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Aspects of the reproductive biology of *Elops lacerta* (valenciennes, 1847) from Epe Lagoon, South Western Nigeria

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Abstract
The present investigation was conducted to study aspects of reproductive biology of *Elops lacerta* from Epe lagoon, South western Nigeria. A total of 800 specimens of *Elops lacerta* were examined between August 2014 – July 2016. Data on sex ratio, total length (TL), gonad (GW) body weight (BW), fecundity, stages of maturation and gonadosomatic index (GSI) were carried out on this specie. The sex ratio of 1 male to 0.6 females was observed. Six stages of maturity: immature, resting, maturing, ripe, spawning and spent were observed in this study. The GSI values varied from 10 to 15%. Fecundity ranged from 716 to 11,345 in number. The eggs were as small as 0.04mm and as big as 1.37 mm in diameter. The fish ranged from 10cm to 25cm standard length. The information generated through this study act as a baseline data for future ecological and biological studies of this species.

Keywords: *Elops lacerta,* fecundity, gonadosomatic index and maturity

1. Introduction
Reproductive behaviour in most animals is cyclic i.e. periodic, this is so for nearly all fishes [12]. The reproductive act in some fishes occurs only once in a very short life time. Most fishes however have a yearly cycle of reproduction, and once they have begun it, they follow it until they die [12]. Several other species spawn more than once in a year and more or less continually. Sex ratio, egg diameter and the gonadotropic indices of the ripe fish have been used as an indicator of gonad development. There is an inverse relation between egg size and fecundity [19]. Gonado-somatic index (GSI) is used to determine amount of body weight a fish puts into gonad production [1]. Ten pounder or West African lady fish, *Elops lacerta* is a member of the Family Elopidae. The family comprises of one genus and six species especially found in tropical and sub tropical seas. It is an economically important fish species in Nigerian waters and widely distributed in estuaries and coastal waters of tropical and sub-tropical sea [9]. Its juveniles had been reported in marine, brackish and fresh waters off Lagos Coast, Lagos and Lekki Lagoons in Nigeria [23]. The predatory tendencies of the genus *Elops* was reported in a man-made lake in Hawaii [15]. Development of fish seeds production has been identified as a rational way of augmenting the dwindling fish supply from the capture fisheries [8]. *Elops lacerta* is esteemed as food on account of its flesh and also as a good aquaculture candidate. However, no progress has been made to culture this specie economically in Nigeria. Several authors have investigated the reproductive biology of different fish species in Nigeria. The sex ratio, reproductive cycle, fecundity of the family Schilbeidae was studied in Kainji Lake and the reproductive features of *S. mystus* in Asejire Lake was determined [18]. Gonads of Mormyrids in Lekki lagoon Lagos was studied [22] and some aspects of the biology of the catfish, *Heterobranchus bidorsalis* in River Ogbese Nigeria [8]. The present investigation was conducted to study the aspect of the reproductive biology of *Elops lacerta* grom Epe lagoon, South Western Nigeria.

2. Materials and Methods
2.1 Study Area
Epe lagoon ($2^0$50'–$4^0$10'N, $5^0$30'-$5^0$40'E) has a surface area of 243km^{-2}. The lagoon has an average depth of about 1.80m and is sandwiched between two lagoons, Lekki lagoon

(Freshwater) in the east and Lagos lagoon (brackish) to the west. (Fig 1). Epe lagoon connects to the sea via Lagos harbor and the vegetation around the lagoon is characterized by stilt rooted trees with dense undergrowth of shrubs and herbs. Epe lagoon supports a major fishery in Lagos State, Nigeria and it is also used as transportation route for people, goods timber, logs from Epe to other places in south-western Nigeria.

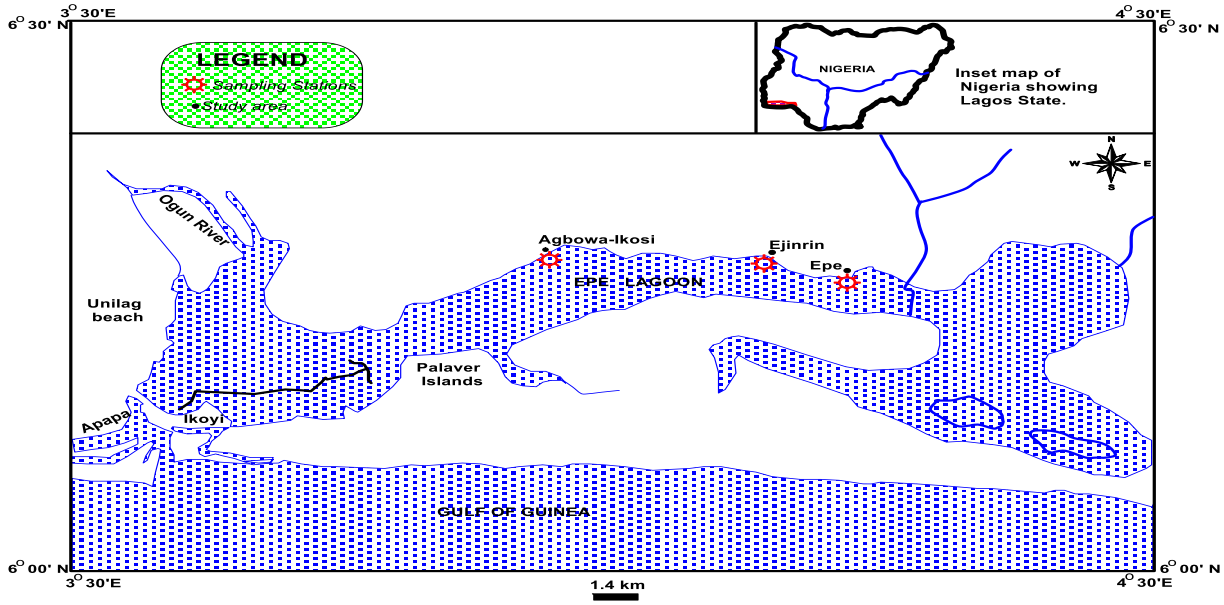

Fig 1: Map of Epe Lagoon showing the study areas

A total of 800 specimens of *Elops lacerta* was examined between August 2014 – July 2016. The specimen was chilled in an ice chest during transportation to the laboratory for investigation and analyses. The standard length (cm) and the weight (g) measurement of specimen were taken. The Gonads were removed by opening up the specimen, the gonads were weighed on a digital Metler balance and kept (for further analyses) in separately labeled plastic tubes. Matured gonads preserved in formal – saline prior to fecundity studies. The sex of each fish was determined by examining the genital papilla. External features like the pot belly in the female and internal feature like the carrying of testis in the male and ovaries in the female were also used to identify the sexes. Maturity of the gonads was determined macroscopically by internal examination of the gonads. The number of male and female specimens was counted monthly. Gonadal stages of development of *Elops lacerta* was assessed and classified using [5]. Immaturity I: Young individuals which have not yet engaged in reproduction. Gonads are of very small size. Resting Stage II: Sexual products have not yet begun to develop. Gonads of very small eggs not distinguished to the naked eyes. Maturation III: Eggs distinguishable to the naked eyes. A very rapid increase in weight of the gonad in progress, testes changes from transparent to a pale rose colour. Maturity IV: Sexual product, ripe gonads have achieved their maximum weights but the sexual products are not still extruded when light pressure is applied. Reproduction V: Sexual products are extruded in responses to very light pressure on the belly. Weight of the gonads decreases rapidly from the start of spawning to its completion. Spent VI: The sexual products have been discharged, genital aperture is inflamed, gonads have appearance of a deflated sac and ovaries usually containing a few left over eggs and the testes contain residual sperm.

Ovaries selected as being representative of each maturity stage were fixed in Bouin's fluid for 24 hours and then transferred to 70% alcohol. These were then embedded in paraffin wax and sections of 5-10µm were cut from the forepart and stained with haematoxylin and eosin. The stained sections were observed under a binocular microscope and the type of oocytes that dominated was noted. Measurement of ova diameter was made from the stained sections using a calibrated eyepiece micrometer to the nearest 0.01mm. Twenty oocytes were selected at random from each gonad development stage and their diameters measured on the horizontal axis irrespective of shape. Only oocytes sectioned through the nucleus was measured and the mean was taken as ova diameter for that gonad developmental stage. For the estimation of fecundity, sub sampling using the gravimetric method was employed as described by [3] using the formula:

$$\text{Fecundity} = \frac{\textit{Total weight of ovary}}{\textit{Weight of sub-sample}} \text{ X } \frac{\textit{No. of eggs in sub-sample}}{1}$$

The data on the body and gonad weight was used to determine the gonadosomatic index. On monthly basis gonadosomatic index was calculated using the following formula:

$$\text{GSI} = \frac{\textit{Gonad weight (g)}}{\textit{SWeight of fish} - \textit{Gonad weight (g)}}$$

Statistical Analysis

Data collected from this study were subjected to descriptive statistical analysis using Microsoft Excel. It was used in analyzing the data in terms of means, frequency distribution and regression co-efficient were used.

3. Results

Monthly sex ratios showed that the male fish were consistently more than the female in Epe lagoon. Of the 800 specimens of *E. lacerta* collected from the Lagoon, 496 (62%) were males and 304 (38%) females giving a sex ratio of 1 male: 0.6 female (Table I). The specimens measured between 10 cm and 35cm respectively. There are five

categories of *E. lacerta* in Epe lagoon, viz: 10 – 15 cm (Immature), 15 – 20cm (Resting), 20-25cm (Maturing), 25-30cm (Ripe & Spawning), 30 -35cm (Spent) Table II. The Maturing stage were the most dominant group, recording its highest numbers in the month of February May and June. The maturity stages observed in *E.lacerta* were mostly at stages III and IV which indicates intensive breeding activity coincident with the rainy seasons (Table III and Figure 2). All the five maturation stages occurred every month throughout the study period except the spent stage (stage V), ripe and spawning stage (stage IV) which was absent only in September 2015, and the immature stage absent in March, May and June 2015 (Table III). In April to July, the increase in female with gonad maturation stage IV shows the onset of rain, so breeding may occur during raining season. Fecundity ranged from 716 in size range 16-17.99cm to 11, 345 in size range 34-35.9cm. The GSI varied from 10% in size range 16-17.99cm to 15% in size range 34-3.99cm meaning that at that stage of maturity there is conversion of its body mass to gonads for reproduction (Table 4).

Table 1: Summary of monthly sex ratio of *Elops lacerta* in Epe Lagoon

Month	No. of specimen	Male	Female	Sex ratio(male:female)
August 2014	19	11	8	1: 0.7
September 2014	33	17	16	1: 0.9
October 2014	12	9	3	1: 0.3
November 2014	17	11	6	1: 0.5
December 2014	31	20	11	1: 0.5
January 2015	39	21	18	1: 0.8
February 2015	32	19	13	1: 0.6
March 2015	34	18	16	1: 0.8
April 2015	38	21	17	1: 0.8
May 2015	29	18	11	1: 0.6
June 2015	49	26	23	1: 0.8
July 2015	44	27	17	1: 0.6
August 2015	27	21	6	1: 0.2
September 2015	32	17	15	1: 0.8
October 2015	12	7	5	1: 0.7
November 2015	19	11	8	1: 0.7
December 2015	32	21	11	1: 0.5
January 2016	28	19	9	1: 0.4
February 2016	47	42	5	1: 0.1
March 2016	46	28	18	1:0.6
April 2016	44	27	17	1: 0.6
May 2016	42	29	13	1: 0.4
June 2016	46	25	21	1: 0.8
July 2016	48	31	17	1: 0.5
TOTAL	800	496 (62%)	304 (38%)	1: 0.6

Table 2: Maturity stages of *Elops lacerta* in Epe Lagoon

Maturation Stage	
I. Immature	No assecory organ was seen with the naked eye. Detected almost throughout the year except in March, June and July.
II. Resting	Ova diameter ranged from 0.04-0.08mm. Small visible ovaries, irregularly shaped and creamy in color. Ovaries were covered with small prominent vessels.
III. Maturing	Ova diameter ranged from 0.1-0.4mm. Free, smooth, yellowish and visible oocytes filling almost 60% of the abdominal cavity
IV. Ripe	Ova diameter ranged from 0.5-0.9mm. Large yellow oocytes were visible. Ovaries filling about 90% of the abdominal cavity
V. Spawning	Ova diameter ranged from 1.0-1.37mm. Ovary occupuing about 99% of the abdominal cavity. Oocytes in their tertiary vitellogenic stage. Eggs flowed from the vent on slight pressure. Occurred mostly from March to July
VI. Spent	Ovaries were greatly reduced in size and flaccid. Ova diameter ranged from 0.04-0.09mm. Dark red in color and highest occurrence were in the months of Feburary to May.

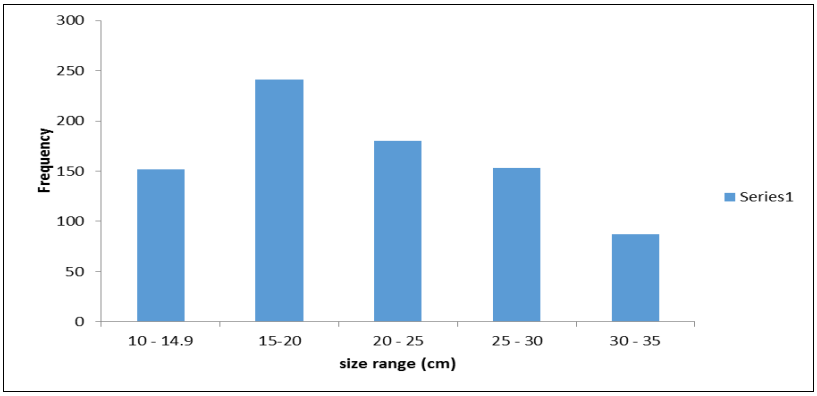

Fig 2: Length Frequency distribution of *Elops lacerta* in Epe lagoon

Table 3: Monthly distribution of *Elops lacerta* by size in Epe lagoon

Month	Length Frequency(cm)				
	10-15	15-20	20-25	25-30	30-35
	Immature	Resting	Maturing	Ripe& Spawning	Spent
August 2014	7	8	3	1	0
September 2014	10	18	8	6	1
October 2014	6	4	2	0	0
November 2014	2	11	2	1	1
December 2014	14	10	7	5	20
January 2015	11	13	6	7	1
February 2015	6	10	10	4	2
March 2015	-	10	9	8	7
April 2015	3	13	9	11	2
May 2015	-	4	17	6	2
June 2015	-	10	14	8	9
July 2015	8	13	10	13	0
August 2015	6	12	2	3	1
September 2015	11	17	4	-	-
October 2015	7	3	1	1	0
November 2015	5	9	2	3	0
December 2015	12	8	4	6	2
January 2016	10	7	5	4	2
February 2016	9	10	9	11	8
March 2016	1	12	9	10	4
April 2016	2	10	6	12	4
May 2016	2	1	19	9	11
June 2016	3	17	8	10	8
July 2016	7	11	14	14	2

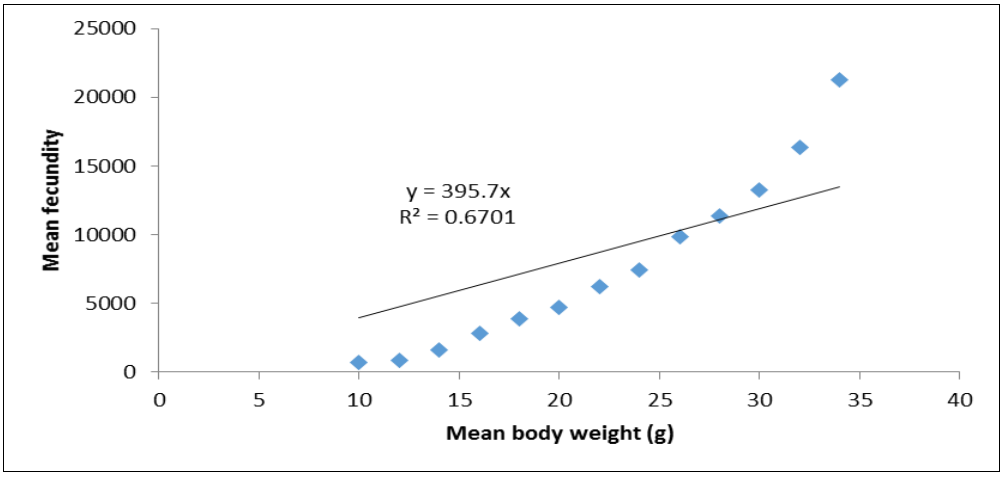

Fig 3: Relationship between body weight and fecundity of *E.lacerta* in Epe Lagoon

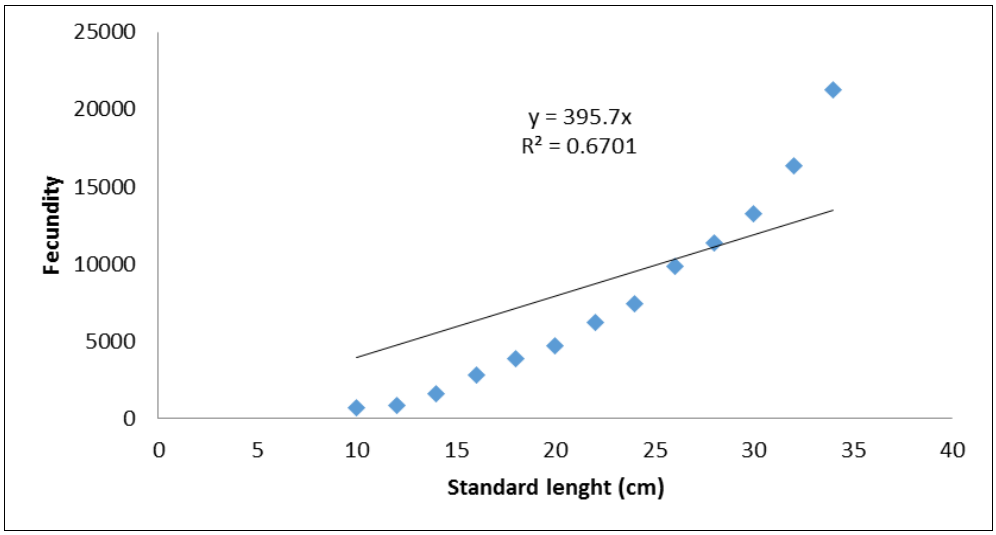

Fig 4: Relationship between body standard lenght and fecundity of *E.lacerta* in Epe Lagoon

Table 4: Size variation of Gonadosomatic Indices and Fecundity of *E.lacerta* in Epe Lagoon

Standard length (cm)	Mean body weight (g)	Mean Gonad weight (g)	Mean GSI %	Mean Fecundity
16 – 17.99	18.6	3.1	10	716
18 – 19.99	27.0	5.3	11	843
20 - 21.99	40.6	7.4	15	1,593
22 – 23.99	72.4	10.3	20	2,784
24 – 25.99	81.3	13.0	25	3,902
26 – 27.99	104.6	14.3	22	4,682
28 – 29.99	122.0	16.0	20	6,201
30 – 31.99	141.8	22.1	19	7,447
32 – 33.99	176.9	27.5	16	9,823
34 – 35.99	204.0	34.2	15	11,345

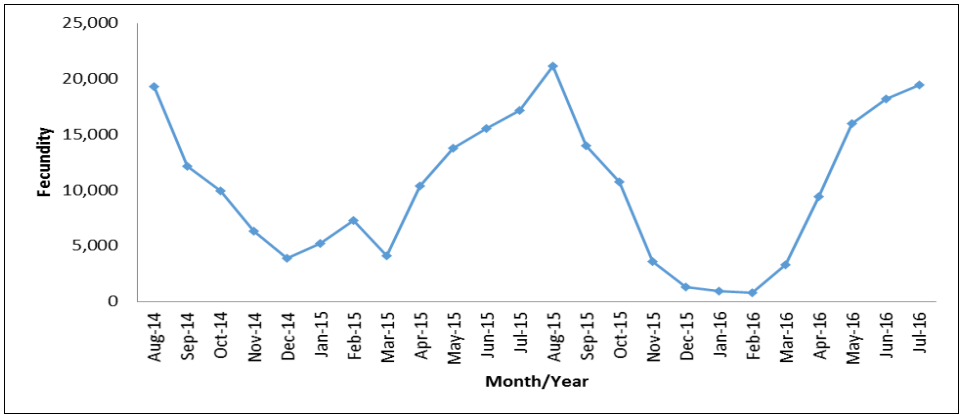

Fig 5: Monthly variation in fecundity of *E.lacerta* in Epe Lagoon

4. Discussion

Information on sex ratio is important for understanding the relationship between individuals, the environment and the state of the population [24]. The sex ratio of *E. lacerta* is presented in Table 1. Monthly sex ratios showed that the male fish were consistently more than the female in Epe lagoon. Of the 800 specimens of *E. lacerta* collected from the Lagoon, 496 (62%) were males and 304 (38%) females giving a sex ratio of 1 male: 0.6 female. This suggests a reproductive behaviour of this species where egg cluster is protected by the parental male until hatching occurs, during this process large number of or more males were caught with gears. Secondly, differential movement of sexes might made more males to be caught. The highest sex ratio of 1male to 0.9 female was in September 2014 and the least ratio of 1male to 0.1 female in Feburary 2016. Sex ratio in *Elops lacerta* which was in favour of males in Lekki, Lagos lagoon and off Lagos coast [23]. It was believed that the spawning activities contributed to the high male to female ratios in favor of the males. The reproductive success of the female is usually related to access to resources and environmental conditions, and not to the number of mating partners as in the case of males [19]. It is also suggested that this species may be protandrous hermaphrodite, a situation where at a certain age or size some females may change sex. However, higher percentages in favor of females were reported in *Ethmalosa fimbriata* [4] in the coastal waters of Cape coast, Ghana. The specimens measured between 10 cm and 35cm respectively. There are five categories of *E. lacerta* in Epe lagoon, viz: 10 – 15 cm (Immature), 15 – 20cm (Resting), 20-25cm (Maturing), 25-30cm (Ripe & Spawning), 30 -35cm (Spent) Table II and III. The Maturing stage were the most dominant group, recording its highest numbers in the month of February May and June. The preponderance of sub-adult *E. lacerta*, 13-27cm, was similar to the observation in Ologe lagoon, Lagos State, Nigeria [14]. It was reported that fish of about 90-169mm TL and 170-269 mm TL constituted 36.305 and 49.5% of the entire population of *E. lacerta* in Ologe lagoon mostly between February and July. In this study, ripe and spawning stage of fish which is the adult stage was also high. This was in agreement with McBride who reported that West African Ladyfish as offshore spawners [16]. The preponderance of adult *E. lacerta* in the marine environment of Nigeria had been earlier reported [23]. Several age groups of *E. lacerta* population were reported in this study unlike in [13] study that reported two age groups dominated by the smaller size groups.

In this study, the immature, resting, maturing, ripening and spent were present in the reproduction stage of *E. Lacerta* (Table II). The most dominant fish were those in their maturing stage, indicating the juveniles have not started migrating away from their natal ground. It is also suggested in this study that some sub-adults or spawners might have gone into burrowing holes to lay eggs, while the post spawning individuals have migrated away from their spawning ground; therefore, they were unable to be caught with gears. It evident from this study that the presence of ripe and spawning category of fish was high in numbers (Table III). This also disagrees with the observation of [23] that the fish matures in the marine environment. Spawning locations of ladyfish are unknown, but have been inferred to be offshore judging from the locations of capture [25]. The maturity stages observed in *E.lacerta* were mostly at stage 3 and 4 which indicates intensive breeding activity coincident with the rainy seasons (Table III and Fig V). All the five maturation stages occurred every month throughout the study period except the spent stage (stages V), ripe and spawning stage (stage IV) which was absent only in September 2015, and the immature stage absent in March, May and June 2015 (Table II and III). Observations of these stages of maturation in the fish though with modifications were in conformity with that of most teleosts [2]. In April to July, the increase in female with gonad

maturation stage IV shows the onset of rain, so breeding may occur during raining season. In this study, examination of the ovaries showed presence of oocytes at different stages of development which agrees with the report for *Merluccius merluccius* [17]. The gonadosomatic index (GSI) varied from 10% in size range 10-11.9cm to 25% in size range 16 – 17.9% meaning that at that stage of maturity there is conversion of its body mass to gonads for reproduction (Table IV). The GSI had been used to describe the development of gonads in Pike, *Esox lucius* by [6]. The significant correlation ($P<0.05$) of fecundity with both somatic weight ($r= 0.606$) and standard length ($r = 0.689$) suggests that fecundity increases with increase in weight and length of *E. lacerta*. An earlier work [11] reported that number of eggs produced increased as the body weight of fish increased, while some authors reported insignificant correlation in the length and fecundity [7, 10, 21]. Higher GSI values of between 0.01 and 8.40% were reported in mudskipper, *Periophthalmus papilio*, a benthic fish from mudflats of mangrove swamps of the adjacent Lagos lagoon, Nigeria [14]. GSI increases progressively with increases in the percentages of ripe individuals towards the spawning seasons [17].

Fecundity ranged from 716 in size range 10-11.9cm to 21, 237 in size range 34-35.9cm. The fecundity recorded in *E. lacerta* in this study is quite low and this could be attributed to the spawning behavior of fish to lay more eggs to account for the losses to predators and adverse external factors. Increase in fecundity observed in April to August may indicate the onset of breeding period as it coincided with rainy season.

5. Conclusion

In conclusion, this study attempts to bring together information on the biological aspects of *Elops lacerta* which are economically valued fish species in Epe lagoon. The current study on *E. lacerta* in Epe lagoon, Nigeria showed a record of higher number of males than females (sex ratio of 1male: 0.6 females). This was a departure from the theoretical 1male:1female ratio. Six stages of maturity: immature, resting, maturing, ripe, spawning and spent were observed in this study. The GSI and fecundity were high in number. A study is currently in progress to investigate the diet composition of this commercially valued fish species in Epe lagoon. It is hoped that this study will be useful for carrying out further ecological studies on this and other fish species of great economic importance in commercial and artisanal fisheries.

6. Acknowledgements

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