

GROWTH PATTERN, DIET AND REPRODUCTIVE FEATURES OF *Hemichromis fasciatus* IN ELEYELE LAKE, SOUTHWESTERN NIGERIA.

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ABSTRACT

The growth pattern, diet and reproductive features of *Hemichromis fasciatus* in Eleyele Lake were investigated. Samples of *H. fasciatus* were collected from artisanal fishermen who captured the fish with gill nets of 50.8mm mesh size in the lake. Length-weight relationship was estimated, and condition factor (K) obtained by means of Fulton condition index. Stomach contents were analyzed using numerical, frequency of occurrence and points methods. Reproductive features including gonadosomatic index (GSI) was calculated and fecundity evaluated by gravimetric method. *Hemichromis fasciatus* exhibited positive allometric growth ($b = 3.295$); mean K factor was 1.733 ± 0.209 and differed significantly between sexes, sizes and months. The food items in the stomach were algae, rotifers, crustaceans, protozoans, macrobenthos and fish fry. The mean absolute fecundity was 1356.39 ± 556.2 eggs. *Hemichromis fasciatus* in Eleyele Lake could be referred to as an invertivore-piscivore based on the prey items encountered in the stomach. The obtained b value, condition factor and wide spectrum of food encountered in the stomach of *Hemichromis fasciatus* in Eleyele Lake is an indication of the suitability of the environment for its production.

Keywords: length-weight relationship, food, Gonadosomatic index, Fecundity, Banded Jewel Fish

INTRODUCTION

In Africa, reservoir fisheries contribute about 10 % to the total inland fisheries (FAO, 1984). These serve as source of animal protein and employment thus lead to food security and economic development. According to Kwado (2012), the productivity of fisheries in these reservoirs fall below their biological potential. Eleyele Lake created (by damming river Ona) primarily for supply of water to Ibadan populace, also support fisheries activities. Cichlids forms a major proportion of fish landed regularly by artisanal fishermen in Eleyele Lake (personal observation). They are of commercial importance being exploited for human consumption and used in aquaria due to their beautiful coloration and fascinating breeding behavior. Cichlids are also hardy, easy to feed and reproduce easily in captivity thus are good aquaculture candidate.

Hemichromis fasciatus is one of the eight species (*Coptodon zillii*, *C. guineensis*, *Sarotherodon melanotheron*, *S. galilaeus*, *H. bimaculatus*, *Oreochromis niloticus*, *Chromidotilapia guentheri*.) of cichlids in Eleyele Lake. There are previous studies on aspects of biology of other cichlids in this reservoir by Zelibe (1990); Ayoade and Ikulala (2007) and Ayoade and Onibonoje (2013). Oronsaye, 2009 observed that no comprehensive work has been published on food and feeding habits of *H. fasciatus* and reported diet of this species in Ikpoba dam. In Eleyele Lake, Olubunmi *et al.*, 2017 provided preliminary information on length weight and condition factor of *H. fasciatus*. This paper intends

to investigate the growth pattern, diet and reproductive features of *H. fasciatus* in Eleyele Lake. This will provide additional knowledge on its biology, which should enhance fisheries management and production.

MATERIALS AND METHODS

Specimens of *H. fasciatus* were obtained at the landing center of local fishermen in Eleyele Lake. The fish were caught with gill nets of 50.8mm mesh size and carried in an ice chest to the laboratory in the Department of Zoology, University of Ibadan. The standard length (SL) and total length (TL) were determined for each individual fish using a measuring board to the nearest 0.1cm. The fish were mopped on a filter paper and their total weight measured by using a top loading digital weighing balance (electronic compact scale model SPJ602/A) to the nearest 0.1g. The fish were dissected; stomachs were removed and preserved in 4% formalin. Sex was determined by visual examination of the gonads (immature fish could not be sexed macroscopically). The gonads were weighed and categorized into six maturity stages as described by Nikolsky, 1963.

Length -Weight Relationship

The length – weight relationship was estimated using the equation by Pauly (1983).

$$W = aL^b$$

The Linear Allometric Model (LAM) was used to estimate parameters a and b by log-transformed weight and length measurements

(Muchlisin *et al.*, 2017). W is total weight of fish, L is total length of the fish, a is the intercept of straight line on the Y – axis of the regression analysis and b is the slope of the regression analysis. The correlation coefficient (r) is the degree of association between the length and the weight and was determined from the linear regression analysis.

Condition Factor

The condition factor was calculated to determine the state of well – being of the fish using the formula by Fulton (1904), $K = \frac{W}{L^3} \times 100$ where W is body weight (g) and L is total length (cm).

Stomach Content Analysis

The stomachs were examined to determine the degree of fullness as full, three-quarter full, half-full, one-quarter full, or empty. Each stomach contents were emptied into a petri dish and food items identified to the lowest possible taxonomic rank using compound microscope. The stomach contents were analyzed using the numerical, frequency of occurrence and point's methods (Ricker, 1975; Hyslop, 1980). For the point's method, the empty, $\frac{1}{4}$ full, $\frac{1}{2}$ full, $\frac{3}{4}$ full and fully distended stomachs were assigned 0, 5, 10, 15, and 20 points, respectively. These points were shared among various contents, considering their relative proportion by volume (Udoh and Jimmy, 2015). The main food categories were determined by calculating the relative importance index using the following formula by George and Hadley, 1979; Hyslop, 1980.

$$RI = \frac{100 AI}{\sum_1^n AI}$$

$$AI = \%N + \%F + \%P$$

Where, RI = Relative importance index; AI = Absolute importance index; n = number of food items; N =number; F = frequency and P = points

Sex Ratio

The proportion of the male to female was used in calculating the sex ratio.

Gonadosomatic Index (GSI)

It is the calculation of the gonad mass in relation to the total body mass. It is used for measuring the sexual maturity of fishes in correlation to ovary and testes development. The GSI was determined with the following formula:

$$\begin{aligned} \text{Gonadosomatic index (GSI)} \\ &= \frac{\text{Weight of gonads}}{\text{Weight of fish}} \\ &\times 100 \text{ (Wootton, 1990)} \end{aligned}$$

Fecundity

Fecundity was taken as the number of ripe eggs in the female just prior to the next spawning season. Ripe ovaries were removed, weighed and then preserved in Gilson's fluid for at least two weeks. The eggs were separated from ovarian tissue and enumerated by gravimetric method. The weight of a known number of subsample of preserved eggs was used to estimate individual egg weight (McGregor, 1968). The relationship between the fecundity and the total length, and weight of the fish species were determined as expressed by the equation $F = aX^b$ (Pauly, 1983).

Where, F is Fecundity, X is total length or weight of fish, a and b are constants obtained from least squares regression analysis using log transformed data.

Statistical Analysis

A student's t-test was used to ascertain whether changes in condition factor with sex for the species were statistically significant and ANOVA was used to detect significant difference in condition factor with months and size groups.

RESULTS

Length Weight Relationship

Two hundred and seventy-four (274) *H. fasciatus* were obtained during the study period from Eleyele Lake. The total length and total weight of female, male and combined *H. fasciatus* during the sampling period were 7.1- 13cm and 6.82 – 46.3g; 7.2 - 13.6cm and 6.16 – 45.26g; and 7.1-13.7cm and 4.68 – 50.59g, respectively. The b value, coefficient of determination and correlation coefficient from the analysis of the length-weight relationship of the studied species for male was 3.3452, 0.9419 and 0.9705; Female was 3.3579, 0.9272 and 0.9629; Combined was 3.295, 0.937 and 0.968, respectively (Figs. 1-3).

The results for LWR of *H. fasciatus* for each month of study are shown on Table 1. The value of slope b was >3 in every month except June, July and October. The coefficient of determination and correlation coefficient for the months was greater than 0.76 and 0.87, respectively.

Condition Factor

The K factor of *H. fasciatus* in Eleyele Lake ranged from 0.914 – 2.177 (mean= 1.733 \pm 0.209) during study period. Monthly variation was recorded in the condition factor with all the values > 1.5 ; highest (1.86) and lowest (1.56) K factor values were obtained in October and April, respectively. There was gradual increase in condition factor with size group, with least mean K factor (1.60 \pm 0.21) recorded in the smallest size group and highest 1.79 \pm 0.20 in the 11.3 – 13.3cm size group. Females had higher K value (1.77 \pm

0.20) than male (1.71 ± 0.22). The variations recorded between the months, size groups and sex were significant $p < 0.05$ Table 2.

Stomach Content Analysis

Fish specimens with food in stomach were encountered more frequently (65.71%) during study period than those with empty stomachs (34.29%). Food organisms that were of plant origin formed 68.78% by number, 58.22% by frequency and 36.38% by points; animal food components constituted 31.22% by number, 41.78% by frequency and 63.62% by points Table 3. Algae encountered included *Anabaena*, *Phormidium*, *Polycystis*, *Spirulina*, *Aphanocapsa*, *Coelosphaerium*, (blue green algae); *Cladophora*, *Tetraspora*, *Mesotaenium* (green algae); *Synedra*, *Nitzschia*, *Navicula*, *Diatoma*, *Campylodiscus*, *Fragilaria* (Diatoms); *Cosmarium*, *Gonatozygon*, *Closterium* (desmids) and *Ophiocytium* (Yellow green algae). Invertebrate animals were *Notholca* (rotifers); *Daphnia*, *Macrothrix* (crustaceans); *Coleps*, *Euplotes*, *Dileptus*, *Oxytricha* (protozoan) and *Chaoborus* larvae (benthos). Vertebrates found were tilapia fry. The more frequently encountered food items were in this order: *Diatoma* > *Chaoborus larvae* > Insect body parts > *Gonatozygon* > fish fry > *Nitzschia* > *Synedra* > *Daphnia*. *Cladophora* was the most numerous item found in the species. Plant food organisms were relatively more important (55.75%) in the diet of *H. fasciatus* than food of animal origin (44.24%) Table 3.

Sex Ratio

Out of the 275 specimens examined, more males (130, 58.0%) than females (94 42.0%) occurred in the samples and 51 were unidentified. Differences occurred in the proportion of males and

females throughout the study period except in August (1:1). The chi – square test showed that males were significantly more than females only in May ($p < 0.05$) Table 4.

Stages of Gonad Maturation

For the females, maturing and ripe gonads were encountered more than immature during the study period Fig.4. On the contrary, immature and maturing gonads occurred more in male *H. fasciatus* Fig.5.

Gonadosomatic Index (GSI)

The GSI of the female *H. fasciatus* ranged from 0.14 – 8.86% (mean = $3.50\% \pm 2.83$) and varied with months Fig. 6. Highest mean GSI was recorded in September ($5.28\% \pm 3.20$) and least in April ($2.12\% \pm 2.87$). Maximum mean GSI (0.27%) was recorded in April for male.

Fecundity

Twenty-eight females with ripe gonads were encountered during the study period and used for fecundity estimates. The minimum absolute fecundity was 336 (Standard length, 6.8cm; Total weight, 10.45g) and the maximum absolute fecundity was 2630 (Standard length, 8.6cm; Total weight, 22.03g). The mean absolute fecundity was 1356.39 ± 556.2 eggs. The relationships between log fecundity and log total length; log fecundity and total weight are shown in Figs. 7 and 8, respectively. The regression equations were the following: $\text{Log F} = 1.753 \text{ Log SL} + 1.458$, ($r = 0.35$, $n = 28$)

$$\text{Log F} = 0.445 \text{ Log TW} + 2.501$$

$$(r = 0.27, n = 28)$$

The correlation between fecundity and standard length ($r = 0.35$) is slightly higher than fecundity and total weight ($r = 0.27$).

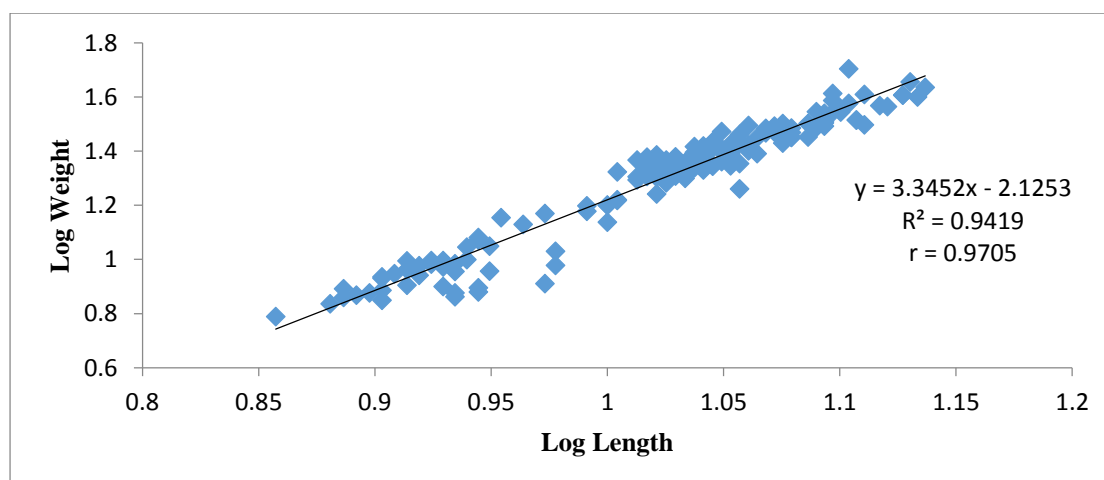


Fig.1: Length weight relationship of Male *Hemichromis fasciatus* in Eleyele Lake

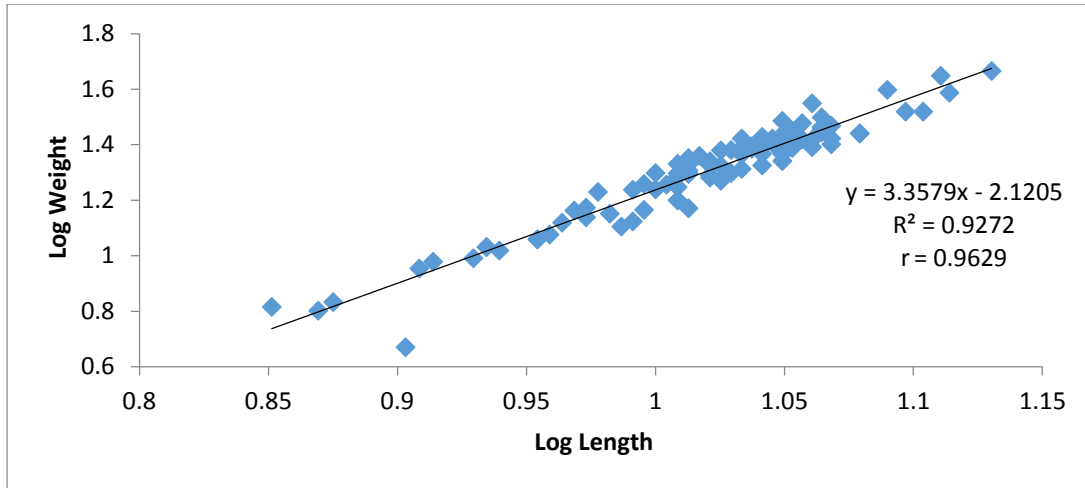


Fig.2: Length weight relationship of Female *Hemichromis fasciatus* in Eleyele Lake

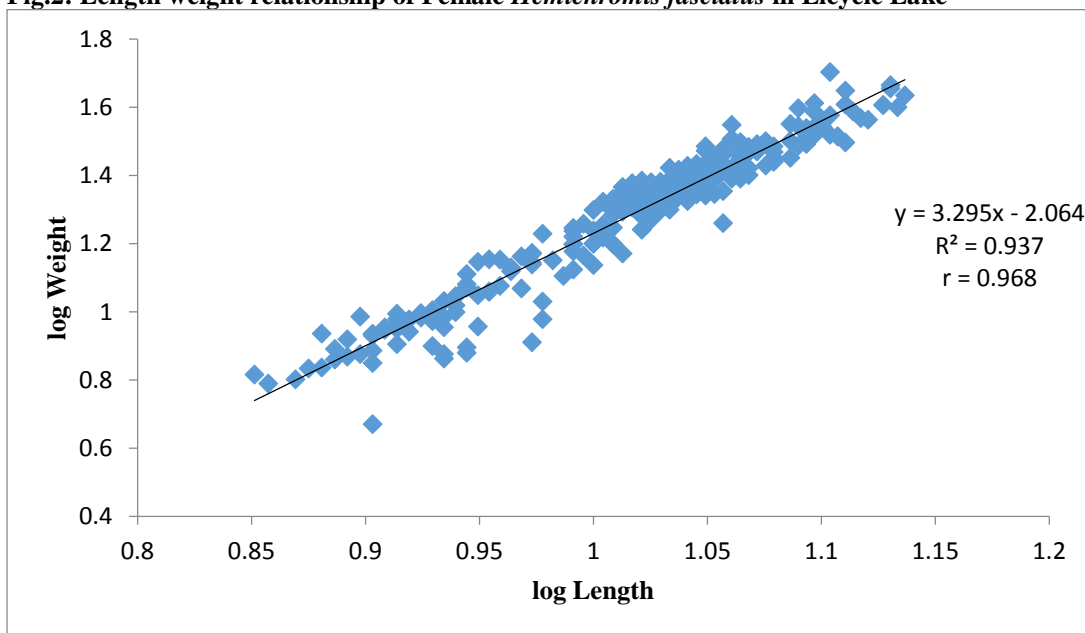


Fig.3: Length weight relationship of *Hemichromis fasciatus* (combined sex) in Eleyele Lake

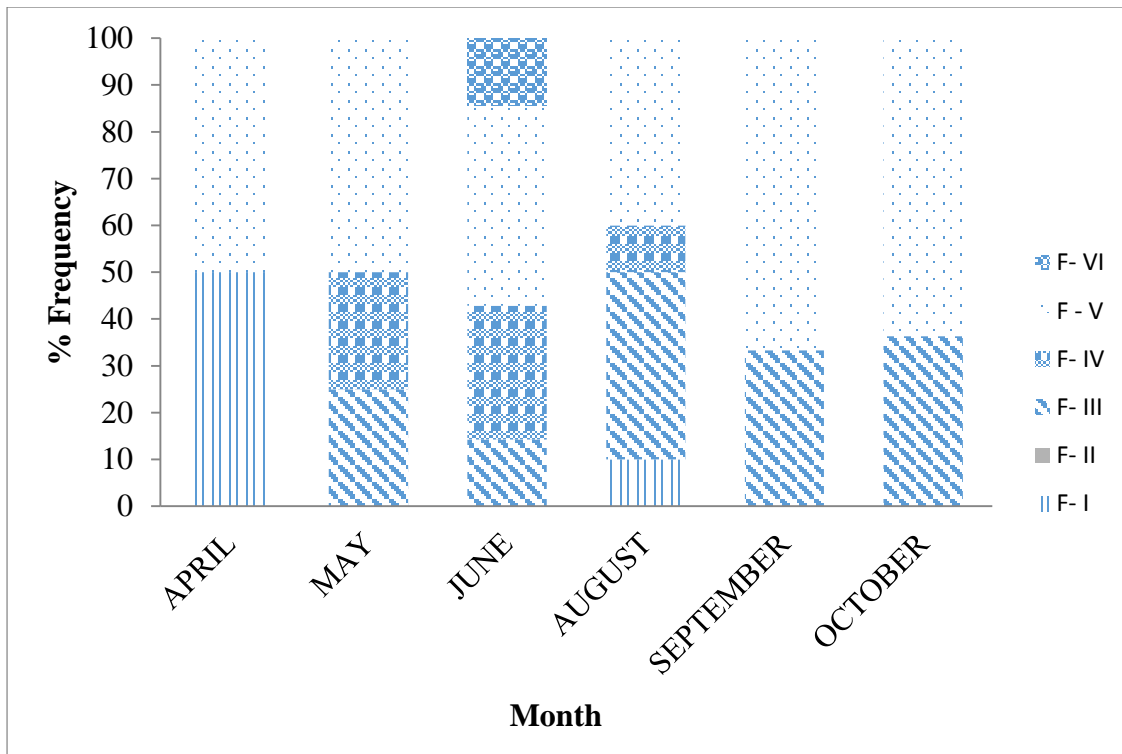


Fig. 4: Monthly percentage of occurrence of different gonad maturation stages in Female *Hemichromis fasciatus* in Eleyele Lake.

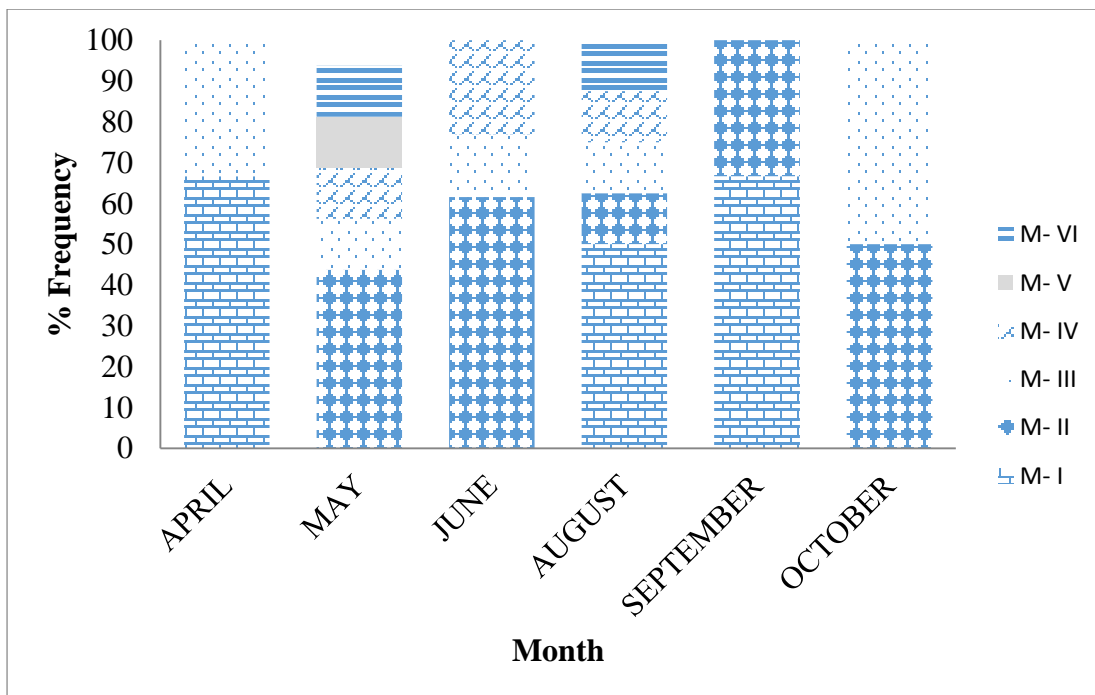


Fig. 5: Monthly percentage of occurrence of different gonad maturation stages in Male *Hemichromis fasciatus* in Eleyele Lake.

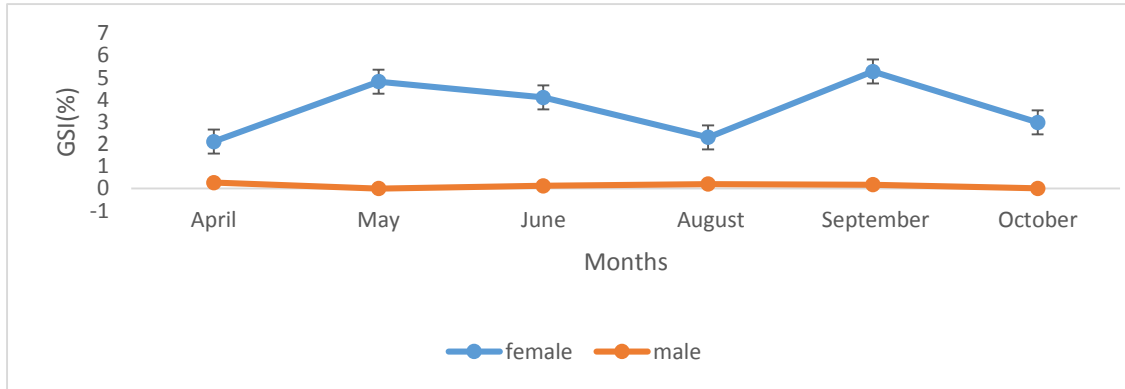


Fig. 6: Variation in mean GSI of female *Hemichromis fasciatus* with months.

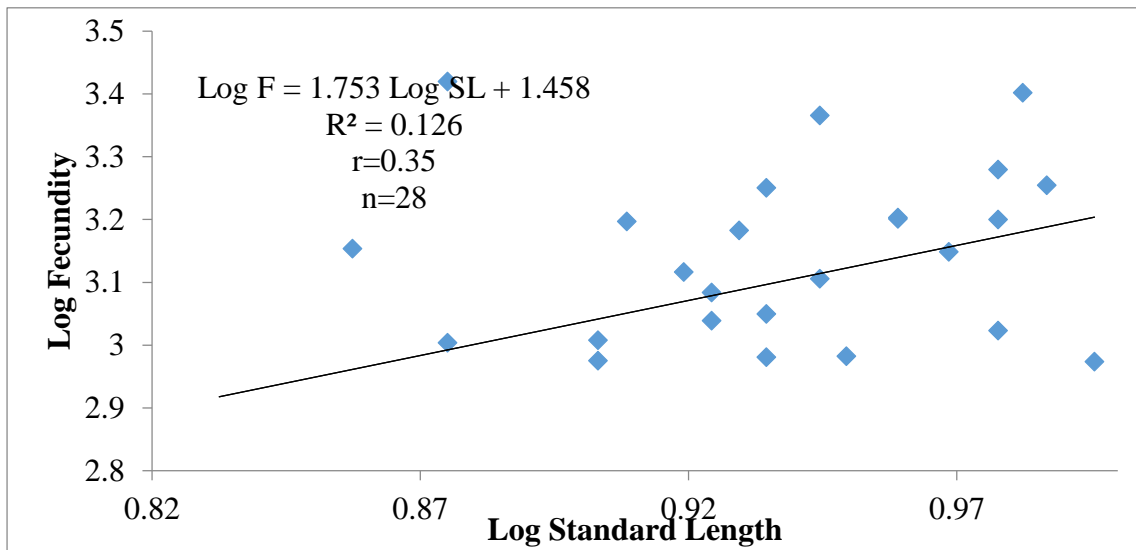


Fig. 7: Log Fecundity and Log Standard Length relationship of *Hemichromis fasciatus* in Eleyele Lake.

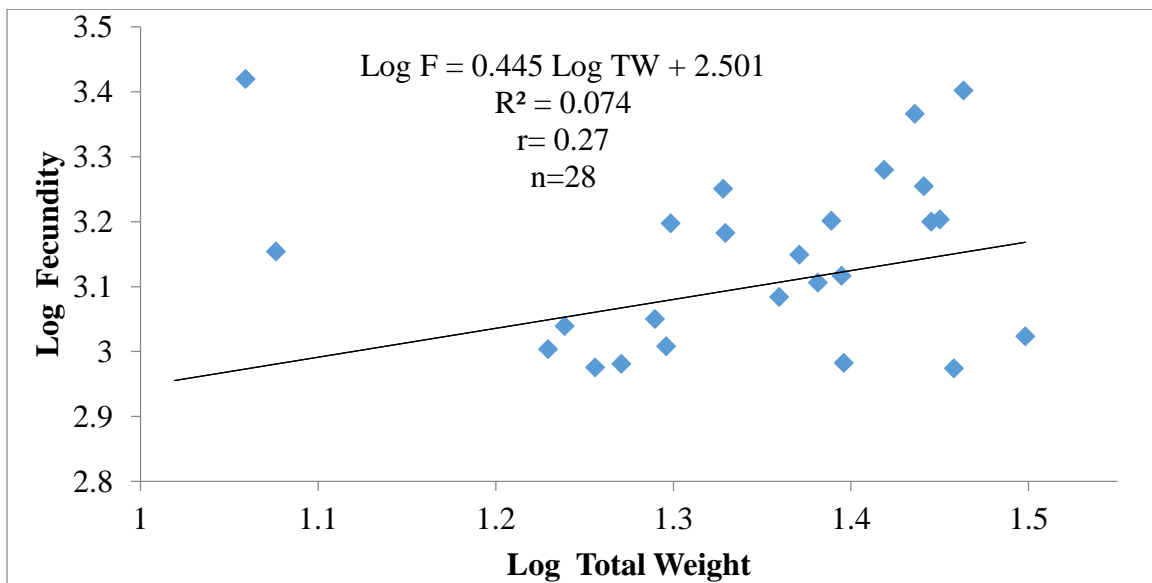


Fig.8: Log Fecundity and Log Total Weight relationship of *Hemichromis fasciatus* in Eleyele Lake

Table 1: Monthly variation in length-weight relationship of *Hemichromis fasciatus* in Eleyele Lake

Month	N	a	b	R ²	R
April	43	-1.9885	3.1836	0.7644	0.8743
May	40	-1.8224	3.0836	0.8168	0.9038
June	40	-1.4773	2.7477	0.8939	0.9455
July	21	-1.2679	2.527	0.8224	0.9069
August	40	-1.9065	3.1458	0.9692	0.9845
September	59	-1.8537	3.0692	0.9864	0.9932
October	31	-1.4708	2.752	0.8535	0.9239

Table 2: Variation in condition factor of *Hemichromis fasciatus* in Eleyele Lake with month, size and sex.

Parameters	Mean	Standard Deviation	P value
April	1.561	0.334135	
May	1.852	0.187124	
June	1.807	0.124642	
July	1.726	0.132604	*0.001
August	1.747	0.138042	
September	1.641	0.098478	
October	1.863	0.157074	
7.1 – 9.1cm	1.60	0.212797	
9.2 – 11.2cm	1.764	0.197417	
11.3 -13.3 cm	1.786	0.197122	*0.001
13.4 – 15.4 cm	1.781	0.143228	
Male	1.702	0.218362	*0.014
Female	1.769	0.198435	
Combined	1.733	0.0209	

*= significant at $p < 0.05$

Table 3: Stomach contents of *Hemichromis fasciatus* in Eleyele Lake

Food Items	% Number	% Frequency	% Point	Absolute Importance Index	Relative Importance Index
Phytoplankton					
Blue-green Algae	12.18	26.09	7.30	45.57	9.96
Green Algae	35.44	6.52	2.35	44.31	9.68
Desmids	7.25	36.95	6.78	50.99	11.14
Diatoms	13.91	80.43	19.95	114.29	24.97
Subtotal	68.78	149.99	36.38	255.16	55.75
Zooplankton					
Rotifers	0.12	2.17	0.13	2.42	0.53
Crustaceans	2.84	15.22	7.8	25.88	5.66
Protozoans	0.32	5.43	1.04	6.79	1.48
<i>Chaoborus</i> larva		36.96	22.56	80.84	17.66
	21.32				
Subtotal	24.60	59.78	31.55	115.43	25.33
Other Animal components					
Insect body Part	3.39	28.26	13.04	44.69	9.77
Tilapia fry	3.23	19.57	19.04	41.84	9.14
Subtotal	6.62	47.83	32.07	86.53	18.91

Table 4: Monthly sex ratio for *Hemichromis fasciatus* in Eleyele Lake.

Month	Male	Female	Total	Sex Ratio (female: male)	Chi square test (p-value)
April	8	12	20	1.5:1	0.5271
May	32	8	40	0.25:1	*0.00729
July	26	14	40	0.54:1	0.1797
August	20	20	40	1:1	1
September	6	18	24	3:1	0.08326
October	38	22	60	0.58:1	0.1441
Total	130	94	224	0.72:1	0.08897

*- significantly different at $p < 0.05$

DISCUSSION

The obtained b value for *H. fasciatus* in Eleyele Lake are within the expected range of $2.5 < b < 3.5$ (Carlander, 1969) and the samples did not have narrow size ranges as suggested by Carlander, 1977, thus our sample collection expressed length weight relationship of the species well. The b value (3.295) indicates positive allometric growth (that is the fish is becoming heavier as length increases) as reported by Pauly, 1983 that b greater than 3 signifies allometric growth. This agree with Yem *et al.*, 2008 and Ibrahim *et al.*, 2012 however, the b value is higher than 2.495 and 2.605 by Kings (1996) in Imo River and Adadama Lake; 2.631 obtained by Agboola and Anetekhai (2008) in Badagry Creek; 3.061 by Ude *et al.* (2011) in Ebonyi River for the species. These differences in the growth pattern could

be due to differing environmental conditions and size ranges.

This is confirmed by Bagenal and Braum, 1978 that geographical, temporal and sampling techniques affect the observed growth pattern of the fish besides the biological and environmental conditions. The coefficient determination (r^2) for combined/unsexed was 0.94, thus 94% of weight gained could be attributed to length. Also, strong relation occurred between the weight and length gained since the coefficient of correlation was higher than 0.96. The obtained b value being lower than 3 (the isometric value) in some months suggested that the Eleyele Lake may not provide suitable condition for the species at this period. This finding is not supported by the Fulton's condition factor since all the monthly values were >

1.5 and Wade, 1992 reported $K \geq 1$ as above average condition. Also, the wide spectrum of food consumed by this species in this study points to availability of food which will favor growth.

The condition factor shows the health of the fish in general, productivity and physiological condition of the fish population (Blackweel *et al.*, 2000; Richter, 2007 as cited by Muchlisin *et al.*, 2017). The condition factor of the female being significantly higher than male could be due to the dissimilarities in gonadal development. The better condition of the larger sized specimens suggests being able to access food more than smaller sized. These findings corroborate the report of Oni *et al.*, 1983 that change occurred in condition factor of a species and population over a time interval could be because of both biotic and abiotic factors such as feeding regime and state of gonadal development. Furthermore, lower condition factor of *H. fasciatus* recorded from July to September (major raining months) coincided with the reproductive season of most cichlids ((Legendre & Ecoutin, 1989; Louca *et al.*, 2010), thus depletion of reserves during this season.

A wide variety of food was encountered in stomach content of *Hemichromis fasciatus* in this study compare to insect parts, fish remains, and detritus found by Kwadwo, 2012 for population in Brimsu Reservoir. The diet of studied species however is like population in Mankessim Reservoir, central region of Ghana reported by Atindana *et al.*, 2016. Food of plant origin being more frequently encountered than those from animal could probably have result from the slow digestibility of plant that led to their persistency in the stomach. Also, the most numerous alga (*Cladophora*) in the stomach could have been consumed to have access to preferred food since it is a filamentous alga readily colonized by epiphytic diatoms, and other algae, and provides a protected foraging environment for the smaller pond creatures such as protozoa, worms, small crustaceans and insect larvae. *Hemichromis fasciatus* in Eleyele Lake could be referred to as an invertivore-piscivore based on the prey items in the stomach according to the trophic guilds used in Wootton (1998) and Esteves *et al.* (2008). This agrees with the findings of Atindana *et al.*, 2016 on the species in Mankessim Reservoir, Ghana. Oronsaye, 2009 reported the species is a carnivore and that the aquatic plants in the food items must have been taken while consuming the insects that were attached to them.

The lack of significant difference in the sex ratio except in May suggests that the male and female did not move separately to the spawning and feeding grounds in the reservoir. However, the fewer mature males encountered in this study suggests the migration of ripe males to deeper waters where fishing did not occur as suggested by Milton and Arthington (1985). Higher GSI recorded

in females indicates more energy being allocated to reproduction than male and agree with the observation by Munro *et al.*, 1990 for African species. Gradual increase in GSI from April with highest value in September shows that the raining season is the breeding season of this species, since it is assumed highest GSI occur in the breeding season of fish (Stumboudi *et al.*, 1993). Lowe-McConnell (1975) points out that many African fish have spawning cycle that are closely related to rain. This is contrary to the record of Guezi and Kara (2015), who observed spawning of *Hemichromis bimaculatus* in the hottest months of the year. The highest female GSI (8.86%) value is greater than 3.64% recorded for same species and 2.98% for *Tilapia mariae* by Olurin and Odeyemi, 2010; 4.462% recorded for *Hemichromis bimaculatus* by Indira *et al.*, 2013. The fecundity (range 1212 – 2246; mean 1614 \pm 222) for *H. fasciatus* reported by Kwadwo (2012) was higher than the present probably due to larger specimens (SL, 8.1 – 13.2 cm) used for the fecundity estimation.

CONCLUSION

The obtained b value, condition factor and wide spectrum of food encountered in the stomach of *Hemichromis fasciatus* in Eleyele Lake is an indication of the suitability of the environment for its production.

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