Research Article

Topographical Anatomical Studies of the Internal Organs of the Blue Swimmer Crab (*Portunus pelagicus*) in Conjunction with its External Features

Reem R. Tahon, Nora A. Shaker*

Assistant Professor of Anatomy and Embryology, Faculty of Veterinary Medicine, Cairo University, Egypt.

Abstract | This study aimed to study morphologically the external features and the anatomical structures of the internal organs of the blue swimming crab (*Portunus pelagicus*). Twenty-two crabs, both male and female, were collected from the Red Sea and the Mediterranean Sea in Egypt. The color of the blue swimmer crab carapace was dark green in males and medium brown with light brown patches in females. The cephalothorax was found to have three pairs of biramous maxillipeds. The pereion was connected to five pairs of uniramous pereiopods, the cheliped, three pairs of walking legs, and the last swimming leg. The abdomen of the male was narrow rostrally with a small telson; while the mature female had a broad triangular abdomen with convex sides and a telson with a small broad base. Male had two pleopods, the first and second gonopods on the ventral surface of the abdomen; while females had several paired biramous pleopods. The gills consisted of paired, triangular masses, and occupied the branchial chamber on each side of the cephalothorax. The female reproductive system consisted of bilateral ovaries, oviducts, seminal receptacles, in addition to single vagina and gonopore, while the male reproductive system consisted of a pair of testes, vas deferens, and gonopods. The stomach was a complex structure whose walls bore calcareous ossicles. It was divided into the cardiac stomach with four ossicles: unpaired mesocardiac, paired pterocardiac, paired lateral zygocardiac, and the unpaired urocardiac ossicle; and the pyloric stomach, which bore three ossicles: unpaired uropyloric, and a pair of exopyloric ossicles.

Keywords | External Anatomy, Stomach, Gills, Gonad, Blue swimmer crab

Received | October 24, 2022; **Accepted** | December 15, 2022; **Published** | December 25, 2022
***Correspondence** | Nora A Shaker, Assistant Professor of Anatomy and Embryology, Faculty of Veterinary Medicine, Cairo University, Egypt; **Email:** dr_norashaker@cu.edu.eg
Citation | Reem RT, Shaker NA (2023). Topographical anatomical studies of the internal organs of the blue swimmer crab (*portunus pelagicus*) in conjunction with its external features. Adv. Anim. Vet. Sci. 11(1): 166-175.
DOI | http://dx.doi.org/10.17582/journal.aavs/2023/11.1.166.175
ISSN (Online) | 2307-8316

INTRODUCTION

Crustacean aquaculture is a rapidly growing industry and important aquaculture commodities (New, 1999). Burkenroad (1963) revealed that true crabs are sub-orders from the order Decapoda. This study examined *Portunus pelagicus*, one of the major crab species (Allen et al., 2011) which belongs to Decapoda due to the anatomical structure of its ten legs. Species: *P. pelagicus,* Kingdom: Animalia, Phylum: Arthropoda, Subphylum: Crustacea, Order: Decapoda, Family: Portunidae, Genus: *Portunus*. The blue swimming crab is an economically high value crustacean (Redzuari et al., 2012), with wide geographical distribution (Zainal, 2013). They are present from the Indo tropical coastal region to the western Pacific region (Ikhwanuddin et al., 2013).

To enable better identification of crab populations, morphometric studies (Rawat et al., 2017; Sajina et al., 2011; Swatipriyanka et al., 2011), and morphological examinations of each species are needed (Mojekwu and Anumudu, 2015).

The evaluation of sexual maturity is important in stock assessment (Dubey et al., 2014), and the details of the male reproductive system enable the collection of mature males for breeding. It is noteworthy that the copulatory organ is a distinct characteristic of the male (Ewers-Saucedo et al., 2015) which is only present in species of the genus *Portunus* (Lai et al., 2010; Trivedi & Vachhrajani, 2012; Padate et al., 2013).

Only a few studies have examined the reproductive systems of the male swimming crab (Ewers-Saucedo et al., 2015; Soundaranpandian et al., 2014) and female swimming crab (Ravi et al., 2008; Johnson et al., 2010). The spawning season is prolonged from November to May, with peak activity recorded from December to February. Until now, no study has been conducted examining the morphology and morphometrics of the male swimming crab.

The aim of this study is to describe the morphology and morphometric studies of blue swimming crab external features, including its carapace, pereiopods and thorax and abdomen and the shape of the gonopodium. Furthermore, this anatomical study of the internal organs includes mouth parts, heart, gills, male and female reproductive organs, hepatopancreas, and the different parts of the digestive tract. This study will be useful in comparing different stocks of the same species from different geographical locations, and will further the development of crustacean aquaculture (Lai et al., 2010).

MATERIALS AND METHODS

Twenty-two crabs (*P. pelagicus*) consisting of both males and females were collected from the Suez region (Red Sea) and from Alexandria (Mediterranean Sea) in Egypt, by commercial trawls operating offshore and from local fishermen supplied fish markets. Blue swimming crabs were collected during various seasons from 2021 to 2022 and were transported alive in seawater using plastic containers to the laboratory in the Anatomy Department, Faculty of Veterinary Medicine, Cairo University.

Samples were examined while still fresh. The adult samples were separated into sexes according to external sexual characteristics by inspecting the ventral side of the body (abdomen). Adult females had semicircular and flab like abdominal segments while adult male abdomens were narrow and triangular (Ikhwanuddin et al., 2010).

In this species sexes are easily differentiated by the color pattern on their exoskeletons. Males are brilliantly bright blue, and females have a dull brown color. This unique feature is not seen in other common portunids (Hosseini et al., 2014).

Morphological examinations were performed on ten crabs (*P. pelagicus*) including external anatomical features (exoskeleton) and internal anatomical organs. Fresh dissections were conducted, and photos were taken using both a Sony 20.1MP camera and a Samsung 48 MP camera, made in china.

The morphometric study included various measurements conducted using digital calipers (adoric).These included the carapace width (CW) (to the ninth tooth) and carapace length (CL) of twelve male and female crabs. Statistical analyses with results shown as mean value ± standard error were conducted using Microsoft Excel 2010 (Microsoft Corp., Redmond, WA, USA).

RESULTS AND DISCUSSION

External anatomical features (Exoskeleton)

The male *P. pelagicus* carapace (Fig. 1A) is dark green with light brown patches, while the female carapace (Fig. 1B) is medium brown with light brown patches, in accordance with Abbas et al. (2016). In contrast, Lai et al. (2010) stated that males have a dark blue-green carapace with white spots. In the present study, female crabs had black marks on the frontal, gastric, and hepatic regions, but in contrast, Lai et al. (2010) documented that *P. pelagicus* females have a black mark on the posterior branchial region. The carapace is a slightly convex, broad, hard protective shield covering the head and thorax dorsally, conversely Tavares (2003) stated that true crabs have a depressed and flat carapace. It has four front teeth (pointed and triangular) (Fig. 1A/2) and nine anterolateral teeth (Fig. 1A/3) on each side, this is similar to previous observations (Abbas et al., 2016). While Tavares (2003) mentioned that true crabs have from five to nine teeth on the anterolateral border. The middle teeth are small, except the first one is medium in size, and the ninth tooth (lateral spine) (Fig. 1A/4) is the largest and tallest as described by (Tavares, 2003).

The carapace morphometric study revealed that the carapace width (at the ninth tooth) in female crabs was longer than in male crabs (Table 1) while the Carapace length was nearly equal in male and female crabs. The male crab's width mean value ± standard error being 11.06 ± 0.11cm. Lai et al. (2010), reported the largest known *P. pelagicus* was a male measured 155.7 × 73.4 mm, and was from Singapore. The observed width length ratio in male crabs was 1.89 ± 0.84 while in female crabs, it was 1.96 ±1.45. This was contrary to Abbas et al. (2016) who reported that *P. pelagicus* carapaces had a breadth-length ratio of 2.13.

Table 1: The Carapace width and length statistical analysis showed as mean value ± standard error.

	Male crabs	Female crabs
Carapace width (CW) (with the nine tooth) cm	11.06 ± 0.11	11.5 ± 0.29
Carapace length (CL) cm	5.83 ± 0.13	5.86 ± 0.20

In the head of the crab (*P. pelagicus*), both males and females have a rostrum (Fig. 1A/5) on the midline of the carapace rostrally, as well as two antennules (Fig. 1A/6) on both sides of the rostrum proceeded by two antennae (Fig. 1A/7), and followed by the right and left eyes, these findings resemble those of Meyer (2014). Both compound eyes and eyestalks (Fig. 2A/8&9) lodge in two shallow depressions called orbits on the rostral edge of the carapace. The cervical groove was absent in this species and replaced by light brown markings without a groove. The inhalant apertures (Fig. 2A/10) consisted of two large openings ventromedial to the eyes in the carapace. They led to the branchial chamber of the gills; with the operculum (Fig. 2A/11) covering the upper boundary of the aperture. A pair of exhalant apertures (Fig. 2A/12) are found lateral to the first and second maxillipeds.

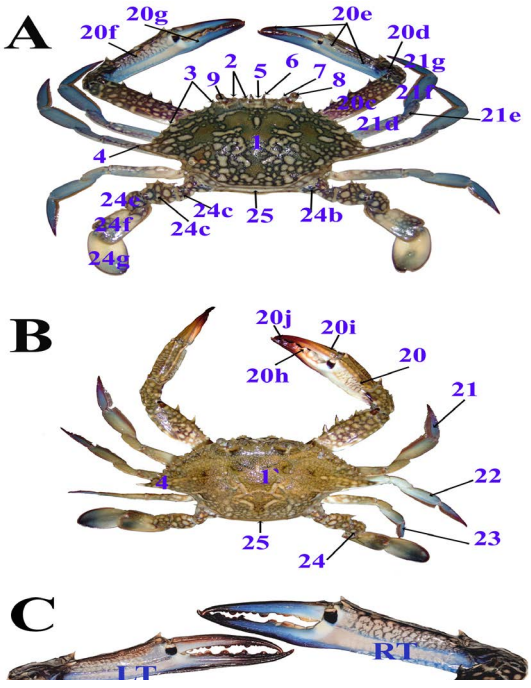

Figure 1: A & B; Photographs showing the dorsal aspect of the male and female blue swimmer crab (*P. pelagicus*), respectively, C; Magnified view of the right (RT) and left (LT) male chelipeds.

The cephalothorax is formed by the fusion of the head segments and the first three thoracic segments and is covered dorsally by the carapace. Each thoracic segment of the cephalothorax carries a pair of maxillipeds, so the cephalothorax has three pairs of biramous maxillipeds. The paired third maxillipeds (Fig. 2B/16) cover the quadrilateral mouth area which arises from the third thoracic segment of the cephalothorax. It is a movable appendage that has two rami. The paired second maxillipeds (Fig. 4A&C/17) and the paired first maxillipeds (Fig. 4A&C/18) are smaller in size than the third pair and arise from the second and first segments of the thorax, respectively.

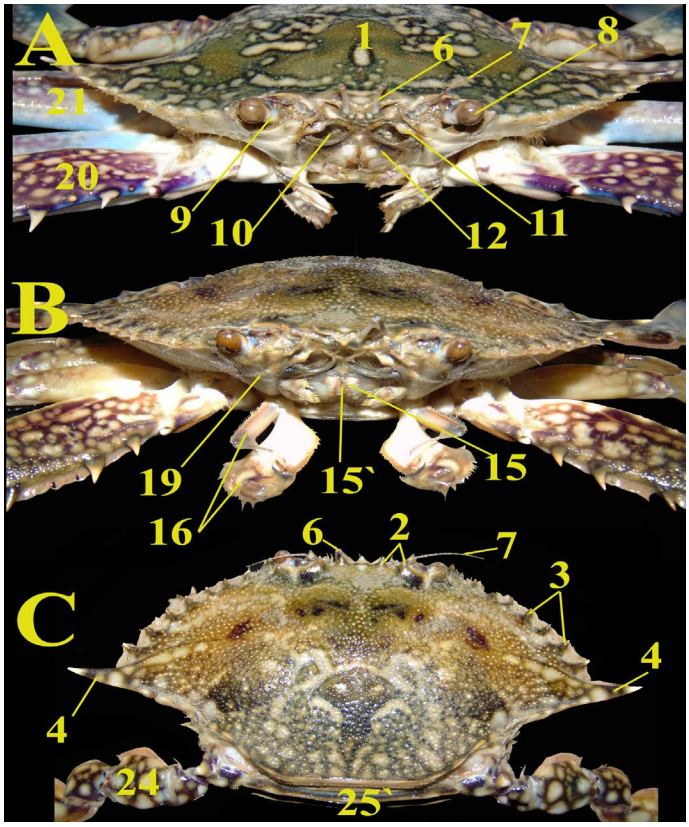

Figure 2: A & B; Photographs showing the frontal view and mouth parts of the male and female blue swimmer crab (*P. pelagicus*), respectively, C; Photograph showing the female crab spines on the carapace after removal of the first four pereiopods.

Mouthparts (Fig. 4) are composed of three pairs of maxillipeds, two pairs of maxillae, and a pair of mandibles (jaws) surrounding the opening of the mouth (Fig. 4B/15`) in accordance with Meyer (2014). All maxillipeds arise from the cephalothorax. The second pair of maxillae (Fig. 4B/13) is the most rostral head appendages and is just caudal of the first maxillipeds. The first pair of maxillae (Fig. 4B/14) is smaller than the second pair. A pair of mandibles (Fig. 4B/15) is presented rostrally to the first maxillae. The mouth opening is located between the upper lip (hard labrum) (Fig. 4B/5`) and two mandibles.

The thorax is composed of three segments fused with the head forming the cephalothorax and five free thoracic segments. Each is covered externally by a plate called a sternite, and on both sides of the abdominal segments called the pereion (thoracic sternum) (Fig. 3B/26), which is connected to five pairs of pereiopods. Crabs have five

pairs of uniramous pereiopods (legs), in agreement with Tavares (2003); the first is the cheliped (first pereiopod) (Fig. 1B/20), three pairs of walking legs (second, third, and fourth pereiopods) (Fig. 1B/21,22,23) and the last leg is the swimming leg or fifth pereiopod (natatory leg) (Fig. 1B/24).

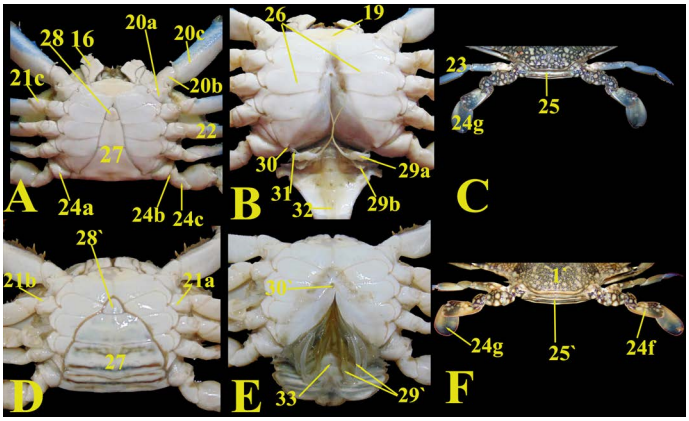

Figure 3: A & D; The ventral view of the male and female blue swimmer crab (*P. pelagicus*) respectively. B & E; The reflection of the abdominal segments in both male and female crabs, respectively. C & F; The caudodorsal view of the male and female crab, respectively.

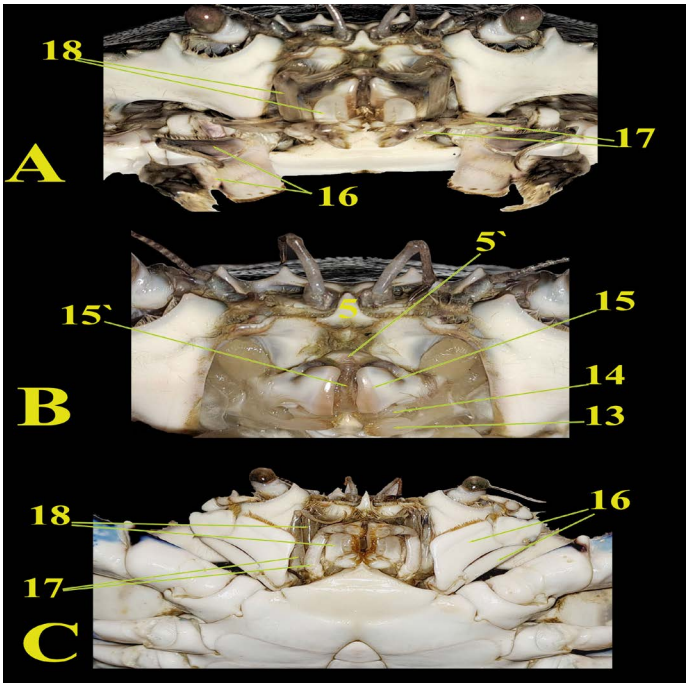

Figure 4: A; Fontal view of the male crab showing the three maxillipeds. B; Reflected maxillipeds showing the second and first maxillae and mandible underneath. C; Magnified ventral view of the maxillipeds of the male crab.

Legend of Figs. 1 to 4:
1, Male carapace; 1`, Female carapace; 2, Front teeth; 3, Anterolateral teeth 4; Lateral spine (ninth tooth); 5, Rostrum; 5`, Upper lip; 6, Antennules; 7, Antennae; 8, Compound eyes; 9, Eye stalk; 10, Inhalant aperture; 11, Operculum; 12, Exhalant aperture; 13, Second maxilla; 14, First maxilla; 15, Mandible; 15`, Mouth; 16, Third maxilliped; 17, Second maxilliped; 18, First maxilliped; 19, Cephalothorax; 20, Cheliped (first pereiopod); 20a, Coxa of first pereiopod; 20b, fused basis ischium; 20c, merus; 20d, Carpus; 20e, Claw; 20f, Palm; 20g, Pollex; 20h, Cutting conical teeth; 20i, Dactylus; 20j, Fingertip; 21, Second pereiopod (walking leg); 21a, Coxa, 21b, Basis; 21c, Ischium; 21d, merus; 21e, Carpus; 21f, Propodus; 21g, Dactylus; 22, Third pereiopod (walking leg); 23, Fourth pereiopod (walking leg); 24, Fifth pereiopod (natatory or swimming leg); 24a, Coxa; 24b, Basis; 24c, Ischium; 24d, merus; 24e, Carpus; 24f, Paddle like propodus; 24g, Paddle like dactylus; 25, Male abdomen (pleon); 25`, Female abdomen (pleon); 26, Thoracic sternum (pereion); 27, Abdominal segments; 28, Male telson; 28`, Female telson; 29a, First gonopod; 29b, Second gonopod; 30, Male gonopore; 30`, Female gonopore (vulva); 31, Penis; 32, Intestine; 33, Anus

Legs (pereiopods) of male blue swimmer crab are mixed blue and purple in coloration with off-white patches, in agreement with the description of Abbas et al. (2016). Conversely, Lai et al. (2010) described that male's chelipeds had rust colored red tips. The female legs are dark brown with off-white patches, while Lai et al. (2010) described that the females had a uniformly brownish-green carapace with red tipped chelipeds.

The cheliped is the strongest and largest one, and functions as a movable finger and carries on its end a chela or claw (pincer), in agreement with Meyer (2014) that in many decapods the first peraeopods had enlarged pincers (chelae) called chelipeds (Brachyura). It is composed of six parts; the coxa (Fig. 2A/20a) proximally which articulates with the body, the fused basis ischium (Fig. 3A/20b), the merus (Fig. 3A/20c) with three spines on the inner margin while no spines are found on the outer margin, the carpus (Fig. 1A/20d) which has an inner carpal spine or tooth, the claw (Fig. 1A/20e) which has a palm, pollex, and cutting conical teeth (Fig. 1A,B/20f,20g,20h), and the dactylus (Fig. 1B/20i) as the fingertip (Fig. 1B/20j), in accordance with Abbas et al. (2016) and Lai et al. (2010). The right claw is slightly larger than the left claw (Fig. 1C).

Walking legs (second, third, and fourth pereiopods) (Fig. 1B/21,22,23) are flattened laterally and are composed of the coxa, basis, ischium, merus, carpus, propodus, and dactylus. The swimming leg (fifth pereiopod) (Fig. 1B/24) has a flat, paddle like dactyl and propodus, in the contrary, Lai et al. (2010) stated that in *P. pelagicus*, the dactylus of the fifth pereiopod was oval and relatively elongated. Moreover, Tavares (2003) mentioned that in swimming crabs, the last pair of legs was usually distinctly adapted for swim-

ming, and was flattened and paddle-shaped, but in a few species it was flattened without being paddle-shaped.

The abdomen (Pleon) (Fig. 3) is present on the caudoventral surface of the crab body, and has six abdominal segments, the telson (terminal end of the abdomen), and pleopods, similarly to the observations of Tavares (2003), who observed that true crabs had a reduced, straight, and symmetrical abdomen bent under the cephalothorax, this abdomen lacked biramous uropods.

The abdomen of the male (Fig. 3A/27) is narrow rostrally with a small telson (Fig. 3A/28), and has a broad base, while the mature female abdomen is a broad triangle with convex sides. Additionally, the female telson (Fig. 3D/28`) has a small broad base. In males, the first and second segments of the abdomen are situated caudally after the end of the carapace, the third, fourth, and fifth segments are fused together, and the sixth segment is free and related to the terminal telson. In contrast, Lai et al. (2010) revealed that in *P. pelagicus* the sixth segment of the male abdomen was relatively short and broad. On the other hand, Meyer (2014) detected that the seven segmented pleon contained appendages; with each segment carrying a pair of biramous pleopods. The first pair of pleopods is the gonopods; while the last pleopods, together with the telson, form the tail fan forming uropods.

In mature females there are six separated abdominal segments (Fig. 3D/27) on the ventral surface of the abdomen; the intestine (Fig. 3B/32) is a small transparent tube that ends at the anus (Fig. 3E/33) located ventrally at the telson. The female vulva or gonopore (Fig. 3E/33`) is a small opening situated along the midline groove at the level of the sixth thoracic segment after reflection of the abdomen. In males, the penis (Fig. 3B/31) carries the male gonopore which is the male genital opening on the penis tip and is located near the fifth leg coxa cranial edge. The penis is a short, thin, transparent organ with a blunt end.

Abdominal appendages (pleopods) (Fig. 3B/29a, b) consist of two pleopods (gonopods) in the male, in accordance with Hidayani et al. (2018). The first and second appear on the ventral surface of the abdomen. The first gonopod (Fig. 3B/29a) is curved, tubular, and is the longer and more cranial one. It is the intromittent organ, While Lai et al. (2010) explored that *P. pelagicus* first gonopod was distinct and angled. Previously, Hidayani et al. (2018) illustrated that in *Portunus armatus* the basal part of first gonopod was rounded. The second gonopod (Fig. 3B/29b) is smaller and caudal to the first one. The female has several paired biramous pleopods (Fig. 3E/29`) situated on each of the abdominal segments except the last one.

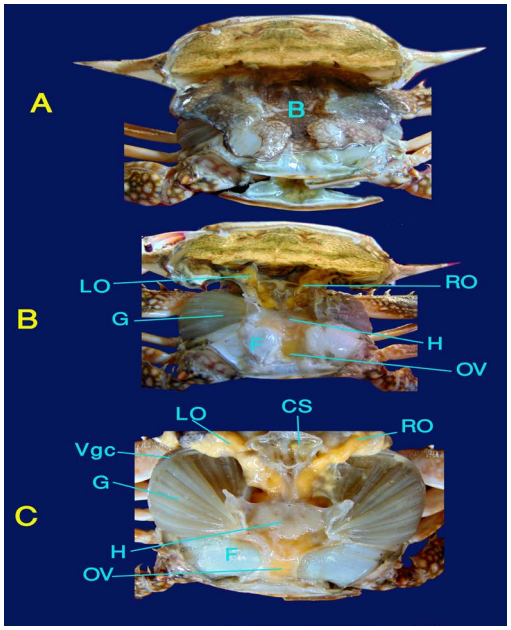

Figure 5: Photographs showing the internal organs of a female blue swimmer crab (*P. pelagicus*), A; The carapace reflected, B; Following removal of branchiostegite, C; Reflected carapace with view of internal organs.

INTERNAL ANATOMICAL ORGAN OF CRAB (*P. PELAGICUS*)

In this crab the branchiostegite (Fig. 5A/B) is formed from a double fold of the body wall. It is a thin, dark pigmented membrane which lies directly under the carapace. The respiratory organs, the gills (branchiae) (Fig. 5,6,7,8/G) are large paired triangular masses which are yellowish or grayish in color. They occupy the branchial chamber on each side of the cephalothorax from the second to fourth segments and are covered by the inner surface of skeletal branchiostegite of the carapace. There are eight gills on each side of body, which are composed of dorsal and ventral parts. Each gill is characterized by paired serial lateral tubular lamellae, which are termed bronchial filaments (Fig. 6B/Bf). These appear closed-spaced and leaf-like, and rise from the long central branchial arch (Fig. 6B/Ba). The dorsal gill cleaner and ventral gill cleaner (Fig. 6/Dgc&Vgc) are small flap-like structures similar to paddles or appendages of the maxilla and are called gill bailers or scaphognathites. These are located above and below the sides along the gills. The anterior edge of the base of the gills (Fig. 4N) is caudal to the first maxilliped. Our results concurred with previous descriptions (Felgenhauer, 1992; Venezia et al., 1992). The heart (Fig. 5B,5C/H) is a soft, white or gray, rectangular shape that lies on the midline, posterior to the stomach and between the flanks (Fig. 5,6A,7/F).

The female crab reproductive system is bilateral in regards to ovaries, oviducts and seminal receptacles, in addition to single vagina, and female gonopore. The ovaries are paired, elongated organs located dorsally in the cephalothorax and thorax in the same relative position as the male testis and

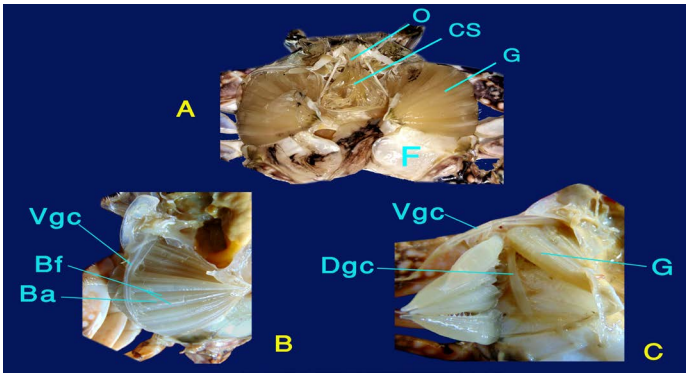

Figure 6: A, B & C; Photographs showing the gills of the crab

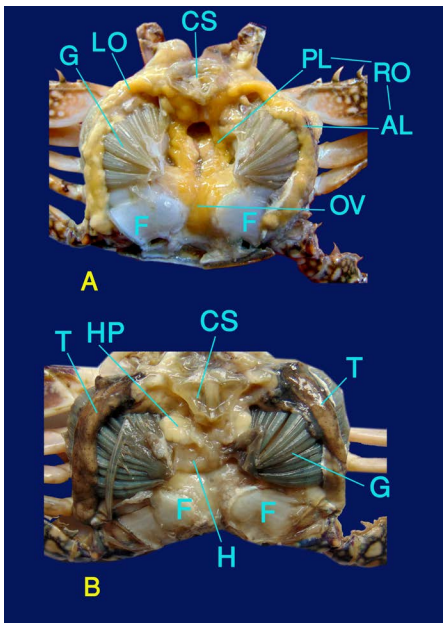

Figure 7: A & B; Photographs showing the internal organs of a female and male blue swimmer crab (*P. pelagicus*), respectively

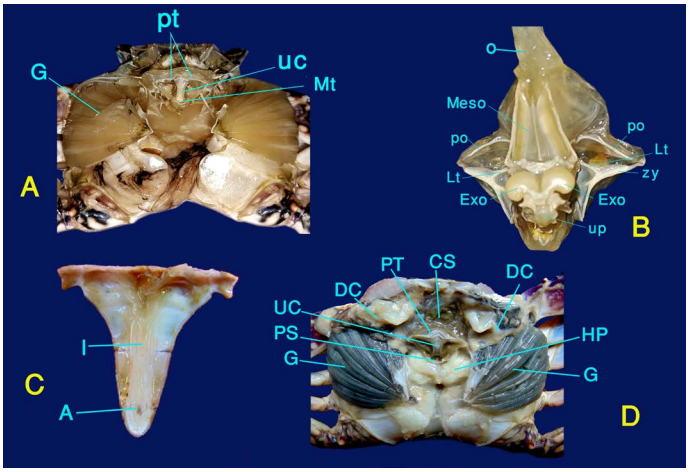

Figure 8: Photographs showing the digestive system of the crab, A, D; Dorsal view of the internal organs after carapace removal, B; Magnified view of the stomach, C. Inverted male abdominal segments

Legend of Fig. (5 to 8):
B, branchiostegite; Bf, branchial filament; Ba, branchial arch; Dgc, dorsal gill cleaner; Vgc, ventral gill cleaner; H, heart; F,flanc; LO, left ovary; RO, right ovary; AL, anterior lobe; PL, posterior lobe; OV, oviduct; T, testis; CS, cardiac stomach; Po, pectineal ossicles; PS, pyloric stomach; Meso, mesocardiac ossicles; Pt, pterocardiac ossicles; Uc, urocardiac ossicle; Zy, zygocardiac ossicles; Up, uropyloric ossicle; Exo; exopyloric ossicle; Mt, median teeth; Lt, lateral teeth; DC, digestive ceca; HP, hepatopancreas; I, intestine; A, anus

lie dorsal to the hepatopancreas. Their size and color depend on the crab's stage of maturity. They extend below the carapace from the lateral spine to the posterior end. The mature ovaries are orange in color and enlarged in size and completely obscure the underlying hepatopancreas. Our observation is similar to those of Krol et al., 1992; Felgenhauer, 1992; Sukumaran & Neelakantan, 1998; Quinito, 2007; Ikhwanuddin et al., 2014; Vallina et al., 2014; Kienbaum et al., 2017. Each ovary consists of anterior and posterior lobes (Fig. 7A/AL&PL). The posterior part of the right and left ovaries (Fig. 7A/RO&LO) are connected by a narrow isthmus to form the oviduct (Fig. 7A/OV) which is situated in the midline, ventral to the heart, and behind the stomach. This result similar to Rotllant et al. (2007) and González-Pisani et al. (2011) in regards to majoid species of crabs. The distal region of the oviduct consists of the seminal receptacle appeared as pouch. It is connected to the ovaries dorsally, and the vagina ventrally, at the sternite of the fifth thoracic segment. The vagina is a short, thin, translucent tube which connects to the exterior in the sixth sternite of the thorax, at the level of the third pair of pereiopods, via two holes called gonopores or vulva (Fig. 3K/33`).

The male crab reproductive system consists of a pair of testes, vas deferens, and gonopods. The testes (Fig. 7B/T) are two small, long, slender, convoluted tubes, which are white or grayish in color. Previous similar reports (Beninger et al., 1988 in snow crab; Vallina et al., 2014 in family Portunidae; Kienbaum et al., 2017 in spider crabs) to those of the current study in the blue swimmer crab clarified that testis were located laterally to the lateral spine, extend anterior and partially obscured of the digestive ceca on either side of the stomach. They then turn to posterior in the midline and then both testes connect medially. The vas deferens are paired, highly convoluted, small-diameter tubules, extending from the posterior end of the testes to the penis (Fig. 3H/31) which has the male genital opening (male gonopore) (Fig. 3H/30).

The digestive tract of the crab is divided into three regions: the foregut, midgut, and hindgut. The foregut is

composed of the mouth, esophagus, and stomach. The midgut contains the digestive ceca and digestive gland (hepatopancreas). The hindgut has a simple straight tube as an intestine that ends in the anus. These findings were in agreement with Felgenhauer (1992) and Ceccaldi (2006). According to similar studies of the phylogeny of feeding mechanisms (Sahlmann et al., 2011; Naderloo et al., 2010; Bro¨sing, 2010), the mouth is associated with specialized prehensile appendages; the maxillae, mandibles, and maxillipeds. The anterior part of the mouth is reinforced by a hard labrum. The esophagus (Fig. 6A,8B/O) is a short straight membranous tube directed posterior to its opening on the anteroventral wall of the cardiac stomach. The stomach (proventriculus) is a large, bulging, transparent, thin-walled sac, which lies dorsally along the midline of the anterior thorax. It is a complex structure whose walls bear calcareous ossicles, and is divided into a large, dorsal cardiac stomach (anterior chamber), and a smaller, ventral, pyloric stomach (posterior chamber) that results resemble studies mentioned by Ceccaldi (2006) and Icely & Nott (1992). The cardiac stomach (Figs. 5C,7A,7B,8A,8D/CS) is a large balloon-like structure with a thin transparent wall in the anterior thorax, and is connected with the short esophagus. The anterior part of the cardiac stomach has a thin, flexible chamber. The posterior region of the cardiac stomach and the pyloric stomach are reinforced and supported by a number of articulated ossicles, and the dorsal wall of the posterior region of the cardiac stomach has four ossicles: the unpaired mesocardiac ossicle, the paired pterocardiac ossicles, the paired lateral zygocardiac ossicles, and the unpaired centrally placed urocardiac ossicle. (Fig. 8B/Meso, Pt, Zy, Uc). The urocardiac ossicle extends from the center of the dorsal wall of the cardiac stomach posteriorly. It is flattened dorsoventrally and has an elongated plate in the anteroposterior direction and a median tooth. The zygocardiac ossicles are paired ossicles which lie posteriorly and laterally of the cardiac chamber and carry lateral teeth on the posterior ends. Pectineal ossicles (Fig. 8B/Po) are paired curved rods located on the lateral walls of the cardiac stomach below the zygocardiac ossicles and are articulated anteriorly with the zygocardiac and pterocardiac ossicles. The pyloric stomach (Fig. 8D/Ps) is a small ventral region of the stomach. It is posterior and ventral to the cardiac stomach. The walls of the pyloric stomach bear three ossicles: the unpaired uropyloric ossicle (Fig. 8B/Up), which is connected to the urocardiac ossicles, and the pair of exopyloric ossicles (Fig. 8B/Exo). Moreover, Sakai (2004); Ceccaldi (2006); Brösing et al. (2007) observed great interspecific variation with differences in number, size, and morphology of supportive ossicles in both the cardiac and pyloric chambers according to different feeding habits. In contrast, in other groups of Decapoda, the stomach was very simple, with just a few ossicles or none at all (Icely and Nott, 1992). Noticeably, the literature reported that the posterior region of the cardiac stomach and the pyloric stomach were reinforced and supported by a number of articulated ossicles. The cardiac stomach had four ossicles and the pyloric stomach bore three ossicles (Felgenhauer, 1992; Paula et al., 2017; Rady et al., 2018). The digestive ceca (Fig. 8D/DC) are large, soft, amorphous, and yellow or greenish organs which blindly end and that occupy the periphery of the dorsal thorax. They may be completely obscured by the ovaries or testis in mature crabs. They extend along the anterior edge of the carapace, over the branchial chambers, and within the spaces around the heart and gonads. These observations agreed with Felgenhauer (1992), but Ceccaldi (1989) reported that crabs of the genus *Cancer* had three elongated tubular cecae; with two anterior symmetrical ones, and one posterior. In comparison, the lobster genus *Homarus* only has one short anterior coecum. The hepatopancreas (Fig. 7B,8D/HP) is a bilobed organ occupying either side of the stomach inside the cephalothorax. The color of the hepatopancreas varies from brown, green, or yellow. This result was in agreement with Ceccaldi (1989); Ramadevi (1990) and Felgenhauer (1992). The intestine (Fig. 8C/I) is a membranous tube without any demarcations that extends from the posterior end of the pyloric stomach along the ventral midline of the abdomen and enlarges to form a rectum at the sixth abdominal segment. It then terminates as a circular opening in the anus (Fig. 8C/A) which is located on the ventral surface of the telson.

CONCLUSION

We concluded that the color of the blue swimmer crab carapace was dark green in males and medium brown with light brown patches in females. The cephalothorax was found to have three pairs of biramous maxillipeds. The pereion was connected to five pairs of uniramous pereiopods. The abdomen of the male has a small telson; while the mature female had a telson with a small broad base. The female reproductive system consisted of bilateral ovaries, oviducts, seminal receptacles and single vagina, and gonopore, while the male reproductive system consisted of a pair of testes, vas deferens, and gonopods. The gills consisted of paired, triangular masses, and occupied the branchial chamber on each side of the cephalothorax. The stomach was a complex structure whose walls bore calcareous ossicles

DECLARATION

Ethical approval

This study was conducted according to international ethical standards set by the Institutional Animal Care and Use Committee (Vet CU 8/03/2022 /429).

Consent to participate

Not applicable as neither commercial trawls operating offshore and local fishermen supplied fish markets were involved in the research.

Consent for publication

Not applicable as neither by commercial trawls operating offshore and local fishermen supplied fish markets were involved in the research.

Data availability statement

The authors confirm that the data used to support the findings of this study are available within the article.

ACKNOWLEDGEMENTS

Not applicable as neither by commercial trawls operating offshore and local fishermen supplied fish markets were involved in the research.

CONFLICT OF INTEREST

There are no conflicts of interest to declare.

Funding

The authors research included into this article did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

AUTHORS CONTRIBUTION

Reem R. Tahon and Nora A Shaker designed the protocol, collected the samples, and performed the topographical anatomy studies of the blue swimming crab. Both authors drafted the manuscript, reviewed it, and approved the final version of the manuscript.

REFERENCES

Abbas E. M., Abdelsalam K. M., Mohammed-Geba K., Ahmed H. O., Kato M. (2016). Genetic and morphological identification of some crabs from the Gulf of Suez, Northern Red Sea, Egypt. Egyptian J. Aquat. Res., 42(3): 319-329.

Allen C.E., Zwaan B.J., Brakefield P.M. (2011). Evolution of sexual dimorphism in the Lepidoptera. Annual Review of Entomology, 56, 445-464. Asian J. Cell Biol. 9(1): 14-22. http:// doi.org/10.1146/annurev-ento-120709-144828

Beninger P.G., Elner R.W., Foyle T.P., Odense P.H (1988). Functional anatomy of the male reproductive system and the female spermatheca in the snow crab Chionoecetes opilio (0. Fabricius) (Decapoda: Majidae) and a hypothesis for fertilization. J. Crustac. Biol., 8: 322–332. https://doi.org/10.1163/193724088X00198.

Bro¨sing A., Richte S, Scholtz G. (2007). Phylogenetic analysis of the Brachyura (Crustacea, Decapoda) based on characters of the foregut with establishment of a new taxon. J. Zoolog. Systemat. Evol. Res. 45: 20–32.

Burkenroad M.D. (1963) The evolution of the Eucarida, (Crustacea, Eumalacostraca), in relation to the fossil record. Tulane Studies in Geology., 2(1): 3-17.

Ceccaldi H.J. (2006) The digestive tract: anatomy, physiology and biochemistry. Treatise on Zoology – Anatomy, Taxonomy, Biology –the Crustacea. 2: 85–203.

Ceccaldi H.J. (1989). Anatomy And Physiology Of Digestive Tract Of Crustaceans Decapods Reared In Aquaculture. Advances In Tropical Aquaculture Tahiti; Feb. 20 - March 4, 1989 Aquacop. Ifremer. Actes De Colloque 9 Pp. 243-259. https://doi: 103923/ajeb. 2014. 14.22.

Dubey S.K., Chakraborty D.C., Bhattacharya C., Choudhury A. (2014). Allometric Relationships of Red Ghost Crab Ocypode macrocera (H. Milne-Edwards, 1852) in Sundarbans Mangrove Eco-Region, India. World J. Fish Marine Sci., 6 (2): 176-181. http://dx.doi.org/10.5829/idosi.wjfms.2014.06.02.82337

Eman M. Abbas, Khaled M. Abdelsalam, Khaled Mohammed-Geba, Hamdy O. Ahmed, Mikio Kato (2016). Genetic and morphological identification of some crabs from the Gulf of Suez, Northern Red Sea, Egypt. Egyptian J. Aquat. Res. (2016) 42: 319–329. https://doi.org/10.1016/j.ejar.2016.08.003

Ewers-Saucedo C., Hayer S., Brandis D. (2015). Functional morphology of the copulatory system of box crabs with long second gonopods (Calappidae, Eubrachyura, Decapoda, Crustacea).– J. Morphol. 276: 77 – 89. https://doi.org/10.1002/jmor.20322

Felgenhauer B. (1992). Internal Anatomy of the Decapoda: An Overview, Chapter 3, JVMicroscopic, Anatomy of Invertebrates , Volume 10: Decapod Crustacea, pages 45-75 , Wiley-Liss, Inc.

González-Pisani X., Barón P., López Greco L.S. (2011). Functional anatomy of the female reproductive systems of two spider crabs (Decapoda, Majoidea). – Invertebrate Biol. 131: 61– 74.

Hidayani A. A., Trijuno D. D., Fujaya Y., Umar M. T. (2018). The morphology and morphometric characteristics of the male swimming crab (Portunus pelagicus) from the East Sahul Shelf, Indonesia. Aquacult. Aquar. Conservat. Legislat., 11(6): 1724-1736.

Hosseini M., Pazooki J., Safaie M., Tadi-Beni F. (2014). The Biology of the Blue Swimming Crab Portunus segnis (Forskal, 1775) along the Bushehr Coasts. Environ. Stud. Persian Gulf., 1 (2): 81-92.

Icely J. D., Nott J. A. (1992). Digestion and absorption: digestive system and associated organs. Microscop. Anatom. Invertebrat., 10: 147–201.

Ikhwanuddin M., Nur Atika J., Abol Munafi A., Farouk M. (2014). Reporoductive Biology On The Gonad Of Female Orange Mud Crab, Scylla Olivacea (Herbst, 1796) From The West Coastal Water of Peninsular Malaysia. https://doi:10.3923/ajcb.2014.14.22

Ikhwanuddin M., Azra M. N., Sung Y. Y., Bolong A. M. A., Long S. M. (2013). Growth and survival of blue swimming crab (Portunus pelagicus) reared on frozen and artificial foods. Agricult. Sci. 4(6A):76-82. https://doi:10.4236/as.2013.46A012

Ikhwanuddin M. (2010). Species diversity, carapace width-bodyweight relationship, size distributionand sexratio of mud crab, genus scylla from setiu wetlands of terengganu

coastal waters, malaysia ikhwanuddin, m.*, Bachok, z°, hilmi, m. G°, azmie, g. And zakaria, m. Z°. J. Sustain. Sci. Manage., 5(2): 97-109.

Johnson DD, Gray CA, William G, Macbeth WG. (2010). Reproductive biology of Portunus pelagicus in a South-East Australian Estuary. J. Crustacean Biolog. 2010;30(2):200–205. https://doi.org/10.1651/08-3076.1.

Kienbaum K, Scholtz G., Becker C. (2017). The morphology of the male and female reproductive system in two species of spider crabs (Decapoda: Brachyura: Majoidea) and the issue of the *velum* in majoid reproduction, Arthropod Systemat. Phylog. — 75 (2) 245-260. https://doi.org/10.1002/jmor.20818

Krol R.M., Hawkins W.E., Overstreet R.M. (1992). Reproductive components. Pp. 295 – 343 in: Harrison F.W., Humes A.G. (eds), Microscopic Anatomy of Invertebrates. Decapod Crustacea.– Wiley-Liss, Inc., New York.

Lai J. C., Ng P. K., Davie P. J. (2010). A revision of the Portunus pelagicus (Linnaeus, 1758) species complex (Crustacea: Brachyura: Portunidae), with the recognition of four species. Raffles Bullet. Zool., 58(2).

Martin J.W., Davis G.E. (2001). An updated classification of the Recent Crustacea. Natural History Museum of Los Angeles County, Science Series., 39: 1-124.

Meyer R. (2014). Integrative taxonomy of decapod crustaceans with traditional and modern methods (Doctoral dissertation, lmu).

Mojekwu TO, Anumudu CI. (2015). Advanced techniques for morphometric analysis in fish. J. Aquac. Res. Develop. 6(8): 1-6. https://doi: 10.4172/2155-9546.1000354.

Naderloo R., Tu¨rkay M., Chen H.-L. (2010). Taxonomic revision ofthe wide-front fiddler crabs of the Uca lactea group (Crustacea:Decapoda: Brachyura: Ocypodidae) in the Indo-West Pacific. Zootaxa. 2500: 1–38.

New M.B. (1999). Global aquaculture; current trends and challenges for the 21st century, World Aquacult., 30(1): 8-13 and 63-79

Padate V. P., Rivonker C. U., Anil A. C. (2013). A new record of Scylla olivacea (Dcapoda, Bachyura, Portunidae) from Goa, central west coast of India - a comparative diagnosis. Indian J. Geo-Marine Sci. 42(1):82-89.

Paula de la barra, Maite narvarte, vero' nica williner (2017). Functional morphology of the gastric mill of the swimming crab Ovalipes trimaculatus (Decapoda: Portunidae) Journal of the Marine Biological Association of the United Kingdom, page 1 of 8. # Marine Biological Association of the United Kingdom, doi:10.1017/S0025315417000844

De La Barra p. , Narvarte M., Williner V. (2018). Functional morphology of the gastric mill of the swimming crab Ovalipes trimaculatus (Decapoda: Portunidae)., J. Marine Biolog. Assoc. United Kingdom., 98(7): 1659-1666. https://doi.org/10.1017/S0025315417000844

Rady A., Sallam W., Abdou N., EL. Sayed A. (2018). Food And Feeding Habits Of The Blue Crab, Callinectes Sapidus(Crustacea: Decapoda: Portunidae) With Special Reference To The Gastric Mill Structure., Egyptian J. Aquat. Biolog. Fisher., 22(5): 417-431. https://do.org/10.21608/Ejabf.2018.23925

Ramadevi K., Shyamasundari K. , Hanumantha K. (1990). Observation On The Hepatopancreas Of *Ocypoda Platytarsis* (Milne-Edwards) (Crustacea, Brachyura) Boll. Zool. 57: 261-265. https://doi.org/10.1080/11250009009355705

Ravi R, Manisseri MK, Kuriakose S., (2008). Relationship between morphometric characteristics and fecundity of Portunus pelagicus (Linnaeus, 1758) J. Marine Biolog. Assoc. India. 2008;50(2):217–220.

Rawat S, Benakappa S, Kumar J, Naik K, Pandey G, Pema CW. (2017). Identification of fish stock based on truss morphometric: a review. J Fish Life Sci. 2(1): 9-14.

Redzuari A., Azra M. N., Abol-Munafi A. B., Aizam Z. A., Hii Y. S., Ikhwanuddin M. (2012). Effects of feeding regimes on survival, development and growth of blue swimming crab, Portunus pelagicus (Linnaeus, 1758) larvae. World Appl. Sci. J. 18:472-478. https://doi:10.5829/idosi.wasj.2012.18.04.313

Rotllant G., González-Gurriarán E., Fernández L., Benhalima K., Ribes E. (2007). Ovarian maturation of the multi-spawning spider crab Maja brachydactyla (Decapoda: Majidae) with special reference to yolk formation. – Marine Biol. 152: 383 – 394.

Sahlmann C., Chan T.Y., Chan B.K. (2011). Feeding modes ofdeep-sea lobsters (Crustacea: Decapoda: Nephropidae and Palinuridae) in Northwest Pacific waters: functional morphology of mouthparts, feeding behaviour and gut content analysis. Zoologischer Anzeiger – J. Comparat. Zool. 250: 55–66.

Sajina AM, Chakraborty SK, Jaiswar AK, Pazhayamadam DG, Sudheesan D. (2011). Stock structure analysis of Megalaspis cordyla (Linnaeus, 1758) along the Indian coast based on truss network analysis. Fish Res. 108: 100-105. https://doi:10.1016/j.fishres.2010.12.006

Sakai K. (2004) The diphyletic nature of the infraorder Thalassinidea(Decapoda, Pleocyemata) as derived from the morphology of the gastric mill. Crustaceana. 77: 1117–1129.

Swatipriyanka S. , Jahageerdar S., Jaiswar AK., Chakraborty SK., Sajina AM., Dash GR. (2011). Stock structure analysis of Decapterus russelli (Ruppell, 1830) from east and west coast of India using truss network analysis. Fish Res. 112: 38-43 https://doi.org/10.1016/j.fishres.2011.08.008

Soundarapandian P., Varadharajan D., Anand T. (2013). Male reproductive system of blue swimming crab, Portunus pelagicus (Linnaeus, 1758). J. Cytol. Histol. 5:206. http://dx.doi.org/10.4172/2157-7099.1000206

Sukumaran K., Neelakantan B. (1998). Maturation process and reproductive cycle in two marine crabs, *Portunus(Portunus) sanguinolentus* (Herbst) and *Portunus (Portunus) pelagicus* (Linnaeus) along the Karnataka coast, Indian J. Fish., 45(3) : *257-264*. http://eprints.cmfri.org.in/id/eprint/177

Tavares M. (2003). "True crabs." FAO species identification sheets for fishery purposes: Western Central Atlantic (Fishing Area 31). FAO, Rome: 327-352.

Trivedi J. N., Vachhrajani K. D. (2012). New record of color morphs of brachyuran crab Charybdis annulata Fabricius, 1798 (Decapoda: Portunidae). Arthropods. 1(4):129-135.

Quinitio E. T., J. De Pedro, F. D. Parado-Estepa. (2007). Ovarian maturation stages of the mud crab Scylla serrata. Aquacult. Res. 38:1434–1441.

Vallina M., Moyano M., Cuartas E., Gavio M. (2014). Reproductive System And Size Maturity Of The Paddle Crab *Ovalipes Trimaculatus* (Brachyura: Portunidae) Along The Argentine Coast., J. Crustacean Biol., 34(3): 357-366. https://doi.org/10.1163/1937240X-00002239

Venezia L.D., Zago C., Siebers D., Menetto A. (1992). Structural elements oi the gills of the shore crab *Carcinus mediterraneus* Helgoi.~Nder Meeresunters 46: 425-434 https://doi: 10.1007/BF02367208

Zainal K. A. Y. (2013). Natural food and feeding of the commercial blue swimmer crab,Portunus pelagicus (Linnaeus, 1758) along the coastal waters of the Kingdom ofBahrain. J. Assoc. Arab Universities Basic Appl. Sci. 13(1):1-7. https://doi:10.1016/j.jaubas.2012.09.002