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Ecology and taxonomic revision of family Fibulariidae (Echinoidea: Echinodermata) inhabiting seagrass bed at the vicinity of Hurghada, Red Sea, Egypt.

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ABSTRACT

Aspects of the distribution, ecology and taxonomy of fibulariid species inhabiting seagrass beds at Hurghada and About Monkar Island, Northern Red Sea, Egypt were characterized. The fibulariid fauna comprised four species belonging to two genera, among them two endemic species to the Red Sea, *Fibularia ovulum* and *Fibularia volva.* On the other hand, the other two species, *Fibulariella acuta* and *Fibularia cribellum* were recorded for the first time from the Red Sea; they are considered new record to the Red Sea echinoderm fauna. The distribution of the recorded species from different regions of the Red Sea were compared with other adjacent areas as well as the ecological geographical distribution were discussed.

Keywords: Echinoidea, Fibulariidae, Ecology, Taxonomy, New Recorded, Seagrass, Red Sea.

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INTRODUCTION

Sea urchins (Echinoidea) form an important group of motile macro invertebrates and a prominent part of the coral reef crypto-and dwelling fauna [1&2]. They are also important members of near-shore biota, contributing significantly to the food chain and to the modification of the substrata [3]. The history of record echinoids from the Red Sea goes back to the France Scholars who followed Napoleon's Military Campaign to the Egypt in 1798. In the description de l'Egypt, [4] describe a numerous new records. During the 19th century and the first half of 20th a number of scientific expeditions to the Red Sea were conducted, resulting in a large collection of the echinoids. Monographs and catalogues resulting from these expeditions added new species, as well as new record from the Red Sea [5, 6, 7, 8&9]. There have been new echinoid records in the subsequent years [10, 11, 12, 13, 14, 15, 16&17], but in the general, the literature on the actual number of the echinoid species of the Red Sea is limited and in some respects lacking.

The aim of the present work is to present comprehensive ecological and taxonomical studies on the members of family Fibulariidae (Echinoidea) inhabiting seagrass bed around Hurghada area, Red Sea.

MATERIALS AND METHODS

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. Ecological information and taxonomic sampling were conducting from two sites (Table, 1).

Table (1): Latitudes & Longitudes recognition and habitat characters of study area sites.

Site Name	Position	Habitat types
Marine Biology Station (NIOF)	°27.286256 **N** °**33.772276 E**	**Rocky substrata, dead and live coral, algae and seagrass, 15 m depth.**
Abou Monkar Island	°27.221284 **N** °33.896852 **E**	**Rocky substrata, algae and seagrass, 10 m depth.**

Sampling and preservation

Seagrass canopy and root sediment samples with their benthic 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 cut using a scissor and quickly putted inside a polyethylene bags including associated fauna among the seagrass blades and the epifaunal organisms. After removing the shoots, root fauna samples were collected using the core at depth 10 cm from surface of the sea bottom. Each core sample was unloaded in a polyethylene bags. The canopy and root samples were preserved in 10 % sea water formalin.

Laboratory work

In the Laboratory, the seagrass canopy and sediment samples were washed and their fauna were extracted through 0.5 mm mesh sieves. Extracted fauna were sorted and preserved in 70 % ethyl alcohol including the irregular echinoids. Critical identification for each specimen and species was carried out using extensive literatures available [15, 17, 18, 19&20]. The fibulariid species recorded from Red Sea and surrounding areas were compiled using our data as well as data from other works of [13, 16, 18, 19&21]. Fibulariid fauna from the different regions of the Red Sea were abstracted from the Echinoderm Zoological Record and other sources. Each Echinoid species were separated counted and photographed with a digital camera. Species density was calculated in seagrass habitat and expressed as a number of individuals per square meter.

The following terms and measurements were used:

Length diameter (l.d.):

The distance between the edge of the test toward the mouth and the opposite test edge toward the anus.

Width diameter (w.d):

The broadest part of the test through the horizontal diameter, which comes at the level of the anterior pair of petals.

Vertical diameter (v.d.):

The vertical diameter from the oral side to the aboral side.

RESULTS

Ecological aspects of seagrass fibulariids.

Overall, four fibulariid species, belong to two genera have been observed after examining all the seasonal canopy and root samples. Seasonal occurrence data (Table, 2) showed that the previously recorded endemic species, *F. ovulum and F. volva*, have been occurred in all seasons among both seagrass canopies and roots except spring season in which *F.* volva was occurred only among the roots at NIOF site. Considering to the other species, *Fibulariella acuta* has been observed during summer season only, while *F. cribellum* has been observed only during spring and summer seasons among both canopies and seagrass roots and only observed among the canopies in winter and never observed in autumn season (Figure, 1).

Table (2): Fibulariidae: species observed and their seasonal densities (Individual/ m^2), in seagrass canopies and roots sediment at two different sites from the Red Sea.

season	sp.	NIOF		Abou Monkar	
		canopy	root	canopy	root
winter	Fibulariella acuta	-	-	-	-
	Fibularia cribellum	8	-	-	-
	Fibularia ovulum	8	10	-	-
	Fibularia volva	4	10	-	-
spring	Fibulariella acuta	-	-	-	-
	Fibularia cribellum	12	15	-	10
	Fibularia ovulum	8	15	8	20
	Fibularia volva	-	10	-	-
summer	Fibulariella acuta	8	10	-	-
	Fibularia cribellum	8	15	-	-
	Fibularia ovulum	20	10	-	10
	Fibularia volva	24	10	-	-
autumn	Fibulariella acuta	-	-	-	-
	Fibularia cribellum	-	-	-	-
	Fibularia ovulum	24	10	-	-
	Fibularia volva	4	10	-	-

Population densities of the fibulariid species (Table, 2) ranged from 4 to 24 Individual/m^2 in seagrass canopies and from 10 to 20 Individual/m^2 in seagrass roots. The highest population densities recorded in summer season followed by spring season. In general, both plant parts have totally a comparable fibulariids density. However, detailed species data showed that *Fibulariella acuta and. F. cribellum* prefer the root parts and vice versa *F. ovulum and F. volva* prefer the canopy parts (Figure, 1). *F. ovulum and F. volva were more dominant* fibulariid species in all seasons except spring in which *F. ovulum and F cribellum* were more dominant (Figure, 1).

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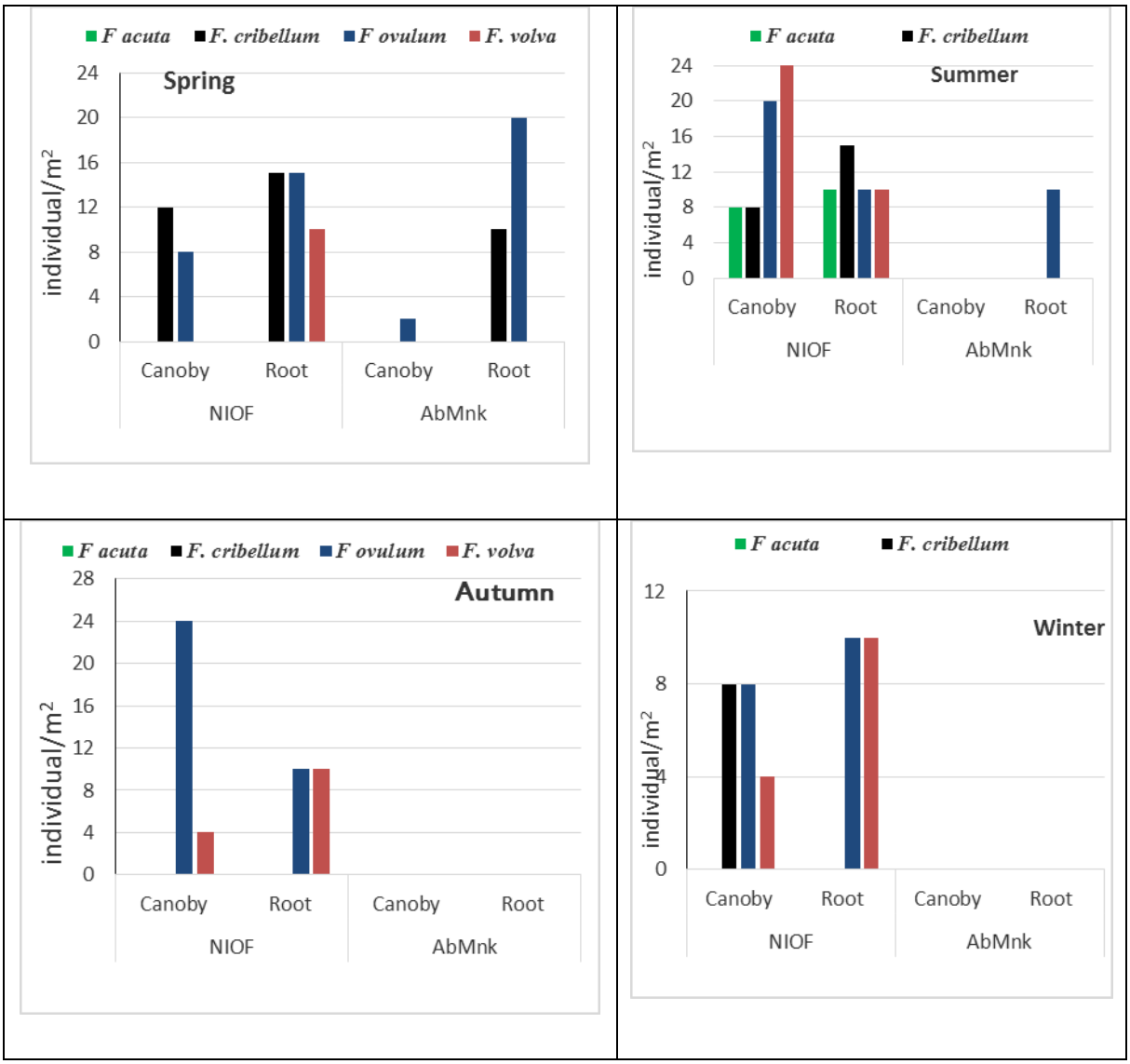

Fig. (1): Distribution and average Abundance of Fibulariidae species (Individual/m²) in seagrass communities (canopy and root) in different investigated sites: marine station site (NIOF) and Abu Monkar island site (AbMnk), Hurghada, Egypt.

Regarding to the distribution of fibulariid species in the Red Sea and adjacent waters (Table, 3), its clear that both *Fibularia ovulum* and *Fibularia volva* were recorded in all regions of the Red Sea and South East of Arabia, However, the first spccies was recoded only from East Africa. However, *Fibulariella acuta* and *Fibularia cribellum,* were recorded only in the Red Sea among the current study as a new record species. In contrast, there is no any record of fibularid species from the Arabian Gulf (Table, 3).

Table (3): Faunal list of fibulariid species recorded from the Red Sea and adjacent waters. (Information: present collection [13,16,18&21].

Species	Gulf of Suez	Gulf of Aqaba	Red Sea		Adjacent areas		
			North	South	S.E.Arabia	Arabian Gulf	East Africa
Fibulariella acuta	----	-----	+ *	------	------	-----	----
Fibularia cribellum	----	----	+ *	------	-------	-----	----
Fibularia ovulum	+	+	+	+	+	------	+
Fibularia volva	+	+	+	+	+	-----	----

*** = New record.**

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Taxonomic aspects of investigated seagrass fibulariid species.

Family: Fibulariidae Gray, 1855

Anus not within the apical system; mouth central; test oval; petal shortly stopping of the ambitus; lantern and teeth present; length rarely more than 10 mm; aboral milliary spines ending in a crown; petal inconspicuous periproct rounded.

Fibulariella acuta (Yoshiwara, 1898)

Plate, I (Fig. 1 & 2)

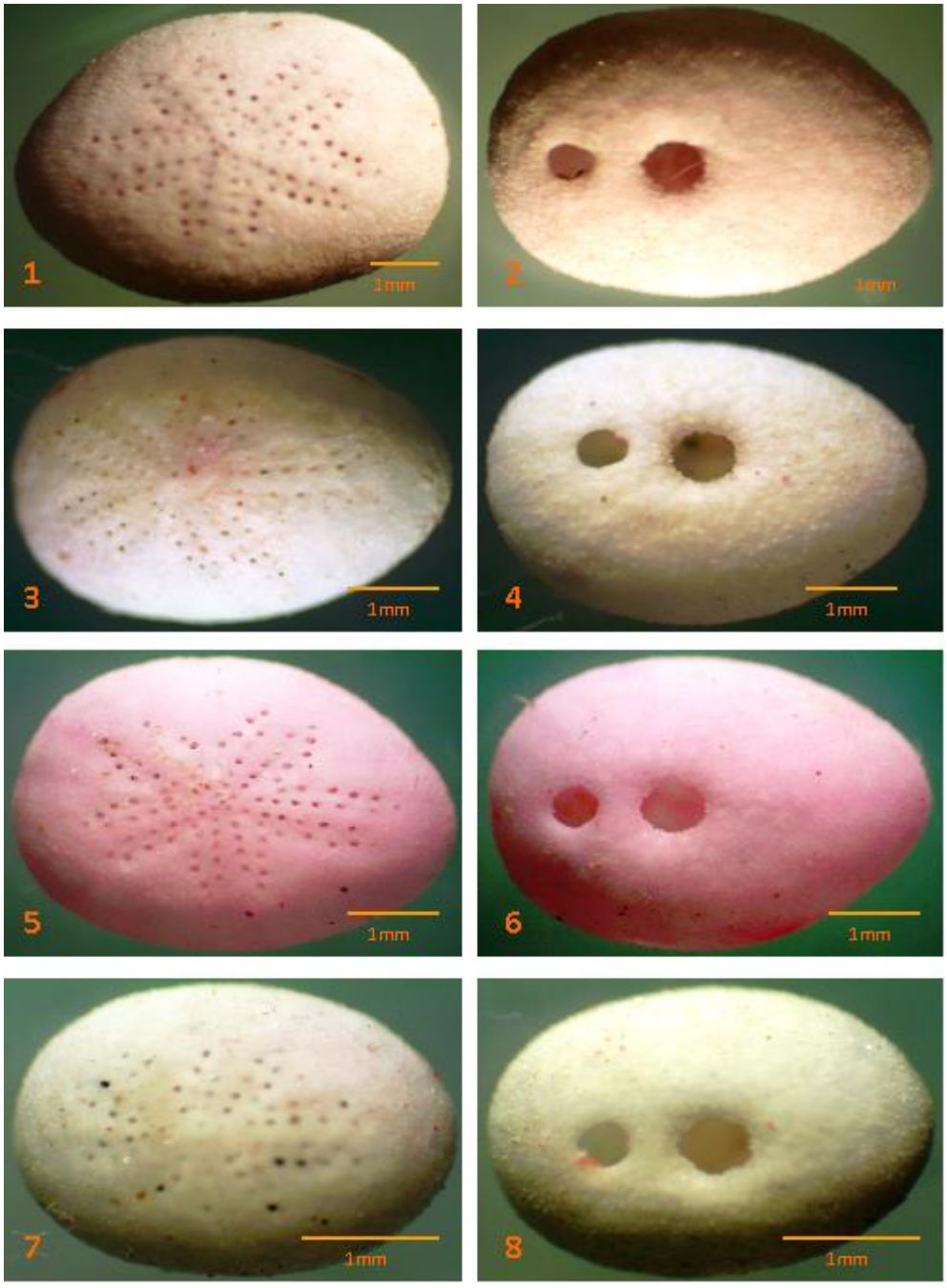

Plate I: 1: *Fibulariella acuta* (aboral side), 2: the same species (oral side); 3: *Fibularia cribellum* (aboral side), 4: the same species (oral side); 5: *Fibularia ovulum* (aboral side), 2: the same species (oral side); (aboral side); 6: the same species (oral side); 7: *Fibularia volva* (aboral side), 2: the same species (oral side).

Synonymys:

Fibulariella acuta (Yoshiwara, 1898); [18&22].
Fibularia (Fibulariella) acuta Yoshiwara, 1898; [23]
Fibtlaria acuta Yoshiwara, 1898, p. 57.
Echinocyamus acutus (Yoshiwara, 1899), p. 121.
***Fibularia aeuta*:** [23&24]
Echinoeyamus aeutus [25]
Echinoeyamus (Thagaslea) aeutus: [26]
Thagastea aeula [27] .
Fibular (Fibulariella) aeuta: [22].

Material examined:

4 specimens, Hurghada (July, 2015). All specimens were collected from canopies and roots of sea grass.

Habitat: This species well known from sandy areas, sea grass beds.

Dimensions: l.d.: 5.2 – 6 mm (av. 5.7 mm); w.d.: 4 – 5.1 mm (av. 4.6 mm); v.d.: 3.5 – 4.2 mm (av.3.9 mm).

Diagnostic characters:

Test low, height about 1/3 of longitudinal diameter, oval in marginal outline; aboral surface not arched, more or less flat; oral surface more or less concave to the peristome; apical system near anterior margin; ambulacral pores numerous; madreporic pores (hydropores) about 10 in number; frontal petal (III) rather well defined; pore-pairs very oblique; antero-lateral petals (II and IV) short, with about 5 pore-pairs in each poriferous zone; peristome near centre; posterior margin rounded; periproct small, scarcely half the peristome, more or less elongated longitudinally; no prominent tubercles near the peristomial region.

Distribution:

Red Sea; East Indies; China and South Japan; Western Japan; South Bonin Islands; Philippines; South Pacific.

Remarks:

The tubercles are not closely distributed on the actinal side as in *F. volva*, Agass. There are no prominent miliares near actinostome as in *F, volva*, Agass, and *F. auslralis*, Desm. This species was recorded from the Red Sea for the first time; hence it considered as a new record for the Red Sea fauna.

Fibularia cribellum de Meijer, 1904
Plate, I (fig. 3 & 4)
Synonyms:
Fibularia cribellum de Meijer, 1904; [18,22,26&28]
Echinocyamus cribellum de Meijer, 1904.
***Echinocyamus* cf. *cribellum*:**[29]

Material examined:

15 specimens from Hurghada and Abu Monkar area. 8 (April 2015), 5 (July 2015), 2 (January 2016). All specimens were collected from canopies and roots of sea grass.

Habitat: This species well known from sandy areas and sea grass beds.

Dimensions: l.d.: 4.7 – 7 mm (av. 5.7 mm); w.d.: 3.7 – 6 mm (av. 4.8 mm); v.d.: 3 – 4 mm (av.3.5 mm).

Diagnostic characters:

Oral surface somewhat concave to the peristome; apical system large; surface and petals not well defined; ambulacral pores very few in number; peristome centrally; periproct small, rounded, oval in outline, slightly elongated transversely and placed at about midway between posterior margin and the peristome; no radiating partition walls within the test; ambital region high, hexagonal in form.

Distribution:

Red Sea; Ceylon; East Indies; Malay region; Philippine Islands; Sulu Sea to Timor Sea and Kei Islands;.

Remarks:

Fibularia cribellum resembles *Fibularia volva,* Agassiz, 1846 but is distinguished from that species by having the fewer and larger ambulacral pores, and by the more oval form of test. This species also much resembles *Fibularia (Fibulariella) angulipora* Mortensen, 1948 in the form of test and in the feature of petals, but differs from that species in having the rounded ambulacral pores, in that species ambulacral pores markedly triangular, and the only one madreporic pore (hydropore), in that species several madreporic pores. This species recorded from the Red Sea for the first time; hence it is considered a new record for the Red Sea echinoderm fauna.

Fibularia ovulum Lamarck, 1816
Plate, I (fig. 5 & 6)

Synonyms:
Fibularia ovulum lamarck: [15, 16, 18, 21& 22]
Fibularia ovulum lamarck, 1816, p.17.
Fibularia trigona Lamarck, 1816, p.17.
Fibularia craniolaris: [6] (non *Echinocyamus craniolaris* Leske = *E. pusillus* Müller).
Echinocyamus craniolaris (Leske)*:* [30]
Echinocyamus craniolaris Leske: [31]
Fibularia craniolaris (Leske)*:* [32]

Material examined:

32 specimens from Hurghada and Abu Monkar area. 10 (April 2015), 10 (July 2015), 8 (October 2016), 4 (January 2016). All specimens were collected from canopies and roots of sea grass.

Habitat: This species well known from sandy areas and sea grass beds.

Dimensions: l.d.: 3 – 7.5 mm (av. 5.1 mm); w.d.: 2.9 – 6.2 mm (av. 4.5 mm); v.d.: 2- 5.1 mm (av.3.5 mm).

Diagnostic characters:

Test oval from above, but more or less flattened, slightly pointed anteriorly and truncated posteriorly; apical system and peristome are in the center of aboral and oral side; petals short, each with 6-7 pore pairs; pores large, rounded, poriferous zones nearly or quite parallel in each petal; primary tubercles irregularly distributed on the test; 4 genital pores; peristome oval and sunken; periproct oblique and placed near to the peristome than to the posterior margin.

Distribution:

Red Sea including gulfs of Aqaba and Suez; East Africa; Seychelles; Madagascar, Maldive area; Bay of Bengal; East Indies; Philippines island; China and south Japan, Australia and south Pacific.

Fibularia volva L. Agassiz in L. Agassiz & Desor, 1847
Plate, I (fig. 7 & 8)

Synonyms:

Fibularia volva Agassiz in Agassiz and Desor 1847 , p. 142; [13,21,22,33 & 34]

Material examined:

13 specimens from Hurghada area. 2 (April 2015), 5 (July 2015), 3 (October 2016), 3 (January 2016). All specimens were collected from canopies and roots of sea grass.

Habitat: This species well known from sandy areas, sea grass beds.

Dimensions: l.d.: 3.7 – 7 mm (av. 4.7 mm); w.d.: 3 – 6 mm (av. 3.9 mm); v.d.: 2.5 – 4.7 mm (av.3.1 mm).

Diagnostic characters:

Test lower, more or less flattened aborally and tapering at each end; pores much smaller, about 100 altogether (i.e. about five pores pairs in each side of each petal); tubercles are closely distributed on the actinal side; there are prominent miliares near actinostome; periproct rounded (rarely irregularly quadrangular or transversely).

Distribution:

Red Sea including gulfs of Aqaba and Suez; Ceylon, Bay of Bengal; East Indies, northern Australia, western Australia; China; south Japan and South Pacific Islands.

DISCUSSION

Echinoidea (sea urchin) are an abundant group of motile invertebrates [36] and they are found in many reef habitats [17, 35, 37 & 38] including algae and seagrass habitats [36] .Although they are not as species rich (51 species) as the brachyuran crabs (361 species, [39] or bivalves (180 species, [40] many of them are large in size and other are very small and numerically abundant.

. The total number of irregular echinoids from the Red Sea is 26 species among them *Fibularia ovolum* and *F. volva* [17 & 18] considered these two species were endemic to the Red sea. The present study added two fibulariid species *Fibulariella acuta* and *Fibularia cribellum* as a new record from the Red Sea, hence the total number of fibulariid species now days became four species and subsequently the total number of irregular echinoids from the Red Sea was 28 species.

The recorded fibulariid species from the Red Sea are Indo-Pacific in their origin [16 &41]. The Red Sea which considered one part of the Indo-Pacific area [18] is richer in its fibulariid fauna (4 species of total 6 Indo-Pacific species) than the adjacent waters. For example, South East Arabia includes two species [16 & 18]; the same authors recorded one species from East Africa and they don't record any species from Arabian Gulf. On comparison such fauna from the Red Sea with other near Indo-Pacific regions, it was found that three species were recorded in Ceylon**,** one species recorded in Midlives and two species recorded in Bay of Bengal [18].

The closest Indo-Pacific regions to the Red Sea in which the two new record fibulariid species were present are East Indies area, for *F. acuta,* and Ceylon area, for *F. cribellum.* Upon the current updated Red Sea fibulariid species list, it was cleared that fibulariid fauna have western extension in their distribution from the original locality in the Indo-pacific regions. This is due to: first, all the recorded fibulariid species recorded before in an Indo-Pacific regions; second, the various sub-regions of the Indo-Pacific distance as well as near [16] have all supplied recruits to the Red Sea fauna and third, that the transport of reproductive disseminules takes place only by ocean current [42]. This current must be of the nature as to aid the transport from the Indo-Pacific sub-region toward the Red Sea.

Unlike most the taxonomic studies, the present work benefit from two advantages: first one was the seasonal collection and the second one was the seagrass habitat choice. The second is due to the seagrass was

riche by fibulariid individuals (Population densities of the fibulariid species ranged from 4 to 24/m^2), and the first is due to that only previously-recorded endemic species, *F. ovulum and F. volva*, were occurred in all seasons. Concerning the new record species, *Fibulariella acuta* were observed only on summer season and *F. cribellum* were observed only on spring and summer seasons. Such accurate and intensive annual surveys in addition to focusing on seagrass habitat allowed to catch a relatively large number of fibulariid species (4 species) and individuals (range = 4 -32 individuals for single species) and these are unlike the early description of species in *Fibularia* which were described based on a limited number of samples.

Sea Urchins are found in temperate, tropical, and subtropical seagrass beds [3]. They are considered as an integral part of seagrass ecosystem dynamics [43]. Despite a considerable number of sea urchins species (nearly about 15 species) are known to consume living seagrass tissue [3]; their contribution in seagrass faunal composition is relatively low. For example, they are represented with other echinoderms by approximately 2.5% of the total benthic seagrass faunal abundance in meadows in southwest Sulawesi, Indonesia [44]. In addition, they have low population densities, for example, [45] estimated an average of 1.6/m^2 for the sea urchin aggregation in the meadows of the seagrass *Thalassodendron ciliatum* in Kenyan lagoon. At Marine Station site, the approximate average population density of the fibulariid species in the present study is 8 individuals/m^2 in seagrass canopies/root. While the second site has very low fibulariid density and this may due to the sensitivity of such species to predation and nutrient supply factors. Evidence of this is that such densities increased in summer and spring seasons reaching up to total 60 and 45 individuals/m^2 in canopies and root, respectively at site 1) with the increasing of nutrients and decreasing of predation in the reproduction season of most predators.

The dominancy investigation in the present study showed that *F. ovulum* is more dominant fibulariid species during all seasons and this agrees with the finding of [46] whom figured out that *Fibularia ovulum* is the most common and widespread clypeasteroid echinoids in the bottom sediment at the Northern Bay of Safaga, Red Sea. Data of the present results showed that *Fibulariella acuta* and *F. cribellum* prefer the root parts and vice versa *F. ovulum and F. volva* prefer the canopy parts.

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