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Palynology of mangrove sediments in the Hamata Area, Red Sea Coast, Egypt: vegetation and restoration overview

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Abstract

The present mangrove vegetation condition in the Abu Ghoson area of the Red Sea coast, Egypt can be recognised through field observations and palynological analysis of the intertidal flat and swamp environments, as well as through cores. In addition to illustrating the pollen distribution on the mangrove site, special attention is paid to *Avicennia marina* pollen distribution, which is the only mangrove pollen species in the investigated area. The maximum concentration of *Avicennia marina* is recorded (> 9000 pcm^2) in the sediments which are taken in proximity to the aerial root (pneumatophore) of mangrove plants. Away from the area of mangrove roots and further seaward, it became rare to absent. This indicates that the pollen grains are inefficiently dispersed by the water current, which is considered the main tool of pollen dispersal away from the area of pollen production. The variation of mangrove pollen frequency in the core sediments can help to understand the vegetational changes associated with paleogeographic modification. In addition to poor pollen production, low catchment run-off and intense browsing have caused high stress conditions in mangrove communities. The threat to mangrove plants by extinction, hydrological changes, and physical stress from resorts around the mangroves would require assessment.

1 Introduction

Mangroves are the most important part of the coastal habitat, which occur in patches along the intertidal zone. Mangroves play a vital role in the health of the marine ecosystem, because they filter and block sediments from the unstable substrates of the wadi and desert, and preventing siltation of sea grass beds and coral reefs. One of the most important roles of mangroves is to increase oxygen into the marine environment. They also eliminate pollutants such as sewage waste, pesticide run-off, and toxins in waste dumped in the wetlands.

This paper gives a precise picture of the current situation of the mangrove vegetation carried out by palynological study and field observation of Abu Ghoson area on the Red Sea coast.

1.1 Mangrove reproductive strategies

Mangroves have a unique characteristic of spreading seedlings for forest continuation (Tomlinson 1986). Generally, the formation of new stands of mangroves, away from the area of origin, depends on the seedlings being carried by tidal action. Their ability to survive periods of immersion allows them to invade suitable coastal niches where they can establish and commence the development of a new formation.

Mangroves exhibit two relatively distinctive reproductive strategies: hydrochory and vivipary (Rabinowitz 1978, Tomlinson 1986). Hydrochory (dispersal by water) is a major means by which mangrove spreads seeds, fruit, or propagules. Tidal action can carry mangrove diaspores long distances from their point of origin. Vivipary means producing seeds that germinate while still attached to the parent plant for 4 to 6 months (McKee 1996). During germination, the seedling receives nutrients and water from the parent tree and it grows uninterrupted until, becoming too heavy to bear, it falls off into the trap of pneumatophores beneath the parent tree whilest others are dispersed by tides nearby or further away. If conditions are appropriate for growth, a new community is established. The seedling feeds off the propagule until its roots develop sufficiently to anchor it in the mud and nutrients are obtained from the substrate.

1.2 Area of study

Abu Ghoson area (350 km2), lies on the Red Sea coast, south Marsa Aalm city (Fig. 1). It is a nature reserve created by Prime Ministerial Decree 143 of 2003. The coastline of the area is retreating inland towards the wadis. Mangrove plants are found in narrow spots along the shore and are extensive in the swamp area behind the coastline (Fig. 2). The mangroves range in length from 5-30 cm tall, except one tree (~ 4 m tall). The substrate is enriched by lime mud in the swamp area and in some areas along the coastline. In other areas, it becomes sandy (medium to coarse grain sand). The intertidal flat extends from the shoreline 60m off-shore and appears to be closed by the natural conglomerate bar at the end. In some localities, there are some small shrubs and remaining ares of low aerial roots.

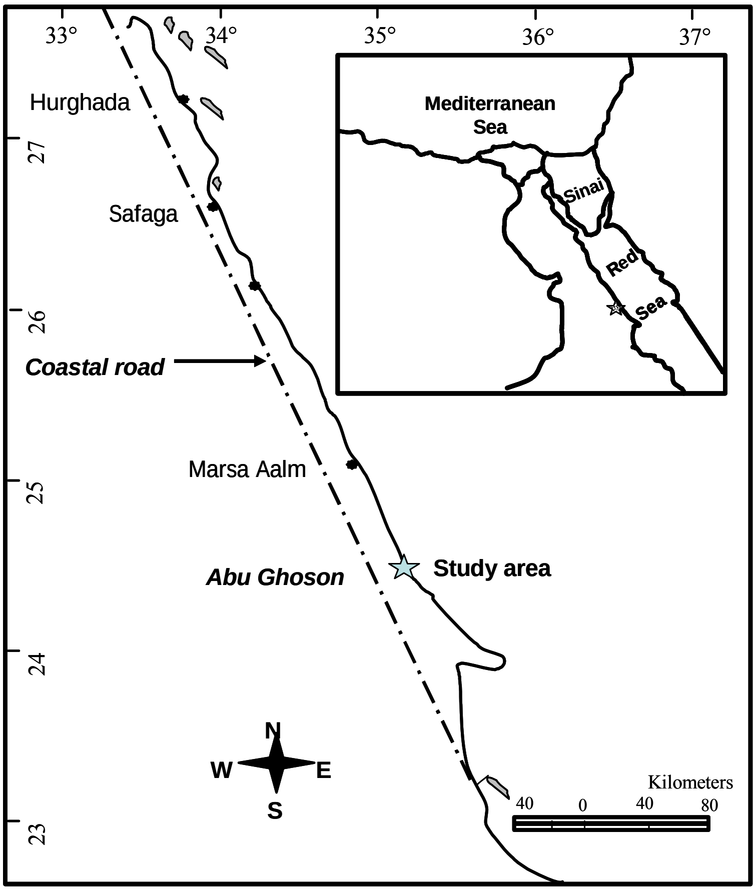

Figure 1: Location map of study area.

1.3 Material and Methods

Thirty-two sediment samples were collected from the swamp area, intertidal zone and from core 2 (14 cm deep) for palynological analysis. Sediments consisted mainly of lime mud and fine to medium grain sands. The intertidal transect covering the whole area, ran West-East starting from the shoreline to off-shore and was located between Latitude 24° 21' 42" and 24° 21' 29" N and Longitude 35° 18' 18" and 35 18' 23" E . The samples were collected (~50 m apart) by spoon and the readings of Hydrolab and GPS were detected (Table 1).

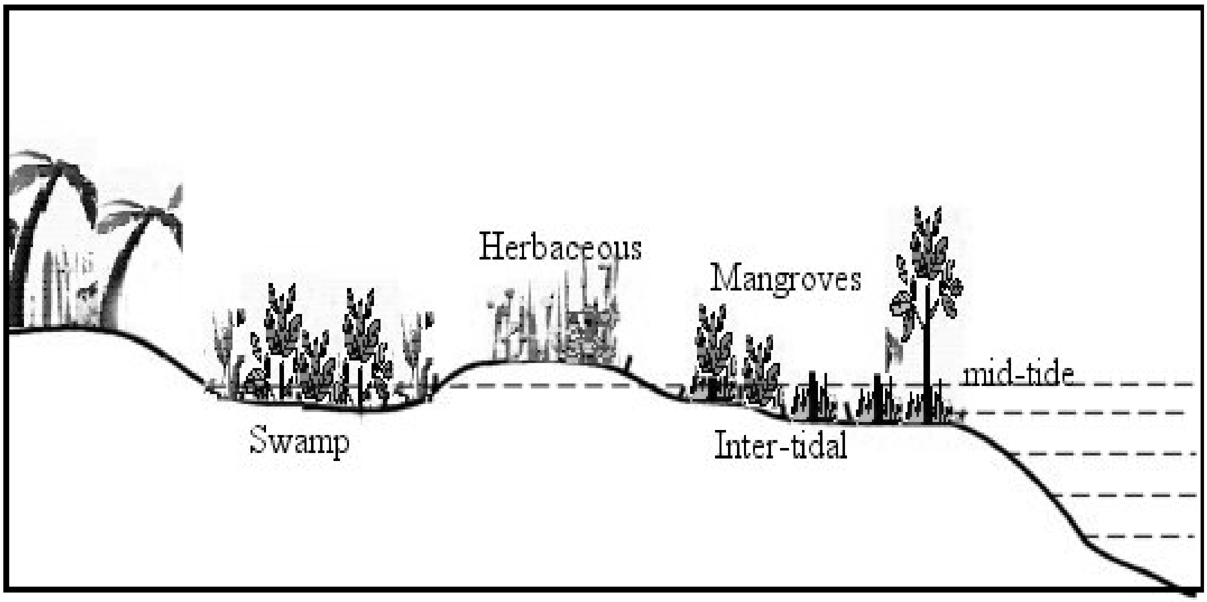

Figure 2: Simple sketch diagram showing the distribution of mangrove in the area of study.

The swamp transect collected from the area was located between Latitude 22º 21' 30" and 24º 21' 32" N and Longitude 35º 18' 12" and 35 18' 13" E and covered the entire swamp spot. The upper three centimetres of sediments were nominated for palynological analysis. The cores samples were selected every 2 cm depth. All samples were treated chemically for pollen extraction following the standard palynological technique, which includes the use of HCl to remove carbonates and HF acid to remove silicates. The ultrasonic cleaner and 10 µm Nylon sieve were used to eliminate the finest particles.

The Lycopodium marker spore tablets were added in the first step of the technique to calculate the number of pollen in a sample using the following equation:

Lycopodium spores added / Lycopodium spores counted * fossil pollen counted = no. of pollen per cubiccm

Concentration was defined as pollen per cubic cm (millilitre).The calculation method of Stockmarr (1971, 1972), Maher (1981) and Bennet & Willis (2002) was applied to calculate the pollen concentration per cm^2. All sediments, palynological slides, and residue were depicted in the Geological lab at NIOF, Alexandria, Egypt.

Nearly 30 species belonging to 22 families were identified. Some of pollen genera could not be assigned to the species level. All pollen grains were counted and put in the tables (2-3), in addition the most abundant pollen families concentration were plotted (Fig. 3-5). Some photographs of some species were taken (Fig. 5-6).

Table 1: Abu Ghoson studied samples; T, S, DO refers to measurements of water temperature (°C), Salinity (ppt), Dissolved Oxygen content (mg/l).

Sample no.	Water Depth [cm]	Latitude N	Longitude E	Hydrolab reading			
				T	S	PH	DO
Intertidal Transect							
1	30	24° 21' 34	35° 18' 10	-	-	-	-
2	50	24° 21' 36	35° 18' 11	22.4	41.4	8.6	6.6
3	70	24° 21' 40	35° 18' 12	23.0	41.3	8.5	7.4
4	20	24° 21' 29	35° 18' 23	22.4	41.3	8.5	6.6
5	40	24° 21' 36	35° 18' 19	22.4	41.4	8.6	6.6
6	50	24° 21' 39	35° 18' 19	22.0	41.2	8.5	7.3
7	80	24° 21' 32	35° 18' 22	21.6	41.3	8.5	6.4
8	120	24° 21' 32	35° 18' 22	23.2	41.0	8.6	7.7
9	140	24° 21' 32	35° 18' 21	23.2	41.2	8.6	7.3
Swamp transect							
10	0	24° 21' 30	35° 18' 19	23.4	44.9	8.6	5.2
11	5	24° 21' 30	35° 18' 19	22.5	44.5	8.6	5.5
12	8	24° 21' 30	35° 18' 19	22.4	45.0	8.4	5.6
13	10	24° 21' 30	35° 18' 18	23.0	44.8	8.4	6.0
14	15	24° 21' 29	35° 18' 18	26.9	45.9	8.4	6.7
15	20	24° 21' 32	35° 18' 13	26.0	45.9	8.4	6.5
16	25	24° 21' 32	35° 18' 13	26.2	45.3	8.7	5.8
17	30	24° 21' 32	35° 18' 13	25.9	45.6	8.7	5.3
18	30	24° 21' 32	35° 18' 12	25.6	45.7	8.5	5.4
19	35	24° 21' 32	35° 18' 12	26.0	45.8	8.4	5.1
20	45	24° 21' 32	35° 18' 12	26.3	45.9	8.5	5.4
Core 2	Depth [cm]	Location					
1	0-2	24° 21' 32					
2	2-4	35° 18' 12					
3	4-6						
4	6-8						
5	8-10						
6	10-12						
7	12-14						

2 Results

2.1 Mangrove pollen

Avicennia marina was the only mangrove pollen species in the study area. It showed a maximal value near the root of mangrove plants with concentration 9292 per cm^2 (first sample of intertidal transect) and with 6194 per cm^2 at the vicinity of mangrove trees (swamp sample 10). On the other hand, it decreased seaward in the intertidal transect to minimum value 495 per cm^2 (sample 8). All core 1 samples from the intertidal zone were barren of any pollen grains except some Poaceae and microforamininferal linings. On the other hand, the mangrove species in core 2 sediments, had a value ranging from 4570 to 3700 per cm^2 in the lower part (depths from 10 to 14 cm) but were poorly represented in the samples 1 and 2 (0 to 4 cm depth).

2.2 Other terrestrial pollen

Other pollen families associated with mangrove pollen are mostly herbaceous pollen. These pollen grains are often associated with mangrove ecosystem in Wadi El-Gemal (KHOLEIF & KHALIL 2006). The first, most dominant families came after *Avicennia* pollen in the studied sediments. These were Chenopodiaceae\Amaranthaceae with the maximal value >7600 per cm^2 in the transect sample 2 and swamp sediments sample 20. It declined to 2425 per cm^2 at 8 cm depth (sample 4) in the studied core (Table 3). The second best representative families in all productive samples were Poaceae and Asteraceae. Poaceae was well represented in the all swamp samples with the concentration a proportion of 7850 to 588 per cm^2. The concentration of Poaceae in the examined sediments was inconsistent with the concentration in Wadi El-Gemal mangrove sediments, as it had the highest percent and concentration in the mangrove sediments (KHOLEIF & KHALIL 2006). Asteraceae had a maximal value in the first sample of studied transect (5013 per cm^2) and least value (120 per cm^2) in the upper core depth (2 cm deep; sample 1).

Palmae came in the third position. It was the main pollen tree family in the Abu Ghoson area. It was well represented in all productive samples and exclusively in the swamp sediments with concentrations ranging from 3562 to 336 per cm^2. This may have been due to the near zone of Palmae tree from swamp area in the mangrove site.

Fabaceae, Meliaceae, Solanaceae, Polypodiaceae, Plantagnaceae, and Brassicaceae were the next most representative families in the studied samples with significant concentration. The other recorded families were represented by low concentration (Tables 2-3).

3 Discussion and Conclusion

The pollen assemblages contained many herbaceous and terrestrial pollen types beside the *Avicennia marina*, among which were Chenopodiaceae\Amaranthaceae, Asteraceae, Poaceae, Fabaceae, Meliaceae, Solanaceae, Polypodiaceae, Plantagnaceae, and Brassicaceae (Fig. 3-5). A high concentration and low percentage (20 % of the total pollen) of *Avicennia marina* was encountered in most of the swamp sediments, the first samples of the intertidal transect and the lower depth of studied core. Based on the field observations and palynological analysis, the concentration of Avicennia in the mangrove site suggested that it is less representative in relation to the *Avicennia* trees. Some causes can be explained: 1) the low pollen production of the mangrove tree, this can be confirmed by the low concentration of mangrove pollen depiction in cores 2 (Fig. 4) taken from swamp area. 2) In general, the distribution pattern of mangrove pollen, and other pollen families can reflect the role of transport processes by marine current at the studied site, which is ineffectual to spread the seed far from the zone of production. This may be due to the unique features of Abu Ghoson intertidal zone, which is nearly separated from off-shore by the conglomeratic barrier. The effective role of the marine current for pollen dispersal is discussed through the study of the other sediments from Wouri estuary (Boyé et al. 1975), sediments from Ivory coast (Fredoux 1980), and continental shelf marine sediments (VAn Campo & Bengo 2004). 3) Absence of mother trees in some areas may result in low or no propagules. The role of monsoon at the studied locality could be responsible for seed dispersal.

In common, the maximum concentration of pollen was recognised during the dry season consistently with the flowering period from December to March (Hutchinson & Dalziel 1972) and in January (Callèja et al. 1993). Hence, we expected the high concentration and absolute abundance of pollen grains in the studied sediments at least near the zone of plant production since the studied samples were collected on the 5th February. This also supported the poor pollen production of the studied mangrove site.

Table 2: Pollen family concentration per cm^2 in the core 2.

Pollen Family	Sample no. 1	2	3	4	5	6	7
Amaranthaceae/ Chenopodiaceae	32	311	511	2425	859	1200	769
Asteraceae	120	331	4310	274	815	524	630
Avicenniaceae	9	225	1210	742	2330	4520	3700
Brassicaceae	0	0	256	375	982	1211	318
Cypraceae	6	0	189	396	247	671	341
Ephedraceae	0	0	98	178	0	0	63
Euphorbiaceae	98	113	0	355	59	200	196
Fabaceae	231	0	567	389	712	1159	2508
Geraniaceae	0	0	149	185	359	216	265
Polypodiaceae	241	162	400	637	305	1310	530
Liliaceae	0	0	132	158	93	271	180
Oxalidaceae	8	89	129	165	210	143	223
Palmae	0	336	510	1298	559	1614	860
Plantagnaceae	0	158	299	611	743	520	780
Poaceae	1152	2195	942	5524	1259	631	7850
Polygonaceae	50	112	230	142	96	176	96
Porate	165	0	210	322	134	543	331
Solanaceae	0	0	133	345	252	163	388
Tiliaceae	0	92	118	353	150	269	188
Meliaceae	270	198	448	367	794	1520	643
Zygophyllaceae	0	0	99	183	395	543	260
Unid pollen	0	0	1210	2159	1199	859	624

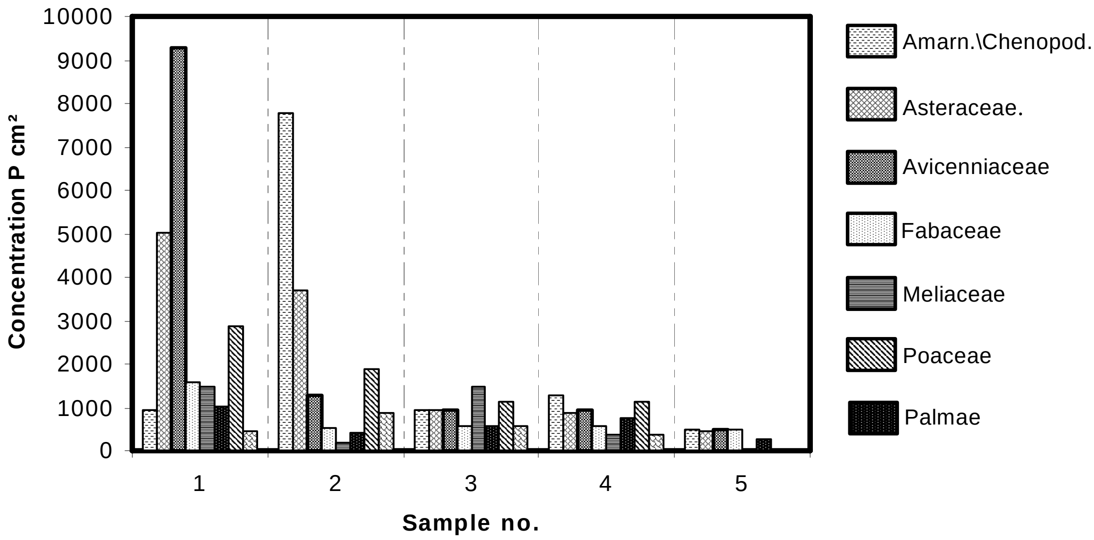

Figure 3: Productive samples pollen diagram (intertidal transect), showing the most abundant pollen family concentration in the Abu Ghoson area, Red Sea Coast.

Table 3: Pollen family concentration (per cm^2) in the transect and swamp sediments; the concentration is calculated by Lycopodium marker spores.

Pollen family	**Transect sample no.**										**Swamp sample no.**									
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
Amaranthaceae Chenopodiaceae	929	7779	929	0	0	0	1301	496	0	0	5110	4248	0	0	588	2001	0	0	0	7690
Asteraceae	5013	3717	929	0	0	0	867	465	0	0	4248	4469	0	0	2144	1282	0	0	0	1666
Avicenniaceae	9292	1296	927	0	0	0	929	496	0	0	6194	4778	0	0	1411	4574	0	0	0	1282
Bisaccate	557	0	248	0	0	0	310	0	0	0	235	429	0	0	0	0	0	0	0	0
Brassicaceae	1301	432	0	0	0	0	0	0	0	0	2168	1062	0	0	823	715	0	0	0	641
Casuarina	465	346	0	0	0	0	0	0	0	0	774	743	0	0	353	429	0	0	0	256
Cypraceae	465	259	0	0	0	0	0	0	0	0	2323	956	0	0	470	715	0	0	0	1410
Ephedraceae	372	173	0	0	0	0	0	0	0	0	774	319	0	0	0	0	0	0	0	0
Euphorbiaceae	929	432	0	0	0	0	0	0	0	0	1858	1062	0	0	588	572	0	0	0	641
Fabaceae	1580	519	557	0	0	0	557	496	0	0	1084	1487	0	0	823	715	0	0	0	769
Geraniaceae	279	432	929	0	0	0	372	0	0	0	1394	850	0	0	588	2573	0	0	0	1025
Liliaceae	372	259	557	0	0	0	0	0	0	0	1549	1274	0	0	588	715	0	0	0	256
Meliaceae	1487	173	1487	0	0	0	372	0	0	0	774	743	0	0	470	715	0	0	0	256
Oxalidaceae	650	432	372	0	0	0	0	0	0	0	774	850	0	0	235	429	0	0	0	256
Palmae	1022	432	557	0	0	0	743	372	0	0	3562	2124	0	0	588	2144	0	0	0	1410
Plantagnaceae	465	519	743	0	0	0	929	248	0	0	6969	5097	0	0	588	3574	0	0	0	897
Poaceae	2880	1902	1115	0	0	0	1115	867	0	0	5420	3398	0	0	588	2144	0	0	0	3460
Polygonaceae	372	259	0	0	0	0	0	0	0	0	774	425	0	0	353	572	0	0	0	384
Polypodiaceae	929	432	557	0	0	0	372	496	0	0	2633	1062	0	0	235	1429	0	0	0	0
Porate	372	605	557	0	0	0	557	0	0	0	774	850	0	0	235	429	0	0	0	513
Solanaceae	465	864	557	0	0	0	372	0	0	0	1084	531	0	0	235	429	0	0	0	256
Tiliaceae	465	0	0	0	0	0	557	0	0	0	2942	2018	0	0	1529	1715	0	0	0	641
Unidentified 1	2230	691	372	0	0	0	372	0	0	0	2478	1911	0	0	823	715	0	0	0	513
Unidentified 2	1951	432	0	0	0	0	0	0	0	0	3097	1593	0	0	588	429	0	0	0	641
Zygophyllaceae	557	432	0	0	0	0	0	0	0	0	1549	850	0	0	353	1429	0	0	0	256

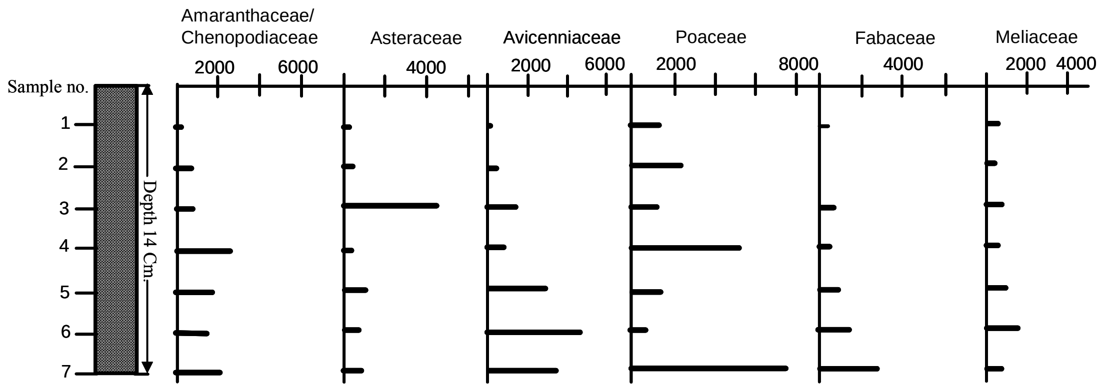

Figure 4: Pollen diagram showing the most abundant pollen families of core 2 sediments of mangrove site, in the Abu Ghoson area, Red Sea Coast: note that the concentration of pollen is defined as pollen per cubic cm using the Lycopodium marker spores.

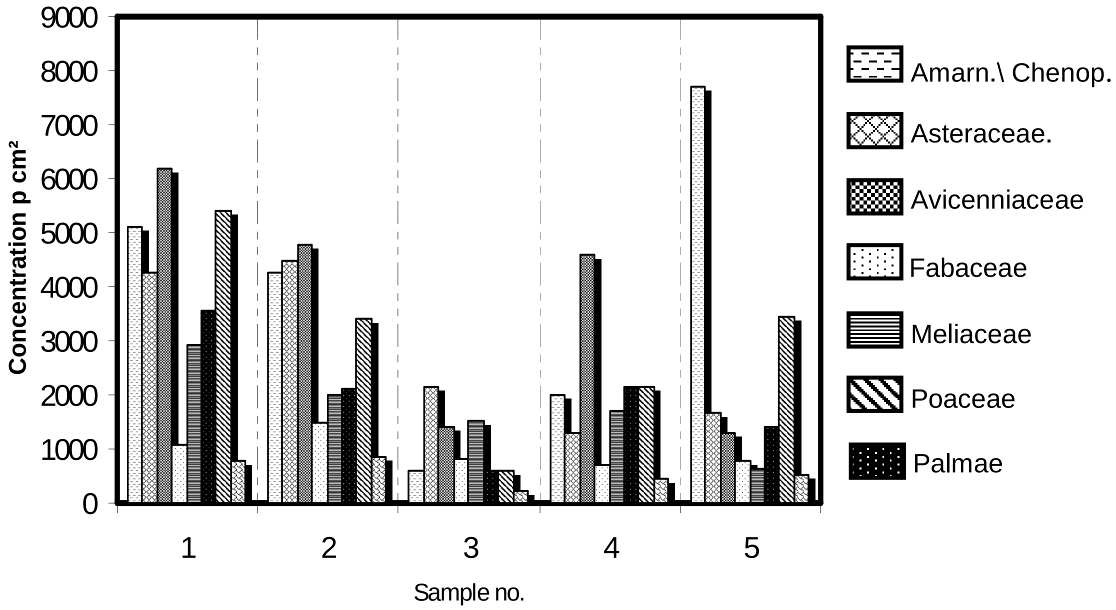

Figure 5: Productive samples pollen diagram (swamp transect), showing the most abundant pollen family concentration in the Abu Ghoson area, Red Sea Coast.

4 Mangroves restoration overview

4.1 Mangrove restoration

A realistic definition of restoration is given by Morrison (1990); “Restoration is the re-introduction and reestablishment of community-like groupings of native species to sites which can reasonably be expected to sustain them, with the resultant vegetation demonstrating aesthetic and dynamic characteristics of the natural communities on which they are based”. The restoration of mangroves has received a lot of attention world wide since the long neglect of ecological and environmental values of mangrove forests was based mainly on the planting of mangroves as the primary tool in restoration. However, a better approach to mangrove restoration would determine the causes for plant loss, remove these causes, and work with natural recovery processes to re-establish mangrove habitat (Lewis & Streever 2000). In addition, deterioration of mangroves has occurred throughout the world leading to coastal erosion, decline of fishery resources and other environmental consequences.

In Egypt, mangrove is an important scarce resource. The tourist industry has been developed in mangroves throughout the Red Sea Coast. Mangroves form a part of the attraction for tourism. The government of Egypt has at last recognised the close link between coral reefs, mangroves and tourism development, which helps contribute to the local and national economy. Accordingly, the Egyptian government started initiating conservation and protection measures for mangroves.

Mangroves in the study area have been affected by some hydrological changes due to as the impact of a new asphalt coastal road. The road interupted the rare fresh water supply, a decrease in nutrients, and an increase in salinity (~ 45 ppt). In addition, the mangrove density and quality have been effected by man-induced change, for instance; resort building, cuting of trees, animal grazing and fishing. Many mangrove bushes of *Avicennia marina* along the Red Sea coast are threatened by extinction because of the physical stress from resorts, cut-off for playground buildings or for the supply of freshwater (Saenger 2002). Mangroves have many very valuable ecological benefits. Nevertheless, these benefits are hard to define and do not offer income for citizens or for the managers of the mangroves who are living in and around mangrove sites. For that reason, mangroves are often considered to be "wasteland" rather than mangrove "wetland". In order to correct this concept and capture the interest and understanding of all people in and around mangroves, it is important to try to convert some of these indefinable ecological values into a financial value. One way in which this can be done is during the development of the tourism industry in the mangroves, through careful planning and consideration of the mangroves unique environment. The tourism industry can provide considerable profits to the environment, local citizens, visitors to the mangroves and the agencies that are responsible for the management of the mangrove areas (FAO 2002). Nevertheless, first we should determine the causes of mangrove loss, remove these causes, and work first with natural recovery processes to re-establish the mangroves as realised by Lewis & Streever (2000).

Finally, it can be recommending that:

- The mangroves inimitability is a link between terrestrial and marine habitats and their ecological significance should be fully understood to awaken the interest and appreciation of mangrove residents, managers, and tourists.
- At the studied site, the threat to mangroves by extinction, hydrological changes, physical stress of resorts around the mangroves would require assessment. However, the damage is caused by browsing that can be recovered once the browsing pressure is lifted.
- Socio-economic study of mangrove values could enhance the re-establishment of mangroves.
- Raising awareness and changing the behaviour of tourists and people - especially those who have direct contact with mangroves.
- As it has often been said, "to care we must understand", so special attention and support should be paid to the marine ecosystem, scientific research and conservation activities.

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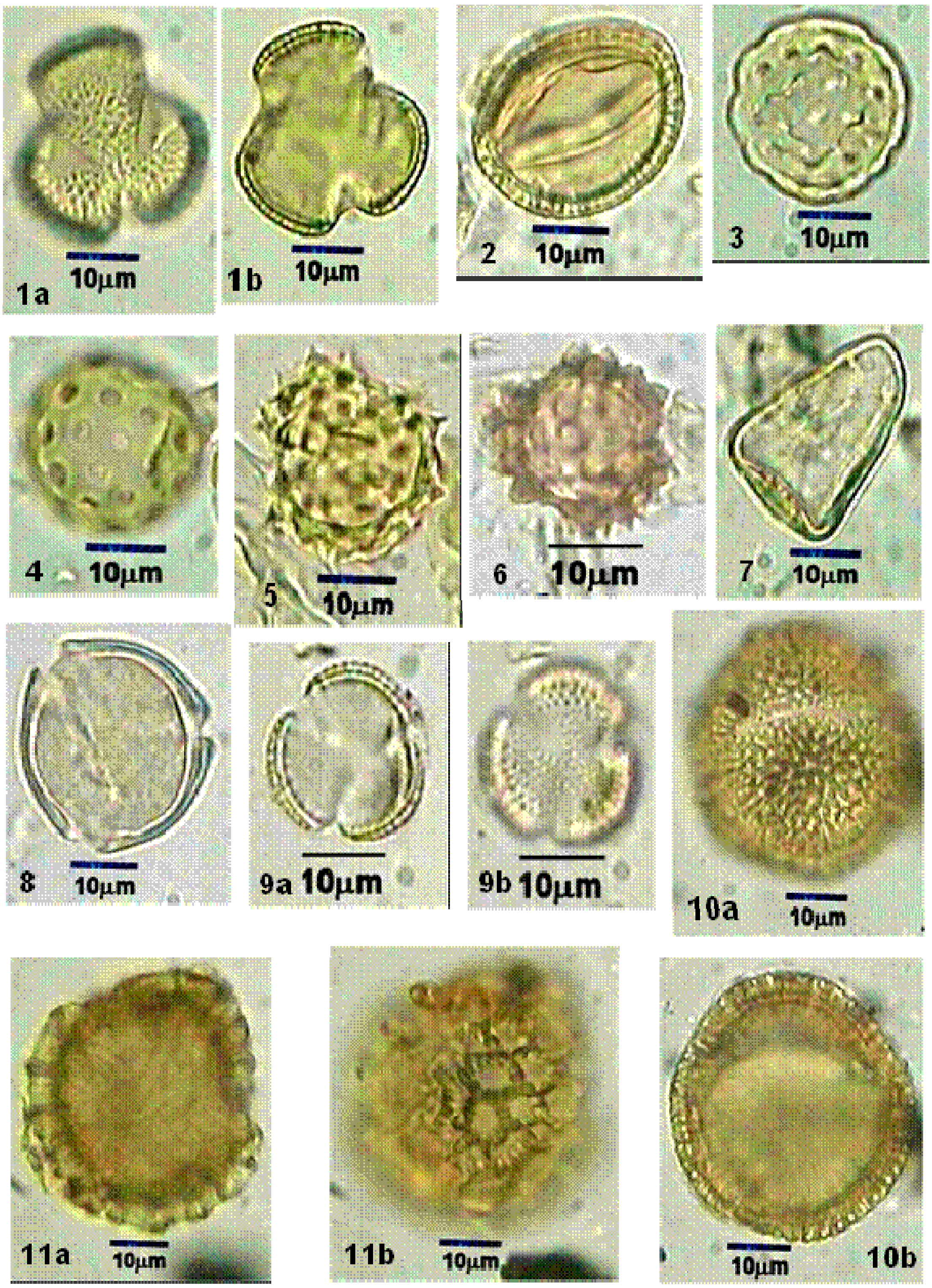

Figure 6: 1-2 *Avicennia marina* (Avicenniaceae); 3-4 Amaranthaceae./ Chenopodiaceae; 5-6 *Aaronsohnia factorovskyi* (Asteraceae); 7 *Cyprus conglomeratus* (Cypraceae); 8 Casuarina; 9a,b *Anastatica hierochuntica* (Brassicaceae) ; 10-11 *Erodium ciconium* (Geraniaceae).

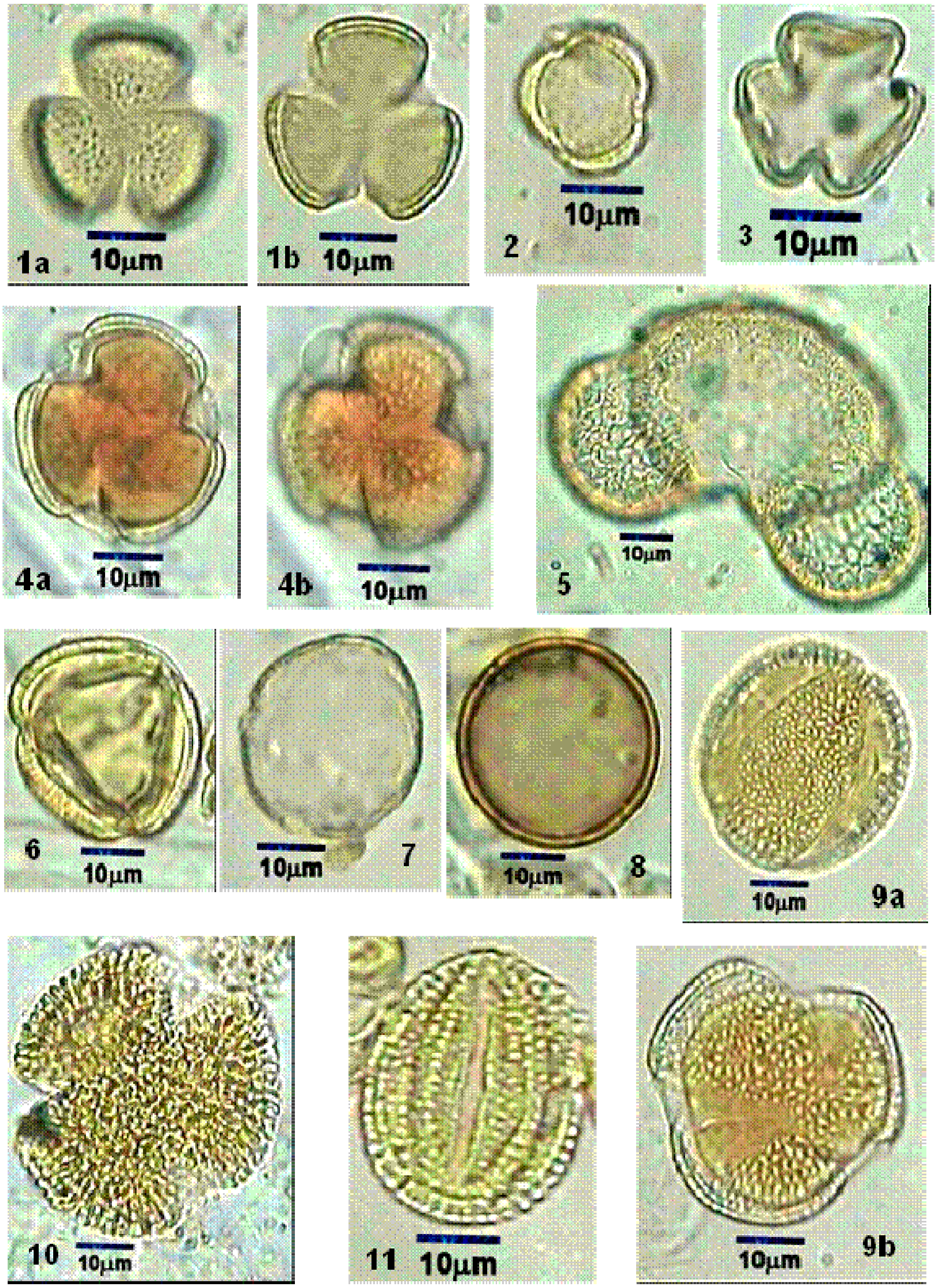

Figure 7: 1a,b Oxalis cf. pes-caprae (Oxalidaceae); 2 Spergularia cf diandra (Solanaceae); 3 Polygonaceae; 4a,b Fagonia spec. (Zygophyllaceae); 5 Podocarpus spec.; 6 Rhamnaceae; 7 Plantago amplexicaulis (Plantagnaceae); 8 Plantagnaceae ; 9a,b Convolvulus spec. (Convolvulaceae) ; 10 Limonium cf axillare (Liliaceae); 11 Euphorbea spec. (Euphorbiaceae).