International Journal of scientific research and management
(IJSRM) ||Volume||1||Issue||9||Pages||476-480 ||2013||
Website: www.ijsrm.in ISSN (e): 2321-3418

Fecundity and Gonadal Development of the Frillfin Goby, *Bathygobius soporator* (Valenciennes, 1837) from the Cross River Estuary, Nigeria

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Abstract: *Fecundity and gonadal development of the Frillfin Goby, Bathygobius soporator from the Cross River Estuary, Nigeria was studied from July 2012 to June 2013. A total of 210 gravid female fish were examined during this period. The results show that fecundity ranged between 5462 eggs for fish of Total Length (TL-cm) 12.4cm, Total Weight (TW-g) 25.0g, Gonad Weight (GW-g) 0.5g, and Mean Egg Diameter (MED-mm) 0.45mm to 63250 eggs for fish of Total Length (TL-cm) 12.9cm, Total Weight (TW-g) 45.0g, Gonad Weight (GW-g) 3.0g, and Mean Egg Diameter (MED-mm) 0.44mm. Gonadosomatic index (GSI) ranged between 1.22% for fish of Total Length (TL-cm) 14.4cm, Total Weight (TW-g) 41.0g and Gonad Weight (GW-g) 0.5g 13.48% for fish of Total Length (TL-cm) 12.3cm, Total Weight (TW-g) 23.0g and Gonad Weight (GW-g) 3.1g. there was a positive significant relationship between fecundity and Total length, total weight, Gonad weight and a positive non-significant relationship between fecundity and mean egg diameter as follows:* $F = 856.6TL^{1.1654}$ *(*$r = 0.2938$ *and* $r^2 = 0.0863$, $P<0.05$*),* $F = 4587.1TW^{1.1654}$ *(*$r = 0.2960$ *and* $r^2 = 0.0876$, $P<0.05$*),* $F = 13863MED^{1.1654}$ *(*$r = 0.010$ *and* $r^2 = 0.0001$, $P>0.05$*) and* $F = 13863MED^{1.1654}$ *(*$r = 0.010$ *and* $r^2 = 0.0001$, $P>0.05$*). Histological sections of the ovaries of B. soporator showed six stages of oocyte development (virgin, maturing virgin, developing, ripened, spawning and spent). This finding is useful in formulating management strategies for B. soporator fishery which is a valuable fish in the Cross River estuary.*

Keywords: Fecundity, Gonad development, *Bathygobius soporator*, Cross River estuary

1. Introduction

The frillfin goby, *Bathygobius soporator* belonging to the family gobiidae is one of the valuable food fish for the inhabitants of Cross River estuary. This family comprising 212 genera and 2000 species occurs in marine, brackish and freshwaters of the tropical and temperate regions [1] but has invaded nearly all benthic habitats from fresh water to the shoreline to depths exceeding 500 m [2]. They are usually secretive in their habits and can be found on a variety of substrata from mud to rubble, and coral reefs are particularly rich in goby species [2]. As reported by [3], *B. soporator* is among the marine intrusive species that is found in the lower Cross river system. Gobies exhibit a wide variety of food habits. Most species are carnivorous, many are omnivorous and a few are herbivorous [1]. Gobies feed mainly on small benthic invertebrates, algae, copepods, caridean shrimp, chironomid larvae [4], smaller crustaceans such as amphipods, copepods, and ostracods [5], smaller insects, mollusks, crabs, small fishes, and eggs of various invertebrates and fishes [6]. Fecundity and gonad development of fish is one of the most important aspects of fish biology. Fecundity defined as the number of egg in the ovary of a gravid fish is used by fisheries scientists in the following areas: stock assessment, egg and larval survival studies, standing stock size estimate, exploited stock prediction, recruitment studies [7] and formulation of management strategies [8]. Studies on gonad development of fish is of great importance in fisheries science since it provides useful information on parameters such as reproductive period, spawning frequency, size at sexual maturity and sex ratios of fish. Few researchers have conducted studies on some aspects of the biology of *B. soporator* [1], [4], [9-10]. Presently, there is no scientific information on the fecundity and gonad development of *B. soporator* in the Cross River estuary. This study attempts to provide information of the fecundity and gonad development of this valuable food fish in the Cross River estuary.

2. Materials and methods

2.1 Study area description

The study area for this research is the Cross River estuary, Nigeria, which lies approximately between latitude 4º and 8ºN and longitude 7º30 and 10ºE in the southern part of Nigeria. It takes its rise from the Cameroon Mountain and meanders westwards into Nigeria and then southward through high rainforest formation before discharging into the Atlantic Ocean

at the Gulf of Guinea. The study area has mangrove forest vegetation [11] with climate characterized by long wet season from April to October and a dry season from November to March. Mean annual rainfall is about 2000 mm [12]. A short dry period known as August break occurs in August. There is usually a cold, dry and dusty period between December and January, referred to as the harmattan season. Temperatures generally range from 22ºC in the wet to 35ºC in the dry seasons. Relative humidity is generally above 60% at all seasons, with close to 90% during the wet season [11-12].

2.2 Collection and identification of *B. soporator* species and their sexes

Two hundred and ten freshly caught gravid females of *B. soporator* were collected between July 2012 and June 2013 from the catches of the artisanal fisheries at Obufa Esuk, Esuk Abitu, Esuk Atu and Euk Anantigha, Calabar, which are the major landing point of the artisanal fisheries of the Cross River estuary. Samples were transported in ice-packed containers to the Fisheries and Aquaculture laboratory, Institute of Oceanography, University of Calabar, for further analysis. Identification of *B. soporator* was based on the identification key given by [13]. Differentiation of sexes was based on external features (anal opening) and internal features such as gonad.

2.3 Measurements of biometric indices

The following biometric parameters were measured for each specimen: Total length (TL-cm), Total weight (TW-g) and Gonad weight (GW-g) and Mean egg diameter (MED-mm). Total length was measured from snout to the base of the caudal fin rays. Measurements were taken to the nearest 0.1 cm and 0.1 g using measuring board for length and Metlar-2000D electronic weighing balance for weight.

2.4 Procedures for fecundity estimation and measurement of egg diameter

Eggs from each specimen were removed by cutting-open the abdominal part of the fish with a sharp pair of scissors. Each specimen was cut-opened through the cloaca. Eggs were washed in distilled water and weighed using Metlar-2000D electronic weighing balance to the nearest 0.1 g. The eggs removed from each sample were fixed in Gilson fluid in order to loosen the tissues surrounding the eggs [14].Fecundity (F) was determined as the product of total weight of eggs in the ovary and count in 1 g of egg mass as follows:

Fecundity (F) = total weight of eggs in the ovary x count in 1 g of egg mass

The diameters of 30 eggs per fish were measured according to [15-16] using a stereo microscope with an ocular micrometer eye piece.

2.5 Procedures for gonad development studies

For histological analysis, ovary of *B. soporator* were extracted and fixed in Bouin's fluid for 48 hours, manually processed and sectioned at 10 µ with a rotary microtome, dewaxed in xylene, stained with haematoxylin and eosin standard method [17] for microscopic examinations. The different gonad developmental stages were classified according to [18].

Gonadosomatic index (GSI) and was calculated according to [19] as follows:

GSI = Gonad weight (g)/ Whole fish weight (g)*100

2.6 Statistical analysis

Values of regression coefficient 'b' intercept 'a' and coefficient of correlation 'r' in relationship between fecundity and body parameters (F/TL-cm, F/TW-g, F/GW-g and F/MED-mm, F/GSI) for *B. soporator* from the Cross River estuary were determined by linear and power regressions.

3.0 Results

3.1 Fecundity of *B. soporator* from the cross river estuary

Fecundity was determined for two hundred and ten (210) specimens of *B. soporator* collected from the Cross River estuary. Fecundity of *B. soporator* ranged between 5462 eggs for fish of Total Length (TL-cm) 12.4cm, Total Weight (TW-g) 25.0g, Gonad Weight (GW-g) 0.5g, and Mean Egg Diameter (MED-mm) 0.45mm to 63250 eggs for fish of Total Length (TL-cm) 12.9cm, Total Weight (TW-g) 45.0g, Gonad Weight (GW-g) 3.0g, and Mean Egg Diameter (MED-mm) 0.44mm.

3.2 Gonadosomatic index (GSI) of *B. soporator* from the Cross River estuary

Gonadosomatic index (GSI) was determined for two hundred and ten (210) specimens of *B. soporator* collected from the Cross River estuary. Gonadosomatic index (GSI) of *B. soporator* ranged between 1.22% for fish of Total Length (TL-cm) 14.4cm, Total Weight (TW-g) 41.0g and Gonad Weight (GW-g) 0.5g 13.48% for fish of Total Length (TL-cm) 12.3cm, Total Weight (TW-g) 23.0g and Gonad Weight (GW-g) 3.1g.

3.3 Relationship between biometric indices and fecundity of *B. soporator* from the Cross River estuary

Fecundity of *B. soporator* from the Cross River estuary showed a linear relationship with the total length (cm). Power regression equation for fecundity (F) and Total length (TL-cm) as shown in figure 1 is as follows:

$F = 856.6TL^{1.1654}$ ($r = 0.2938$ and $r^2 = 0.0863$, $P<0.05$)

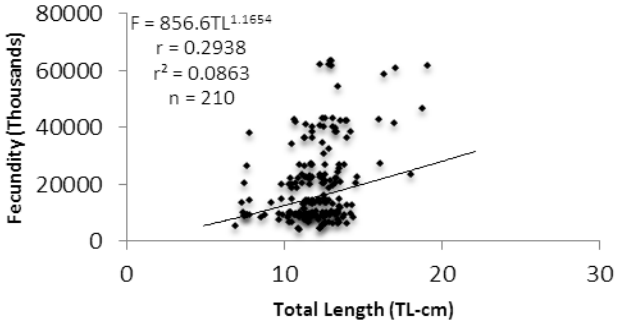

Figure 1: Power regression of fecundity against Total length (TL-cm) of *B. soporator* from the Cross River Estuary

Fecundity of *B. soporator* from the Cross River estuary showed a linear relationship with the total weight (g). Power regression equation for fecundity (F) and Total Weight (TW-g) as shown in figure 2 is as follows:

$F = 4587.1TW^{1.1654}$ ($r = 0.2960$ and $r^2 = 0.0876$, $P<0.05$)

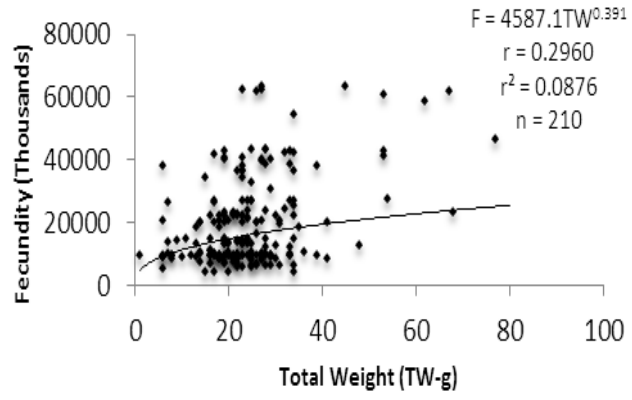

Figure 2: Power regression of fecundity against Total Weight (TW-g) of *B. soporator* from the Cross River Estuary

Fecundity of *B. soporator* from the Cross River estuary showed a linear relationship with the mean egg diameter (MED-mm).

Power regression equation for fecundity (F) and mean egg diameter (MED-mm) as shown in figure 3 is as follows:
$F = 13863MED^{1.1654}$ ($r = 0.010$ and $r^2 = 0.0001$, $P>0.05$)

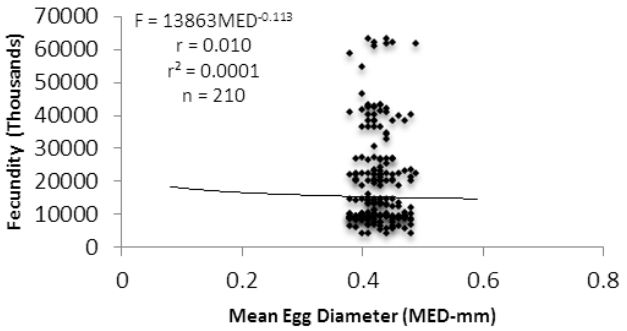

Figure 3: Power regression of fecundity against Mean egg diameter (MED-mm) of *B. soporator* from the Cross River Estuary

Fecundity of *B. soporator* from the Cross River estuary showed a linear relationship with the gonadosomatic index (GSI). Power regression equation for fecundity (F) and Gonadosomatic Index (GSI) as shown in figure 2 is as follows:
$F = 5471GSI^{0.7407}$ ($r = 0.6608$ and $r^2 = 0.4366$, $P>0.05$)

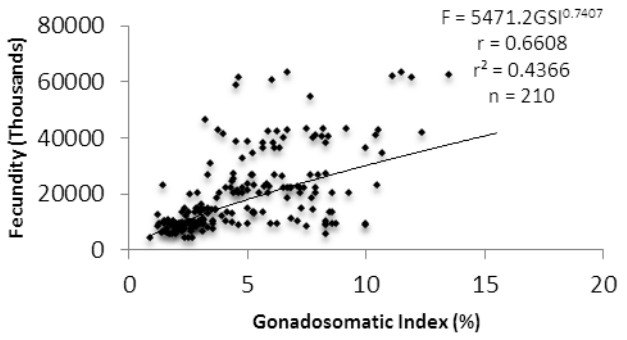

Figure 4: Power regression of fecundity against Gonadosomatic index (GSI-%) of *B. soporator* from the Cross River Estuary

3.4 Stages of oocytes development in *b. soporator* based on histological analysis

The ovarian development of *B. soporator* from the Cross River estuary was classified into six stages (Plate a-f) based on the presence of the most advanced oocytes with the histological observation summarized below:

Stage 1: This is the virgin stage with a visible nucleus surrounded by the cytoplasm. This stage is also known as the immature or inactive stage.

Stage 2: This is the maturing virgin or early active stage where the oocytes increase in size.

Stage 3: This is the developing stage where ripening oocytes continues to increases in size.

Stage 4: This is the ripped stage where gonads reach their maximum weight. Individual female fish becomes gravid.

Stage 5: Oocyte development is complete and spawning occurs.

Stage 6: This is where the eggs are spent with gonad appearing like empty sac with very few eggs.

Table 1 shows the monthly occurrence of different egg developmental stages of *B. soporator* from the Cross River estuary between July 2012 to June 2013.

Table1: Monthly occurrence of different egg developmental stages of *B. soporator* from the Cross River estuary between July 2012 to June 2013.

Months	Egg Developmental Stages						
	Stage 1	Stage 2	Stage 3	Stage 4	Stage 5	Stage 6	Total
July	5	6	8	4	3	-	26
August	3	5	10	6	4	-	28
September	4	6	5	7	6	2	30
October	8	7	4	8	7	1	35
November	5	4	5	6	5	-	25
December	6	7	5	8	4	-	30
January	3	5	2	-	-	-	10
February	2	4	5	-	-	-	11
March	4	3	4	1	-	-	12
April	2	1	-	-	-	-	3
May	-	-	-	-	-	-	-
June	-	-	-	-	-	-	-
	42	48	48	40	29	3	210

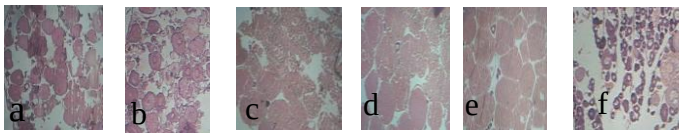

Plate a-f: Histological sections of the six developmental stages of *B. soporator* from the Cross River estuary (a-stage1, b-stage 2, c- stage 3, d- stage 4, e- stage 5 and f- stage 6).

4.0 Discussion

Information on fecundity and gonadal development of the Frillfin Goby, *B. soporator* from the Cross River Estuary provided in this study is crucial in conservation and management of this species in the Cross River estuary. Fecundity of *B. soporator* showed a positive significant ($P<0.05$) relationship with biometric indices such as body weights, total lengths and gonadosomatic index (GSI) and a positive non-significant ($P<0.05$) relationship with mean egg diameter. The positive value of correlation coefficient (r) obtained in this study indicates that fecundity increases with increase in these biometric indices and this findings is similar to findings of [9] who reported similar observation for *B. soporator* in Lagos lagoon. According to [20], fecundity is necessary to evaluate the reproductive capacity of individual fish species. In the present study, fecundity of *B. soporator* ranged between 5462 eggs for fish of Total Length (TL-cm) 12.4cm, Total Weight (TW-g) 25.0g, Gonad Weight (GW-g) 0.5g, and Mean Egg Diameter (MED-mm) 0.45mm to 63250 eggs for fish of Total Length (TL-cm) 12.9cm, Total Weight (TW-g) 45.0g, Gonad Weight (GW-g) 3.0g, and Mean Egg Diameter (MED-mm) 0.44mm. The fecundity range for *B. soporator* obtained in this study is lower than 808,911 eggs reported for *Pseudotholitus elongatus* by [21] but higher than 11,280 eggs reported for *Chrysichthys nigrodigitatus* by [20], all in the Cross River estuary. This fact clearly indicates that fecundity varies according to individual fish species. Also, one important observation made in the present study is that *B. soporator* of the same size had different ovary weight and fecundity which agrees with [22] who reported a similar observation in *Clarias gariepinus* fed Unical Aqua feed and Coppens feed in earthen pond and [23] who also reported a similar observation on *Mystus bleekeri* from the River Padma near Rajshahi City. Gonadosomatic index (GSI) is an important index in maturation study of fishes [24]. Gonadosomatic index (GSI) determined for two hundred and

ten (210) specimens of *B. soporator* collected from the Cross River estuary ranged between 1.22% for fish of Total Length (TL-cm) 14.4cm, Total Weight (TW-g) 41.0g and Gonad Weight (GW-g) 0.5g 13.48% for fish of Total Length (TL-cm) 12.3cm, Total Weight (TW-g) 23.0g and Gonad Weight (GW-g) 3.1g. GSI range and gonad weight range in the present study is similar to 0.21 – 26.58% (GSI) and 0.10 – 4.20g (gonad weight) reported by [9] for *B. soporator* in Lagos lagoon but fails to corroborate with *B. soporator* GSI range of 0.00 to 2.89% reported by [1] in Badagry creek, Lagos. This low GSI range could be attributed to dominance of male (98.95%) compared to females (1.05%) in *B. soporator* population from Badagry creek, Lagos. According to [25], reproductive studies of the fishes require knowledge of the stage of the gonad development in the teleost. The structural alterations were observed in the *B. soporator* oocytes during the oocyte development in the histological studies performed. Histological sections revealed that the oocyte development of *B. soporator* was divided into six stages. In this study, the first four stages (virgin, maturing virgin or early active, developing and ripened) represented the pre-spawning stages in *B. soporator*, followed by spawning stage where oocytes development is complete. However, the post spawning stage where the eggs are spent was present. [1] reported the presence of the pre spawning and spawning stages and absence of the post spawning stages for *B. soporator* in Badagry creek, Lagos. Results from this study showed that *B. soporator* in the pre spawning stages were the most dominant, followed by fish in the spawning stage whereas fish in the post spawning stage was the least abundant. The absence of oocyte developmental stages in *B. soporator* in the month of May and June is an indication that does not spawns all year round rather; it spawns between July and December in the Cross River estuary.

5. Conclusion

Information on fecundity and gonad development of *B. soporator* provided in this study would hopefully be useful in formulating management strategies for *B. soporator* fishery which is a valuable fish in the Cross River estuary.

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