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SHORT COMMUNICATION

Reproductive Biology of Red Pandora (*Pagellus bellottii* Steindachner, 1882) from the Coast of Ghana and Implications for Management

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Abstract: A total of 933 samples of *Pagellus bellottii* were obtained from the coast of Ghana between January and December 2019, from commercial catches to determine the sex ratio, maturity stages, spawning period, and length at first maturity. The male to female ratio was 1.39:1. July and May were the main spawning peaks for female individuals of the assessed fish species. Two spawning periods were observed with a minor spawning period from November to January and major spawning from March to September. Female individuals matured slightly earlier than male individuals at 20 cm and 20.8 cm respectively. The results of this study could help to revise the existing minimum capture size of Red Pandora in Ghana.

Anahtar kelimeler:

Sparidae
Eşeysel olgunluk
Pagellus bellottii
Üreme
Gana kıyısı

Gana Kıyısındaki Kırmızı Pandora'nın (*Pagellus bellottii* Steindachner, 1882) Üreme Biyolojisi ve Yönetime Yönelik Etkileri

Öz: Ocak 2019 ile Aralık 2019 tarihleri arasında Gana kıyılarından ticari avlardan cinsiyet oranı, olgunluk safhaları, yumurtlama dönemi ve ilk eşeysel olgunluk boyunu belirlemek amacıyla toplam 933 *Pagellus bellottii* örneği elde edilmiştir. Erkek-dişi oranı 1.39:1 idi. İncelenen balık türünün dişi bireyleri için Temmuz ve Mayıs ayları, en yüksek ana yumurtlama aylarıydı Kasım'dan Ocak'a kadar küçük yumurtlama dönemi ve Mart'dan Eylül'e kadar büyük yumurtlama dönemi olmak üzere iki yumurtlama dönemi gözlemlenmiştir. Dişi bireyler erkeklere göre sırasıyla 20 cm ve 20,8 cm, daha erken olgunlaşmıştır. Bu çalışmanın sonuçları, Gana'daki kırmızı pandora'nın mevcut minimum avlanma boyunun revize edilmesine yardımcı olabilir.

Introduction

The Red Pandora, distributed in the eastern Atlantic portion of the ocean, is mostly found between 10 m and 50 m (Kouame *et al.*, 2018). It is an important component of the multispecies marine demersal fish in the Eastern Central Atlantic (Russell and Carpenter, 2014). *P. bellottii* is a commercially important demersal fish in Ghana, accounting for about 70% of the demersal fishes landed in Ghana (Lazar, 2017). However, from the coastal waters of Ghana, the catch size of the assessed species is currently on the decline since 2005 which demands proper management measures (Ayivi, 2012). For sustainable management of this species, there is the need for science-based information which largely precipitates from several biological studies including the reproductive studies (Adebiyi, 2012). Studies on reproductive biology of fishes is essential in fisheries management because it provides an understanding of the spawning behavior of the species, dynamics unpinning the dominance of a particular sex, seasonal variations in fish growth, physiological wellbeing of fishes and the dynamics controlling the addition of juveniles to the fish stock (Ismail *et al.*, 2018; Shamsan *et al.*, 2010; Sangun, Akamca, & Akar, 2007; Walker *et al.*, 2005).

Despite the importance of studies on the reproductive biology of fishes to sustainable management, the only study published on Red Pandora in Ghana mainly revolve around population parameters (i.e. Amponsah *et al.*, 2016). In addition, the only study on reproductive biology of *P. bellottii* is linked to Asare-Ameyaw (2000). The paucity of such important ecological information limits the options needed for sustainable management of this commercially important species. Thus, the objective of this was to provide an update on some aspects of reproductive studies of Red Pandora in Ghana. Such information is a necessary contribution to the ecologically based management of the species from the coast of Ghana.

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Material and Methods

Study area

The study focused on six fishing communities along the coast of Ghana, namely Elmina, Kpone, Tema, Prampram, Sakumono and Nungua fishing communities along the coast of Ghana (Fig. 1). Table 1 shows the geographical coordinates of the fish sampling communities used in the study. These fishing communities were selected based on the intensity of fishing activities and predominant landing of fish species in the Sparidae family.

Table 1. Geographical coordinates of sampling locations

Locations	Geographic coordinates
Elmina	5° 4'58.94"N, 1°21'10.66"W
Kpone	5°40'22.61"N, 0° 2'36.74"E
Tema	5°38'37.46"N, 0° 1'0.15"E
Prampram	5°42'19.00"N, 0° 6'57.11"E
Sakumono	5°36'40.70"N, 0° 2'41.85"W
Nungua	5°35'42.91"N, 0° 4'13.85"W

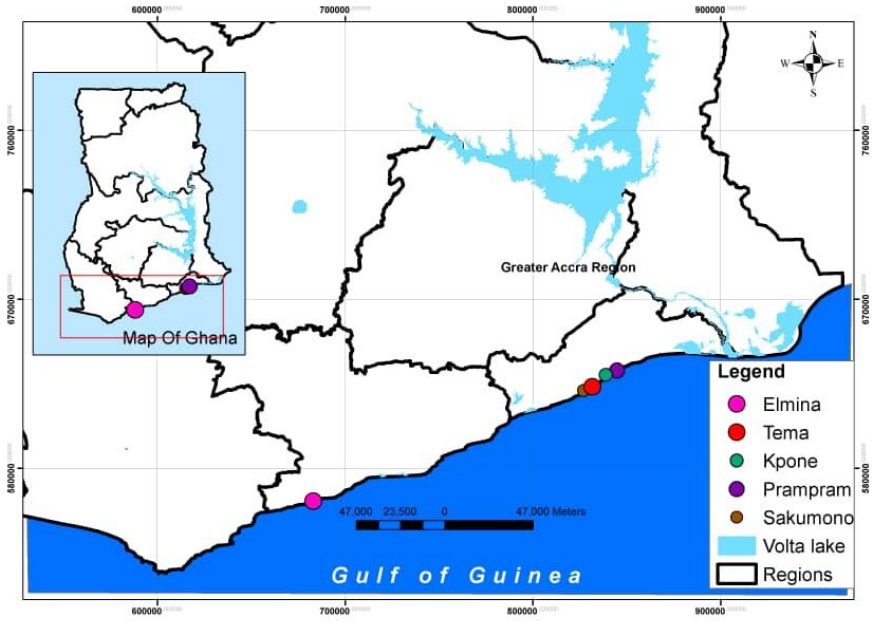

Figure 1. Map showing the sampling locations of the study

Data collection

Samples were sourced from different types of artisanal fishing gears, particularly hook and line from January to December 2019 and identified in situ using Kwei and Ofori-Adu (2005) identification keys. Samples obtained were then preserved on ice and sent to the fish laboratory at the University of Ghana for further analysis. At the laboratory, total length of the samples was measured to the nearest 0.1 cm using a wooden measuring board. A digital balance was used to record body and gonad weight of the specimen to the nearest 0.01g.

Methods

Length-Weight Relationships (LWR)

The total length and body weight of fish were used for the Length-Weight Relationships. The Length-Weight relationships were represented using the log transformed procedure: Log W = a + b log TL (Pauly, 1984), where W = body weight (g), TL = total length (cm), a and b are constants for intercept and growth pattern respectively.

Condition factor (CF)

The condition factor (CF) indicates the physiological wellbeing of fishes. This was estimated monthly using the equation: fish weight *100/total length^3 (Froese, 2006).

Maturity stages

Macroscopical assessment for sex and maturity stages was done for each of the gonads obtained. Categorization of the maturity stages was as follows: I, immature; II, resting; III, ripe; IV, ripe and running; V, spent (Chaouch *et al.*, 2013).

Sex ratio

Sex ratio provides information on the representation of male and female fish present in a population. The sex ratio was calculated as the proportion of males to females (Chaouch *et al.*, 2013).

Length at first maturity

For the calculation of the length at which 50% of individuals were matured, only maturity stages III and IV were used. From the cumulative length frequency of

matured individuals, 50 % on the cumulative axis was extrapolated to the length axis for the length at first maturity estimation.

Gonadosomatic index (GSI)

Determination of GSI aids in quantifying the changes in gonad weight during the annual sexual cycle and identifying the spawning season. The gonadosomatic index (GSI) was determined as gonadal weight * 100/eviscerated weight (g) (Analbery, 2004).

Data analysis

Variation in reproductive parameters such as GSI, length, and condition factor between male and female individuals were statistically analyzed using a T-test at a significance threshold of $P < 0.05$. Chi-square test was used to investigate the differences in sex ratio from an expected 1:1 ratio.

Results

Length distribution

The length measurement ranged from 7 cm to 33.9 cm for female individuals with a mean length of 19.6 ± 0.2 cm (Table 2). For male individuals, the mean length was 19.4 ± 0.1 cm with minimum and maximum lengths as 7 cm and 32.3 cm, respectively (Table 2).

Length weight relationship (LWR)

In the LWR, the growth pattern (b) for male and female individuals of *P. bellottii* was 3.03 (Fig. 2) and 3.02, respectively (Fig. 3). The variation in log transformed length of both male and female individuals explained more than 96 % of the variation in log transformed weight (Table 3).

Table 2. Descriptive statistics of length distribution of male and female individuals of *P. bellottii*

Sex	N	Mean	SE	Min/cm	Max/cm	T-test P-value
Female	391	19.6	0.2	7	33.9	0.32
Male	542	19.4	0.1	7	32.3	

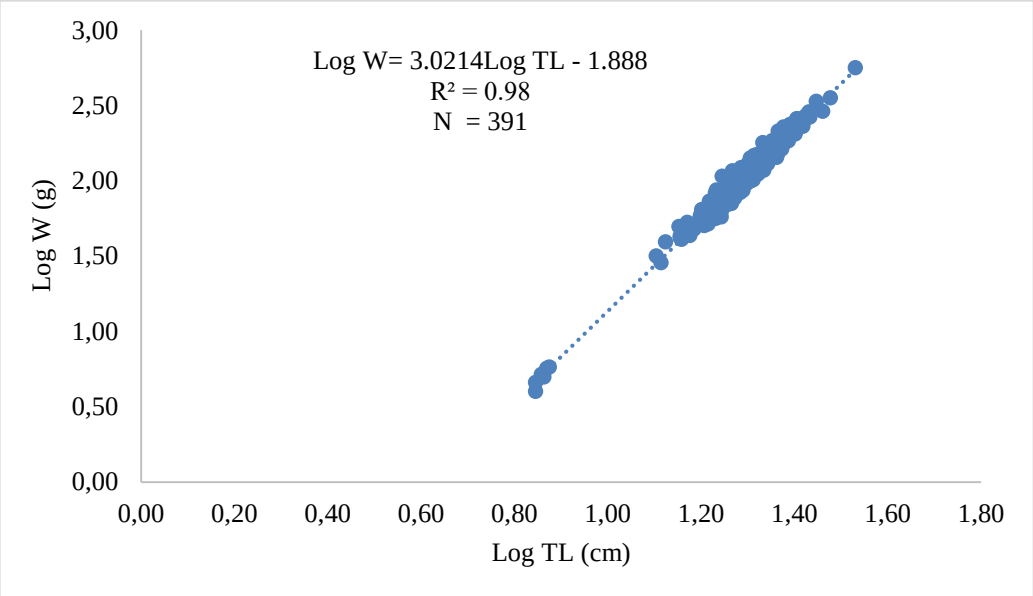

Figure 2. Linearized length weight relationship (LWR) of female individuals obtained during the study period

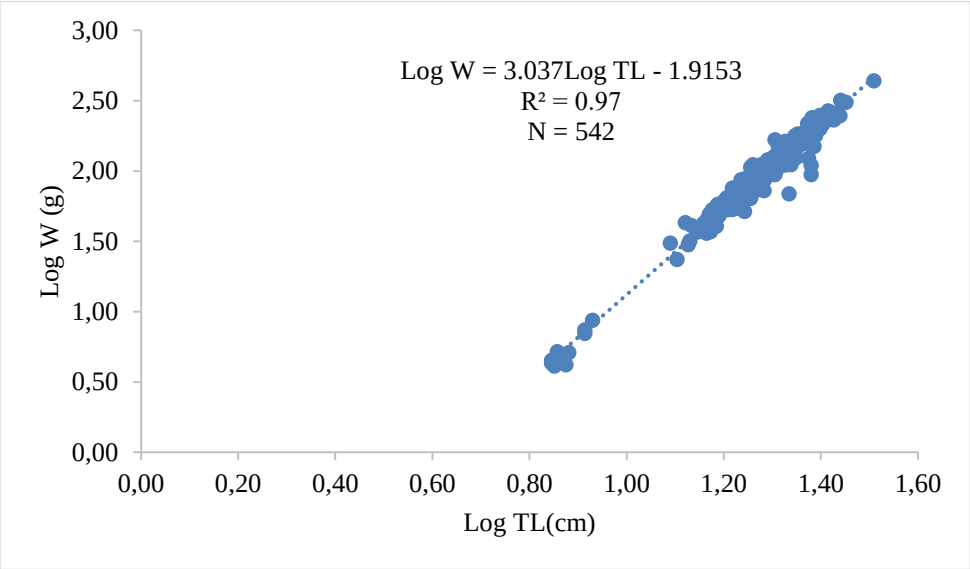

Figure 3. Linearized length weight relationship (LWR) of male individuals obtained during the study period.

Table 3. Regression output for LWR of male and female individuals of P. bellottii obtained during the study period

Sex	b	a	95% CL 'a'	95% CL 'b'	R^2
Males	3.037	0.012	0.011-0.013	2.993-3.081	0.97
Females	3.021	0.013	0.012- 0.015	2.974-3.069	0.98

Condition factor

The condition factor spanned from 1.08 to 1.97 for female individuals and 0.68 to 2.02 for male individuals of *P. bellottii*. The mean condition factor was 1.36 for males and 1.38 for females, respectively (Table 4).

Sex ratio

A total of 542 males and 391 females were observed out of 933 samples obtained. Sex ratio in the study was favoured by males with a ratio of 1.39 male: 1 female. Chi-square analysis showed significant difference from the theoretical ratio of 1:1 between male and female individuals (Goodness of Fit Chi-square = 24.4, N =533, df=1, p-value <0.001).

Table 4. Descriptive statistics of condition factors of *P. bellottii*

Sex	N	Mean	SE	Min	Max	T-test P-value
Female	391	1.38	0.006	1.08	1.97	0.01
Male	542	1.36	0.006	0.68	2.02	

Gonadosomatic index (GSI)

The mean GSI for matured female individuals ranged from 0.54 in Octoberto 5.14 in July, with the major spawning peak in July and a minor spawning peak in May (Fig. 4).

Length at first maturity

The size at which 50% of female and male individuals mature was 20.0 cm (Fig. 5) and 20.8 cm (Fig. 6), respectively.

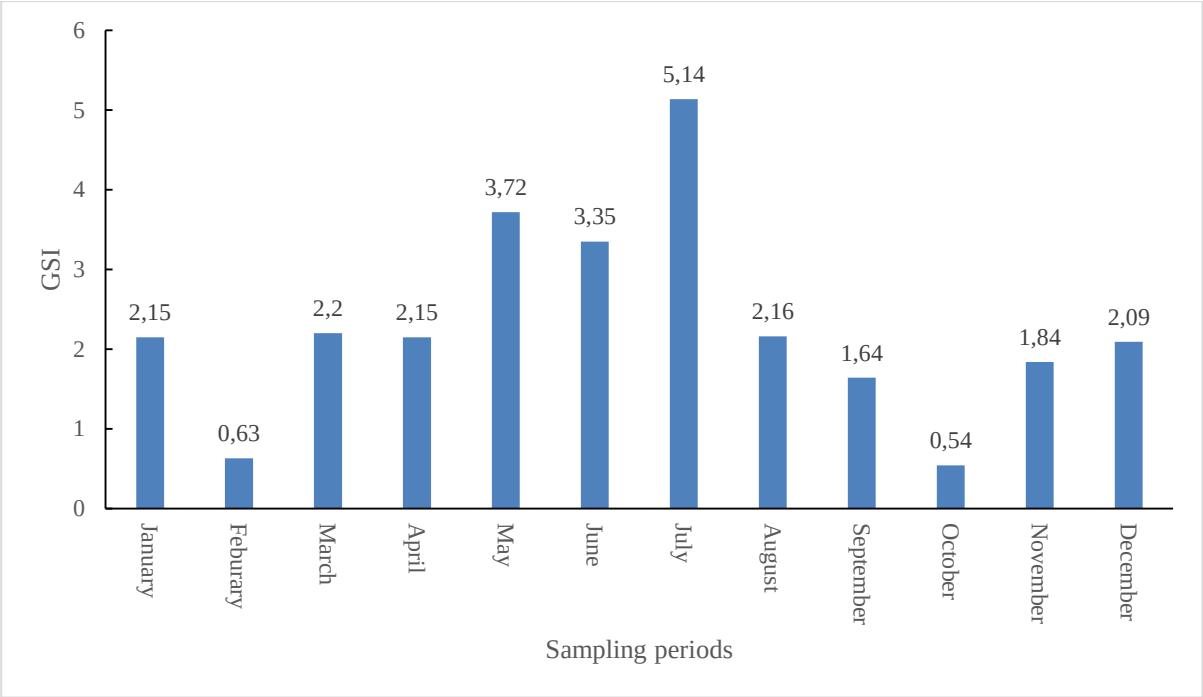

Figure 4. Monthly estimated GSI of individuals obtained during the period of sampling

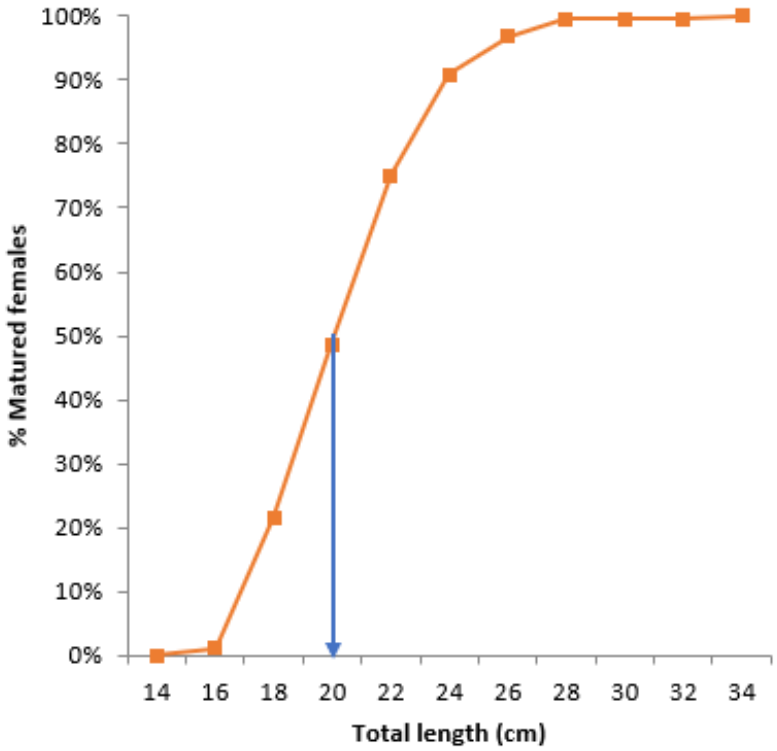

Figure 5. Length at first maturity of female individuals obtained during the sampling period

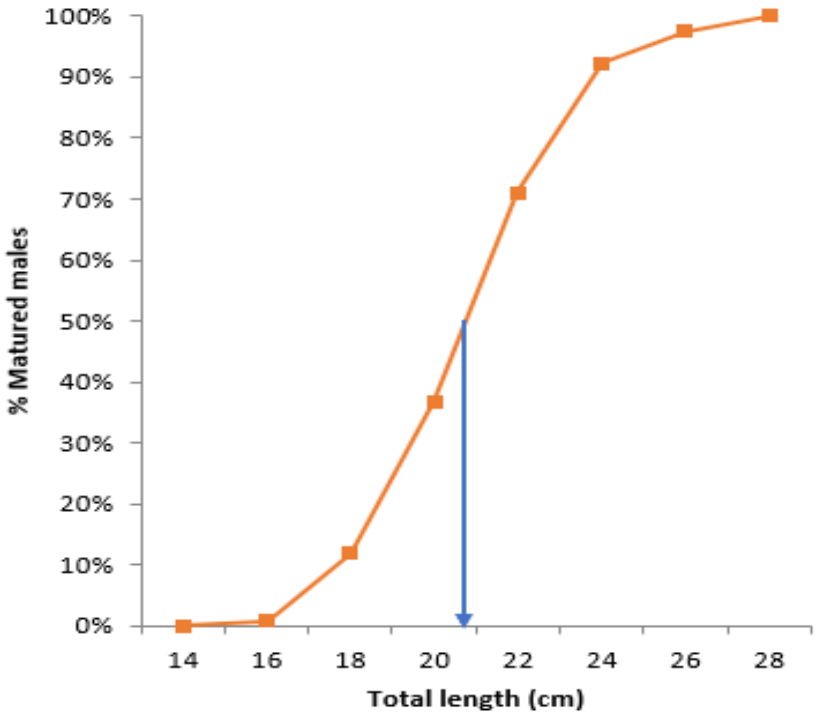

Figure 6. Length at first maturity of male individuals obtained during the sampling period

Discussion

Growth pattern of fish species is an essential length weight parameter for managing fish species (Ndiaye *et al.*, 2022). The LWR of *P. bellottii* from the study showed an isometric growth pattern for both male and female individuals which implies equal growth in length and weight. The implication of the growth pattern (b) for both male and female individuals of the Red Pandora from the study resonated with findings by other researchers such as Pauly (1984); Froese (2006) and Amponsah *et al.* (2017). Studies by Mansaray and Konomiya, (2020) from the coastal waters of Sierra Leone recorded a negative allometric growth pattern (b > 3.0) for male Red Pandora individuals and isometric growth pattern (b = 3.0) for female individuals. The variation in growth pattern for male individuals may be linked to factors such as seasonal effect, habitat type, stomach fullness level, obtainability of feed items, size variations, weight of species, environmental conditions, maturation stage, health status, and population size (Ndiaye *et al.*, 2022). Nonetheless, the recorded "b" value for both sexes was within the suggested range of 2.5 to 3.5 by Thomas *et al.*, (2003) for most tropical fish species.

The mean condition factor of both male and female individuals of the assessed species was above 1.0 which implies the existence of conducive environmental factors in the marine environment of Ghana. This suggests the relatively sound physiological well-being of both male and female individuals of the assessed fish species. Furthermore, this assertion has been confirmed by other scholars such as Ayode (2011) and Adebiyi (2013). Mansaray and Konomiya (2020) recorded higher condition factor for males than females of Red Pandora which was consistent with finding from this study. The variation in condition factor between male and female individuals may be due to the rate of growth in both sexes and the weight of the individual fishes (Oliveria *et al.*, 2017; Agbugui, 2013).

In the present study, males were numerically more than females, leading to violation of the theoretical ratio of 1:1 for males and females. Findings from the study was similar to studies by Mansaray and Konomiya (2020) and Kouame *et al.*, (2018) from the Ivorian waters and Asabere-Ameyaw (2000) from the Ghanaian waters. The higher number of male individuals than females could be due to high vulnerability of males than females to fishing gears (Vicentini and Araujo, 2003). In addition, spatial or vertical variation of sexes may have contributed to higher number of males than females (Sims *et al.*, 2001). Furthermore, Ali Ben Smida and Hadhri (2014); Benina (2015); Mahdi *et al.*, (2017) and Dobroslavić *et al.*, (2017) have inferred that one of the sexes of fish species will always be predominant.

The most important biological parameter for determining the breeding season of fish as well as their gonadal maturity is the gonadosomatic index (Bindu *et al.*, 2012; Raghavan *et al.*, 2016). The GSI increases with maturity and decreases with the end of gonadal activity after spawning (Jan *et al.*, 2014; Geremew *et al.*, 2015). In the study, a minor spawning period was observed from November - January and a major spawning from March to September based on the variation in GSI. This was similar to studies by Asabere-Ameyaw (2000) who documented minor and major spawning phases in January-February and June to September, respectively. Nonetheless, the relatively small breeding activities observed in all months of the study

could suggest a continuous spawning behavior (Lazar, 2017). In addition, ICE (2004) has inferred *P. bellottii* to be a multi-spawner species fish due the presence of matured individuals all year round.

In this study, females reached first maturity earlier than males which was in accordance with findings by Kouame *et al.*, (2018), Ndiaye (2014) from Senegalese waters and Asabere-Ameyaw (2000). Zarrad *et al*. (2010) attributed difference in size at first maturity to growth differences of populations influenced by temperature and food quality and availability. Also, changes in length at first maturity may be directly connected to demographic density, environmental conditions, differences in reproductive biology, growth rates, fishing catches, availability of food, and hydrological conditions (Perez-Palafox *et al.,* 2021). Nonetheless, the size at first maturity for both males and female individuals was similar to those estimated by Asabere-Ameyaw (2000), but higher than the estimates by Amponsah *et al.* (2016) which may be due to differences in the scientific approach used in the estimation process. Size at sexual maturity (L_{50}) is an essential parameter for fisheries management as it gives the authorities to decide on mesh size in fishing zones and therefore, to avoid fishing juveniles (Hossain *et al.*, 2013). The use of appropriate meshes will prevent the capture of immature individuals and therefore, sustain the potential for reproduction (Lin *et al.,* 2013).

Conclusion

This study sheds light on some aspects of the reproductive biology of the Red Pandora in the coastal waters of Ghana. The results revealed that male and female individuals of Red Pandora exhibit isometric growth with a mean value of condition factor greater than 1.0. The sex ratio of individuals in the study favored males. GSI studies displayed two spawning periods. This information will contribute to knowledge essential for sustainably managing the population of *P. bellottii* in Ghana.

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Conflict of Interest

The author declare no conflict of interest.

Ethics Approval

Ethics committee permission is not required for this study.

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