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Fecundity, maturation and spawning frequency of *Mormyrus rume* (Cuvier And Valenciennes, 1894) from Epe Lagoon, Nigeria

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Abstract
This study aims at studying its reproductive biology of *Mormyrus rume* using Epe Lagoon as a case study during the period of August 2014 to July 2016. A total of 867 specimens were collected using gill and cast net. Standard techniques were used in the analysis of sex ratio, total length (TL), gonad weight (GW), body weight (BW), fecundity, stages of maturation and gonadosomatic index on the fish species. Sex ratio of 1 male to 1.13 females was observed. Six stages of maturity: Immature, resting, maturing, ripe, spawning and spent were observed in this study. The immature fishes occurred mostly in October to March and the spawning stage occurred mostly from May to August. Egg size ranged from 0.3mm to 1.86mm Fecundity estimates for this species ranged from 4,211 to 31,499 eggs and the gonadosomatic index ranged from 8.85% to 104% meaning a high percentage of fish body mass was converted to gonads for reproduction. It was observed that spawning was not synchronized in the fish species. Therefore this study provides information on some aspects of the reproductive biology of this commercially important fish species in Epe Lagoon for its optimum utilization, conservation and potential for aquaculture.

Keywords: *Mormyrus rume,* fecundity, gonadosomatic index, Epe lagoon

1. Introduction
The family Mormyridae is endemic to Africa and are found in almost every freshwater in the sub-Sahara [13]. Their habitats range from bottom dwellers to top feeders of deoxygenated swamps to swift rapids [13]. Although the types of habitats are diverse, most contain suspended particles, making the water murky [18]. The family Mormyridae commonly called elephant snout fishes is represented by twenty six different species belonging to six genera in Nigerian freshwater. They are highly variable in their head shape. They have cycloid scales. Their common characteristics include: upward inferior mouth and distinct and rounded mouth pointing pectoral fins, narrow gill openings and their eyes are small and weak and covered by a thin layer of skin [1]. One of the most important factors necessary in the successful culturing of a fish species is obtaining a basic understanding of it key biological processes. The most important of these biological processes is the reproductive cycle and formation of gametes. Development of fish seeds production has been identified as a rational way of augmenting the dwindling fish supply from the capture fisheries [7]. Gonadal growth and development of fishes are classified basically in maturity stages as immature; ripening; ripe and spent. Sex ratio, egg diameter and the gonadotropic indices of the ripe fish have been used as an indicator of gonad development. Within a family, egg size is more or less similar for all the species. There is an inverse relation between egg size and fecundity. Gonado-somatic index (GSI) is used to determine amount of body weight a fish puts into gonad production [2].
For the female, gonads are weighed individually, but for males, all gonads of the same length group are weighed because of their very low individual weight (the GSI is always less than 2% and for numerous species less than 1%). Few literatures exist on the research efforts conducted on reproductive biology of fishes [20], studied sex ratio, reproductive cycle fecundity of the family Schilbeidae in Kainji Lake and determined reproductive features of *S. mystus* in Asejire Lake. Olatunde studied the gonads of Mormyrids in Lekki lagoon Lagos [24]. *Mormyrus rume* is an ecologically and economically important species. Reproduction is one of the basic biological features that enable continuity of any species [22]. Comprehensive knowledge of reproductive strategies employed by a species in response to environmental factors will

determine the degree of survival of that species in such environment. In the present study on the fish *M. rume*, sex ratio, GSI, fecundity, egg diameter and stages of maturity were discussed in order to clarify some characteristics of its reproductive biology. This study therefore aims to study its reproductive biology in Epe lagoon for maximum utilization of this fish species and to provide data for future study of this nature in the lagoon.

2. Material and Methods

2.1 Study Area

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. Epe lagoon supports a major fishery in Lagos State, and is the major source of water for the inhabitants of Epe and the other villages situated along its bank.

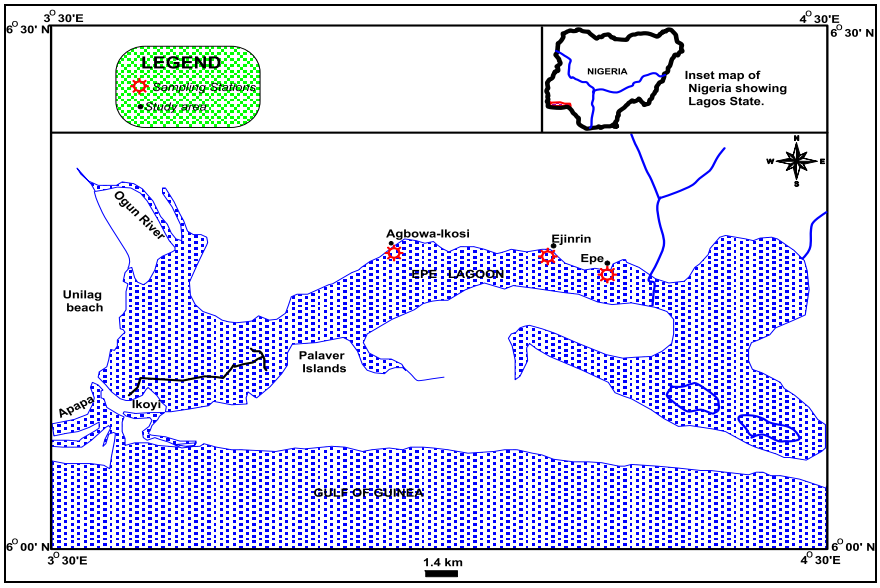

Fig. 1: Map of Epe Lagoon showing the study areas

2.2 Fish sampling

A total of 867 specimens of *Mormyrus rume* was examined between August 2014 – July 2016. Identification were also based on the taxonomy keys prepared by Field Guide to the commercial marine resources of the Gulf of Guinea [10] and personal communication with experienced fisher folks on the local name of the fishes was done.

2.3 Gonad study

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. 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. Gonadal stages of development of *M. rume* were assessed and classified using Nikolsky's guide: Gonadal stage I –Immature, Gonadal stage II – Maturing stage, Gonadal stage III – Partially mature, Gonadal stage IV and V – Mature and running ripe, Gonadal stage VI – spent condition [19]. 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 (Olympus optical, RF 200 Japan) and the type of oocytes that dominated was noted. Measurement of ova diameter were 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 [5]. Matured gonads were carefully excised from the body cavity and weigh to the nearest grams using a top loading balance. The mature ovaries were preserved in 4% formalin for 24 hours. During this period, the jar was shaken repeatedly to separate the eggs from the ovarian tissue and assist in the penetration of the preservative. After 24 hours, the 4% formalin fluid was decanted and replaced by water in order to clean the eggs.

Sub-sampling using the gravimetric method was used for the estimation of fecundity as described by [5]. The total number of eggs per ovary was then estimated by extrapolation. Fecundity of each fish was obtained by actual count of all the eggs in the sample. The total number of eggs was then estimated from the egg count using the formula:

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

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:

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

2.4 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

Out of 867 fishes worked on, 489 (56.4%) were female and 378 (43.6%) were males giving a sex ratio of 1 male: 1.3 female (Table 1). In this study six stages of gonad development were observed (Table 2). These stages were classified as: (1) Pre-spawning class which was represented by immature and maturing stages. (2) Spawning represented by ripe and ripe running stages and (3) Post-spawning class which was represented by spent periods of the fish in Epe lagoon. The specimens measured between 20 cm and 45cm respectively. There are five categories of *E. lacerta* in Epe lagoon, viz: 20 – 25 cm (Immature), 25 – 30cm (Resting), 30-35cm (Maturing), 35-40cm (Ripe & Spawning), 40 -45cm (Spent) Table 4. The GSI varied from 8.85 in size range 26-27.99cm to 18.34% in size range 44 – 46cm. (Table 3) The fecundity of *M. rume* recorded in this study varied between 4,211 and 31,499. Fecundity of *M. rume* increases with increase in size in Epe lagoon (Fig 3 and 4).

Table 1: Summary of monthly sex ratio of *Mornyrus rume* in Epe Lagoon

	No. of specimen	Male	Female	Sex ratio (Male: Female)
August 2014	37	17	20	1: 1.2
September 2014	24	11	13	1: 1.2
October 2014	59	28	31	1: 1.1
November 2014	28	11	17	1: 1.5
December 2014	39	19	20	1: 1.1
January 2015	42	19	23	1: 1.2
February 2015	30	11	19	1: 1.7
March 2015	41	19	22	1: 1.6
April 2015	43	19	24	1: 1.2
May 2015	36	18	18	1: 1
June 2015	41	14	27	1: 1.9
July 2015	39	16	23	1: 1.4
August 2015	34	14	20	1: 1.4
September 2015	40	19	21	1: 1.1
October 2015	31	17	14	1: 0.8
November 2015	29	13	16	1: 1.2
December 2015	30	9	21	1: 2.3
January 2016	28	13	15	1: 1.2
February 2016	27	11	16	1: 1.5
March 2016	19	7	12	1: 1.7
April 2016	52	27	25	1: 0.9
May 2016	44	20	24	1: 1.2
June 2016	40	15	25	1: 1.6
July 2016	34	11	23	1: 2.0
TOTAL	867	378 (43.6%)	489 (56.4%)	1: 1.3

Table 2: Gonad maturation stages of *Mornyrus rume* in Epe Lagoon

Maturation Stage	Description
I. Immature	Ovary is colorless, threadlike in structure and not developed. Not visible with the naked eye. Found in young virgin fishes. Detected in very low numbers from August to April.
II. Resting	Ova diameter ranges from 0.3mm – 0.94mm. Light yellow and transparent ovary. Not easily distinguishable.
III. Maturing	Ova diameter ranges from 0.18-0.83mm diameter. Visible with the naked eye. Detected almost throughout the year.
IV. Ripe	Ova diameter ranges from 0.96 – 1.60mm. Ovary almost occupying the whole visceral cavity. Ova is yellowish in color and scatters easily. Full vitellogenesis of the oocytes. Highest occurrence is in the months of march to September.
V. Spawning	Ova diameter ranges from 1.20 – 1.86mm. Ovary is dull yellow, greatly enlarged with round oocytes. Ovary is full and eggs released under slight pressure. Occupies about 80% of the abdominal cavity. Genital aperture is swollen and reddish.
VI. Spent	Ova diameter ranges from 0.46 -1.0mm in diameter. Appears flabby and having a granular appearance and sometimes an empty sac. Highest occurrence detected in the months of November to January.

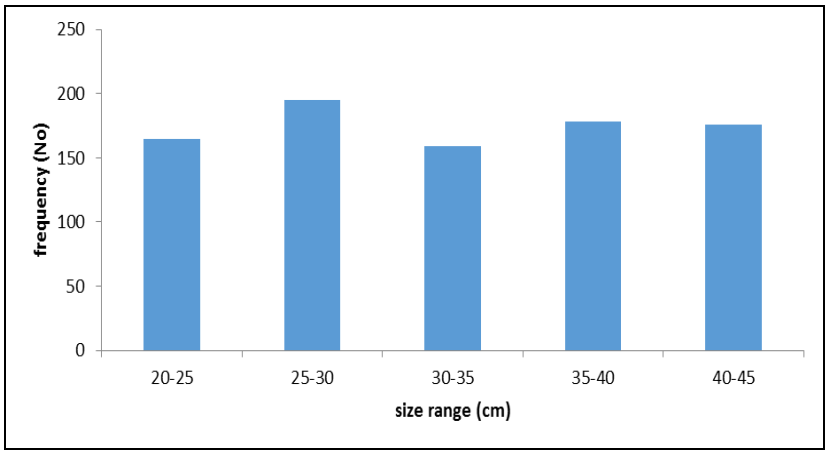

Fig 2: Length-frequency distribution of *Mornyrus rume* in Epe lagoon.

Table 3: Size variation of gonado-somatic indices and fecundity of *Mormyrus rume* in Epe lagoon

Standard length (cm)	Mean somatic wt. (g)	Mean gonad wt. (g)	Mean GSI %	Mean fecundity
26 – 27.99	160.4	18.2	8.85	4,211
28 – 29.99	199.0	24.1	10.76	6,189
30 – 31.99	253.4	27.3	11.59	7,823
32 – 33.99	290.1	42.0	12.64	8,412
34 – 35.99	328.7	49.0	13.71	11,946
36 – 37.99	361.8	52.3	11.9	15,248
38 – 39.99	412.9	64.1	14.48	18,105
40 – 41.99	483.5	74.2	17.51	23,394
42 – 43.99	527.4	88.0	16.79	27,722
44 – 45.99	600.0	104.0	18.34	31,499

Table 4: Monthly distribution of *Mornyrus rume* by size in Epe lagoon.

	Length Frequency(cm)				
	20-25	**25-30**	**30-35**	**35-40**	**40-45**
	Immature	**Resting**	**Maturing**	**Ripe & spawning**	**Spent**
August 2014	4	6	5	12	10
September 2014	3	-	-	11	10
October 2014	18	21	5	9	6
November 2014	11	4	-	-	13
December 2014	10	3	5	8	11
January 2015	16	26	-	-	-
February 2015	14	13	2	1	-
March 2015	17	14	4	6	-
April 2015	10	9	13	4	8
May 2015	6	7	11	10	2
June 2015	2	8	12	11	8
July 2015	3	10	7	8	11
August 2015	-	3	10	9	12
September 2015	2	5	12	13	8
October 2015	-	-	6	10	15
November 2015	-	1	3	9	15
December 2015	6	-	2	4	18
January 2016	2	7	9	8	12
February 2016	-	16	11	-	-
March 2016	6	10	3	-	-
April 2016	18	12	11	9	2
May 2016	9	7	10	14	5
June 2016	8	6	11	10	5
July 2016	-	10	7	12	5

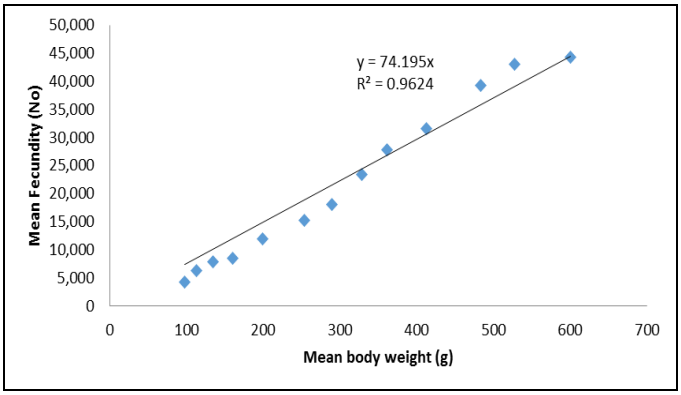

Fig 3: Relationship between somatic weight and fecundity of *Mormyrus rume* in Epe lagoon

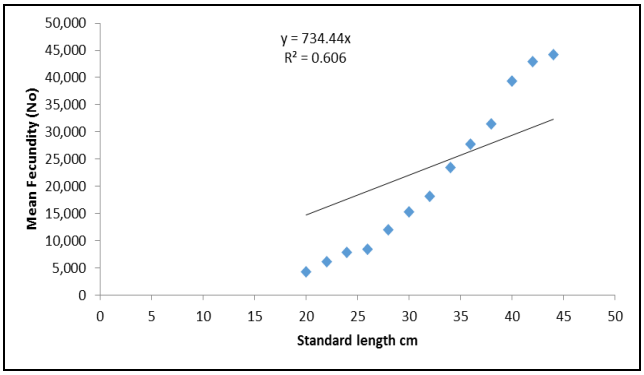

Fig 4: Relationship between standard lenght and fecundity of *Mormyrus rume* in Epe lagoon

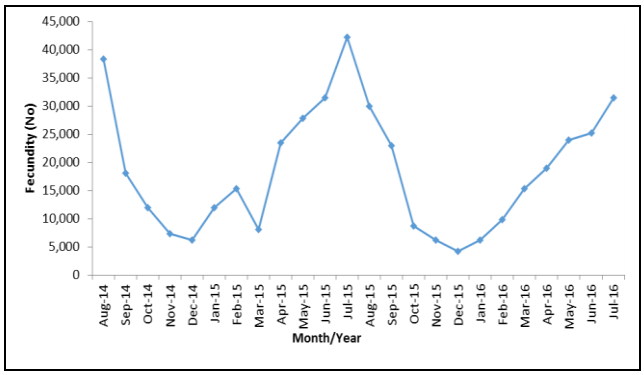

Fig 5: Monthly variation in fecundity of *Mormyrus rume* in Epe Lagoon

4. Discussion

Sex ratio of this species in Epe lagoon indicated that females were significantly more than the males. Out of 867 fishes worked on, 489 (56.4%) were female and 378 (43.6%) were males giving a sex ratio of 1 male: 1.3 female (Table 1). This is a departure from theoretical (1:1) male to 1female sex ratio. The results from this study tally's with the report on *E. fimbriata* [8, 6] in some West African lagoons in which there was high percentage sex ratio in favour of females. However, high percentages sex ratio in favour of males during the spawning period was reported in non-related species such as *E. lacerta* [24, 16] and *Chrysichthys walker* [15]. Nikolsky recorded that sex ratio of 1:1 represent lack of difference in the longevity of the sexes [19]. The sex ratio of 1 male: 1.3 female obtained from this study suggests that females might actually live longer than the males. This result also disagrees with the findings of Fawole [9] that reported that the population of *M. rume* male was significantly higher than that of female in Lekki lagoon with a ratio of 1:0.55.

The specimens measured between 20 cm and 45cm respectively. There are five categories of *E. lacerta* in Epe lagoon, viz: 20 – 25 cm (Immature), 25 – 30cm (Resting), 30-35cm (Maturing), 35-40cm (Ripe & Spawning), 40 -45cm (Spent) (Fig 3). The ripe and spawning stage were the most dominant group, recording its highest numbers in the month of May and June. The size range of *M. rume* in Epe lagoon was different to that obtained in Lekki lagoon where the total length ranged from 15.0 to 24.9 cm [9].

In this study six stages of gonad development were observed (Table 2). These stages were classified as:

1) Pre-spawning class which was represented by immature, resting, and maturing stages.
2) Spawning represented by ripe and ripe running stages and
3) Post-spawning class which was represented by spent periods of the fish in Epe lagoon.

Observations of these stages of maturation in the fish though with modifications were in conformity with that of most teleosts [4]. The presence of oocytes at different stages of development was an indication that this species belongs to the fish with prolonged and fractional spawning season. Therefore, the fish may spawn more than once during the spawning season. This was in agreement with reports of Shinkafi[21] on *Mugil seheli*, and Mohamed [17] on *Merluccius merluccius.* The eggs of *M. rume* in Epe lagoon were as small as 0.18 and as big as 1.86mm (Table 2).

The GSI varied from 8.85 in size range 26-27.99cm to 18.34% in size range 44 – 46cm. (Table 3). Fawole obtained a GSI of 7.87% for *M.rume* in Lekki lagoon [19]. GSI increases progressively with increased percentage of the ripe individuals towards the spawning seasons [17]. Females showed higher fecundity values with increase in body weight (Figure 4) indicating that female body mass were committed to gonad development by this species. The fecundity of *M. rume* recorded in this study varied between 4,211 and 31,499 suggesting that the species has high fecundity. This also indicates that the specie can produce large numbers of seeds for pond stocking and thus be useful in artificial breeding. Low fecundity characterizes species that exhibit high parental care. Anibeze C.I.P and Gomiero L.M confirmed that better condition during the wet season was due to the availability of food and enhancement during their gonad development. However, Epe lagoon did not experience extremes of weather conditions such as drought throughout the study. The water level during the dry season was never below than one meter [3]. This indicates that there was no shortage of food available for the fish during the dry season and this fish growth was expected to be unaffected [11]. An average fecundity of 2991 eggs was also reported for *M. rume* at Lekki lagoon [9], whereas a higher fecundity (7,130 to 73,000 eggs) was recorded for *Synodontis schall* in Lake Kainji [25]. Fecundity of *M. rume* increases with increase in size in Epe lagoon. Holden M and Reed W confirmed that, female Mormyrids usually grow in larger size than males and are highly prolific. Basically, for *Mormyrus rume* in particular, its pattern was mostly influenced by the effect in seasonal variation [12]. The immature fishes occurred mostly in From October to March and the spawning stage occurred mostly from May to August (Table 4) and fecundity was higher during the rainy months (Fig 6). Fig 5 shows increase in fecundity with standard length of the fish. Authors reported that number of eggs produced increased as the length of fish increased, while some authors reported insignificant correlation in the length and fecundity [14] and Shinkafi [22].

5. Conclusion

In summary this study establishes some aspects of the reproductive biology of *Mormyrus rume* in Epe lagoon, Nigeria. Results from this study showed that spawning was not synchronized in the fish species. Sex ratio of 1 male to 1.13 females was observed. Six stages of maturity: Immature, resting, maturing, ripe, spawning and spent were observed in this study. The immature fishes occurred mostly in October to March and the spawning stage occurred mostly from May to August. Egg size ranged from 0.3mm to 1.86mm Fecundity estimates for this species ranged from 4,211 to 31,499 eggs and the gonadosomatic index ranged from 8.85% to 104%. The relatively high fecundity of *M. rume* observed from this study when compared with other lowly fecund species could mean that the species can produce large numbers of seeds for pond stocking useful in artificial breeding. The knowledge of the fecundity and GSI of fish species helps in the assessment of the breeding activity of fish which can be applied in the commercial production of the fish species in captivity. Data from this work will be useful in assessing the aquaculture potential of *Mormyrus rume.*

6. Acknowledgements

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