Egyptian Journal of Aquatic Biology & Fisheries
Zoology Department, Faculty of Science,
Ain Shams University, Cairo, Egypt.
ISSN 1110 – 6131
Vol. 27(4): 755 –771 (2023)
www.ejabf.journals.ekb.eg

Abundance, Distribution and Diversity of Intertidal Macro-Algal Associated with Amphipods in the Red Sea, Egypt

Ghada S. Elsebakhy[1], Amr F. Zeina[2,*], Salah E. Abdel-Gaid[2], Faten A. ElFeky[1], Neveen H. Mahmoud[1]

[1-] Zoology Department – Faculty of Science (Girls), Cairo, Al-Azhar University, Egypt.
[2-] Zoology Department – Faculty of Science (Boys), Cairo, Al-Azhar University, Egypt.
[*]**Corresponding Author: afzeina@azhar.edu.eg**

ARTICLE INFO
Article History:
Received: March 28, 2023
Accepted: July 27, 2023
Online: Aug. 11, 2023

Keywords:
Red Sea,
Algae,
Amphipod,
Diversity,
Distribution,
Abundance

ABSTRACT
Macro-algal communities play an important role in food, rearing, reproduction, and refuge for most vertebrates and invertebrates-associated fauna in the intertidal zone along the Red Sea coasts. Thus, the present study was designed to study the distribution, diversity, and abundance of amphipod fauna. Samples were collected from five sites along the Egyptian Red Sea coast between late August 2019 and early March 2020, covering the warm and cold seasons. Overall, the collected amphipod species belong to 26 genera and 16 families, associated with 12 macro-algal species. Consequently, 2726 individuals were counted from the study area representing 29 species. Results indicate that 11 amphipod species were recorded on one type of algae species only, and the remaining 18 species were found to share more than one alga. The highest species abundance was recorded (72.04%) during the winter season, while abundance sharply decreased to (27.25%) during the summer season. Data showed that five species (*Ampithoe ramondi*, *Elasmopus seticarpus*, *Cymadusa filosa*, *Photis lamellifera*, and *Stenothoe gallensis*) collectively comprised 78.02% of total abundance. On the other hand, red algae *Palisada perforata* and brown algae *Cystoseira crinita* were represented by 16 & 14 species, respectively, and collectively comprised 52.38% of the total relative abundance.

INTRODUCTION

Amphipods are small aquatic herbivores feeding on seagrasses, macroalgae and small zooplanktons, which can alter the population dynamics of their hosts and the structure of benthic assemblages **(Poore *et al.*, 2008)**. They are among the most common species associated with many benthic marine habitats **(Lörz, 2001)**. In addition, they are associated with different benthic habitat like seagrass, sponges, algae, corals, soft bottom and rocky substrates. They are classified as one of the most diverse crustacean taxa **(Marques & Bellan-Santini, 1990)**. Moreover, amphipods play an important role in the aquatic food chain, particularly for some fish species as live food such as Lutjanidae, snappers and pinfish as well as invertebrates such as shrimp **(Sudo & Azeta, 1996)**.

The choice of amphipod habitat and development of its community depending on the shape, isolation and the type of the living place play a main role in the evolution of the amphipod community **(Aikins & Kikuchi, 2001; Gabr *et al*., 2020a)**. Amphipods use algal habitat as an environment for protection from wave action, predators and sometimes for feeding on macro-algae and different types of epiphytes associated with their hosts **(Wahl, 1989)**.

Several physical and chemical variables have an influence on abundance and diversity of herbivorous invertebrates, particularly amphipods **(Kunin, 1999; Doak, 2000)**. Most research on the associated fauna on marine algae recorded most diverse and high densities of crustaceans comparable to other groups of associated fauna; besides, some of these studies distinguish between the different crustacean content on the hosted algae **(Aumack *et al*., 2011)**.

Most of the previous research on amphipods in the Red Sea focused on taxonomic and biodiversity studies of macro and microcosms communities among different habitats **(Lyons & Myers, 1990, 1991, 1993; Osman, 2010; El Haddad, 2011; Zeina, 2012)**. Recently, some communities on the Red Sea coasts were investigated in detail to comprehend the types of relations between different habitats **(Shaban & Abdel-Gaid, 2019; Shaban & Abdel-Gaid, 2020)** and their associated fauna (**Gabr, 2020; Gabr *et al*., 2020b; Attallah *et al*., 2021; Attallah *et al*., 2022)**.

The present study aimed to survey and record all amphipod species that are associated with different intertidal macroalgae on the Red Sea coast. Additionally, this investigation focused on the amphipod dynamics associated with macroalgae during warm and cold seasons, evaluating the spatial distribution, abundance and diversity of all recorded amphipods at different sites in the Red Sea.

MATERIALS AND METHODS

1. Study area

In the present investigation, the study area (Fig. 1) is about 320km along the Egyptian Red Sea coastline, starting from Safaga (77km south Hurghada City) to northern Shalateen (located 40km northern Shalateen City) (Table 1). The study area included five sites representing different environments according to their nature and exposure to anthropogenic activities. The location of sampling site was determined using the Geographical Positioning System (GPS).

2. Sample collection

Algal samples with its associated fauna were collected during summer and winter 2020. The collection of samples was done at each site during low tide in the inter-tidal zone. At each site, the algae samples with its associated fauna were collected by snorkeling from shallow area. Algae samples were collected manually with their associated fauna using nylon net bags (15 x 15 cm capture opening) with mesh size of 500µm. The bags covered all the sample area carefully to prevent the escape of any associated fauna. By using sharp gift, the target algae were manually cut off from the hard substrate. All the collected samples were immediately fixed onshore with 70% ethanol-seawater and kept in polypropylene field box *in situ*. While, in laboratory, the samples were reopened, and the nylon bags were washed 3- 5 times with tap water to remove all associated amphipods using a 0.5mm-sieve for filtration. The associated amphipods on the branched algae were removed using fine dissecting needle or forceps. The algal species were identified to some extent to the nearest species, based on the field manual of marine algae **(Dhargalkar, 2004)**.

Table 1. Geographical limits and biotopes description of algal sampling sites along the Red Sea, Egypt

No.	Site name	Habitat
I	**Safaga** 26^0 46′ 30″ N 33^0 56′ 42″ E	The sea bottom composed of pure sandy substrate with scattered patched of macro algae during seasons (*Padina pavonica*, *Hormophysa cuneiformis*, *Digenea simplex, Palisada perforata*, *Dichotomaria obtusata*, Galaxaura sp. and *Jania rubens*). Depth gently increased until 5m; the area appeared to be covered with *Halophila stipulacea* seagrass.
II	**Quseir** 26^0 33′ 25.92″ N 34^0 02′ 16.8″ E	The sea bottom composed of sandy to mixed substrate. The area from shore line to 30m long consists of large gravels and small rocks in addition to the presence of scattered patches of *Cystoseira crinita, Hydroclathrus clathratus, Turbinaria triquetra, Digenea simplex, Palisada perforate* and *Dichotomaria obtusata*.
III	**Abu dabab** 25^0 23′ 42″ N 34^0 42′ 18″ E	The sea bottom composed of sandy to mixed substrate. The area from shore line to 50m long consists of large gravels, small rocks and small branched coral, with scattered patched of macro algae (*Cystoseira crinita, Turbinaria triquetra* and *Digenea simplex*).
IV	**Lahmi** 24^0 22′ 48″ N 35^0 16′ 30″ E	The sea bottom composed of pure sandy substrate. The area from shore line to 600m long consists of large gravels and small rocks, with scattered patched of macro algae (*Padina pavonica, Cystoseira crinita,* and *Sargassum latifolium*).
V	**Shalateen** 23^0 28′ 58.08″ N 35^0 29′ 32.64″ E	The substrate consists of rough sand and calcareous limestone. This area was covered by many algal patches (*Padina pavonica, Cystoseira crinita,Turbinaria triquetra, Digenea simplex, Laurancia obtuse,* Galaxura sp. and *Jania rubens*), few sponge species and rocks, as well as dead and live corals.

Afterwards, amphipod specimens were isolated under dissecting stereo microscopes models OPTIKA-SLX-3, (Italy) & EUROMEX-RZT, (Netherlands). Amphipod individuals were sorted, identified to the lowest possible taxon, and counted using traditional taxonomic methods and keys of **Lincoln (1979)**, **Barnard and Karaman (1991a, b)**, **Lowry and Myers (2013)**, **Zeina and Guerra-García (2016)** and **Zeina and Asakura (2017)**.

3. Data analysis

Cluster analysis was estimated by using primer ver. 5.2 for windows to investigate similarity between benthic fauna inhabiting different algae at the study sites. Two-way ANOVA statistical analysis was performed on amphipod data, using different season and sites as independent variables along with these variables' interaction. Target-amphipod' data that were used in ANOVA analysis included total number of species and individuals.

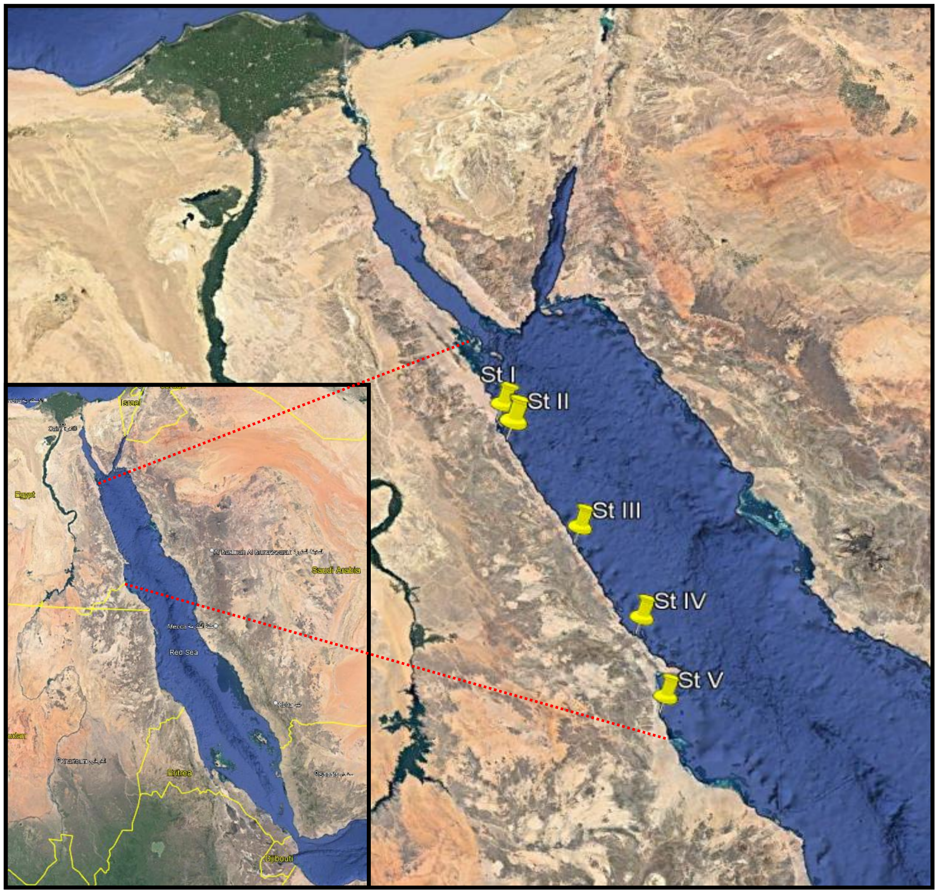

Fig. 1. Google Earth map showing entire Red Sea supported with focused map on the Egyptian coast with the study sites of marine amphipods collection

RESULTS

Algae community structure

12 algal species were detected in the study sites, provided with their temporal and spatial distributions. These are red algae, *Dichotomaria obtusata* Lamark, 1816, *Digenea simplex* Agardh, 1822, Galaxaura sp. Lamouroux, 1812, *Jania rubens* Lamouroux, 1816, *Laurencia obtuse* Lamouroux, 1813, and *Palisada perforate* Nam, 2007 in addition to brown algae *Cystoseira crinite* Agardh, 1820, *Hormophysa cuneiformis* Silva, 1987, *Hydroclathrus clathratus* Bory de Saint-Vincent, 1825, *Padina pavonica* Thivy, 1960, *Sargassum latifolium* Agardh, 1820 and *Turbinaria triquetra* Lamouroux, 1825 (Table 2). Data showed the detection of 10 species during the summer season against 8 algal species recorded during winter season (66.7% of all algae). Regarding the spatial distribution of algal species, the data showed that Safaga and Shalateen sites were

inhabited by the same number of algal species (7 algal for each), whereas Abu dabab and Lahmi sites was inhabited by a low number of species being three for each.

Table 2. Qualitative temporal and spatial distribution of algal species recorded from the study sites during the study period

Algal Type	species	Seasonal		Site				
		Summer	Winter	Safaga	Quseir	Abu dabab	Lahmi	Shalateen
Brown	*Padina pavonica*	+	+	+			+	+
	Cystoseira crinita	+	+		+	+	+	+
	Sargassum latifolium		+				+	
	Hormophysa cuneiformis	+		+				
	Hydroclathrus clathratus		+		+			
	Turbinaria triquetra	+			+	+		+
Red	*Digenea simplex*	+	+	+	+	+		+
	Laurencia obtusa	+						+
	Palisada perforata	+	+	+	+			
	Dichotomaria obtusata	+	+	+	+			
	Galaxaura sp.	+	+	+				+
	Jania rubens	+		+				+
Species number		**10**	**8**	**7**	**6**	**3**	**3**	**7**
% of total number		**83.3**	**66.7**	**58.3**	**50**	**25**	**25**	**58.3**

Amphipod occurrence and distribution among different algal species

Data presented in Table (3) show that, out of 29 amphipod species associated with twelve algal species, 11 amphipod species (37.9 % of total) were recorded at least on one algal species (8.3 % frequency of occurrence), while no recorded amphipods inhabited all algal communities. Among them, three amphipod species observed associated with red algae; *Anamixis* sp and *Quadrimaera inaequipes* associated with *Palisada perforata* as specific microcosm in addition to *Perioculodes aequimanus* associated with *Dichotomaria obtusata.*

In addition, eight species were associated with brown algae; namely, *Quadrimaera massavensis*, *Quadrimaera quadarimana*, *Podocerus brasiliensis* and *Monocorophium sextonae* associated with *Turbinaria triquetra*; while *Biancolina* sp. and *Leucothoe* sp. were reported with *Cystoseira crinite*. The rest amphipod species observed were associated with only one algal species during this study.

Ampithoidae and Maeridae are the most common families among algal macro benthic communities. On the other side, *Palisada perforata* was associated by the highest number of amphipod species (16, 55.2% occurrence), while *Jania rubens* was occupied by only two species, *Elasmopus seticarpus* and *Photis lamellifera* (Table 3).

Table 3. List and distribution of amphipod species among different algae species recorded in the study area during the study period

Family	Genus	Species	Brown						Red						Frq.
			C.c.	*H.c.*	*Hy.c.*	*Pa.p.*	*S.L.*	*T.t.*	*D.o.*	*D.s.*	*Ga.*	*J.r.*	*L.o.*	*P.p.*	
Amphilochidae	Gitanopsis	*Gitanopsis sp*									+			+	16.7
Ampithoida	Ampithoe	*Ampithoe ramondi*	+	+	+	+	+	+	+	+	+			+	83.3
	Cymadusa	*Cymadusa filosa*	+	+	+	+			+	+	+		+	+	75
	Biancolina	*Biancolina sp*	+												8.3
	Paradusa	*Paradusa sp*			+										8.3
Aoridae	Globosolembos	*Globosolembos ruffoi*	+				+	+					+	+	41.7
	Lembos	*Lembos podoceroides*	+	+	+	+					+			+	50
Caprellidae	Hemiaegina	*Hemiaegina minuta*			+				+						16.7
	Paradeutella	*Paradeutella multispinosa*	+					+							16.7
Corophiidae	Monocorophium	*Monocorophium sextonae*						+							8.3
Cyproideidae	Cyproidea	*Cyproidea ornata*	+			+	+				+			+	41.7
Dexaminidae	Dexamine	*Dexamine spinosa*		+											8.3
Hyalidae	Parhyale	*Parhyale hawaiensis*						+			+			+	25
Ischyroceridae	Jassa	*Jassa falcata*								+			+		16.7
Leucothoidae	Leucothoe	*Leucothoe sp*	+												8.3
	Anamixis	*Anamixis sp*												+	8.3
Maeridae	Ceradocus	*Ceradocus sp*	+	+	+	+					+			+	50
	Elasmopus	*Elasmopus seticarpus*	+		+	+		+	+	+		+	+	+	75
	Hemimaera	*Hemimaera hemigera*			+					+				+	25
	Quadrimaera	*Quadrimaera inaequipes*												+	8.3
		Quadrimaera massavensis						+							8.3
		Quadrimaera quadarimana						+							8.3
		Quadrimaera schellenbergi		+	+									+	25
Oedicerotidae	Perioculodes	*Perioculodes aequimanus*							+						8.3
Phliantidae	Pereionotus	*Pereionotus alaniphlias*	+						+					+	25
Photidae	Gammaropsis	*Gammaropsis chelifera*	+						+						16.7
	Photis	*Photis lamellifera*	+	+	+	+			+		+	+	+	+	75
Podoceridae	Podocerus	*Podocerus brasiliensis*						+							8.3
Stenothoidae	Stenothoe	*Stenothoe gallensis*	+		+			+						+	33.3
Total number of species			14	7	11	7	3	10	8	5	8	2	5	16	

C.c.: *Cystoseira crinita*; **H.c.:** *Hormophysa cuneiformis*; **Hy.c.:** *Hydroclathrus clathratus*; **Pa.p.:** *Padina pavonica*; **S.L.:** *Sargassum Latifolium*; **T.t.:** *Turbinaria triquetra*; **D.o.:** *Dichotomaria obtusata*; **D.s.:** *Digenea simplex*; **Ga.:** *Galaxaura sp*; **J.r.:** *Jania rubens*; **L.o.:** *Laurencia obtuse*, and **p.p.:** *Palisada perforata*

Diversity and faunal composition of amphipod associated with algal communities

Data presented in Table (3) show that, the total number of recorded amphipod species was 29 under 26 genera belonging to 16 families. Family Maeridae is the most diverse one and is represented by seven species (24.14 % of all recorded species) in four genera (15.3 %). Followed by family Ampithoidae, which is represented by four species (13.7 %), belonging to four genera (15.3 %). However, four families (Aoridae, Caprellidae, Leucothoidae and Photidae) each of which is represented by two species (6.9 %), and ten families each of which is represented by only one species (3.4 %) (Table 3).

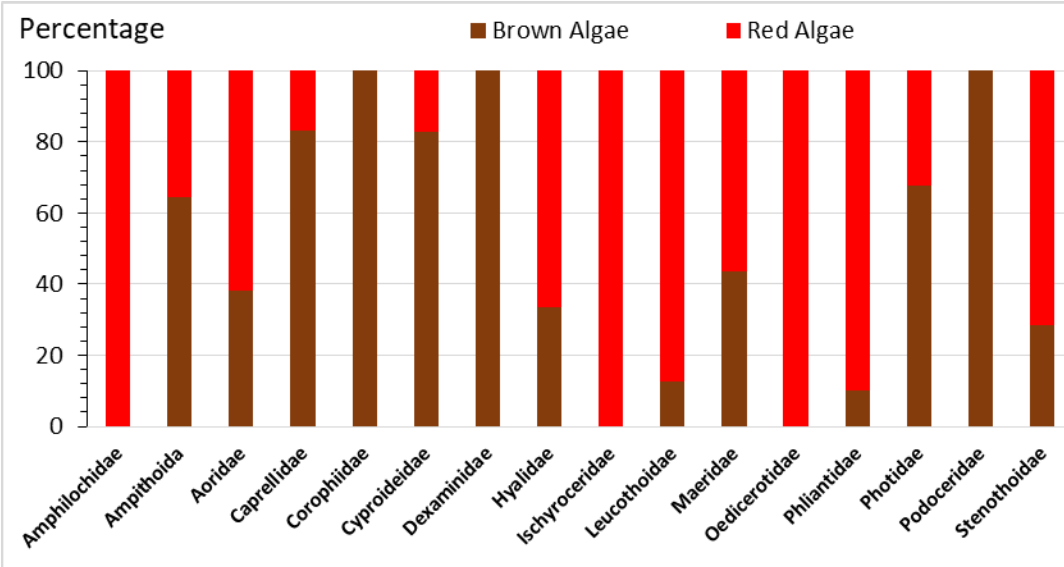

Fig. 2. A histogram showing the relative abundance of amphipod families inhabiting different algal types

Results on the percentage of amphipod families inhabiting two different algal types are presented in Fig. (2). Data clearly showed that families Amphilochidae, Ischyroceridae and Oedicerotidae are associated with red algae only, while families Corophiidae, Dexaminidae and Podoceridae are associated with brown algae only. The remaining ten families were found to share more than one algal type. However, the relative abundance values of the remaining amphipod families fluctuated between algal types.

The abundant amphipod species associated with algal types and species

Out of 2726 individuals recorded during the study period, there are five amphipod species that are the most abundant, and collectively comprised 2127 individuals (78.02% of total amphipod). *A. ramondi* (family: Ampithoidae) was the most abundant species with 1130 individuals, among which 792 and 338 individuals inhabited brown and red algae, respectively, followed by *C. filosa* (family: Ampithoidae) that is represented by 357 individuals and well distributed over two algal types, recording 167 and 190 individuals, respectively. While, *P. lamellifera* (family: Photidae) came in the third rank of abundance and comprised 247 individuals. *S. gallensis* and *G. ruffoi* were represented by 221 and 172 individuals, respectively, and mainly associated with red algae (Fig. 3).

Diversity and abundance of amphipods associated with algal species

Data presented in Table (4) reveal great variations in the total number of species during two seasons from site to another. The highest number of recorded species was observed during winter at Quseir site, with 17 species (58.62 % of total) represented by

1055 individuals with 38.7 % relative abundance. In contrast, the abundance and diversity of amphipod species decreased greatly during summer at the same site, where the number of species was 4 with 21 individuals (0.77 % relative abundance). While, the lowest numbers of species was of only one species and recorded during winter at Abu dabab sites; it was represented by seven individuals. Generally, the overall amphipod abundance was 2726 individuals, of which 762 (27.95 %) individuals were recorded during summer against only 1964 (72.05 %) individuals recorded during the season of winter (Table 4).

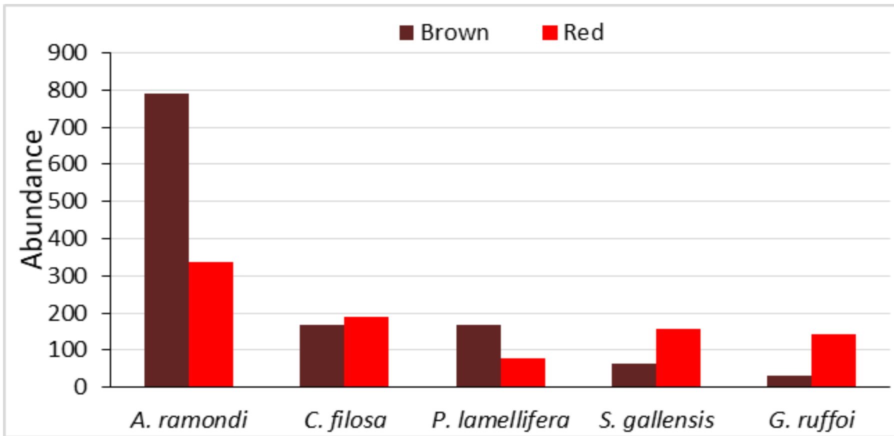

Fig. 3. A histogram showing abundance of the most abundant amphipod species inhabiting different algal types

Table 4. Spatial variation of associated amphipods diversity & abundance ((sp. no.) ind. no.) among different algal species recorded throughout the study (S1= Safaga; S2 = Quseir; S3 = Abu dabab; S4 = Lahmi; S5 = Shalateen).

Algal species		Summer					winter					Total	%
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5		
Brown	*C. c.*			(2)2	(5)7			(10)368			(10)258	**(14)635**	**23.29**
	H. c.	(7)116										**(7)116**	**4.26**
	H. c.							(11)191				**(11)191**	**7.01**
	P. p.	(6)133								(3)65		**(7)198**	**7.26**
	S. l.									(3)276		**(3)276**	**10.12**
	T. t.			(10)123								**(10)123**	**4.51**
Red	*D. o.*	(4)99					(5)60					**(8)159**	**5.83**
	D. s.					(4)12	(4)6		(1)7			**(5)25**	**0.92**
	Ga.	(5)63	(4)21									**(8)84**	**3.08**
	J. r.					(2)6						**(2)6**	**0.22**
	L. o.					(5)120						**(5)120**	**4.40**
	P. p.	(6)60						(12)496		(8)237		**(16)793**	**29.1**
Total		**(11)471**	**(4)21**	**(10)125**	**(5)7**	**(6)138**	**(9)66**	**(17)1055**	**(1)7**	**(9)578**	**(10)258**	**(29)2726**	**100**

C.c.: *Cystoseira crinita*; **H.c.:** *Hormophysa cuneiformis*; **Hy.c.:** *Hydroclathrus clathratus*; **Pa.p.:** *Padina pavonica*; **S.L.:** *Sargassum Latifolium*; **T.t.:** *Turbinaria triquetra*; **D.o.:** *Dichotomaria obtusata*; **D.s.:** *Digenea simplex*; **Ga.:** *Galaxaura sp*; **J.r.:** *Jania rubens*; **L.o.:** *Laurencia obtuse*, and **p.p.:** *Palisada perforata*

For amphipod abundance among different algal species, the red algae *Palisada perforata* showed the highest amphipod diversity, with 16 species (represented by 793 individuals) of which 6 species were recorded during summer at Safaga site with 60 individuals in addition to 12 and 8 species recorded during winter at Quseir and Lahmi sites, respectively. These species were represented by 496 and 237 amphipod individuals, respectively. The brown algae, *Cystoseira crinita*, comprised 14 amphipod species (represented by 635 individual) of which 2 and 5 species were recorded during summer at Abu dabab and Lahmi and represented by 2 and 7 individuals, respectively, as well as 10 species recorded at each Quseir and Shalateen during winter, with 368 and 258 individuals, respectively. In contrast, there are only two algae species (*P. perforata* and *C. crinita*) consuming collectively 1428 individuals (52.38.89 % of all abundance) against the remaining (10) algae, inhabited by 1298 individuals (47.6%) (Table 4).

Histogram in Fig. (4) displays the red algae *P. perforata* having the highest relative abundance of amphipods (26.5%); it was recorded during winter, followed by brown algae *C. crinita* with 22.6 %. The abundance experienced a great decrease during both seasons at the above algae, being 2.17 during winter and 0.33 during summer, respectively. Two brown algae (*H. cuneiformis* and *T. triquetra*) and three red algae, (*Galaxaura* sp., *J. rubens* and *L. obtusa*) were not detected during winter. Furthermore, brown algae (*H. clathratus* and *S. Latifolium*) were not detected during summer.

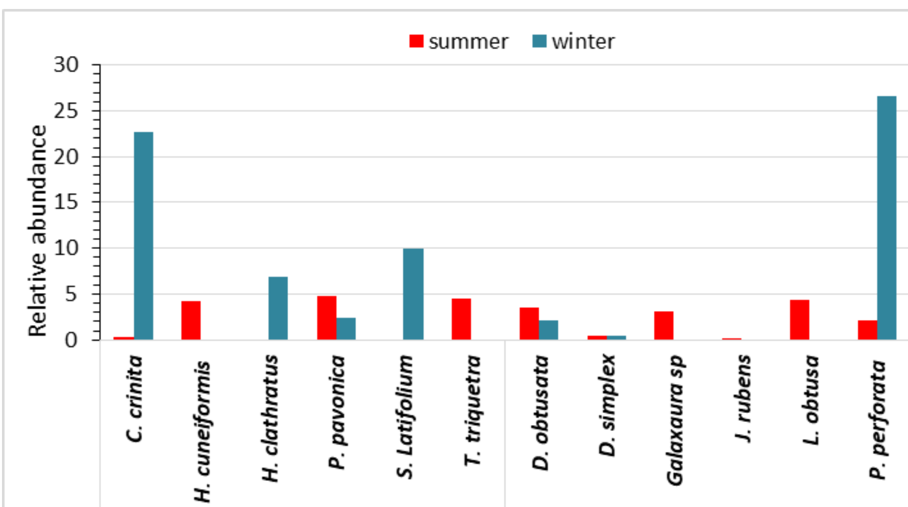

Fig. 4. Histogram displaying seasonal variation in relative abundance of amphipods inhabiting different algae species

Biodiversity data analysis

Results of cluster analysis among different study sites showed that Abu dabab site is separated from the four other sites in a single cluster. Whereas, the other sites are separated in two sub-clusters; the first one includes Lahmi and Quseir sites and linked with each other at 52.87 % similarity index; whereas, Shalateen and Safaga sites are linked in the second sub-cluster at 59.7 %. Then, subsequently the two sub-clusters got linked with Abu dabab site at 24.06 % similarity index (Fig. 5).

Table 5. Two-way ANOVA statistical analysis performed on amphipod data during two study seasons at different study sites

	Abundance					Diversity				
Variable	**SS**	**df**	**MS**	***F***	***P-value***	**SS**	**df**	**MS**	***F***	***P-value***
Site	**19849.78**	**4**	**4962.446**	**0.98**	**0.42**	**20.13**	**4**	**5.03**	**0.76**	**0.55**
Season	**12040.03**	**1**	**12040.03**	**2.38**	**0.13**	**0.41**	**1**	**0.41**	**0.06**	**0.80**
Interaction	**54107.72**	**4**	**13526.93**	**2.68**	**0.04**	**58.13**	**4**	**14.53**	**2.20**	**0.07**
Within	**555534.8**	**110**	**5050.317**			**727.92**	**110**	**6.62**		
Total	**641532.4**	**119**				**806.59**	**119**			

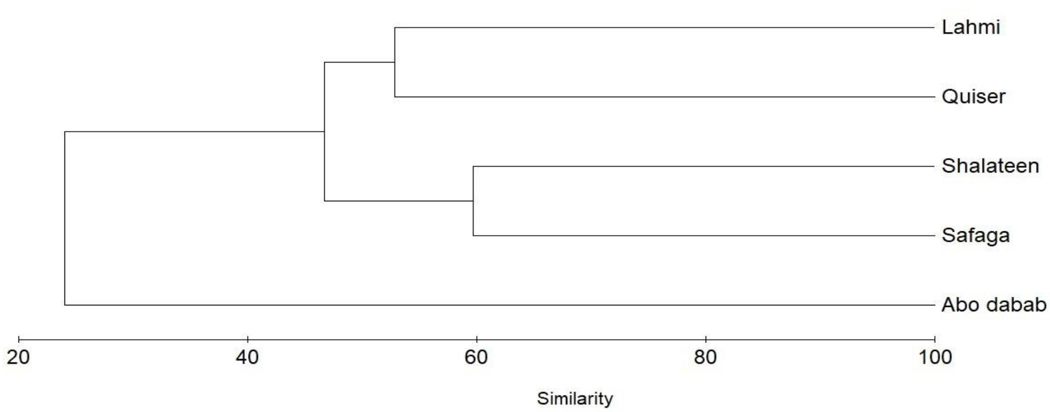

Fig. 5. **Dendrogram of similarity index among varying study sites during the study period**

Based on the total number of individuals and species inhabited by different algal types, the statistical analysis was performed using the analysis of variance test (ANOVA). One-way analysis proved that there is no significant difference in species number and individuals during seasons and between different sites. Additionally, data showed that the two-way analysis (interaction) between sites and seasons was non-significant in total species. However, two-way ANOVA statistical analysis showed significant differences in the total abundance values of amphipods across different sites/seasons (Table 5).

DISCUSSION

The Red Sea is one of the most famous aquatic environments that researchers have been interested in for more than two centuries. Despite the dire diversity of plant and animal species inhabiting marine environments in the Red Sea, very little information about these environments has been published worldwide. Many scattered research was conducted on the Red Sea, but these researches are still limited and did not give enough information on the Red Sea fauna and flora, especially in Egypt. Since the middle of the last century, many physiological and chemical as well as geological research has been conducted on the Red Sea and its flora and fauna.

The spatial distribution of algal species in the present study recorded variation between study sites, where seven species were found at each sites of Safaga and Shalateen, opposite to three species recorded at each Lahmi and Abu dabab. This may be due to the different topography of each site, varried substrate composition and ability of algae to settle on the substrate. The spatial distribution of algae and its frequency of occurrence were studied by many researchers and cited **(El Sharouny *et al*., 2001; Zeina, 2012; Gabr, 2020)**.

The variation in species abundance and diversity between the study sites may be attributed to the different activities that may occur in one station relative to the other, such as fishing, diving and snorkeling. Reef communities are degraded worldwide in accelerating rates, mainly because of human activities **(Naim *et al*., 2000; Cole, 2003; Sheppard, 2003; McCulloch *et al*., 2003)**. Increases in human populations and coastal development along the Egyptian coast of the Red Sea over the past 20 years have intensified the pressure on corals' environmental requirements and threaten the health and viability of coral reefs and their related communities. Rubbish and other by- products of human activities in coastal areas cause many problems for the coral reef ecosystem **(Thomsen & McGlathery, 2005)**. Damage occurs from direct impact of divers and snorkelers and indirect impacts caused by developing tourism facilities including landfill, dredging for artificial beaches, boat anchors and grounding and sedimentation **(Kotb *et al*., 2008)**. In addition, the expected physical damage, the increasing sedimentation rate because of intensive SCUBA diving also caused a serious impact on coral reef communities **(Hanafy, 2012)**. Eminently, any impact on the coral reefs affects the coral accompanying communities such as microbenthic communities.

The present study revealed that amphipod fauna in the Red Sea are represented by 29 species, belonging to 26 genera and 16 families. These results are consistent with the large body of literature that describes marine habitat as productive habitats with a high density and diversity of organisms. **Gabr (2020)** revealed that, the amphipod fauna from Ras Mohamed Protectorate represented by 23 species under 19 genera belong to 10 families, of which five species are considered as new record; in addition, out of 23 amphipod species, there are at least two species that may be new species.

In the present study, data showed that families Maeridae were the more diverse ones and represented by seven species under four genera, followed by family Ampithoidae, with four species belonging to four genera. Moreover, the species *A. ramondi*, *C. filosa*, *P. lamellifera*, *S. gallensis* and *G. ruffoi* were the most abundant. However, **Zeina (2012)** listed 12 amphipod species belonging to two suborders, seven families and ten genera. The author elucidated that, only the genus *Elasmopus* has three species; family: Maeridae is the most diverse, with four species, followed by the Caprellidae and Ampithoidae families, each with two species. In addition, in the study of **Ortega *et al*. (2010)**, the authorrs found that the amphipod, *A. ramondi*, was the most abundant species.

The global distribution of the Red Sea fauna varied according to the special geographic position of this water body. Some of the collected amphipod fauna had a worldwide distribution such as *C. filosa* and *C. ornata*, while other species had a special distribution range like *P. aequimanus* from the Mediterranean Sea and the North Atlantic Ocean **(Guerra-García, 2006; Hughes & Takeuchi, 2016)**.

Anthropogenic activities worldwide have contributed to vegetation changes in many coastal areas; these changes may in turn affect faunal and algal assemblages in the involved ecosystems. Changes in the abundance and/or composition of macrophytes, on the shore areas, may in turn affect other organisms in an ecosystem by altering associated invertebrate communities, particularly crustacean assemblages **(Benedetti-Cecchi *et al*., 2001; Reed & Hovel, 2006; Wikstrom & Kautsky, 2006)** as well as fish assemblages **(Guidetti *et al*., 2003)**.

The abundance and diversity of amphipod assemblages were significantly different among different macroalgae. The factors affecting the epifaunal diversity on algae differ in relation to the scale of investigation. At large scales of investigation, factors such as geographical changes in algae composition and seasonal cycles affect the epifaunal community structure on algae **(Arrontes & Anadón, 1990; Hull, 1997; Russo, 1997; Pereira *et al*., 2006)**. At small scales, factors such as seaweed biomass, surface area and branching patterns influence epifaunal community structure **(Russo, 1990; Knowles & Bell, 1998; Christie *et al*., 2003)**. In this context, our results agree with those of numerous authors, who found that the abundance and diversity of amphipod vary in each algal species according to shape, depth and the exposed surface area **(Huang *et al*., 2007; Amsler *et al*., 2008; Aumack *et al*., 2011; Eilertsen *et al*., 2011; Wiencke & Amsler, 2012)**. Hence, losing habitat formation may cause an imbalance in its main function (shelter and protection), resulting in drastic consequences facing the number of individuals and species of its associated fauna **(Machado *et al.*, 2019)**.

CONCLUSION

It can be deduced that, the most non-selective amphipods associated with different algal types were the most abundant species, while the target host amphipods showed limited distribution and abundance.

ACKNOWLEDGEMENT

This work was financially funded by Science, Technology & Innovation Funding Authority (STIFA) for Young Researchers call 8 (YR-30198). One of the authors (AZ) also is grateful to M. Maaty, K. Darweesh and A. Nofal for their help during sampling process.

REFERENCES

Aikins, S. and Kikuchi, E. (2001). Studies on habitat selection by amphipods using artificial substrates within an estuarine environment. Hydrobiologia, 457(1): 77 – 86.

Amsler, C. D.; McClinton, J. B. and Baker, B. J. (2008). Macroalgal chemical defense in polar marine communities. In: Amsler, C. D. (ed) Algal chemical ecology. Springer, Berlin, 91 – 100.

Amsler, C. D.; McClintock, J. B. and Baker, B. J. (2012). Amphipods exclude filamentous algae from the Western Antarctic Peninsula benthos: experimental evidence. Polar Biology, 35: 171 – 177.

Arrontes, J. and Anadón, R. (1990). Seasonal variation and population dynamics of isopods inhabiting intertidal macroalgae. Sci. Mar., 54(3): 231 – 240.

Attallah, M. A.; Hellal, A. M.; Abdelrazek, F. A.; Abdel-Gaid, S. E.; Gabr, M. K. and Zeina, A. F. (2021). Soft-bottom exploration of assemblage patterns of the Red Sea amphipods at multiple spatial and vertical scales. The Egyptian Journal of Aquatic Research, 47(4): 365 – 371.

Attallah, M. A.; Hellal, A. M.; Abdelrazek, F. A.; Gabr, M. K.; Abdel-Gaid, S. E. and Zeina, A. F. (2022). Occurrence and distribution of caprellids from the Egyptian Red Sea coast, with first records of two genera. The Egyptian Journal of Aquatic Research, 48(3): 247 – 255.

Aumack, C. F.; Amsler, C. D.; McClintock, J. B. and Baker, B. J. (2011). Changes in amphipod densities among macroalgal habitats in day versus night collections along the Western Antarctic Peninsula. Marine biology, 158: 1879 – 1885.

Barnard, J. L. and Karaman, G.S. (1991). The Families and Genera of Marine Gammaridean Amphipoda (Except Marine Gammaroids) (Part 1& 2). Records of the Australian Museum, 1 – 417 & 419 – 866.

Benedetti-Cecchi, L.; Pannacciulli, F.; Bulleri, F.; Moschella, P. S.; Airoldi, L.; Relini, G. and Cinelli, F. (2001). Predicting the consequences of anthropogenic disturbance: large-scale effects of loss of canopy algae on rocky shores. Marine Ecology Progress Series, 214: 137 – 150.

Christie, H.; Jørgensen, N.M.; Norderhaug, K.M. and WaageNielsen, E. (2003). Species distribution and habitat exploitation of fauna associated with kelp

(Laminaria hyperborea) along the Norwegian coast. J. Mar. Biol. Ass. U.K., 83: 687 – 699.

Cole, J. (2003). Dishing the dirt on coral reefs. Nature, 421(6924): 705 – 706.

Dhargalkar, V. K. (2004). Seaweeds – a field manual. National Institute of Oceanography, Dona Paula, Goa. 42pp.

Doak, P. (2000). Population consequences of restricted dispersal for an insect herbivore in a subdivided habitat. Ecology 81: 1828 – 1841.

Eilertsen, M.; Norderhaug, M.I. and Sjotun, I. (2011). Does the amphipod fauna associated with epiphytes on kelp (Larninaria hyperborea) change with depth?. Marine Biology Research, 7: 224 – 234.

El-Haddad, K. M. (2011). Ecological studies on macro invertebrate's species inhabiting Abu Galum reef South Sinai, Doctoral dissertation, Msc. Thesis, Azh. Univ. Egy., 182pp.

El-Sharouny, H. M.; El-Tayeb, M. A. and Ismail, M. S. (2001). Macroalgae associated with mangroves at Hurghada and Safaga of the Egyptian Red Sea coast. Journal of King Abdulaziz University, Marine Sciences, 12 (1): 241 – 251.

Gabr, M. Kh.; Zeina, A. F. and Hellal, A. M. (2020a). Influence of algal architecture and shore exposure on population dynamics of marine amphipods at Ras Mohamed Protectorate, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 24(6): 59 – 72.

Gabr., M. Kh.; Zeina, A. F. and Hellal, A. M. (2020b). Abundance and diversity of amphipod species associated with macro-algae at Ras-Mohamed, Aqaba Gulf, Red Sea, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 24(3): 1 – 15.

Guerra García, J. M. (2006). Caprellidae (Crustacea: Amphipoda) from the Great Barrier Reef and adjacent localities. Records of the Australian Museum, 58: 417 – 458.

Guidetti, P.; Terlizzi, A.; Fraschetti, S. and Boero, F. (2003). Changes in Mediterranean rockyreef fish assemblages exposed to sewage pollution. Marine Ecology Progress Series, 253: 269 – 278.

Hanafy, M. (2012). Effects of recreational scuba diving and snorkeling on coral reefs of the sheltered bays of the Red Sea, Egypt. Egyptian Journal of Aquatic Biology and Fisheries, 16(4): 43 – 56.

Huang, Y. M.; Amsler, M. O.; McClintock, J. B.; Amsler, C. D. and Baker, B. J. (2007). Patterns of gammaridean amphipod abundance and species composition associated with dominant subtidal macroalgae from the western Antarctic Peninsula. Polar Biology, 30: 1417 – 1430.

Hughes, L. E. and Takeuchi, I. (2016). Two New Species of Quadrisegmentum (Phtisicidae: Amphipoda: Crustacea) from the Central Indo-Pacific, with Notes on the Type Species Q. triangulum Hirayama, 1988. Records of the Australian Museum, 68: 231 – 244.

Hull, S. L. (1997). Seasonal changes in diversity and abundance of ostracods on four species of intertidal algae with differing structural complexity. Marine Ecology Progress Series, 161: 71 – 82.

Knowles, L.L. and Bell, S.S. (1998). The influence of habitat structure in faunal-habitat associations in a Tampa Bay seagrass system, Florida. Bulletin of Marine Science, 62: 781 – 794.

Kotb, M. M.; Hanafy, M. H.; Rirache, H. O.; Matsumura, S. A.; Al-Sofyani, A. A.; Ahmed, A. G.; Bawazir, G. and Al-Horani, F. A. (2008). Status of coral reefs in the Red Sea and Gulf of Aden region. Status of coral reefs of the world, 67 – 78.

Kunin W. E. (1999) Patterns of herbivore incidence on experimental arrays and field populations of ragwort, Senecio jacobaea. Oikos 84: 515 – 25.

Lincoln, R. J. (1979). British marine amphipoda: Gammaridea. British Museum (Natural History), 818: 1 – 658.

Lörz, A. N. (2001). Low diversity of spongicolous Amphipoda (Crustacea) observed in the Antarctic autumn. Organisms Diversity & Evolution, 1(2): 133 – 138.

Lowry, J. K. and Myers, A. A. (2003). New amphipod crustaceans from the Indo-West Pacific (Amathillopsidae: Eusiridae: Iphimediidae). Raffles Bulletin of Zoology, 51(2): 219 – 256.

Lyons, J. and Myers, A. A. (1990). Amphipoda Gammaridea from coral rubble in the Gulf of Aqaba, Red Sea, Families Acanthonotozomatidae, Ampeliscidae, Ampithoidae, Anamixidae, Aoridae and Colomastigidae. Journal of Natural History, 24: 1197 – 1225.

Lyons, J. and Myers, A. A. (1991). Amphipoda Gammaridea from coral rubble in the Gulf of Aqaba, Red Sea, Families Dexaminidae, Eusiridae, Isaeidae, Ischyroceridae, Leucothoidae, Liljeborgiidae and Lysianassidae. Journal of Naturalll History, 25: 597 – 621.

Lyons, J. and Myers, A. A. (1993). Amphipoda Gammaridea from coral rubble in the Gulf of Aqaba, Red Sea: families Megaluropidae, Melitidae, Phliantidae, Phoxocephalidae, and Urothoidae. Journal of Natural History. 27: 575 – 598.

Machado, G.B.O.; Ferreira, A.P.; Bueno, M.; Siqueira, S.G.L. and Leite, F.P.P. (2019). Effects of macroalgal host identity and predation on an amphipod assemblage from a subtropical rocky shore. Hydrobiologia, 836(1): 65 – 81.

Marques, J. C. and Bellan-Santini, D. (1990). Benthic Amphipod Fauna (Crustacea) of the Portuguese Coast: Biogeographical Considerations. Marine Nature 3: 43 – 51.

McCulloch, M.; Fallon, S.; Wyndham, T.; Hendy, E.; Lough, J. and Barnes, D. (2003). Coral record of increased sediment flux to the inner Great Barrier Reef since European settlement. Nature, 421: 727 – 730.

Naim, O.; Cuet, P. and Mangar, V. (2000). The Mascarene Islands. In: Obura D. O. (ed.) Coral Reefs of the Indian Ocean. Oxford Univ. Press, Oxford, 353 – 381.

Ortega, I.; Díaz, Y. J. and Martín, A. (2010). Feeding rates and food preferences of the amphipods present on macroalgae Ulva sp. and Padina sp. Zool. baetica, 21: 45 – 53.

Osman, E. (2010). Ecological studies on fauna associated with seagrass habitat at Hurghada-Red Sea. M. Sc. Zoology Department, Faculty of Science, Al Azhar University.

Pereira, S.G.; Lima, F.G.; Queiroz, N.C.; Ribeiro, P.A. and Santos, A.M. (2006). Biogeographic patterns of intertidal macroinvertebrates and their association with macroalgae distribution along the Portuguese coast. Hydrobiologia, 555: 185 – 192.

Poore, A. G.; Hill, N. A. and Sotka, E. E. (2008). Phylogenetic and geographic variation in host breadth and composition by herbivorous amphipods in the family Ampithoidae. Evolution: International Journal of Organic Evolution, 62(1): 21 – 38.

Reed, B. J. and Hovel, K. A. (2006). Seagrass habitat disturbance: how loss and fragmentation of eelgrass Zostera marina influences epifaunal abundance and diversity. Marine Ecology Progress Series, 326: 133 – 143.

Russo, A. R. (1990). The role of seaweed complexity in structuring Hawaiian epiphytal amphipod communities. Hydrobiologia, 194: 1 – 12.

Russo, A. R. (1997). Epifauna living on sublittoral seaweeds around Cyprus. Hydrobiologia, Vol. 344: 169 – 179.

Shaban, W.M. and Abdel Gaid, S.E. (2019). Temporal variations and edge effects on polychaetes in continuous and fragmented seagrass beds in northern Red Sea, Egypt. Egyptian Journal of Aquatic Biology & Fisheries 23: 491 – 504.

Shaban, W.M. and Abdel Gaid, S.E. (2020). Drivers of change in the epifaunal assemblages associated with intertidal macro- algae at the Mangrove site south Safaga, Egypt, Red Sea. 24(3): 225 – 243.

Sheppard, C. R. (2003). Predicted recurrences of mass coral mortality in the Indian Ocean. Nature, 425(6955): 294 – 297.

Sudo, H. and Azeta, M. (1996). Life history and production of the amphipod Byblis japonicus Dahl (Gammaridea: Ampeliscidae) in a warm temperate zone habitat, Shijiki Bay, Japan. Journal of experimental marine biology and ecology, 198(2): 203 – 222.

Thomsen, M. S. and McGlathery, K. (2005). Facilitation of macroalgae by the sedimentary tube forming polychaete Diopatra cuprea. Estuarine, Coastal and Shelf Science, 62(1-2): 63 – 73.

Thurston, M. (2000). Benthic Gammaridea [Crustacea: Amphipoda] in the deep sea. Polskie Archiwum Hydrobiologii, 47 (3, 4): 353 – 377.

Wahl, M., (1989). Marine epibiosis, I, Fouling and antifouling: some basic aspects, Marine Ecology Progress Series, 58: 175 – 189.

Wiencke, C. and Amsler, C. D. (2012). Seaweeds and their communities in Polar Regions. Seaweed biology: novel insights into ecophysiology, ecology and utilization, pp.265 – 291.

Wikström, S. A. and Kautsky, L. (2007). Structure and diversity of invertebrate communities in the presence and absence of canopy-forming Fucus vesiculosus in the Baltic Sea. Estuarine, Coastal and Shelf Science, 72(1-2); 168 – 176.

Zeina, A. F. (2012). Studies on the intertidal epibenthic fauna at the Red Sea coast (Hurghada) with special emphasis on order" Amphipoda. Unpublished Ph. D. thesis. Al-Azhar University, 311pp.

Zeina, A. F. and Guerra-Garcia, J. M. (2016). Caprellidae (Crustacea: Peracarida: Amphipoda) from the Red Sea and Suez Canal, with the redescription of Metaprotella africana and Paradeutella multispinosa. Zootaxa, 4098(2): 227 – 253.

Zeina, A. and Asakura, A. (2017). A new species of Cerapus Say, 1817 (Amphipoda: Ischyroceridae) from the Red Sea, with a key to the worldwide species of the genus. Journal of Crustacean Biology, 37(3): 296 – 302.