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Effect of habitat fragmentation on abundance and diversity of seagrass-associated crustacean assemblage at Hurghada, Red Sea

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ABSTRACT

Seagrass beds in Red Sea are increasingly subject to both natural and anthropogenic disturbance and fragmentation, resulting in an increase in the edge habitats. Consequently, the present study was designed to study the effect of habitat fragmentation of seagrass on the diversity and abundance of epiphytic crustaceans inhabiting seagrass canopies. For this purpose, two sites, containing different seagrass patch sizes, were selected for seasonal sampling during the period from mid-April 2015 to mid-January 2016 around Hurghada, Red Sea. Evaluations of the differences in crustacean assemblage structure, abundance and diversity between fragmented and continuous seagrass beds as well as the edge and center of the same seagrass patches were figured out.

Overall, 33 crustacean species belong to 30 genera, 25 families, and 7 orders were recorded, from all different seagrass patches with a comparable temporal and spatial distribution; whereas all recorded crustacean species belong to class Malacostraca. Results indicated that large seagrass patches harbor higher crustacean's densities than medium and small seagrass patches, which promote the assumption of the negative effect of seagrass fragmentation. The abundance of crustacean groups are also markedly increase in the large patches except decapods in one site. Reduction of habitat size led to reducing the number of crustacean species in both sites. However, Evenness values (J') showed that habitat fragmentation had no effect on diversity. THE Total crustaceans abundance is relatively increase toward the patch edge with a percentage of increase up to 18 %. However, crustacean species richness was insensitive to differences in patch edge-center microhabitat. Relation between seagrass shoot density/biomass and the total crustacean abundance also figured out in this study.

Key words: Crustacea, Habitat fragmentation, Ecological edge, Abundance, Diversity, Seagrass, Red Sea

INTRODUCTION

Seagrasses are clonal, sessile, submerged angiosperms with a relatively simple, modular morphology. Seagrass meadows are increasingly subject to both natural and anthropogenic disturbance and fragmentation[1]. Natural disturbances include major storms such as cyclones and hurricanes[2], as well as smaller scale grazing by animals such as dugongs[3]. Anthropogenic causes range from propeller scars to dredging[4,5].

Seagrass community response to disturbance, fragmentation, and increased edge is of interest as these plants provide a number of ecosystem functions and services. Several studies have been conducted on seagrasses, at both the level of the patch and the individual organism, to determine whether seagrass growth changes in response to resource patchiness and/or disturbance. For example, at the patch level, evidence of correlations between the landscape-level spatial patterns of seagrass beds and local hydrodynamic exposure, disturbance, and water depth is recorded by Fonseca and Bell[6]. At the individual level, Jensen and Bell found that *Halodule wrightii* morphology varied according to spatial position (edge vs. center) in a patch and investigated the relationship between such variation and sediment nutrient availability[7]. Changes in seagrass morphology have also been used to trace sediment disturbances such as the movement of subaqueous dunes[8] and erosional scarps[9]. Duarte *et* al. affirm that seagrass density can provide useful evidence for reconstructing seagrass patch dynamics, tracing accretion and erosion, and indicating changes in sediment chemistry[10].

An ecological "edge" is generally understood as the abrupt transition between two adjacent ecosystems[11]. Both terrestrial and marine edge studies often focus on visually distinct habitat transitions and the effect of such boundaries on associated floral and faunal communities. "Edge effects" are defined as either marked increases or decreases in species density or richness, concentrated within a given distance from a habitat patch boundary[12]. Center-to-edge transects, as well as comparisons of differently-sized patches with varying amounts of edge, are commonly used to identify edge responses[13-16].

Studies of seagrass edge responses may potentially provide insights into broader effects of ecosystem disturbance[7,17]. Seagrasses have demonstrated consistent edge responses in numerous studies, with predictable differences in densities, growth rates, biomass, rhizome morphology, and productivity observed between patch centers and edges, regardless of species or climatic region[3, 7, 18,19]. Hypothesized mechanisms for recorded edge responses often claim that differences in resources such as light[3] or nutrients[7] may be responsible. However, a general mechanism has not been determined.

Despite the increase in anthropogenic and natural disturbance that affect seagrass habitat along the Egyptian Red Sea coast, there is no studies have examined the relationship between seagrass fragmentation and their associated fauna in this particular area in the Red Sea.

The present study is the first attempt to test the response of seagrass associated mobile fauna (represented here by Crustacea) to seagrass fragmentation in the Red Sea by using the dominant Red sea seagrass, *Halophila stipulacea,* as an ideal seagrass beds. For this purpose, we compare the diversity and abundance of epifaunal crustaceans that associated with several seagrass patches (different in size) at two replicate sites around Hurghada, Red Sea, Egypt. Particular attention is given to a comparison of the epifaunal assemblages in the edge and center of such seagrass patches. In addition to study the relationship between seagrass shoots density/biomass and the abundance of their associated crustaceans.

MATERIALS AND METHODS

1- Study area

The present study was carried out during the period from mid-April 2015 to mid-January 2016 around Hurghada city, Egyptian Red Sea Coast. Two investigated sites containing fragmented seagrass patches, and a reference large and continued seagrass bed were selected (Fig. 1). The first site is located front of Marine Station Site (°27.286256 N, °33.772276 E) and considered as a typical coastal site. Seagrass bed and patches were found at this site at 2-7 m depth beside rocky substrata, dead and live corals and algae. The second site is located near the eastern coast of Abou Monkar Island (27.221284° N, 33.896852° E). Seagrass bed and patches were found at this site at 4 m depth beside rocky substrata and algae.

Fig. (1): Map showing the study area sites (Google map).

2- Field work Design:

This study was restricted to beds of the dominant seagrass, *Halophila stipulacea*, which occur in shallow waters of 2- 7 m depth. Three representative beds in relation to size patch were chosen at both Marine Station (site I) and Abou Monkar Island (site II). The three different bed sizes are designated here as small, medium and large patches at each site depending on the coverage area of each patch. Seagrass patch size, morphology, as well as floristic data were determined in investigated sites. Several longitudinal line-transects will placed throughout the different regions, these transects will incorporate both center and edge locations to examine center-to-edge crustacean fauna dynamic along with the seagrass floristic data throughout the different patch size.

In order to test the hypothesis that plant biomass (gm/m^2), and shoots density (number of shoots /m^2) of the selected seagrass patches are affected by seagrass fragmentation, such floristic data were determined at the edge and center of all 6 experimental beds to quantify possible confounding effect.

3- Sampling and examination

Seagrass canopy samples with their crustacean fauna were collected seasonally from each site using SCBUPA diving. Three replicates from each were taken in the same time during the mid-season. Canopy fauna were collected using a propylene quadrate frame (25 x 25 cm). Seagrass shoots were cute using a scissor and quickly putted inside a polyethylene bags including associated fauna among the seagrass blades and the epifaunal crustacean. Samples were preserved in 10 % seawater formalin.

In the Laboratory, the seagrass canopy samples were washed and their fauna were extracted through 0.5 mm mesh sieves. Crustacean species extracted, sorted and preserved in 70 % ethyl alcohol. Critical identification for each specimen and species was carried out using extensive available literatures **(**eg**:** 20, 21, 22, 23, 24**)**. Each crustacean species were separated counted and photographed with a digital camera. Species density (number of individuals per square meter), Species Richness, Shannon Index and Evenness were also calculated for each single seagrass microhabitat. Correlation between seagrass floristics data (shoots biomass/density) and crustacean abundance were also reported.

RESULTS

1-Faunal composition:

Total crustacean species number recorded in all seagrass patches at the two study sites was 33 species belonging to 7 orders, 25 families and 30 genera. Order Decapoda are the most diverse crustacean group, which represented by 17 species (51.52 %) and 12 families (48 %), followed by Amphipoda, which represented by 7 species (21.21 %) and 6 families (24 %), and then Isopoda which represented by 4 species (12.12 %) and 3 families (12 %). However, the other rest orders (Cumacea, Leptostraca, Mysida, and Stomatopoda) are represented by 5 species (15.15 %) and 5 families (16 %) (Fig. 2). Crustacean species list, species occurrence, and variation of species densities (Individual/m^2) at different seagrass patches and microhabitat (Patch edge and center) of the seagrass, *Halophila stipulacea,* at the two study sites are given in Table (1). However, associated-crustacean species photographs were shown in Plates (I-IV).

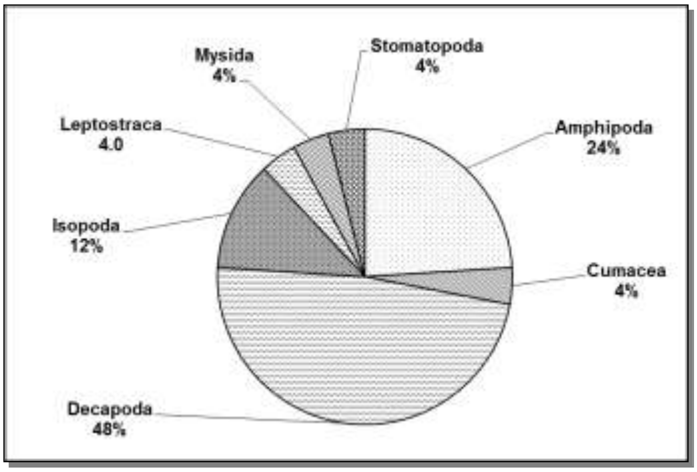


Fig. (2): Percentage of occurrence of different crustacean families irrespective to sites.

2-Effect of seagrass fragmentation:

Figure (3) gives the changes of the annual average crustacean density (ind. /m^2) in different seagrass patch size for each investigated site. Generally seagrass canopy in large patches at both sites promotes higher crustacean densities than medium and small seagrass patches. The highest mean density was recorded in large seagrass patch at Abou Monkar Island, being 2067 (ind. /m^2), of which decapods and amphipods were the most dominant groups with average densities of 1195 (ind. /m^2) and 835 (ind. /m^2) respectively. Large patch in Marine Station site came in the second order with mean density of 1038 (ind. /m^2), of which Decapoda and Amphipoda groups were the most dominant groups with average densities of 478 (ind. /m^2) and 257 (ind. /m^2) respectively.

Changing in crustacean groups densities among the different patch sizes (Figure, 4) have the similar pattern of total crustacean density which are markedly increase in the large patches except decapod densities in site (I) which are approximately equal in both large and median patch. Amphipods at Abo Monkar site have deviated values where their abundance was higher in small patches than medium patches.

Crustaceans diversity also affected by patch size, where the number of species-inhabited large patches at two sites (29 and 28 species in site II and site I respectively) were higher than those recorded from medium patches (20 and 16 species in site II and site I, respectively) and small patches (12 and 17 species in site II and site I respectively) (Table 1 and Fig. 5). Reduction in the number of crustacean species occurred when 4-3 amphipod spp., one cumacea sp., 5-6 decapod spp., 1-3 isopod spp. and1-2 leptostraca spp. were undetected in either medium or small patches, respectively. However, members of orders Mysidea and Stomatopoda were undectected in medium and small seagrass patches of site (II) (Table 1).

Diversity indices values of epiphytic crustacean assemblage were compared in different patch size in both investigated sites and such data represented in Figures (6 A and B). Based on the abundance of different crustacean species, Shannon winner index showed that the highest index value at Abo Monkar was observed in large patch (H'=2.56). Then the value decreased with the decreasing in patch size reaching its minimum at small patch (H'=1.51). At Marine station site, the highest H' was observed in large patch (H'=3.02) and decreased in medium and small patches which is approximately equal (H'=2.44 in medium patch and =2.61 in small one). Evenness values exhibited the same pattern as shown in Shannon index with normal increase toward large patch at Abo Monkar site (range of J' ≈ 0.61- 0.77). However, at Marine station site, it ranged from 0.81 in medium patch to 0.92 in small patch.

Species richness is dealing with densities of faunal species at different patch size showed high fluctuations of richness index values increasing of their values toward the large patches for each site. The values reach to score the highest value in large patch at Marine Station site being, d ≈ 4.1. After that, they were markedly decreased reaching the lowest index value (d≈1.7) in small patch at Abou Monkar Island.

3-Effect of edge in abundance and diversity:

Total crustacean abundance was slightly increased towards the seagrass patch edge at Abo Monkar site with only 3.4 % percentage of increase. At Marine Station site, however, such increase was clear with 29.4 % as a percentage of increase (Fig. 7). The differences among crustacean orders were given in Figure (8) which showed that the most crustacean orders response to edge effect and being more abundant than the center of the patch. Amphipods, decapods and isopods at Abo Monkar sites have an opposite colonization pattern and their densities increase in the center of the patch (Fig. 8).

At Abo Monkar site, seagrass crustacean fauna being more diverse in the patch edge with 32 species inhabiting such microhabitat versus 24 species recorded in the center. At Marine Station site, however, the opposite distribution is observed with 28 species inhabiting the center of the patches versus 24 species recorded in the edge (Fig. 9). The same conclusion was confirmed by species richness (d) values (Fig. 10 A&B). But regrades to abundance of different crustacean species, Shannon winner index and Evenness (Fig. 10 A&B) showed an a distinct increase in their values towards the edge except the eveness value of the center and edge at marine station site which is reatively equal for each other (J' ≈ 0.86 for edge and 0.89 for center).

3-Effect of shoots density/biomass on crustacean abundance and diversity:

The results indicate that seagrass shoot count and biomass of the selected seagrass patches are negatively affected by seagrass fragmentation, in which their seasonal outcome decrease when the patch size decreased with relatively higher production toward the center. The relationship between seagrass shoot density or biomass and the total crustacean abundance represented in Figure (11 A&B) with a bell-shaped distribution in which the carrying capacity of crustaceans abundance is restricted with shoots densities of the range 1600-2700 (shoots/m^2) and biomass of the range 100-150 (gm/m^2).

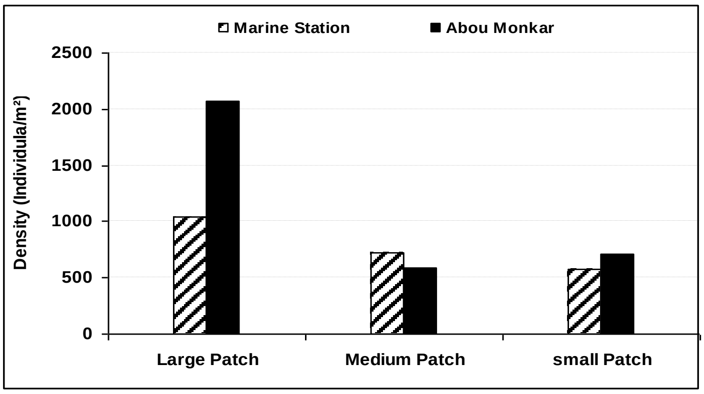


Fig. (3): Total annual crustaceans densities (Individual/m^2), inhabiting the seagrass, *Halophila stipulacea,* in relation to the patch size.

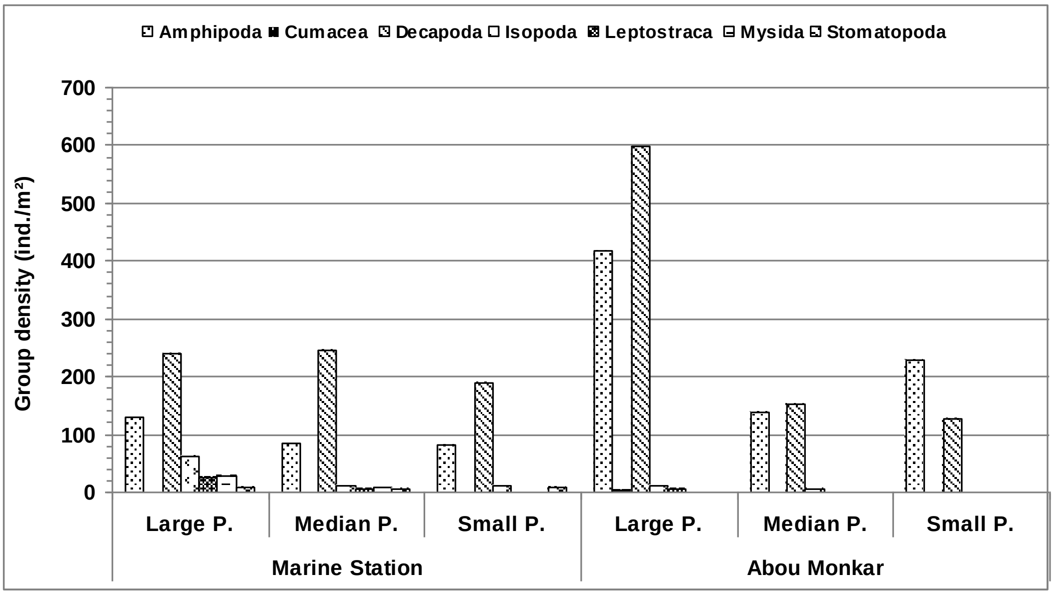


Fig. (4): Average densities (individual/m^2) of epifaunal crustacean orders inhabiting different seagrass patch size at two studied sites.

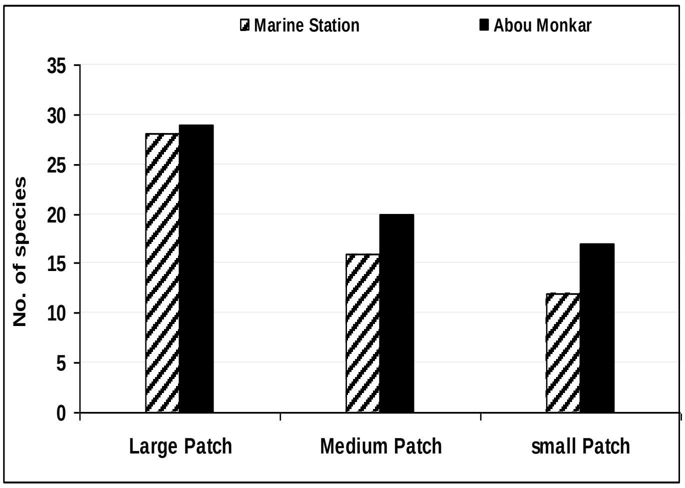


Fig. (5): Total number of crustacean species, inhabiting the seagrass *Halophila stipulacea,* in relation to patch size.

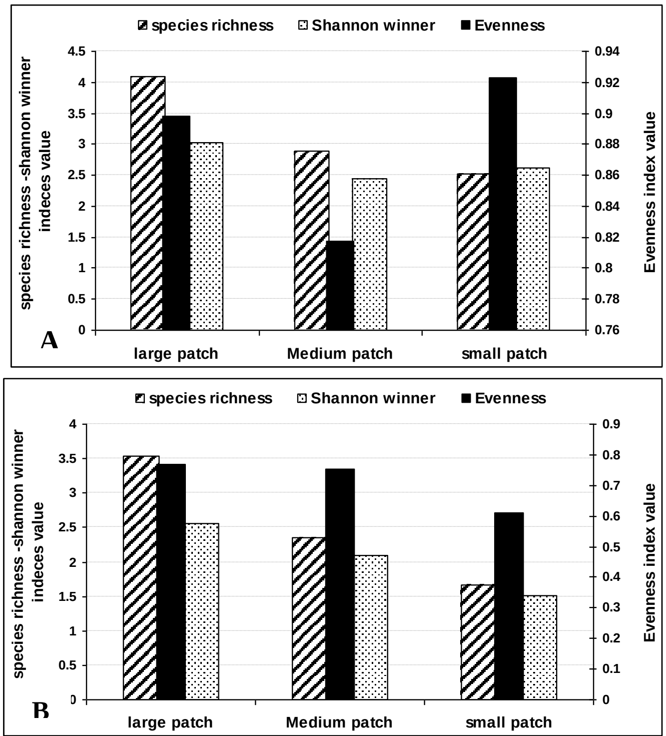


Fig. (6): Diversity Indices of crustacean assemblage, inhabiting the seagrass *Halophila stipulacea,* in different patch size at both Marine station site (A) and Abou Monkar site (B).

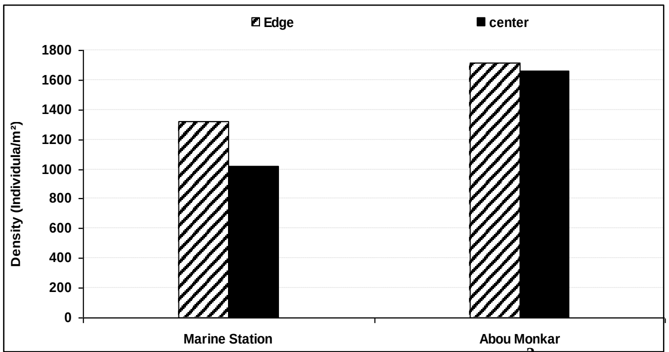


Fig. (7): Tota annual crustaceans densities (Individual/m^2), at edge and center of the sea grass, *Halophila stipulacea,* patches.

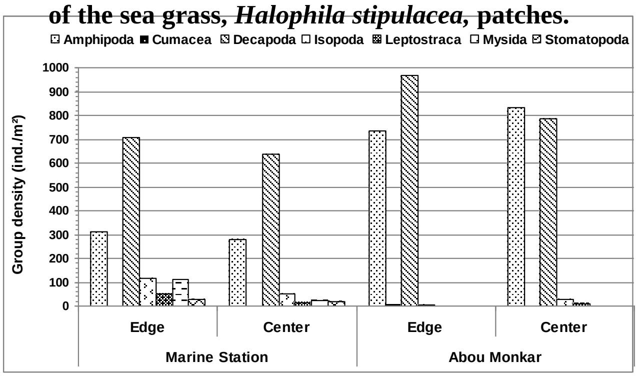


Fig. (8): Average densities (individual/m^2) of epifaunal crustacean orders in edge and center of seagrass patches at two sites in the study area.

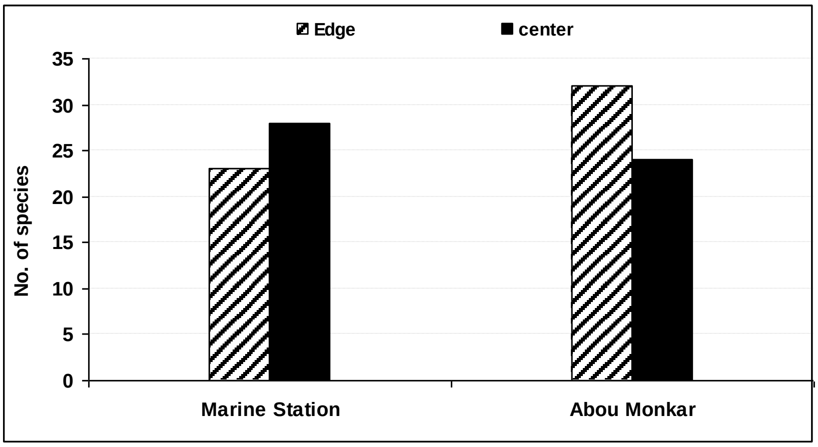


Fig. (9): Total number of crustacean species at edge and center of the patches of the seagrass, *Halophila stipulacea,* at two studied sites.

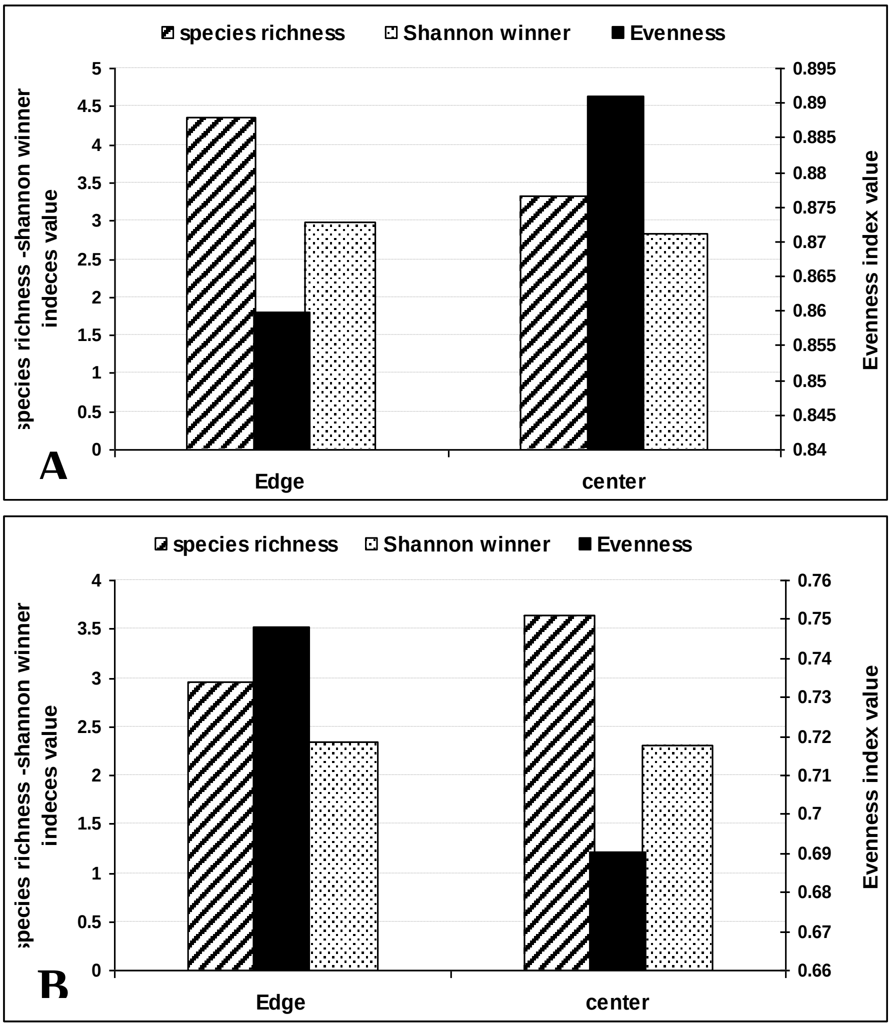
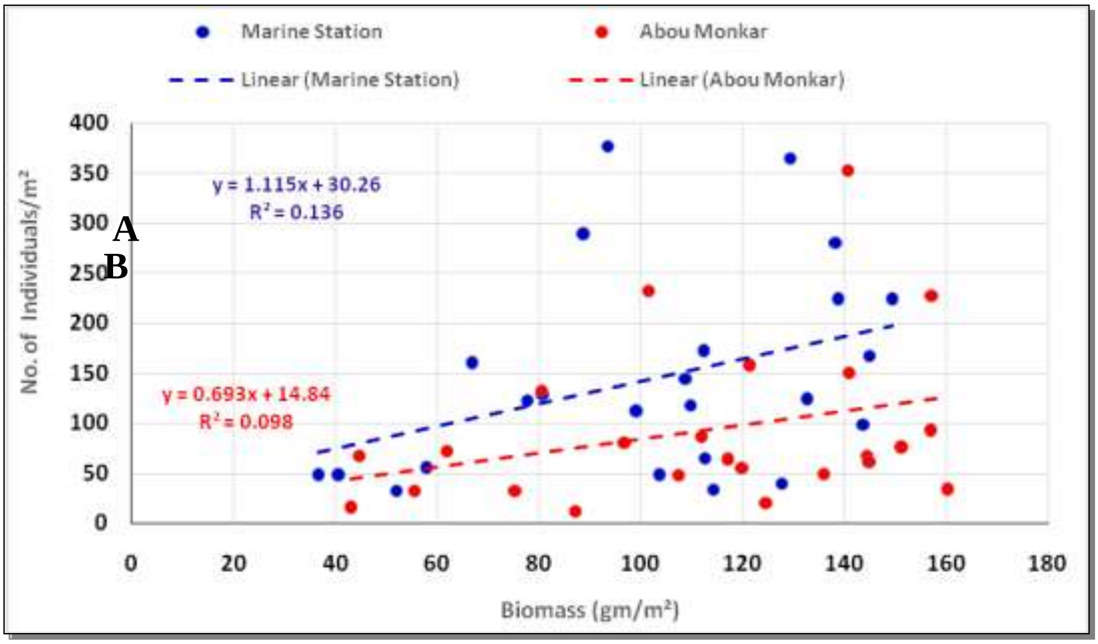


Fig. (10): Diversity Indices of crustacean assemblage at edge and center of the patches of the seagrass *Halophila stipulacea* in both marine station site (A) and Abou Monkar site (B).



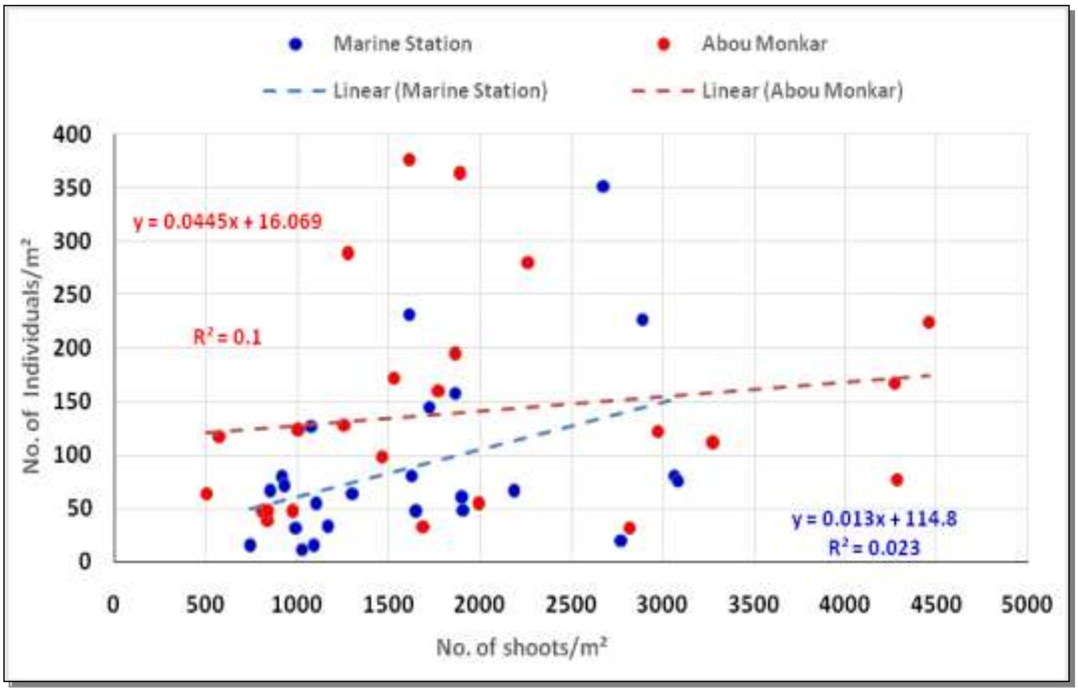


Fig. (11): Relationship between plant [shoots count (shoots/m^2) (A) and biomass (gm/m^2) (B)] and crustacean abundance (individual/m^2) inhabiting seagrass beds in the study area.

Table (1): Spatial distribution, occurrence, and density (Individual/m^2) of epifaunal crustaceans inhabiting different patches of the seagrass *Halophila stipulacea* at two sites in the study area. (C: Center; E: Edge; P: Patch).

sp.	Site (1): Marine Station site						Site (2): Abou Monkar Island					
	large p.		**Medium p.**		**small p.**		**large p.**		**Medium p.**		**small p.**	
	E.	**C.**	**E.**	**C.**	**E.**	**C.**	**E.**	**C.**	**E.**	**C.**	**E.**	**C.**
Amphipoda												
Ampithoe ramondi	12	-	-	-	-	16	20	12	-	-	-	-
.Jassa sp	10	-	-	-	-	-	5	17	10	5	-	-
Ceradocu sp	17	5	5	-	-	-	5	20	-	-	-	-
Parelasmopus suluensis	12	5	-	-	-	16	29	-	-	-	-	16
.Leucothoe sp	133	16	57	108	28	72	336	312	133	108	128	316
.Lysianassa sp	20	-	-	-	-	-	46	12	20	-	-	-
.sp Photis	17	10	-	-	-	32	5	16	-	-	-	-
Cumacea												
.Diastylis sp	-	-	-	-	-	-	5	-	-	-	-	-
Decapoda												
Alpheus sp.1	-	-	5	12	-	-	116	68	51	29	-	16
Alpheus sp. 2	12	12	5	5	-	48	28	-	-	-	-	16
Athanopsis australis	29	24	-	-	-	4	-	28	-	-	-	16
.sp Rochinia	24	12	17	12	-	32	57	-	-	12	-	16
.sp Galathea	37	28	22	17	-	-	112	52	17	21	16	48
.sp Elamena	-	-	37	16	-	48	25	16	-	-	-	-
.Pyromaia sp	69	21	114	25	-	16	74	40	5	26	32	-
Coleusia signata	-	12	12	-	-	-	-	-	-	-	-	-
Ebalia sp	29	-	-	-	16	-	4	12	5	-	-	-
.sp Cyphocarcinus	5	-	-	-	-	-	4	5	5	-	-	-
.sp Brachycarpus	-	-	-	-	4	64	23	28	20	-	-	-
.Periclimenes sp	5	-	12	5	16	-	-	16	21	24	-	16
.Chlorotocella sp	24	12	-	-	-	48	21	24	-	-	-	16
.sp Leptochela	-	12	17	12	-	-	-	28	-	-	-	-
.Nectocarcinus sp	49	16	37	20	-	48	113	64	5	28	-	-
Thalamita sima	17	-	40	24	16	16	125	49	22	-	16	32
.sp Chlorodiella	24	5	12	12	-	-	38	25	12	-	-	16
Isopoda												
Anthura gracilis	52	17	-	5	4	16	-	12	-	5	-	-
Gnathia africana	12	-	-	-	-	-	-	-	-	5	-	-
Idotea metallica	12	12	5	-	-	-	5	5	-	-	-	-
.Idotea sp	17	-	12	-	-	-	-	-	-	-	-	-
Leptostraca												
Nebalia bipes	36	-	-	-	-	-	-	5	-	-	-	-
.Nebalia sp	5	12	10	-	-	-	-	5	-	-	-	-
Mysida												
.Gastrosaccus sp	5	-	5	-	-	-	-	-	-	-	-	-
Stomatopoda												
.Anchisquilloides sp	5	12	5	5	16	-	-	-	-	-	-	-

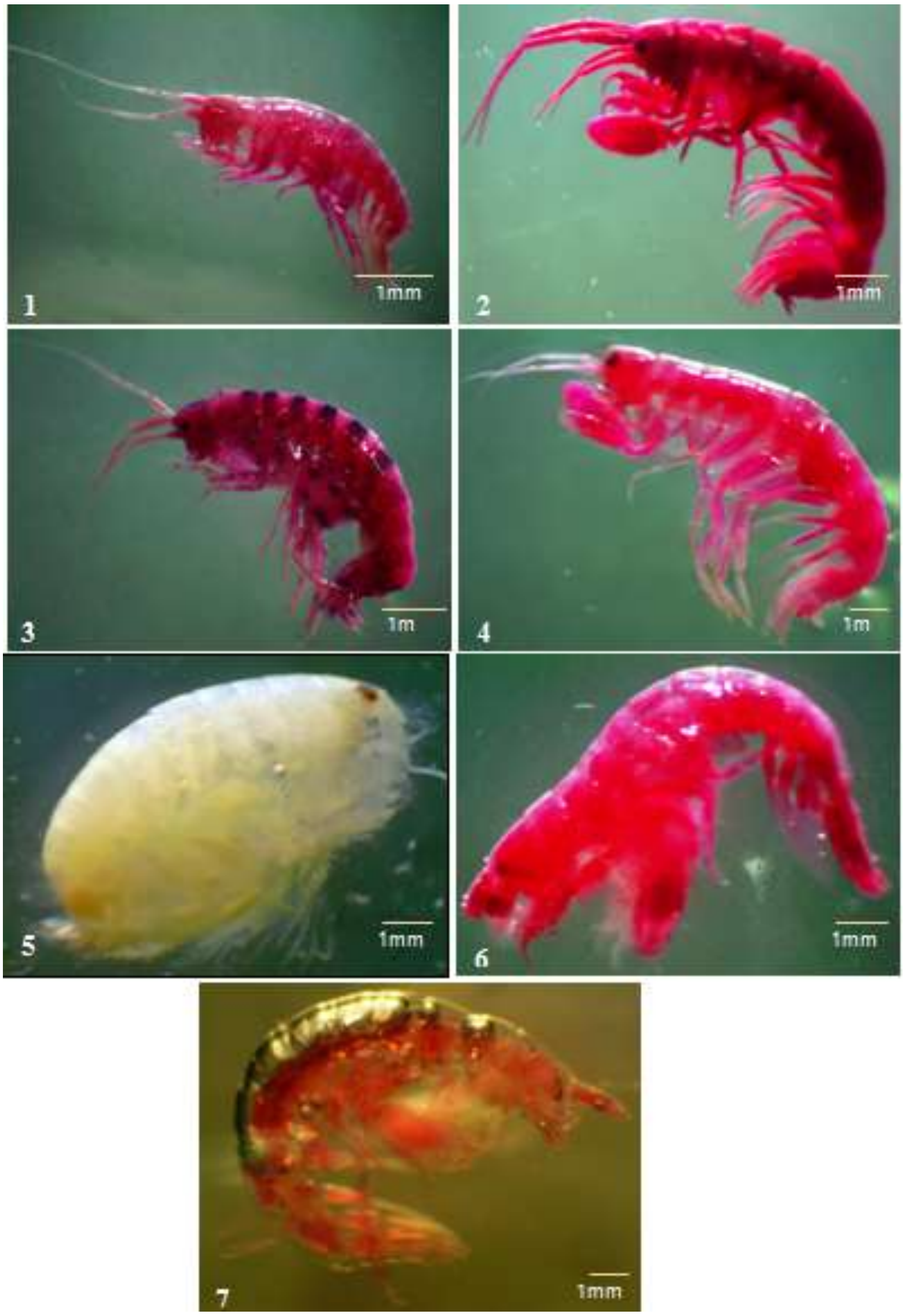


Plate 1: Order Amphipoda: ***Ampithoe ramondi*** **(1);** ***Ceradocus sp*** **(2);** ***Parelasmopus suluensis*** **(3);** ***Leucothoe sp*** **(4);** ***Lysianassa sp*** **(5);** ***Jassa sp*** **(6) and** ***Photis sp*** **(7).**

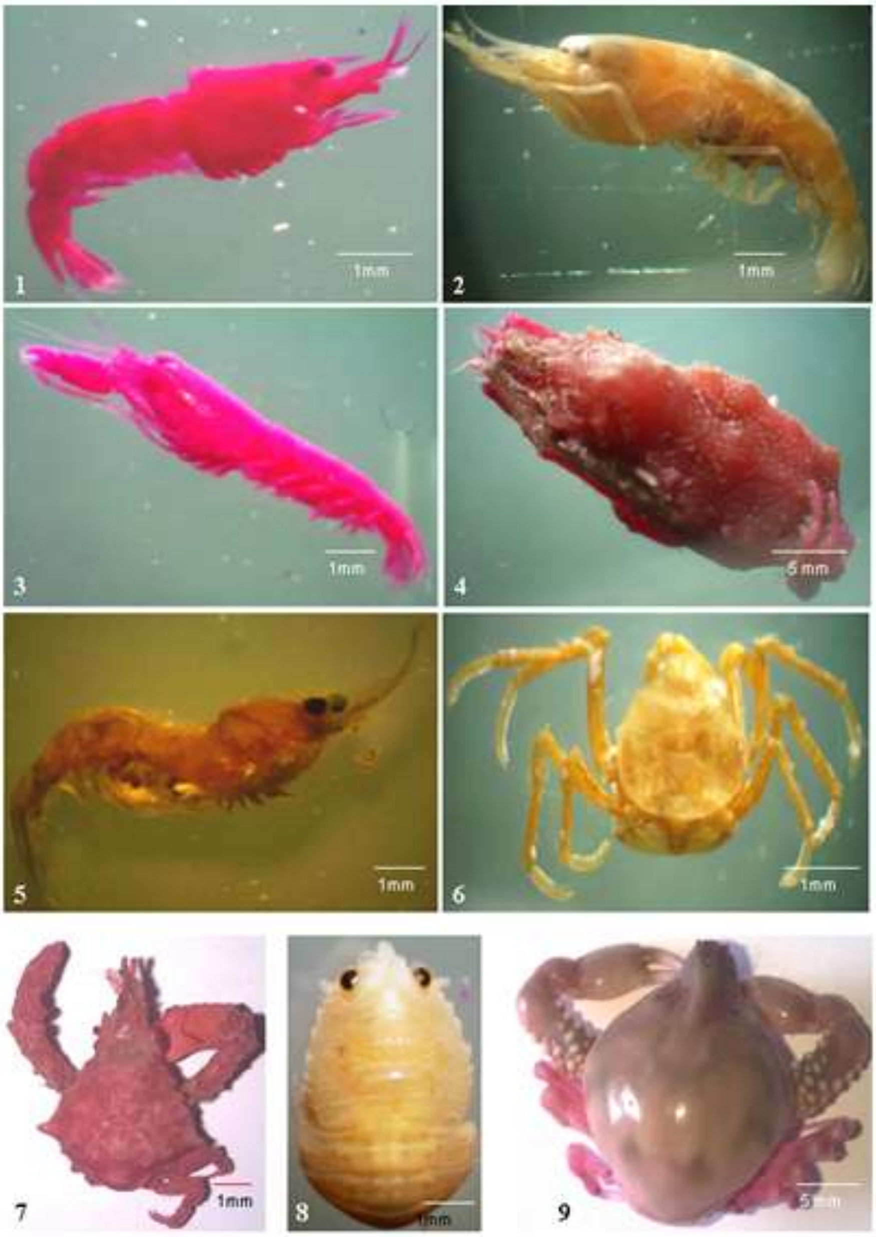


Plate II: Order Decapoda: ***Alpheus sp.1*****(1);** ***Alpheus sp.2*** **(2);** ***Athanopsis australis*** **(3);** ***Rochinia sp*** **(4);** ***Periclimenes sp*** **(5),** ***Elamena sp.*****(6);** ***Pyromaia sp*** **(7);** ***Galathea sp.*****(8) and** ***Coleusia signata*** **(9).**

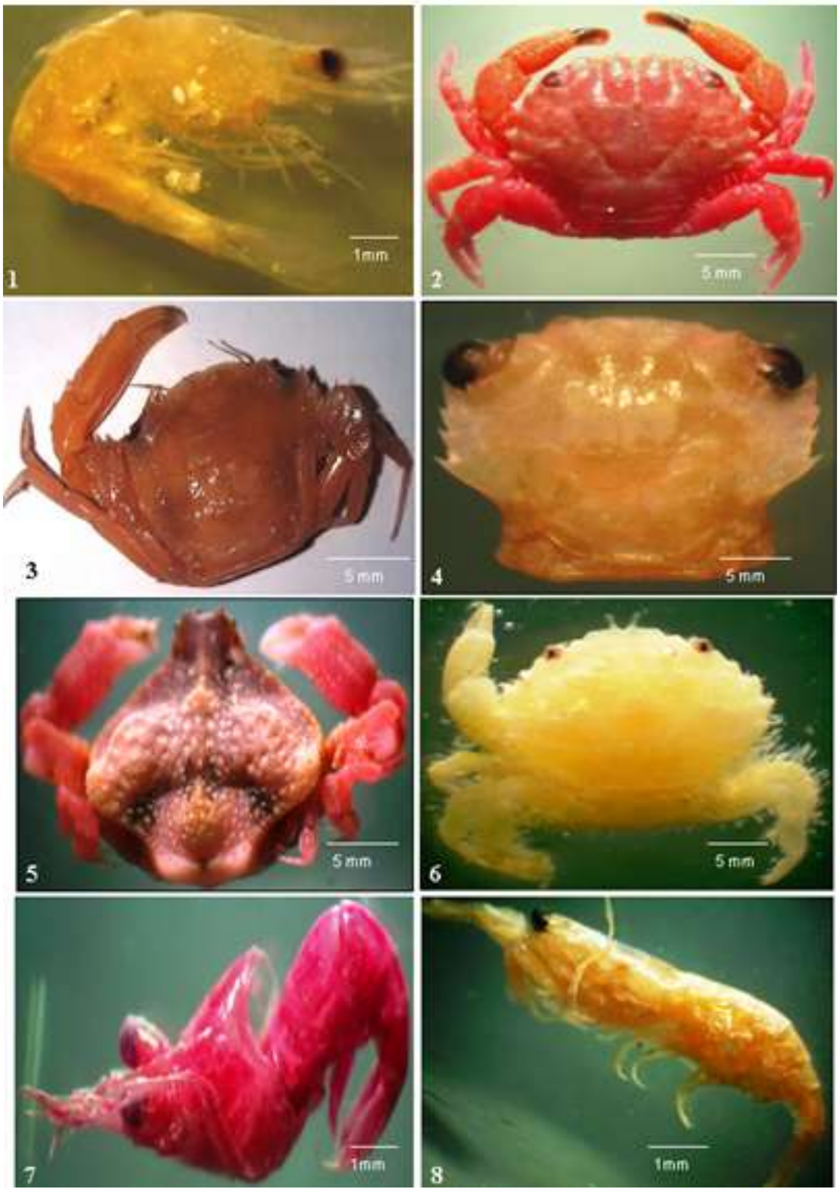


Plate III: Order Decapoda: ***Chlorotocella sp.*****(1);** ***Nectocarcinus sp.*** **(2);** ***Thalamita sima*** **(3);** ***Chlorodiella sp.*****(4);** ***Ebalia sp.*****(5);** ***Chlorodiella sp.*****(6);** ***Brachycarpus sp.*** **(7) and** ***Leptochela sp.*****(8).**

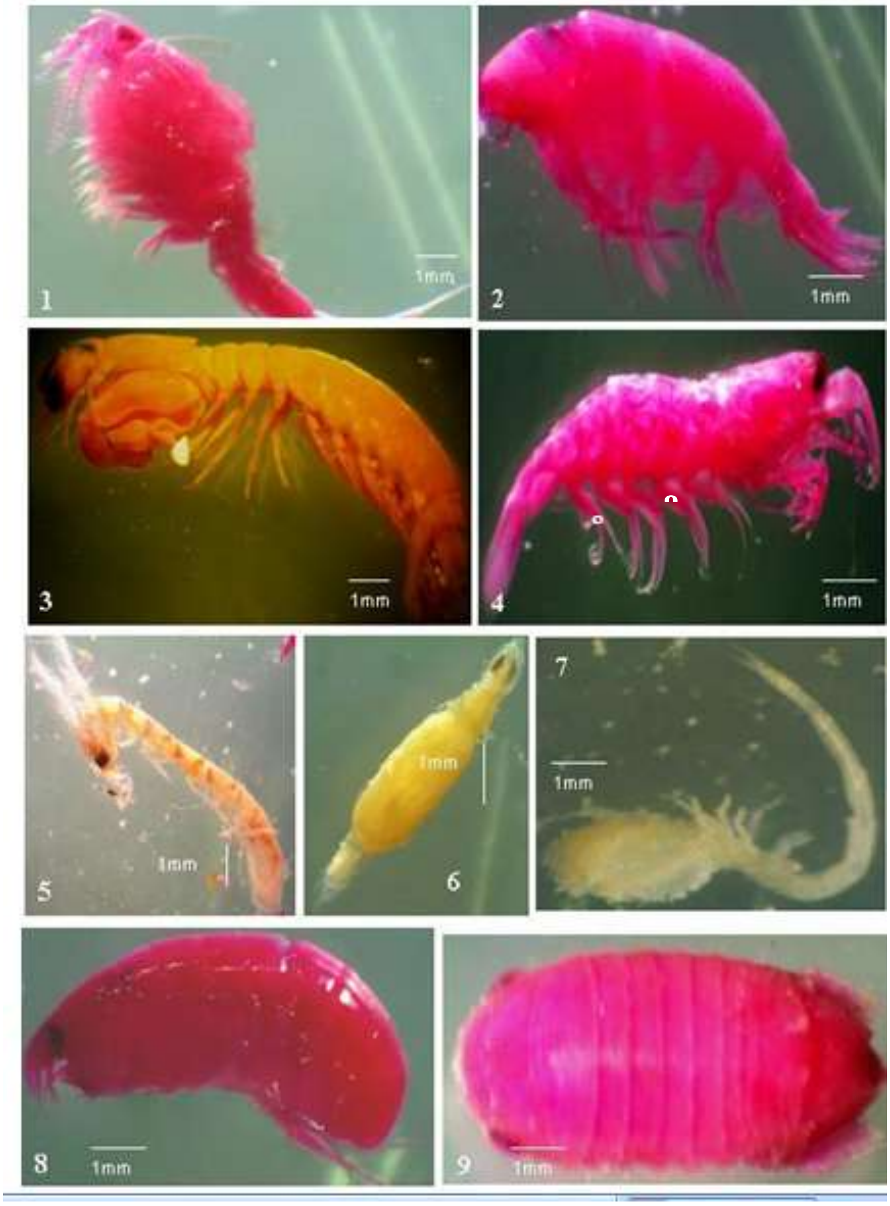


Plate IV: Other Crustacea species: ***Nebalia bipes*** **(1);** ***Nebalia sp.*** **(2)*****; Anchisquilloides sp.*** **(3);** ***Gastrosaccus sp*****.(4)*****;Anthura gracilis*** **(5)*****; Gnathia Africana*** **(6)*****; Diastylis sp*****.(7)*****;*** ***Idotea metallica*** **(8) and** ***Idotea sp*****(9).**

DISCUSSION

Seagrass beds are an ecologically significant marine habitat providing food and shelter for benthic invertebrates, which in turn provide food for fish, large crustaceans and shore bird communities. Seagrass beds are highly productive ecosystem; they fulfill a key role in the coastal zone with important ecological and economic functions, notably their importance to fisheries[25] and their role in preventing coastal erosion and siltation of coral reefs[26]. Despite its value and importance, they are very sensitive and its health is affected by a wide range of natural and human disturbances that occur at a range of spatial and temporal scales**.** This paper involved studying the effect of seagrass habitat fragmentation, and in turn the edge effect on crustacean community inhabiting seagrass beds at two sites in Hurghada area.

Regarding the negative or positive effect of seagrass fragmentation, data in the present study indicated that seagrass canopies in large patches harbor higher crustaceans' densities than medium and small seagrass patches, which promotes the assumption of the negative effect of seagrass fragmentation. Crustacean groups' abundance is also markedly increases in the large patches except decapod at Marin Station site in which their abundance are approximately equal in both large and median patch. Amphipods have deviated values whereas their abundance was higher in small patches than medium patches at Abo Monkar site.

Accordingly, the fragmentation studies on terrestrial habitats it is feasible to predict that density and diversity of related fauna is decreased in the smaller habitat patches when compared with larger and continuous ones[27,28]. Such prediction is not consistent in marine habitat in which neutral or even positive effects of habitat fragmentation on faunal abundance and diversity were reported in many studies[16, 29, 30, 31, 32, 33, 34, 35,36].

However, the negative effect of habitat fragmentation notably in marine seagrass, as found in the present study, attributed to the direct effect of habitat isolation[37]**.** Nevertheless, there are unexpected opposite colonization pattern of associated fauna especially crustaceans such as amphipods in the seagrass in north gulf of Mexico and Baltic Sea in Gustafssun and Salo[37] whom suggested that associated fauna are not equally sensitive to patch isolation in different regions.

Habitat fragmentation have different impacts on biodiversity that can be both positive and negative[38, 35, 39,36]. In the present study, reduction of habitat size led to reducing the number of crustacean species in both sites. In addition, the Shannon index (H') and species richness (D) promotes this conclusion although the closest values in medium and small patches. However, Evenness values (J') showed that habitat fragmentation had no effect on diversity. Such disturbed data may raise from the difficulties that facing us to take a replicated samples in small patches, which led to the increase of species abundance in small patches. In addition, high mobility of crustacean fauna contributes in reducing the fragmentation effect due to their positive response to edge effect. This is consistent with the similar findings related to effect of seagrass fragmentation on fish assemblage by Macreadie *et al.*[36] who suggested that positive edge effects compensated for area loss.

Faunal responses to increased habitat patchiness and edge effects are largely determined by individual dispersal abilities, which are higher in marine than in terrestrial environments[39]. Many animals move across edges in their search for food, mating opportunities or avoidance of predators[40]. Alternatively, organism preferences or active habitat choice for edges or interior parts of patches can be an important factor in their colonization of fragmented habitats[16,41]. In this study, total crustaceans' abundance is relatively increased toward the patch's edge with a percentage of increase up to 29.4 %. The weak positive effect of the edge in Abo Monkar site (3.4%), in the present study, is due to two reason; the first is related to the manner of data expression, which is calculated as an average of seasonal values. The second reason is related to the natural differences within crustacean groups and even species. Some crustacean groups (including amphipods, decapods and isopods) have an opposite colonization pattern at Abo Monkar site and their densities increase toward the center in this site. Negative edge effect also noticed in crustacean amphipod in the seagrass of north Gulf of Mexico and Baltic Sea[37]

In the present study, crustacean species richness was alternatively dynamic across microhabitat (patch edge and center) in both sites, suggesting that species richness is insensitive to differences in patch edge-center microhabitat **[**18, 42&43**]**. Although edges may be advantageous to some mobile crustaceans, they are also sites of increased predation risk[1].

Seagrass patch shoots at bed edges are first to encounter changes in resource availability or quality, or to be subjected to a given disturbance. Changes in growth patterns may reflect changes in environmental conditions otherwise difficult to detect, and may be mirrored in associated faunal communities. For example, clonal plasticity may allow seagrasses to “forage” for resources and concentrate growth in resource-rich areas **[**7&17**]**. Although, the weak correlation between seagrass shoot density/biomass and the total crustacean abundance, in the current study, but we easily figured out that a specific range of shoots density/biomass that can support the maximum crustacean abundance. Such findings suggested that the mobile crustaceans attend to colonize a moderate shoots density which allow it to avoid predation and, in the same time, to compete for food/oxygen resources and movement in more clonal plasticity[7].

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Effect of habitat fragmentation on abundance and diversity of seagrass-associated crustacean assemblage at Hurghada, Red Sea

تأثير تفتت البيئات على الوفرة والتنوع لتجمعات القشريات المصاحبة للحشائش البحرية بمنطقة الغردقة، البحر الأحمر

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المستخلص

مروج الحشائش البحرية في البحر الأحمر تتعرض بصورة متزايدة إلى الاضطرابات الطبيعية والبشرية والتفتت، مما يؤدي إلى عزل بقع الحشائش الناتجة عن تفتت تلك المروج وزيادة مساحة الحافة. ولأجل ذلك صممت هذه الدراسة لاختبار مدى تأثير عاملي "تفتت البيئات" و"الحافة البيئية " على الوفرة العددية والتنوع لتجمعات القشريات المصاحبة للحشائش البحرية. تم اختبار العوامل السابقة حقلياً حيث تم اختيار موقعين حقليين يتميزان بوجود تنوع في أحجام بقع الحشائش البحرية ليتم تجميع فونة القشريات منهما بشكل كمي وعلى مدار أربع مواسم خلال الفترة من منتصف أبريل 2015 إلى منتصف يناير 2016 وذلك من ساحل البحر الأحمر بمدينة الغردقة. من خلال الدراسة تم تقييم الاختلافات في وفرة الأفراد وعدد الأنواع للقشريات محل الدراسة تبعاً لاختلاف حجم بقعة الحشائش وكذلك الاختلاف بين تجمعات القشريات المتواجدة على الحافة والمتواجدة في المركز لهذه البيئات.

من خلال الدراسة تم رصد 33 من أنواع القشريات ينتمون إلى 30 جنسا، 25 عائلة و 7رتب تصنيفية وهي تنتمي جميعها لطائفة "مالاكوستراكا". هذا وقد تم تسجيل هذه الأنواع من جميع موائل الأعشاب البحرية (تحت الظروف المختلفة) وان اختلفت هذه الأعداد باختلاف التوزيع الزماني والمكاني لهذه الأنواع المسجلة. هذا وقد بينت النتائج أن بيئة الحشائش البحرية المتواجدة في مروج كبيرة متواصلة في موقعي الدراسة تشتمل على أعلى وفرة عددية من القشريات مقارنة مع البقع الحشائشية ذات الأحجام المتوسطة والصغيرة مما يعزز فرضية التأثير السلبي للتفتت على تجمع القشريات. كما تبين أيضاً زيادة وفرة كل المجموعات القشرية بشكل ملحوظ في البقع الكبيرة فيما عدا مجموعة "ديكابودا" (في أحد موقعي الدراسة). هذا وكان من الواضح أن تقلص حجم بيئة الحشائش قد أدى إلى انخفاض عدد أنواع القشريات في موقعي الدراسة مما يعزز التأثير السلبي للتفتت حتى مع استخدام مدلولات التنوع النسبية. ولكن مدلول التنوع البيولوجي المعتمد على عدالة التوزيع (J') باستخدام معامل وفرة الأفراد لكل نوع قد أظهر عدم وجود تأثير للتفتت على تنوع القشريات. هذا وقد أظهرت النتائج أن موقعي الدراسة قد تضاربا في مدول تأثير الحافة على التنوع مما يعنى عدم حساسية تنوع القشريات لتأثير الحافة البيئية. هذا وقد تعرضت النتائج أيضاً لتأثير الكثافة والكتلة الحيوية للنبات السطحي للحشائش البحرية ووفرة القشريات لهذه البيئة البحرية.