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Full Length Research Paper

Brachyuran crabs (Crustacea: Decapoda) in the Suez Canal, Egypt, and their associated epifauna

Hamed A. El-Serehy[1]*, Mohamed H. Abd Al-Hameid[2], Khaled A. Al-Rasheid[1] and Mohamad M. Gewik[1]

[1]Zoology Department, College of Science, King Saud University, P. O. Box 2455 Riyadh 11451, Saudi Arabia.
[2]Department of Marine Science, Faculty of Science, Port Said University, Port Said, Egypt.

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The Suez Canal is the main connecting link between the Red Sea and the Mediterranean. On its route from the Red Sea in the south to the Mediterranean in the north, it crosses different lakes which represent different habitats, and in some cases, hinder the migration of the faunal community from one sea to the other. Ten Brachyuran species belonging to ten genera and eight families were recorded in the canal water, all of Indo-Pacific origin. Eight of these species have been introduced into the Mediterranean, while four are a new geographical record for the Suez Canal. The two families of Leucosiidae, and Portunidae were represented by two species each, while the other six families of Euryplacidae, Grapsidae, Galenidae, Pisidae, Majidae and Xanthidae each included one species. The integuments of the pisid *Hyastenus hilgendorfi* and the majid *Schizophrys aspera* from the Suez Canal were densely covered with an assortment of animal materials, both living and dead. The two spider crabs use their mask primarily for camouflage and are well adapted as immigrant species to the canal ecosystem.

Key words: Brachyura, Suez Canal, Egypt.

INTRODUCTION

The Suez Canal is the main connecting link between the Red Sea and the Mediterranean. On its route, from the Mediterranean Sea in the north to the Red Sea in the south, it crosses Timsah Lake, the Great Bitter Lake and Little Bitter Lake. The original length of the canal was 163 km, only 70 km of which were cut from dry land. In the earlier years after its opening in 1869 the canal had a navigational depth of 8 m and a surface width of 59-98 m; successive projects to widen and deepen the canal have brought its depth to 25 m and its width to 205 m. There are no locks on the main canal; for most of the year the mean sea level at Suez is slightly above that at Port Said and a north-bound current flows through the central parts of the canal, while south-bound currents occur from July-September when the Mediterranean at Port Said is a little higher than the Red Sea at Suez. With the opening of the Suez Canal for shipping, the way was also opened for the movement of the marine organisms from the Red Sea to the Mediterranean Sea and vice versa (Aron and Smith, 1974; Por, 1978).

Crustaceans are important members of marine benthic communities. In addition to the value of the larger and more abundant species for human consumption, a tremendous variety of small species contribute to the complexity and functioning of ecosystems (Hendrickx, 1995). Among decapod crustaceans, the infraorder Brachyura is prominent because of its great diversity, comprising about 1271 genera and 6793 species worldwide (Ng et al., 2008; De Grave et al., 2009).

Brachyuran crabs were recorded for the first time in the Suez Canal by Keller (1883) then by Krukenberg (1888) who identified two crab species (*Portunus pelagicus* Linnaeus, 1758 and *Pilumnopeus vauquelini* Audouin, 1826). Since that time no more information concerning Brachyuran crabs in the canal were available until

*Corresponding author. E-mail: helserehy@ksu.edu.sa. Tel: +966 1 4675758. Fax: + 966 1 4678514.

the Cambridge Expedition at the end of 1924 where some authors gave attention to this animal group, for example Fox, (1926), Calman, (1927) and Gruvel, (1936). More recently, Brachyuran crabs of the Suez Canal had attracted the attention of a few authors including Holthuis (1956), Kadry (2007) and Sallam and Wicksten (2011).

Some Brachyuran crabs are known as masking crabs, because they select materials from their environment to attach to various parts of their bodies. The materials are usually sessile organisms such as algae, bryozoans, and sponges. These adventitious materials are collected and applied to the body using the chelipeds and are held in position by peculiar hooked setae. The organisms used in covering continue to grow (Woods and McLay, 1994). Many species of crabs also have epibionts, which attach themselves to the surface without action of the crab (Hartnoll, 1993).

The purpose of this study is to update the species check-list and to report new records of Brachyuran crab species inhabiting the Suez Canal ecosystem, in order to facilitate further studies on this fauna by interested researchers. The masking behaviour of the majoidean crabs collected from the Suez Canal was also studied with the aim of building up faunistic information about immigrant species to this new habitat, which is still subjected to continuous repeated major and drastic changes.

MATERIAL AND METHODS

Specimens were collected on a monthly basis from September 2007 to August 2008 from six locations along the Suez Canal. These locations were selected to represent the best known fishing sites along the canal: Ismailia, on Timsah Lake; El-Ferdan and El-Kantara (Both on the Suez Canal proper); Deversoir, Fayed and Fanara, on Bitter Lakes (Figure 1). Crabs were obtained using an epibenthic trawl of 2.7 m mouth width and a net with 20 –mm mesh size, especially designed to be operated from a small inflatable dinghy. Trawls were pulled at a speed of 0.65-0.80 ms^{-1} during 10-30 min. The range of fishing depths extended from 5-25 m. After sampling all crabs were immediately fixed in 4% buffered formalin seawater.

In the laboratory, crabs were sorted by species, sex, ovigerous condition and presence of epibionts. The standard measure of body size (carapace length: CL, carapace width: CW, and carapace height: CH) was determined to the nearest 0.1 mm by means of a digital caliper. The main sources for species identification, synonymies and geographical distribution were Barnard (1950), Banerjee (1960), Crosnier (1962), Guinot (1967), Serene (1968), Stephenson (1972), Barnes (1977), Griffin and Tranter (1974), Bowman and Abele (1982), Galil (2000), Galil et al. (2002), Yokes and Galil (2004), Galil (2006), Ng et al. (2008), and Appeltans et al. (2011). Where present, macro-epibionts were examined and the area covered by each taxon was estimated visually as a percentage of the total carapace area. Identification to species level was done as much as possible using the following references: Por and Lerner-Seggev (1966), Millar (1970), and Hooper and Van Soest (2002).

The percentage frequency of occurrence index (*F*) was calculated for the various epibiont categories according to the following formula:

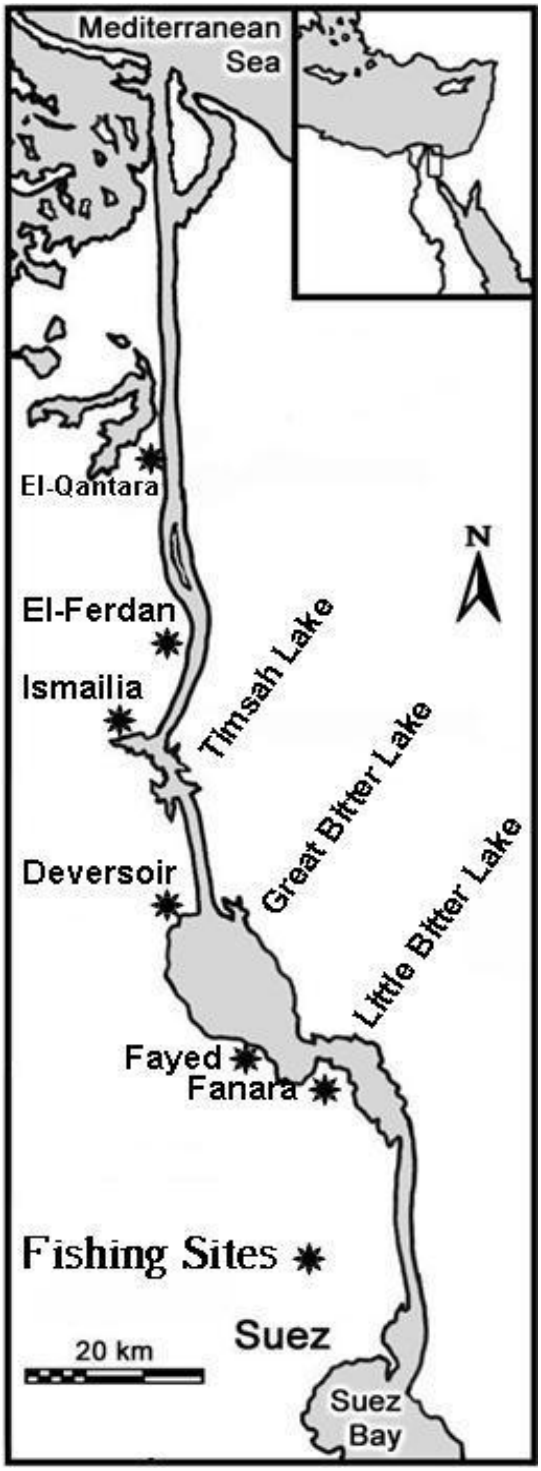

Figure 1. Map of the Suez Canal showing the location of the fishing sites.

$$\% F = (ni/N) \times 100$$

Where *ni* is the number of crabs with epibiont category on the integument, and N is the total number of crabs with covering materials (Sallam and Wicksten, 2011).

Table 1. Brachyuran species collected from the Suez Canal, with origin and/or native range and occurrence in the Red Sea, Suez Canal and/or Mediterranean indicated with a positive "+" Legend. New record in the Suez Canal indicated with a (*) Legend; I: Indian; IP: Indo-Pacific; IWP: Indo-West Pacific; RS: Red Sea; TL: Timsah Lake; BL: Bitter Lakes; SCP: Suez Canal Proper; [1] Appeltans et al., 2011, [2] Zenetos et al., 2010, [3] Galil et al., 2002 (update 2008), [4] Galil, 2006.

Species	Origin [1] [2] [3]	Red Sea [1] [3]	Suez Canal [4]	Suez Canal Present study	Mediterranean [2] [3] [4]
Leucosiidae					
Coleusia signata (Paulson, 1875)	IWP	+	+	+ (BL, TL)	+
Myra subgranulata Kossmann, 1877	I, RS	+	+	+ (BL)	+
Pisidae					
Hyastenus hilgendorfi De Man, 1887	IWP	+	+	+ (BL)	+
Majidae					
Schizophrys aspera (H. Milne Edwards, 1834)*	IWP	+			
Portunidae				+ (BL)	
Portunus segnis (Forsskål, 1775)	I	+	+	+ (BL, TL, SCP)	+
Thalamita poissonii (Audouin, 1826)	IWP	+	+	+ (BL, TL, SCP)	+
Euryplacidae					
Eucrate crenata De Haan, 1835	IP	+	+	+ (BL, TL)	+
Grapsidae					
Grapsus tenuicrustatus Herbst, 1783*****	IP	+		+ (BL, TL)	
Galenidae					
Halimede tyche (Herbst, 1801)*****	IWP			+ (BL)	+
Xanthidae					
Atergatis roseus (Rüppell, 1830)*	IP	+		+ (SCP)	+

RESULTS

A total of 6421 Brachyuran specimens, belonging to ten species, were collected during the present survey. Of the ten species identified, four are new geographical records for the Suez Canal (Table 1 and Figure 3). All Brachyuran species collected from the Suez Canal during the present study have also been recorded either from the Red Sea or from the Mediterranean (Table 1). The families Leucosiidae and Portunidae were each represented by two species while the other six families (Euryplacidae, Grapsidae, Galenidae, Majidae, Pisidae and Xanthidae) were each represented by one species. Among the ten species recorded, *Portunus segnis*, with 1450 individuals collected, was the most common (22.6%), while *Grapsus tenuicrustatus*, with 188 individuals collected, was the least common (2.9 %). Table 2 shows the standard measure of body size (carapace length, carapace width and carapace height) in mm, percentage of males, non-ovigerous and ovigerous females collected during the present study.

Of the 1625 individuals of the spider crabs *Schizophrys aspera* (734) and *Hyastenus hilgendorfi* (891) collected, 243 and 301, respectively, were devoid of masking material. Figure 2 displays the percentage cover of the different covering materials for each sex in the two species. Considerable differences in total percentage of cover were found between groups. Statistically, significant differences were recorded between the two species among the various groups of epibiota utilized for masking ($p < 0.05$), however, these differences were found to be not significantly different among the sexes of the same species ($p > 0.05$). Male carapaces were covered with detritus more than those of females in the two species. Barnacles showed the highest occurrence among other epifauna for the two groups of individuals in *Hyastenus hilgendorfi* (34% for males and 21.2% for females) while tube worms showed the highest occurrence among other epifauna for the two groups (males and females) of individuals in *Schizophrys aspera* (10.6 and 18.5%, respectively).

A total of 27 species of epifauna were identified in the mask composition of the two spider crabs (*Hyastenus hilgendorfi* and *Schizophrys aspera*). Identified covering material was classified into seven basic groups (Table 3): sponges (Porifera), hydrozoans (Cnidaria), tube worms (Annelida), barnacles (Crustacea, Cirripedia), bryozoans (Bryozoa), bivalves (Mollusca), tunicates (Urochordata). Table 4 displays the differences between the sex in the two decorator crabs: males [*Schizophrys aspera* (333); *Hyastenus hilgendorfi* (500)} and females {*Schizophrys aspera* (401); *Hyastenus hilgendorfi* (391)] in the occurrence of the various groups of epifauna.

DISCUSSION

The present study adds four species (*Schizophrys*

Table 2. The ten Brachyuran crab species collected from the Suez Canal during the present study with their measurements (in mm) of carapace length (CL), carapace width (CL), carapace height (CH) and numbers of different male and female categories.

Species	Carapace length CL (mm)	Carapace width CW (mm)	Body height CH (mm)	Number of individuals collected							
				Males		Ovigerous females		Non-Ovigerous females		Total	
				Number	%	Number	%	Number	%	Number	%
Coleusia signata (Paul'son, 1875)	6.5-20	6-21	5.9-21	410	43.6	105	11.2	425	45.2	940	14.6
Myra subgranulata Kossmann, 1877	32-52	19-42.5	19-22	170	55.6	46	15.0	90	29.4	306	4.8
Hyastenus hilgendorfi De Man, 1887	22-40	21-28.3	17.8-19	500	56.1	91	10.2	300	33.7	891	13.9
Schizophrys aspera (H. Milne Edwards, 1834	25-75	19-64.4	33-35.8	333	45.4	83	11.3	318	43.3	734	11.4
Portunus segnis (Forsskål, 1775)	22-44.5	78-86.3	20-22.7	490	33.8	370	25.5	590	40.7	1450	22.6
Thalamita poissonii (Audouin, 1826)	18-53	24-53	18-19.5	230	46.5	77	15.6	188	38.0	495	7.7
Eucrate crenata De Haan, 1835	9-27.5	11-33	8-17	366	50.1	117	16.0	248	33.9	731	11.4
Grapsus tenuicrustatus Herbst, 1783	37-53	47-57	18-23	93	49.5	30	16.0	65	34.6	188	2.9
Halimede tyche (Herbst, 1801)	22-37	33-45.5	17-22.2	60	31.4	38	19.9	93	48.7	191	3.0
Atergatis roseus (Rüppell, 1830)	32-38	48-53.3	21-21.5	230	46.5	77	15.6	188	38.0	495	7.7
Total										6421	

aspera, *Grapsus tenuicrustatus*, *Halimede tyche* and *Atergatis roseus*) to the number of Brachyuran species reported in previous studies conducted in the canal waters (Calman, 1927; Gruvel, 1936; Holthuis, 1956; Por and Ferber, 1972). This increase in Brachyuran species could be due to the increased migration activity of marine organisms between the Red Sea and Mediterranean through the Suez Canal.

All ten species recorded from the Suez Canal in this work are of Indo-Pacific origin, the major part recorded also in the Red Sea. Eight of these species, have been introduced into the Mediterranean (Galil, 2006; Zenetos et al., 2010). Many authors have attempted to explain the one-sided migrational phenomenon of the fauna from the Red Sea to the Mediterranean. Early investigators (Fox, 1924; Fox, 1926; Por, 1978) asserted that the northbound currents, which prevailed in the canal during most of the year, might have been responsible for the preponderance of Red Sea over Mediterranean species inhabiting the canal.

It was claimed that the environmental conditions and community structure of the Mediterranean favor colonizers from the Red Sea, whereas colonizers from the Mediterranean are far less adapted to successfully colonize the Red Sea (Aron and Smith, 1974; Por, 1978). Furthermore, by utilizing a hydraulic model for the canal's water currents, Agur and Safriel (1981) were able to confirm that the Suez Canal currents do serve as a bottleneck inhibiting the process of southbound dispersal, and, thus, contributing to the asymmetry of colonization in the two seas. Therefore, the ten Brachyuran crab species can be considered as Red Sea immigrant fauna to the Suez Canal, and the presence of ovigerous females (Table 2) indicates that each of the immigrant crab has a prolonged breeding period in the Suez Canal water. Thus Brachyuran crabs not only use the Suez Canal as a passage way but also as a habitat.

Crabs of the Superfamily Majoidae use materials found in their environment to camouflage themselves (Wicksten, 1980; Wicksten, 1983; Wicksten, 1993). This behavior is called masking. Two species of the family Pisidae, and Majidae that is, *Hyastenus hilgendorfi* and *Schizophrys aspera*, respectively, were recorded in the canal water with epifuna on their integument. The epifauna that existed on the integument of those species fell into two categories: those accumulated by passive acquisition such as barnacles, tube worms, and bivalves and those transplanted by the crab such as sponges, hydroids, bryozoans and tunicates.

Similar interpretation was given for other spider crabs (Hartnoll, 1993). Detritus was also acquired in substantial amounts by all individuals. The

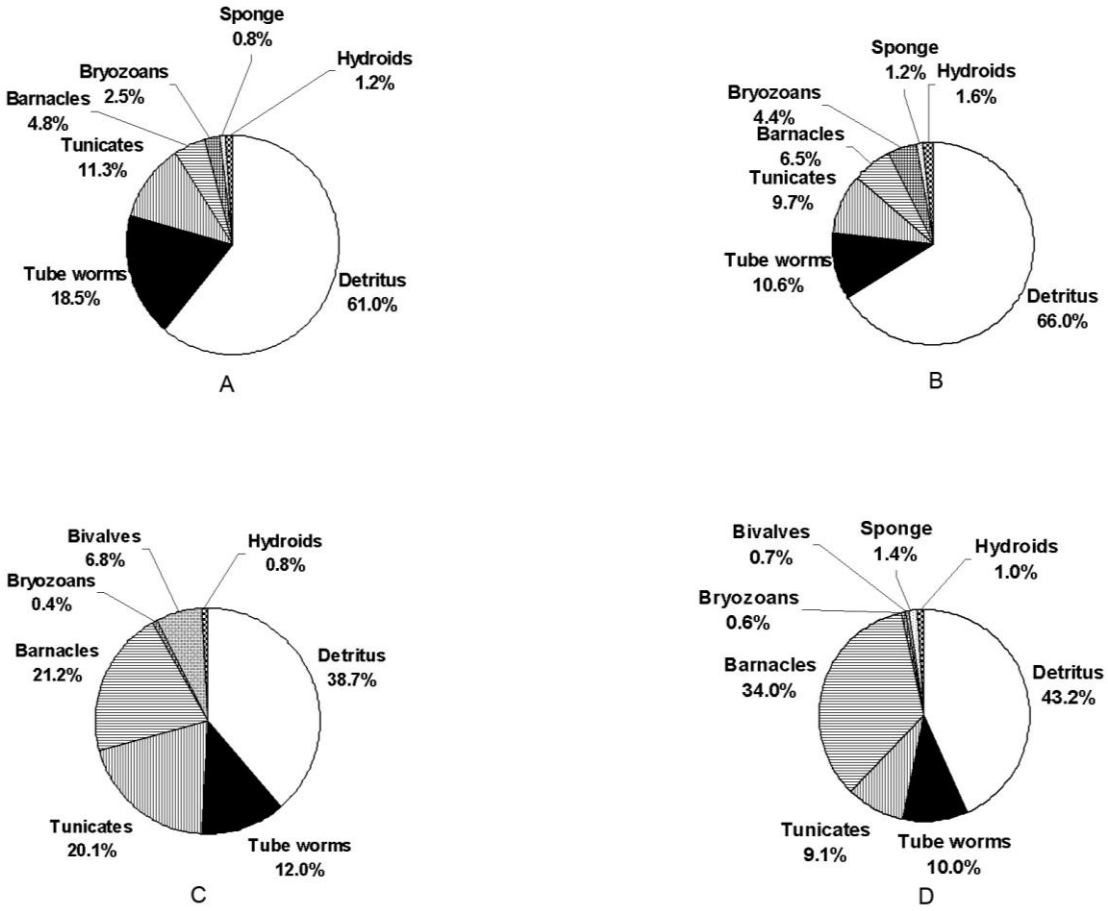

Figure 2. Percentage cover of the different covering materials of the two decorator crabs collected from the Suez Canal during the present study. A: *Schizophrys aspera* Females, B: *Schizophrys aspera* Males**,** C**:** *Hyastenus hilgendorfi* Females and C: *Hyastenus hilgendorfi* Males.

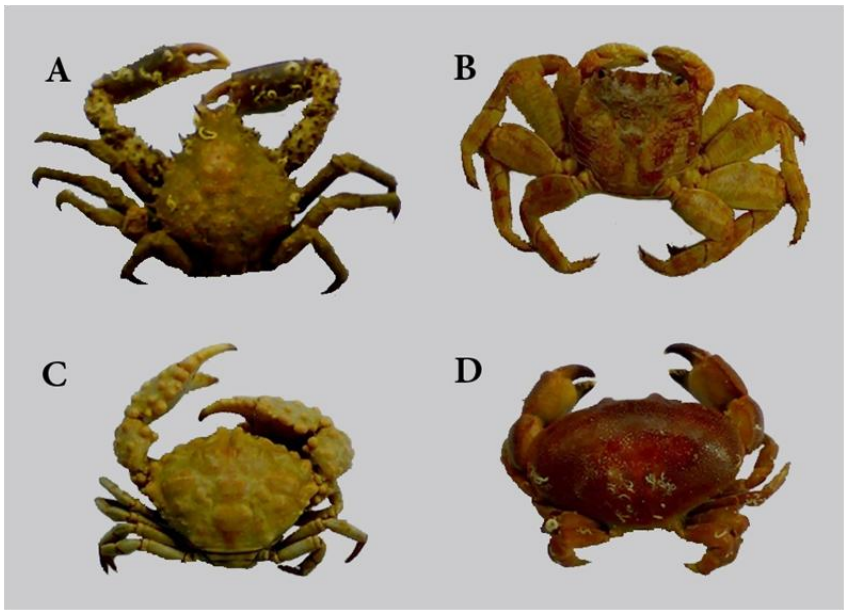

Figure 3. The new record in the Suez Canal water, A) *Schizophrys aspera*, B) *Grapsus tenuicrustatus*, C) *Halimede tyche*, D) *Atergatis roseus*.

Table 3. Categories of masking materials on the integument of *Hyastenus hilgendorfi* (De Man) and *Schizophrys aspera* (H.Milne Edwards).

Epibionts	Crab Species	
	Hyastenus hilgendorfi	***Schizophrys aspera***
Epifauna:		
Porifera:		
1-*Leucosia* sp.	■	
2-*Geodia micropunctata*	■	■
3-*Tethya* sp.	■	
Cnidaria:		
4-*Obelia geniculata*	■	
5-*O. dicotoma*	■	■
6-*Bougainvilla* sp.	■	
7-*Pinnaria* sp.	■	
8-*Plumularia* sp.	■	■
Annelida:		
9-*Hydroides elegans*	■	■
10-*H. dirampha*	■	
11-*Spirobranchus* sp.	■	
12-*Janua* sp.	■	■
13-*Dasychone* sp.	■	
14-*Syllis* sp.	■	■
15-*Pileolaria* sp.	■	
Crustacea		
16-*Amphibalanus amphitrite*	■	■
17-*A. eburneus*	■	■
Bryozoa:		
18-*Bugula neritina*	■	■
19-*B. turbinata*	■	
20-*Zoobotryon* sp.	■	■
21-*Electra pilosa*	■	
Mollusca		
22-*Brachidontes variabilis*	■	
23-*Parvicardium sueziensis*	■	
Urochordata:		
24-*Styela partita*	■	■
25-*Ciona intestinalis*	■	
26-*Phallusia nigra*	■	■
27-*P. mamillata*	■	

detritus could have been incidentally picked up by the crab during its resting, or during limited movements.

Passive acquisition of the detritus coating has been reported for other spider crab species (Wicksten, 1980). The pattern of coverage of the two species indicated that *Hyastenus hilgendorfi* as the densely cover in both sexes than *Schizophrys aspera*. Sallam and Wicksten (2011) reported *Hyastenus hilgendorfi* as a heavily encrusted decorator crab inhabiting the Suez Canal. Moreover, the differences in coverage pattern and extent for the two

Table 4. Frequency of occurrence (%*F*) of different covering materials on the integument of the two decorator crabs collected from the Suez Canal during the present study. The number of individuals is given in parentheses.

Group	Species	No. of crabs examined	No. of crabs with covering materials	Categories of covering materials	%F
Females	*Schizophrys aspera*	401	266	Sponges	2.3 (6)
				Hydroids	6.8 (18)
				Barnacles	9.0 (24)
				Bryozoans	9.0 (24)
				Tunicates	27.4 (73)
				Tubeworms	29.7 (79)
				Bivalves	0
				Others	35.3 (94)
Males	*Schizophrys aspera*	333	225	Sponges	5.3 (12)
				Hydroids	7.1 (16)
				Barnacles	14.7 (33)
				Bryozoans	13.8 (31)
				Tunicates	20.4 (46)
				Tubeworms	38.2 (86)
				Bivalves	0
				Others	56.9 (128)
Females	*Hyastenus hilgendorfi*	391	300	Sponges	0
				Hydroids	1.3 (4)
				Barnacles	80.3 (241)
				Bryozoans	0.7 (2)
				Tunicates	52.7(158)
				Tubeworms	44.3 (133)
				Bivalves	1.3.0 (4)
				Others	38.0 (114)
Males	*Hyastenus hilgendorfi*	500	380	Sponges	0.5 (2)
				Hydroids	1.1 (4)
				Barnacles	68.7 (261)
				Bryozoans	0.3 (1)
				Tunicates	47.1 (179)
				Tubeworms	30.0 (114)
				Bivalves	2.1 (8)
				Others	42.1 (160)

species inhabiting the same environment (Suez Canal) and use of the same coverage material provided suggest that masking pattern is a species specific behaviour for the decorator crabs. Although camouflage background matching is the most obvious benefit of this masking (Sallam et al., 2007; Sallam and Wicksten, 2011), it is not the only one. This masking material can also be used as food store, chemical or tactile deterrent against predators or even as an escape mechanism (Wicksten, 1993; Ertel 2008).

Conclusions

In conclusion, ten Brachyuran species belonging to 10 genera and eight families were recorded in the canal water, all of Indo-Pacific origin. Eight of these species have been introduced into the Mediterranean, while four are new geographical record to the Suez Canal. Each of the ten crab species recorded has a prolonged breeding period in the Suez Canal water due to the presence of ovigerous females in most months. The decorating behavior is an activity for which the two spider crab species of *Hyastenus hilgendorfi* and *Schizophrys aspera* are well adapted, as migrant species, to thrive in the canal. These two species can use masking as a defensive tactic because they are slow moving, do not bury, have hooked setae on their carapace and legs and do not shed after the terminal molt puberty.

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