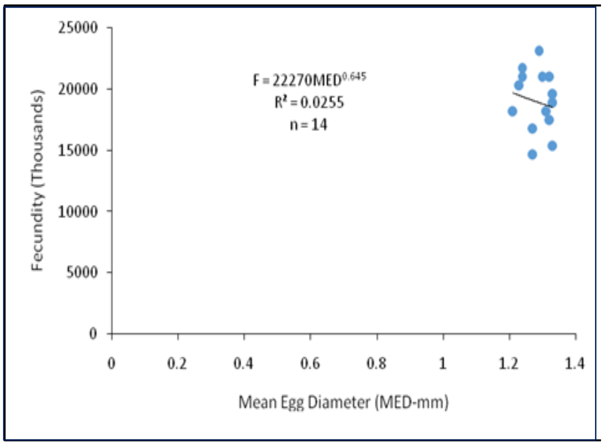

Figure 8: Relationship between fecundity and mean egg diameter (MED-mm) of *C. gariepinus* fed Weevil Infested feed (WIF)

shows the power regression equation for fecundity and body parameters of fish fed the two experimental diets.

3.3. Gonadosomatic Index (GSI) of Female C. gariepinus Fed the Experimental Diets

Results obtained for the gonadosomatic index (GSI) of female *C. gariepinus* fedthe experimental diets **(Table 4)** showed that in fish fed Feed A (control), GSI ranged between 8.02 % for fish with body weight of 486 g, total length (41.8 cm) and ovary weight (39 g) to 10.34 % for fish with body weight of 416 g, total length (37.5 cm) and ovary weight (43 g), with a mean of 9.38 ± 0.16 %. For fish fed Feed B (weevil infested feed), GSI ranged between 6.14 % for fish with body weight of 342 g, total length (35.0 cm) and ovary weight (21 g) to 9.57 % for fish with body weight of 345 g, total length (35.1 cm) and ovary weight (33 g), with a mean of 8.09 ± 0.29 %.

3.4. Gonadosomatic Index (GSI) of Male *C. gariepinus* Fed the Experimental Diets

Results obtained for the gonadosomatic index (GSI) of male *C. gariepinus* fedthe experimental diets **(Table 5)** showed that in fish fed Feed A (control), GSI ranged between 0.51 % for fish with body weight of 392 g, total length (40.1 cm) and gonad weight (2 g) to 0.95 % for fish with body weight of 422 g, total length (38.4 cm) and gonad weight (4 g), with a mean of 0.78 ± 0.03 %. For fish fed Feed B (weevil infested feed), GSI ranged between 0.57 % for fish with body weight

Table 4: Gonadosomatic Index (GSI) of female *C. gariepinus* fed the experimental diets

Parameters	Feed A (Control)	Feed B (WIF)
Mean Weight (g)	418.53 ± 10.45^a	338.00 ± 3.42^b
Mean Length (cm)	38.52 ± 0.58^a	34.57 ± 0.31^b
Mean Gonad Weight (g)	39.20 ± 0.96^a	27.29 ± 0.94^b
Mean GSI (%)	9.38 ± 0.16^a	8.09 ± 0.29^b

#WIF = Weevil infested feed, mean with the same superscript are not significantly different (P>0.05)

Table 5: Gonadosomatic Index (GSI) of Male *C. gariepinus* fed the experimental diets

Parameters	Feed A (Control)	Feed B (WIF)
Mean Weight (g)	408.17 ± 8.78[a]	334.25 ± 2.86[b]
Mean Length (cm)	39.90 ± 0.49[a]	34.08 ± 0.35[b]
Mean Gonad Weight (g)	3.17 ± 0.17[a]	2.42 ± 0.15[b]
Mean GSI (%)	0.78 ± 0.03[a]	0.72 ± 0.45[a]

#WIF = Weevil infested feed, mean with the same superscript are not significantly different (P>0.05)

of 349 g, total length (35.3 cm) and ovary weight (3 g) to 0.92 % for fish with body weight of 326 g, total length (33.5 cm) and ovary weight (3 g), with a mean of 0.72 ± 0.45 %.

3.5. Gonad Gross Morphology *C. gariepinus* Fed the Experimental Diets

The histological sections of testes and ovaries of fish fed the two experimental diets showed that there was a normal distribution of testicular and ovarian cells in their developments. Theinterstitial cells of the male testes were normal **(Figure 9:** Plate 1**)** and thefemale oocytes **(Figure 9:** Plate 2**)** were fully matured.

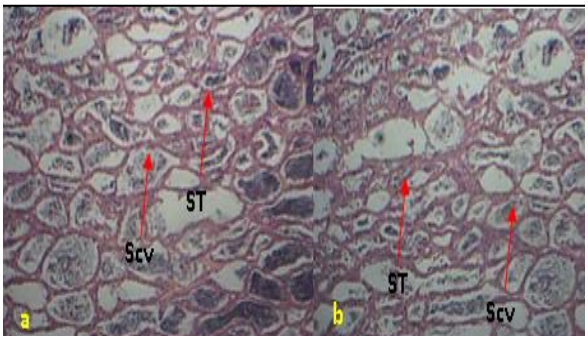

Figure 9: Plate 1- Histological sections of testes of fish fed the control diet (a) and weevil infested feed (b). Arrow indicates normal distribution of spermatocytes in the semniferous tubules. Scy: Spematocytes, ST: Semniferous tubules (X 40, H&E stains).

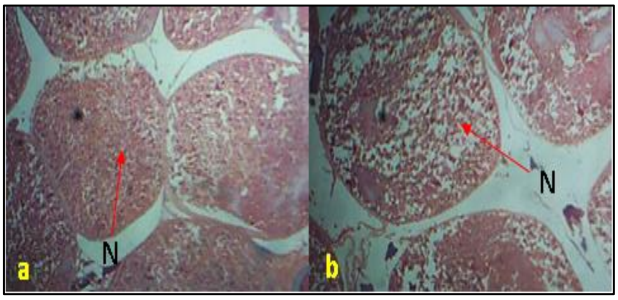

Figure 10: Plate 2- Histological sections of ovaries of fish fed the control diet (a) and weevil infested feed (b). Arrow indicates normal structure of ovarian lamellaecontaining the oocytes. N: nucleus (X 40, H&E stains).

3.6. Mean Water Quality Parameters of the Experimental Units

Results obtained for mean water quality parameters of the experimental units (Table 6) showed that in tarpaulin tank A fed the control diet, mean water temperature ranged from 28.67± 0.33 (°C) in week 4 to 30.00± 0.33 (°C) in week 12 and week 16. In tarpaulin tank B fed with weevil infested feed, mean water temperature ranged from 29.00 ± 0.00 (°C) in week 2, 4 and 10 to 30.00 ± 0.33(°C) in week 16.

Mean dissolved oxygen (mg/l) in tarpaulin tank A (control) ranged between 4.03 ± 0.03 mg/l in week 6 to 4.80 ± 0.00 mg/l in week 0. In tarpaulin tank B fed with weevil infested feed, mean dissolved oxygen (mg/l) ranged between 4.03 ± 0.03 mg/l to 4.80 ± 0.00 mg/l in week 0.

Table 6: Mean water quality parameters of the experimental units

Period	Tarpaulin tank A (Control Feed)			Tarpaulin tank B (weevil infested feed)		
	Tempt (°C)	DO (mg/l)	pH	Tempt (°C)	DO (mg/l)	pH
Week 0	30.00 ± 0.00	4.80 ± 0.00	7.20 ± 0.00	30.00 ± 0.00	4.80 ± 0.00	7.20 ± 0.00
Week 2	29.33 ± 0.33	4.47 ± 0.03	6.77 ± 0.06	29.00 ± 0.00	4.43 ± 0.03	6.73 ± 0.03
Week 4	28.67± 0.33	4.27 ± 0.03	6.80 ± 0.06	29.00 ± 0.00	4.30 ± 0.06	6.87 ± 0.03
Week 6	29.67 ± 0.33	4.03 ± 0.03	6.67 ± 0.03	30.00 ± 0.00	4.13 ± 0.03	6.83 ± 0.03
Week 8	30.00 ± 0.00	4.17 ±0.03	6.67 ± 0.03	30.00 ± 0.00	4.03 ± 0.03	6.77 ± 0.03
Week 10	29.00 ± 0.00	4.23 ± 0.07	6.97 ± 0.09	29.00 ± 0.00	4.17± 0.09	6.83 ± 0.03
Week 12	30.00± 0.33	4.13 ± 0.67	6.83 ±0.03	30.00 ± 0.00	4.20 ± 0.06	6.80 ± 0.06
Week 14	29.00 ± 0.00	4.24 ± 0.03	6.85 ± 0.06	29.33 ± 0.33	4.15 ± 0.03	6.78± 0.03
Week 16	30.00 ± 0.33	4.18 ± 0.07	6.92 ± 0.03	30.00 ± 0.33	4.22 ± 0.03	6.82 ± 0.03
Week 18	29.67 ± 0.33	4.25 ± 0.03	6.80 ± 0.03	29.33 ± 0.33	4.10 ± 0.03	6.85 ± 0.03

Mean pH in tarpaulin tank A (control) ranged between 6.67 ± 0.03 in week 6 and 8 to 7.20 ± 0.00 in week 0. In tarpaulin tank B fed with weevil infested feed, mean pH ranged between 6.73 ± 0.03 in week 2 to 7.20 ± 0.00 in week 0.

4. Discussion

In aquaculture and fisheries science, fecundity is considered as a very important aspect of fish culture system because it is the number of eggs carried by a gravid female fish and is also related to the average reproductive trait of fish [19]. Fecundity of the African Catfish (*C. gariepinus*) have been documented by different authors to be affected by feed type and quality [2], [19] and [20]. Results of this study agrees with findings of other authors including [2], [19], and [20] that fecundity of *C. gariepinus* can be affected by feed. In this study, results showed that fecundity of *C. gariepinus* fedthe control diet ranged between 22,400 eggs to 31,500 eggs with a mean of 27,440 ± 670.03 eggs while fecundity of fish fed weevil infested feed ranged between 14,700 eggs to 23,100 eggs with a mean of 19,100 ± 654 eggs. Mean fecundity of fish fed the control diet was significantly higher different (P<0.05) than fecundity of fish fed weevil infested feed. This is an indication that feeding fish with weevil infested feed will negative affect the fecundity of *C. gariepinus*. According to [21], the quantity and composition of dietary protein are known to affect the fecundity of fish. Significant variation (P<0.05) observed in this study for fecundity of fish fed the two experimental diets could be attributed to the differences in the quality of the two diets. Proximate analysis of the two experimental feed showed that nutrient composition of the control feed including crude protein level, crude fibre, ash, moisture, crude fat and Nitrogen free extract was significantly higher (P<0.05) than that of weevil infested feed. Long-term infestations of insects may negatively impact on feed through loss or deterioration of feed condition, quality, palatability, odor and taste which may make the feed unacceptable. [22] reported a deterioration in nutrient quality of maize exposed to weevil infestation. This implies that weevil infestation in feed could led to deterioration in the nutrient composition of feed and this could result in reduced fecundity as obtained in this study. Comparing the physical quality of the two diets, Feed A (control) was more stable compared to weevil infested feed which disintegrated easily due to the holes bored in the feed pellets by weevil. When weevil infested feed was fed to fish, the feed disintegrated easily in water, allowing the leaching of nutrients into the aquarium water. According to [2] and [8], feed should provide nutrients that are bioavailable for fish for optimal growth and good health. In this study, leaching of nutrients when weevil infested feed was fed to the experimental fish hindered the bioavailability of essential nutrients required for growth and this could be responsible for the low fecundity obtained for fish fed weevil infested feed. Findings of the present study agrees with findings of those of [19] and [20] who reported that utilization of high quality feed will lead to growth of ovaries and increase in fecundity of *C. gariepinus*. A linear relationship was obtained between fecundity and body parameters (total length, body weight, ovary weight, and mean egg diameter) of *C gariepinus* fed the two experimental feeds. However, correlation analysis showed a positive significant (P<0.05) relationship between fecundity of *C. gariepinus* fed feed A (control) with all the body parameters (total length, body weight, ovary weight, and mean egg diameter). For fish fed feed B (weevil infested feed), there was a positive significant (P<0.05) relationship between fecundity and ovary weight, and mean egg diameterwhereas total length and total weight showed a negative relationship. The significant relationship obtained in this study is similar to findings of [19] and [20] for *C. gariepinus* fed Coppens and Unical Aqua feed in earthen pond and concrete tank.In fisheries science, gonadal development in fish is commonly evaluated using gonad weight and gonadosomatic index which is the ratio of gonad weight to body weight. According to [2], gonad development in *C. gariepinus* could be significantly affected by feed quality. Results obtained in this study showed that female gonad weight and female gonadosomatic index GSI) was significantly higher (P<0.05) I fish fed the control diet compared to fish fed weevil infested feed. Gonadosomatic index (GSI) of female *C. gariepinus* fedthe control diet ranged between 8.02 % to 10.34 % with a mean of 9.38 ± 0.16 % whereas GSI of female fish fed weevil infested feed ranged between 6.14 % to 9.57 % with a mean of 8.09 ± 0.29 %. Similarly, male gonad weight of fish fed the two experimental diets did not vary significantly (P>0.05) whereas male gonadosomatic index (GSI) was significantly better (P<0.05) in fish fed the control diet. However, male gonadosomatic index (GSI) of *C. gariepinus* fed Feed A (control) ranged between 0.51 % 0.95 % with a mean of 0.78 ± 0.03 % whereasGSI of male fish fed Feed B (weevil infested feed), ranged between 0.57 % to 0.92 % with a mean of 0.72 ± 0.45 %. This could be attributed to the quality of the two experimental diets which agrees with findings of [2] for *C. gariepinus* fed Coppens and Unical Aqua feed and [6] for *C. gariepinus* fed plant and animal-based diets. The histological sections of testes and ovaries of fish fed the two experimental diets revealed a normal distribution of testicular and ovarian cells in their developments. This findings is similar to findings of [2] for *C. gariepinus* fed Unical Aqua feed and Coppens feed. This findings indicates that weevil infested feed did not impact a negative effect on the oocytes and testicular cells of *C. gariepinus*. Weevils infested feed only affected the gonad size in *C. gariepinus* and the implication of this is that in female fish, the fecundity will be reduced since fecundity is directly proportional to gonad size. In aquaculture systems, environmental factors such as temperature, ammonia, photoperiod and dissolved oxygen are known to affect fish growth, fecundity and gonad development [23] and [24]. However, results obtained for physicochemical parameters in this study such as pH, dissolved oxygen and water temperature did not influence fecundity and gonadal development as they were within the recommended level for optimal growth and good health of freshwater fishes [25].

5. Summary and Conclusion

In summary, infestation of weevils in aqua feed has a negative impact on the physical and nutrient quality of feed such as poor stability leaching of nutrients into pond water which will consequently influence fish growth negatively. Also, long-term infestations of weevils in fish feed insects may lead to loss or deterioration of feed condition, quality, palatability, odor and taste which may affect feed acceptability. Therefore, feeding *C. gariepinus* with weevil infested aqua feed has resulted in reduced fecundity and poor gonadal development. It is concluded that to obtain high fecundity and a better gonad development, weevils infested feed should be avoided. Feed should be stored in a good hygienic and sanitary conditions and infested feed should be destroyed with a serious implementation of sanitation and prevention practices to prevent the infestation from recurrence.

6. References

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