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Some Rreproductive Features of Blue Swimmer Crab (*Portunus pelagicus*) in the Suez Gulf, Egypt

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ABSTRACT

Crustacean decapods form a significant and important component of commercial fisheries in the region of the Suez Gulf. Current investigation was carried out mainly to examine the reproductive system of blue swimmer crab's (*Portunus pelagicus*) males and females. Samples of Blue swimmer crab were collected from the Suez Gulf. Histological sections were applied to confirm the morphological stages of blue crab's males and females' gonads. The results obtained showed that the reproductive system of both males and females' gonads in *P. pelagicus* was like that of other decapod crustaceans. Male of *Portunus pelagicus* is bilaterally symmetrical, consist of a pair of ejaculatory ducts internally and a pair of vas deferentia. Vas deferentia consist of three parts, the Anterior (AVD), the Median (MVD), and the Posterior (PVD). Also, the investigation of the ovaries indicated that the females could spawn throughout the year. The results suggest that local management of the blue swimming crab fishery recommend setting closed seasons to preserve juvenile crabs of this species, protecting areas of spawning and nursery grounds from illegal fishing, pollution, and habitat loss.

INTRODUCTION

Crustaceans are thought to be the most dominating and successful aquatic group. They are usually represented by a large number of species with a wide and a great array of lifestyles. Crustacean groups' diversity is usually a result of their life patterns and reproductive strategies (Sastry, 1983). Crustacean decapods form a significant and important component of commercial fisheries in the region of the Suez Gulf.

The fishing for brachyuran crabs in the Gulf of Suez is dominated by a single family, Portunidae. The Portunidae family is found in all the world's seas and ranges from tropical to sub-temperate **(Garth and Stephenson, 1966)**. Major unique characteristics of the Portunidae are the morphological changes and adaptations of the most posterior pereiopods to paddle-like appendages for swimming, while the three more anterior pairs retain their original walking function. The four pairs of thoracic appendages are employed for walking in all other brachyuran groups **(White and Spirito, 1973)**. The blue swimming crab, *Portunus pelagicus*, is one of the

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commercially exploited edible crabs in the Portunidae family (Linnaeus, 1758).

The blue swimming crab is an economically significant species that lives in a variety of inshore and continental shelf environments, including sandy, muddy, and sea grass habitats from the intertidal zone to at least 50 m deep. Both near-shore and estuary waters are habitat for the blue swimming crab. Blue swimming crab market demand is highly strong due to its flavour **(Sudtongkong, 2006)**. It is mostly a tropical and subtropical species, although it has also been documented in temperate locations **(Potter *et al*., 1983)**. It is also found in the Red Sea and the eastern Mediterranean **(Apel and Spiridonov, 1998)**.

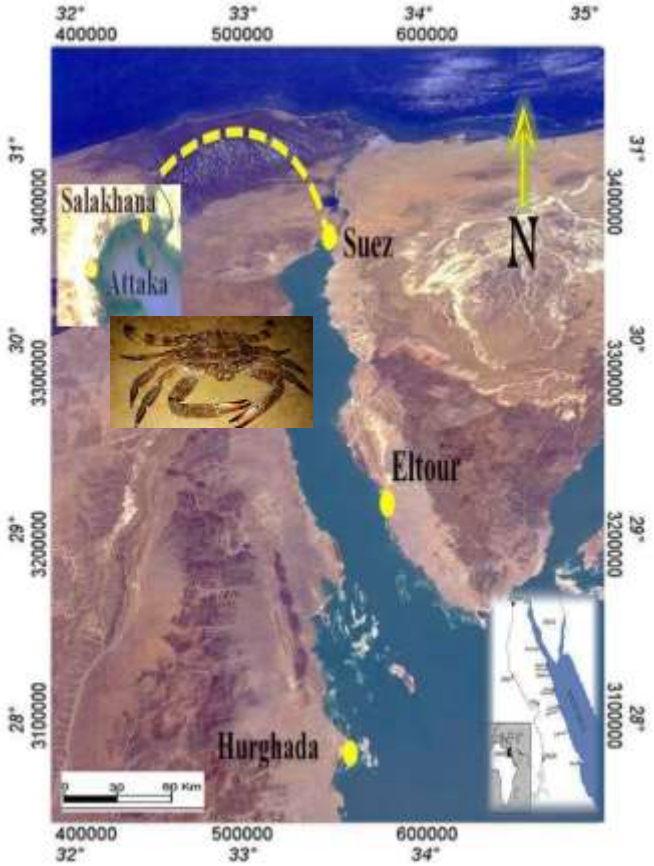


Fig. 1. shows the sampling sites in Suez governorate.

https://www.millenniumassessment.org/en/SGA.Egypt.html

Management and conservation of Blue swimming crabs require further study focus on reproductive biology, population dynamics, and habitat **(Nurdin *et al*., 2020)**. The study of reproductive biology is required to have a broad understanding of population variations and dynamics. This is also necessary for policymakers and managers to devise and implement regulatory measures to protect the population of edible and commercially significant brachyuran crabs. The current study was carried out to characterise the exterior aspects of the reproductive system, plus the microscopic-histological gonad development of the blue swimming crab (*P. pelagicus*).

MATERIALS AND METHODS

1. Study sites, and sampling methods

Samples of blue swimmer crabs' males and females were collected from the Suez Gulf. The Suez Gulf is bordered by Egypt entirely and considered the most important fishing area in Egypt **(Sharaan *et al.,* 2017)**. It contributes approximately 37.52 % of the total marine fish catch comes from the Red Sea; while crabs contribute with approximately 1.3 % of total marine fish catch from the Suez Gulf **(GAFRD, 2019)**. Samples were collected from commercial fisheries in the Suez Gulf (Fig.1). 537 specimens of P. pela *pelagicus*, 305 males and 232 females were collected during a fishing season from September to April. Blue swimmer crabs' were caught using trammel net (Crab's net) and trawl gear (are mainly caught as by-catch in bottom trawls, which target shrimps and fishes). Gonads of males and females were classified according to a maturity stage scale visually prior to fixation. All crabs were sexed. Samples were also retained for further examination in the laboratory.

2. Histological Analysis:

Specimens of 3 males' and 3 females' gonads/ month had been placed in histology cassettes then fixed in Bouin's solution for 24 hours (75% saturated picric acid, 25% formalin, and 5% acetic acid glacial). Tissues had been dehydrated in an ethyl alcohol series of ascending concentrations

(70%, 80%, 90%, 95%, 100%), after that it had been maintained in Methyl Benzoate overnight and then embedded in paraffin wax, blocked, and sectioned at 5-6 µm. ribbons and mounted on slides **(Drury and Wallington, 1980; Mohamed, 2009)**. The slides had been stained with haematoxylin-eosin (H×E) and examined by "Leica" microscope and assigned a stage. Male staging was done using a scale of 0–3.

RESULTS AND DISCUSSION

1. Reproductive system:

1.1 Males' reproductive system: (Testes)

The males' reproductive system of *P. pelagicus* was morphologically creamy to whitish in color, internally: consist of a couple of testes, a pair of vas deferentia, and a pair of ejaculatory ducts. While externally: a pair of penes, pair of secondary pleopods, and the pair of major pleopods as an additional accessory reproductive organ, which present on the inner side of the abdominal flab.

Vas deferens can be divided to three portions: the anterior or proximal (AVD), the median or medial (MVD) and the posterior or distal (PVD). The male crab's gonad development was studied both macroscopically and histologically. The presence of spermatophores in the crabs' vas deferens showed the size at maturity of the male crabs, and this is according to the morphological analysis of *Portunus pelagicus* males. The male gonad always had three distinct stages, including immature, maturing, and matured- ripped, and other sub-stages. In the current study, maturing phase examined to be appeared as a paired organ medially that interconnected by a commissure that approximated the shape of a letter "H". Its location just at dorsal to the digestive gland and under the hypodermis of the carapace (Fig. 2a). The testis extends from the center of the carapace's posterior-lateral border to the stomach, then follows the curvature of the carapace's anterior-lateral border to the stomach.

Developmental stages of males' gonads:
it could be characterized as follows:

-Immature stage (I): The gonads of the immature crabs in this stage were tiny and creamy in color, lying on either side of the stomach. Testes, and vas deferens are not well or clearly distinguished (**Fig. 3-A**).

-Maturing stage (II-III): The testes and vas deferens are well formed and developed, distinct, and creamy white in color. Testes appeared as a large, coiled tube which starched laterally and posteriorly to the stomach. Anterior vas deferensa become larger, while the middle and posterior vas deferens become straight and opaque, reaching to both sides of the heart (**Fig. 4-B& Fig. 5-C**).

-Matured stage (IV-V): The vas deferens become coiled and exceedingly swollen, filling the whole-body cavity, and this causing additional growth of the testes. The AVD and MVD were expanded and appeared milky white in hue, whereas the PVD was enlarged and convoluted but remained opaque (**Fig**. **6-D & Fig. 7-E**).

1.1. Females' reproductive system:(Ovaries)

P. pelagicus' female reproductive system was yellowish to orange in color and comprised of a pair of ovaries. The ovary is located dorsally in relation to the hepatopancreas and extends posteriorly along both sides of the hindgut (Fig. 2b). It curves along its anterior-lateral boundary, locked in place by a connective tissue sheath rich in black chromatophores.

Developmental stages of females' gonads:
it could be characterized as follows:

- **Immature stage (I):** The immature females had quite tiny, flattened gonads and off-white color. The small anterior portion is not moved by the hepatopancreas. The dorsal surface is weakly connected to the central "H"-shaped section in the abdominal region. The posterior part divides into two parallel lobes that are seen in the cardiac and intestinal regions (**fig. 9-A)**.

Early development stage (II): Ovaries Noticeably larger than stage I, tend to be pale yellow and a little nodulated. The hepatopancreas is only slightly displaced by the anterior region, and the

two lobes of the posterior region are starting to become convoluted. (**Fig. 10-B**).

-Late development stage (III): Ovaries are nodulated obviously, large, and yellow.The hepatopancreas is replaced by the anterior region, and the gastric, posterior, and intestinal cavities are almost entirely occupied by the central and posterior sections (**Fig. 11-C).**

-**Fully mature (IV):** Ovaries now are bulky, deep yellow to orange, and significantly nodulated. The growth of the anterior ovarian part has totally displaced the hepatopancreas from its previous location. The extended central and posterior portions of the ovary entirely occupy the stomach, posterior, and intestinal cavities. The ovary completely covers the spermathecal part. The enlarged lobes of mature ovaries, which are deep orange in color, totally hide the hepatopancreas beneath them (**Fig. 12-D**).

- Recovery stage (V): Ovaries shrinking in size. Off-white in color, similar to the ovary's shape of stage (I) but the difference between recovery and immature stage is that the ovaries have an intensive collapse in the connective tissue **(Fig. 13-E**).

(Best *et al*., 2017). Female crab; adapted from **(Lyons *et al*., 2012).** Three sections of each stage were observed under the microscope for each sample. Sections of examined gonads were photographed as requested (50µ).

P. pelagicus's female and male gonad reproductive systems were identical to those of other decapod crustaceans. The anatomy of P. pelagicus' male reproductive system, consisted of a "H" shaped structure comprising a pair of testes, a pair of vas deferentia, and an ejaculatory ducts, was identical to that of Portunus pelagicus' reproductive systems reported in the study of **(Soundarapandian *et al*., 2013)**. The gonad details anatomy of P. sanguinolentus presented in the study of **(Ryan, 1967)**, and P. pelagicus were fully characterised in the research of **(De Lestang *et al*., 2003)**. Portunus pelagicus testes are tube-shaped organs with many microscopically visible lobules that attached to the seminiferous duct; hence, they have been classed as lobular testes according to the classifications (lobular and tubular) as proposed by **(Nagao and Munehara, 2003)**. Lobular tastes are abundant in portunid crabs. Vas deferens (VD) is a pair of elongated and convoluted tubules that run longitudinally in the posterior section of the body **(McLaughlin, 1983)**. The vas deferens in P. pelagicus was divided into three distinct regions based on morphological and functional criteria in Portunus sanguinolentus, the anterior, middle, and posterior vas deferens **(Boopathi, 2011)**. The stages of ovarian development discovered in this study were comparable to those described in previous research for P. pelagicus **(De Lestang *et al*., 2003)**; P. sanguinolentus **(Kumar *et al*., 2003)**. Generally, there are two stages of ovarian development: the first stage, which corresponds to ovarian stages I and II, and the second stage, which corresponds to vitellogenesis. Vitellogenesis might be divided into two stages: (I) ovarian stage 3 and (II) ovarian stage 4, which culminates in oviposition **(Stewart *et al*., 2007)**.

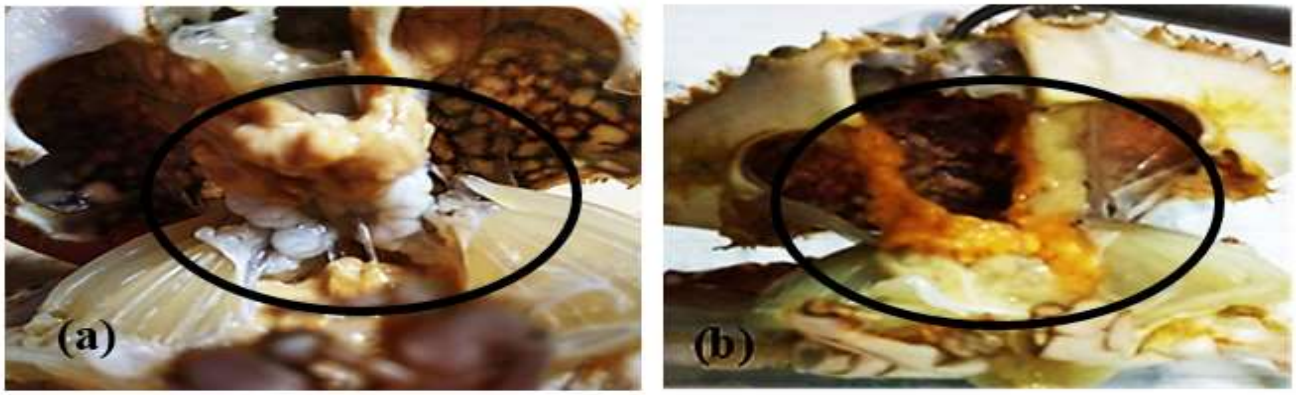
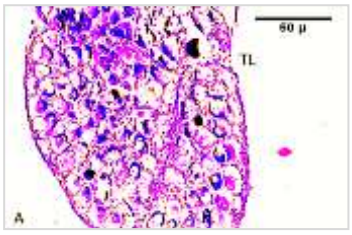
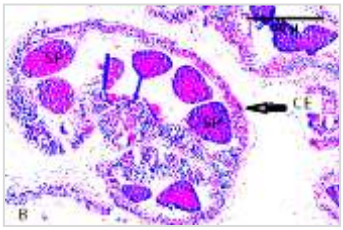
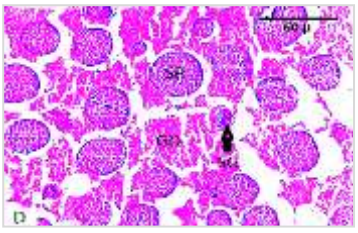
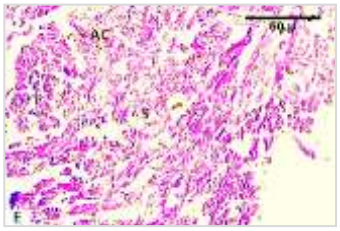


Fig. 2 (a-b): Reproductive system of blue swimming crab (*Portunus pelagicus*), Male reproductive system: Testes (a). Female reproductive system: Ovary (b)

Table 1. Stages of maturation scales for males' gonads.

Stage	Microscopic and histological	Morphological observation	Macro microscopic results
Male I			**Fig. 3 (A):** Anterior vas deferens (AVD) from (*P. pelagicus*), show testis lobe (TL).
Male II			**Fig. 4 (B):** Anterior vas deferens (AVD), with Columnar epithelium (CE), and Spermatophores (SP).
Male III			**Fig. 5 (C):** Lobules filled with spermatozoa mass (SPZ)., Columnar epithelium (CE).
Male IV			**Fig. 6 (D):** Median vas deferens (MVD), showing lobules filled with spermatophores (SP), Spermatogonia (SG) and Granular droplets (GD).

Male V		**Fig. 7 (E):** Spent testis (S) with Accessory cells (AC) during spawning season.

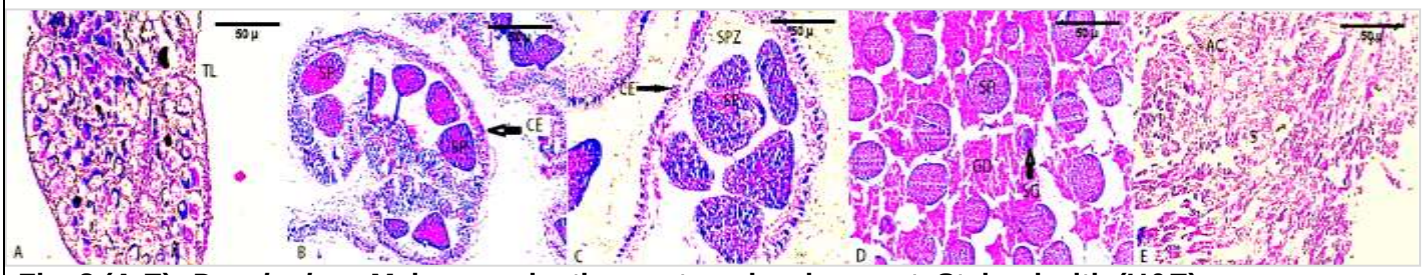
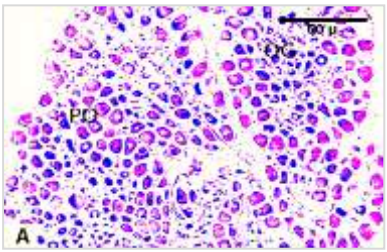
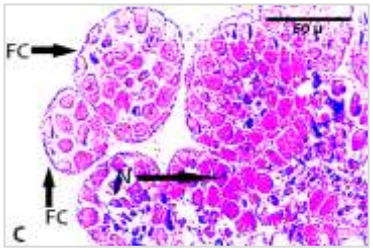
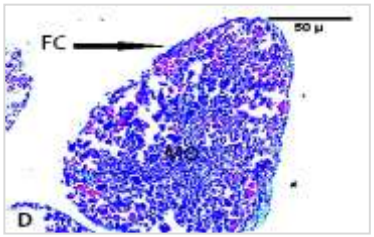
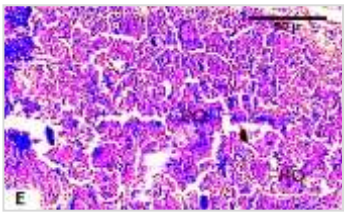


Fig. 8 (A-E): *P. pelagicus* Male reproductive system development, Stained with (H&E).

Table 2. Stages of maturation scales for Female gonads

Stage	Microscopic and histological	Morphological observation	Macro microscopic results
Female I			**Fig.9 (A)** immature females showing, Oogonia (OG), and Previtellogenic oocyte (PO).
Female II			**Fig.10 (B)** pre-mature female showing, Previtellogenic oocyte (PO), Early vitellogenic oocytes (EVO).

Female III			**Fig.11 (C)** Matured female in pre-spawning stage, showing Follicle cells (FC), Nucleus (N).
Female IV			**Fig.12 (D)** Late vitellogenic or maturing female at stage IV, showing Maturing oocyte (MO) and Follicle cells (FC).
Female V			**Fig. 13 (E)** re-covered ovary with residual previtellogenic oocyte, at stage V, showing Previtellogenic oocyte (PO) and Resorbing ova (RO).

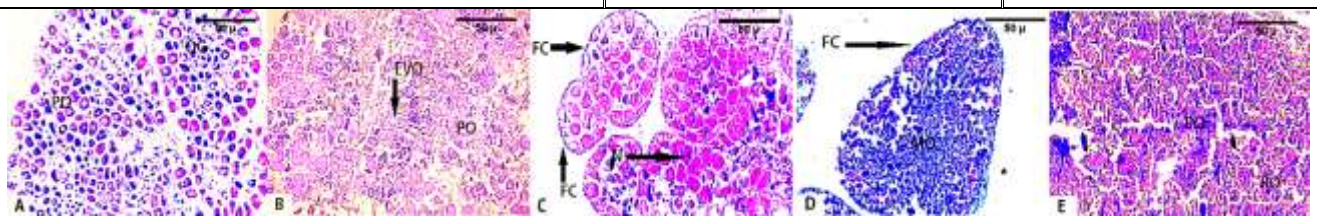


Fig. 14 (A-E): *P. pelagicus* female reproductive system development, Stained with (H&E).

Table 3. Prices according to different sizes of *P. pelagicus'* (males and females) in markets of the Suez governorate.

Size	Type	Price	Consumer selection
Small	**Female**	50-70 Egyptian pounds.	Affordable but not most favorable for consumers.
Large	**Female**	Reach 260 Egyptian pounds.	Expensive but most favorable for consumers.
Small	**Male**	40-60 Egyptian pounds.	Consumer in the region prefer females more than males. And this may lead to a slightly decrease in the prices of males.

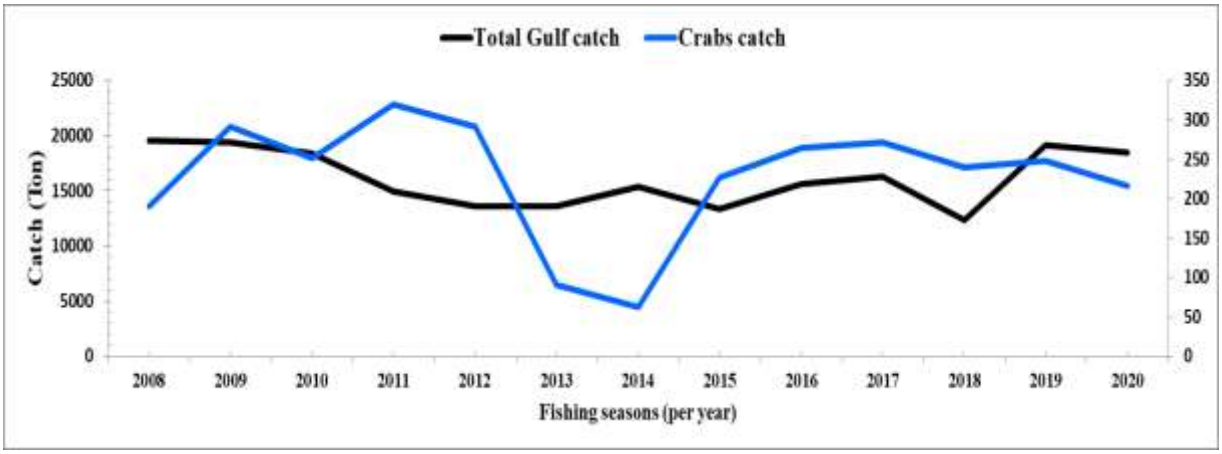


Fig. 15. show the Suez Gulf total catch and crabs catch trend in the Gulf of Suez over the years -GAFRD (2008: 2020)

Table 3 showed crabs with different sizes can be sold in local fish markets, with concern of about the price of the crab (Local sellers). On the other hand, it has shown a fluctuated catch, probably because of the excessive capture for both small-sized crabs and ovigerous females that may have led to a declined in recruitment. The fishing of ovigerous female crabs occurs because of the high local market and restaurants demand for crab females and the high prices of big and heavy females.

Mahmoud (2022), Crabs catch instability observed over these years. In the Suez Gulf, the crabs catch fluctuated between a maximum of 320 ton during 2011 and a minimum of 63 during 2014 with a mean value of 229 ton all through the entire period. The crab catch was greater than before in the period from 2008 to 2011 (190 to 320 ton) with a percent increase from 0.97 to 2.14 % from the Suez Gulf total catch. Then there were some fluctuations during the whole period (2012 – 2014) (292 to 63 ton) with a percentage decrease from 2.15 to 0.41 % from the Suez Gulf total catch. This is maybe referred to the fishing of small-sized individuals and they don't get the chance to reproduce at least once before trawling them. In the period from 2015 to 2017 there was a continual growth in the crab catch (227 to 271 ton) with a percentage from 1.70 to 1.66 % from the Suez Gulf total catch, with respect the total landed catch from the Suez Gulf in 2015 was 13321 ton which is far less than the catch in 2017, with 16279 ton as shown in **fig.15.**

CONCLUSION

The Suez Gulf is one of the most productive areas for a long way of the Red Sea's Egyptian coast, and it contributed by about 36 % of the Red sea total production **(GAFRD, 2020)**. The Crab caught as by- Catch from bottom trawl and target species by the gill and trammel net. Macroscopic examination and microscopic examination for gonads showed that the spawning scheme in *P. pelagicus* is partial spawning around the year. The species catch fluctuation indicates that the species didn't have the opportunity to spawn at least once before fishing. Square mesh size is suitable for leaving small scrabs to grow and reproduce at least once in the life span. The results suggested that local management of the blue swimming crab fishery should consider both the spatial of small-sized and ovigerous females in the population before applying regulations and other management actions. It is also recommended to set closed seasons to preserve juvenile crabs of this species, protecting areas of spawning and nursery grounds from illegal fishing, pollution, and habitat lose conditions.

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