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ARTICLE

Abundance and Distribution, Growth Pattern, Sex Ratio and Gonadosomatic Index (GSI) of *Liza falcipinnis* (Valenciennes, 1836) from Ojo Axis of Badagry Creeks, Lagos, Nigeria

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ABSTRACT

A study on seasonal abundance, morphometric and meristic data, growth pattern, condition factor, sex ratio and gonadosomatic index of Liza falcipinnis (Valenciennes, 1836) from the Ojo axis of Badagry creek, Nigeria was conducted from May 2019 to March 2020. A total of 1012 species were randomly selected, having 499 females and 513 males. The length frequency analysis and length-weight relationships (LWR) were determined. Sex ratio was determined by Chi-square analysis. The results showed that morphometric data are: 0.5 - 2.5 mm for ED, 2.1 - 12 mm for HL, 1.7 - 8.1 mm for HD, 2.5 - 11.7 for BD, 2.6 - 233.3 mm for TL and 9.23 - 1006 g for BW for the combined sexes. The slope (b) shows an allometric growth pattern. The intercept 'a' and slope 'b' of the LWR (LogW = a + bLogL) were Log W= 15.39+ 0.34 LogL (r= 0.54) for combined sexes, Log W= 12.49+ 0.02 log L (r= 0.38) for males and Log W= 18.23+ 0.01 log L (r=0.16) for females. The length frequency distribution indicated that species were dominated by two year classes (Ages 1 and 2). Condition factors were generally low. The values ranged between 0.68 - 0.85 for combined sexes. The gonadosomatic index for female was highest in August, 2019 (17.77%) with Mean±SD of 2.88±0.75; which indicated the peak of spawning period in the study area. Sex ratio difference was significant (P<0.05). Sexual differences were significant; the females are phenotypically larger than the male.

1. Introduction

Liza falcipinnis, is a bony fish of the family Mugilidae, Class Actinopterygii (ray-finned fishes) and the Order Perciformes. The family consists of 17 genera and 80 species. Although, Chelon, Liza, Mugil and Valamugil. *Liza dumerilli* (grooved mullet), *L. grandisquamis* (large-scale mullet), *L. argentea* (flat-tail mullet) and *L. triscuspider* (stripped mullet) are said to be the most common members of the genus Liza. [24] reported on the aspects of *L. falcipinnis* from the Lagos lagoon, Nigeria. Mugilidae are cultured in many countries due to their high-quality flesh. According to [31], they are of great economic importance in tropical inland waters of West Africa and they play significant roles in the ecology of African freshwater. They are easily recognizable with their thick yet streamlined bodies, hard angled mouth, large, cycloid or faintly ctenoid scales, sub abdominal pelvic fin and two widely separated dorsal fin, the first containing only four spines [33]. They have no lateral line, pectoral fin is high on body

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and mouth is small terminal or inferior with pre-maxillae protractile, their teeth are small, feeble and could be hidden [31]. Body is elongated, cylindrical with broad flattened head with blunt snout (Figure 1). They are silvery in colour, often with 3 to 9 longitudinal streaks on the back, fins are hyaline and husky. The streamlined body of the mullet allows them to avoid numerous predators that attack their schools on the shallow inshore water. They spawn in the sea and then enter lagoon, estuaries and freshwater for feeding [19]. Length-weight relationship (LWR) shows that the average weight of fish at a given length by making use of a mathematical equation to show relationships between the two. Fish can attain either isometric or allometric growth [32]. Isometric growth indicates that both length and weight are increasing at the same rate. Allometric growth can be either positive or negative. Positive allometric implies increase in weight with increase in length. Negative allometric implies the fish becomes lighter as its length increases. However, LWR is assumed to be uniform for an entire fish stock in stock assessment studies [14]. Knowledge of the relationship between the length and weight of a given species is useful to transform the length structures obtained into the weights of fish captured and to monitor health status of a population. [4], opined that fluctuation in fish growth is a common phenomenon in tropical and subtropical waters because of environmental variations, spawning and dynamics of food composition.

Condition factor (CF) is an estimation of general well-being of fish as stated by [27] and is based on the hypothesis or assumption that heavier fish (at a given length) are in better condition than the lighter ones. The condition factor of 1.0 or greater indicates the good condition of fish while less than 1.0 shows bad condition [2]. It is a useful index for estimating growth rate and age and for assessing environmental quality and can be influenced by season, sex, type of food organism consumed by fish, age, and environmental conditions. The gonadosomatic index (GSI), is described as gonad mass as a percentage of total body weight and is widely used as a simple measure of the extent of reproductive investment, gonadal development and maturity of fish in relation to spawning [12,9]. Gonadosomatic index of fish increases with maturity and abruptly declines after spawning. GSI is particularly helpful in identifying season of spawning as the female gonads increase in size prior to spawning [18]. Study on reproductive biology of fish is essential for conservation and selecting fish candidates of aquaculture from the wild. Reproduction is an important physiological system that is crucial in the life cycle of fish. Fecundity is the number of ripened or vitellogenin eggs or oocytes in the female prior to the next spawning period and varies intra- and interspecifically. It is also stated that the number of eggs produced by fish in a spawning season is species-specific and varies with genetic characteristics, size, age, environmental factors and physiological conditions of the fish. For instance, large female fish in better condition tend to exhibit higher fecundity than those in poor condition. This information is useful in estimating spawning stock biomass and management [18].

In the study area, *Liza falcipinnis* is known to be abundant and this has been related to their feeding habits. The monthly incidence of occurrence of *L. falcipinnis* in canoe landings of artisanal fishermen in the Ojo axis of Badagry creek showed that it occurred in the lagoon on a year-round basis. However, there is not enough information on the species in the study area. This research is therefore geared towards reporting significant data on the species' condition factor, fish growth pattern, and reproductive biology (gonadosomatic index GSI) with the hope that this scientific information can be useful in the ecological, biological management and also biodiversity of the species. This information is needful for sustainable management of *Liza falcipinnis* in Ojo axis of Badagry creek, where it is caught in large numbers with unregulated fishing gears and methods. The major problem of this research is that adult sizes of the fish were rarely caught in Ojo lagoon. The specific objectives are to determine the species' growth pattern using Length- Weight relationship (LWR) of the Vonbertalanffy growth equation; length frequency of the year classes in the population using Petersen method; condition factor (K-Factor) i.e. condition of well-being of the species; the gonadosomatic index of the species (GSI) and sex ratio using the Chi-square (X^2).

2. Study Area

Ojo axis of Badagry creek is along the Badagry water system in the Northern area, this is shown in Figure 1 (marked X) in the map of the Lagos lagoon complex, which comprises of the Epe lagoon in the south; Lagos lagoon in the middle, Ologe lagoon and the Badagry creek in the north. The Ojo axis of the creek extends from Ojo Army Barracks down to ijanikin Local Government Area Headquarters, Lagos state. The samples were collected specifically within coordinates: 6°28N 3°11E and 6.467°N 3.183°E. [24] stated that Badagry creek is a long stretch of water body that runs parallel to the Atlantic Ocean in the south; it extends from Lake Nokue near Port-Novo to Apapa area of Lagos, and from there opens into the Ocean through the Lagos harbour. Fish species are highly diversed in the Ojo creek; examples are *Ethmalosa, Gobioides, Cynoglossus, Pomadasys, Pseudotolithus, Tilapia, Liza, Clarias, Selene, Macrobrachium and Callinectes.*

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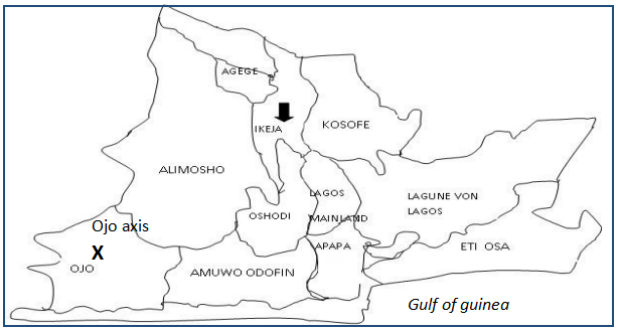

Figure 1. Map of the Lagos lagoon complex, showing the Ojo axis (marked X) of Badagry creek, Lagos, Nigeria

3. Material and Methods

3.1 Fish Sample Collection and Laboratory Analysis

Edible fishes were procured from the fishermen on the creek (Ojo) on a monthly basis from May, 2019 to March, 2020. The sampling gears used for fishing by the fishermen include baited long lines, cast nets and set gill net. A total of at least 1012 samples of *Liza falcipinnis* were collected for the analysis. The samples were transported in an ice chest to the Fisheries Laboratory at the Department of Fisheries, Lagos State University, Ojo, Lagos State for proper identification and examination. Fish identification was made to the lowest taxonomic level. Relative abundance of species was calculated by dividing number making up a species by the total number of fish sampled multiplied by 100%. The total and standard length of fish sampled were measured using measuring board graduated in cm. Range of the length frequency was determined and recorded. Weight was measured using a weighing balance. The average weight of these samples was used to estimate the number of individuals from the total catch for the week. The biometric data such as total length were taken to the nearest grams. Identification was done as following [3].

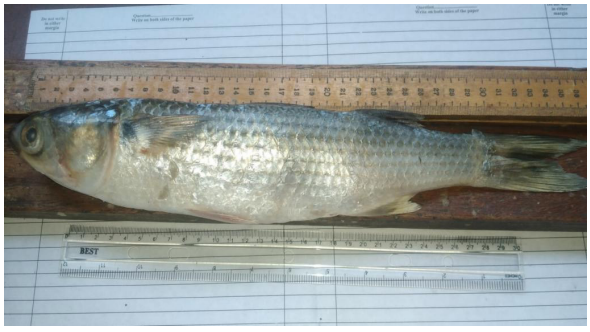

Figure 2. Sample of *Liza falcipinnis* (mullet) from Ojo axis of Badagry creek, Lagos, Nigeria

3.2 Length Weight Relationship and Length Frequency Analysis

The length weight relationships were obtained from the linear regression analysis

Intercept:a = $[\frac{\sum Y}{N} - (b.\frac{\sum X)}{n}]$

The slope ('b') as: $b = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sum X - \frac{(\sum X)^2}{n}}$

And the correlation Coefficient ('r') as: $|r| = \frac{[\sum XY - \frac{(\sum X)(\sum Y)}{n}]}{[\sum X - \frac{(\sum X)^2}{n}][\sum Y2 - \frac{(\sum Y2)}{n}]}$

Where: X= Lengths of fish, Y= Weights of fish, and n= number of specimens.

The length-weight relationships for males and female specimens were obtained and a scattered diagram was drawn to determine the statistical relationships.

The relationship was expressed as: **W= a + bL.**

The same data was converted to logarithms and straight-line graph was drawn and the relative slope (b) was obtained from the relationship:$\mathbf{Log_{10}W = a + b\ log_{10}\ L.}$

3.3 Length-Frequency Method (Petersen Method)

The method currently in use for the analysis of length-frequency data; all finds their origin from the work of Petersen (Petersen methods). With this method, the assumptions were made as to the time interval separating the various peaks of one length frequency sample. These peaks were assumed to represent distinct age groups in a year class.

3.4 Condition Factor (K)

Fulton's condition factor (K) obtained for both sexes was expressed as:

$$\mathbf{K = 100W/L^3}$$

Where W= weight of fish (g), L= Length of fish (mm). Therefore, the condition factor (K) was used to compare the condition, fatness or well- being of both sexes of the fish [22].

3.5 Sex Ratio

The differentia in sex distribution of the pollution of *Synodontis clarias* was determined from the separation of sexes into males and females. The chi-square technique was used where the observed (X^{2tab}) was measured against the chi-square calculated (X^{2cal}) as expressed below:

$$\mathbf{X^2 = (O - E)^2/E}$$

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3.6 Gonadosomatic Index (GSI)

The gonadosomatic index (GSI) was determined or calculated based on the formula suggested by [22] which is expressed as:

$$GSI = \frac{\text{Gonad weight (g) x 100}}{\text{Total body weight (g)}}$$

4. Results

4.1 Seasonal Abundance

Seasonal variations in number and weight are shown in Figure 4 for both sexes. Highest catches in the total number of fish occurred in June 2019; while the highest catches in weight occurred in February 2020 in the study area. However, Figure 5 showed the seasonal abundance in the population of female *Liza falcipinnis* from Ojo axis of Badagry creek. It reveals that the highest female catches in number were in October, December 2019, and February 2020. This thus coincides with peak of rainy season, while the highest peak of catches in weight was reported in February 2020. The male sex showed a different seasonal distribution. The male had the peak population in number in June 2019 and March 2020 with a corresponding highest catch in weight in the same month as shown in Figure 3. The population distribution in terms of catches was lowest from August to February 2020 for the males in term of weight and total number of fish.

4.2 Morphometric Analysis and Length Weight Relationships

The result of the monthly morphometric analysis, length weight relationship and condition factor of Liza falcipinnis from Ojo axis of Badagry creek from May, 2019 to March, 2020 are presented in Table 1. The mean length for combined sexes was between 15.9 cm (May, 2019) and 30.5 cm (Jan 2020). The mean weight was between 35.19 g (may, 2019) to 247.4 g (Feb, 2020). However, the intercept of the length weight relationships was positive through-out the year, values were between 8.9 cm to 17.6 cm. The slope of the graph was equally all positive which suggests positive allormetrism, the lowest b value was 0.02 and the highest value was 0.1, this is shown in Figure 3, 4 and 5. The correlation coefficients (r) were generally high from 0.46 to 0.8. The mean length for female was between 15.89 cm (May 2019) to 31.74 cm (Jan 2020). The mean weight was between 34.29 g (May, 2019) and 296.09 g (Feb, 2020). The length weight relationship for female was positive through-out the year. Values were between 7.64 cm and 18.20 cm. The slope of the graph was also positive which showed an allometric growth pattern. The lowest b value was 0.02 and the highest was 0.11 (Table 1). The correlation coefficient (r) was generally high from 0.55 to 0.96. The mean length for male was between 15.92 cm (May) and 28.42 (November). The mean weight was between 35.7 g (May, 2019) and 161.44 g (Jan 2020) (Table 1).

Table 1. Changes in Seasonal Abundance of *Liza falcipinnis* in Ojo axis of Badagry Creek, Lagos

Month	Combine sexes				Females				Males			
	No of fish	% No of fish	Total Wt (g)	% Total Wt	No. of fish	% No of fish	Total Wt (g)	% Total Wt	No of fish	% No of fish	Total Wt (g)	% Total Wt
May	74	7.31	2604.2	2.2	27	5.4	925.9	1.3	47	9.2	1678.1	3.6
June	146	14.4	10163.9	8.6	33	6.6	3156.7	4.8	113	22.0	7007.8	15.2
July	119	11.8	9698.1	8.2	35	7.0	4448.5	6.2	84	16.2	5249.6	11.4
August	96	9.5	11041.1	9.3	45	9.0	6182.8	8.8	51	9.9	4858.3	10.5
September	91	9.0	9361.4	8.0	51	10.2	5347.6	7.4	40	7.9	4091.9	8.8
October	94	9.3	12227.8	10.3	60	12.2	7900.6	10.9	34	6.6	4327.1	9.4
November	54	5.3	8122.7	6.8	38	7.6	5598.0	7.7	16	3.1	2524.7	5.5
December	88	8.7	12119.5	10.2	62	12.4	8579.0	11.9	26	5.1	3540.5	7.7
January	73	7.2	11192.3	9.5	51	10.2	7802.1	10.8	22	4.1	3390.2	7.4
February	86	8.5	21275.8	18.0	61	12.2	18061.5	25.0	25	4.9	3214.3	6.9
March	91	9.0	10361.88	8.8	36	7.2	4133.7	5.7	55	10.9	6226.1	13.5

Note: Wt = fish weight in grams.

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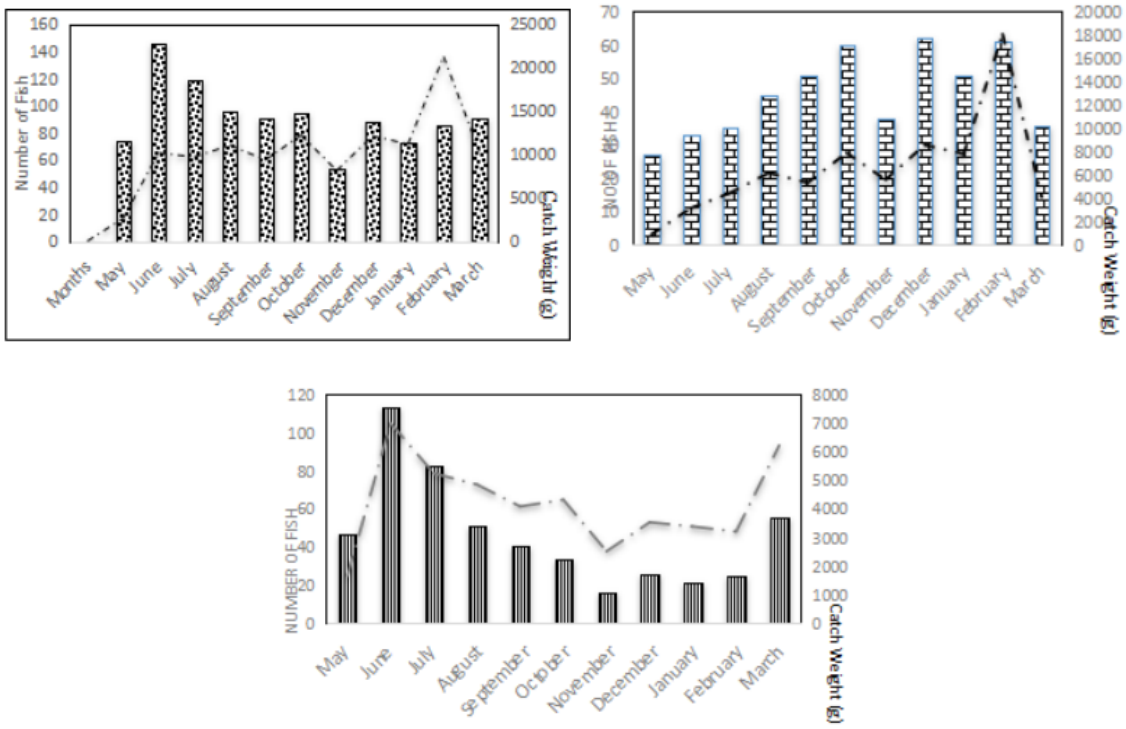

Figure 3. Changes in Seasonal abundance of (1) Combine sex, (2) Females and (3) Males of Liza falcipinnis from Ojo axis of Badagry creek, Lagos-Nigeria.

Table 2. Morphometric measurements in *Liza falcipinnis* from Ojo axis of Badagry creek, Nigeria

Morphometric measurements (mm)L	Combined sex(n = 1012)			Males(n = 513)			Females(n = 499)		
	Range		Mean±SD	Range		Mean±SD	Range		Mean±SD
	Min	Max		Min	Max		Min	Max	
Eye diameter (ED)	0.5	2.5	1.23±0.1	0.7	2.6	1.13±0.22	0.5	2.5	1.34±0.68
Head length (HL)	2.1	12	4.63±0.5	2.1	10.4	4.25±0.94	2.5	12	5.03±1.23
Head depth (HD)	1.7	8.1	3.56±0.4	1.7	7.7	3.27±0.75	2.0	8.1	3.85±0.86
Body depth (BD)	2.5	11.7	4.68±0.5	2.5	9.7	4.35±0.87	2.6	11.7	5.02±1.1
Total length (TL)	2.6	233.3	24.95±2.8	12.5	44.4	21.78±4.88	2.6	233.3	26.19±10.6
Body weight (g)	9.23	1006	121.7±55.1	9.23	700	107.1±40.6	15.6	1006	134.6±62.9

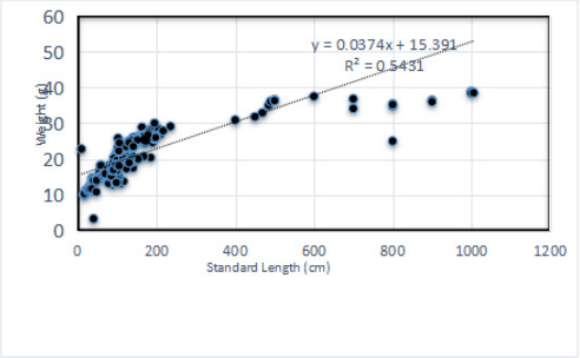

Figure 4. Standard Length-Weight relationship in Combined sexes of Liza falzipinnis from Ojo axis of Badagry creek, Lagos Nigeria

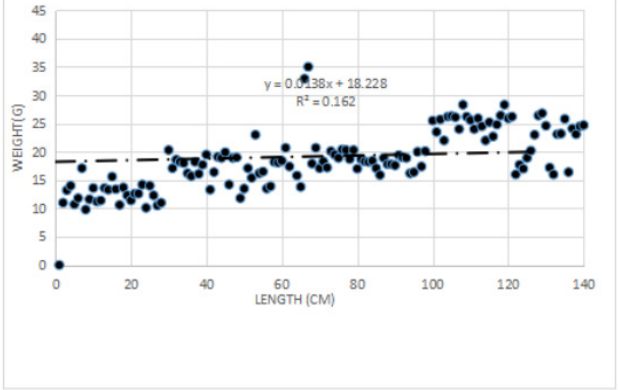

Figure 5. Length-Weight Relationship of Female Liza Falzipinnis from Ojo axis of Badagry creek

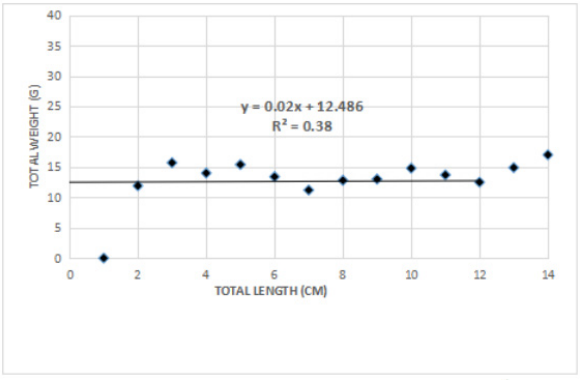

Figure 6. Length-Weight Relationship of Male Liza Falzipinnis from Ojo axis of Badagry creek

4.3 Length Frequency Analysis

Fish total length measurements were categorized into 21 modal classes for combined sexes which showed a bi - modal distribution of Liza falcipinnis from Ojo axis of Badagry creek. The cohort were from 1.9 cm to 39.9 cm (TL). The modal length was from 17.19 cm to 19 cm and 22.8 cm to 24.7 cm for combined sexes with frequency of 17.8% of the population and 17.5%. The distribution of species in the population skewed more to the right, this means that they were larger fish species in the sampled population. There was large number of fish between 17.1 cm and 19 cm and between 22.8 cm to 24.7 cm (TL). Two age groups (Age 1 and 2) were obtained from the sampled population which was ascertained from the modal distribution of length frequency histogram in Figure 7[A] for combined sex of *Liza falcipinnis* from Ojo axis of Badagry creek Lagos Nigeria. Total length measurement for female *Liza falcipinnis* were categorized into 18 modal classes as shown in Figure 7[B]. The cohort were from 2.2 cm to 39.6 cm (TL). Modal length was from 24.2 cm to 26.4 cm with frequency of 14.3% of the population. There were large numbers of fish between 24.2 cm and 26.4 cm. Two age groups (Age 1 and 2) were also obtained from the sampled population through the length frequency histogram (Figure 7). The total length measurement for male *Liza falcipinnis* from Ojo axis of Badagry creek were categorized into 21 modal classes (Figure 7C). The cohort were from 0.1 cm to 46.2 cm. Modal lengths were from 19.8 cm to 22 cm with frequency of 9.1% of the population. There was a large number of fish between 17.6 cm and 22 cm. Two age group from the sampled population were observed in length frequency histogram.

4.4 Condition Factor

The condition factor of the combined sex is shown and elucidated in Table 2 and it showed that the fish were not in good condition with the lowest condition factor of 0.68 (Dec., 2019) while the highest condition was 0.85 (June, 2020). These values showed that the female *Liza falcipinnis* from Ojo axis of Badagry creek were in better condition. The females gained more weight than the males. The females had the best condition in February (0.83) and the poorest condition in October (0.69), the males had a better relative increase of condition which was observed in June 2019 and low condition in November 2019 (0.68).

4.5 Sex Ratio

Samples of *Liza falcipinnis* from Ojo axis of Badagry creek showed differences in the distribution in term of sexual dimorphism (distribution of male and female species). This is shown in Table 4. Sexual differences were observed throughout the year. The males were numerically more dominant than the female (P<0.05) in May

Table 3. Summary of monthly morphometric analysis, Length-Weight Relationship and condition factors of *Liza falcipinnis* from Ojo axis of Badagry Creek, Lagos. (2019 - 2020)

Months	Combine sexes						Females						Males					
	Mean length	Mean weight	a	b	r^2	k	Mean length	Mean weight	a	b	r^2	k	Mean length	Mean weight	a	b	r^2	K
May	15.91	35.19	8.92	0.1	0.86	0.83	15.89	34.29	8.68	0.11	0.96	0.81	15.92	35.7	9.05	0.1	0.82	0.83
June	19.83	69.62	10.52	0.07	0.77	0.85	22.72	95.64	11.25	0.06	0.55	0,79	18.98	62.02	10.38	0.07	0.79	0.86
July	20.73	82.19	11.71	0.05	0.85	0.81	24.67	127.10	13.73	0.04	0.91	0.79	19.08	63.25	11.1	0.06	0.81	0.83
August	24.60	115.01	8.97	0.1	0.85	0.76	26.56	137.4	11.52	0.09	0.83	0.73	22.87	95.26	5.72	0.14	0.82	0.8
September	23.37	102.87	8.13	0.1	0.71	0.81	23.64	104.86	7.64	0.11	0.73	0.79	22.97	99.8	9.13	0.1	0.68	0.82
October	26.21	130.08	10.48	0.1	0.77	0.70	26.28	131.68	10.96	0.09	0.72	0.69	26.08	127.27	9.82	0.1	0.85	0.71
November	27.64	150.42	17.59	0.05	0.60	0.72	27.32	147.32	17.05	0.05	0.83	0.73	28.42	157.79	19.87	0.03	0.16	0.69
December	27.19	137.72	16.52	0.06	0.89	0.68	27.21	138.37	16.58	0.06	0.87	0.68	27.15	136.17	16.44	0.06	0.93	0.68
January	30.54	155.45	17.60	0.04	0.66	0.70	31.74	152.98	17.94	0.04	0.68	0.69	27.63	161.44	16.59	0.05	0.64	0.74
February	28.04	247.39	16.98	0.02	0.78	0.82	29.95	296.09	18.20	0.02	0.79	0.83	23.39	128.57	13.61	0.04	0.85	0.81
March	24.48	112.63	11.34	0.07	0.46	0.77	24.34	114.88	10.97	0.07	0.65	0.79	24.56	111.18	11.46	0.08	0.42	0.75

Note: LWR = length-weight relationship, a = intercept, b = slope of graph, r = correlation coefficient, K-factor = condition factor, mean length in cm and mean weight in grams

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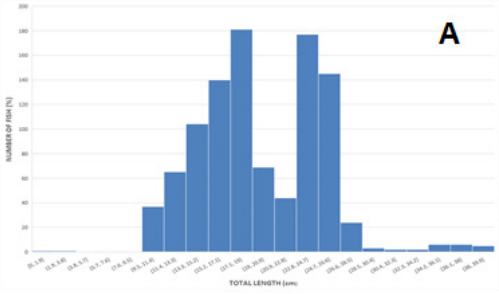
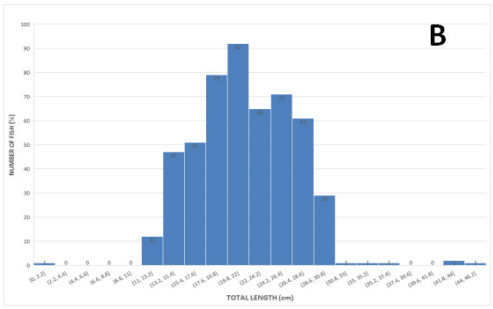
(2.0: 1.0), June (3.4: 1.0), July (2.4: 1.0), August (1.1: 1.0), 2019 and march (1.5: 1.0), 2020. The monthly sex ratio analysis (Male: Female) is in favour of the females; in September (1:1.3), October (1:1.8), November (1:2.4), December (1:2.4), January (1:2.3) and February (1:2.4). However, the Chi-square analysis (Table 4) revealed a rejection of the null hypothesis [there were no differences in sex distribution] ($P<0.05$), because the Chi calculated (X_{cal}) values were significantly higher than Chi tabulated (X_{tab}) for most part of the period of study; except for the months of August (0.38), and September (1.33), as against the Chi $_{tab}$ of 3.841.





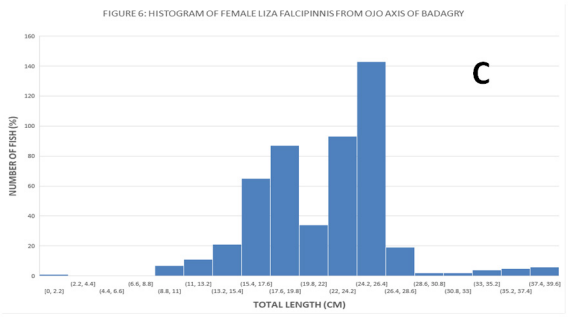


Figure 7. Length frequency distribution (Histogram) of Combined sexes [A], male [B] and Females [C]; Liza falcipinnis from Ojo axis of Badagry creek, Lagos, Nigeria.

4.6 Gonadosomatic Index (GSI) and Spawning Period

The monthly gonadosomatic index (GSI) values for female *Liza falcipinnis* from Ojo axis of Badagry creek is shown in Table 5. GSI values varied from 0.73 - 6.16 (2.3±2.79) in May, 0.17 - 10.12 (1.75±5.35) in June, 0.1 - 3.84 (1.27±1.91) in July, 0.24 - 17.77 (2.88±9.45) in August, 0.19 - 1.81 (0.92±0.81) in September, 0.4 - 4.78 (1.56±2.27) in October, 0.6 - 5.39 (2.05±2.46) in November, 0.78 - 8.24 (3.27±3.8) in December, 2019; 0.13 - 8.6 (2.18±4.42) in January, 0.14 - 9.97 (2.15+5.19) in February, and 0.47 - 10.03 (3.28±4.91) in March, 2020 respectively. GSI value for the female were found to vary with time (monthly) and the highest index observed was in August, 2019 (17.77) with mean of 2.88±0.75 and the lowest in July, 2019 (0.1) with mean of 1.27±0.01.

Table 4. Sex distribution, ratio and Chi-square analysis of *Liza falcipinnis* in the monthly samples from Ojo axis of Badagry creek, Lagos

Months	No. of fish Combined sexes	E	No. of males (O)	No. of females (O)	Sex ratio M:F	$\frac{(O-E)^2}{E}$ male	$\frac{(O-E)^2}{E}$ Female	X^2_{Cal}	X^2_{tab} at [P<0.05
May	74	37	47	27	2.0:1.0	2.70	2.70	5.41	3.841
June	146	73	113	33	3.4:1.0	21.92	21.92	43.84	3.841
July	119	59.5	84	35	2.4:1.0	10.09	10.09	20.18	3.841
August	96	48	51	45	1.1:1.0	0.19	0.19	0.38	3.841
September	91	45.5	40	51	1.0:1.3	0.66	0.66	1.33	3.841
October	94	47	34	60	1.0:1.8	3.60	3.60	7.19	3.841
November	54	27	16	38	1.0:2.4	4.48	4.48	8.96	3.841
December	88	44	26	62	1.0:2.4	7.36	7.36	14.73	3.841
January	73	36.5	22	51	1.0:2.3	5.76	5.76	11.52	3.841
February	86	43	25	61	1.0:2.4	7.53	7.53	15.07	3.841
March	91	45.5	55	36	1.5:1.0	1.98	1.98	3.97	3.841

Note: E = expected, O = observed, X^2 = Chi-square, X^2_{tab} = tabulated chi square < 0.05 confidence limit and X^2_{cal} = Chi-square calculated

Table 5. Monthly GSI for female Liza falcipinnis in Ojo axis Badagry Creek, Lagos

Months	MIN GSI	MAX GSI	MEAN GSI+SD
May	0.73	6.16	2.3±2.79
June	0.17	10.12	1.75±5.35
July	0.1	3.84	1.27±1.91
August	0.24	17.77	2.88±9.45
September	0.19	1.81	0.92±0.81
October	0.4	4.78	1.56±2.27
November	0.6	5.39	2.05±2.46
December	0.78	8.24	3.27±3.8
January	0.13	8.6	2.18±4.42
February	0.14	9.97	2.15±5.19
March	0.47	10.03	3.28±4.91

5. Discussion

Relative high abundance of *Liza falcipinnis* in Ojo axis of Badagry creek was observed in the study, during the study period. Although, the total number caught for each month varied (as shown in Table 1) and this can be related to seasonal changes, fishing activities, recruitment, availability of food and changes in the behaviour of the fish. This opinion was shared by [28] who worked on the biology of two species of catfishes: *Synodontis schall* and *Synodontis nigrita* from Queue River, Benin. They reported that high species yield in catches during April and May corresponds to the beginning of rainy season, when food availability is highest due to flood introducing nutrients and mixing of water by rapid currents. Such ecological situations are favourable to fishes and may cause them to venture out of their hidden crevices making them vulnerable for fishing. The current study reveals that the highest catches by number was in June and July 2019. This result corresponds with the above result as reviewed. Increase in fish abundance due to the combination of physiochemical properties and presence of food items has been reported by [11]. However, catches in weight was contrasted to catches in number, which showed that there is overfishing in the study area.

Morphometric and meristic characters were studied on *Liza falcipinnis*, 6 morphometrics and 4 meristic characters were examined for each sex. It was compared to find out the phenotypic differences in the population (Table 2). The morphometric measurements between male and female *Liza falcipinnis* showed some slight variations, but not sufficient to discriminate between male and female sexes. The male and female individuals showed similarities with each other with respect to all morphological characteristics. The variation between both sexes revealed that the female exhibited higher measurement values than that of the male which was supported by [24] who observed similar results. The present study revealed that though some variations were observed in each morphometric and meristic characters between sexes, but such variations or differences were insignificant ($p<0.05$). Therefore, this indicated a negligible effect of sex on variations in the morphometric and meristic characters. This report agrees with [34]. The above data indicates that the female sex is phenotypically larger than the male. [34] and [8] reported that both meristic and morphometric character of fish maybe influenced by certain environmental factors e.g. turbidity, food availability, temperature, therefore variation showed in the present study on morphological characters among male and female of *Liza falcipinnis* might be as a result of differences in the environmental condition of the habitat, availability of food, sample size, sex condition, sexual maturity; all these may lead to produce the phenotypic differences between the male and female sexes of species as previously corroborated by some workers including [29], [17] and [13].

Growth of fish can be described as either allometric or isometric depending on the value of 'b' (regression coefficient). The b value of *Liza falcipinnis* from Ojo axis Badagry creek were 0.04, 0.01 and 0.02 for combined, male, and female sexes respectively. This indicated that the fish exhibited a negative allometric growth pattern which shows that the species under this study became thinner as they grew longer. The results also showed that the species are in poor condition and were not robust enough, relative to its length. Similarly, to [15] who reported a weak correlation coefficient (r) for Australian mullet with r = 0.87 for males and 0.86 for females. In this current study, the r^2 values were 0.54 for combined sexes, 0.16 for females and 0.38 for males, showing a strong relationship between total length and body weight measurements of the fish. Though, there was increase in total length with corresponding increase in bodyweight; the general condition of the species in the study area are considered slightly weak. Length weight relationship are useful tools for fisheries research because they allow the conversion of growth in length equation to growth in weight for use in stock assessment model, and allows for the estimation of biomass from length observation, Also, the estimate of the condition of the fish and are useful tools for regional comparism of life histories of certain species [25].

The condition factor of fish is regarded as the fitness or relative well-being of the fish. It indicates the general metabolism of fish. These values indicated poor well-being of the assessed fish. [7] related low condition to the period when accumulated fat is used for spawning, while high values indicate a period of increase rate of feeding followed by a gradual increase in accumulated fat, which suggest preparation for a new reproductive period. This

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result is similar to the report of [24] on the same species from Badagry creek. He reported condition value of 0.0079, 0.0087, 0.0097 for immature, males, and females respectively. He therefore suggested that the reason for low condition of *Liza falcipinnis* from Badagry creek is due to ecological and environmental factors and also an indication of how well the species is in this water body. The value for condition factor in this study varied slightly between the male and female fish. The slight variation could be attributed to food availability, gonad development and gender of fish [30,16].

The length frequency distribution of all the species were not having equal interval due to the presence of small sized fish in the assessed population. The length frequency distribution graph (Figure 7A, 7B and 7C) indicated that the *Liza falcipinnis* from Ojo axis of Badagry creek were dominated by two modal lengths or year classes or age groups/cohorts (representing ages 1 and 2). For combined sexes, the sampled population was dominated by fish of length 24.2 - 26.4 cm, while the male population was dominated by fish of length 19.6 - 22 cm. This observation implies that the females have bigger dominant sizes within the population. Gonadosomatic index is one of the essential parameters in studying the reproductive biology of the fish. It's used to describe the gonadal stage or development/ spawning stage/level of ripeness of the ovary in the different sexes of fish. In this study, the Gonadosomatic Index (GSI) for female *Liza falcipinnis* from Ojo axis of Badagry creek was studied between May 2019 to March, 2020. The GSI was highest in August 2019 with 17.77% (as shown in Figure 3) which indicated the peak of spawning in this species in the study area. Figure 3 shows that gonadal maturation actually began in June (2019) and was completed in August (2019) which coincides with the peak period of rain season. It decreased thereafter from September (2019) to November (2019) showing a period of sexual rest. [10] reported that gonadal maturity began in September (dry season) and was completed in November (rain season) for the same species from two lagoons in Cote D-Ivoire and this coincide with flood season of the area and thus creates an ideal condition for the survival of larval and fingerlings due to abundance of food. During flood season nutrients are drained by the rich run-off in organic matter, the decomposition of organic matter enriches the environment in mineral salts which will lead to proliferation of algae according to [20]. The availability of food during this period is utilized by the larvae therefore they do not have to travel long distance in search of food as opined by [26].

Sexual dimorphism or unbalanced sex ratio in the mullet has been observed by several authors: [24,1,5] amongst others. The prevalence of one of the sexes is a relatively frequent phenomenon in many teleosts and this could come from differential growth according to sex. In the current study, the males were dominant in May, June, July, August, 2019, and March, 2020. (2:1, 3.4:1, 2.4:1, 1.1:1, and 1.5:1 respectively). The variation was an indication that sex was in favour of the males during this period. Sex ratio that favoured the females may account for its reproductive success in Ojo axis of Badagry creek. The female sex was dominant in September, October, November, December, 2019, January and February, 2020. (1:1.3, 1:1.8, 1:2.4, 1:2.4, 1:2.3, 1:2.4 male: female respectively). [10] also reported the dominance of female *Liza falcipinnis* from Ebrie and Grand-Lahou lagoon. He stated that the reason may be due to higher mortality of the male at larva stage and less accessibility of the male due to ethological differences related to sex. According to [6] and [17] the female Mugilidae reaches sexual maturity at larger size than the male.

6. Conclusions

The implication of the results is that fish abundance (by number) in June and July, 2019 prompted more fishing activities leading to recruitment overfishing and growth overfishing. Sexual differences in relation to seasonal abundance were clearly observed and highlighted.

The female sex is phenotypically larger than the male. The report thus concludes that both meristic and morphometric characters of fish maybe influenced by certain environmental factors.

The growth of the species was negatively allormetric. There was increase in total length with corresponding increase in bodyweight; but the general condition of the species in the study area are considered slightly weak. The results are essential because they allow the conversion of growth in length equation to growth in weight for use in stock assessment model.

The values of condition factor indicate poor well-being of the assessed fish. The males were dominant in May, June, July, August, 2019, and March, 2020.

The sex variation showed that sex was in favour of the males during some period. Sex ratio favoured the females during reproductive periods which coincides with the months of September, October, November, December, 2019, January and February, 2020 in the study area.

The GSI was the highest in August 2019 with 17.77%. Gonadal maturation actually began in June (2019) and was completed in August (2019) which coincides with the peak period of rain season.

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