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Biological Parameters of the Red Pandora (*Pagellus bellottii* Steindachner, 1882) in Soumbedioune, Senegal, West Africa

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Abstract: New information on the reproductive biology of *Pagellus bellottii* (Steindachner, 1882) a Sparid fish in Senegalese waters is provided in this study. Little aspects on the reproductive biology of this fish are reported in Senegal, West Africa. The objective of the study is to examine the length-weight relationship, the condition factor and the reproductive parameters of *P. bellottii* from the Senegalese waters. A total of 360 specimens (males = 197 and females = 163) bought from fishermen were used for the study. Specimens were collected monthly (thirty individuals per month) from October 2019 to September 2020 from Soumbedioune of Western part of Dakar, Senegal. Each individual was measured with an ichthyometer and weighed with a precision balance. For dissected individuals, sex was determined by macroscopic observation of the gonads. The gonads were extracted to calculate the Gonadosomatic Index. The length-weight relationship gave a negative allometric growth for both sexes. The value of "k" being greater than 1; the species was in good condition in this environment. The sex ratio (1:0.82) was favourable to males. The reproductive period was from March to June with a spawning peak in April for both sexes. Males and females had size at first sexual maturity at 178- and 180-mm total length, respectively. Males matured at smaller sizes than females. The data obtained in this study on some aspects of the reproductive biology of *P. bellottii* will be essential for better management of fish stocks in Senegal and in the sub-region.

Keywords: Length-Weight Relationship, Reproductive Biology, *Pagellus bellottii*, Soumbedioune, Senegal

1. Introduction

For a better use of fish resources and a sustainable exploitation of the stocks, it is important to have knowledge on the reproductive biology [1, 2]. Understanding the reproductive aspects of fish is also very important for providing sound scientific advice in fishery management [3, 4].

Fishing in general, and fishing for species of the Sparidae family in particular, plays a very important economic role for populations in West Africa. This family is well represented in the landings and exportations of fish with a high commercial value. According to Fricke *et al.* [5], the Sparidae contains 148 species in 37 genera. Eschmeyer's Catalog of Fishes [6], a large database on fish taxonomy, contains 445 records of Sparid fishes, including 166 currently recognized valid species, 201 regarded as synonyms, and 78 nominal species with no status.

Despite the *Pagellus bellottii* economic and social importance, there is few information on its reproductive biology in Senegal. The species is present in the eastern Atlantic, Angola and the Canary Islands [7]. The species' range also extends to the southwestern Mediterranean, the Alboran Sea, the Algerian coast and the Gulf of Gabes [8]. The red pandora occupies an important place in the industrial and artisanal fisheries in West Africa, particularly in Ghana and Senegal [9, 10]. This species is heavily landed in Senegal and occupies a valuable place in the demersal stocks [11]. The gears that catch this species are bottom trawls, line gear and traps (Canary Islands). Its flesh is also used for the production of fishmeal and oil.

Biological surveys provide useful information for good

management of fisheries resources [12, 13]. The assessment of biological parameters such as reproduction, growth and stock assessment allow for effective management of fisheries [14]. Thus, for proper resource management and conservation, it is necessary to understand the reproductive biology of fish species [15-17]. Determination of Gonadosomatic Index, maturation size and spawning period are essential for biological studies [18].

The length-weight relationship of fish is also an essential parameter to describe the biology of fish. It is a mathematical model that allows to analyze the evolution of the growth in weight of the species, knowing the length and vice versa [19]. This relationship is an essential asset for the management of fisheries resources [20].

Size at first sexual maturity is used to determine the smallest catch length for females to reproduce at least once in their life [21]. It is, therefore, necessary to apply management measures prohibiting the capture of spawners during the reproduction period in order to sustain fish production. Therefore, the control of fish reproduction parameters is crucial for fisheries managers [22, 23]. The lack of data on fish reproduction in Senegal very often leads to the destruction of stocks and the failure of established management plans. In West Africa, including Senegal, information on the reproductive parameters of *P. bellottii* is scarce or even non-existent.

The general objective of this study is, therefore, to investigate the reproductive biology of the red pandora in Senegal. This study also aims to investigate the length-weight relationship, condition factor, sex ratio, reproductive cycle and sexual maturity of *P. bellottii* during a complete cycle (12 months) on the west coast of Senegal. The information obtained in this study can serve as an important reference for good management of *P. bellottii*.

2. Materials and Methods

2.1 Study Area

The Exclusive Economic Zone (EEZ) of Senegal extends from 18°00' N, 20°00' W to 12°15' N, 16°30' W. Dakar is located between 14°30' N and 15°00' N, in the extreme west of Africa (Figure 1). Its coastline has rocky areas of volcanic origin, distributed in the western part of the peninsula, alternating with sandy beaches, where the fishing village of Soumbédioune is located. The hydroclimate is characterized by the alternation of two hydrological seasons, a cold water season from January to April (average surface temperatures: 16°C to 18°C), and a warm water season from July to October (average surface temperatures: 26°C to 28°C) [24].

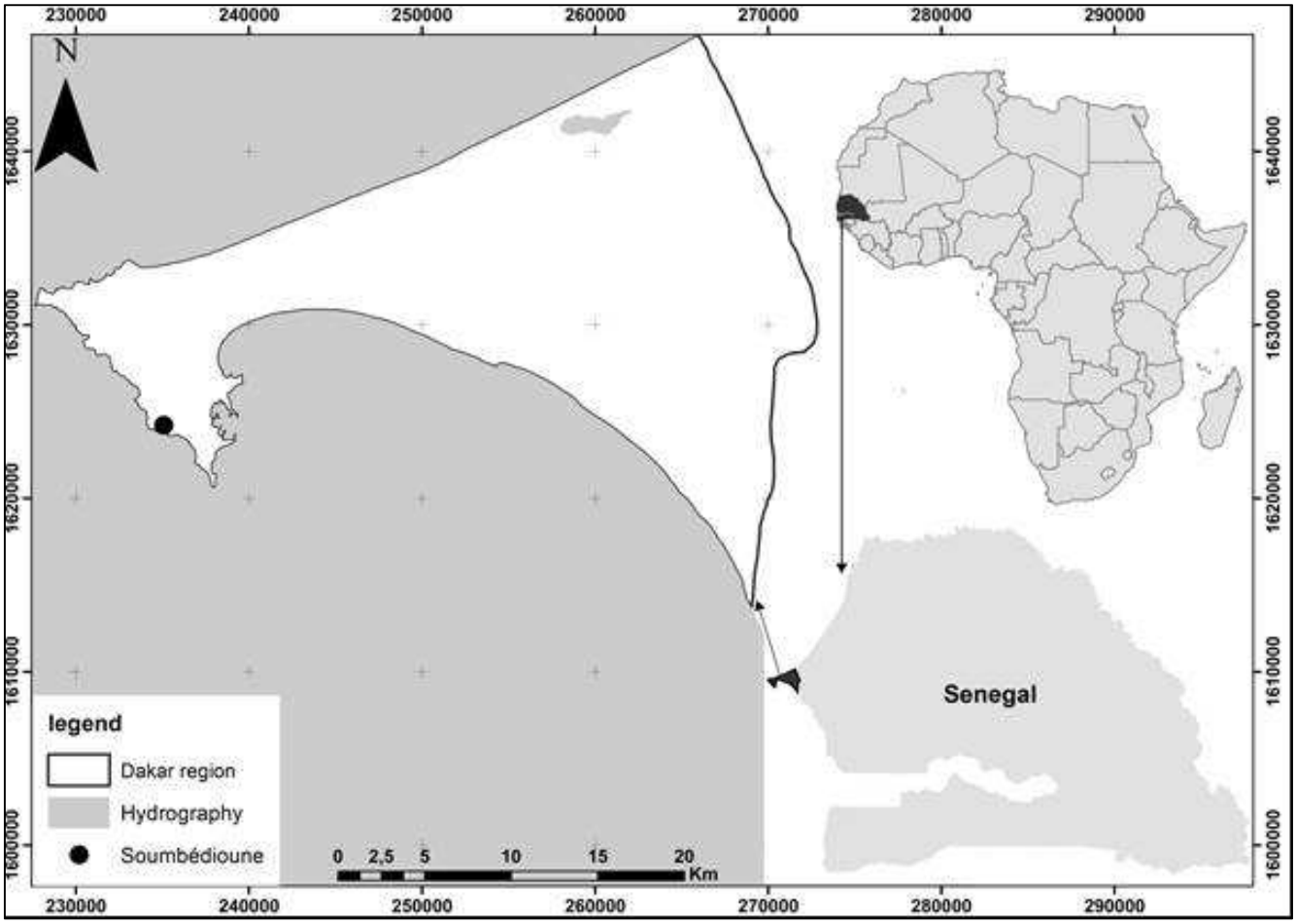

Figure 1. *Map showing Pagellus bellotti capture location Soumbedioune of Dakar, Senegal in West Africa (Source: Waly Ndiaye, 2021).*

2.2. Fish Sampling

Fish samples were bought monthly from local fishermen from Soumbedioune landings (Dakar, West Senegal) during October 2019 to September 2020. The specimens were measured with an ichthyometer to determine the total length (TL) and wet-weight (TW) on a digital balance (Ohaus Corporation, Scout Pro SP2001; precision of 0.1 g). Thirty (30) fish from each sampling were dissected and sexed. The sex of individual was determined by macroscopic examination of gonads after dissecting the specimen. The gonads were extracted and weighed (GW) on a digital balance (Ohaus Corporation, Scout Pro SP202; precision of 0.001 g) to calculate the Gonadosomatic Index (GSI).

2.3. Length-Weight Relationship (LWR)

The length-weight relationship (LWR) was analyzed by measuring length and weight of fish specimens collected from study area. The statistical relationship between these parameters of fishes were established by using the Pauly [25] equation:

$$W_T = aL_T^b \quad (1)$$

Where, W_T is the total weight (g), L_T is the total length (mm), "a" is the intercept of the regression line and "b" is the coefficient of regression line.

2.4. Condition Factor (K)

Condition factor (K) is used to determine the physical condition of the fish in its environment. It is used for comparing the condition or well-being of fish, based on the assumption that heavier fish of a given length are in better condition. The Condition factor, K, was calculated according to Gomiero and Braga [26]:

$$K = (W_T/L_T^3) \times 10^5 \quad (2)$$

Where, W_T is the total weight of the fish (g), L_T is the total length of the fish (mm).

2.5. Sex Ratio (Sr)

Sex ratio (Sr) determines the percentage of males or females' fish present in the total population. Its knowledge is necessary to assess the reproductive potential of fish and to estimate the size of stocks. Sex ratio was calculated for different months and size groups of fish using the Kahn [27] formula:

$$Sr = F/M \text{ or } Sr = M/F \quad (3)$$

Where, Sr is the sex ratio, F is the number of females, M is the number of males.

2.6. Gonadosomatic Index (GSI)

In order to monitor the sexual cycle, the spawning period was determined based on monthly Gonadosomatic Index (GSI) variations according to Benitez-Villalobos *et al.* [28]:

$$GSI = (Wg/W_T) \times 100 \quad (4)$$

Where, Wg is the gonad weight (g), W_T is the total weight (g) of the fish.

2.7. Length at First Maturity (L_{50})

The size at first ripening was determined by establishing the relative frequency of females and males in each size class of 100 mm. Fish were considered to be mature when they showed gonads in stages III, IV and V. Total length classes were then plotted against the percentage of adult species, adjusted by the iterative non-linear least squares technique to obtain the value of TL50 using the logistic equation [29]:

$$P = (1/1+e^{-a\,(LT-L50)}) \quad (5)$$

Where, P is the percentage of mature females in the total length class, "a" is the slope of the curve, L_T is the upper limit of the total length class, and L_{50} is the mean total length at first maturation.

2.8. Data Analysis

The Sex ratio was determined on a monthly basis and the Chi-square test (χ^2) with a significance level of 5% was used to assess whether the Sex ratio was different from 1:1. Comparisons of monthly GSI and K values were performed using one-way ANOVA. The Statistica 7.1 software package was used and all analysis were considered significant at $P < 0.05$.

3. Results

3.1. Length-Weight Relationship

Females ranged in overall length from 112 to 322 mm and ranged in weight from 29.8 to 461.2 g. Males' total length varied from 115 to 326 mm and weight varied from 31.4 to 460.3 g (Table 1). There was no significant difference in total body length compared to body weight (ANOVA, F (1,25) = 7.54, P>0.05) for males and females. The regressions of the length-weight relation were calculated separately only for individuals (n = 360): male, female and combined.

Table 1. *Summary of the length-weight relationship for P. bellotti.*

Sexes	N	Length (mm)			Weight (g)			LWR parameters		
		Min	Mean	Max	Min	Mean	Max	*a*	*b*	r^2
Females	164	112	217	322	29.8	245.5	461.2	0.04	2.72	0.93
Males	196	115	220	326	31.4	245.8	460.3	0.03	2.75	0.94
Sexes combined	360	112	219	326	29.8	245.5	461.2	0.03	2.76	0.94

N = sample size; Min = minimal; Max = maximal; a = intercept; b = allometric coefficient; r^2 = coefficient of determination.

Length-weight curves for both sexes and combined are shown in Figure 2. Results from the LWR analysis showed that male had a b-value of 2.75 and female fish had a b-value of 2.72. For sex combined, the b-value was 2.76. There was no significant difference in the length-weight relationship for males, females and the sexes combined (ANOVA, F (1,25) = 8.34, P>0.05). The length-weight relationship was positively correlated with a determination coefficient $r^2 = 0.93$, F1,66 = 306.87, P < 0.001) for female and $r^2 = 0.94$, F1,66 = 306.87, P<0.001) for males and grouped sexes.

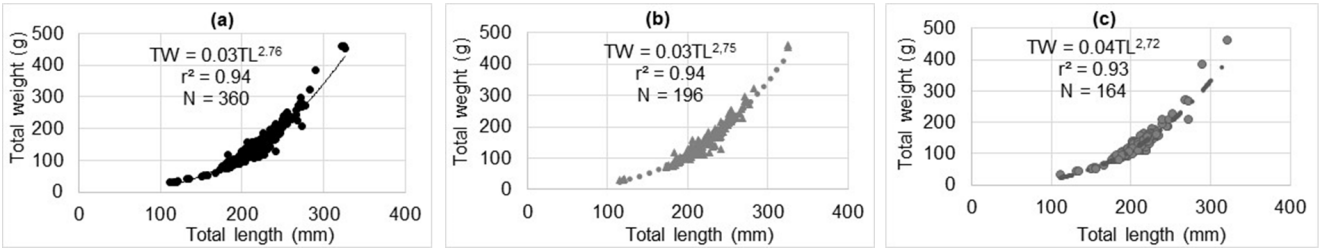

Figure 2. *Length-weight relationship of Pagellus bellotti based on linear allometric model (a) combined, (b) males and (c) females. TW - total weight, TL - total length, r² - coefficient of determination, N - number of fish sample.*

3.2. Condition Factor

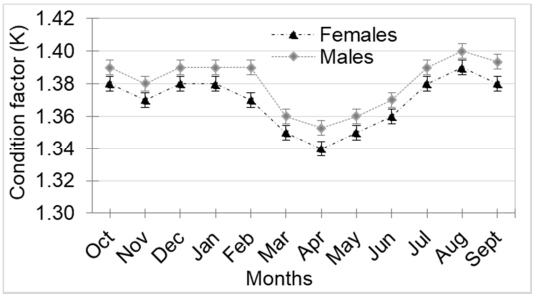

Figure 3. *Monthly variation of Condition factor of Pagellus bellottii females and males in Soumbedioune, Senegal. Vertical bars indicate Standard Deviations.*

The Condition factor (K) showed slight monthly variations in *P. bellottii* by sex in the Senegalese coasts (Figure 3). Monthly variations curve of K generally showed the same pattern for both sexes. The highest values were recorded between October to February (mean 1.36 for female; 1.38 for male) and July to September (mean 1.38 for female; 1.39 for male), while values of K were lower between March to June (mean 1.34 for female; 1.35 for male). Statistically, K-values did not show significant differences in both sexes (ANOVA, F (1,25) = 8.34, P>0.05). Therefore, K-values were significantly lower (ANOVA, F (1,25) = 9.47, P<0.05) in March-June for both sexes.

3.3. Sex Ratio

The sex ratio calculated based on the 360 specimens of *P. bellottii* collected from fisheries in Senegalese waters during the study period from January 2015 to December 2015 are presented in Table 2. Out of the 360 fishes examined, 197 (54.72%) were males and 163 (45.28%) were females. When monthly samples were pooled, a ratio of 1 male: 0.82 female was obtained. Males outnumbered females almost all the months except April, July and August. Overall male *P. bellottii* (n = 197) was significantly higher ($\chi^2 = 22$, df = 11, P<0.05) in number in comparison with the female *P. bellottii* (n = 163).

Table 2. *Monthly and total sex ratio for males and females of Pagellus bellottii in Soumbedioune, Senegal.*

Months	Total	Male	Female	Sex ratio (M:F)	Chi square (χ^2)	*p*-value
October	30	18	12	1:0.66	1.32	0.10
November	30	15	15	1:1	0.00	0.81
December	30	15	15	1:1	0.00	0.81
January	30	18	12	1:0.66	1.32	0.09
February	30	21	9	1:0.42	8.02	0.04
March	30	19	11	1:0.57	2.13	0.21
April	30	10	20	1:2	2.09	0.10
May	30	22	8	1:0.36	8.80	0.03
June	30	19	11	1:0.57	2.13	0.21
July	30	13	17	1:1.30	0.20	0.08
August	30	12	18	1:1.50	1.32	0.09
September	30	15	15	1:1	0.00	0.81
Total	360	197	163	1:0.82	27.33	0.02

3.4. Gonadosomatic Index (GSI)

Monthly variation curve in the female, male and mixed GSI for *P. bellottii* are presented in Figure 4. The lowest mean GSI of female fish was obtained in October. A sudden increase in female's GSI started after February (1.27), peaking in April (2.48) and declined in April and May through September (1.25). Average female GSI in July,

August, September, October, November, December, January and February was statistically similar (ANOVA, F (1,25) = 9.47, P>0.05) and were statistically smaller than the remaining months of sampling (ANOVA, F (1,25) = 7.37, P<0.05). Monthly mean GSI for females, males and combined sexes showed similar seasonal trends.

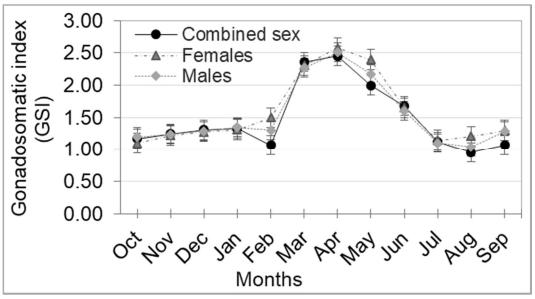

Figure 4. *Monthly change in the female, male and combined sex Gonadosomatic Index (GSI) for Pagellus bellottii in Soumbedioune, Senegal. Vertical bars indicate Standard Deviations.*

3.5. Length at First Sexual Maturity (L_{50})

The length at which 50% of individuals reached sexual maturity (L_{50}) was considered the size of the first maturity. Lengths when first sexually mature males and females were about 178 and 180 mm of total length, respectively (Figure 5). *P. bellottii* males became mature earlier than females. The length at first maturity did not differ between the sexes (ANOVA, F (1,25) = 9.52, P>0.05).

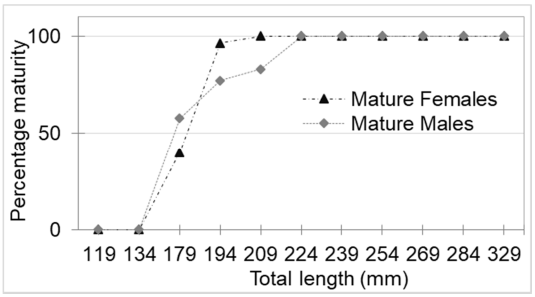

Figure 5. *Maturity curve of Pagellus bellottii, female and male showing the early maturity size of Soumbedioune, Senegal.*

4. Discussion

Fish length-weight relationships are an important tool in evaluating fish stocks for growth status and management [30]. The LWR of *P. bellottii* in Soumbédioune were negative allometric growth with a *b*-value of 2.72 for females, 2.75 for males and 2.76 for combined sexes. Thus, the negative allometric growth shows a higher growth in length than in weight. This value was not significantly different from those of the literature. Lazar [31] reported a *b*-value in Ghana equal to 2.88 for males, 2.79 for females and 2.91 for overall. For the same species studied in Liberia, the allometric coefficient was 2.33 for males, 2.82 for females and 2.88 for combined sexes indicating negative allometric growth [32]. In Ivory Coast, it was found 3.43 for males, 3.14 for females and 3.28 for combined sexes with positive allometric [32]. There are many factors that cause this, including seasonal effect, habitat type, stomach fullness level, gonadal maturity, sex, health status, food availability, differences in observed length ranges and fatness of species as well as physical factors such as temperature and salinity [33, 34]. The negative allometry in this study was due to the long dry seasons resulting in a very large decrease in food. In general, parameters of fish length-weight relationships are influenced by factors such as environmental conditions, maturation stages, gender, gastric fullness, health status, season, population and differences between species [35]. Variations in *b*-values between females and males may be influenced by a variety of factors, such as the number of samples examined and the sampling season.

The Condition factor of both males and females was above 1.0 on a monthly basis. This showed that fish were in higher than average conditions in Senegalese waters. The Condition factor showed a reverse relationship to the Gonadosomatic Index and is therefore a good indicator of reproduction for *P. bellottii* in the Senegalese coast. The lower K-values in females were found between March and June corresponding to gonad maturation phases, indicating the mobilization of energy reserves for egg laying [36]. Da Costa *et al*. [37] made the same observation and suggested that during these periods, much of the energy was allocated for growth and egg laying resulting in a relatively lower Condition factor. In addition, the difference in K-values between females and males could be attributed to metabolism during maturation or spawning and changes in feeding activity.

Monthly evolution of the sex ratio showed a difference between males and females of *P. bellottii*. According to Konoyima and Mansaray [32], in a natural fish population, the ideal sex ratio is close to 1:1. In the current study, male dominated female in the majority of the months with an annual average male: female ratio of 1:0.82. Several factors may cause this variation, including differential mortality, longevity, sex reversal, seasons, migration and fishing methods [38-40]. Oliveira *et al.* [41] indicated that the preponderance of one sex in a population is due to the sexual difference in the growth rate.

The most important biological parameter for determining the breeding season of fish as well as their gonadal maturity is the Gonadosomatic Index [42, 43]. The GSI increases with maturity and decreases with the end of gonadal activity after spawning [44, 45]. Monthly variations of Gonadosomatic Index (GSI) showed that the reproduction season occurred from March to June with a peak in April for males and females in *P. bellottii*. This period was also reported by other authors who investigated the marine areas. Ndiaye [46] reported that *P. bellottii* spawned twice in Senegal, March and October. In Ivoirian coast, Kouame *et al*. [47] found a spawning season from April to September. In Ghanaian waters, Asabere-Ameyaw [48] noted that variations in Gonadosomatic Index (GSI) suggested a minor spawning period in January-February, and a major spawning from June to September. This species was thus observed during the

upwelling seasons in Ghanaian waters. *P. bellotii* also appears to spawn mainly between April and June through some breeding activities as was observed in January, September and December [31].

Size at sexual maturity (L_{50}) is an essential parameter for fisheries management as it gives the authority to decide on mesh size in fishing zones and therefore to avoid fishing juveniles [49-51]. The use of appropriate meshes will prevent the capture of immature individuals and, therefore, will not reduce the potential for reproduction [52]. In the present study, TL_{50} in *P. bellottii* was found to be 165 mm TL for males and 179 mm TL for females. It showed that males attained their sexual maturity at smaller length than females. Asabere-Ameyaw [48] recorded similar size range in (TL_{50}) for *P. bellottii* from Ghanaian waters (male-136 and female-135 mm TL). Ndiaye [46] found in Senegalese waters a TL_{50} in *P. bellottii* equal to 167.6 and 167.5 mm TL for male and female, respectively. The length at first maturity estimated in Ghana by Amponsah *et al.* [12] was 13 cm. Kouame *et al*. [47] showed that males were mature at an average of 13.33 cm fork length whereas females at 12.41 cm fork length in Ivoirian coast. The differences in length at first maturity may be directly linked to demographic density and environmental conditions; difference in reproductive biology and environmental conditions [53]; growth rates, fishing removals, availability of food and hydrological conditions [54, 55]. According to Pérez-Palafox *et al.* [56], the variation in size of first maturity depends on several factors such as living environment, abiotic parameters and fishing pressure. Differences of length at first maturity results can be related to the choice of parameter (standard length, fork length or total length) of specimens.

5. Conclusion

This research work provides information on the length-weight relationships, Condition factor and the length at first maturity of the red pandora, *P. bellottii* in Soumbédioune of Senegal. The information provided by this study, particularly on morphometric relationships and Condition factor, has greatly contributed to the understanding of the population structure of this species. The results showed that *P. bellottii* had a negative allometric growth for females and males. The mean value of the Condition factor for both females and males was greater than 1.0, thus the environmental condition of Soumbedioune were favourable for the growth of red pandora. The results of this study showed that the sex ratio favouring males was not significantly different from the expected 1:1 distribution. The protogyny of this species was not described in Sengalese waters. *P. bellottii* has annual sexual cycle with one spawning period from March to June. Males reached early first maturity at a size smaller than that of females. This information will participate to the knowledge of the reproductive biology of *P. bellottii* and is important for the sustainable management of its fisheries.

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References

[1] Cochrane, K. L. (2002). A fishery manager's guidebook: management measures and their application. FAO fisheries technical paper, Rome, p 231.

[2] Temesgen, M. (2017). Status and trends of fish and fisheries in a tropical rift valley lake, Lake Langeno, Ethiopia. PhD dissertation, Department of Zoological Sciences. Addis Ababa: Addis Ababa University.

[3] Hossain, M. Y., Hossen, M. A., Islam, M. S., Jasmine, S, Nawer, F., & Rahman, M. M. (2017). Reproductive biology of *Pethia ticto* (Cyprinidae) from the Gorai River (SW Bangladesh). Journal of Applied Ichthyology, 33, 1007-1014. https://doi.org/10.1111/jai.13427

[4] Khatun, D., Hossain, M. Y., Nawer, F., Mostafa, A. A., & Al-Askar, A. A. (2019). Reproduction of *Eutropiichthys vacha* (Schilbeidae) in the Ganges River (NW Bangladesh) with special reference to the potential influence of climate variability. Environmental Science and Pollution Research, 26, 10800-10815. DOI: 10.1007/s11356-019-04523-5.

[5] Nelson, J. S., Grande, T. C., & Wilson, M. V. H. (2016). Fishes of the world. Hoboken, New Jersey: John Wiley & Sons.

[6] Fricke, R., Eschmeyer, W. N., & van der Laan, R. (2019). Eschmeyer's Catalog of Fishes: Genera, Species, References. In: Eschmeyer, W. N., Fricke, R., & van der Laan, R. (ed) Catalog of Fishes: Genera, Species, References. Academy of Sciences, California, pp 35-52.

[7] Russell, B., & Carpenter, K. E. (2014). *Pagellus bellottii*. The IUCN Red List of Threatened Species. http://dx.doi.org/10.2305/IUCN.UK.2014 3.RLTS.T170162A1285147

[8] Oral, M. (2010). Alien fish species in the Mediterranean - Black Sea Basin. Journal of the Black Sea / Mediterranean Environment, (16), 87-132.

[9] Koranteng, K. A., & Pitcher, T. J. (1987). Population parameters, biannual cohorts, and assessment in the *Pagellus bellotti* (Sparidae) fishery off Ghana. Journal du Conseil Permanent International pour l'Exploration de la Mer, 43 (2), 129-138.

[10] Koranteng, K. A. (2003). A trawling survey off Ghana, 1981/1982. CECAF/TECH/84/68.

[11] Fall, M., Samba, A., & Laloe, F. (2006). Fishing tactics and strategies in coastal demersal trawling fisheries in Senegal. Aquatic Living Resources, 19, 307-316. https://doi.org/10.1051/alr:2007001

[12] Amponsah, S. K. K., Ofori-Danson, P. K., Nunoo, F. K. E., & Ameyaw, G. A. (2016). Aspects of population dynamics of Red Pandora, *Pagellus bellottii* (Steindachner, 1882) from the coastal waters of Ghana. Journal of Scientific and Innovative Research, 5 (6), 215-224.

[13] Konoyima, K. J., Mansaray, A, Ndomahina, E. T., & Amara, E. B. (2020). Length-Weight relationship and condition factor of *Coelotilapia joka* (Thys van den Audenaerde 1969) in the Rokel/Seli River, West Africa. International Letters of Natural Sciences, 77, 27-40. doi: 10.18052/www.scipress.com/ILNS.77.

[14] Tracey, S. R., Lyle, J. M., & Haddon, M. (2007). Reproductive biology and per-recruit analyses of striped trupeter (*Latris lineata*) from Tasmania, Australia: Implications for management. Fisheries Research, 84, 358-367.

[15] Brewer, S. K., Rabeni, C. F., & Papoulias D. M. (2007). Comparing histology and Gonadosomatic index for determining spawning condition of small-bodied riverine fishes. Ecology of Freshwater Fish, 17, 54-58. doi.org/10.1111/j.1600-0633.2007.00256.x

[16] Grandcourt, E. M., Al Abdessalaam, T. Z., Francis, F., Al Shamsi, A. T., & Hartmann, S. A. (2009). Reproductive biology and implications for management of the orange-spotted grouper *Epinephelus coioides* in the southern Arabian Gulf. Journal of Fish Biology, 74, 820-841. doi: 10.1111/j.1095-8649.2008.02163.x.

[17] Muchlisin, Z. A., Musman, M., & Azizah, M. N. S. (2010). Spawning seasons of *Rasbora tawarensis* (Pisces: Cyprinidae) in Lake Laut Tawar, Aceh Province, Indonesia. Reproductive Biology and Endocrinology. 8, 49. https://doi.org/10.1186/1477-7827-8-49

[18] Hossain, M. Y., Jewel, M. A. S., Nahar, L., Rahman, M. M. Naif, A., & Ohtomi, J. (2012). Gonadosomatic index-based size at first sexual maturity of the catfish *Eutropiichthys vacha* (Hamilton 1822) in the Ganges River (NW Bangladesh). Journal of Applied Ichthyology, 28, 601-605. doi.org/10.1111/j.1439-0426.2012.01954.x

[19] Kuriakose, S. (2014). Estimation of length weight relationship in fishes. Training Manual on Fish Stock Assessment and Management, Reprinted from the CM FRI, FRAD (2014), p. 15.

[20] Wahono, B., & Lumingas, L. J. L. (2013). Size-frequency and allometric growth of the yellowfin tuna, *Thunnus albacares* (Bonnaterre, 1788), caught in the Molluca Sea, Indonesia. Aquatic Science & Management, 2, 72-74. https://doi.org/10.35800/jasm.1.2.2013.7274

[21] Rahman, M. M. (2017). Gonadosomatic index-based size at first sexual maturity of males and females of *Amblygaster clupeoides* (Bleeker, 1849) (Clupeidae) at the east coast of the Malaysian peninsular. Journal of Applied Ichthyology, 33, 579-582. DOI: 10.1111/jai.13252.

[22] Jakobsen, T., Fogarty, M. J., Megrey, B. A., & Moksness, E. (2009). Fish reproductive biology: Implications for assessment and management. Oxford, Blackwell

[23] Trindade-Santos, I., & Freire, K. M. F. (2015). Analysis of reproductive patterns of fishes from three large marine ecosystems. Frontiers in Marine Science, 2, 1-10. https://doi.org/10.3389/fmars.2015.00038

[24] Rebert, J. P., & Domain, F. (1977). Hydrologie océanique. Atlas National du Sénégal [Oceanic hydrology. National Atlas of Senegal]. Paris, Institut Géographique National, pp 36-37.

[25] Pauly, D. (1993). Linear regressions in fisheries research. Journal of the Fisheries Research Board of Canada, 30, 409-434.

[26] Gomiero, L. M., & Braga, F. M. S. (2005). The condition factor of fishes from two river basins in Sao Paulo state, Southeast of Brazil. Acta Scientiarum, 27 (1), 73-78.

[27] Kahn, J. E., Watterson, J. C., Hager, C. H., Mathies, N., & Hartman, K. J. (2021). Calculating adult sex ratios from observed breeding sex ratios for wide-ramping, intermittently breeding species. Ecosphere, 12 (5), 1-11.

[28] Benitez-Villalobos, F., Avila-Poveda, O. H., & Gutiérrez-Méndez, I. S. (2013). Reproductive biology of *Holothuria fuscocinerea* (Echinodermata; Holothuroidea) from Oaxaca, Mexico. Sexuality and Early Development in Aquatic Organisms, 1, 13-24.

[29] White, T., Hall, G., & Potter, C. (2002). Size and age compositions and reproductive biology of the nervous shark *Carcharhinus cautus* in a large subtropical embayment, including an analysis of growth during pre- and postnatal life. Marine Biology, 1153-1164.

[30] Ujjania N. C., Kohli M. P. S., & Sharma L. L. (2012). Length-weight relationship and Condition factors of Indian major carps (*Catla catla*, *Labeo rohita*, and *Cirrhinus mrigala*) in Mahi Bajaj Sagar. Indian Journal of Pharmaceutical and Biological Science, (2), 30-6. DOI: 10.21077/ijf.2017.64.special-issue.76263-27.

[31] Lazar, N. (2017). Baseline Assessment of Demersal Fish Stocks Of The Western Region Of Ghana. The USAID/Ghana Sustainable Fisheries Management Project (SFMP). Narragansett, RI: Coastal Resources Center, Graduate School of Oceanography, University of Rhode Island.

[32] Konoyima, K. J., & Mansaray, A. (2020). Sex Ratio, Gonad Maturity and Size-Structure of *Pagellus bellottii* in Sierra Leone. Journal of Applied Sciences Environmental Management, 24 (12), 2153-2159. DOI: https://dx.doi.org/10.4314/jasem.v24i12.22

[33] Rahman, M. M., Hossain, M. Y., Jewel, M. A. S., Rahman, M. M., Jasmine, S., Abdallah, E. M., & Ohtomi, J. (2012). Population structure, length-weight, length-length relationships, condition and form factors of the Pool barb *Puntius sophore* (Hamilton, 1822) (Cyprinidae) from the Chalan Beel, North-Central Bangladesh. Sains Malaysiana, (41), 795-802.

[34] Hossain, M. Y., Hossen, M. A., Islam, M. M., Pramanik, M. N. U., Nawer, F., & Paul, A. K. (2016). Biometric indices and size at first sexual maturity of eight alien fish species from Bangladesh. Egyptian Journal of Aquatic Research, 42 (3), 331-339. https://doi.org/10.1016/j.ejar.2016.09.001

[35] Froese, R. (2006). Cube law, condition factor and weight-length relationships: history, meta-analysis and recommendations. Journal of Applied Ichthyology, 22 (4), 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

[36] Blackwell, B. G., Brown, M. L., & Willis, D. W. (2000). Relative weight (Wr) status and current use in fisheries assessment and management. Reviews in Fisheries Science, 8, 1-44.

[37] Da Costa, M. R., & Araujo F. G. (2003). Length-weight relationship and condition factor of *Micropogonias furnieri* (Desmarest) (Perciformes, Sciaenidae) in the Sepetiba Bay, Rio de Janeiro State. Revista Brasileira de Zoologia, 20, 685-690. https://doi.org/10.1590/S0101-81752003000400022

[38] Vicentini, R. N., & Araujo, F. G. (2003). Sex ratio and size structure of *Micropogonias furnieri* (Desmarest, 1823) (Perciformes, Sciaenidae) in Sepetiba Bay, Rio de Janeiro, Brazil. Brazilian Journal of Biology, 63 (4), 559-566. DOI: 10.1590/S1519-69842003000400003.

[39] Koutrakis, E. T., Kamidis, N. I., & Leonardos, I. D. (2004). Age, growth and mortality of a semi-isolated lagoon population of sand smelt, *Atherina boyeri* (Risso, 1810) (Pisces: Atherinidae) in an estuarine system of northern Greece. Journal of Applied Ichthyology, 20, 382-388. DOI: 10.1111/j.1439-0426.2004.00583.x.

[40] Deepak, P. K. (2005). Life history traits of vulnerable *Catla catla* (Hamilton-Buchanan) and endangered *Chitala chitala* (Hamilton-Buchanan). PhD Thesis. Bhopal, India: Barkatullah University.

[41] Oliveira, M. R., Costa, E. F. S., Araújo, A. S., Pessoa, E. K. R., Carvalho, M. M., Cavalcante, L. F. M., & Chellappa, S. (2017). Sex Ratio and Length-Weight Relationship for Five Marine Fish Species from Brazil. Journal of Marine Biology & Oceanography, 1 (2), 1-3. doi: http://dx.doi.org/10.4172/2324-8661.1000103

[42] Bindu, L., Padmakumar, K. G., Sreerekha, P. S., & Joseph, N. (2012). Reproductive biology of the golden catfish, *Horabagrus brachysoma* (Günther, 1864), an endemic species of the Western Ghats, India. Journal of Applied Ichthyology, 28, 772-777. DOI: 10.1111/j.1439-0426.2012.02026.x.

[43] Raghavan, R., Philip, S., Ali, A., Katwate, U., & Dahanukar, N. (2016). Fishery, biology, aquaculture and conservation of the threatened Asian Sun catfish. Reviews in Fish Biology and Fisheries, 26, 169-180. DOI: 10.1007/s11160-016-9418-1.

[44] Jan, M., Jan, U., & Shah, G. M. (2014). Studies on fecundity and gonadosomatic index of *Schizothorax plagiostomus* (Cypriniformes: Cyprinidae). Journal of Threatened Taxa, 6, 5375-5379. https://doi.org/10.11609/JoTT.o3269.5375-9

[45] Geremew, A., Getahun, A., & Dejen, E. (2015). Reproductive biology of *Garra regressus* and *Garra tana* (Cypriniformes: Cyprinidae) from Lake Tana, Ethiopia. Journal of Threatened Taxa, 7, 7223-7233. DOI: 10.11609/jott.2019.7223-7233.

[46] Ndiaye, A. M. (2014). Etude du cycle sexuel et l'inversion sexuelle de *Pagellus bellottii* (Téléostéen: Sparidae) dans les eaux sénégalaises. Afrique Science, 10 (4), 257-266.

[47] Kouame, A. C., Sylla, S., Arra, S., Kouakou, K. F., & Yao, S. S. (2018). Parameters of Reproductive biology of Red Pandora *Pagellus bellottii* (Steindachner, 1882) in the Ivoirian coast (Cote d'Ivoire). Journal of Biodiversity and Environmental Sciences, 12 (4), 185-193. http://www.innspub.net

[48] Asabere-Ameyaw, A. (2000). Aspects of the reproductive biology of the red pandora *Pagellus bellottii* (Pisces: Sparidae) in Ghana. Journal of the Ghana Science Association, 2 (1), 23-30. DOI: 10.4314/jgsa.v2i1.17835.

[49] Lucifora, L. O., Valero, J. L., & Garcia, V. B. (1999). Length at maturity of the green-eye spurdog shark, *Squalus mitsukuii* (Elasmobranchii: Squalidae) from the SW Atlantic, with comparisons with other regions. Marine and Freshwater Research, 50, 629-632. DOI: 10.1071/mf98167.

[50] Hossain, M. Y., Arefin, M. S., Mohmud, M. S., Hossain, M. I., Jewel, M. A. S., Rahman, M. M., Ahamed, F., Ahmed, Z. F., & Ohtomi, J. (2013). Length-weight relationships, condition factor, Gonadosomatic-index based size at first sexual maturity, breeding season and fecundity of *Aspidoparia morar* (Cyprinidae) in the Jamuna River (Brahmaputra River distributary), northern Bangladesh. Journal of Applied Ichthyology, 29, 1166-1169. DOI: 10.1111/jai.12127.

[51] Lee, C. F., Liu, K. M., Su, W. C., & Wu, C. C. (2005). Reproductive biology of the common ponyfish *Leiognathus equulus* in the south-western waters off Taiwan. Fisheries Science, 71, 551-562. DOI: 10.1111/j.1444-2906.2005.00999.x.

[52] Liu, C., Gao, X., Wang, H., Liu, H., Cao, W., & Danley, P. D. (2013). Reproductive characteristics of *Ancherythroculter nigrocauda*, an endemic fish in the upper Yangtze River, China. Fisheries Science, 79, 799-806. DOI: 10.1007/s12562-013-0656-z.

[53] El-Greisy, Z. A. (2005). Reproductive Biology and Histology of Female Brushtooth Lizardfish *Saurida undosquamis* (Richardson), Family: Synodontidae, from the Mediterranean Coast of Egypt. Egyptian Journal of Aquatic Research, 31 (I), 25-34.

[54] Potts, J. C., & Manooch, C. S. (2001). Differences in the age and growth of white grunt (*Haemulon Plumieri*) from North Carolina and South Carolina compared with southeast Florida. Bulletin of Marine Science Miami, 68 (1), 1-12. https://www.researchgate.net/publication/233611946

[55] Hood, P. B., & Johnson, A. K. (2000). Age, growth, mortality, and reproduction of red porgy, *Pagrus pagrus*, from the eastern Gulf of Mexico. Fishery Bulletin, 98, 723-735.

[56] Pérez-Palafox, X. A., Morales-Bojórquez, E., Aguirre-Villaseñor, H., & Cruz-Escalona, V. H. (2021). Length at Maturity, Sex Ratio, and Proportions of Maturity of the Giant Electric Ray, *Narcine entemedor*, in Its Septentrional Distribution. Animals, 12 (120), 1-11. https://doi.org/10.3390/ani12010120