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Parameters of Reproductive biology of Red Pandora *Pagellus bellottii* (Steindachner, 1882) in the Ivoirian coast (Cote d'Ivoire)

Amoin Céline Kouame[1,2], Soumaïla Sylla[*2], Stanislas Arra[2,3], Kouadio Frederic Kouakou[1], Stanislas Silvain Yao[1]

[1]*UFR Biosciences, Université Félix Houphouët Boigny Abidjan, Abidjan, Côte d'Ivoire*

[2]*Centre de Recherches Océanologiques (CRO), B.P.V 18 Abidjan, Côte d'Ivoire*

[3]*UFR-SGE, Université Nangui Abrogoua, Laboratoire d'Environnement et de Biologie Aquatique, Abidjan, Côte d'Ivoire*

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Abstract

From to March 2016 to February 2017, some aspects of *Pagellus bellottii* reproductive biology in Côte d'Ivoire were investigated and focused on sex ratio, gonadosomatic and liver somatic index, condition factor, size at first maturity, stages of gonadal development. Sampling was done each month by trawler fishing. 386 fish with body length varied from 9 to 25 cm fork lengths (FL) and body weight from 17. 25 to 327.7g was used. Sex ratio was 1:1.08 (male to female). The protogynous hermaphrodism character of *Pagellus bellottii* was not confirmed. Gonadosomatic index (GSI), hepatosomatic index (HIS) and the condition factor (K) indicated two spawning periods. The first one lasts from April to September with a Female's GSI peak about 4.52±0.49 in June and the second one from December to February. The main spawning period is long about 6 months from April to September. The hepatic reserves are not used for the energitic requirements of the reproduction. Males and females reach first maturity at 13.33 and 12.41cm FL respectively.

***Corresponding Author:** Soumaïla Sylla ✉ syllasoumahila@yahoo.fr

Introduction

Pagellus bellottii (Steindachner, 1882), red pandora is one of tropical and subtropical demersal fish. It lives over hard or sandy bottoms in coastal marine waters. *P. bellottii* inhabits to 250m depth, but is more common between 10 and 50m. It is distributed in the eastern Atlantic (Bauchot and Hureau, 1986). This fish species belongs to Sparidae familly constituting the demersal fish in the Gulf of Guinea. *Pagellus* genus is generally known as hermaphrodite, *P. bellottii* as protogynous (Fischer *et al.,* 1987).

Sparidae family is one of the most economically important marine fish families that inhabit the West African coast; this family is well represented by the diversity of species and high commercial value. *P. bellottii* is widespread and is one of the most abundant Sparidae species on the West African coast from Gibralta to Angola. It is a significant component of the multi-species coastal demersal fisheries in the Eastern Central Atlantic (Russell and Carpenter, 2014).

In Ivoirian waters *P. bellottii* constitute an important fishery resource. This species has been captured by trawl fleet. It is an extremely valuable component of the Ivoirian fishery; both in terms of abundance and quality, accounting for 10.3% of the total marine fish catch **(**FAO, 2008).

The aspects of fish reproductive biology are necessary for successful fisheries management and recruitment in natural water bodies and aquaculture of fish species (Adebiyi, 2012). Despite its wide geographical distribution, its commercial value and its importance to the Ivoirian marine fishery, few biological studies of this species have been conducted in West Africa. Data on biological aspects in Africa waters are very scarce and concern only, in Mauritanian coast (Le Trong-Phan and Komowski, 1972); in Ghanaian coast Rujavec (1973) and in Senegalese coast Ndiaye (2014). To date there is no information published on the biology of *P. bellottii* in Côte d'Ivoire.

It is therefore essential to determine life history of this specie to obtain a better understanding of its biology, a suitable evaluation of its population dynamics and a good management of its fisheries. Thus, the aim of this paper was to study the sex ratio maturity, gonadosomatic index, hepatosomatic index, reproduction period, condition's factor, Gonadal and repartition development stage and length at first maturity of *P. bellottii.*

Materials and methods

Study area and sampling

The Ivorian oceanic zone is bordered to the north by the Gulf of Guinea shoreline stretching from the Cape Palmas (7°30W) and the Cape Three Points (2°W). The shoreline is 550km long with a narrow continental shelf of 10, 200 km² and is characterized by a series of sandy beaches forming a wide arch opened to the Atlantic Ocean (Le Loeuff and Marchal, 1993). The period from January to February corresponds to the minor upwelling whilst a major upwelling is usually observed between July and October Colin (1988). Fish samples were collected monthly from March 2016 to February 2017 in continental shelf of Côte d'Ivoire fishery at Port (Abidjan, Côte d'Ivoire) through the industrial fishing carried out by trawlers. A total of 386 specimens were collected. The samples were transported to the laboratory and preserved in a deep freezer until examination and analysis. In the laboratory, specimens were measured to the nearest cm for total and fork length and weighted to the nearest gram for total weight. After dissection, the gonads and the liver were weighted to the nearest g and the eviscerated weight was recorded to the nearest g. Sexing of fish was based upon the external appearance of gonads as males, females, immatures and hermaphrodites. The Sexes were distinguished after macroscopic observation of gonads. When gonads were very thin and translucent, and the sex could not be clearly identified, fish were considered as immature. Specimens are considered as males if they had only testes and females if they had only ovaries. Fish was classified as hermaphrodite when it presents a gonad with both ovarian and testicular tissues clearly visible to the naked eyes. The macroscopic gonad development stage of in the fishes was determined

using the scale of Fontana (1969). The number of males and females in the different gonadal development stages was counted and recorded.

Sex ratio

Sex ratio studies provide information on the representation of male and female fish present in a population. It constitutes basic information necessary for the assessment of the potential of fish reproduction and stock size estimation in fish population (Vicentini and Araujo, 2003). Sex ratios were estimated [male/female]. *Chi-square tests* were used to investigate the differences in sex ratios from an expected 1:1 ratio.

Gonadosomatic index

To quantify the changes in gonad weight during the annual sexual cycle and to determine the spawning season, we calculated the gonad-somatic index (GSI) the following formula:

$$GSI = \frac{Wg}{We} \times 100$$ (Analbery, 2004)

Where, Wg=gonad weight (g); We= eviscerate weight (g)

Hepathosomatic index

The hepatosomatic index was calculated according to Pardoe *et al.,* (2008).

$$HSI = \frac{Wl}{We} \times 100$$

Where, Wl= liver weight (g); We= eviscerate weight (g)

Condition factor

$$K = \frac{W}{L^3} \times 10^2$$; Lalèye, 1995; Froese, 2006)

Where K= condition factor, W= gutted body weight (g) and L= total length (cm)

Size at first maturation

Size at first maturity (L_{50}) was also determined from the population of mature fish in each size group using a logistic curve fitted by a weighted non-linear least squares regression:

$$P = \frac{1}{1+e^{-(a+bFL)}}$$ (Ghorbel *et al.*, 1996)

Where P is the proportion of mature fish for the fork length FL, b is the slope of the maturity curve, and FL_{50} is the size at which 50% of the fish are mature.

$$FL_{50} = -\frac{a}{b}$$

Statistical analyses

Data were analyzed using Analysis of variance (*ANOVA*) and *chi-square* analysis. The sex ratio was tested for the expected 1:1 ratio by using *chi-square analysis*. The *ANOVA test* was used for length and weight mean comparisons between male and females.

Results

Sex ratio

A total of 196 males and 190 females were observed out of 386 samples examined. The sex ratio was 1: 1.08 (female to male). The difference in sex ratio was not significant ($p > 0.05$).

Gonadosomatic index

Males and females's gonadosomatic index's mean variation shows similar patterns (Fig. 1). The monthly values of gonadosomatic index ranged between 0.71% and 4.52% and from 0.43% to 2.17% respectively for females and males. Gonad somatic index 's mean was 2.00±1.19% and 1.11±0.74% respectively for females and males. From April to June the mean values reached the highest values, with a peak in June (4.52±0.49%) for females and (2.17±0.82%) for males. A second peak for the females was observed on January (2.05±1.02%) and for males with a value about 1.41± 0.6 %. Those values are low from August to October. According the gonadosomatic index, the female's main spawning period is about to 6 months. It starts from April (1.05±0.60%) to September (1.69±0.78%).

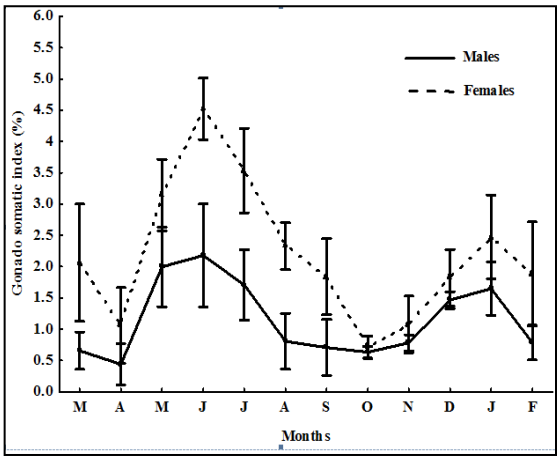

Fig. 1. Monthly changes in gonadosomatic index (GSI) of *Pagellus bellottii* males and females during one cycle.

Hepathosomatic index

Males's hepathosomatic index variation was almost similar to that observed in females (Fig. 2). Monthly hepathosomatic index values ranged between 0.23% and 1.44% for females and from 0.23% and 1.02% for males. Maximal values in both sexes were observed in May (1.27±0.51%) and December (0.71±0.19%). Hepathosomatic index 'values for the both sexes decreases from October (0.61±0.25%) to November (0.23±0.20%). Monthly hepathosomatic and gonadosomatic index variations are the same trend for the both sexes.

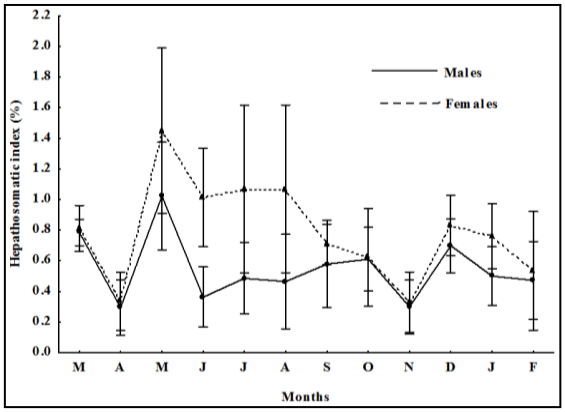

Fig. 2. Monthly changes in hepatosomatic index (HSI) of *Pagellus bellottii* males and females during one cycle.

Condition factor

The condition factor for females (2.00±0.16%) was identical that of males (1.99±0.15%). The condition factor for the combined sexes ranged from 1.90% to 2.11% with a mean value of 1.99±0.15% (Fig. 3).

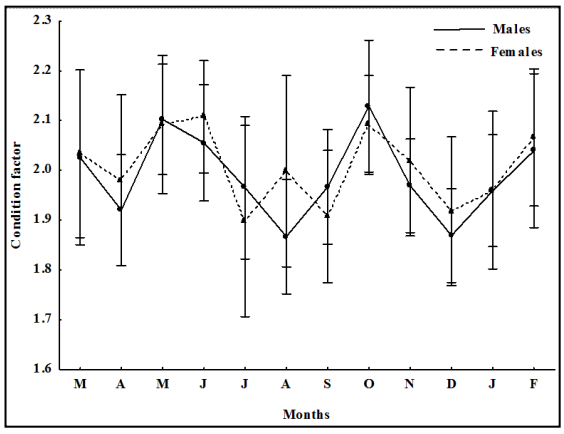

Fig. 3. Monthly changes in condition factor of *Pagellus bellottii* males and females during one cycle.

Size at first sexual maturity

An analysis of length at first maturity L_{50} showed that males were mature at an average of 13.33cm fork length where as females at 12.41cm fork length (Fig. 4). Thus, females mature at shorter size than males.

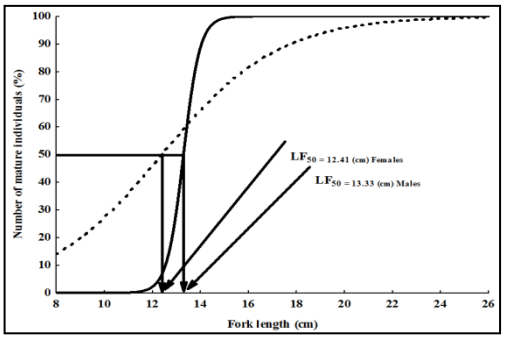

Fig. 4. Percentage of mature of *Pagellus bellottii* shown separately for males and females.

Gonadal and repartition development stages

In this study, six gonadal development stages were observed. Table 1 and Fig. 5 show the macroscopic features of the stages of ovarian and testicular development of *P. bellottii*. Gonads' aspect changed during sexual development (Fig. 5). Gonads 'macroscopic examination indicated that the immature were observed in March to May and in August to February. The mature (Fig. 6).

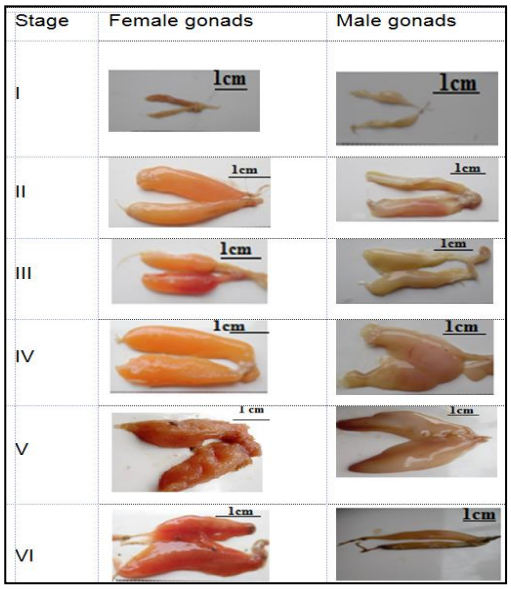

Fig. 5. Six macroscopic maturity stages of *Pagellus bellottii* female and male 's gonads. Stage I (Immature); Stage II (Early maturing); Stage III (Developing); Stage IV (Developed / Pre spawning); Stage V (Spawning); Stage VI (Spent).

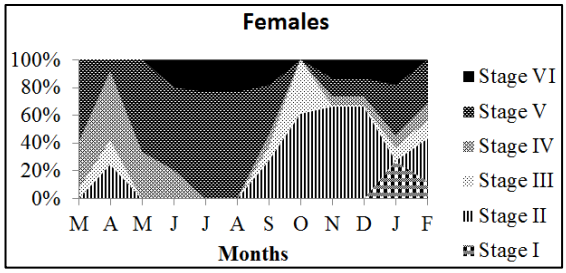

Fig. 6. Monthly variation in maturity stages of gonads for females *Pagellus bellottii.*

Discussion

The sex ratio of *P. bellottii* in the Ivoirian coast suggested that the males and females' number are the same trend in the sampling. Dia *et al.*, (2009) are observed the same trend for another Sparidae species called *Diplodus sargus cadenati*. Also, Adebiyi (2012) are obtained a similar result for a one of the demersal fish like *Brachydeuterus auritus* in Lagos coast. Several studies investigated for Sparidae species are contrary to our results. Thus Ali Ben Smida and Hadhri (2014); Bensahla, (2014); Benina (2015) ; Mahdi *et al.*, (2017); Dobroslavić *et al.*, (2017) are shown one of the sexes was always predominant.

The hermaphrodism character which is common in Sparidae was not confirmed for this species in our study. In contrast, according the data for Ndiaye (2014), in Senegalese water, *P. bellottii* is protogynous hermaphrodite fish. The absence of hermaphrodite individuals in our samples could be explained by environmental factors such as the temperature and fishing intensity. Also, according Busalacchi *et al.*, (2014), the sex change does not occur in each individual. Moreover, sampling biases could also account for skewed sex-ratio, which is attributed to fishing at different depths or because of spatial or vertical separation of sexes (Sims *et al.*, 2001).

P. bellottii of the Ivoirian coast shows two spawning period. Similar results were obtained by Ndiaye (2014) for the same species in Senegal water**.** Another's authors were obtained the same results for the *Pagellus* genus in Algerian west coasts (Bensahla (2014), Mahdi *et al.* 2017). Ndiaye (2015) found two spawning period for another species of Sparidaes as *Diplodus bellottii* in Senegalese Coast. In this study, A longer spawning period observed indicates that favourable environmental conditions for hatching and larval development. In effect, in Côte d'Ivoire, the upwelling period take place from June to October (Bard and Koranteg, 1995; N'goran, 2006). The nutrient-rich upwelled water stimulates the growth and reproduction of primary producers such as phytoplankton. The environment's factors influence the spawning period according to (Gonçalves and Erzini, 2000; Tsikliras *et al.,* 2010). An extensive spawning period has also been found for *Pagellus erythrinus* (Ghorbel, 1996) and for *Sparus aurata* (Hadj Taieb *et al.*, 2010) and an even extended period was found for *Diplodus vulgaris* for the Atlantic Ocean (Gonçalves and Erzini, 2000; Gonçalves *et al.*, 2003; Pajuelo *et al.*, 2006).

Table 1. gonadal developments Stages of for males and females of *Pagellus bellottii* (adapted from Adebiyi, 2012).

Stage of gonadal development	Macroscopic features	
	Ovary	Testis
Stage I (Immature)	Ovary was very small, thin, thread like pale in colour, occupying a small part of the body cavity.	Testis was thiny, slender translucent and pale in colour.
Stage II (Early maturing)	Ovary become slightly larger and increase in weight, translucent.	Testis became enlarge, flat, increase in weigth and volume, and creamy white in colour.
Stage III (Developing)	ovary was large, opaque and light yellow in colour, blood vessels were seen on the surface.	Testis enlarge, increase in weight an volume, light pinkish and look more vascular.
Stage IV (Developed/ Pre spawning)	Ovary became more enlarge occupying almost entire body cavity, yellowish in colour and eggs were clearly visible.	Testy was enlarged, milky white. Milt release with a slight pressure.
Stage V (Spawning)	Ovary walls become thin almost transparent. Ripe eggs are visible through	Testy became flabby, thin and dull white in colour.

Stage of gonadal development	Macroscopic features	
	the ovarian wall and some ripe eggs are present in the oviduct.	
Stage VI (Spent)	Ovary was flaccid, sac like and reduced in volume. Ovary contains ripe unspawneddarkned eggs and a large number of small ova.	Testis became flaccid empty with evidence of hemorraging (blooding).

The same trend found between gonadosomatic index and Hepatosomatic index indicates that this fish probably stores its energetic reserves in liver during the gonadal maturation period. Such reserves not used for the energetic requirements of the spawning. Contrary to the result found by Ndiaye (2014) for the same species in Senegal water. For this author, the liver reserves are mobilized for gonad maturation or the energy stored in the liver is channeled to muscular activity. It seems that the energy stored in the liver are used in sex change in *Pagellus bellottii* and non for the reproduction as mentioned by Ndiaye (2014). In effect, Munday and Molony (2002) are demontred that the lipid concentrations in the liver of males and females are mobilized for the sex change. According to Hoffman *et al.* (1985), the sex change incurs costs in terms of the energy expended in reorganising gonadal tissue and lost mating opportunities during or after transition.

The condition factor constitutes an important quantitative element for the evaluation of the relationship between the body shape and relative weight of a species (Isaac-Nahum and Vazzoler, 1983). The condition factor exhibited an inverse relationship to the gonadosomatic index and is therefore a good reproductive indicator for *P. bellottii* in the Ivoirian coast. Azevedo *et al.* (2017), on the eastern Amazon (Brazil), found for the similar result for another demersal fish species like *Micropogonias furnieri.*

Females reach first maturity at a length smaller than males. Similar result was reported for this specie by Ndiaye (2014), in Senegal waters. The inter-population variation in length at first maturity seems to be linked to growth differences of populations that are affected by environmental factors such as temperature and food quality and availability (Zarrad *et al.,* 2010).

The mature specimens are widely represented in the samples all the years. Thus, *P. bellottii* could be included in the multi-spawner species fish as reported by ICE (2004).

Conclusion

The results of this study signified that the deviation in sex ratio from the 1: 1 distribution which was in favor of males was not significantly different from the expected 1:1 distribution. The protogyny of *Pagellus bellottii* was not observed in the Ivoirian coast. *P. bellottii* has annual sexual cycle including two spawning periods. The first one lasts from April to September and the second one from November to February. The second period is less important than the first one. Lengths at first maturity L_{50} were 13.33 and 12.41cm LF for males and females, respectively. Length at first maturity L_{50} for females is reached at 12.41cm LF. We note females reach first maturity at a length smaller than that of males. This information will contribute to knowledge of reproductive biology of *P. bellottii* and is relevant for its successful fisheries management.

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