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Habitats and Plant Communities in the Nile Delta of Egypt
I. Deltaic Mediterranean Coastal Habitat

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Abstract: The present study aims at investigating the vegetation-soil relationships in the Deltaic Mediterranean coastal land of Egypt. The Deltaic coast of the Mediterranean Sea of Egypt can be distinguished into five habitat types, namely: sand dunes, salt marshes, sand sheets, sandy fertile lands and lake shorelines (Manzala, Burullus and Idku). These habitats are categorized into four vegetation groups namely, group A dominated by *Rumex pictus*, group B codominated by *Pancratium maritimum-Cyperus capitatus-Lolium perenne*, group C codominated by *Arthrocnemum macrostachyum-Atriplex portulacoides-Typha domingensis* and group D codominated by *Echinochloa stagnina-Typha domingensis-Phragmites australis*. One hundred and thirty plant species are recorded in this coast and belonging to 38 families. Out of the recorded species, about 41.54% are annuals, 2.31% biennials and 56.15% perennials. The percentages of the life-form indicated that, therophytes attained the highest representation (43.85%). The floristic analysis revealed that, 55.38% of the recorded species are Mediterranean elements. The ecological amplitudes of the leading species along the gradient of edaphic factors are discussed.

Key words: Nile region, habitat, vegetation, classification, ordination, edaphic factors

INTRODUCTION

The Deltaic Mediterranean coast forms a narrow belt extending in the E-W direction for about 180 km^2 between Port-Said to Abu-Qir and in the N-S direction for an average of about 10 km^2 from the coast (Mashaly, 2002). The vegetation of the Mediterranean coastal region of Egypt is considered to be one of its major natural resources. 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 Deltaic Mediterranean coast of Egypt can be divided ecologically into four main habitats: Salt marshes, sand formations, reed swamps and unfertile lands (Zahran *et al*., 1990). On the other hand, El-Kady *et al*. (2000) classified the Nile Delta region into many natural and man-made types of habitats. The main natural habitats are the northern coastal dunes, salt marshes, sand sheets and brackish shallow lakes. The main man-made habitats are: the water courses (canals and drains), the roads and railways, the abandoned and cultivated fields. There are three shallow lakes occupying the northern part of the Nile Delta: Lake Manzala in the east, Lake Burullus in the middle and Lake Idku in the west. These lakes receive the main bulk of the drainage water from the Nile Delta and are connected with the sea by outlets. The variation in the vegetation of the Deltaic Mediterranean coast is not only affected by sea water but it is also affected by water of the northern lakes and the Damietta and Rosetta branches of the River Nile.

The Deltaic Mediterranean coast has been studied ecologically and phytosociologically from several stand points by many authors, e.g., Zahran *et al*. (1988) studied the vegetation structure and plant communities of the sand formations of Damietta-Port-Said coast. El-Demerdash *et al*. (1990) and Zahran *et al*. (1990) studied the ecology and vegetation types of the Deltaic Mediterranean coast of Egypt. Al-Sodany (1992) studied the vegetation structure of the northern part of the Nile Delta. El-Kady and Sharaf El-Din (1993) recognized the vegetation groups along the Alexandria-Rosetta roadside. Mashaly (1993) reported a comparative ecological study on two halophytes: *Juncus subulatus* and *Diplachne fusca*, in the Nile Delta region. El-Halawany (1999) studied the effect of protection on coastal and inland vegetation in the Nile Delta. Serag (1999) studied the ecology and vegetation analysis of four succulent halophytes in the Mediterranean coast of Damietta Province. Mashaly (2001) contributed to the ecology of the Deltaic Mediterranean coast of Egypt. El-Halawany (2003) analysed the vegetation changes in the north Nile Delta region within two decades. Mashaly and Awad (2003a, b) descried the floristic features and vegetation analysis of

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the weed flora associated with the major orchards in North Nile Delta region. Mashaly (2006) also studied the vegetation-soil relationships in Lake Borrollus protected area in the Deltaic Mediterranean costal belt of Egypt. El-Halawany *el al*. (2008) studied the ecology and fodder potentiality of some non-conventional forage weeds in the northern part of Nile Delta region. Abu Ziada *et al.* (2008) reported an ecological studies on the aquatic vegetation in North East Nile Delta.

The present study aims at the assessment of the floristic features, vegetation analysis and the edaphic factors controlling the distribution and abundance of the plant communities in the Deltaic Mediterranean coastal land of Egypt.

THE STUDY AREA

The middle section of the Mediterranean coastal land of Egypt (Deltaic coast) extends from Abu-Quir at west to Port-Said at east and it is characterized by three Northern shallow lakes: Lake Manzala at the east, Lake Burullus at the middle and Lake Idku at the west. The area chosen for the present study is located in the Northern part of the Nile Delta region of Egypt which covers the north limit of four Governorates namely, Damietta, El-Dakahlia, Kafr El-Sheikh and El-Behira. Nine localities are selected to represent most of the plant life in the Coastal habitats of this region. The selected localities are: the New Damietta, Gamasa, Baltim, Motobas, Sedi-Salim, Rosetta, Idku and Kafr El-Dawwar (Fig. 1).

According to the map of the world distribution of the arid region (UNESCO, 1977), the climatic conditions of the Nile Delta are similar to those of the Northern part of Egypt. Summer is warm and ranges in average temperature between 20 and 30°C and winter is mild and ranges in average 10 and 20°C. According to this map, the Northern part of the Nile Delta lies in the arid region in which P/E+P ratio ranges from 0.03 to 0.20 (where P is annual precipitation and E is annual evaporation).

MATERIALS AND METHODS

Sixty stands have been chosen to cover all physiographic variations in the Deltaic Mediterranean coastal habitat. The sampling process was carried out during 2003-2005. The sampled stands are distributed as follows: 13 stands in sand dunes, 7 stands in salt marshes, 8 stands in sand sheets, 2 stands in sandy fertile lands, 14 stands in lake Manzala shorelines, 10 stands in lake Burullus shorelines and 6 stands in lake Idku shorelines.

Seasonal records of the weed flora are carried out during regular visits. The description and classification of life forms are according to Raunkiaer (1934). The classification, identification, nomenclature and floristic categories are according to Tutin *et al.* (1964-1980), Zohary (1966 and 1972), Feinbrun (1978-1986) and Boulos

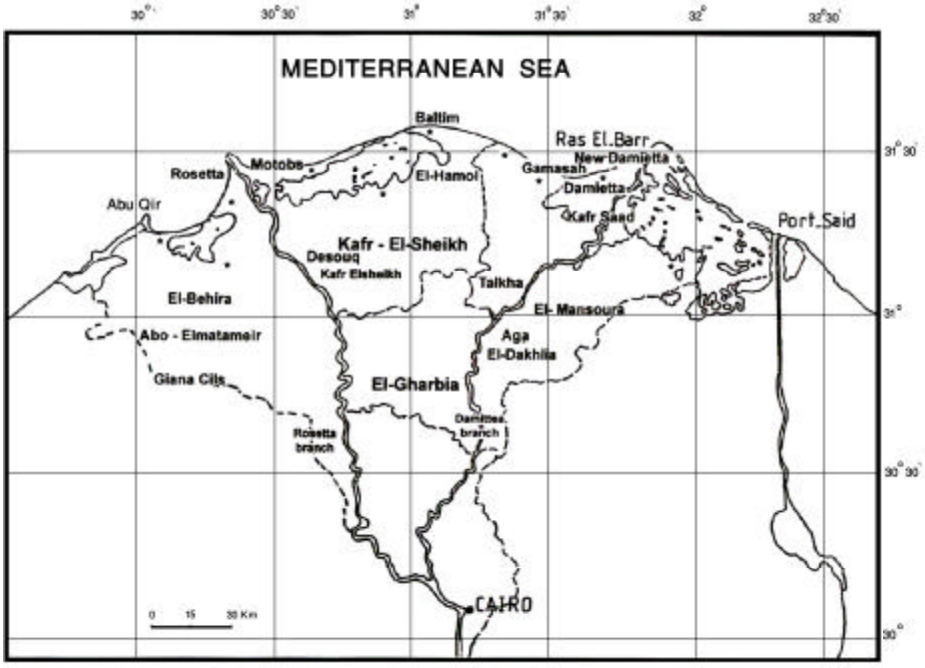

Fig. 1: Map of the Nile Delta regions showing different localities (sites) as indicated by (*) in the study area

(1999-2005). The density and phytomass of each species have been estimated in each selected stand. The relative values of density and phytomass are calculated for each plant-species and summed up to give an estimate of its importance value (IV) in each stand which is out of 200.

Soil samples are collected from each stand which representing profile at a depth of 0-50 cm. The soil texture is determined using sieve method for course soil, where the heavy textured soil samples are determined by the Bouyoucous hydrometer method (Piper, 1947). The moisture content and water-holding capacity (using Hilgard Pan Box) are determined according to Piper (1947). The calcium carbonate is determined by titration against 1N NaOH (Jackson, 1962). The oxidizable organic carbon is determined using Walkely and Black rapid titration method as mentioned by Piper (1947). The soil solution is prepared by adding 500 mL of distilled water to 100 g of air dry soil. Electrical-pH meter (Model Lutron pH 206) with glass electrode is used to determine the soil solution (Jackson, 1962). Electrical conductivity is measured using YSI Incorporated Model 33 conductivity meter (Jackson, 1962). Estimation of chlorides is carried out by titration method using N/35.5 silver nitrate (Jackson, 1962). Sulphate content is estimated gravimetrically using barium chloride solution (Piper, 1947). Carbonates and bicarbonates are determined by titration method using 0.1N HCl (Pierce *et al*., 1958). Determination of Na^{+}, K^{+}, Ca^{++} and Mg^{++} in the soil solution is carried out using flame photometer (Allen *et al*., 1974). The Sodium Adsorption Ratio (SAR) and Potassium Adsorption Ratio (PAR) are calculated according to Mckell and Goodin (1984).

The classification technique applied here is the Two-Way Indicator Species Analysis (TWINSPAN), while the ordination technique is Detrended Correspondence Analysis (DECORANA) (Hill, 1979a, b; Ter Braak, 1988). All statistical treatments applied here are according to Snedecor and Cochran (1968).

RESULTS

The total number of the recorded plant species surveyed in the present study is 130 species belonging to 55 genera and related to 38 families. Table 1 showed that, Gramineae comprises 21 species (16.15%) of the total recorded species, followed by Compositae which includes 18 species (13.85%), Chenopodiaceae (13 species = 10%), Leguminosae (9 species = 6.92%), Cyperaceae (9 species = 6.92%), Polygonaceae (6 species = 4.62%), Caryophyllaceae (4 species = 3.08%) and Cruciferae (4 species = 3.08%). The previous eight families are represented collectively by 84 species (64.61% of the total recorded species).

According to the duration or life-span, the weed flora recorded in this habitat type can be classified into 54 annuals (41.54%), 3 biennials (2.31%) and 73 perennials (56.15%). The life-forms of the weed flora in the present study are grouped under eight types. The majority of the recorded species are therophytes (43.85%), followed by geophytes (15.38%), then hemicryptophytes (13.85%), chamaephytes (10.77%), helophytes (6.15%), nanophanerophytes (6.15%), hydrophytes (3.08%) and parasites (0.77%).

The floristic analysis of the study area as shown in Table 1 revealed that, 72 species (55.38% of the total recorded species) are Mediterranean taxa. These taxa are either Pluriregional (24 species = 18.46%), Biregional (29 species = 22.31%) and Monoregional (19 species = 14.61%). It has been also found that, 38 species or about 29.23% of the total number of the recorded species are either Cosmopolitan (9.23%), Pantropical (9.23%), Palaeotropical (7.69%) or Neotropical (3.08%). On the other hand, the Saharo-Sindian element is represented by 7 species, Irano-Turanian by 3 species, Sudano-Zambezian by 5 species, Naturalized and Cultivated elements by 3 species and the Australian element by 2 species.

The dendrogram resulting from the application of TWINSPAN classification based on the importance values of 120 plant species recorded in 60 sampled stands representing the Deltaic Mediterranean coastal habitat led to the recognition of four vegetation groups (Fig. 2). The vegetational composition of these groups are presented in Table 2. Group A comprises 18 stands dominated by the indicator species *Rumex pictus* with the highest importance value (IV = 22.95). The most common associated species in this group are *Senecio glaucus* (IV = 17.45), *Imperata cylindrica* (IV = 12.02), *Pancratium maritimum* (IV = 10.96) and *Echinops spinosus* (IV = 10.83). Group B includes 10 stands codominated by the indicator species *Pancratium maritimum* (IV = 18.40), with two abundant species, namely: *Cyperus capitatus* (IV = 14.38) and *Lolium perenne* (IV = 14.25). The most common species in this group are *Stipagrostis lanata* (IV = 12.65) which is also considered as indicator species, *Plantago squarrosa* (IV = 11.69) and *Echinops spinosus* (IV = 11.01). Group C consists of 25 stands codominated by the indicator halophyte *Arthrocnemum macrostachyum* (IV = 17.89), with two abundant species namely: *Atriplex portulacoides* (IV = 16.28) and *Typha domingensis* (IV = 15.31). The most important species in this group include: *Limbarda crithmoides* (IV = 11.94), *Schoenoplectus litoralis* (IV = 11.88), *Bolboschoenus glaucus* (indicator species with IV = 10.29) and *Juncus rigidus* (IV = 10.03). Group D includes 7 stands codominated by *Typha domingensis* (IV = 34.54) and the two abundant species

Table 1: Floristic composition of the plant life in the deltaic Mediterranean coastal habitat

Taxon	Life-span	Life-form	Floristic category
Moraceae			
Ficus carica L.	Per.	NPh	CULT
Polygonaceae			
Calligonum polygonoides L. subsp. *comosum*	Per.	NPh	SA-SI+IR-TR
Emex spinosa (L.) Campd	Ann.	Th	ME+SA-SI
Persicaria salicifolia Brous ex Willd	Per.	G	PAL
Polygonum equisetiforme Sibthi and Sm.	Per.	G	ME+IR-TR
Rumex dentatus L.	Ann.	Th	ME+IR-TR+ER-SR
Rumex pictus Forssk.	Ann.	Th	ME+SA-SI
Aizoaceae			
Mesembryanthemum nadiflorum L.	Ann.	Th	ME+SA-SI+ER-SR
Mesembraynthemum crystalinum L.	Ann.	Th	ME+ER-SR
Caryophyllaceae			
Silene succulenta Forssk.	Per.	H	ME
Silene pseudoatocion Desf.	Ann.	Th	ME+IR-TR
Silene vivanii Steud.	Ann.	Th	SA-SI
Spergularia marina (L.) Griseb	Bi.	Th	ME+ER-SR+IR-TR
Chenopodiaceae			
Chenopodium murale	Ann.	Th	COSM
Chenopodium album L.	Ann.	Th	COSM
Atriplex prostrate DC.	Ann.	Th	ME+ER-SR+IR-TR
Atriplex semibaccata R.Br.	Per.	H	AUST
Atriplex halimus L.	Per.	NPh	ME+SA-SI
Atriplex portulacoides L.	Per.	Ch	ME+SR-ER+IR-TR
Bassia indica (Wight) A.J.Seott.	Ann.	Th	S-Z+IR-TR
Halocnemum strobilaceum (Pallas) M. Bieb.	Per.	Ch	ME+IR-TR+SA-SR
Arthrocnemum macrostachyum (Moric.) Moris et De/Ponte	Per.	Ch	ME+SA-SI
Suaeda vera Forssk. ex. J.F. Gmelin	Per.	Ch	ME+SA-SI+ER-SR
Suaeda pruinosa Lang	Per.	Ch	ME
Suaeda maritima (L.) Dumort. subsp. *salsola* (L.) Pall.	Ann.	Th	COSM
Salsola kali L.	Ann.	Th	COSM
Amaranthaceae			
Amaranthus lividus L.	Ann.	Th	ME+IR-TR
Ranunculaceae			
Ranunculus sceleratus L.	Ann.	Th	ME+IR-TR+ER-SR
Nymphaceae			
Nymphaea lotus L. var. *aegyptia* Tuzs.	Per.	Hy	PAL
Ceratophyllaceae			
Ceratophyllum demersum L.	Per.	Hy	COSM
Cruciferae			
Malcolmia pygmaea (DC.) Boiss	Ann.	Th	SA-SI
Lobularia libcya (Viv.) C.F.W. Meissn	Ann.	Th	SA-SI
Brassica tournefortii Gouan	Ann.	Th	ME+IR-TR+SA-SI
Cakile maritima Scop. subsp. *aegyptiaca* (Willd) Nyman	Ann.	Th	ME+ER-SR
Neuradaceae			
Neurada procumbeus L.	Ann.	Th	SA-SI+S-Z
Leguminosae			
Ononis serrata Forssk.	Ann.	Th	ME+SA-SI
Melilotus indicus (L.) All.	Ann.	Th	ME+IR-TR+SA-SI
Lotus creticus L.	Per.	H	ME
Lotus halophilus Boiss.	Ann.	Th	ME+SA-SI
Sesbania sericea (Willd.) Link	Ann.	Th	PAL
Astragalus hamosus L.	Ann.	Th	ME+IR-TR
Alhagi graecorum Boiss.	Per.	H	PAL
Vigna lnteola (Jacq.) Benth	Per.	H	PAL
Acacia nilotica (L.) Delile	Per.	NPh	AUST
Geraniaceae			
Erodium laciniatum (Cav.) Willd.	Ann.	Th	ME
Zygophyllaceae			
Zygophyllum album L.	Per.	Ch	SA-SI+ME
Zygophyllum aegyptium Hosny	Per.	Ch	ME
Zygophyllum coccineum L.	Per.	Ch	SA-SI+S-Z
Euphorbiaceae			
Chrozophora plicata (Vahl) A. Juss.	Ann.	Th	S-A+SA-SI
Euphorbia terracina L.	Per.	H	ME
Tiliaceae			
Corchorus olitorius L.	Ann.	Th	PAN

Table 1: Continued

Taxon	Life-span	Life-form	Floristic category
Malvaceae			
Malva parviflora L.	Ann.	Th	ME+IR-TR
Tamaricaceae			
Tamarix tetragyna Ehrenb.	Per.	NPh	SA-SI+ME+IR-TR
Tamarix nilotica (Ehrenb.) *Bge*	Per.	NPh	SA-SI+S-Z
Frankeniaceae			
Frankenia pulverulenta L.	Ann.	Th	ME+ER-SR+IR-TR
Lythraceae			
Ammannia baccifera L.	Ann.	Th	S-Z+IR-TR
Umbelliferae			
Pseudorlaya pumila (L.) Grande	Ann.	Th	ME
Daucus litoralis Sm.	Ann.	Th	ME
Plumbaginaceae			
Limonium narboneuse Mill.	Per.	H	ME
Limonium pruinosum (L.) Chaz	Per.	H	SA-SI
Asclepiadaceae			
Cynanchum acutum L.	Per.	H	ME+IR-TR
Convolulaceae			
Ipomoea carnea Jacq.	Per.	G	PAN
Cressa cretica L.	Per.	H	ME+PAL
Boraginaceae			
Anchusa hamilis (Desf.) I.M. Johnst.	Ann.	Th	ME+SA-SI
Moltkiopsis ciliate (Forssk.) I.M. Johnst.	Per.	Ch	SA-SI+S-Z+ME
Echium angustifolium Mill. subsp. *sericeum*	Per.	H	ME
Verbenaceae			
Phyla nodiflora (L.) Greene	Per.	Ch	PAN
Solanaceae			
Solanum nigrum L.	Ann.	Th	COSM
Lycium schweinfurthii Dammer	Per.	NPh	ME
Nicotiana glauca R.C. Graham	Per.	Ch	NAT
Orobanchaceae			
Cistanche phelypaea (L.) Cont.	Per.	PG	ME+SA-SI
Plantaginaceae			
Plantago squarrosa Murray	Ann	Th	ME
Plantago lauceolata L.	Per.	H	ME+ER-SR+IR-TR
Plantago major L.	Per.	H	COSM
Compositae			
Echinops spinosus L.	Per.	H	ME+SA-SI
Carduus getulus Pomel	Ann.	Th	SA-SI
Atractylis carduus (Forssk.) C. Chr	Per.	H	SA-SI+ME
Centaurea calcitrapa L.	Bi.	Ch	ME+ER-SR
Carthamus lanatus L.	Bi.	Th	ME
Carthamus tenuis (Boiss and Blanche) Bornm	Ann.	Th	ME
Pinchea discoridis (L.) DC.	Per.	NPh	S-Z+SA-SI
Conyza bonarieusis (L.) Cronquist, Bull	Ann.	Th	NEO
Symphytrichum squamatum (Spreng.) nesom	Per.	Ch	NEO
Ifloga spicata (Forssk.) Sch. Bip.	Ann.	Th	SA-SI+ME
Limbrada crithmoides (L.) Dumort	Per.	Ch	ME+ER-SR+SA-SI
Eclipta prostrata (L.) L.	Ann.	Th	NEO
Senecio glancus L.	Ann.	Th	ME+SA-SI+IR-TR
Picris asplenioides L.	Ann.	Th	ME+IR-TR
Launaea fragilis (Asso.) Paut	Per.	H	ME+SA-SI
Reichardia tingitana (L.) Roth	Ann.	Th	ME+SA-SI+IR-TR
Aetheorhiza bulbosa (L.) Cass.	Per.	G	ME
Sonchus oleracous L.	Ann.	Th	COSM
Asparagaceae			
Asparagus stipularis Forssk.	Per.	G	ME+SA-SI
Amarylidaceae			
Bancratium maritimum L.	Per.	G	ME
Pontederiaceae			
Eichhornia crassipes (C. Mart.) Solms.	Per.	Hy	NEO
Juncaceae			
Juncus subulatus Forssk.	Per.	He, G	ME+IR-TR+SA-SR
Juncus acutus L.	Per.	He	ME+IR-TR+ER-SI
Juncus rigidus Desf.	Per.	He, G	ME+SA-SI+IR-TR
Gramineae			
Bromus diandrus Roth	Ann.	Th	Me
Cutandia memphitica (Spreng.) Benth	Ann.	Th	ME+IR-TR+SA-SI
Eragrostis pilosa (L.) P. Beauv.	Ann.	Th	PAL
Arundo donax L.	Per.	He, G	CULT+NAT

Table 1: Continued

Taxon	Life-span	Life-form	Floristic category
Phragmites australis (Cuv.) Trin. ex Steud.	Per.	G, He	COSM
Elymus fractus (Viv.) Runem. subsp. *juncoum* Runem	Per.	G	ME
Aegilops bicornis (Forssk.) Jaub.	Ann.	Th	ME+SA-SI
Hordeum murinum L.	Ann.	Th	ME+IR-TR+ER-SR
Lolium perenue L.	Per.	Th	ER-SR+ME+IR-TR
Trisetaria linearis Forssk.	Ann.	Th	ME+SA-SI
Polypogon mouspelieusis (L.) Desf.	Ann.	Th	COSM
Sporobolus pungeus (Schreb.) Kunth	Per.	G	PAN
Stipagrostis lanata (Forssk.) DeWinder	Per.	G	SA-SI
Leptochloa fusca (L.) Kunth	Per.	He, G	PAN
Cynodon dactylon (L.) Pers.	Per.	G.	PAN
Eleusine indica (L.) Gaertn	Ann.	Th.	PAL
Brachiaria mutica (Forss.) Stapf	Per.	H	PAN
Panicum repeus L.	Per.	G	PAN
Paspalidium geminatum (Forssk.) Stapf	Per.	He	PAL
Echinochloa stagnina (Retz.) P. Beauv.	Per.	G, He	PAL
Imperata cylindrica (L.) Raeusch.	Per.	H	ME+PAL
Lemnaceae			
Lemna gibba L.	Per.	Hy	COSM
Typhaceae			
Typha domingeusis (Pers.) Poir ex Steud.	Per.	He	PAN
Cyperaceae			
Schoenus nigricans L.	Per.	G	ME+IR-TR+ER-SR
Schoenoplectus litoralis (Schard.) Palla	Per.	G	PAL+Me
Bolboschoenus glancus (Lam.) Smith	Per.	G	COSM
Cyperus laevigatus L.	Per.	G, He	PAN
Cyperus conglomerates Rottb.	Per.	G	SA-SI+S-Z
Cyperus capitatus Vand.	Per.	G	ME
Cyperus difformis L.	Ann.	Th	PAL
Cyperus articulatus L.	Per.	G, He	PAN
Cyperus alopercuroides Rottb.	Per.	He	PAN

A: Life-span, Aun.: Annual, Bi.: Biennial, Per.: Perennial,
B: Life-form, Th: Therophyte, Ch: Chamaephyte, H: Hemicryptophyte, He: Helophyte, G: Geophyte, Hy: Hydrophyte, Nph: Nanophanerophyte, P: Parasite
C: Floristic category, COSM: Cosmopolitan, PAN: Pantropical, PAL: Palaeotropical, NEO: Neotropical, ME: Mediterranean, ER-SR: Euro-Siberian, SA-SI: Sahro-Sindian, IR-TR: Irano-Turanian, S-Z: Sudano-Zambezian, AUS: Australian, CULT: Cultivated

Table 2: Mean value and coefficient of variation (value between brackets) of the importance values (out of 200) of indicator and preferential species in the different vegetation groups resulting from the TWINSPAN classification of the sampling stands in deltaic Mediterranean coastal habitat

	Vegetation group			
Species	A	B	C	D
Aegilops bicornis (Forssk.) Jaub. and Spach	1.27 (4.12)	4.85 (1.41)	0.27 (4.90)	-
Aetheorhiza bulbosa (L.) Cass.	-	0.78 (3.00)	-	-
Alhagi graeorum Boiss	3.13 (1.92)	1.62 (2.59)	0.96 (2.73)	0.37 (2.45)
Amaranthus lividus L.	-	-	0.38 (4.90)	-
Ammannia baccifera L.	-	-	-	0.28 (2.45)
Anchusa hamilis (Desf.) I. M. Johnst.	2.19 (2.96)	1.59 (2.25)	-	-
Arthrocnemum macrostachyum (Moric.) K. Koch	4.47 (2.35)	-	17.85 (0.93)	3.91 (1.82)
Arundo donax L.	-	-	8.17 (2.82)	-
Astragalus hamosus L.	-	0.30 (3.00)	-	-
Atractylis cardnus (Forssk.) C. Chr.	4.91 (1.28)	0.61 (3.00)		-
Atriplex halimus L.	-	-	1.38 (3.34)	-
Atriplex portulacoides L.	-	-	16.28 (1.23)	0.32 (2.45)
Atriplex prostrate DC.	-	-	3.88 (2.80)	0.33 (2.45)
Atriplex semibaccata R.Br.	-	-	1.99 (3.43)	1.14 (2.45)
Bassia indica (Wight) A.J. Scott	2.13 (2.39)	-	4.15 (2.03)	6.20 (1.10)
Bolboschoenus glancus (Lam.) S.G. Smith	-	-	10.29 (1.57)	0.88 (2.45)
Brachiaria mutica (Forssk.) Staff.	-	-	0.28 (4.89)	5.08 (1.83)
Brassica tournefortii Gouan	5.72 (1.70)	-	-	-
Bromus catharticus Vahl	0.23 (3.87)	-	-	-
Bromus diandrus Roth	0.73 (2.97)	-		-
Cakile maritime Scop.	8.30 (1.37)	1.94 (2.06)	1.38 (3.40)	-
Calligonum polygonoides L.	7.57 (1.91)	-	-	-
Carthamus tenuis (Boiss and Blanche) Bomm.	1.52 (2.93)	-	0.14 (4.90)	-
Centaurea calcitrapa L.	2.74 (2.74)	-	-	-
Ceratophyllum demersum L.	-	-	-	0.84 (1.64)
Chenopodium album L.	-	-	0.35 (4.90)	-
Chenopodium murale L.	0.52 (9.00)	-	3.03 (2.22)	-
Cistanche phelypaea (L.) Cout.	3.34 (2.65)	-	-	-

Table 2: Continued

Species	Vegetation group A	B	C	D
Conyza bonarieusis (L.) *Cronquist*	-	-	0.80 (4.90)	-
Corchorus olitorius L.	-	-	0.15 (4.91)	-
Cressa cretica L.	1.25 (2.45)	0.78 (3.00)		
Cutandia memphitica (Spreng.) K. Richt.	0.52 (4.12)	0.95 (2.01)		
Cynanchum acutum L.	1.76 (2.57)	0.11 (3.00)	2.48 (1.91)	8.57 (1.26)
Cynodon dactylon *(l.) Pers.*	0.57 (4.13)	1.82 (2.02)	2.89 (2.37)	4.61 (1.21)
Cyperus alopecuroides Rottb.	-	-	-	4.67 (1.78)
Cyperus articulatus L.	-	-	1.54 (4.90)	1.09 (2.45)
Cyperus capitatus Vand.	1.79 (1.89)	14.38 (1.13)	0.89 (4.90)	-
Cyperus difformis L.	-	-	-	0.97 (2.45)
Cyperus laevigatus L.	-	5.90 (2.14)	7.58 (1.89)	-
Cyperus rotundus L.	-	-	0.16 (4.90)	-
Daucus litoralis Sm.	0.61 (4.12)	7.28 (1.25)	0.27 (4.90)	-
Echinochloa stagnina (Retz.) P. Beauv.	-	-	1.38 (4.80)	29.66 (0.63)
Echinops spinosus L.	10.83 (1.26)	11.01 (1.09)	-	-
Echium angustifolium Mill. sub sp. Sericeum Vahl) Klotz	-	5.75 (2.62)	-	-
Eclipta prostrate (L.) L.	-	-	-	4.19 (2.07)
Eichhornia crassipes (C. Mart.) Solms	-	-	-	20.25(0.97)
Eleusine indica (L.) Gaertn.	-	-	0.81 (4.90)	-
Elymus farctus (Viv.) Ranemark ex. Melderis.	7.03 (3.39)	5.72 (2.29)	-	-
Emex spinosa (L.) Campd.	4.76 (2.54)	1.91 (3.00)	0.54 (3.43)	-
Eragrostis pilosa (L.) P. Beauv.	0.20 (2.41)	-	-	-
Erodium laciniatum (Cav.) Willd. subsp. laciniatum	5.58 (1.52)	1.17 (2.02)	0.13 (4.90)	-
Euphorbia terrancina L.	-	0.84 (2.00)	0.13 (4.91)	-
Ficus carica L.	-	0.65 (3.00)	-	-
Halocnemum strobilaceum (Pall.) M. Bieb.	1.69 (3.18)	-	4.24 (3.15)	-
Hordeun marinum Huds.	4.54 (1.87)	0.86 (6.47)	0.65 (3.42)	-
Ifloga spicata (Forssk.) Sch. Bip.	1.41 (3.00)	-	-	-
Imperata cylindrica (L.) Raeusch.	12.02 (4.12)	7.63 (1.30)	1.27 (4.90)	-
Ipomoea stolonifera (Cry.) J.F. Gmel	-	1.82 (2.01)	0.07 (4.80)	-
Juncus acutus L.	-	0.93 (3.00)	8.48 (0.90)	-
Juncus rigidus Desf.	-	1.25 (3.00)	10.03 (0.97)	-
Juncus subulatus Forssk.	-	-	1.28 (4.90)	-
Launaea fragilis (Asso) Pau	6.87 (1.50)	6.82 (1.10)	-	-
Lemna gibba L.	-	-	-	5.03 (1.68)
Leptochloa fusca (L.) kunth	-	-	0.17 (4.91)	0.77 (2.45)
Limbarda crithmoides (L.) Dumont.	0.54 (4.12)	1.35 (2.01)	11.94 (1.13)	2.48 (1.89)
Limonium narboneuse Mill	0.77 (4.12)	0.38 (4.90)	0.90(4.79)	-
Limonium pruinosum (L.) Chaz.	2.31 (4.12)	-	0.16(4.90)	-
Lolium perenne L.	-	14.25 (0.86)	-	-
Lotus creticus L.	-	1.97 (2.01)	-	-
Lotus halophillus Boiss. and Spruner	3.78(1.58)	0.12 (3.00)	-	-
Lycium schweinfurthii Dammer	-	1.13 (3.00)	-	-
Malva parviflora L.	0.53 (4.12)	-	0.99 (2.43)	-
Melilotus indicus (L.) All.	2.89 (1.96)	-	-	-
Mesembryanthemum crystallinum L.	3.34 (1.33)	-	2.17 (2.64)	-
Mesembryanthemum nodiflorum L.	4.21 (1.93)	-	0.71 (4.90)	-
Meltkiopsis ciliata (Forssk.) I.M. Johnst.	-	5.40 (1.29)	-	-
Neurada procumbeus L.	-	0.70 (3.00)	-	-
Nicotiana glauca Graham	-	-	1.13 (3.61)	-
Nymphaea lotus L.	-	-	-	1.29 (2.45)
Onouis serrata Forssk.	4.40 (1.56)	0.77 (2.01)	-	-
Pancratium maritimum L.	10.96 (1.46)	18.40 (1.31)	-	-
Panicum repeus L.	-	-	0.27 (4.90)	8.11 (1.86)
Paspalidium geminatum (Forssk) Stapf.	-	-	-	5.06 (2.45)
Persicaria salicifolia (Willd.) Assenov	-	-	1.35 (2.90)	1.04 (2.45)
Phragmites australis (Cav.) Trin. ex steud	0.20 (4.13)	3.63 (2.11)	8.58 (0.98)	29.48 (0.84)
Phyla nodiflora (L.) Greene	-	-	1.37 (0.50)	-
Picris asplenioides L.	-	5.49 (2.13)	-	-
Plantago squarrosa Murray	-	11.69 (1.36)	-	-
Pluchea dioscoridis (L.) DC.	-	0.86 (3.00)	3.72 (1.54)	2.75 (2.45)
Polygonnm equisetiforme Sm.	3.39 (2.45)	3.41 (2.52)	-	1.45 (2.45)
Polypogon mouspelieusis (L.) Desf.	-	1.28 (3.00)	1.27 (2.38)	2.33 (2.45)
Pseudorlaya pumila (L.) Grande	-	0.29 (3.00)	-	-
Ranunculus sceleratus L.	-	-	0.50 (4.90)	1.14 (2.45)

Table 2: Continued

Species	Vegetation group A	B	C	D
Reichardia tingitana L.) Roth	0.66 (2.84)	-	-	-
Rumex dentatus L.	-	-	1.34 (2.12)	1.60 (1.59)
Rumex pictus Forssk.	22.95 (0.77)	5.14 (1.49)	-	-
Salsola kali L.	1.31 (2.27)	0.89 (2.00)	-	-
Schoenus nigricans L.	2.67 (4.12)	3.41 (3.00)	-	-
Schoenoplectus litoralis Schard. .	-	-	11.88 (1.84)	5.88 (2.45)
Senecio glaucus L.	17.45 (0.52)	5.50 (0.89)	1.65 (2.69)	-
Sesbania sericea (Willd.) Link.	-	-	0.18 (4.89)	-
Silene pseudoatocion Desp.	3.45 (2.00)	1.46 (3.00)	-	-
Silene succulenta Forssk.	3.46 (2.96)	5.01 (1.56)	0.07 (4.90)	-
Silene vivianii Steud.	5.34 (2.48)	1.13 (2.00)	-	-
Solanum nigrum L.	-	-	0.67 (3.39)	-
Sonchus oleraceus L.	-	-	0.14 (4.90)	-
Spergularia marina (L.) Griseb.	-	-	1.43 (2.51)	0.93 (2.45)
Sporobolus pungens (Schreb) kunth.	-	0.13 (3.00)	0.30 (4.89)	-
Stipagrostis lanata (Forssk.) de Winter	1.72 (2.27)	12.65 (1.22)	-	-
Suaeda maritima (L.) Dumort.	-	-	4.63 (1.72)	-
Suaeda pruinosa Lange	-	-	1.38 (2.17)	-
Suada vera Forssk. ex J.F. Gmel.	-	-	1.25 (4.90)	0.40 (1.95)
Symphyotrichum squamatum (Spreng) Nesom	-	-	0.18 (4.90)	2.72 (2.24)
Tamarix aphylla (L.) H. karst.	-	-	1.02 (4.90)	-
Tamarix nilotica (Ehrenb.) Bunge	-	1.70 (2.33)	3.78 (1.72)	-
Trisetaria linearis Forssk.	2.84 (1.50)	-	-	-
Typha domingensis (Pers.) Poir. ex Steud.	-	-	15.31 (1.39)	34.54 (0.71)
Zygophyllum aegyptium Hosny	3.48 (2.11)	-	1.14 (4.10)	-
Zygophyllum album L.f.	3.07 (2.84)	-	-	-
Zygophyllum coccineum L.	-	-	0.80 (4.90)	-

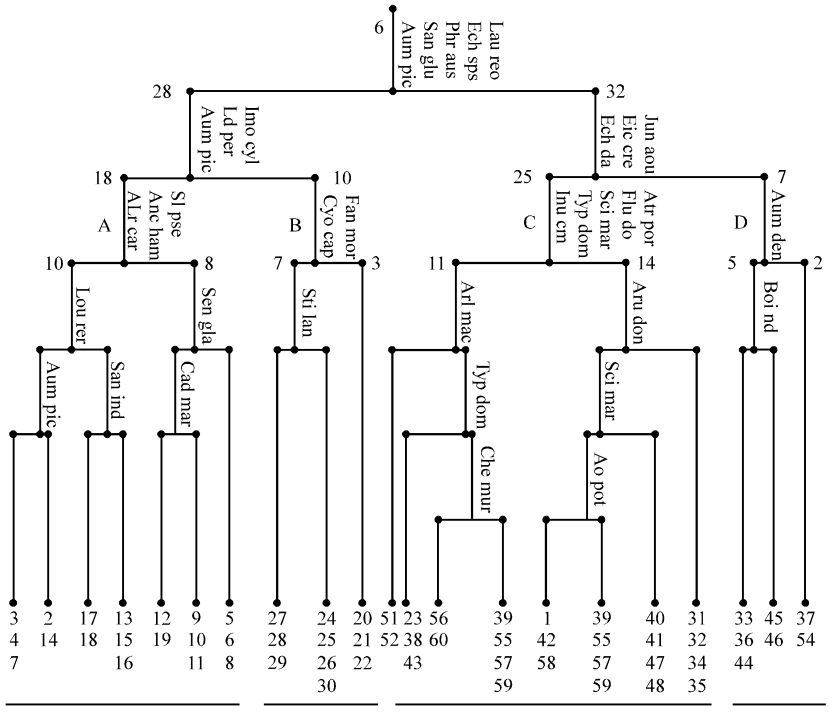

Fig. 2: Two way indicator species analysis (TWINSPAN) dendrogram of 60 sampled stands based on the importance values of 121 plant species of the deltaic Mediterranean coastal habitat in the North Nile delta region. The indicator species are abbreviated by the first thee letters of genus and species, respectively

namely: *Echinochloa stagnina* (IV = 29.66) and *Phragmites australis* (IV = 29.48). The most common species which has relatively moderate IV is *Eichhornia crassipes* (IV = 20.25). The indicator species are *Bassia indica* (IV = 6.20) and *Rumex dentatus* (IV = 1.60).

The ordination diagram of the sampled stands of the Deltaic Mediterranean coastal habitat is shown in (Fig. 3). All the vegetation groups are located on the positive sides of the first and second axes. Groups A and B are obviously separated at the left side of the diagram, while the other two groups (C and D) are separated at the right side.

The variation in soil variables (mean value ± standard error) within the groups of sampled stands represented by the TWINSPAN classification of the Deltaic Mediterranean coastal habitat are presented in Table 3. It is obvious that, the physical soil variables are comparable in all groups of this habitat. The highest percentages of coarse fraction (sand = 98.37%) and clay fraction (0.23%) are attained in group A. While, the lowest mean percentages of sand and clay fractions (93.21 and 0.14%, respectively) are attained in group D. On the contrary, the highest percentage of silt fraction (6.64%) is attained in group D and the lowest percentage (1.39%) is attained in group A. The moisture content associated with water-holding capacity are attained their highest values (41.88 and 51.21%, respectively) in group D and the lowest values (0.85 and 29.68%, respectively) in group B. The soil of group D has the highest mean contents of calcium carbonate (22.71%) and organic carbon (2.59%), while group A has the lowest mean contents (2.39 and 0.23%, respectively). The soil reaction (pH) varied between 7.46 in group A to 8.03 in group B. The highest mean average of electrical conductivity (4.37 mmhos cm^{-1}) is recorded in group D, while the lowest content (0.10 mmhos cm^{-1}) is estimated in group B. The highest values of chlorides and sulphates are estimated in group D (0.71 and 0.26%, respectively). While the lowest percentage are attained in group B (0.02%) and A (0.09%). The carbonate and bicarbonate contents are generally low in all soils of vegetation groups, where carbonate content varied from nil in most groups to 0.002% in group C and bicarbonate content ranged between 0.07% in group B to 0.16 in group D. The highest mean concentrations of sodium and potassium cations are estimated in groups D and A (421.56 and 6.36 mg/100 g dry soil, respectively), while the lowest values (5.99 and 1.68 mg/100 g dry soil) are attained in group B. On the other hand, group B attained the highest concentration of calcium content (63.04 mg/100 g dry soil) and the lowest value is attained in group D (32.59 mg/100 g dry soil). On the contrary, the highest mean concentration of magnesium cation is estimated in group D (19.97 mg/100 g dry soil) and the lowest concentration is attained in group B (4.76 mg/100 g dry soil). The sodium adsorption ratio is estimated in its highest mean value (85.09) in group D and the lowest mean value (1.98) in group A. While, the potassium adsorption ratio varied from 0.80 in group D to 2.80 in group A.

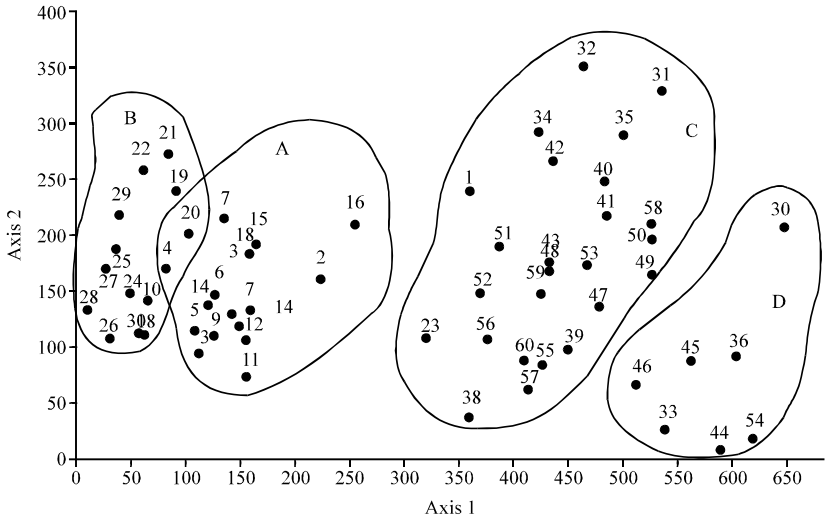

Fig. 3: Detrended Correspondence Analysis (DCA) ordination diagram of 60 sampled quadrates of Deltaic Mediterranean coastal habitats in the North Nile Delta region

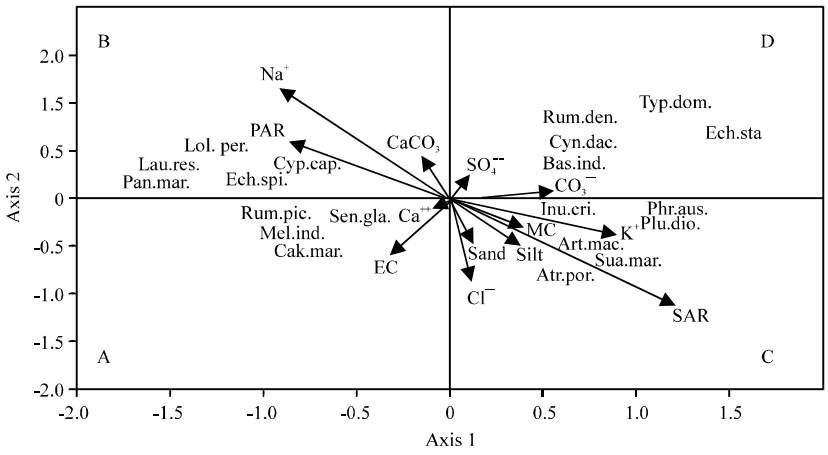

Fig. 4: Canonical Correspondence Analysis (CCA) ordination diagram of plant species in the Deltaic Mediterranean coastal habitat along the gradient of environmental variables (arrows) in the north Nile Delta. The indicator and preferential species are indicated by three first letters of genus and species, respectively

Table 3: Mean value and standard error of the different soil variables in the sampling stands representing the different vegetation groups obtained by TWINSPAN classification of the deltaic Mediterranean coastal habitat

	Groups			
	Vegetation group			
Soil variables	A	B	C	D
Sand (%)	98.37±0.14	97.65±0.16	95.06±0.24	93.21±0.15
Silt (%)	1.39±0.13	2.15±0.15	4.79±0.24	6.64±0.12
Clay (%)	0.23±0.02	0.19±0.01	0.15±0.04	0.14±0.05
Moisture content (%)	2.03±0.49	0.85±0.26	28.73±2.24	41.88±2.09
W.H.C. (%)*	31.79±0.69	29.68±0.31	36.12±0.12	51.21±1.63
$CaCO_3$ (%)	2.39±0.25	12.70±0.48	16.72±1.41	22.71±1.49
Organ carbon (%)	0.23±0.02	0.36±0.01	2.17±0.19	2.59±0.19
pH	7.46±0.05	8.05±0.02	7.77±0.05	7.67±0.02
EC (mmhos cm^{-1})*	0.37±0.05	0.10±0.01	3.71±0.43	4.37±0.55
Cl^- (%)	0.01±0.0007	0.02±0.001	0.17±0.04	0.71±0.10
SO_4^{--} (%)	0.09±0.011	0.06±0.003	0.18±0.02	0.26±0.02
CO_3 (%)	0.00±0.0	0.00±0.0	0.002±0.0009	0.00±0.0
HCO_3 (%)	0.16±0.005	0.07±0.002	0.14±0.008	0.16±0.008
mg/100 g dry soil				
Na^+	8.48±0.79	5.99±0.94	334.96±46.99	421.56±60.81
K^+	6.36±1.08	1.68±0.13	4.05±0.28	3.96±0.38
Ca^{++}	48.36±22.03	63.04±23.84	40.70±216.62	32.59±1.82
Mg^{++}	8.41±1.12	4.76±0.19	16.96±1.84	19.97±1.56
SAR	1.98±0.26	2.61±0.41	60.70±6.42	85.09±12.08
PAR	2.80±0.49	0.86±0.07	0.84±0.06	0.80±0.08

The correlation coefficient (r) between the different soil variables in the sampled stands of the Deltaic Mediterranean coastal habitat are shown in Table 4. Sand, silt, clay, moisture content, water-holding capacity, calcium carbonate, organic carbon, pH, electrical conductivity, bicarbonates and extractable cations (Na^+, K^+, Ca^{++} and Mg^{++}) are significantly correlated with each other. While, carbonates, sodium and potassium adsorption ratios have no correlation with any of other soil variables. The application of Canonical Correspondence Analysis (CCA) indicated that, the most effective soil variables controlling the distribution and abundance of the identified vegetation groups in the Deltaic Mediterranean coast (Fig. 4) are sodium cation, sodium adsorption ratio, potassium, potassium adsorption ratio, chlorides and electrical conductivity.

Table 4: Pearson-moment correlation (r) between the different soil variables in the sampling stands surveyed of the deltaic Mediterranean coastal habitat

	Sand.	Silt	Clay	MC	WHC	$CaCO_3$	OC	pH	EC	Cl^-	SO_4^{--}	CO_3^-	HCO_3^-	Na^+	K^+	Ca^{++}	Mg^{++}	SAR	PAR
Sand	1.000																		
Silt	-0.994***	1.000																	
Clay	-0.025	-0.086	1.000																
MC	-0.670***	0.704***	-0.330**	1.000															
WHC	-0.439***	0.468***	-0.276*	0.506***	1.000														
$CaCO_3$	-0.645***	0.652***	-0.084	0.492***	0.200	1.000													
OC	-0.594***	0.637***	-0.407**	0.740***	0.607***	0.496***	1.000												
pH	0.025	-0.009	-0.143	-0.005	0.065	-0.017	0.105	1.000											
EC	-0.536***	0.541***	-0.060	0.425***	0.471***	0.392**	0.394**	0.003	1.000										
Cl^-	-0.375**	0.398***	-0.221	0.625***	0.359**	0.157	0.269*	-0.024	0.155	1.000									
SO_4^{--}	-0.416***	0.416***	-0.019	0.347**	0.470***	0.316*	0.331*	0.009	0.821***	0.124	1.000								
CO_3^-	-0.222	0.228	-0.059	0.296*	0.299*	0.012	0.362**	0.220	0.039	0.150	0.088	1.000							
HCO_3^-	-0.141	0.152	-0.107	0.281*	0.339**	-0.016	0.307*	-0.462***	0.094	0.153	0.032	0.039	1.000						
Na^+	-0.564***	0.568***	-0.060	0.397**	0.426***	0.441***	0.389**	-0.037	0.956***	0.167	0.781***	0.062	0.076	1.000					
K^+	0.005	-0.024	0.173	-0.012	0.065	-0.192	0.026	0.001	0.041	-0.098	0.079	0.110	0.275*	0.050	1.000				
Ca^{++}	-0.483***	0.497***	-0.141	0.576***	0.265*	0.207	0.495***	-0.009	0.642***	0.309*	0.644***	0.110	0.155	0.559***	-0.029	1.000			
Mg^{++}	-0.392**	0.384**	0.069	0.419***	0.294*	0.138	0.317*	-0.250*	0.569***	0.212	0.639***	-0.042	0.241	0.527***	0.012	0.749***	1.000		
SAR	-0.639***	0.640***	-0.028	0.441***	0.452***	0.585***	0.423***	-0.058	0.906***	0.191	0.702***	0.085	0.082	0.956***	0.026	0.439***	0.410***	1.000	
PAR	0.180	-0.200	0.185	-0.176	-0.104	-0.276*	-0.173	-0.014	-0.169	-0.136	-0.095	0.012	0.169	-0.141	0.946***	-0.237	-0.192	-0.149	1.000

*Significant at p≤ 0.05, **: Significant at p≤ 0.01, ***: Significant at p≤ 0.001, OC: Organic Carbon

DISCUSSION

The natural plant wealth of the Deltaic Mediterranean coastal habitat is composed of 130 flowering plant species belonging to 55 genera and related to 38 families. Out of these families Gramineae (21 species), Compositae (18 species), Chenopodiaceae (13 species), Leguminosae (9 species), Cyperaceae (9 species), Polygonaceae (6 species), Caryophyllaceae (4 species) and Cruciferae (4 species) are considered the major families as they contribute collectively about 64.61% of the total recorded species. This indicated that, these eight families are the leading taxa and constitute the major bulk of the flora of the study area. On the basis of plant longevity (duration), the flora of the study area (130 species)is composed of 54 annual species (41.54%), 3 biennial species (2.31%) and 73 perennial species (56.15%). The predominance of life-span is related to perennial species. This agrees with Zahran *et al.* (1990), Mashaly (2001, 2002) and Mashaly *et al.* (2002).

The life-form spectra are important physiognomic attributes which have widely used by ecologists and chorologists in the vegetation and floristic studies (Cain and Castro, 1959). In the present study, the life-form spectrum is predominantly therophytes (43.85%), geophytes (15.38%), hemicryptophytes (13.85%) and chamaephytes (10.77%). The floristic analysis of the present study indicated that, the Mediterranean element is represented by relatively high percentage of plant species (55.38%), followed by Cosmopolitan (9.23%), then Pantropical (9.23%), Palaeotropical (7.69%) and Neotropical elements (3.08%). The high percentage of these elements may be attributed to their capability to penetrate this region. Similar results had been obtained by El-Demerdash *et al.* (1990), Mashaly (2001) and Mashaly *et al.* (2003).

The phytosociological study on the Deltaic Mediterranean coastal habitat revealed that, the vegetation structure is classified by TWINSPAN classification into four groups. Group A is dominated by the indicator species *Rumex pictus,* group B is codominated by *Pancratium maritimum*, *Cyperus capitatus* and *Lolium perenne,* group C is codominated by *Arthrocnemum macrostachyum*, *Atriplex portulacoides* and *Typha domingensis* and group D is codominated by *Typha domingensis*, *Echinochloa stagnina* and *Phragmites australis.* Groups A and B may represent the vegetation types of sand formations (dunes and flats), group C may represent the vegetation type of the salt marsh habitat and group D may represent the reed swamp and lake shoreline habitats. According to Braun-Blanquet's floristic association system, the identified vegetation groups in the present study can be categorized into three classes: Echinopetea, Arthrocnemetea and Phragmetetea. The class Echinopetea represented the sand formations (dunes and flats), the characteristic species which may be related to the first class are: *Echinops spinosus*, *Rumex pictus*, *Ononis serrata*, *Senecio glaucus*, *Pancratium maritimum*, *Cakile maritima*, *Silene succulenta*, *Atractylis carduus* and *Stipagrostis lanata.* Two alliances could be distinguished under class Echinopetea: a) *Pancration martimi* which occupies the coastal dunes and the characteristic species include *Pancratium maritimum*, *Silene succulenta*, *Senecio glaucus*, *Launaea fragilis*, *Cyperus capitatus*, *Echium angustifolium* and *Alhagi graecorum* and b) *Plantagion squarrosa* which occupies mostly the inland sand dunes and characterized by *Plantago squarrosa*, *Echinops spinosus*, *Ononis serrata*, *Lycium schweinfurthii*, *Pseudoralya pumila*, *Erodium laciniatum*, *Launaea fragilis*, *Siline pseudoaction*, *Lotus halophilus* and *Rumex pictus.* The second class

(Arthrocnemetea) occupies a medium position along the moisture gradient. It includes many habitats e.g. salt marshes and lake shorelines, the characteristic species comprise *Arthrocnemum macrostachyum*, *Halocnemum strobilaceum*, *Suaeda pruinosa*, *Zygophyllum album*, *Mesembryanthemum crystallinum*, *Atriplex halimus*, *Tamarix nilotica*, *Juncus rigidus*, *Limbrada crithmoides*, *Cressa cretica* and *Phragmites australis*. The third class is Phragmetatea which occupies the moist habitat (swampy). The characteristic species include *Phragmites australis*, *Lemna gibba*, *Paspalidium geminatum*, *Typha domingensis* and *Eichhornia crassipes*. Under this class two alliances could be distinguished. a) *Lemnion gibbae* which occupies, the open water bodies and b) *Typhion austrlaii* which occupies littoral zone of lakes.

The most soil gradients correlated with the distribution of vegetation as recognized by Mashaly (1987), Zahran *et al.* (1990) and El-Halawany (2003) are: soil salinity (EC), moisture gradient, soil fertility, soil texture and soil reaction. In the present study, the application of Canonical Correspondence Analysis (CCA-biplot) indicated that, the most important soil variables correlated with the distribution and abundance of weed vegetation in the Deltaic Mediterranean coastal habitat are: sodium, sodium and potassium adsorption ratios, soil salinity, soil texture, potassium, calcium and moisture content.

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