OnLine Journal of Biological Sciences 1 (7): 628-635, 2001

Contribution to the Ecology of the Deltaic Mediterranean Coast, Egypt

Ibrahim A. Mashaly
Botany Department, Faculty of Science, Mansoura University, Egypt

Abstract: The ecology of the western section of the Deltaic Mediterranean Coast of Egypt provides a quantitative assessment of the vegetation structure, the main soil characteristics and an evaluation of the relationships between the recognized vegetation groups and environmental attributes. Vegetation and soil were sampled in 75 stands representing the physiographic variation and/or different habitat types in the study area. Relative values of frequency, density and cover for each perennial and the annuals were also recorded. The soil characteristics of collected samples were determined for each stand. 75 sampled stands were classified according to multivariate analysis (classification & ordination) into nine defined vegetational groups, namely: group A dominated by *Alhagi graecorum* Boiss., group B codominated by *Phragmites australis* (Cav.) Trin. ex Steud. and *Halocnemum strobilaceum* (Pallas) M. Bieb, group C dominated by *Arthrocnemum macrostachyum* (Moric.) Moris et Delponte, group D dominated by *Sporobolus spicatus* (Vahl) Kunth, groups E & F dominated by *Sporobolus viriginicus* (L.) Kunth, group G dominated by *Stipagrostis scoparia* (Trin. & Rupr.) De Winter, group H dominated by *Echium sericeum* Vahl and group I dominated by *Lotus creticus* L. Detrended Correspondence Analysis (DCA) and Canonical Correspondence Analysis (CCA) were used to evaluate vegetation-environment relationships. Moisture content, soil texture (coarse & fine sand), soil reaction (pH), calcium carbonate content, sodium adsorption ratio, extractable cations (calcium and potassium) and electrical conductivity were highly correlated with the first and second ordination axes. Thus, these soil variables seem to be the main important environmental factors affecting the distribution of vegetation in the study area.

Key words: Deltaic Medit, coast, halophytes, psammophytes, salt marsh, sand formation, chorotype

Introduction

The Mediterranean coastal land of Egypt has a narrow coastal belt that extends between Sallum (on the Libyan borders) eastward to Rafah (on the Palestinian borders) for about 970 Km, with an average width ranging between 20-25 km in north-south direction. Ecologically, the Mediterranean coast of Egypt can be divided into three sections: 1) a western section, the Mareotis coast, between Sallum and Abu-Qir (550 Km); 2) the middle section, a Deltaic coast between Abu-Qir and Port-Said (180 Km); and 3) an eastern section, the Sinai coast, between Port-Said and Rafah (240 Km) (Zahran *et al.* 1990). The vegetation of the Mediterranean coastal region of Egypt is considered to be one of its major natural resources (Shaltout, 1983). Its proper utilization plays a key role in the sound of development of this region which is known to have enjoyed prosperity during the Graeco-Roman times (Kassas, 1972). The vegetation of the western and eastern Mediterranean coasts have been extensively studied from several stand points: climatology, geology, geomorphology, hydrology, flora, phytosociology, etc. (Bornkamm & Khel, 1990), while the middle coast (Deltaic) has been studied by many authors: Batanouny & El-Fiky 1984; Zahran *et al.*, 1989 & 1990; El-Demerdash *et al.*, 1990; Mashaly 1993; Mashaly *et al.*, 1993; Hegazy *et al.*, 1994; Shaltout *et al.*, 1995; Khedr 1997, 1998 & 1999; Khedr & Zahran 1999; etc.

The project aims at the following objectives: 1) to depict the vegetation analysis in the western section of the Deltaic Mediterranean coast, 2) to assess the role of the soil factors in the study ecosystems and 3) to compare the results of the present investigation with those the previous studies conducted in this and other sections of the Deltaic Mediterranean coastal land of Egypt.

The Study Area: The study area is situated in the western sector of the Deltaic Mediterranean coast of Egypt. It extends for a distance of about 100 Km along the coast from Burg El-Borullus in the east to Abu-Qir in the west, and to an average distance of 10 Km in N-S direction from the coast, i.e. the study site covers an area of about 1000 Km^2 (Fig. 1).

A geological account of this area was given by Said (1962) and the soils belong to the Semistatic Silic Ergosols, the Marshy and Humic Solonchaks and Humic Solonetzs (El-Gabaly *et al.* 1969). According to Ayyad *et al.* (1983) and Zahran & Willis (1992) the study area belongs to the attenuated arid province characterized by a short dry period, and annual rainfall from 100-160 mm, warm summer (27-31°C), mild winter (8.2-24°C), and aridity index (P/ETP) less than 0.03.

Materials and Methods

Seventy-five stands (13 x 13 m^2 each) were chosen along the study coastal area to represent the prevailing physiographic and physiognomic variations as well as to cover most of the recognizable habitats. The sampling process was carried out during March-August 1999, the period of maximum vascular plant species diversity. In each stand, relative density and relative frequency were estimated quantitatively using the point-centered quarter method (Cottam & Curtis, 1956; Ayyad, 1970). While, relative cover was estimated by applying the line intercept method (Canfield, 1941). Species abundance as expressed by the relative values of density, frequency and cover were calculated for each perennial species and summed up to give an estimate of its importance value (out of 300). The annual species were only recorded. Plant specimens were collected, identified and preserved at the Herbarium of Faculty of Science, Mansoura University. The life-forms were according to Raunkiaer (1934). Species identification and floristic categories were according to Tackholm(1974); Boulos (1995, 1999 & 2000); Wickens (1976); Townsend & Guest (1966-1985); Feinbrun (1978 & 1986).

Three soil samples (0-50 cm) were collected from each stand, pooled together to form one composite sample, spread over sheets of paper, air dried, passed through 2 mm sieve, and packed in plastic bags ready for analysis. Physical and chemical analyses of soil sample were carried out according to Piper 1947; Jackson 1962; U.S. Salinity Laboratory Staff 1954 and Allen *et al.*, 1974.

Two trends of multivariate analysis, namely: classification and ordination are commonly followed. The classification technique applied was the Two-Way Indicator Species Analysis using TWINSPAN-a FORTRAN Program (Hill 1979; Hill *et al.*, 1975; Gauch, 1982). While the ordination techniques applied were the Detrended Correspondence Analysis (DCA) and the Canonical Correspondence Analysis (CCA) using CANOCO-a FORTRAN Program (ter Break 1986, 1987 & 1988). The relationships between vegetation gradients and environmental variables can be indicated on the ordination diagram produced by the Canonical Correspondence Analysis (CCA biplot), on which points represent species and arrow represent environmental variables. The statistical treatment applied were according to Snedecor & Cochran 1968 and Nie *et al.*, 1975.

Results

Life-form spectrum and phytogeographical affinity: Thirty-five perennials and forty-two annuals have been recorded in the study area (Appendix). These recorded species are grouped under five major types of life-forms: therophytes (54.5%), cryptophytes (19.5%), hemicryptophytes (14.3%), chamaephytes (9.1%) and phanerophytes (2.6%). The phytogeographical affinities of the recorded species revealed that they are mostly of Mediterranean origin (51 species or about 66%), either pluriregional (28%), biregional (20%) or monoregional (18%). 26 species (34%) are belonging to different floristic elements with poor representation.

TWINSPAN-classification: The application of TWINSPAN classification on the importance values of 35 perennial species recorded in 75 sampled stands led to recognition of nine vegetation groups (Fig. 2) and the vegetation structure of these groups is presented in Table 1. It is obvious that, the leading dominant species of the identified vegetation groups are the indicator species in the same groups.

Group A comprises 5 stands dominated by the indicator species *Alhagi graceorum* with the highest mean importance value (IV) of 178.9 (out of 300). Other important species which attain relatively high IV is *Zygophyllum aegyptium* (IV = 97.3).

Group B comprises 9 stands codominated by two indicator species: *Phragmites australis* (IV = 120.2) and *Halocnemum strobilaceum* (IV = 104.4). The important species in this group is also *Zygophyllum aegyptium* (IV = 67.2).

Group C consists of 10 stands dominated by the indicator species *Arthrocnemum macrostachyum* (IV = 110.9). Other important indicator species in this group is *Elymus farctus* which attain IV = 75.7. Group D consists of 14 stands dominated by the indicator species *Sporobolus spicatus* (IV = 124.9). The rush *Juncus acutus* can be considered as the second important species in this group where it attained IV = 47.1. Group E (4 stands) and group F (8 stands) both are dominated by the indicator species *Sporobolus virginicus* where, it attained IV = 176.2 in group E and IV = 170.6 in group F. The difference between these two vegetational groups is, in group E the second indicator species is *Inula crithmoides* (IV = 82.1) while in group F the second indicator species is *Alhagi graceorum* (IV = 109.3). Group G comprises 6 stands dominated by the indicator species *Stipagrostis scoparia* (IV = 92.3). The other important indicator species in this group are: *Echium sericeum* (IV = 55.1) and *Centropodia forsskalii* (IV = 51.4). Group H consists of 11 stands dominated by the indicator species *Echium sericeum* (IV = 107.6). In this group *Stipagrostis scoparia* (IV = 87.3) is the second important indicator species that follows the former dominant indicator species. Group I comprises 8 stands dominated by the indicator species *Lotus creticus* (IV = 94.6). Other important species which attain relatively high IV, these are *Alhagi graceorum* (IV = 79.8), *Stipagrostis scoparia* (IV = 67.6) and *Cyperus capitatus* (IV = 38.6). The common associated annual species in the study area include: *Cakile maritima* subsp. *aegyptiaca*, *Senecio glaucus*, *Salsola kali*, *Ononis serrata*, *Lotus halophilus*, *Aegilops bicornis*, *Beta maritima*, *Bassia indica*, *Bromus rigidus*, *Erodium laciniatum*, *Mesembryanthemum crystallinum*, *M. nodiflorum*, *Plantago squarrosa*, etc.

Variations in environmental factors: The soil variables of the nine groups identified by TWINSPAN classification are presented in Table 2. Most of the soil characteristics show a remarkable variations between the different groups of stands. The soil texture in all groups is formed mainly of coarse sand and partly of medium and fine sand. The percentage of soil moisture content is obviously high in groups C, D & E (14.27%, 12.16% & 16.38% respectively) and it is relatively low in the other groups (0.90%-3.87%). Porosity and water-holding capacity are comparable in all groups. Calcium carbonate content attained the highest mean value (13.50%) in group B and the lowest (1.69%) in group F. While, organic carbon content attained the highest mean value (0.25%) in group C and the lowest (0.06%) in group I. The pH values indicate that, the soil reaction varies from slightly acidic, neutral to alkaline in different groups. The electrical conductivity (EC) attained its highest mean values (2.36 & 2.39 mmhos/cm) in groups C & E and its lowest mean values (0.17 & 0.19 mmhos/cm) in groups A & G. Parallel results were obtained regarding of chloride, sulphate and bicarbonate contents. The soluble carbonate content was nil in all groups. The highest content of total nitrogen (1.22 mg/100 gm dry soil) was obtained in group B, but the lowest value (0.36 mg/100 gm dry soil) in group G. The concentrations of extractable cations: Na^+, K^+ and Ca^{+2} as well as SAR and PAR were generally high in groups C, D & E, but low in group A. However, Mg^{+2} was relatively high in group C, but low in group I. The correlation coefficient (r) between the different soil variables in the sampled stands are shown in Table 3. Most edaphic variables are significantly correlated with each other such as soil texture (medium & fine sand), porosity, water-holding capacity, $CaCO_3$, organic carbon, pH value, EC, Cl^-, HCO_3^-, total nitrogen and extractable cations (Na^+, K^+, Ca^{+2} & Mg^{+2}). Sulphate and carbonate contents show a limited significant correlations with other soil variables. However, fine fractions (silt & clay) and soil moisture content have no correlations with any of the other edaphic variables.

Detrended Correspondence Analysis (DCA-ordination): The ordination diagram resulting from DCA is shown in Fig. 3a for stands and in Fig. 3b for species. It is clear that the vegetation groups yielded by TWINSPAN calssification are markedly distinguishable and having a clear pattern of segregation on the first and second ordination planes.

Groups A & B are separated at the upper left side of the diagram and are positively correlated with axis 2. The corresponding species are hummock forming halophytes: *Halocnemum strobilaceum*, *Zygophyllum aegyptium*, *Phragmites australis* and *Alhagi graceorum*.

Groups C,D,E & F are segregated at the lower left side of the diagram and are negetatively correlated with axis 2. The corresponding species are halophytes: *Arthrocnemum macrostachyum*, *Sporobolus spicatus*, *Sporobolus virginicus*, *Elymus farctus*, *Juncus acutus* and *Inula crithmoides*.

Groups G, H & I are separated at the mid-right side of the DCA diagram and are correlated with axis 1. The corresponding

Table 1: Mean of the importance values of the perennial species in the different vegetation groups resulting from classification technique of the sampled stands in the study area

No	Species	Group								
		A	B	C	D	E	F	G	H	I
1	Alhagi graecorum	178.9	1.5	-	2.4	-	109.3	12.0	39.6	79.8
2	*Arthrocnemum macrostachyum* -		2.3	110.9	14.5	22.4	10.7	-	-	-
3	*Asparagus stipularis*	-	-	-	-	-	-	-	1.6	-
4	*Astragalus alexandrinus*	-	-	-	-	-	-	-	1.1	-
5	*Astragalus fruticosus*	-	-	-	-	-	-	1.5	-	-
6	*Atractylis carduus* -	-	-	-	-	2.9	15.5	0.6	-	
7	*Atriplex portulacoides*	-	-	18.7	-	-	-	-	-	-
8	*Calligonum comosum*	-	3.6	-	-	-	-	-	-	-
9	*Centropodia forsskalii*	-	-	-	-	-	-	51.4	1.5	-
10	*Cressa cretica*	-	-	5.8	-	-	-	-	-	-
11	*Cynodon dactylon*	-	0.5	-	-	-	-	-	4.2	-
12	*Cyperus capitatus*	-	-	-	-	-	-	-	2.3	38.6
13	*Cyperus conglomeratus*	-	-	-	-	-	-	33.8	2.3	1.1
14	*Cyperus laevigatus*	-	-	-	-	-	-	-	-	0.7
15	*Echinops spinosissimus*	-	-	-	1.0	-	0.2	22.7	33.3	7.5
16	*Echinops tackholmiana*	-	-	-	-	-	-	-	2.3	-
17	*Echium sericeum*	-	-	-	-	-	-	55.1	107.6	7.6
18	*Elymus farctus*	-	-	75.7	30.4	-	3.1	-	-	-
19	*Frankenia hirsuta*	-	-	-	-	-	0.8	-	-	-
20	*Halocnemum strobilaceum*	12.3	104.4	-	-	-	-	-	-	-
21	*Inula crithmoides*	-	-	22.0	29.8	82.1	-	-	-	-
22	*Juncus acutus*	-	-	-	47.1	3.6	-	-	-	-
23	*Juncus rigidus*	-	-	-	2.1	12.6	-	-	-	-
24	*Limonium pruinosum*	-	-	7.4	-	-	-	-	-	-
25	*Lotus creticus*	-	-	0.2	-	-	-	14.4	1.9	94.6
26	*Moltkiopsis ciliata*	-	-	-	-	-	-	-	10.8	-
27	*Phoenix dactylifera*	-	-	-	0.1	-	-	-	-	-
28	*Phragmites australis*	10.4	120.2	14.7	25.6	-	-	1.6	0.3	-
29	*Saccharum spontaneum*	-	-	-	-	-	-	-	3.1	2.4
30	*Sporobolus spicatus*	-	-	-	124.9	3.4	-	-	-	-
31	*Sporobolus virginicus*	-	-	21.4	23.2	176.2	170.6	-	-	-
32	*Stipagrostis lanata* -	-	-	-	-	-	-	0.4	0.1	-
33	*Stipagrostis scoparia*	-	-	-	-	-	2.2	92.3	87.3	67.6
34	*Tamarix nilotica* -	-	1.8	1.7	-	-	-	0.1	-	-
35	*Zygophyllum aegyptium*	97.3	67.2	21.8	0.1	-	0.1	-	-	-

Table 2: Mean value of the soil variables in different TWINSPAN vegetation groups

Soil variables	Vegetational groups								
	A	B	C	D	E	F	G	H	I
Soil variables									
Coarse sand (%)	81.20	65.80	90.04	78.54	92.35	90.03	88.30	86.60	84.10
Medium sand (%)	9.60	19.70	4.99	14.36	4.70	5.35	6.80	8.50	11.30
Fine Sand (%)	10.50	14.00	3.39	6.51	2.78	4.16	3.10	4.70	4.40
Fine fractions (%)	0.60	0.60	0.89	0.45	0.18	0.46	0.20	0.10	0.10
Moisture content (%)	0.90	1.50	14.27	12.16	16.38	3.87	1.30	1.70	1.00
Porosity (%)	37.60	32.30	45.10	42.00	45.50	47.35	44.40	42.10	40.10
WHC (%)	25.30	27.40	42.23	40.02	36.90	32.15	26.50	30.50	29.70
Calcium carbonate (%)	4.10	13.50	2.60	2.82	10.13	1.69	2.40	2.80	1.90
Organic carbon (%)	0.08	0.08	0.25	0.19	0.21	0.14	0.09	0.07	0.06
PH	7.74	7.97	8.69	9.13	9.11	8.07	7.11	6.92	6.94
EC (mm hos/cm)	0.17	0.45	2.36	1.73	2.39	0.67	0.19	0.22	0.24
Cl (%)	0.03	0.05	0.83	0.70	0.53	0.14	0.02	0.02	0.02
SO_4^{-2} (%)	0.09	0.14	0.37	0.17	0.15	0.08	0.08	0.07	0.08
HCO_3^-(%)	0.04	0.01	0.13	0.16	0.11	0.08	0.07	0.08	0.06
N mg\100gm dry soil	1.11	1.22	1.10	0.68	1.17	0.89	0.36	0.50	0.94
Na^+	29.40	42.70	222.30	229.64	238.75	68:38	46.60	43.10	42.70
K^+	4.50	6.10	18.65	23.22	28.13	10.18	9.50	8.50	10.20
Ca^{+2}	0.40	0.90	2.10	2.03	2.04	1.23	0.50	0.44	0.42
Mg^{+2}	0.50	0.92	1.25	0.45	1.04	1.08	0.32	0.29	0.28
SAR	43.30	46.30	176.16	2 03.24	196.24	71.07	60.50	70.41	71.50
PAR	7.10	6.70	15.53	21.38	22.59	10.28	15.00	14.20	17.20

WHC = water-holding capacity, EC = electrical conductivity SAR = sodium adsorption ratio, PAR = potassium adsorption ratio

Table 3: Pearson moment correlation (r) between the measured soil variables in the stands surveyed in the study area

Soft variables																				
Coarse sand	Cs																			
Medium sand	-0.94**	Ms																		
Fine sand -	0.86**	0.65**	Fs																	
Fine fractions	-0.24	0.09	0.28	Ff																
Moisture content	0.26	-0.25	-0.28	0.3	Mc															
Porosity	0.21	-0.25	-0.2	0.52**	0.4*	Po														
WHC	0.06	-0.05	-0.14	0.61**	0.68**	0.49**	WHC													
Calcium carbonate	-0.49**	0.4*	0.51**	0.18	-0.05	-0.19	-0.06	Cc												
Organic carbon	0.21	-0.25	-0.19	0.68**	0.7**	0.57**	0.73**	-0.04	Oc											
pH	0.06	0.08	0.01	0.07	0.7**	0.08	0.5**	0.05	0.34*	PH										
EC	0.18	-0.21	-0.18	0.54**	0.86**	0.48**	0.75**	0.02	0.82**	0.56**	EC									
$C1^-$	0.06	-0.08	-0.08	0.46**	0.59**	0.47**	0.63**	-0.03	0.62**	0.36*	0.73**	Cl^-								
$SO4^-$	-0.09	0.07	0.06	0.33*	0.22	0.1	0.31	0.18	0.24	0.25	0.32	0.33*	$SO4^-$							
$CO3^-$	-0.15	0.16	0.09	0.01	0.24	0.07	0.24	-0.18	0.01	0.4*	0.18	0.25	0.04	CO3						
$HCO3^-$	0.32	-0.28	-0.31	-0.02	0.46**	0.1	0.45**	-0.3	0.24	0.59**	0.39*	0.23	0.15	0.35*	$HCO3^-$					
Total Nitrogen	-0.05	-0.06	0.15	0.69**	0.21	0.37*	0.41*	0.2	0.49**	0.03	0.4*	0.27	0.17	-0.21	-0.07	Tn				
Na^+	0.17	-0.19	-0.18	0.38*	0.87**	0.44**	0.77**	-0.05	0.71**	0.69**	0.92**	0.81**	0.31	0.33*	0.52**	0.22	Na^+			
K^+	0.13	-0.11	-0.16	0.18	0.72**	0.33*	0.64**	-0.04	0.52**	0.62**	0.76**	0.7**	0.22	0.39*	0.5**	0.03	0.89**	K^+		
Ca^{++}	0.07	-0.07	-0.11	0.42*	0.8**	0.39*	0.7**	0.05	0.7**	0.63**	0.91**	0.8**	0.32	0.27	0.38*	0.27	0.92**	0.82**	Ca^{++}	
Mg^{++}	-0.07	0.0	0.08	0.58**	0.31	0.36*	0.32	0.28	0.52**	0.01	0.54**	0.5**	0.21	-0.17	-0.23	0.47**	0.36*	0.23	0.6**	Mg^{++}
SAR	0.21	-0.2	-0.22	0.19	0.82**	0.3	0.73**	-0.15	0.57**	0.78**	0.76**	0.62**	0.24	0.39*	0.67**	0.06	0.92**	0.88**	0.78**	0.05

Abbreviation Cs = corase sand, Ms = medium sand, Fs = fine sand, Ff= fine fractions, Mc = moisture content, Po = porosity, WHC = water holding capacity, Cc = calcium carbonate, Oc = organic carbon, Tn = total nitrogen, SAR = sodium adsorption ratio. * is significant at p level 0.05 and** is significant at p level 0.01

Appendix

List of perennial and annual species recorded in the study area and their life-forms and floristic categories.

A- Perennials

No	Species	Life form	Floristic category
1	*Alhagi graecorum* Boiss.	H	PAL
2	*Arthrocnemum macrostachyum* (Moric) Moris et Delponte	Ch	ME + SA-SI
3	*Asparagus stipularis* Forssk.	G	ME + SA-SI
*4	*Astragalus alexandrinus* Boiss. Syn. *A. caprinus* L.	H	SA-SI
*5	*Astragalus tomentosus* Lam.		
Syn.	*A. fruticosus* Forssk	Ch	SA-SI
6	*Atractylis carduus* (Forssk.) Christ	H	SA-SI + ME
7	*Calligonum comosum* L'Her.	Nph	SA-SI + IR-TR
*8	*Centropodia forsskalii* (Vahl) cope		
Syn.	*Astenatherum forsskalii* (Vahl) Nevski	G	SA-SI + IR-TR
9	*Cressa cretica* L.	H	ME + PAL
10	*Cynodon dactylon* (L.) Pers.	G	PAN
11	*Cyperus capitatus* Vand.	G	ME
12	*Cyperus conglomeratus* Rottb.	G	SA-SI + S-Z
13	*Cyperus laevigatus* L.	G,He	PAN
14	*Echinops spinosissimus* Turra	H	ME-SA-SI
15	*Echinops tackholmina* A. Amin	H	Egypt (Endemic)
*16	*Echium sericeum* Vahl Syn. *E. angustifolium* subsp. sericeum (Vahl) Klotz	H	ME
17	*Elymus farctus* (Viv.) Runemark	G	ME
18	*Frankenia hirsuta* L.	H	ME+ER-SR+IR-TR
*19	*Halimione portulacoides* (L.) Aellen		
Syn.	*Atriplex portulacoides* L.	Ch	ER-SR+ME+IR-TR
20	*Halocnemum strobilaceum* (Pallas) M. Bieb.	Ch	ME+IR-TR+SA-SI
21	*Inula crithmoides* L.	Ch	ME+ER-SR+SA-S I
22	*Juncus acutus* L.	He	ME+IR-TR+ER-SR
23	*Juncus rigidus* Desf.	He,G	ME+SA-SI+IR-TR
24	*Limonium pruinosum* (L.) O. Kuntze	H	SA-SI
25	*Lotus creticus* L.	H	ME
26	*Moltkiopsis ciliata* (Forssk.) I.M. Johnst.	Ch	SA-SI+S-Z+ME
27	*Phoenix dactylifera* L.	MMph	Cult
28	*Phragmites australis* (Cav.) Trin. ex Steud.	G,He	COSM
29	*Saccharum spontaneum* L.	G,He	PAL + ME
30	*Sporobolus spicatus* (Vahl) Kunth	G	S-Z+SA-SI+ME
31	*Sporobolus virginicus* (L.) Kunth	G	PAN
32	*Stipagrostis lanata* (Forssk.) De Winter	G	SA-SI
33	*Stipagrostis scoparia* (Trin. & Rupr.) De Winter	H,G	SA-SI
34	*Tamarix nilotica* Ehrenb.	Nph	SA-SI+S-Z
35	*Zygophyllum aegyptium* A. Hosny	Ch	ME

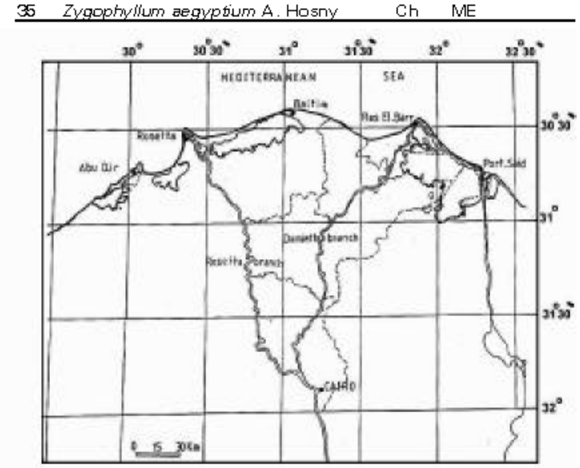

Fig. 1: Map showing the study area in the Deltaic (middle) section of the Mediterranean coastal region of Egypt

B-Annuals

No	Species	Floristic category
1	*Aegilops bicornis* (Forssk.) Jaub & Spach	ME+SA-SI
2	*Anchusa aggregata* Lehm.	ME + SA-SI
3	*Atriplex prostrata* DC.	ME+ER-SR+IR-TR
4	*Bassia indica* (Wight) A.J. Scott	S-Z + IR - TR
5	*Bassia muricata* (L.) Ascherson	SA-SI + IR - TR
6	*Beta maritima* L.	ME+ER-SR+IR-TR
7	*Bromus rigidus* Roth	ME
8	*Cakile maritima* Scop. subsp. *aegyptiaca* (Willd.) Nyman	ME+ER-SR
9	*Calendula micrantha* Tineo et Guss.	ME
10	*Carthamus tenuis* (Boiss. et Blanche) Bornm. Subsp. *foliosus* Hanelt	ME
11	*Centaurea glomerata* Vahl	ME
12	*Centaurium pulchellum* (Swartz) Durce	ME+IR-TR+ER-SR
13	*Chenopodium glaucum* L.	ER-SR+ME
14	*Conyza bonariensis* (L.) Crong.	NEO
15	*Cutandia memphitica* (Spreng.) K. Reichb	ME+IR-TR+SA-SI
16	*Daucus guttatus* Sibth. & Sm.	ME
17	*Erodium laciniatum* (Cav.) Willd.	ME
18	*Frankenia pulverulenta* L.	ME+ER-SR+IR-TR
19	*Hordium marinum* Huds	ME+IR-TR+ER-SR
20	*Ifloga spicata* (Forssk.) Sch. Bip.	SA-SI+ME
21	*Juncus bufonius* L.	COSM
22	*Lobularia arabica* (Boiss.) Muschl.	SA-SI
23	*Lotus halophilus* Boiss. et Sprun.	ME+SA-SI
24	*Malcolmia pygmaea* (DC.) Boiss.	SA-SI
25	*Mesembryanthemum crystallinum* L.	ME+ER-SR
26	*Mesembryanthemum nodiflorum* L.	ME+SA-SI+ER-SR
27	*Neurada procumbens* L.	SA-SI+S-Z
28	*Ononis serrata* Forssk.	ME+SA-SI
29	*Parapholis incurva* (L.) C.E. Hubbard	ME+IR-TR+ER-SR
30	*Plantago squarrosa* Murr.	ME
31	*Polypogon monspeliensis* (L.) Desf.	COSM
32	*Pseudorlaya pumila* (L.) Grande	ME
33	*Reichardia tingitana* (L.) Roth	ME+SA-SI+IR-TR
34	*Rumex pictus* Forssk.	ME+SA-SI
35	*Salsola kali* L.	COSM
36	*Schismus barbatus* (L.) Thell.	ME+IR-TR+SA-SI
37	*Senecio glaucus* L.	ME+SA-SI+IR-TR
38	*Silene colorata* Poir.	ME
39	*Spergularia marina* (L.) Bessler	ER-SR+ME+IR-TR
40	*Sphenopus divaricatus* (Gouan) Reich	ME+IR-TR+SA-SI
41	*Suaeda maritima* (L.) Dumort.	COSM
42	*Trisetaria linearis* Forssk.	ME+SA-SI

A- Legend to Floristic categories:	B- Legend to Life-forms:
COSM : Cosmopolitan	MMPH: Mesco & Megaphanerophytes
PAN : Pantropical	Nph: Nanophanerophytes
PAL : Palaeotropical	Ch: Chamaephytes
NEO : Neotropical	H: Hemicryptophytes
ME : Mediterranean	G: Geophytes
ER-SR: Euro-Siberian	He: Helophytes
SA-SI : Saharo-Sindian	Syn: Synonmy
IR-TR : Irano-Turanian	
S-Z : Sudano-Zambezian	
Cult. : Cultivated	

species are psammophytes: *Stipagrostis scoparia, Echium sericeum, Lotus creticus, Centropodia forsskalii, Echinops spinosissimus, Cyperus capitatus* and *Cyperus conglomeratus*.

Canonical Correspondence Analysis (CCA-ordination): The vegetation-environment relationship is indicated on the ordination diagram produced by Canonical Correspondence Analysis (CCA) of the perennial species (Fig. 4a) and the biplot of species-environment (Fig. 4b). The length and direction of an arrow representing a given environmental factor provide an indication of the importance and direction of the gradient of environmental change, for that factor, within the set of samples measured. The angle between an arrow and each axis is a reflection of its degree of correlation with the axis. As shown in Fig. 4b, it is obvious that the soil moisture, soil texture, soil reaction (pH), calcium carbonate content, sodium adsorption ratio, extractable cations Ca^{+2} & K^{+} as well as electrical conductivity were highly correlated with the first and

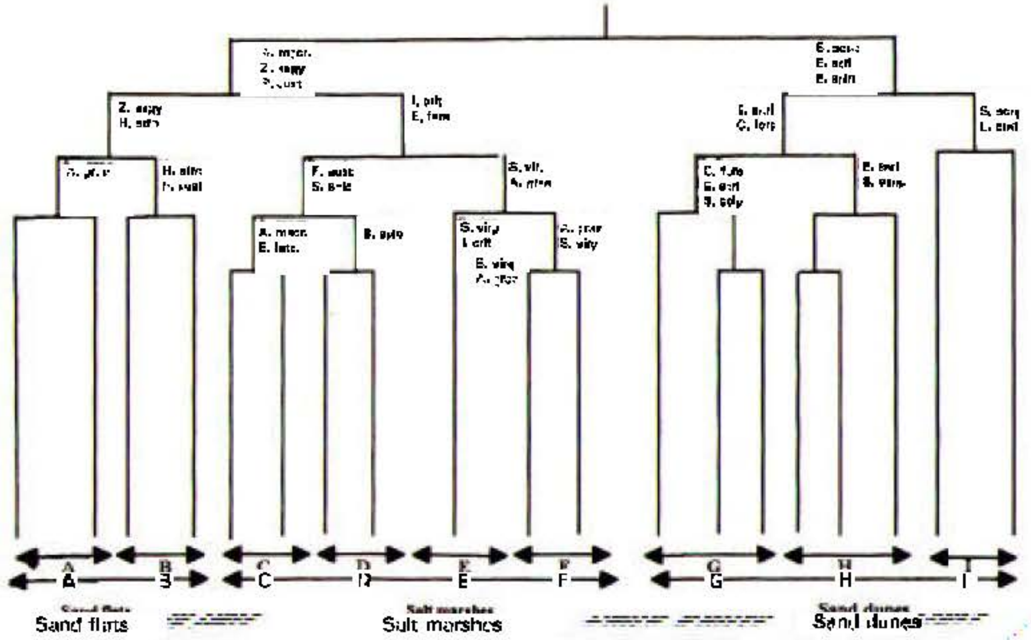

Fig. 2: TWINSPAN dendrogram of 75 standas based on improtance value of 35 species in the study area. Indicator species names are abbreviated on the first latter of the genus and four letter of the species name

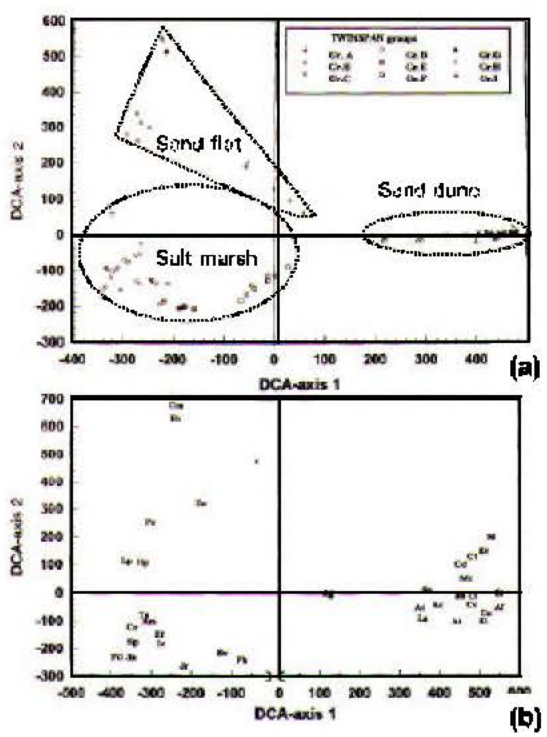

Fig. 3: (a) DCA-ordination of 75 stands with TWINSPAN groups super imposed. (b) DCA-ordination of the species with the names abbreviated into the first letters of the genus and species.

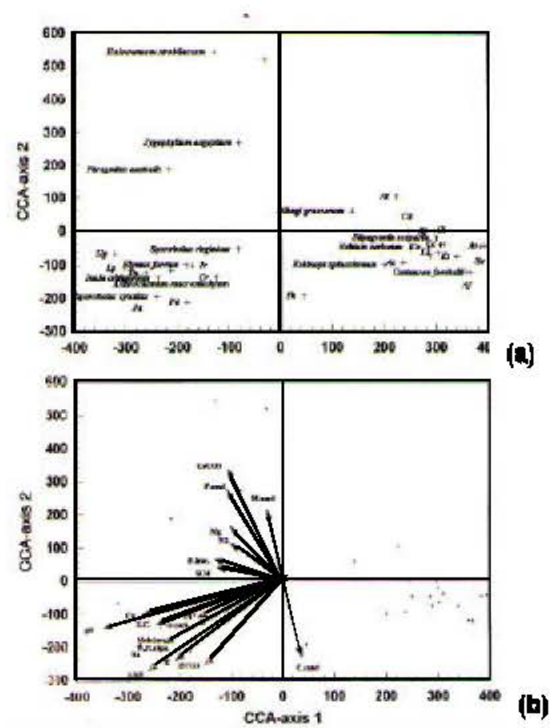

Fig. 4: (a) CCA-ordination of 35 perennial species represented by points and soil variables indicated by arrow (b) CCA-biplot of 35 perennial species represented by point and soil variables indicated by arrows.

second ordination axes.
The species of groups A & B (*Halocnemum strobilaceum*, *Zygophyllum aegyptium* and *Phragmites australis*) which are separated at the upper left side of the CCA-biplot diagram show a positive relationship with $CaCO_3$ and soil texture (medium & fine sand). On the other hand, the species of groups C, D, E & F (*Arthrocnemum macrostachyum*, *Sporobolus spicatus*, *Sporobolus virginicus*, *Inula crithmoides* and *Elymus farctus*) which are segregated at the lower left-side of the biplot diagram exhibit a negative correlation with soil moisture, pH, SAR, Ca^{+2}, K^{+} and EC. However, the species of groups G, H & I (*Stipagrostis scoparia*, *Echium sericeum*, *Lotus creticus*, *Centropodia forsskalii* and *Echinops spinosissimus*) which are separated at the mid right side of the CCA-biplot diagram have no correlations with any soil variables.

Discussion

The object of the description of vegetation is to enable people other than the observer to build a mental picture of an area and its vegetation and to allow the comparison and ultimate classification of different units of vegetation (Kershow & Looney, 1985).
The vegetation of the western part of the Deltaic Mediterranean coast of Egypt is classified by multivariate analysis (TWINSPAN classification) into nine groups. Each group comprises number of stands which are similar in terms of vegetation and characterized by dominant, indicator and/or preferential species. The recognized vegetation groups in the study area named after their dominants and/or codominants as follows: *Alhagi graceorum* (group A), *Phragmites australis-Halocnemum strobilaceum* (group B), *Arthrocnemum macrostachyum* (group C), *Sporobolus spicatus* (group D), *Sporobolus virginicus* (groups E & F), *Stipagrostis scoparia* (group G), *Echium sericeum* (group H) and *Lotus creticus* (group I).
It is clear that, the vegetational groups: A, B, C, D, E and F are characterized by dominant indicator halophytic species, this indicates the saline nature of their habitats in the study area. All these groups have analogues in the Mareotis coast (Tadros 1953; Tadros & Atta 1958; Ayyad & El-Ghareeb 1982) and in the salt marshes of the Deltic coast (Zahran *et al.* 1989 & 1990; El-Demerdash *et al.* 1990; Shaltout *et al.* 1995). This could be emphasized through consideration of certain similarities in both climatic condition (Mediterranean climate) and the salt affected lands supporting the growth of these groups especially all of them are located under the same effect of maritime influence (littoral salt marshes) of the Mediterranean Sea.
Out of the recognized clusters group A dominated by *Alhagi graceorum* and group B codominated by *Phragmites australis* and *Halocnemum strobilaceum* may represent the sand flats (sand sheets) in the study area. While, group C dominated by *Arthrocnemum macrostachyum*, group D dominated by *Sporobolus spicatus* and groups E & F dominated by *Sporobolus virginicus* are obviously represent the salt marsh habitat. As shown from the soil analysis and the vegetation structure of the sampled stands, group F may be considered as a transitional state between the salt marsh and sand formation habitat types in the study area.
On the other hand, group G dominated by *Stipagrostis scoparia*, group H dominated by *Echium sericeum* and group I dominated by *Lotus creticus* markedly represent the sand formation habitat. Some of these groups may be related to the alliances recognized by Eig (1939) and other groups may be related to the associations recognized by El-Ghonemy & Tadros (1970). However, the studies by Ayyad (1973) and Ayyad & El-Bayyoumy (1980) on the phytosociology of sand dunes of the western Mediterranean coastal land of Egypt and the studies of Kassas (1955), Batanouny (1965) and Danin (1978 & 1983) on the sand dunes of the eastern Mediterranean coastal land of Egypt led to the recognition of vegetational groupings which are not similar to the groups recognized on the sand formations in the present study. This may be attributed to the fact that the nature and origin of the sand formations in the Deltaic coast (study area) differ from those of Mareotis and Sinai coasts, despite prevailing of, almost, the same Mediterranean climate on the whole northern coastal land of Egypt.
Moreover, comparing the vegetation groups that characterize the sand formations in the present study with the clusters recognized in the Deltaic Mediterranean coast of Egypt by the study of El-Demerdash *et al.* 1990, the studies of Zahran *et al.* 1989 & 1990 and the study of Shaltout *et al.* 1995, we found that the group (G) dominated by *Stipagrostis scoparia*, group (H) dominated by *Echium sericeum* and group (I) dominated by *Lotus creticus* are not represented in the previous studies carried out in the other parts of the Deltaic coast. This may be attributed to the fact that, the area of the present investigation occupies the western section of the Deltaic coast that represents a transitional sector between Mareotis and Deltaic coasts where the two dominant communities: *Echium sericeum* and *Lotus creticus* are originally common in the Mareotis coast. It is also interesting to notice that, these two communities have not been recorded eastward of Rosetta till Port-Said coastal area; this observation needs further investigation.
In the present study, the application of Canonical Correspondence Analysis (CCA-biplot) between the position of vegetation groups on the ordination planes and soil variables of their stands indicates that, soil moisture content, soil texture (coarse & fine sand) soil reaction (pH values), clacium carbonate content, sodium adsorption ratio (SAR), extractable cations (calcium & potassium) and electrical conductivity are the most important edaphic factors controlling the distribution and richness of vegetation in the study area.

References

Allen, S.E., H.M. Grimshaw, J.A. Parkinson, C. Quarmby and J.D. Roberts, 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publication, Oxford.

Ayyad, M.A., 1970. Application of the point-centered quarter method to the vegetat ion of two types of desert habitat at Mareotis, U.A.R. J. Bot., 13: 225-234.

Ayyad, M.A., 1973. Vegetation and environment of the western Mediterranean coastal land of Egypt: The habitat of sand-dunes. J. Ecol., 61: 509-525.

Ayyad, M.A. and M.A. El-Bayyoumy, 1980. Phytosociology of sand dunes of the western Mediterranean desert of Egypt, in: Glimpses of Ecology (Prof. R. Misra commemoration volume). Ed. J.S. Singh & B. Gopal. Published by: International Scientific Publications.

Ayyad, M.A. and R. El-Ghareeb, 1982. Salt marsh vegetation of the western Mediterranean desert of Egypt. Vegetatio, 49: 3-19.

Ayyad, M.A., M. Abdel-Razik and A. Mehanna, 1983. Climatic and Vegetaional Gradients in the Mediterranean Desert of Egypt. Pre-report of the Mediterranean Bioclimatology Symposium, Montpellier (France, 18-20 May pp. III-I-III-2-14).

Batanouny, K.H., 1965. Sand dune vegetation of El-Arish area. Bull. Fac. Sci., Cairo Univ., 39: 11-23.

Batanouny, K.H. and A.M. El-Fiky, 1984. Water hyacinth in Egypt: Distribution and magnitude. Proc. Inter. Conf. on Water Hyacinth, Hyderabad, India, U.N. Envir. Prog.

Bornkamm, R. and H. Khel, 1990. The plant communities of the western desert-of Egypt. Phytocoenologia, 19: 149-231.

Boulos, L., 1995. Flora of Egypt, Checklist. Al Hadara Publishing, Cairo, Egypt.

Boulos, L., 1999 & 2000. Flora of Egypt. Vols. 1 & 2. All Hadara Publishing, Cairo, Egypt.

Canfield, R., 1941. Application of the line interception method in sampling range vegetation. J. For., 39: 288-393.

Cottam, G. and J.T. Curtis, 1956. The use of distance measures in phytosociological sampling. Ecology, 37: 451-460.

Danin, A., 1978. Plant diversity and ecological districts of the Sinai desert. Vegetatio, 36: 83-93.

Danin, A., 1983. Desert Vegetation of Israel and Sinai. Cana Publishing House.

Eig, A., 1939. The vegetation of the light soil belt of the coastal plain of Palestine. Palest. J. Bot., Jerusalem Ser., 1: 255-312.

El-Demerdash, M.A., M.A. Zahran and M.S. Serag, 1990. On the ecology of the Deltaic Mediterranean coastal land, Egypt. III. The habitat of salt marshes of Damietta-Port Said coastal region. Arab Gulf J. Scient. Res. 8: 103-119.

El-Gabaly, M., I.M. Gewaifel, M.N. Hassan and G. Rozanov, 1969. Soil map and land resources of the United Arab Republic. Res. Bull., 22: 1-14.

El-Ghonemy, A.A. and T.A. Tadros, 1970. Sociological studies of the natural plant communities along a transect 200 Km long between Alexandria and Cairo. Bull. Fac. Sci. Alex., 10: 392-407.

Feinbrun, N.D., 1978 & 1986. Flora Palaestina. Vols. 3 & 4. The Israel Academy of Sciences and Humanities, Jerusalem.

Gauch, H.G., 1982. Multivariate analysis in community ecology. Cambridge Studies in Ecology, Cambridge University Press.

Hegazy, A.K., M.I. Soliman and I.A. Mashaly, 1994. Perspectives on the Biology of *Heliotropium curassavicum* in the Deltaic Mediterranean Coast of Egypt. Arab Gulf J. Scient. Res., 12: 525-545.

Hill, M.O., 1979. TWINSPAN-a FORTRAN Program for arranging multivariate data in an ordered two way table by classification of the individuals and attributes. Section of Ecology and Systematics Cornell University, Ithaca, New York.

Hill, M.O., R.G. Duncc and M.W. Shaw, 1975. Indicator species analysis, a divisive polythetic method of classification and its application to the survey of native pine wood in Scotland J. of Ecology, 63: 596-613.

Jackson, M.L., 1962. Soil Chemical Analysis. Constable and Co., London.

Kassas, M., 1955. Rainfall and vegetation belts in arid North-East Africa. Plant Ecology Proc. of the Montpellier Symposium, 49-59.

Kassas, M., 1972. A brief history of land-use in Mareotis region, Egypt. Minerva Biologica, 1: 167-174.

Kershaw, K.A. and J.H. Looney, 1985. Quantitative and Dynamic Plant Ecology. 3rd. Ed. Edward Arnold.

Khedr, A.A., 1997. Aquatic macrophyte distribution in Lake Manzala, Egypt. International J. Salt Lake Res. Kluwer Academic Publishers, 5: 221-239.

Khedr, A.A., 1998. Vegetation zonation and management in the Damietta estuary of the River Nile. J. Coastal Conservation, Opulus Press Uppsala, 4: 79-86.

Khedr, A.A., 1999. Floristic composition and phytogeography in a Mediterranean deltaic lake (Lake Burollos), Egypt. Ecologia Mediterranean, 25: 1-11.

Khedr, A.A. and M.A. Zahran, 1999. Comparative Study On The Plant Life Of Two Mediterranean Deltaic Lakes In Egypt. Ass. Univ. Bull. Environ. Res., 2: 1-4.

Mashaly, I.A., 1993. Comparative ecological studies on two halophytes: *Juncus subulatus* and *Diplachne fusca*, deltaic Mediterranean coast, Egypt. J. Envirl. Sci. Mansoura Univ., 5: 279-295.

Mashaly, I.A., A.K. Hegazy and M.I. Soliman, 1993. On the ecology of *Zygophyllumaegyptium* in Egypt-H. Lieth and A. Al Masoom (eds): Towards the rational use of high salinity tolerant plants. Kluwer Acad. Publ., 1: 423-433.

Nie, N., C. Hadlai Hull, J.G. Jenkins, K. Steinbrenner and H.D. Bent, 1975. SPSS-Statistical Package for the Social Sciences 2nd ed., McGraw-Hill, New York.

Piper, C.S., 1947. Soil and plant analysis. Interscience Publishers, Inc., New York.

Raunkiaer, C. 1934. The Life Forms of Plants and Statistical Plant Geography. Translated by Garter, Fausboll and Tansley; Oxford Univ. Press, London.

Said, R., 1962. The Geology of Egypt. Elsevier Pub. Company, Amesterdam, New-York.

Shaltout, K.H., 1983. An Ecological Study of *Thymelaea hirsuta* (L.) Endl. In Egypt. Ph.D. Thesis, Fac. Sci., Tanta Univ.

Shaltout, K.H., H.F. El-Kady and Y.M. Al-Sodany, 1995. Vegetation analysis of the Mediterranean region of Nile Delta-Vegetatio, 116: 73-83.

Snedecor, G.W. and W.G. Cochran, 1968. Statistical Methods, Sixth Edition. The Jowa State Univ., Press. U.S.A.

Tackholm, V., 1974. Students'Flora of Egypt. 2nd eddition. Cairo Univ., Press.

Tadros, T.M., 1953. A phytosociological study of halophilous communities from Mareotis (Egypt). Vegetatio, 4: 102-124.

Tadros, T.M. and B.A. Atta, 1958. The plant communities of barley fields and uncultivated desert areas of Mareotis (Egypt). Vegetatio, 8: 161-175.

ter Braak, C.J., 1986. Canonical Correspondence Analysis: a new eigen vector technique for multivariate direct gradient analysis. Ecology, 67: 1167-1179.

ter Braak, C.J., 1987. The analysis of vegetation environment relationships by Canonical Correspondence Analysis (CCA). Vegetatio, 69: 69-77.

ter Braak, C.J., 1988. CANOCO-a FORTRAN Program for Canonical Community Ordination by Partial Detrended Correspondence Analysis, Principal Component Analysis and Redundancy Analysis (Version 2.1). Agric. Math. Group, Wageninign, The Netherlands.

Townsend, C.C. and E.R. Guest(ed), 1966-1985. Flora of Iraq. Vols. 2,3,4,8 & 9. Ministry of Agriculture and Agrarian Reform, Baghdad.

U.S. Salinity Laboratory Staff, 1954. Diagnosis and improvement of saline alkali soils U.S. Agr. Hankbook, 60, U.S. Department of Agriculture.

Wickens, G.E., 1976. The flora of Jebel Marra (Sudan Republic) and its geographical affinities. Royal Botanic Gardens, Kew. Kew Bulletin Additional Series V.

Zahran, M.A. and A.J. Willis, 1992. The Vegetation of Egypt, first edition. Chapman & Hall. London.

Zahran, M.A., M.A. Abu Ziada, M.A. El-Demerdash and A.A. Khedr, 1989. A note on the vegetation on islands in Lake Manzala, Egypt. Vegetatio, 85: 83-88.

Zahran, M.A., M.A. El-Demerdash and I.A. Mashaly, 1990. Vegetation types of the deltaic Mediterranean coast of Egypt and their environment. J. Veg. Sci. 1: 305-310.

Zohary, M. 1966 & 1972. Flora Palaestina. Vols. 1&2. The Israel Academy of Science and Humanities, Jerusalem