http://www.pjbs.org

PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 5(5): 626-632, 2002

Characterization of the Wetlands Habitat Alongside the Fish Farms in the North Nile Delta, Egypt

E.F. El-Halawany
Department of Botany, Faculty of Science, Mansoura University, Egypt

Abstract: The present study aims at analyzing the vegetation of the wetlands alongside the fish farms in coastal deltaic region and focusing the attention towards the environmental variables that affect this type of vegetation. Classification and ordination of the data revealed seven vegetation groups (A-G) with the following dominant species: *Bassia indica* and *Convolvulus arvensis* (A), *Cakile maritime* (B), *Phragmites australis* (C), *Phragmites australis* and *Suaeda pruinosa* (D), *Eichhornia crassipes* and *Cyperus alopecuroides* (E), *Amaranthus lividus, Sisymbrium irio* and *Amaranthus hybridus* (F) and *Eichhornia crassipes* and *Persicaria salicifolia* (G). Canonical Correspondence Analysis (CCA) was applied to study the species – environment relationships. Contents of soil organic carbon, texture, pH and salinity are the main operating edaphic factors that control the distribution of this vegetation.

Key words: Wetlands, vegetation, classification, ordination, edaphic factors

Introduction

The Nile Delta supports 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 (Maruit, Idku, Borullos and Manzala). The main man-made habitats are the water courses (canals and drains), the roads and railways, the abandoned and cultivated fields and fish farms.

The vegetation of the wetlands in the Nile Delta of Egypt has been the subject of floristic and plant ecological studies for several years (e.g. El-Sheikh, 1989; Serag, 1991; Shehata, 1996; Khedr and El-Demerdash, 1997; Khedr and Serag, 1998; Khedr and Zahran, 1998; El-Kady *et al.*, 2000 and Abd El-Aziz, 2002). The present work aims at studying the floristic features, quantitative analysis of the vegetation structure and the factors controlling the distribution of the plant communities of the wetlands habitats alongside the fish farms in the Nile delta.

Materials and Methods

The studied fish farms form a belt extending between Rosetta and Damietta near the Mediterranean sea (Fig. 1). The northern Mediterranean coast of Egypt belongs to the arid and hyperoid regions (UNESCO., 1977). The climatic conditions are warm summer (20-30°C), and mild winter (10-20°C). The aridity index (P/PET) ranges between 0.03 and 0.02 (where P is the annual precipitation and PET is the annual potential evapotranspiration). Sixty stands (size 10x10 m^2 of each) with a reasonable degree of physiographic and physiognomic homogeneity were selected to represent the study area. The density and plant cover of each species have been estimated in each stand. The estimation of plant cover, has been measured by using the line-intercept method (Canfield, 1941). Relative values of density and cover of each species were calculated and summed up to give an estimate of its importance value (IV) in each stand which is out of 200. The species were classified in terms of life forms according to Raunkiaer (1934). The identification, nomenclature and floristic categories are according to Tutin *et al.* (1964 & 1980), Zohary (1972), Feinbrun-Dothan (1978 & 1986), Tackholm (1974) and Boulos (1995, 1999 & 2000).

Soil samples were collected (one from each stand which representing profile of 50cm depth. Soil texture was determined using Bouyoucos hydrometer. The percentage of soil porosity was determined according to Piper (1947). $CaCO_3$ percentage was estimated by titration against 1N HCl as described by Jackson (1962). Oxidizable organic carbon was estimated using Walkely and Black rapid titration (Black, 1979). Soil salinity (E.C.) and soil reaction (pH) were estimated in 1:5 soil water extracts using the electric conductivity and pH-meters, respectively. The determination of bicarbonates and sulphates were carried out using the titration against 0.1N HCl and gravimetric with ignition of residues respectively. Na^+, K^+ and Ca^{++} were extracted using ammonium acetate solution at pH 7 and estimated using a spectrophotometer (Allen *et al.*, 1974).

Two trends of multivariate analysis, namely: classification and ordination are commonly followed. Both trends have their merits in helping to understand the vegetational and environmental phenomena. The classification technique applied here was the Two-Way Indicator Species Analysis Using TWINSPAN-a FORTRAN Program (Hill, 1979; Hill *et al.*, 1975). While the ordination techniques applied were the Detrended Correspondence Analysis (DCA) and the Canonical Correspondence Analysis (CCA) using CANOCO- a FORTRAN Program (Ter Breack, 1986, 1987). 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 arrows represent environmental variables. The statistical treatments applied in present study were according to Snedecor & Cochran (1968) and Nie *et al.* (1975).

Results

Sixty eight species belonging to 57 genera and 24 families were recorded in the study area. These species included 35 annuals (51.5%) and 33 perennials (48.5%). The recorded species included 19 monocot, and 49 dicots, *Chenopodiaceae, Compositae, Cruciferae* and *Polygonaceae* were the most represented families (60.3%). The life-form spectrum analysis indicated that the therophytes were highly represented (50%) followed by cryptophytes (geophytes – helophytes + hydrophytes = 22%) and chamaeophytes (13.2%). The geographical affinities of the recorded species reveal that, they are mostly the Mediterranean taxa. These taxa are either Pluriregional (22 species), Biregional (14 species) and Monoregional (2 species) [see Appendix].

The application of TWINSPAN classification on the importance values of 68 species recorded in 60 sampled stands led to the recognition of 7 vegetation groups (Fig. 2). The vegetation types are presented in synoptic Table 1. Group A comprises three stands codominated by *Bassia indica* (IV = 14.4%) and *Convolvulus arvensis* (IV = 12%). Other important species which attain relatively high IV are *Sencio glaucus* (10.9%) and *Cakile maritime* (IV = 9.1%). The indicator species identified by TWINSPAN classification in this group is *Bassia indica* (IV = 28.3%). Group B comprises three stands dominated by *Cakile maritime* which also identified as indicator species. The most common species in this group are *Phragmites australis* (IV = 15.8%) and *Senecio glaucus* (13.5%). Group C comprises 37 stands dominated by *Phragmites australis* (IV = 20.4%) which is also identified as indicator species for this group. The important species were

Table 1: Percentages mean of the importance values (out of 200) of the common weed species in different TWINSPAN groups.

Species	Groups						
	A	B	C	D	E	F	G
Aeluropus lagopoides	-	-	4.1	6.7	-	-	-
Alternanthera sessilis	-	1.2	0.2	-	-	-	-
Amaranthus hybridus	-	-	-	-	-	13.9	3.1
Amaranthus lividus	-	-	-	-	-	17.4	1.6
Arthrocnemum macrostachyum	-	2.0	7.5	4.2	-	-	-
Aster squamatus	-	-	2.6	-	-	-	-
Atriplex halimus	-	-	3.1	1.8	-	-	-
Atriplex prostrate	-	-	0.7	-	-	-	-
Atriplex semibaccata	-	3.9	4.0	3.2	-	-	-
Bassia indica	14.4	-	-	7.2	-	-	-
Beta vulgaris	-	-	1.3	0.7	-	-	-
Brassica rapa	2.3	-	0.1	-	0.7	-	-
Brassica tournefortii	2.5	-	-	-	-	-	-
Bromus scoparius	3.6	-	0.3	-	-	-	1.0
Cakile maritime	9.1	28.3	0.7	-	-	-	-
Chenopodium album	-	-	0.5	-	1.82	-	1.6
Chenopodium ambrosoides	-	-	0.2	-	0.3	-	1.3
Chemopodium murale	-	-	1.2	-	0.7	-	1.2
Cistanche phelypaea	-	-	0.1	-	-	-	-
Convolvulus arvensis	12.0	-	-	-	-		1.5
Cressa cretica	-	-	-	1.8	-	-	-
Cutandia memphitica	-	-	-	-	2.1	-	-
Cynanchum acutum	-	-	0.1	-	-	-	-
Cynodon dactylon	7.7	-	4.3	-	1.9	-	-
Cyperus alopecuroides	-	-	-	-	19.2	3.8	-
Cyperus rotundus	-	9.6	0.3	-	1.4	4.3	5.0
Desmostachya bipinnata	-	-	-	-	2.3	-	-
Echinochloa colona	6.1	-	-	-	2.1	5.7	-
Eichhornia crassipes	-	-	0.7	-	23.7	4.2	25.5
Emex spinosa	4.9	-	0.5	-	-	-	-
Halocenmum strobilaceum	-	-	-	2.4	-	-	-
Heliotorpium curassavicum	-	-	2.9	-	-	-	-
Hordeum murinum	-	-	0.5	3.1	-	-	-
Imperata cylindrica	-	-	-	-	-	-	13.6
Inula crithmoides	-	-	7.0	4.5	-	-	-
Juncus acutus	-	-	8.1	-	-	-	-
Juncus rigidus	-	-	6.1	-	-	-	-
Launaea resedifolia	-	-	-	-	-	3.3	-
Lolium perenne	-	-	0.4	-	-	-	-
Malva parviflora	4.2	-	0.8	3.8	-	-	2.0
Melilotus indicus	5.6	-	1.8	-	-	3.3	2.7
Mesembryanthemum crystallinum	5.5	8.0	0.2	-	-	-	-
Mesembryanthemum nodiflorium	-	2.9	3.2	-	-	-	-
Orobanche cernnua	-	2.9	-	-	-	-	-
Parapholis incurve	-	-	0.5	3.0	-	-	-
Persicaria salicifolia	-	--	-	-	-	2.9	21.6
Phragmites australis	-	15.8	20.4	17.6	6.2	3.5	-
Phyla nodiflora	-	-	-	-	9.5	-	-
Pluchea dioscorides	-	-	1.3	-	-	-	-
Polygonum equisetiforme	-	-	1.7	-	1.6	-	-
Polypogon monspeliensis	-	-	0.1	10.1	-	4.8	-
Portulaca oleracea	-	-	-	-	-	6.5	1.7
Ranunculus sceleratus	-	-	0.2	-	3.6	-	1.7
Roripa palustris	-	-	-	-	3.5	-	-
Rumex dentatus	-	-	0.9	-	4.2	-	0.5
Salsola kali	6.5	2.1	-	-	-	-	-
Senecio glaucus	10.9	13.5	0.4	-	-	-	-
Setaria verticillata	-	-	-	1.8	-	-	-
Sisymbrium irio	-	-	-	-		15.8	1.2
Solanum nigrum	-	-	-	-	-	-	4.3
Sonchus oleraceus	-	-	0.5	-	1.3	2.9	-
Spergularia marina	-	-	0.6	-	14.9	6.2	-
Suaeda pruinosa	-	-	1.3	15.9	-	-	-
Suaeda vera	-	-	0.5	5.2	-	-	-
Tamarix nilotica	2.6	-	3.5	7.0	1.8	-	-
Tamarix tetragyna	-	-	0.7	-	-	-	-
Typha domingensis	-	-	3.1	-	7.2	1.3	8.8
Zygophyllum aegyptium	2.0	9.9	0.8	-	-	-	-

Appendix: Life span, life form and chorotype of plant species recorded in the study area.

Families	Species	Life-span	Life-form	Chorotype
Aizoaceae	*Mesembryanthemum crystallinum L.*	Ann.	Th	ME+ ER-SR
	Mesembryanthemum nodiflorium L.	Ann.	Th	ME+ SA-SI+ ER-SR
Amaranthaceae	*Alternanthera sessilis* (L.) DC.	Per.	He	PAN
	Amaranthus hybridus L.	Ann.	Th	PAL
	Amaranthus lividus L.	Ann.	Th	ME+ IR-TR
Asclepiadaceae	*Cynanchum acutum* L.	Per.	H	ME+ IR-TR
Boraginaceae	*Heliotropium curassavicum* L.	Per	Ch	NEO
Caryophyllaceae	*Spergularia marina* (L.) Griseb.	Ann.	Th	ME+ ER-SR+ IR-TR
Chenopodiareae	*Arthrocnemum macrostachyum* (Moric.) Moris et Delponte	Per	Ch	ME+ SA-SI
	Atriplex halimus L.	Per	NPH	ME+ SA-SI
	Atriplex prostrate DC.	Ann.	Th	ME+ ER-SR+ IR-TR
	Atriplex semibaccata R.Br.	Ann	Th	Australia
	Bassia indica (wight) A.J. scott	Ann.	Th	S-Z+ IR-TR
	Beta vulgaris L.	Ann.	Th	ME+ IR-TR+ ER-SR
	Chenopodium album L.	Ann.	Th	COSM
	Chenopodium ambrosoides L.	Ann.	Th	COSM
	Chenopodium murale L.	Ann.	Th	COM
	Halocnemum strobilaceum (Pallas) (M. Bieb)	Per	Ch	ME+ IR-TR+ SA-SR
	Salsola kali L.	Ann.	Th	COSM
	Suaeda pruinosa Lang	Per	Ch	ME
	Suaeda vera Forssk. Ex J.F. Gmelin	Per.	Ch	ME+ SA-SI+ ER-SR
Compositae	*Aster squamatus* (Sprengi) Hieron	Per	Ch	NEO
	Inula crithmoides L.	Per	Ch	ME+ ER-SR+ SA-SI
	Launaea resedifolia (L.) Kuntze	Ann.	H	ME+ SA-SI
	Pluchea dioscorides (L.) DC	Per	Nph	S-Z+ SA-SI
	Senecio glaucus L.	Ann.	Th	ME+ SA-SI+ IR-TR
	Sonchus oleraceus L.	Ann.	Th	COSM
Convolvulaceae	*Convolvulus arvensis* L.	Per	H	COSM
	Cressa cretica L.	Per	H	ME+ PAL
Cruciferae	*Brassica rapa* L.	Ann.	Th	CULT
	Brassica tournefortii Gouan	Ann.	Th	ME+ IR-TR+ SA-SI
	Cakile maritime Scop.	Ann.	Th	ME+ ER-SR
	Rorippa palustris (L.) Besser	Ann.	Th	ER-SR+ IR-TR+ ME
	Sisymbrium irio L.	Ann.	Th	ME+ IR-TR+ ER-SR
Cyperaceae	*Cyperus alopecuroides* Rottb	Per	He,G	PAN
	Cyperus rotundus L.	Per	G.	PAN
Gramineae	*Aeluropus lagopoides* (L.) Trin. ex. Thwaites	Per	He,G	ME+ SA-SI+ IR-TR
	Bromus scoparius L.	Per	G	ME+ ER-SR+ IR-TR
	Cutandia memphitica (Spreng.) K. Richt.	Ann	Th	ME+ SA-SI
	Cynodon dactylon l(L.) Pers.	Per.	G.	COSMO
	Desmostachya bipinnata (L.) Stapf.	Per	He,G	COSMO
	Echinochloa colona (L.) Link	Ann.	Th	PAN
	Hordeum murinum Huds	Ann.	Th	ME+ IR-TR+ ER-SR
	Imperata cylindrical (L.) Raeusch	Per	H	PAL
	Lolium perenne L.	Per	Th	ME+ ER-SR+ IR-TR
	Parapholis incurve (L.) C.E. Hubb	Ann	Th	ME+ IR-TR+ ER-SR
	Phragmites australis (Cav.) Tyin. Ex Steud	Per	He.G	COSMO
	Polypogon monspeliensis (L.) Desf	Ann	Th	COSMO
	Setaria verticillata (L.) P. Beauv.	Ann.	Th	COSMO
Juncaceae	*Juncus acutus* L.	Per	He	ME+ IR-TR+ ER-SR
	Juncus rigidus Desf	Per	HeG	ME+ IR-TR+ SA-SI
Leguminosae	*Melilotus indicus* (L.) All.	Ann.	Th	ME+ IR-TR+ SA-SI
Malvaceae	*Malva parviflora* L.	Ann.	Th	ME+ IR-TR
Orobanchareae	*Cistanche phelypaea* (L.) P. Court.	Per	P	ME+ SA-SI
	Orobanche cernnua Forssk	Ann	P	ME+ IR-TR
Polygonaceae	*Emex spinosa* (L.) campd.	Ann	Th	ME+ SA+ SI
	Persicaria salicifolia Brouss. Ex willd	Per	G	PAL
	Polygonum equisetiforme Sibth Sm.	Per	G	ME+ IR-TR
	Rumex denttus L.	Ann.	Th	ME+ IR-TR+ ER-SR
Pontederiaceae	*Eichhornia crassipes* (C. Mart) Solms	Per	Hy	NEO
Portulacaceae	*Portulaca oleracea* L.	*Ann.*	Th	COSM
Ranunculaceae	*Ranunculus sceleratus* L.	Ann.	Th	ME+ IR-TR+ ER-SR
Solanaceae	*Solanum nigrum* L.	Ann	Th	COSM
Tamaricaceae	*Tamarix nilotica* (Ehrenb) Bge	Per	Nph	SA-SI+ S-Z
	Tamarix tetragyna Ehrenb	Per	Nph	ME+ SA-SI+ IR-TR
Thyphaceae	*Typha domingensis* (Pers.) Poirex steud.	Per	He	PAN
Verbenaceae	*Phyla nodiflora* (L.) Greene	Per	Ch	PAN
Zygophyllaceae	*Zygophyllum aegyptium* A. Hosny	Per	Ch	ME

Legend to life-span: Ann. = Annuals Per = Perennials

- Legend to life-forms: Th: Therophytes, Ch: Chamaeophytes, H : Hemicryptophytes, He: Helophytes, Hy: Hydrophytes, G: Geophytes, P: Parasites and Nph: Nanophanprophytes.
- Legend to chorotype: ME: Mediterranean, PAN: Pantropical, PAL: Palaeotropical, COSMO: Cosmopolitan, NEO: Neotropical, Cult: Cultivated, ER-SR: Euro-Siberian, SA-SI: Saharo-Sindian, IR-TR: Irano-Turanian , S-Z: Sudano-Zambezian.

Table 2: Mean and standard error of different soil variables that characterize the stands of different TWINSPAN groups.

Soil variables	Groups						
	A	B	C	D	E	F	G
Sand (%)	89.67± 2.45	91.02± 2.10	91.97± 3.34	91.26± 2.17	90.51± 1.90	89.25± 0.35	88.2± 1.10
Silt (%)	8.80± 2.30	7.10± 2.25	6.69± 2.80	7.36± 2.05	7.82± 2.15	8.55± 0.63	9.20± 1.15
Clay (%)	2.16± 0.30	1.88± 0.16	1.38± 0.32	1.38± 0.52	1.79± 0.34	2.20± 0.28	2.60± 0.14
Porosity (%)	32.23± 4.55	39.00± 5.06	36.18± 6.53	34.95± 5.40	38.1± 6.83	35.7± 2.76	35.90± 1.16
Organic carbon (%)	1.43± 0.25	1.73± 0.03	1.84± 0.30	1.72± 0.08	1.44± 0.44	2.60± 0.07	2.76± 0.03
Calcium carbonates (%)	5.23± 1.60	4.16± 0.76	4.69± 1.66	3.19± 0.53	4.00± 0.41	2.50± 0.14	2.62± 0.30
pH	7.95± 0.08	7.92± 0.03	7.66± 0.99	7.90± 0.26	7.93± 0.13	7.50± 0.14	7.57± 0.21
Electric conductivity (µmhos/cm)	2450± 540	1530± 468	7899± 2940	7300± 2670	3670± 422	995± 7.07	880± 26
Bicarbonates (%)	0.38± 0.45	0.10± 0.14	0.12± 0.04	0.11± 0.08	0.12± 0.02	0.08± 0.02	0.09± 0.03
Sulphates (%)	0.14± 0.09	0.13± 0.07	0.15± 0.05	0.15± 0.11	0.16± 0.07	0.27± 0.01	0.27± 0.04
Sodium (mg/100 gm dry soil)	3.840.35	2.83± 0.36	6.50± 2.32	6.42± 1.56	5.19± 3.30	3.08± 0.37	2.77± 0.41
Potassium (mg/100 gm dry soil)	0.41± 0.21	2.35± 0.13	0.79± 0.19	0.77± 0.14	0.69± 0.17	0.39± 0.23	0.48± 0.21
Calcium (mg/100 gm dry soil)	1.57± 0.63	2.90± 0.68	3.40± 1.50	3.15± 1.09	2.48± 0.71	1.90± 0.09	1.55± 0.21

Table 3: Pearson-moment correlation (r) between different soil variables in the stands of study area. [Por. = Porosity, O.C. = Organic carbon, E.C. = Electric Conductivity'*. Significant at P≤0.05 ** Significant at P≤0.01 *** Significant at P≤0.001.

	Sand	Silt	Clay	Por.	O.C	$CaCO_3$	pH	EC	HCO_3^-	SO_4^{-}	Na^+	K^+	Ca^+
Sand	1.000												
Silt	-0.942***	1.000											
Clay	-0.491***	0.192	1.000										
Por.	-0.019	0.021	-0.072	1.000									
O.C.	-0.297*	0.147	0.519***	-0.225	1.000								
$CaCO_3$	0.210	-0.189	-0.081	-0.050	-0.275	1.000							
pH	0.185	-0.221	0.024	-0.014	-0.255*	0.244	1.000						
E.C.	0.184	-0.059	-0.383**	-0.116	-0.202	0.221	-0.421**	1.000					
HCO_3^-	0.143	-0.116	-0.067	0.058	-0.040	0.055	-0.192	-0.096	1.000				
SO_4^{-}	0.192	-0.163	-0.156	0.059	-0.118	0.218	-0.106	0.001	-0.109	1.000			
Na^+	-0.026	0.152	0.313*	0.079	-0.225	0.150	-0.365**	0.846***	-0.064	-0.143	1.000		
K^+	0.062	0.025	-0.240	0.007	0.235	0.119	-0.079	0.602	0.116	0.025	0.570	1.000	
Ca^+	0.290*	-0.259*	-0.247	0.100	-0.013	0.211	-0.092	0.368**	-0.016	0.224	0.315*	0.169	1.000

Table 4: Comparison between some floristic variables in the present study and some previous related studies.

Habitats	Floristic variables					
	Recorded species	Perennials	Annuals	Families	Genera	% of common occurrence species
The present study	68	33	35	24	57	100
Lakes: Manzala: (Khedr and Zahran, 1998)	102	57	45	36	89	76.0
Burollus: (Khedr and Zahran, 1998)	135	70	65	41	109	76.0
Aquatic: Dakahleya province: (Khedr and El-Demerdash, 1997)	41	29	12	22	36	20.6
Qalubia, Monoufia and El-Gharbia provinces. (Shehata, 1996)	27	26	1	13	25	14.7
Damietta province: (Khedr and Serag, 1998)	34	27	7	18	30	19.1
Rice fields: Dakahleya province: (Zaki and Mashaly, 1992)	9	5	4	5	7	3.0
Damietta province: (Abde El-Aziz, 2002)	22	9	13	11	18	7.4
Egypt: (Imam and Kosinova, 1972)	50	24	26	20	33	13.2
Canal bank: Gharbia province: (El-Sheikh, 1989)	178	78	100	43	125	53.0
North of Nile delta: (Al-Sodany, 1998)	227	121	106	56	160	55.9
Salt Marsh: Damietta and Port-Said province, (El-Demerdash *et al.*, 1990)	39	26	13	13	35	30.9
Dakahleya and Damietta province: (Mashaly, 1987)	50	37	13	21	36	36.8
Kafr El-Sheikh and El-Behyra province (El-Kady *et al.*, 2000)	35	22	13	15	30	30.9

Arthrocnemum macrostachyum (IV = 7.5%), *Inula crithmoides* (IV = 7%) and *Juncus rigidus* (IV = 6.1%). Group D comprises 8 stands codominated by *Phragmites australis* (IV = 17.6%) and *Suaeda pruinosa* (indicator species IV = 15.9%). *Polypogon monspeliensis* (IV = 10.1%), *Bassia indica* (IV = 7.2%) and *Tamarix nilotica* (IV = 7%) are the most common species of this group. *Eichhornia crassipes* (IV = 23.7) and *Cyperus alopecuroides* (IV = 19.2) are the codominant species of group E which comprises four stands. The indicator species was *Eichhornia crassipes* while *Spergularia marina, Phylla nodiflora, Typha domingensis* and *Phragmites australis* are the most important members of this group. Group F comprises two stands and co-dominated by *Amaranthus lividus* (IV = 17.4%), *Sisymbrium irio* (IV = 15.8) and *Amaranthus hybridus* (IV = 13.9%). Other important species are *Portulara oleracea* and *Spergularia marina* while the indicator species for this group is *Sisymbrium irio*. Group G comprises three stands and is codominated by *Eichhornia crassipes* (IV = 25.5%) and *Persicaria salicifolia* (IV = 21.6%). *Typha domingensis* (IV = 8.8%) and *Cyperus rotundus* (IV = 5%) are the most common species. *Imperata cylindrical* (IV = 13.6%) is the indicator species identified by TWINSPAN classification in this group.

The ordination diagram given by Detrended Correspondence Analysis (DCA) is shown in Fig. 3(a & b) for stands and the species respectively. The DCA ordination of stands and species are indicated on the plane of the first and second DCA axes. It is clear that the vegetation groups yielded by TWINSPAN classification are markedly distinguishable and having a clear pattern of segregation on the ordination planes. Group A (codominated by *Bassia indica* and *Convolvulus arvensis*) and group B (dominated by *Cakile maritime*) are separated at the upper left side. However, group C (dominated by *Phragmites australis*) is separated at the lower left side. Group D (codominated by *Phragmites australis* and *Suaeda pruinosa*) is separated at the middle left side. Group E (codominated by *Eichhornia crassipes* and *Cyperus alopercuroides*) is separated at the lower right side, while, group F (codominated

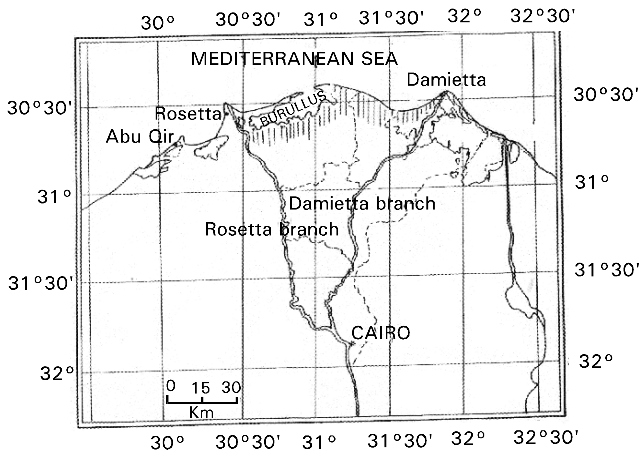

Fig. 1: Location map showing the study area.

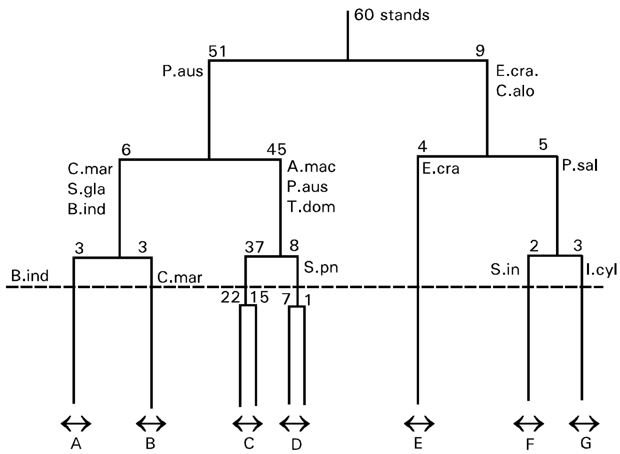

Fig. 2: TWINSPAN Dendrogram of stands based on the importance values of 68 species in the wetlands alongside the fish farms in the Nile Delta. The indicator species are abbreviated to the first letters of the genus name and first three letters of species name.

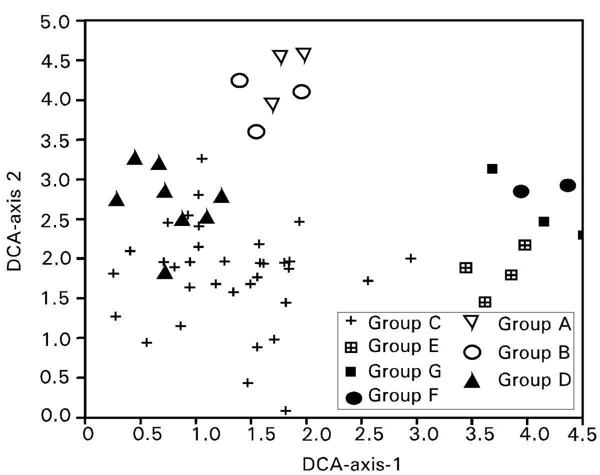

Fig. 3a: DCA ordination of 60 stands with TWINSPAN group.

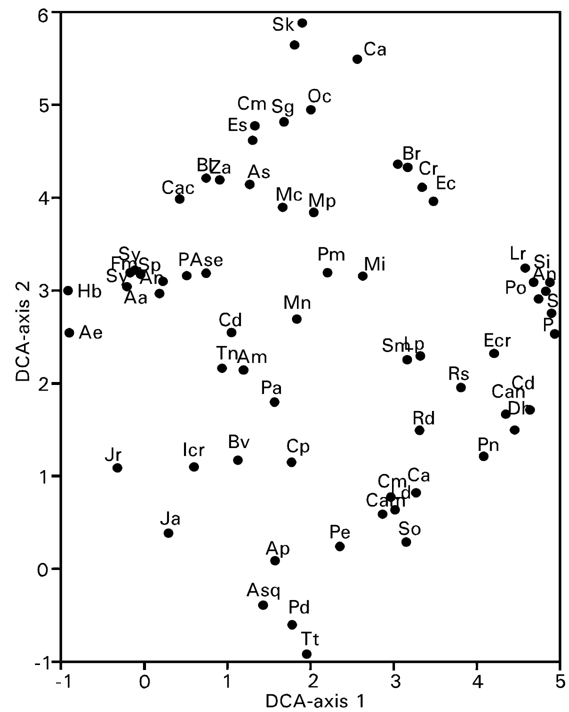

Fig. 3b: DCA ordination of the species with names abbreviated into the first letters of the genus and species. For complete name see the Appendix

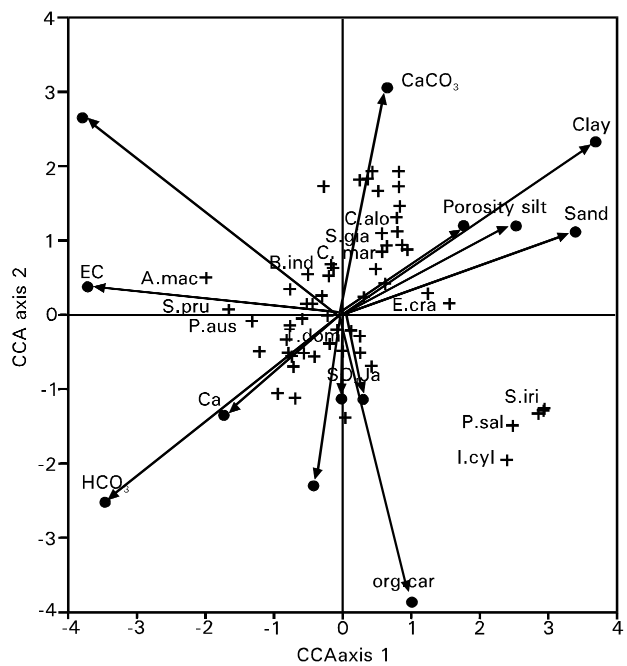

Fig. 4: Canonical correspondence analysis (CCA) ordination of the species and soil variables (arrows) in the wetlands alongside the fish farms in the Nile Delta. The indicator and preferential species are indicated by the first letters of the genus name and the first three letters of species name.

by *Amaranthus lividus, Sisymbrium irio* and *Amaranthus hybridus*)5 and group G (codominated by *Eichhornia crassipes* and *Persicaria salicifolia*) are segregated at the upper right side of the DCA diagram.

The soil variables of the seven groups of stands derived from TWINSPAN classification are presented in Table 2. The soil texture of all the vegetation groups is formed mainly of sand and partly of silt and clay. The percentage of the soil porosity is obviously comparable in all groups. Organic carbon content attained the highest mean value in the soil of group G (2.76%) and the lowest in that of group A (1.43%). The highest content of calcium carbonates (5.53%) was attained in the soil of group A, but the lowest (2.50%) in that of group F. The pH values indicate that the soil reaction is slightly alkaline in all groups. The electric conductivity (E.C.) attained its highest mean value (7899 µmhos/cm) in the soil of group C and the lowest in that of group G (880 µmhos/cm). The soil of group A had highest mean bicarbonates (0.38%), while that of group F had the lowest (0.08%). The soil of groups F and G attained the highest mean of sulphates (0.27%), while that of group B attained the lowest (0.13%). The concentrations of extractable cations, [sodium, potassium and calcium] were higher in the soils of group C than the other groups.

The correlation coefficient between different soil variables in the sampled stands are shown in Table 3. Several edaphic variables are significantly correlated with each other such as sand, silt, clay, organic carbon, pH, electric conductivity and extractable cations (Na^+, K^+ and Ca^{++}). However, porosity, calcium carbonates, bicarbonates and sulphates contents have no correlations with any of the other soil variables (Table 3).

The correlation between vegetation and soil is indicated on the ordination diagram produced by Canonical Correspondence Analysis (CCA) of the biplot of species-soil is shown in Fig. 4. The length and direction of an arrow representing a given environmental variable provide an indication of the importance and direction of the gradient of environmental change for that variable. The angle between an arrow and each axis is a reflection of its degree of correlation with the axis. The most effective environmental variables which have high significant correlation with the distribution of the recorded species are organic carbon, clay, pH value, bicarbonates and salinity.

Discussion

The wetlands are considered as homes to many different types of species; their high plant productivity supports large numbers of animal species; many migratory birds stop on wetlands on the way to their winter or summer homes; act as natural water purification systems removing sediment, nutrients and toxins form flowing water; stabilize shorelines and reduce the damage caused by storm surges; important for recreation and reduce the effect of flooding.

Fish farms form a living system with its distinctive composition, structure, environmental relations, development and functions; it is entirely a man-made system. Man create this ecosystem artificially for his own purpose favouring the use of cultured fish production.

The present study show that the wetlands alongside the fish farms in the coastal Nile Delta, support a relatively low number of perennial and annual species. Sixty eight species constitute the bulk of its flora. In general the unstable conditions along the banks of water bodies (e.g. erosion, cleaning particles, repeatable change in the water level and excessive human disturbance) may inhibit the establishment of plants from seed, but favour the colonization by creeping growth (Roberts & Ludwig, 1991).

With regard to the life form spectrum of the present study, the therophytes (50%) is the most common life form followed by cryptophytes (22%). For the Egyptian flora as a whole, the percentage of these two life forms are 59 and 16.2% respectively (Hassib, 1951). For eastern part of the north Delta, the values are 55.6 and 20.5% (Mashaly, 1987) and for the water courses in the middle are 56.2% and 25.8% respectively (Shaltout *et al.*, 1994). The nature of the prevailing climate in the study area, water availability and the sandy nature of this habitat help therophytes to predominate during the favourable seasons. On other hand the high frequency of cryptophytes in the study area may be according to McKee and Seneca (1982) due to the resistance of their rhizome to decomposition under constant submergence than other life forms. The low percentage of hydrophytes may be due to the regular change of water in the fish farms (see Appendix).

This study indicates the presence of Mediterranean phytogeographic belt in Egypt and this belt represents a transition between the pure Mediterranean and the Saharo-Arabian territory. This conclusion is based on the richness of the Mediterranean taxa (55.9%) in the present study area and also the bioclimatic features and life form spectrum. In contrast Zohary (1972) concluded that there is a gap in the Mediterranean territory between southern Palestine and Libya in which the Saharo-Arabian belt closely approach the Mediterranean coast.

Kershaw and Looney (1985) stressed the importance of a comprehensive description of vegetation, to build a mental picture of an area and its vegetation and to allow a comparison as well as the ultimate classification of different vegetational units. These have sought to reduce the complexity of a set of field data either by classification and/or ordination based on floristic data. The results of vegetation analyses have been related to environmental data. Alternatively, vegetation-habitat relationships have been derived from a single analysis of combined floristic and environmental variables (Ter Break, 1987). The classification of the vegetation of the wetlands alongside the fish farms in the coastal Nile Delta following TWINSPAN analysis identified seven distinct vegetational groups. The dominant species of these groups are: *Bassia indica, Convolvulus arvensis, Cakile maritime, Phragmites australis, Suaeda pruinosa, Eichhornia crassipes, Cyperus alopecuroides, Amaranthus lividus, Sisymbrium irio, Amaranthus hybridus* and *Persicaria salicifolia.* In the Nile Delta, several ecological studies have been made, such studies have enumerated several plant communities, many of which are comparable to those recognized in the present study (Table 4).

The analysis of the relationships between the vegetation composition and environmental variables indicated that the species distribution is mainly controlled by soil texture, organic carbon, pH and salinity.

Comparing the recorded species in the present study (68 species) with those of the previous related studies on the other wetlands habitats (Table 1), it was found that 76% of them were recorded in the study of Khedr and Zahran (1998) in the two Mediterranean Deltaic Lakes (Lakes Manzala and Burollos). Along irrigation canals and drains, 55.9% and 53% of them recorded in the study of Al-Sodany (1998) on the north Nile Delta and El-Sheikh (1989) on the middle Delta, respectively. In salt marshes habitat, 36.8, 30.9 and 30.9% of them were recorded in the study of Mashaly (1987) in the coastal region of dakahleya and Damietta province; El-Demerdash *et al.* (1990) in the coastal region of Damietta and Port-Said province and El-Kady *et al.* (2000) in the coastal region of Kafr El-Sheikh and Behyra province, respectively. In aquatic habitats, 20.6, 19.1 and 14.7% of them were recorded in the study of Khedr and El-Demerdash (1997) in dakahleya province, Khedr and Serage (1998) in Damietta province and Shehata (1996) in Qalubia, Monoufia and El-Gharbia province, respectively. In rice fields habitat, 13.2, 7.4 and 3.0% of them were recorded in the study of Imam and Kosinova (1972) in Egypt, abd El-Aziz (2002) in Damietta province and Zaki and Mashaly (1992) in Dakahleya province, respectively.

From this comparison, we can conclude that, the vegetation of the wetlands habitat alongside the fish farms is related to lakes and canal banks habitat more than the other wetlands habitats in the north Nile Delta.

Acknowledgments

The author sincerely thank Prof. Dr. K.H. Shaltout, Faculty of Science, Tanta University for revising the manuscript. I wish to thank also Dr. A. Khedr for his kind help in the multivariate data analysis.

References

Abd El-Aziz, G.O., 2002. Ecological studies and economic potentialities of some weed flora of Damietta area, Egypt. M.Sc. Thesis, Faculty of Science, Mansoura University.

Al-Sodany, Y.M., 1998. Vegetation analysis of canals, drains and lakes of Northern part of Nile Delta region. Ph.D. Thesis, Tanta University, Tanta.

Allen, S.E., 1974. Chemical Analysis of Ecological Materials. Blackwell Scientific Publications, London, UK., Pages: 565.

Black, C.A., 1979. Methods of soil analysis. Am. Soc. Agron., 2: 771-1572.

Boulos, L., 1999. Flora of Egypt. Vol. 1, Al-Hadara Publishing, Cairo, Egypt, Pages: 419.

Boulos, L., 1995. Flora of Egypt: Checklist. Al-Hadara Publishing, Cairo, Egypt, pp: 287.

Boulos, L., 2000. Flora of Egypt. Vol. 2. Al Hadara Publishing, Cairo, Egypt.

Canfield, R.H., 1941. Application of the line interception method in sampling range vegetation. J. For., 39: 388-394.

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-Sheikh, M.A., 1989. A study of the vegetation-environmental relationships of the canal banks of middle Delta region. M.Sc. Thesis, Faculty Science, Tanta University, Egypt.

Feinbrun-Dothan, N., 1978. Flora Palaestina. Vol. 3. Israel Academy of Sciences and Humanities, Jerusalem.

Feinbrun-Dothan, N., 1986. Flora Palaestina. Vol. 4. The Israel Academy of Science and Humanities, Jerusalem.

Hassib, M., 1951. Distribution of plant communities in Egypt. Bull. Fac. Sci. Fouad Univ., 29: 259-261.

Hill, M.O., 1979. TWINSPAN: A FORTRAN Program for Arranging Multivariate Data in an Ordered Two Way Table by Classification of Individual and Attributes Ecology and Systematics. Cornell University, Ithaca, NY., USA., Pages: 90.

Hill, M.O., R.G.H. Bunece and M.W. Shaw, 1975. Indicator species analysis, a divisive polythetic method of classification and its application to a survey of native pinewoods in Scotland. J. Ecol., 63: 597-613.

Imam, M. and J. Kosinova, 1972. Studies on the weed flora of cultivated land in Egypt. Botanische Jahrbucher Systematik Stuttgart, 92: 90-107.

Jackson, M.L., 1962. Soil Chemical Analysis. Constable and Co. Ltd., London, pp: 394.

Kady, H.F.E., K.H. Shaltout, M.N.E. Shourbagy and Y.M. Al-Sodany, 2000. Characterization of habitats in the North Western part of the Nile delta. Int. Conf. Biol. Sci. Tanta Univ. Egypt, 1: 144-157.

Kershaw, K.A. and J.H. Looney, 1985. Quantitative Dynamics of Plant Ecology. 3rd Edn., Edward Arnold, London.

Khedr, A.A. and M.A. El-Demerdash, 1997. Distribution of aquatic plants in relation to environmental factors in the Nile Delta. Aquat. Bot., 56: 75-86.

Khedr, A.A. and M.S. Serag, 1998. Environmental influences on the distribution and abundance of waterlettuce (Pistia stratiotes L.) in Egypt. Limnologica, 28: 387-393.

Mashaly, I.A., 1987. Ecological and floristic studies of dakahlia-damietta region. Ph.D. Thesis, Mansoura University, Egypt.

McKee, K.L. and E.D. Seneca, 1982. The influence of morphology in determining the decomposition of two salt marsh macrophytes. Estuaries, 5: 302-309.

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

Piper, C.S., 1947. Soil and Plant Analysis. Interscience Publishers Inc., New York, USA.

Raunkiaer, C., 1934. The Life Forms of Plants and Statistical Plant Geography. Oxford University Press, London, Pages: 631.

Roberts, J. and J.A. Ludwig, 1991. Riparian vegetation along current B exposure gradients in flood plain wetlands of River Murray. Aust. J. Ecol., 79: 117-127.

Serag, M.S., 1991. Studies on the ecology and control of aquatic and canal bank weeds of the Nile Delta, Egypt. Ph.D. Thesis, Faculty of Science, Mansoura University, Egypt.

Shaltout, K.H., A.S. El-Din and M.A. El-Sheikh, 1994. Species richness and phenology of vegetation along irrigation canals and drains in the Nile Delta, Egypt. Vegetatio, 122: 35-43.

Shehata, M.N., 1996. Ecological studies on Vossia cuspidata (Roxb.) griff: In the nile delta of Egypt. Egypt. J. Bot., 36: 37-51.

Snedecor, G.W. and W.G. Cochran, 1968. Statistical Methods. 6th Edn., Iowa State University Press, Ames, IA., USA.

Tackholm, V., 1974. Student's Flora of Egypt. 2nd Edn., Cairo University Press, Egypt, Pages: 887.

Ter Braak, C.J.F., 1986. Canonical correspondence analysis: A new eigenvector technique for multivariate direct gradient analysis. Ecology, 67: 1167-1179.

Ter Braak, C.J.F., 1987. The analysis of vegetation-environment relationships by canonical correspondence analysis (CCA). Vegetatio, 69: 69-77.

Tutin, T.G., V.H. Heywood, N.A. Burges, D.H. Valentine, S.M. Walters and D.A. Webb, 1964. Flora Europaea Volume 1: Lycopodiaceae to Platanaceae. Cambridge University Press, UK.

Tutin, T.G., V.H. Heywood, N.A. Burges, D.M. Moore, D.H. Valentine, S.M. Walters and D.A. Webb, 1980. Flora Europaea Volume 5: Alismataceae to Orchidaceae. Cambridge University Press, UK.

UNESCO., 1977. Map of the world distribution of arid region. MAB Technical Notes 7, UNESCO., France.

Zaki, M.A. and I.A. Mashaly, 1992. Seasonal aspects of the flora of the field crops, Nile Delta, Egypt. Mansoura Sci. Bull., 19: 187-202.

Zohary, M., 1972. Flora Palaestina. Vol. 2, The Israel Academy of Sciences and Humanities, Jerusalem.