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## **Observations on the Sex Ratio, Fecundity, Egg Size and Gonadosomatic Index of Grey Mullet, *Mugil cephalus* from High Brackish Tropical Lagoon**

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### **ABSTRACT**

The 2661 specimens of the striped mullet, *Mugil cephalus* L., used for this study, were collected from high brackish lagoon in south-west Nigeria for 24 months. The size of the 2661 specimens of *M. cephalus* used for this study ranged from 1.7-29.5 cm standard length (total length: 1.9-39.0 cm). The sex ratio for *M. cephalus* was 1:0.53 and this showed a statistically significant ( $p < 0.05$ ) dominance of the males over the females for the size range. The fecundity estimates varied from 635,568-1,520,185 and was positively correlated to the fish length and weight. Oocyte diameter averaged  $409.64 \pm 40.67 \mu\text{m}$  and this is indicative of an early stage of gonad maturation of the specimens in the lagoon before final spawning occurred. The GSI indicated that spawning activity occurred from December to May in the open ocean.

**Key words:** Mature, spawning, specimens, male, female

### **INTRODUCTION**

Mulletts (Mugilidae) are common fishes in the coastal waters of tropical and subtropical countries of the world. Sixteen species have so far been identified in West Africa (Fowler, 1936; Cadenat, 1954; Blay, 1995) and these constitute an important proportion of the catches of commercial and subsistence fishermen in some countries in this area (Brulhet, 1975; Payne, 1976). General information on the biology of striped mullet has been well documented (Anderson, 1958; Thomson, 1963, 1966; Chubb *et al.*, 1981) but limited information is available on the reproductive biology of wild populations (Anderson, 1958; Greeley *et al.*, 1987; Render *et al.*, 1995). Ditty and Shaw (1996) reported that *Mugil cephalus* are isochronal spawners, with all oocytes reaching maturity at the same time. It sheds its eggs in batches (Silva and de Silva, 1981; Greeley *et al.*, 1987; Render *et al.*, 1995). A thorough knowledge of the fecundity of fish is essential for evaluating the commercial potentialities, stock study, life history study, practical culture and actual management of the fishery (Das, 1977; Rheman *et al.*, 2002). A few reports are available on the biology of mullet species in the coastal waters of West Africa and were principally on the food and feeding habits (Facade and Olaniyan, 1973; Brulhet, 1975; Blay, 1995; Soyinka, 2008). Information on the reproductive biology of mullet species is essential to understanding the population dynamics and the recruitment pattern of the fish, to harness it for conservation and management. The present investigation reports on the sex ratio, fecundity and the gonadosomatic index of *M. cephalus* from a high brackish lagoon in Nigeria, West Africa.

### **MATERIALS AND METHODS**

**Description of study area:** The Lagos Lagoon (Fig. 1) which lies between longitudes  $3^{\circ} 20'$  and  $3^{\circ} 40'E$  and latitudes  $6^{\circ} 15'$  and  $6^{\circ} 40'$  has an area of  $208 \text{ km}^2$  and is the largest of the lagoon

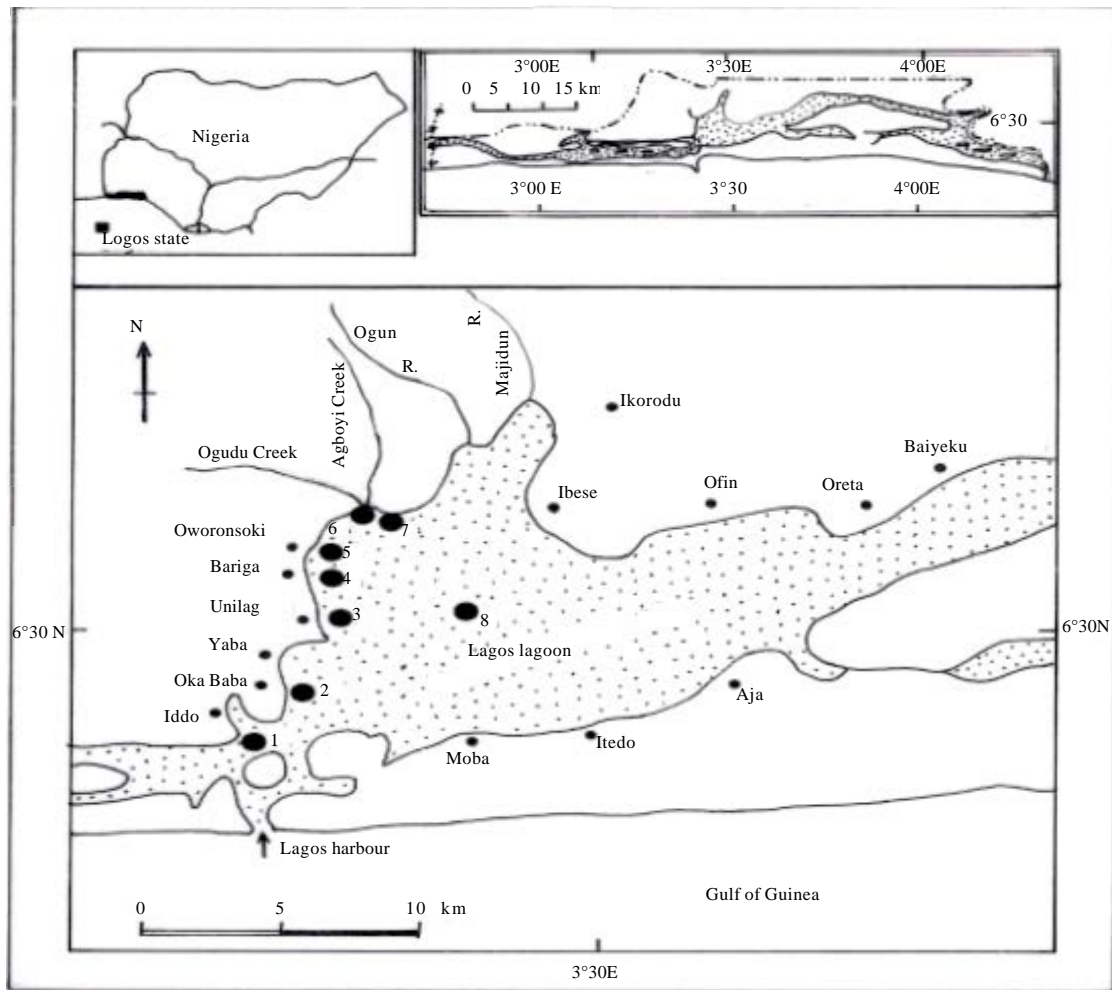


Fig. 1: Map of Lagos Lagoon, Nigeria showing the sampling stations (1-8)

systems of the West African sub-region. It is the largest of the nine coastal lagoons of south-western Nigeria (others are Yewa, Badagry, Iyagbe, Ologe, Kuramo, Epe, Lekki and Mahin Lagoons) (FAO., 1969). It has supported decades of small scale fisheries which have shown sign of continuous decline (Solarin, 1998). The lagoon characterized with seasonal fluctuation in salinity-high brackish water during the dry season (December-May) while freshwater condition exist in the rainy season (June-November) (Facade and Olaniyan, 1974; Kusemiju, 1975; Solarin, 1998). The lagoon is surrounded by swamp forest and riparian forest consisting of mangrove vegetation: *Rhizophora racemosa*, *R. harrisonii*, *Aerosticum aureum*, *Paspalum orbiculare*, *Langucularia* sp. and *Avicennia germinans*. The lagoon empties into the Atlantic Ocean via the Lagos Harbour (Ogunwenmo and Kusemiju, 2004). The lagoon is shallow in depth and in most places a little more than 1.5 m depth (Solarin and Kusemiju, 2003).

**Field studies:** The specimens of the grey mullet, *Mugil cephalus* were collected from the Lagos Lagoon by fisher-folks who use active fishing gears for fishing. The collections were made fortnightly between February 2004 and January 2006. Fish were placed in ice-chest on the field but later transferred into a deep freezer at temperature of  $-20^{\circ}\text{C}$  in the laboratory for

further analysis. The salinity of the lagoon was determined *in-situ* twice a month between 8.00-11.00 a.m for 24 months using a Refractometer (BIOMARINE, Aqua Fauna Model).

**Laboratory procedures:** The specimens were removed from the freezer and allowed to thaw before being examined. Excess water from the fish was drained away or by using filter paper. The Standard Length (SL) and Total Length (TL) of the specimens were measured on a measuring board to the nearest 0.1 cm. The total weight of the fish was taken on a 'Sartorius' top loading balance (Model 1106 2608053) or a triple beam balance to the nearest tenth of a gram.

**Sex determination:** The fish were separated into males, females and juvenile or immature fish after dissecting the fish and observing the genital papillae visually. The male has a pair of thread-like tubes with whitish milt, the female has a pair of bulging or sac-like ovaries while the gonad of immature fish could not be differentiated with the naked eye.

**Fecundity and egg diameter:** Females with ripe ovaries were used for this study. The ripe ovaries were removed carefully from the abdominal region of the fish, the weight measured on the balance, before preserving in 10% formalin or 4% Gilson's fluid. The eggs were separated from the ovarian tissue into petri dish. Two methods were used for the enumeration. By gravimetric method, the number of eggs in a known weight was used to estimate the total number in the dry sample. By volumetric method, the number of eggs in 1 mL using 'Gilson Pipetman' egg counting device (Model: D-82-13103) were counted under a microscope and used to estimate the total number in the remaining volume. The relationship between the fecundity, length and weight was expressed as:

$$Y = a+bX$$

Where:

- Y = Fecundity estimate
- X = Standard length (cm)/total weight (g)
- a = Regression constant
- b = Regression coefficient

**Egg diameter:** For the egg diameter, eggs were placed on a slide, observed under a graduated eye-piece of a light microscope and the average diameter recorded.

**Gonadosomatic index:** This indicates gonadal development and maturity of fish. It increases with the maturation of fish declining abruptly thereafter (Rhemana *et al.*, 2002; Parameswari *et al.*, 1974; McDonough *et al.*, 2003). This was estimated thus:

$$GSI = \frac{\text{Weight of the gonad}}{\text{Weight of the fish}} \times 100$$

## RESULTS

**Sex ratio:** The 2661 specimens of *M. cephalus* collected from the Lagos Lagoon were made up of 426 males and 224 female fish giving a sex ratio of 1: 0.53 (male/female). The calculated Chi-square ( $\chi^2$ ) test showed that the males were significantly ( $p < 0.05$ ) more abundant than the females in Lagos Lagoon.

The monthly sex ratio values showed that in Lagos Lagoon (Fig. 2), the males were more than the females throughout the period of study except in the dry season of February 2004 and December 2004. They were nearly the same in the dry season of April 2004. Statistically, Chi-square ( $\chi^2$ ) values of sex ratio were significantly different in February and July 2004, April, May, June, July, August, September and October 2005.

The relationship between the sex ratio and the salinity fluctuations which is the critical physico-chemical parameter affecting the distribution of species in the Lagos Lagoon is illustrated in Fig. 3. The result showed that immature specimens were predominant in the low brackish to fresh water condition of the lagoon; males were significantly more than females in most months while the population of females was more abundant during dry season than the wet season.

**Fecundity of *M. cephalus*:** The number of fecund females collected throughout the sampling period was very few. Only 28 fecund *M. cephalus* specimens from the Lagos Lagoon were examined for fecundity. They ranged from 16.5-19.2 cm standard length (total length, 22.0-24.9 cm) and weighed between 90.00-145.99 g. The fecundity estimates varied from 635,568-1,520,185 eggs. An

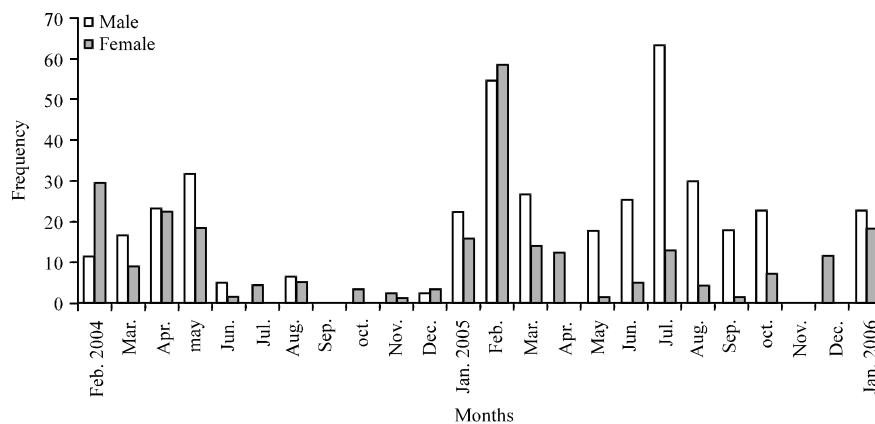


Fig. 2: Monthly variation in sex ratio in *M. cephalus* from Lagos Lagoon (February 2004 to January 2006)

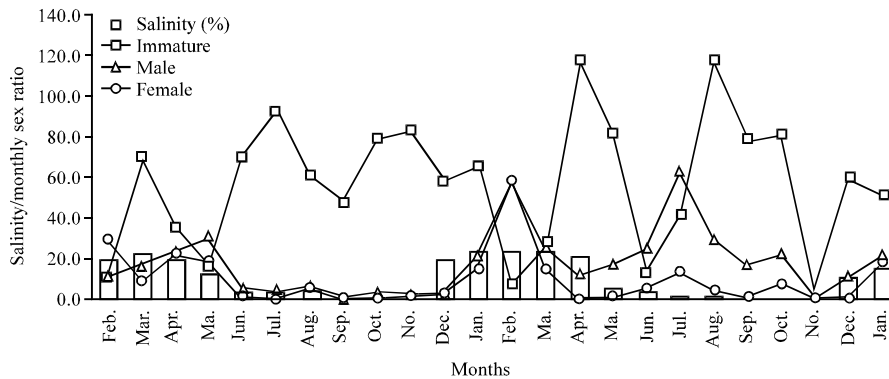


Fig. 3: Sex ratio/salinity relationship for *M. cephalus* in Lagos Lagoon (February 2004 to January 2006)

average fecundity estimate was 832,270±156,016 eggs. The log fecundity-log standard length and log fecundity-log weight relationships are shown in Fig. 4 and 5, respectively.

A slightly high correlation existed between fecundity and the standard length ( $r = 0.5423$ ) and the weight ( $r = 0.5054$ ) of the fish.

The linear regression equations were:

- Log fecundity = 3.7751+1.7039 log standard length (n = 28, r = 0.5423)
- Log fecundity = 4.8541+0.5168 log total weight (n = 28, r = 0.5054)

**Egg diameter of *M. cephalus*:** The diameter of eggs of mature females in the Lagos Lagoon ranged from 360-460 µm (0.36-0.46 mm) as shown in Table 1. The least total size of female fish with ripe gonad was 22.0 cm (standard length: 16.5 cm).

Table 1: Diameter of eggs in mature females of *M. cephalus* from Lagos Lagoon

Parameters	Values	Mean
Size range/total length (cm)	22.0-24.9 (SL: 16.5-19.2)	17.82±0.66
No. of eggs	635,568-1,520,185	832,270±156,016
Egg diameter	360-460 µm (0.36-0.46 mm)	409.64±40.67 µm

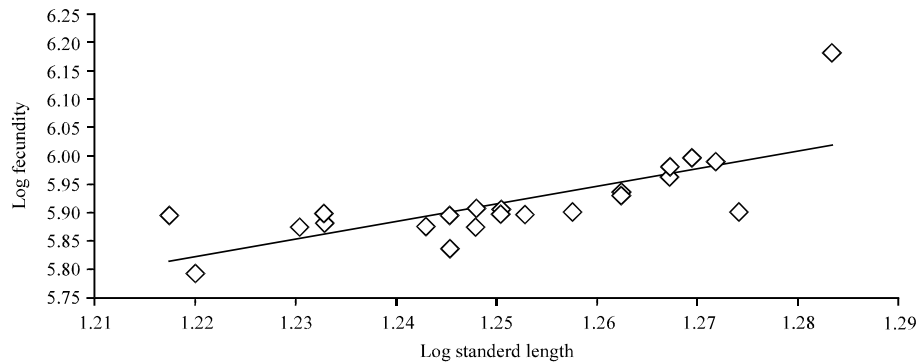


Fig. 4: Log standard length/log fecundity relationship of *M. cephalus* from Lagos Lagoon

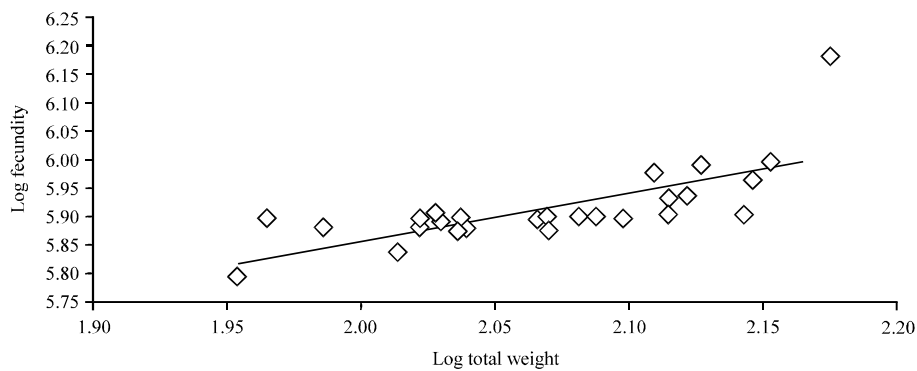


Fig. 5: Log weight/log fecundity relationship of *M. cephalus* from Lagos Lagoon

**Gonadosomatic index:** The Gonadosomatic Index (GSI) of 28 specimens of *M. cephalus* from the Lagos Lagoon was examined. The GSI values ranged from 6.45-10.00%. The mean value was  $8.16 \pm 0.97$ . This indicated that *M. cephalus* on the average used 8.16% of its body weight for egg production.

## DISCUSSION

In the sex ratio of *M. cephalus* collected from the Lagos Lagoon, the males were significantly more than the females as shown in the calculated Chi square ( $\chi^2$ ) test. This indicated that probably, more male *M. cephalus* occur in the Lagos Lagoon than the females. McDonough *et al.* (2005) recorded a male to female ratio of 2:1 until the fish were larger than 32.5 cm TL. The ratio was 1:3.8 for fish greater than 32.5 cm TL. The ratio of 2:1 in South Carolina estuary almost agreed with the present study from the Lagos Lagoon. Mature females with ripening and ripe gonads were collected often in the dry season (December-May) with peak between late January and March, when salinity is high in the Lagos Lagoon. Facade and Olaniyan (1974) reported the availability of the fish during brackish (0.5-28.0%) condition of Lagos Lagoon. The monthly variation in sex ratio of the species from Lagos Lagoon showed that the males were more than the females except in February 2004 and December 2004 which fall within the dry season. In Fig. 3, there was an increase in number of female fish caught in the dry season (high salinity) than the wet season (low salinity). This coincided with the period females with ripe gonads were found in the collection. Male specimens, with sexually differentiated gonads also had a slightly similar seasonal distribution pattern but the immature ones were more available at both seasons. This depicted that salinity does influence gonad maturation in the grey mullet. McDonough *et al.* (2005) reported that striped mullet are sexually undifferentiated for the first 12 months, began differentiation at 13 months and are 90% fully differentiated by 15-19 months of age and 22.5 cm TL. The abundance of 1 and 2 years old striped mullet in South Carolina indicated that immature fish dominated the estuarine population. This agreed with the present study.

In this study, an average fecundity estimate of 832,270 eggs (~0.83 million eggs) was recorded for fish ranging in standard length from 22.0-24.9 cm and weight 90.00-145.99 g. Fecundity was averagely correlated with standard length and body weight. Silva and de Silva (1981) recorded a fecundity of 0.45-4.2 million in *M. cephalus* ranging in length from 32-56 cm and weight from 0.7-2.2 kg, fecundity was significantly correlated to body length, body weight and gonad weight. Collins (1985) estimated fecundity of striped mullet at 0.5-2.0 million eggs per female, depending on the size of the female. Ditty and Shaw (1996) reported that *Mugil cephalus* are isochronal spawners, with all oocytes reaching maturity at the same time. It sheds its eggs in batches (Silva and de Silva, 1981; Greeley *et al.*, 1987; Render *et al.*, 1995). The minimum spawning size of females is between 31 and 34 cm (Ditty and Shaw, 1996) while Silva and de Silva (1981) recorded female maturity at 31.5 cm and males at 34.0 cm. McDonough *et al.* (2005) recorded male spawning size at 24.8-30.0 cm while the spawning size for the female was 29.1-40.0 cm. This implied that the specimens in the present investigation were still at the early stage of gonad maturation and would not spawn possibly until they embark on the open ocean spawning migration where the gonads reach final maturation. Size at maturity has been found to range widely from 23.0 cm standard length (Thomson, 1963; Greeley *et al.*, 1987) to 41.0 cm SL (Thomson, 1963; Chubb *et al.*, 1981) for two and three-year-old fish. The slightly earlier lower end of the maturation size of fish recorded in the present study could probably be as a result of the tropical climate of the Lagos Lagoon.

The measurement of the diameter of the ripe eggs of mature females of *M. cephalus* from the Lagos Lagoon showed slight variation in egg sizes. McDonough *et al.* (2003) recorded oocyte diameter of 463-682  $\mu\text{m}$  (mean size, 596  $\mu\text{m}$ ). Rottmann *et al.* (1991) reported an approximate mature egg diameter of 0.6-0.8 mm for *Mugil cephalus*. The slight variation of the lower end of the egg diameter in the present study is because of the size of fish used.

McDonough *et al.* (2003) reported a GSI value rang of 7.7-27.7 for fecund specimens in South Carolina estuary. The value of 8.16 recorded in this study falls within that range. It is clear that the gonad weight had a considerable influence on total body weight in fecund specimens (McDonough *et al.*, 2003). The value of the GSI levels calculated in fish during the dry season (December-May) with peak between late January and March, showed that reproductive activity is within that period. McDonough *et al.* (2003) reported that striped mullet that recruit into South Carolina estuaries spawn from October through April. The information provided in the present study would be helpful in the adequate management of the *M. cephalus* stock in the Lagos Lagoon.

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