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BIODIVERSITY AND DISTRIBUTION OF EPIPHYTES COMMUNITY ASSOCIATED WITH PNEUMATOPHORES OF THE MANGAL *AVICENNIA MARINA* (FORSSK.) VIERH, ALONG EGYPTIAN RED SEA COAST

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ABSTRACT

Pneumatophores of the mangrove trees *Avicennia marina* along the Egyptian Red Sea coast were investigated, to measure the spatial variability in their epiphytic community. Forty eight species of epiphytes (36 algae and 12 invertebrates) were recorded all over the investigated sites. With the resulting data being subjected to comparison indices (Jaccard), the more adjacent sites were the more similar in their biotic contents. This spatial variability is not a geographical trend but it could be attributed to the abiotic and biotic components characteristic to each site.

INTRODUCTION

Mangroves of the Egyptian Red Sea coast are almost monospecific forests of *Avicennia marina* which live under extreme conditions of high salinity, and low winter temperature (Por *et al.*, 1977). Although mangals are equal in importance to coral reefs, mangrove forests have been little studied (Por *et al.*, 1977), and most studies (Kassas and Zahran, 1967; Por and Dor, 1975; Dor and Por, 1977; Dor and Levy, 1984; Por, 1984; Ascherson, 1887) deal with mangal ecology and productivity.

Mangal surveys have been undertaken in other parts of the Red Sea such as Sudan (Kassas, 1957), Ethiopia (Hemming, 1961), Yemen (Draz, 1956), and Saudi Arabia (Vesey-Fitz-Gerald, 1955, 1957; Zahran 1974, 1980; Eesal, 1983) giving details of the mangals especially its fauna.

Few studies (Dor, 1975; Por *et al.*, 1977; and Dor, 1984) concerned mangrove epiphytes on the Egyptian coast and described their vertical zonation on the aerial roots of the Sinai mangal *Avicennia marina.* However, other studies have been carried out all over the world (Kolehmainen & Hildner, 1975; Potts, 1980; Davey ý& Woelkerling, 1985; Lambert *etal.* 1987, 1989; Tanaka & Chihara, 1987; Coppejans & Gallin, 1989; Steinke & Naidoo, 1990; and Phillips *et al.* 1994, 1996).The current study attempts to fill in gap in the knowledge about epiphytic biota of *Avicennia marina.* The aim herein was to determine the biodiversity of epiphytic biota, their spatial distribution, and zonation on the pneumatophores of the mangrove *Avicennia marina* along the Egyptian Red Sea coast.

MATERIALS AND METHODS

A detailed description of the study area and sampling sites is given by Por *et al.* (1977) and GEF/ WB (Global Environment Facility/ World Bank) (1997). The study was conducted in Nabq area (situated at the mouth of Wadi Kid, western shore of Gulf of Aqaba), and the western shore of the Red Sea. The geographical position of the sampling sites is shown in Table 1 and Figure 1. Twelve sites along the shore, occupied by mangrove trees of *Avicennia marina* were investigated during 1998. At each study site, a sample transect was sited perpendicular to the shore and extending from the water line to the pneumatophore periphery. Because the *Avicennia marina* trees along the transect, as well as, their pneumatophores steadily increased in morphometric parameters, epiphyte

occurrence and biomass as being further of the shore, thus the average morphometric parameters of the mangal were measured at the pneumatophore periphery at each site.

Some pneumatophores were harvested and preserved in a solution of 10% formaline and sea water. In the laboratory, epiphytic biota were removed by scraping clean the pneumatophores, then identifying the species present at different sampling sites, using standard references mainly Nasr (1947), Jaasund (1976), and Natour *et al.* (1979a,b) for algae; and Sharabati (1984), Vine (1986), and Schuhmacher & Hinterkircher (1996) for invertebrates. Occurrence and distribution data of these epiphytes were analyzed and entered into a database for the determination of coefficient of similarity (Jaccard's Similarity Index) between different sites.

RESULTS

1- Species composition and geographical distribution of the mangals

Mangals of the Egyptian Red Sea coast are mainly represented by two species of mangrove trees which are *Avicennia marina* and *Rhizophora macronata*. The first species *A. marina* is widely distributed, extending from latitude 23° N to 28° N, and forming monospecific mangals in different sites along the shore. The other species *Rhizophora macronata* was recorded and represented only by five trees at Hamirah (23° 28' 32.7"N, 35° 29' 26" E). These trees are terrestrial in nature and do not harbour any marine flora and fauna.

2- Morphometric characteristics of *A. marina* and its pneumatophores

Morphometric characteristics of Avicennia *marina* along the shore show a steady increase from high water mark to the subtidal region. In addition, they show a direct relation with the type of sediment, where trees on soft thick bottom substrates in the lower intertidal zone show the

maximum values of morphomertric characteristics. Mangrove trees have a maximum height of 7 and 9 metres at El-Monkata'a and El-Rawisia, respectively, while the minimum height is of 2 metres at El-Gonah. Their breast diameter show a maximum of 34 and 35 metres (Table2) at El-Rawisia and El-Monkata'a, respectively. While, the minimum breast diameter of 8 metres was recorded for the mangrove trees at El-Gonah, which are mainly intertidal mangal. Table 2 reveals that the breast diameter and height of the trees of the other sites lie in between the above mentioned figures.

The maximum pneumatophore numbers of 550 and 650/m^2 were recorded at El-Rawisia and El-Monkata'a, respectively, while the minimum of 120/m^2 was recorded at El-Gonah. The height of pneumatophores showed a maximum of 85 and 90 cm (Table 2) at El-Rawisia and El-Monkata'a, respectively, while the minimum was recorded at El- Gonah where pneumatophores have a height of 30cm.

3. Species composition and spatial variation of epiphytes

The pneumatophores of *Avicennia marina* at the different investigated sites show spatial variation in number of the epiphytic species (Table 3). Some sites show a high number of macro-epiphytic species where 23, 27, 21, and 25 species were recorded at El-Monkata'a, Safaga South, Abu Hamrah, and Sharm El-Bahri, respectively. The minimum numbers (0, and 5) of species were recorded at El-Gonah and Masturah, respectively. Reasonable moderate numbers of algal epiphytic species (16, 17, 15, 12, 12, and 12) were recorded at El-Rawisia, El-Ghargana, Qula'an, Hamata North, Hamata South, and El-Homirah, respectively (Table3&4).

Thirty-six species of algal epiphytes were recorded all over the studied sites. Table 4 reveals that Rhodophyta were the leading in the species number at different sites, while Cyanophyta were least at many sites. On the other hand, Phaeophyta were not detected at some sites,

namely Masturah, Hamata North, Hamata South, and El-Homirah which are very shallow and have no lagoons on the seaward periphery.

Twelve invertebrate species were recorded on the pneumatophores of the mangrove trees *Avicennia marina* all over the investigated sites. The most common species is the crustacean cirriped *Balanus amphitrite*, which usually inhabits the intertidal zone of the pneumatophores, while the other species were recorded at their subtidal zone. The high number of species (Table 4) were recorded at El-Monkata'a (10 species) and Safaga South (8 species). Moderate number of species (7, 7, and 5) were recorded at the sites El-Rawisia, El-Ghargana, and Abu Hamrah, respectively. Other sites showed minimum figures of recorded species.

Table 5 represents the similarity between different sites. Adjacent sites were mostly more similar than apart ones. The highest similarity was 50%, which was recorded between sites Abu Harman and Qala'an; Hamata North and Hamata South; Hamata North and El-Homirah.

4. Vertical zonation of epiphytes

Epiphytes showed a vertical zonation (Table 3) on their pneumatophores, which is mainly a reflection to the tidal regime. Generally, any pneumatophore could be marked into three zones. The first zone (supralittoral), where the apex is naked or sometimes covered with some blue greens. The second zone (littoral) which is covered by barnacles e.g. *Balanus amphitrite* and *Tetrachthamalus oblitteratus*. In some sites (e.g. Masturah, Qala'an, Hamatah North, Hamata South, and El-Homirah) the algal species *Bostrychia tenella* extends to and cover all the intertidal zone of the pneumatophores, along with the barnacles.

The third zone (sublittoral) of the pneumatophores is covered mainly by algae. These algal epiphytes especially *Bostrychia tenella, Champia irregularis, Codium dwarkense, Cystoseira merica, Dictyosphaeria caverinosa, Digenea simplex, Hypnea* spp., *Laurancia*

obtusa, Padina pavonica, and *Spridia filamentosa* were common and usually formed the main bulk (in terms of biomass) of the macro-epiphytes on the pneumatophores of the *Avicennia marina*, however, in some cases sponges e.g. *Haliclona tenuiramosa*, *Tedania anhelans* or ascidians share in the huge biomass of macro-epiphytes associated with these pneumatophores.

The highest recorded biomasses (wet weight / root) of epiphytes were 197, 155, 135, and 128g at El-Rawisia, El-Monkata'a, Sharm El-Bahri, and El- Ghargana, respectively (Table 4). While the minima of 5, 5, and 4g were recorded at Hamata North, El-Homirah and Hamata South, respectively.

DISCUSSION

Egyption Red Sea mangal lives without exception under conditions of high salinity of more than that 41‰. It is metahaline mangal rather than a brackish or "euryhaline" marine ones. Its northern geographical distribution is determined mainly by temperature, where the northmost mangal was recorded at 28 °N on Sinai shores.

It is also evident that the height and cover of investigated mangrove trees is a reflection of the presence and thickness of sediment available and this is not a southern trend as mentioned by Price *et al.* (1977), whereas in this study which is done through a sector of more than 900 km between Nabiq and Shalateen, we could not find any southern trend and the trees on soft-bottom sediment in different sites (even the northern ones) usually flourish, being the heighest or having the maxima of cover. While trees on hard bottom with or without a thin layer of sediment usually short and have a poor cover. So, it is a reflection of sediment thickness and its organic matter content as well.

Regarding epiphytes of pneumatophores, it is clear that, there is a zonation pattern which reflects the tidal pattern from their apices to the

basal region, respectively. Three zones were marked on the pneumatophores at the studied sites: an upper zone have no epiphytes or some blue greens, a mid barnacle zone (in some sites, *Bostrchyia tenella* was replacing barnacles) and a lower for many different species of algal and invertebrates epiphytes. Similarly, some studies (Dor, 1975; Por *et al.*, 1977; and Dor, 1984) on Sinai mangrove trees have shown the zonation of epiphytes on their pneumatophores.

It is clear that the most stressful conditions were in the uppermost zone on the pneumatophores (apices), where harsh environmental conditions, particularly desiccation prevailed. During ebb tides, the outer surfaces of the pneumatophores were observed to be less moist. Epiphytic associates, like algae, could therefore also be subjected to desiccation at this time, and the resultant stress was associated with higher temperatures and intense radiation which lead to increased evaporation (Dor,1984). This explains why algal species richness and frequency were lower in this zone of investigated pneumatophores, where such conditions probably eliminates the least adapted algal species (Phillips *et al.* 1994, 1996). The pneumatophores often had bare apices, but this could be ascribed to their growth regions. Basal regions of pneumatophores also had sparse algal covers, comprising mostly blue greens. This is ascribed to the abrasive action of the soil particles, would keep these regions relatively free of epiphytic algae (Davey & Woelkerling,1985).

In conclusion, this study showed a vertical zonation of epiphytes along the pneumatophores from their apices to the sediment-water interface. This is also mentioned by many authors (Por *et al.*, 1977; Davey & Woelkerling, 1985; Tanaka & Chihara, 1987; Coppejans & Gallin, 1989; Phillips *et al.*, 1994; Phillips *et al.*, 1996). This zonation usually reflects the changes in the environmental conditions, notably tidal ebb and the associated increased exposure to sunlight and thereby increased temperature, evaporation and salinities, all of which explained

their positions coincident with diurnal ebb and flow of water down and up the aerial roots. Wetting frequency, salinity and desiccation are related strongly to tidal phenomena, and together with light intensity and temperature, appeared to contribute to the vertical zonation of epiphytes.

The spatial variation in species composition of epiphytic community at different sites of the current study could be attributed to distinct seasonal pulses of larval recruitment, massive senescence and death of established organisms, disturbances or if the site is protected or not, where protected roots has less diverse epiphytic community. Also many processes e.g. physical environmental conditions, predation by benthic organisms may cause spatial variability between different mangrove sites. It is difficult to presume any geographical trend, where it was observed that in the same site, many of the epiphytes which were not recorded on the pneumatophores of the *Avicennia marina*, were found epiphytic on seaweads and seagrasses. Many Studies (Smith *et al.*, 1950; Sutherland, 1976; Sutherland & Karlson, 1977; Mook, 1983; Warner, 1984; Hirata, 1987) have shown that these variabilities are expected, due to different environmental biotic and abiotic conditions characterizing to each site.

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Table 1. Geographical position of different sampling sites.

Site number	Region	Position
1	El-Monkata'a	28° 12′ 40.0" N 34° 25′ 18.0" E
2	El-Rawisia	28° 11′ 26.0" N 34° 26′ 33.0" E
3	El-Ghargana	28° 07′ 02.0" N 34° 26′ 36.0" E
4	El-Ghona	27° 24′ 22.4" N 33° 40′ 34.0" E
5	Safaga South	26° 36′ 89.9" N 34° 00′ 56.1" E
6	Abu Hamrah	26° 23′ 49.7" N 34° 07′ 04.6" E
7	Sharm El-Bahri	25° 52′ 12.9" N 34° 25′ 00.6" E
8	Masturah	24° 22′ 55.0" N 35° 15′ 40.0" E
9	Qula'an	24° 21′ 56.0" N 35° 16′ 55.5" E
10	Hamata North	24° 19′ 30.2" N 35° 20′ 31.3" E
11	Hamata South	24° 18′ 40.4" N 35° 21′ 39.2" E
12	El-Hamirah	23° 28′ 32.7" N 35° 29′ 26.0" E

Table 2. Measurements of morphometric parameters of the mangrove trees *Avicennia marina* at different sampling sites

Parameter	Pneumatophores		Trees	
Region	No./m²	Height (Cm)	Height (m)	Breast diameter (m)
El-Monkata'a	650	90	7	35
El-Rawisia	550	85	9	34
El-Ghargana	320	60	4	32
El-Ghona	120	30	2	08
Safaga South	350	70	4	23
Abu Hamrah	300	75	5	16
Sharm El-Bahri	400	80	6	18
Masturah	190	50	5	13
Qula'an	170	45	4	15
Hamata North	250	40	4	17
Hamata South	130	45	2	09
El-Hamirah	400	55	6	29

Table 3. Recorded epiphytes of different mangrove sites along Egyptian Red Sea coast

Site	1	2	3	4	5	6	7	8	9	10	11	12
TAXA												
ANIMALS												
PORIFERA												
Haliclona tenuiramosa (C)	*		*		*	*						
Tedania anhelans (C)	*	*				*						
CNIDARIA												
HYDROZOA												
Dynamene sp. (C)	*		*									
ZOANTHARIA												
Boloceroides sp. (C)	*	*										
Stylophora pistillata (C)	*				*							
CRUSTACEA												
Balanus amphitrite (B)	*	*	*		*	*	*	*	*	*	*	*
Tetrachthamalus oblitteratus (B)		*	*									
MOLLUSCA												
Crassostrea cucullata (B&C)	*	*	*		*							
BRYOZOA												
Bugulla sp. (C)	*				*	*					*	
Schizoporella sp. (B&C)	*	*	*		*		*					
ASCIDIAN												
Ascidia sp. (C)					*	*						
Diplosoma herdmanni (C)	*	*	*		*							
SEAWEEDS												
CYANOPHYTA												
Calothrix sp. (A&B&C)		*				*						
Lyngba sp. (A&B&C)			*		*					*	*	
Oscillatoria sp. (A&B&C)						*			*			*
Rivularia polyotis (A&B&C)	*	*	*		*	*			*	*		*
CHLOROPHYTA												
Bryopsis corymbosa (C)	*				*							
Chaetomorpha .sp. (C)	*		*			*	*	*	*	*		*
Cladophora sp. (C)	*	*			*		*	*		*	*	
Codium dwarkense (C)	*	*			*		*					
Dictyosphaeria cavernosa (C)							*		*			
Enteromorpha sp. (C)						*						
PHAEOPHYTA												
Cystoseira merica (C)						*			*			
Dictyopteris membranacea (C)	*						*		*			
Dictyota dichotoma (C)	*	*			*							
Lobophora variegata (C)			*		*		*					

Table 3. Continued.

Padina pavonica (C)		*			*		*					
RHODOPHYTA												
Amphiroa fragillissima (C)						*	*		*			
Bostrychia tenella (C&B)										*	*	*
Centroceros clavulatum (C)	*	*	*						*		*	*
Ceramium gracillimum (C)	*		*			*	*	*	*	*	*	*
Champia irrugularis (C)	*		*		*		*					
Chondria repens (C)		*			*		*					
Crountia attenuata (C)					*	*	*		*		*	*
Digenea simplex (C)					*	*			*			
Giffordia indica (C)						*	*		*	*		*
Gracilaria arcuata (C)	*		*									
Griffithsia tenuis (C)					*	*	*		*		*	
Polysiphonia figariana (C)					*	*	*		*	*	*	
Herposiphonia tenella (C)					*	*	*	*		*	*	*
Hypnea cornuta (C)						*	*					
Hypnea esperi (C)							*					
Laurancia obtusa (C)					*	*	*					
Leveillea sp. (C)	*	*	*		*		*			*		*
Liagora rugosa (C)	*											
Neomeris annulata (C)					*		*					
Spermothamnion investiens (C)					*		*			*	*	*
Spridia filamentosa (C)			*				*					
Total no. of species	23	16	17	0	27	21	25	5	15	12	12	12

1- El-MonKata'a
2- El-Rawisia
3- El-Ghargana
4- El- Gonah
5- Safaga South
6- Abu Hamrah
7- Sharm El-Bahri
8- Masturah
9- Qala'an
10- Hamata North
11- Hamata South
12- El-Homirah

A: Upper zone of pneumatophores (supralittoral)
B: Middle zone of pneumatophores (littoral)
C: Lower zone of pneumatophores (sublittoral)

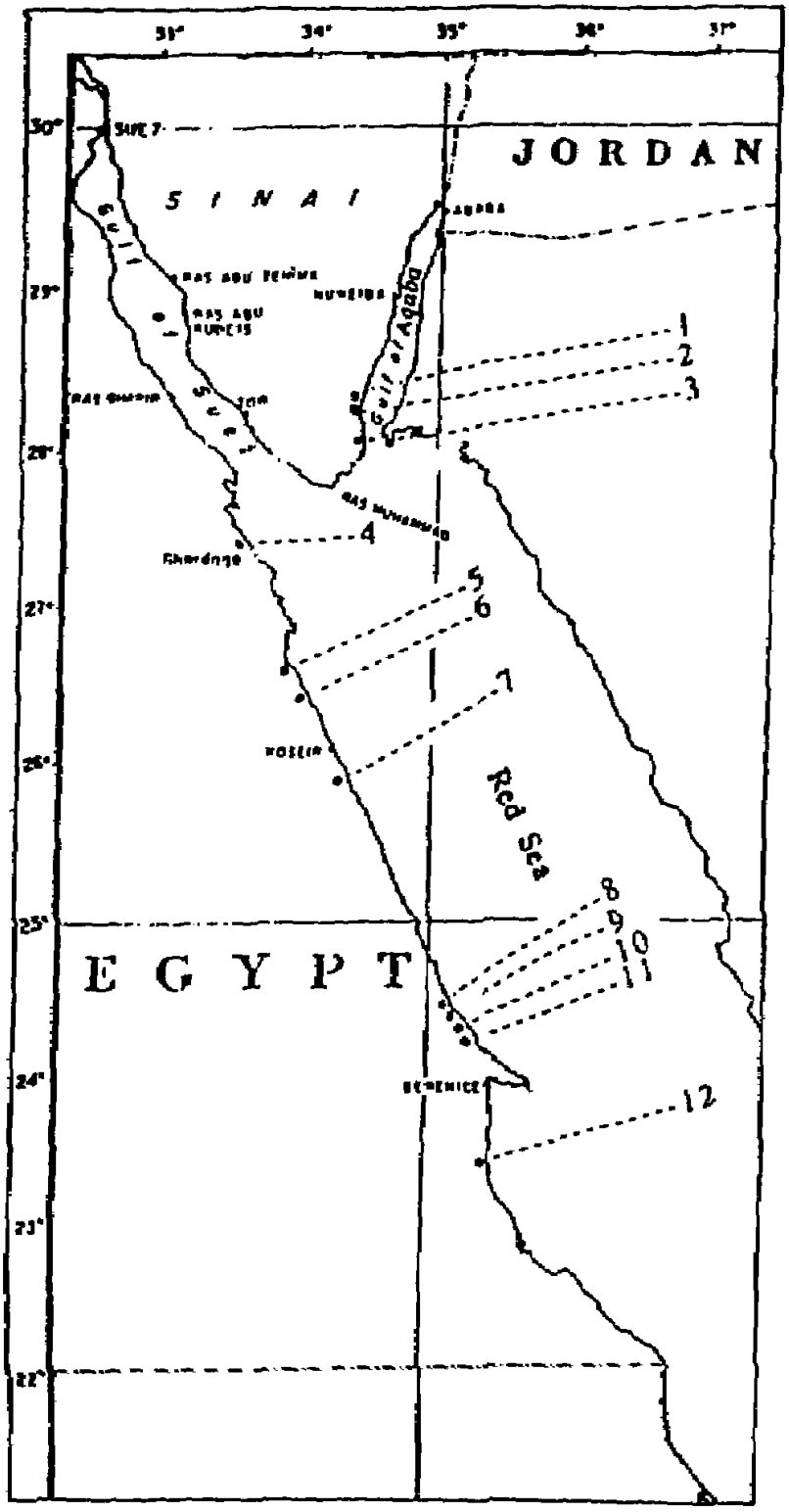

Figure 1. Map of the Egyptian Red Sea coast showing the different sampling sites.

1- El-Monkata'a
2- El-Rawisia
3- El-Ghargana
4- El- Gonah
5- Safaga South
6- Abu hamrah
7- Sharm El-Bahri
8- Masturah
9- Qala'an
10- Hamata North
11- Hamata South
12- El- Homisah