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Full Length Research Paper

Reproductive Strategies and Gonadosomatic Index of *Bathygobius soporator* in the Estuarine Ecosystem of Badagry Creek

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A study was conducted in Badagry Creek in Lagos, Nigeria on food and feeding habits and reproduction of Frillfin goby *(Bathygobius soporator).* Data collected from the study intend to serve as a baseline for carrying out further study on the fishes and fisheries of this water body. *B. soporator* is one of the numerous and diverse fishes of the family Gobiidae which share certain similarities in their life histories. Gobies are among the most successful fishes. They are resident intertidal species which could be found in pools, rocky pools, lagoons, creeks and estuaries. Specimens were collected from the Badagry Creek via Oto-Awori Fish Jetty between January, 2008 and January, 2009. Foods and feeding habits and reproduction were studied in this creek. Seven groups of food items were encountered in the stomachs of the fish, viz; Crustaceans, Pisces, Insects, Detritus, Bivalves, unidentified food materials and Gastropods. The most eaten of these were the crustaceans contributing 34% by number and 38.30% by frequency of occurrence. The presence of other fish species in the stomachs explained the piscivorous habit while the unidentified food materials demonstrate its herbivorous character. Its predatory and carnivorous tendency was exhibited by the presence of insects, bivalves, crustaceans, and gastropods. Presence of sand grains was an indicator of its benthic nature. The specimens were classified as either male or female. Four hundred and seventy and five specimens representing 98.95 and 1.05% of total catch were classified as males and females, respectively giving 1 (male): 0.01 (female) sex ratio. This is significantly different (P>0.05) from the expected or theoretical one male:one female ratio and not in conformity with sex ratios that were reported for some fishes in the adjacent Ologe, Lagos, Lekki and Epe lagoons which favoured more females. The Gonadosomatic index (GSI) of this species varied from 0.00 to 2.89%, meaning less than 2.89% of the fish's body mass was converted to gonads for reproduction. The pre-spawning and spawning stages of this species contributed 86.75 and 13.25% of the specimens, respectively. Post spawning stages were absent.

Key words: Gonadosomatic index, spawning, Ologe, Badagry, Lekki, Epe.

INTRODUCTION

Frill fin Goby (*Bathygobius soporator*) belongs to Family Gobiidae occurring in marine, brackish and freshwaters of the tropical and temperate regions. The family comprises 212 genera and 2000 species. Members are generally small fishes, ranging from 5 to 10 cm long (Herald, 1961), but some species may exceed 50 cm. The smallest fishes in the world belong to this family. Many species are commensals, living in association with burrowing shrimps and echiuroids (MacGinitie, 1934, 1939; Luther, 1958; Magnus, 1967), most are cryptic bottom dwelling carnivores of small benthic invertebrates some are planktivores and others are known to remove ectoparasites from other fishes. Some of the genera; include

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Boleophthalmus, Gobius, Periophthalmus, Periophthalmadon, Scartelaos, and *Brachygobius*. The five currently recognized subfamilies are Oxudercinae, Amblyopinae, Sicydiinae, Gobionellinae, and Gobiinae (Berra, 2001). *B. soporator* is demersal in nature; non-migratory and inhabits the depth that ranges between 0 to 16 m. There are approximately 52 species in *Bathygobius.* Nguyen and Nguyen (2006) recognized coral reef as their special habitat. *B. soporator* was discovered in Lagos Lagoon, Nigeria in 1968 with the geographical area in Bight of Benin, Atlantic. The morphometric and meristic characteristics of this fish was described by Robins and Ray (1986) and Ross and Rhode (2004). The recent developments on this species and its relatives include that of Lima et al. (2005), Saeki et al. (2005), Adámek et al. (2007), Emmanuel and Onyema (2007) and Hung Liu et al. (2008).

Food habits of gobies are very diverse. Although most species are carnivorous, many are omnivorous and a few are herbivorous. Most near shore, medium-sized gobies appear to feed mainly on small benthic invertebrates and algae. In contrast, tropical reef-dwelling species may have very specialized food habits. Several species are semi-pelagic and feed on planktonic copepods. Species living in freshwater streams and lakes often feed on diatoms and other microalgae. The feeding of *B. soporator* is mainly on animals (Alfred-Ockiya, 2000); caridean shrimp, chironomid larvae, smaller crustaceans such as amphipods, copepods, and ostracods (Odum, 1970), and smaller insects (Darcy, 1978); on mollusks, crabs, small fishes, and eggs of various invertebrates and fishes (Allen and Robertson, 1994; Berra, 2001; Harmelin-Vivien, 2002).

Various techniques are available when undertaking gut analysis of fish. The selection of an appropriate technique will ultimately be determined by the investigation type, presented hypothesis, or nature of the food to be analyzed (Windell and Bowen, 1978); although on occasions the equipment, time scale or site restriction may take precedence. The simplest available method takes organism occurrence as the main consideration. Recording the number of stomachs containing one or more specific food category can be graphically represented as the percentage of stomachs containing each organism or group (Hyslop, 1980).

This method is expeditious and only requires the minimal of apparatus, but seldom gives evidence of accurate quantities or preferences regarding each food category present. In relation to previously discussed environmental influences, this technique is ideal for portraying seasonal changes in diet composition (Frost, 1977). Numerical methods can be applied by enumerating the individuals in specific categories; this is undertaken for all stomachs, the sum is expressed as a percentage of total individuals in all food classifications (Crisp et al., 1978). This application is relatively fast and simple; this will be influenced by the feasibility of prey item identification. Methods of sub-sampling may be performed to eradicate the tiresome nature of very diminutive organisms. With a view to statistical analysis, this technique allows the computation of the mean organisms in each stomach. As with any method, hin- drances will be apparent, inaccuracies when dealing with detritus and microalgae, overemphasis of importance regarding small prey items (Crisp et al., 1978). Crucially, Hyslop (1980) notes that number of organisms in a carp stomach are difficult to appraise due to mastication of food items before they reach the area of examination.

The mode of reproduction in *B. soporator* is dioecism, their fertilization is external and description of life cycle and their mating behavior is of benthic spawning (Cole, 1990). Its pre spawning, spawning and post spawning behavior have been documented by Breder (1943), Tavolga (1950), Runyan (1961), Peters (1983), and Breitburg (1999). Gobies are of considerable importance ecologically and commercially. They can be very abundant at certain localities, where they form an important component of the food web (De Sylva, 1975). Several species of gobies are fished commercially for food, especially in the Far East; they are of great significance as they are prey species for commercially important fish like cod, haddock, sea bass, and flatfish.

Presently, there are dearths of information concerning members of the family Gobiidae, including *B. soporator* especially in Badagry creek. This study attempts to bring together information on its biological aspects of this economically valued fish species in Badagry creek. It is hoped that this study will be useful as baseline data for carrying out further ecological studies on this and other fish species of great economic importance in commercial and artisanal fisheries. Secondly, the importance of these and other species in the estuarine ecosystems (especially their roles in coastal food chains) of the creek are of interest.

MATERIALS AND METHODS

Description of study area: Badagry creek

Badagry Creek (Figure 1) in Lagos Nigeria is endowed with lagoon system, deltaic distributaries, floodplains and mangrove swamps. It lies within longitude 2°42'E and 3°42'E and stretches between Latitude 6°22'N and 6°42'N, sharing boundary with Republic of Benin. It directly connects with Nigeria's 960 km of coastline bordering the Atlantic Ocean in the Gulf of Guinea, a maritime area of 46,500 km^2 with depth of up to 50 m and an Exclusive Economic Zone of 210,900 km^2 (World Resources, 1990) . It is important for both artisanal and commercial fisheries, and as well as transportation, recreation and domestic purposes. It serves as a mean of livelihood for many villagers, and fishermen and women. The creek separates the mainland sedimentary basin of South-west Nigeria from the Atlantic coastline. The creek exhibits relatively high species richness, which might possibly be due to succession of species temporarily using the environment for feeding, spawning and shelter. High biological diversity of fish species on this creek shows the need for good management and conservation practices especially with its locals. The fish population from the creek exhibits relatively high diversity, species richness and a high biological

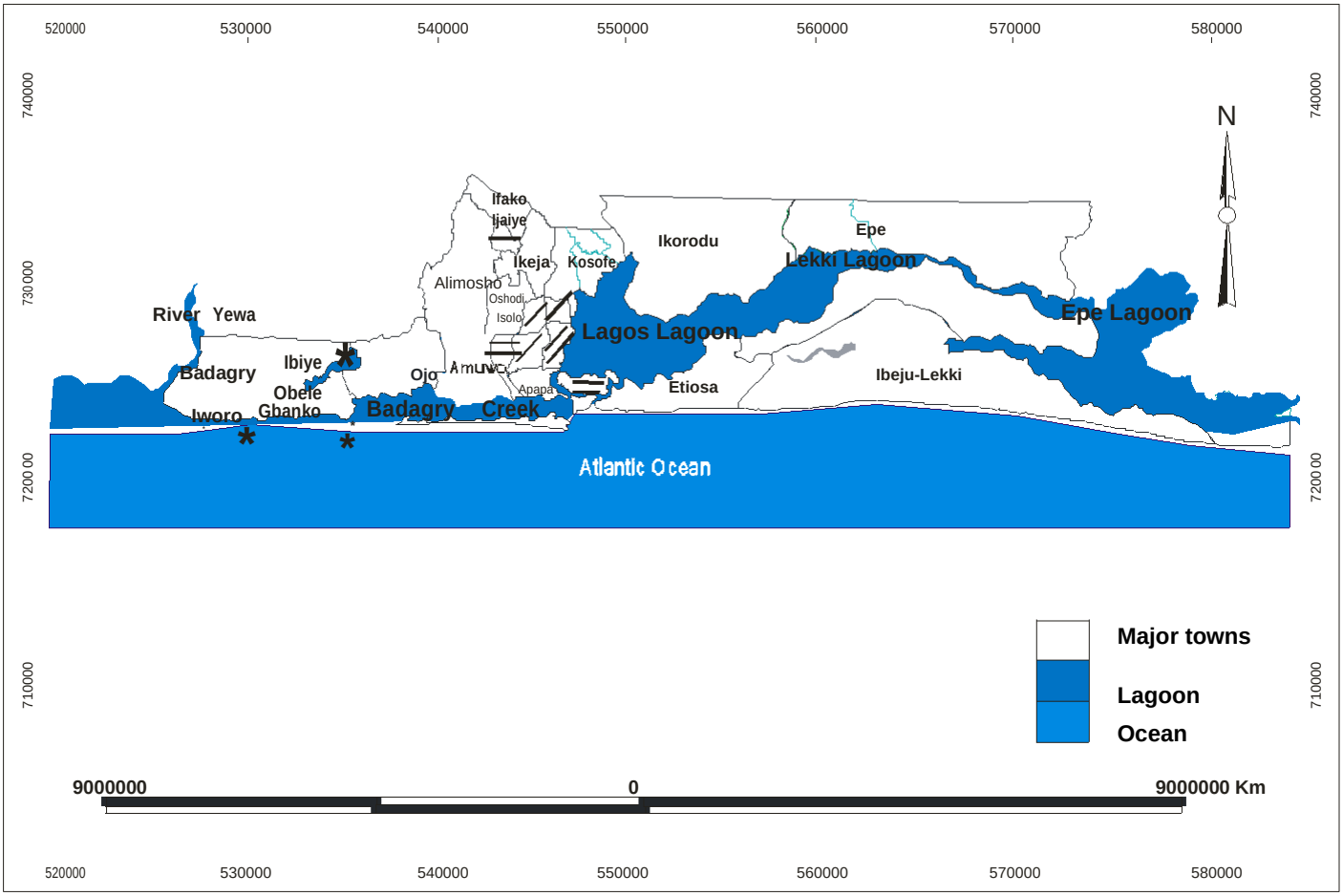

Figure 1. Map of lagos showing the Badagry creek complex (sampling station*). Source: Cartography Laboratory, Geography Department, LASU, Ojo, Lagos State, Nigeria.

productivity than many other comparable water bodies in West Africa. Thus, the potential of Badagry Creek for great fishery resources cannot be over emphasized and the need for future aquaculture on this water body may not be out of place.

Collection of specimens

In January 2008 to January 2009, a total sum of five hundred and six specimens of *B. soporator* were collected from the study sites, Badagry, Iworo, Obele, Ibiye, Gbanko, and Oto Awori. Collections were carried out daily with assistance of local fishermen on motorized canoes which were native of these riverine villages. Specimens were caught with aid of gill nets and non-return valve traps.

Laboratory procedures

Biometric data

In the laboratory, biometric data on sex, body weight and total length measurements were carried out on the individual specimen. The specimens were tagged.

Analysis of the food items

The foods of the specimens were determined by making incision from the anus through the throat to reveal the alimentary canal. The stomach contents were identified. The analysis of the food items in the stomachs of the specimens was undertaken monthly by numerical and frequency of occurrence methods. The numerical method took the number of food items into consideration. The value was expressed as a percentage of the total number of all food items consumed by the fish. The frequency of occurrence considered the number of times each food item occurred in the stomachs examined. The frequency of occurrence was calculated relative to the number of stomachs containing food items. The merits and demerits of these methods have been examined by Hyne (1950) and Hyslop (1980). The values of 0, 1, 2, 3, 4 and 5 were used to represent the various capacity of the stomachs occupied by the food materials in which they are empty, one quarter, half, three-quarter full, distended and ruptured stomachs, respectively.

Reproductive biology

The specimens were observed externally for sexual dimorphism, they were dissected to extract the urogenital apparatus in both sexes, and the gonads were weighed using an analytical balance

(Metler PM 400) to the nearest 0.1 g. The maturity stages of the specimens were determined by both macro and micro examinations of the gonads.

Sex ratio

Sex ratio was determined by counting the number of male and female specimens monthly. Test for goodness of fits was determined statistically by Chi-square (X^2) test.

$$X^2 = \frac{(O-E)^2}{i=1\ E}$$

Where O = Observed, and E = Expected.

Gonado-somatic Index (GSI)

The gonadosomatic indexes of the specimens were recorded monthly. The GSI of individual specimens was calculated using

$$GSI = \frac{\text{Gonad weight [GW]} \times 100}{\text{Body weight [BW]}}$$

Where, GW = gonad weight (g) and BW = body weight (g).

RESULTS

Food and feeding habits of *B. soporator*

Indexes of stomachs

Indixes of 506 stomachs of *B. soporator* from Badagry creek are presented in Table 1. Food items found in the stomachs represented the food ingested by the species. The observations of their stomachs gave six stomach indixes viz; empty (0), semi half (1), half (2), semi-full (3), full (4), distended (5) and ruptured; constituting 206 (40.71%), 96 (18.97%), 75 (14.18%), 39 (7.71%), 38 (7.51%), 25 (4.94%) and 27 (5.34%), respectively.

Analysis of the food items

Summary of food items encountered in the stomachs of *B. soporator* is given in Table 2. Seven categories of food items were encountered. These included crustaceans, pisces, insects, bivalves, gastropods, detritus and unidentified materials contributing 34.0, 25.8, 7.4, 17.0, 3.4, 8.0 and 4.4% by number and occurring in 38.30, 24.31, 11.66, 21.98, 5.66, 1.67, 2.66% of the stomachs with food items. Of the crustaceans, shrimps (*Penaeus notialis)* and crabs (*Portunus hastatus)* were most eaten.

Reproduction in *B. soporator*

Sex ratio

Summary of monthly sex ratio in *B. soporator* is presented in Table 3. 470 (92.89%) males to 5 (0.99%) females were obtained giving a sex ratio of 1 (male):0.01 (female). Males were significantly more than females ($P<0.05$). Highest number of 110 males to 0 female (sex ratio: 1 (male):0.00 (female) was recorded in February, 2008 and the lowest value of 21 males to 0 female in May 2008 (Table 3).

Gonadosomatic index

The monthly Gonadosomatic indexes (GSI) in male *B. soporator* are presented in Table 4. The observable gonads were 340 specimens. The mean GSI ranged between 0.000% in February, April and December, 2008 and 2.890% in March, 2008. The lowest mean value of 0.09 ± 0.11% was recorded in February, 2008 and the highest mean value of 0.24 ± 0.24% in May, 2008.

Gonad weight–Total length relationship

The gonad–weight -total length relationship in *B. soporator* is expressed as:

GW = -0.17 + 0.00TL (r =0.40) (Figure 2).

Gonad maturation stages

The gonad maturation stages in *B. soporator* from Badagry creek. Find below in Figure 3. The pre spawning and spawning stages were encountered among the specimens in the creek. The pre spawning stage were immature (stage I), immature and developing (stage II) and ripening (stage III) which respectively contributed 35.77, 43.87 and 7.11% of the gonads used in this work. The spawning stages of ripe (stage IV) and ripe running (stage V) contributed 13.25 and 0% respectively. However, the post spawning stages of spent (stage VI) and recovery (stage VII) were absent.

DISCUSSION

Food and feeding habits of *B. soporator*

The dietary preferences of *B. soporator* are poorly reported. However, the demersal lifestyle of the goby suggests that it may feed upon small invertebrates, fishes and detritus from rocky intertidal areas. In this study, seven categories of food were encountered in the stomachs of this fish species. These included crustacean, pisces, insect, detritus, bivalve, gastropods, and unidentified food materials. The presence of sand grains in the diet was an indication of its benthic behaviour while the presence of crustaceans, insects, bivalves, and gastropods demonstrated its carnivorous and predatory

Table 1. Indices of stomachs in *B. soporator* from Badagry Creek.

Stomach capacity	Index	Number of stomachs of occurrence	Percentage of occurrence (%)
Empty	0	206	40.71
Semi half	1	96	18.97
Half	2	75	14.18
Semi full	3	39	7.71
Full	4	38	7.59
Distended	5	25	4.94
Ruptured	6	27	5.34

Table 2. Summary of food contents in 300 stomachs* of *B. soporator* from Badagry Creek.

Classes of food items	Numerical method		Frequency of occurrence	
	No.	%	No.	%
Crustaceans crabs (*Portunus hastatus)* and shrimps *(Penaeus notialis)*	170	34.0	115	38.30
Pisces (tilapia fry)	129	25.8	73	24.31
Insects	37	7.4	35	11.66
Bivalves (*Donax rugossus, Pitar tumens*	85	17.0	66	21.98
Gastropods (*Mactra nitida)*	17	3.4	17	5.66
Detritus (sand grains)	40	8.0	5	1.67
Unidentified food masses	22	4.4	8	2.66

*No. of stomachs that contained food items.

Table 3. Summary of monthly sex ratio in *B. soporator* from Badagry Creek.

Year	Month	No. of specimen	Male	Female	Sex-ratio (Male: Female)
2008	January	51	51	-	1 : 0.01
2008	February	110	110	-	1 : 0
2008	March	45	43	1	1: 0.02
2008	April	89	87	-	1 : 0
2008	May	21	21	-	1 : 0
2008	June	57	52	1	1: 0.02
2008	July	-	-	-	-
2008	August	-	-	-	-
2008	September	-	-	-	-
2008	October	-	-	-	-
2008	November	-	-	-	-
2008	December	105	84	3	1 : 0.04
2009	January	23	22	-	1 : 0
	Total (percentage)	506	470 (92.89%)	5 (0.985%)	1 : 0.01

tendencies. However, presence of fish fry exhibited its piscivorous habits. The tilapia fry as a part of the diet explained the ecological relationship that exists between tilapia and frill goby. The occurrence of empty stomachs is a characteristic feature of predatory fishes which is associated with rapid rate of digestion. This phenomenon may also be related to regurgitation of large food items from stomachs of predatory fishes by pronounced development of striated muscles of oesophagus extending to the stomachs of *B. soporator.* Presence of these food items was confirmed in some related studies by Saeki et al. (2005), Adámek et al. (2007), Hung Liu et al. (2008) and Özcan (2009) and may probably be the characteristics foraging nature of the members of family

Table 4. Summary of monthly Gonadosomatic Index (GSI) in *B. soporator* from Badagry Creek.

Year	Month	Sample size	Range		Mean value
			Min.	Max.	
2008	January	21	0.016	1.880	0.22±0.41
2008	February	71	0.000	0.550	0.09±0.11
2008	March	33	0.009	2.890	0.21±0.49
2008	April	76	0.000	1.330	0.16±0.23
2008	May	19	0.020	0.843	0.24±0.24
2008	June	49	0.005	0.584	0.18±0.17
2008	July	-	-	-	-
2008	August	-	-	-	-
2008	September	-	-	-	-
2008	October	-	-	-	-
2008	November	-	-	-	-
2008	December	55	0.000	0.510	0.11±0.11
2009	January	16	0.020	0.440	0.13±0.11

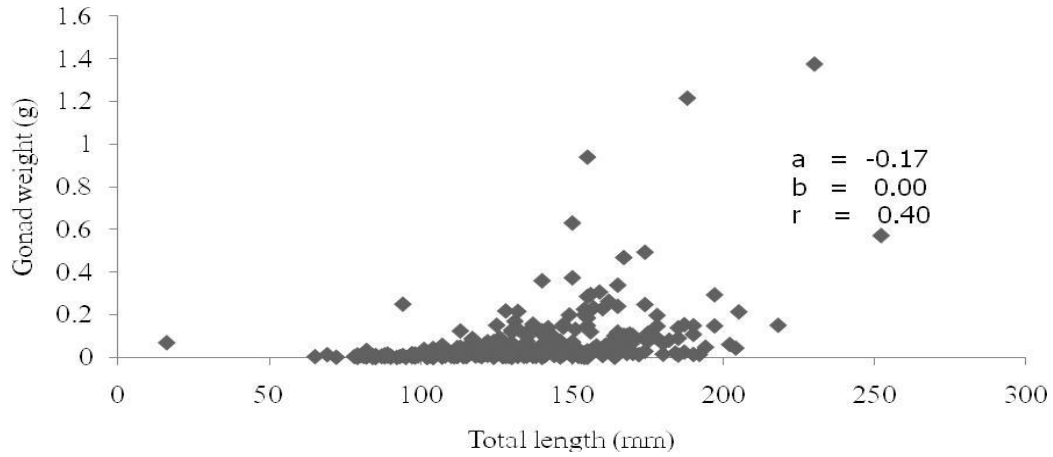

Figure 2. Gonad weight - Total length relationship in *B. soporator* from Badagry Creek, Lagos.

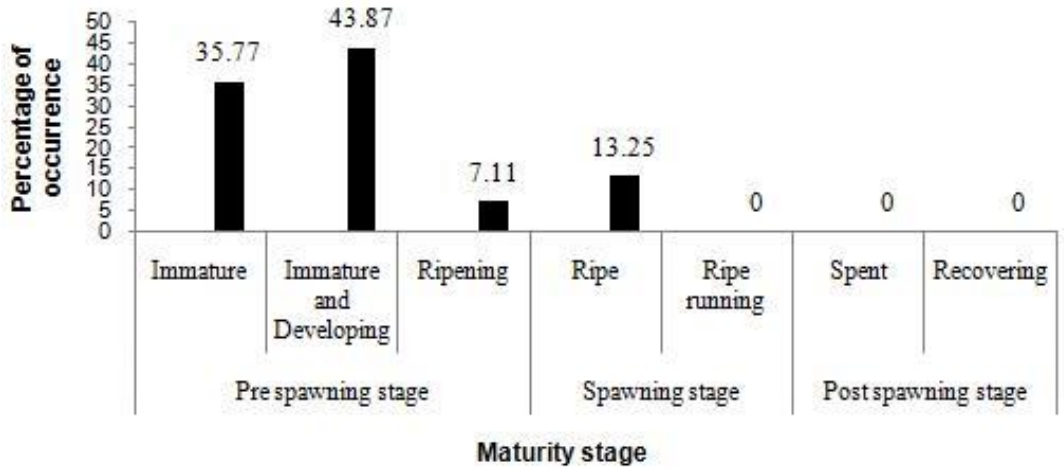

Figure 3. Gonad maturation stages in *B. soporator* from Badagry Creek, Lagos.

Gobiidae

Reproduction in *B. soporator*

In this study, the sex ratio of the species indicates that males were significantly (P<0.05) more than the females with a sex ratio of 1 (male):0.01 (female) suggesting 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 (Lawson and Aguda, 2010).

We also suggested that this species may be protandrous hermaphrodite, a situation where at a certain age or size some females may change sex. Higher percentages in favour of males were reported in some non related species such *Elops lacerta* in adjacent Lekki lagoon (Ugwumba, 1984) and Ologe lagoon (Lawson and Aguda, 2010) in Lagos, Nigeria. However, higher percentages in favour of females were reported in *Ethmalosa fimbriata* by Blay and Eyeson (1982) in the coastal waters of Cape coast, Ghana and in Mullet, *Mugil cephalus* by Lawson (1991) in Lagos lagoon, Lagos.

The gonadosomatic index (GSI) varied between 0.000 and 2.890% indicating the fish converted between 0 (in February, April, and December, 2008) and 2.895% (in March, 2008) of its body mass to gonads for reproduction. The GSI had been used to describe the development of gonads of Pike, *Esox lucius* by Danileko (1983). Higher GSI values of between 0.01 and 8.40% were reported by Lawson (2011) in mudskipper, *Periophthalmus papilio,* a benthic fish from mudflats of mangrove swamps of the adjacent Lagos lagoon, Nigeria. GSI is an important index in maturation study of fishes (Washio et al., 1993; Guyana, 2000; Srijunngam and Wattanasirmkit, 2001; Okuthe, 2004; Bucholtz et al., 2008; Mohamed, 2010; Saeed et al., 2010).

In this study, the immature, immature and developing and ripening stages represented the pre spawning stages in *B. soporator*, while the spawning stages were ripe and ripe running. However, the post spawning stages (spent and recovery) were absent. The most dominant fish were those in their immature and developing stages, 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.

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