53

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 southwest Nigeria for 24 months. The size of the 2661 specimens of M. cephalus used for this study ranged from 1.7–29.5cm standard length (total length: 1.9 to 39.0cm). 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 ± 40.67μm 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.

Keywords: Mature, spawning, specimens, male, female.

Introduction

Mullets (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 and 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 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; Rhema, 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 (Fagade 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° 20' and 3° 40'E and latitudes 6° 15' and 6° 40' has an area of 208km² and is the largest of the lagoon systems of the West African subregion. 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) (Fagade and Olaniyan, 1974; Kusemiju, 1975 and 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 metres depth (Solarin and Kusemiju, 2003).

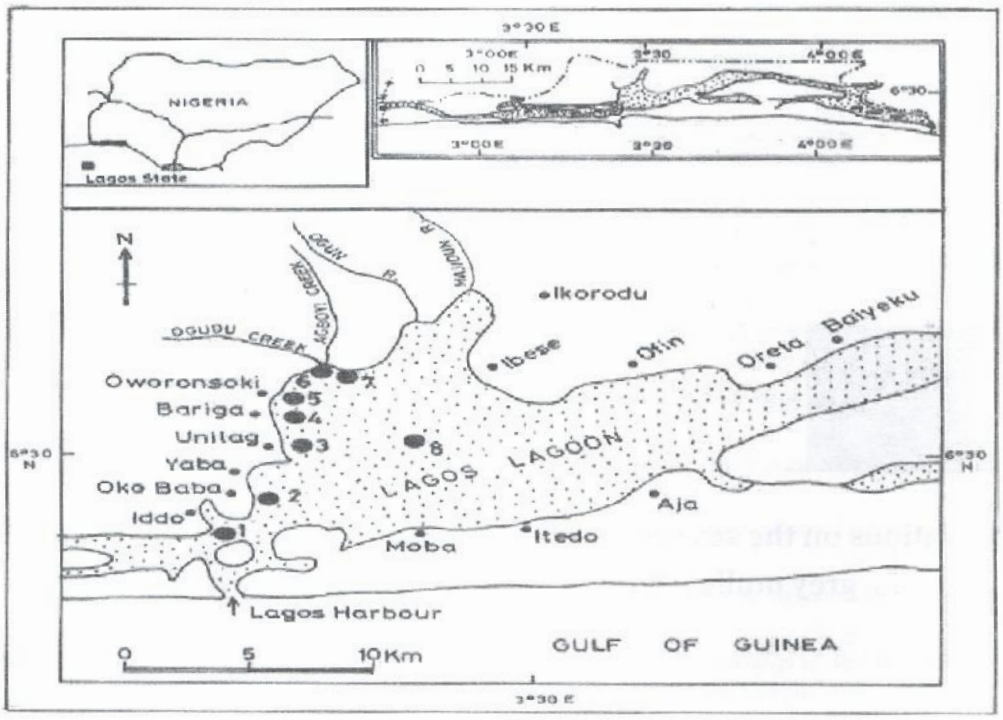

Fig. 1: Map of Lagos Lagoon showing the sampling stations (1 – 8).

- **Field Studies.** The specimens of the grey mullet, *Mugil cephalus* were collected from the Lagos Lagoon by fisherfolks 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°C in the laboratory for further analysis. The salinity of the lagoon was determined *in-situ* twice a month between 8.00 – 11.00a.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 centimeter. The total weight of the fish was taken on a 'Sartorious' top loading balance (Model 1106 2608053) or a triple beam balance to the nearest tenth of a gram.

(a) 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.

(b) 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 1ml 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

(c) 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.

(d) Gonadosomatic index. This indicates gonadal development and maturity of fish. It increases with the maturation of fish declining abruptly thereafter (Rhema et al., 2002). This was estimated thus:

$$G.S.I. = \frac{Weight\ of\ the\ gonad}{Weight\ of\ the\ fish} \times 100$$

(Parameswarn, et al. *1974; McDonough* et al., *2003)*

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 (χ^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 (χ^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.

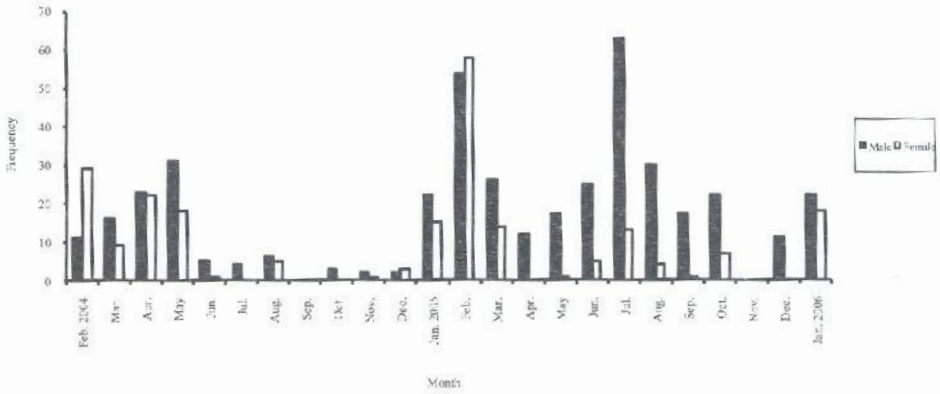

Fig. 2: Monthly variation in sex ratio in *M. cephalus* from Lagos Lagoon (February 2004 – January 2006)

- **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 – 19.2cm standard length (total length, 22.0 – 24.9cm) and weighed between 90.00 – 145.99g. The fecundity estimates varied from 635,568 – 1,520,185 eggs. An average fecundity estimate was 832,270 ± 156,016 eggs. The Log fecundity – Log standard length and Log fecundity – Log weight relationships are shown in Figs 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:

$$a) \quad Log\ fecundity = \frac{3.7751 + 1.7039\ Log\ standard\ length}{(n = 28, r = 0.5423)}$$

$$b) \quad Log\ fecundity = \frac{4.8541 + 0.5168\ Log\ total\ weight}{(n = 28, r = 0.5054)}$$

- **Egg diameter of *M. cephalus*.** The diameter of eggs of mature females in the Lagos Lagoon ranged from 360µm – 460µm (0.36 – 0.46mm) as shown in Table 1. The least total size of female fish with ripe gonad was 22.0cm (standard length: 16.5cm).
- **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 ± 0.97. This indicated that *M. cephalus* on the average used 8.16% of its body weight for egg production.

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

Size range/total length (cm)	Number of eggs	Egg diameter
22.0 – 24.9 (SL: 16.5 – 19.2cm)	635,568 – 1,520,185	360µm – 460µm (0.36 – 0.46mm)
(mean = 17.82 ± 0.66)	(mean = 832,270 ± 156,016)	(mean = 409.64 ± 40.67µm)

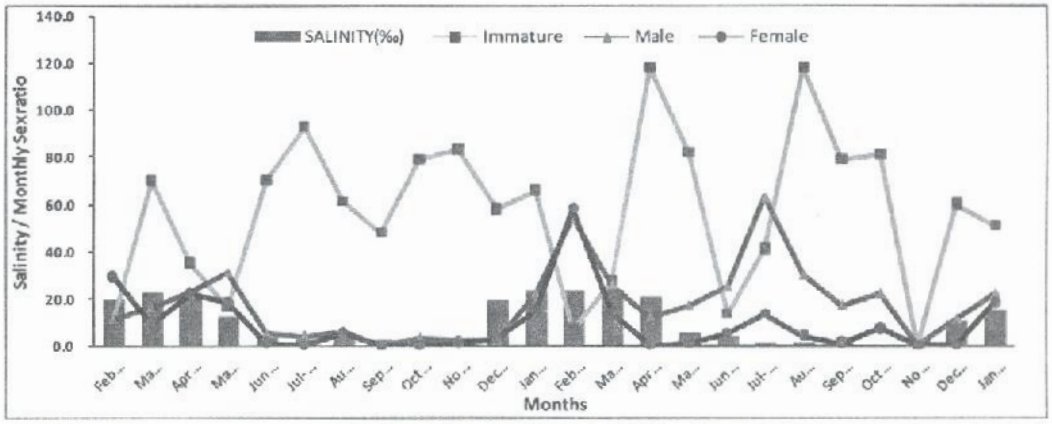

Fig. 3: Sex ratio / salinity relationship for *M. cephalus* in Lagos Lagoon (February 2004 – January 2006)

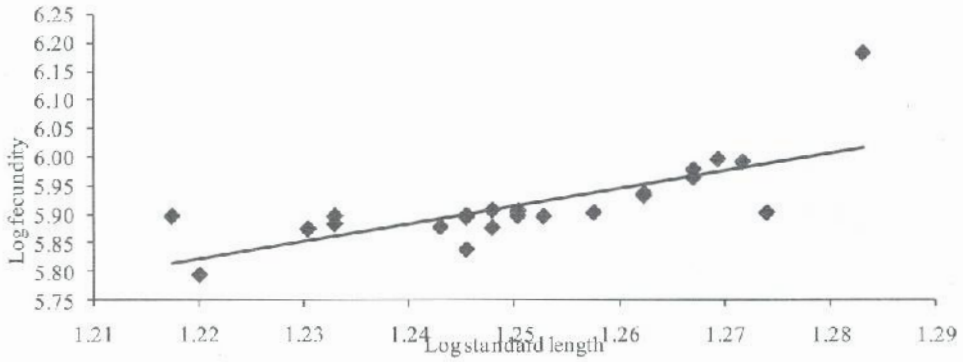

Fig. 4: Log standard length / Log fecundity relationship of *M. cephalus* from Lagos Lagoon.

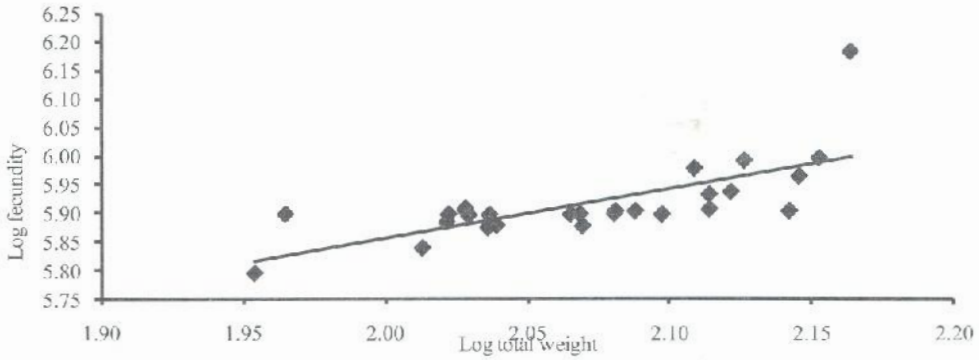

Fig. 5: Log weight / Log fecundity relationship of M. cephalus from Lagos Lagoon.

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 (χ^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 32.5cm TL. The ratio was 1:3.8 for fish greater than 32.5cm 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. Fagade and Olaniyan (1974) reported the availability of the fish during brackish (0.5 to 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 22.5cm 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 – 24.9cm and weight 90.00 – 145.99g. Fecundity was averagely correlated with standard length and body weight. Silva and Silva (1981) recorded a fecundity of 0.45 to 4.2 million in *M. cephalus* ranging in length from 32 – 56cm and weight from 0.7 – 2.2kg; 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 Silva, 1981; Greeley et al., 1987; Render et al., 1995). The minimum spawning size of females is between 31 and 34cm (Ditty and Shaw, 1996), while Silva and Silva (1981) recorded female maturity at 31.5cm and males at 34.0cm. McDonough et al. (2005) recorded male spawning size at 24.8 – 30.0cm, while the spawning size for the female was 29.1 – 40.0cm. 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 23.0cm standard length (Thomson, 1963; Greeley et al., 1987) to 41.0cm 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 to 682µm (mean size, 596µm). Rottmann et al. (1991) reported an approximate mature egg diameter of 0.6 – 0.8mm 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.

REFERENCES

Anderson, W. W. (1958): Larval development, growth, and spawning of striped mullet (*Mugil cephalus*) along the south Atlantic coast of the United States. *Fishery Bulletin*, 58, 501–519.

Blay, J. (1995): Food and feeding habits of four species of juvenile mullet (Mugilidae) in a tidal lagoon in Ghana, *Journal of Fish Biology* 46, 134–141.

Brulhet, J. (1975): Observations on the biology of *Mugil cephalus ashanteensis* and the possibility of its aquaculture in the Mauritanean coast. *Aquaculture* 5, 271–281.

Cadenat, J. (1954): Note d'ichthyologie oust-africain 8. Regime alimentairesur les mullets de la cote occidental d'Afrique. *Bulletin de l'Institutefrancaisd'Afrique noire (ser. A)* 16, 584–591.

Chubb, C. F., Potter, I. C., Grant, C. J., Lenanton, R. C. J. and Wallace, J. (1981). Age structure, growth rates and movements of sea mullet, Mugil cephalus L., and yellow eye mullet, Aldrichetta forsteri (Valenciennes), in the Swan-Avon river system, Western Australia. *Australian Journal of Marine and Freshwater Research* 32, 605–628.

Collins, M. R. (1985): *Species profiles: Life histories and environmental requirements of coastal fishes and invertebrates (South Florida) striped mullet*. U.S. Army Corps of Engineers, TR EL – 82.4, 11pp.

Das, H.P. (1977): The fecundity of grey mullet, *Mugil cephalus* L. along the Goya coast. *Mahasagar Bull. Natn. Inst. Ocean.* 10, 79–82.

Ditty, J.G. and Shaw, R.F. (1996): Spatial and temporal distribution of larval striped mullet (*Mugil cephalus* L.) and white mullet (*M. curema*, fam: *Mugilidae*) in the northern Gulf of Mexico, *Agonostomusmonticola. Bull. Mar. Sci.* 59(2): 271–288.

Fagade, S.O. and Olaniyan, C.I.O. (1973): The food and feeding interrelationship of the fishes in the Lagos Lagoon. *Journal of Fish Biology* 5, 205–225.

Fagade, S.O. and Olaniyan, C.I.O. (1974): Seasonal distribution of the fish fauna of the Lagos Lagoon. *Bull de l'I.F.A.N.A.* 36/1: 244–452.

FAO. (1969): Fisheries survey in the western and mid-western regions of Nigeria.FAO/SF74/NIR6.

Fowler, H. W. (1936): The marine fishes of West Africa. *Bulletin of the American Museum of Natural History* 70, 1–605.

Greeley, M. S., Calder, D. R. And Wallace, R. A. (1987): Oocyte growth and development in the striped mullet, *Mugil cephalus*, during seasonal ovarian recrudescence: relationship to fecundity and size at maturity. *Fishery Bulletin*, 85, 187–200.

Kusemiju, K. (1975): The bionomics and distribution of the pink shrimp, *Penaeus duorarum* (Burkenroad) off Lagos coast, Nigeria. *Bull de l'I.F.A.N.A.* 37(4): 775 – 783.

McDonough, C. J., Roumillat, W. A. and Wenner, C. A. (2003): Fecundity and spawning season of striped mullet (Mugil cephalus L.) in South Carolina estuaries. *Fishery Bulletin 101* (4): 822 – 834.

McDonough, C. J., Roumillat, W. A. and Wenner, C. A. (2005): Sexual differentiation and gonad development in striped mullet, Mugil cephalus (Linnaeus) in South Carolina estuaries. *Fishery Bulletin* 103 (4): 601–619.

Ogunwenmo, C.A. and Kusemiju, K. (2004): Annelids of a West African estuarine system. *J. Environ. Biol.*25 (2): 227–237.

Parameswarn, S., Sevaraj, C. and Radhakrisshnan, S. (1974): Observation on the biology of *Labeo gonius*. *Indian J. Fish.* 21: 54–75.

Payne, A. L. (1976): The relative abundance and feeding habits of the grey mullet species occurring in an estuary in Sierra Leone, West Africa. *Marine Biology* 35, 277–286.

Render, J. H. Thompson, B. A. and Allen, R. L. (1995): Reproductive development of stripped mullet in Louisiana estuarine waters with notes on the applicability of reproductive assessment methods for isochronal species. *Trans. Am. Fish. Soc.* 124(1): 26–36.

Rhema, S., Islam, M. L., Shah, M. M. R., Mondal, S. and Alan, M. J. (2002): Observation on the fecundity and Gonadosomatic Index (GSI) of Grey mullet, *Liza parsia*. *Online Journal of Biological Sciences*. 2(10): 690–693.

Rottmann, R. W., Shireman, J. V. and Chapman, F. A. (1991): Determining sexual maturity of broodstock for induced spawning of fish. *Southern Regional Aquaculture Center* (SRAC) No. 423, 4pp.

Silva, E. I. and Silva, S. S. (1981): Aapects of the biology of grey mullet, *Mugil cephalus* L., adult populations of a coastal lagoon in Sri Lanka. *Journal of Fish Biology* 19 (1): 1–10.

Solarin, B.B. (1998): The hydrobiology, fishes and fisheries of the Lagos Lagoon, Nigeria. PhD Thesis, University of Lagos. 235pp.

Solarin B.B. and Kusemiju, K. (2003):An appraisal of gender participation in trap and liftnet fisheries in Lagos lagoon Nigeria. *Afric. J. of Appol. Zool. Env. Biol.* 5: 75–81.

Soyinka, O.O. (2008): The feeding ecology of *Mugil cephalus* (Linnaeus) from a high brackish tropical lagoon in southwest Nigeria. *Afr. J. Biotech.*7 (22) 4192–4198.

Thomson, J. M. (1963): Mullet life history strategies. *Australian Journal of Science*, 25, 414–416.

Thomson, J. M. (1966): The grey mullets. *Oceanogr. Mar. Biol. Ann. Rev.* 4, 301–335.