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Vegetation Analysis Along Irrigation and Drain Canals in Damietta Province, Egypt

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Abstract: The present study provides an investigation of the vegetation analysis, a quantitative assessment of the main soil characteristics and an evaluation of the relationships between the major identified vegetation groups and environmental attributes along the canals and drains in Damietta Province. Vegetation and soil were sampled in 65 stands representing the net of canals, drains and the shoreline of Lake Manzala at the borderland of Damietta area. Relative values of cover and density were determined for each species and were summed up to provide an estimate of its importance value. The physical and chemical characteristics of soil samples were determined for each stand. The classification (TWINSPAN) and ordination (DCA) techniques of the stands led to recognition of four vegetation groups, namely: group A dominated by *Cynodon dactylon*, group B dominated by *Phragmites australis*, group C codominated by *Arthrocnemum macrostachyum- Phragmites australis* and group D dominated by *Phragmites australis*.
The light was thrown on the main factors influencing the vegetational group using Canonical Correspondence Analysis [CCA]. The percentages of clay,moisture content, electrical conductivity, organic carbon, chlorides, sodium,calcium and potassium are the most effective environmental variables which showed significant correlations with the first and second ordination axes. Accordingly, these soil variables seem to be the most important ecological factors influencing the distribution of vegetation in the study area.

Key words: Vegetation, classification, ordination, irrigation canal, drain, edaphic factors

Introduction

The Egyptian cultivated lands are almost irrigated by the River Nile through a network of canals and drained by a similar network of drains. The total length of both networks (excluding private ditches and drains) exceeds 47000 Km, > 31000 Km of canals and > 16000 Km of drains (Khattab & El-Gharably, 1984). The history of digging most of these canals and drains is related to the last 150 years (Hurst, 1952). The Nile system has been subjected to a series of large-scale schemes of river control, using a series of barrages and dams which have been built across the river and its tributaries. These canals and drains are infested by aquatic weeds. The degree of infestation is affected by environmental factors, including water transparency, depth of water, physicochemical water quality, water currents and air temperature. El-Gharably *et al*. (1982) attributed the increasing spread of aquatic weeds in the irrigation and drainage canals of the Nile Delta to some other ecological factors, e.g. increasing pollution from agricultural practices, industrial centres and human activities along canals and drains. The factors that control the species composition and richness of the vegetation along the banks of rivers and other water bodies are still poorly understood (Nilsson *et al*., 1989). Studies have been done on canal banks in the Nile Delta by many authors. Simpson (1932) studied the weed flora of irrigation channels, this was the earliest study. Recently Shaltout and Sharaf El-Din (1988) gave information about the vegetation of some small canals and drains along Cairo – Alexandria agriculture road. Also, Shaltout and El-Sheikh (1991) evaluated the behaviour of 15 common weeds, distributed along the net of canals and drains in the middle Delta region, in relation to environmental gradients of some variables. The vegetation of the canals and drains in the middle of the Nile Delta using multivariate techniques and species diversity indices in order to assess the relation between the vegetation types and the environmental variation were studied by Shaltout and El-Sheikh (1993). Zahran *et al*. (1994) studied the ecology of canal bank vegetation in the Nile Delta region. Shaltout *et al*. (1994) evaluated the species richness, phenology and effect of environmental factors on the composition of canal and drain vegetation in the Nile Delta. In the study of plant life at Kafr El-Sheikh Province, Shalaby (1995) recorded the flora of canal bank habitat. Serag and Khedr (1996) studied the shoreline of El-Salam canal (Egypt). A model of the relation between aquatic macrophytes and their environment in the irrigation and drainage canals in the north-eastern part of the Nile Delta was developed by Khedr and El-Demerdash (1997). The zonation of the vegetation and management along the saline and freshwater marshes of Damietta estuary of the River Nile was studied by Khedr (1998). The vegetation analysis of canals, drains and lakes of northern part of Nile Delta region was studied by Al-Sodany (1998). El-Hennawy (1999) studied the ecology of aquatic plants in Dakahlia and Damietta provinces.

Damietta Province is located in the downstream part of the Damietta branch of the River Nile at 31° 20′ E - 31° 30′ E latitude and 31° 30′ N-32° 00` longitude to the north east of the Nile Delta region of Egypt (Fig. 1). The coast of Damietta Governorate extends from El-Deeba village westward to Gamasa along the Mediterranean Sea for about 42 Km. This province is bounded by Lake Manzala at the east, Mediterranean Sea from the north and El-Dakahlia Governorate from the west and the south. The total average area of Damietta Province is about 1029 Km^2 and the total agricultural area is about 115892 Feddans. The Damietta Governorate comprises four districts: Damietta, Kafr-Saad, Farskour and El-Zarka. The first two districts are located west of Damietta branch of the River Nile, while the later two districts are situated east of Damietta branch. The climate of the area is typically Mediterranean type and belongs to the arid province which is characterized by a short dry period (Ayyad *et al*., 1983). The annual mean rainfall at Damietta is 102 mm. The air temperature varies from 13.3°C to 27.4°C with warm summers and mild winters. Relative humidity varies from a minimum of 69% during summer to a maximum of 84% during winter.

The present study aims at the analysis of vegetation of the canals and drains in Damietta Province using multivariate techniques in order to assess the relation between the vegetation types and the environmental variations.

Materials and Methods

Sampling sites were selected to cover the irrigation and drainage canals in four districts and the Lake Manzala embankment of Damietta province. Sixty five stands (1 x 5m^2 each), representing the apparent physiognomic variations in the vegetation and environmental features were used. The density and plant cover of each species have been estimated in each stand. The plant cover was estimated by using line-intercept method. The relative values of density and cover were calculated for each species and summed up to give an estimate of its importance value (IV) in each stand which is out of 200. The sampling processes of the study sites the plant species have been carried out during the years 1999-2000. The nomenclature of the species follows Täckholm (1974) and Boulos (1995, 1999 & 2000). Soil samples were collected from each stand at a depth of 0 – 50 cm. Soil texture was determined using sieve method for coarse soil and Bouyoucous hydrometer for the heavy soil samples. Moisture content and water-holding capacity (using Hilgard Pan-box) were determined according to Piper (1947). Organic carbon was determined using Walkly and Black rapid titration method. Calcium carbonate was determined by titration against 1N NaOH (Jackson, 1962). Soil salinity (EC) and soil reaction (pH) were estimated in 1:5 soil-water extract using the conductivity and pH meters, respectively. Chloride was determined by titration against N/35.5 silver nitrate. Sulphate was estimated gravimetrically using 5% barium chloride. Carbonate and bicarbonate were determined using 0.1 N HCl. The cations Na^+, K^+ and Ca^{++} were estimated using flame photometer as describy Allen *et al.* (1974). Two trends of multivariate analysis, namely classification and ordination were commonly followed. The classification technique applied here was the two-way indicator species analysis using TWINSPAN-a FORTRAN program (Hill, 1979 and Gauch, 1982). While ordination techniques applied were the detrended correspondence analysis (DCA) and the canonical correspondence analysis (CCA) using CANOCO-a FORTRAN program (Ter Braak, 1987 & 1988). The relationships between gradients and environmental variables can be indicated on the ordination diagram produced by canonical correspondence analysis (CCA biplot), on which points represent species and arrows represent environmental variables. The statistical treatments applied in the present study were according to Snedecor & Cochran (1968) and Nie *et al.* (1975).

Results

Classification of stands: The application of TWINSPAN classification on the importance values (out of 200) of 109 flowering plant species recorded in 65 stands representing the canal and drain bank habitat type, led to the recognition of four vegetation groups (Fig. 5). The vegetational composition of these groups is presented in Table 1.

Group A comprises 7 stands dominated by *Cynodon dactylon* with the highest mean importance value (IV = 52.80). The other important species which attain relatively high IV are: *Portulaca oleracea* (IV = 17.21), *Phyla nodiflora* (IV = 16.55), *Imperata cylindrica* (IV = 13.85) and *Mentha longifolia* (IV = 11.31). The indicator species identified by TWINSPAN classification in this group which attains low IV (5.89) is *Saccharum spontaneum*.

Group B comprises 40 stands dominated by *Phragmites australis* with the highest mean importance value (IV = 28.29). The important species in this group are: *Cynodon dactylon* (IV = 13.90) and *Pluchea dioscoridis* (IV = 12.38). The indicator species in this group which have moderate and low IV are: *Cynodon dactylon* (IV = 13.90) and *Rumex dentatus* (IV = 2.80).

Group C consists of 14 stands codominated by *Arthrocnemum macrostachyum* which is also identified as indicator species with (IV = 37.06) and *Phragmites australis* with (IV = 33.33). The most common species in this group are: *Atriplex portulacoides* (IV = 15.15), *Juncus subulatus* (IV = 11.36) and *Inula crithmoides* (IV = 10.80).

Group D consists of 4 stands dominated by *Phragmites australis* (IV = 32.52). The most important species in this group is *Zygophyllum aegyptium* (IV = 21.74), followed by other important species including *Halocnemum strobilaceum* (IV = 15.58), *Mesembryanthemum nodiflorum* (IV = 13.07), *Suaeda vera* (IV = 12.33) and *Arthrocnemum macrostachyum* (IV = 11.59). The indicator species in this group which have high and low IV are: *Zygophyllum aegyptium* (IV = 21.74) and *Pluchea dioscoridis* (IV = 2.29).

Ordination of stands: The ordination of stands of canal and drain bank habitat of the study area given by detrended correspondence analysis (DCA) (Fig. 3). The DCA ordination of stands 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 dominated by *Cynodon dactylon* is separated at the outermost lower right side of the DCA diagram. However, group B dominated by *Phragmites australis* is separated at the outermost upper right side of the diagram. On the other hand, group C codominated by *Arthrocnemum macrostachyum* and *Phragmites australis* is segregated at both lower and upper middle parts of the left side. While, group D dominated by *Phragmites australis* is segregated at the innermost middle part of the left side of the DCA diagram.

Variations in soil variables: The soil variables of the four groups of stands derived from TWINSPAN classification are presented in Table 2. Most of the soil characteristics show a little variation between the different groups of stands. The soil texture in all groups is formed mainly of sand and partly of fine fractions (silt & clay). The percentages of soil moisture contents are higher in groups C (34.12%) and B (28.32%) than in groups A (13.44%) and D (14.25%). The mean value of water holding-capacity is relatively high in group B (64.30%) as compared with the other groups A (48.13%), C (44.28%) and D (41.07%). The calcium carbonate and organic carbon contents are obviously comparable in all groups. The pH values indicate that the soil reaction is slightly alkaline in all groups. The electrical conductivity (EC) attained the highest mean value in group D (7212.50 μmhos/cm) and the lowest mean value in group A (580.00 μmhos/cm). The percentage of chloride and sulphate contents also attained the highest mean values in group D (0.73% and 0.20%) while, the lowest mean values attained in group A (0.03% and 0.10%, respectively). The soluble carbonate was trace or nil in all groups. On the other hand, the bicarbonate content was relatively low. The concentrations of extractable cations: Na^+, K^+ and Ca^{++} were high in the soil of group D (514.05, 42.41 and 44.13 mg/100g dry soil), while the low concentrations of these cations were estimated in the soil of group A (28.65, 11.59 and 5.50 mg/100g dry soil, respectively).

The correlation coefficient (r) between the different soil variables in the stands of canal and drain banks are shown in

Table 1: Mean and coefficient of variation (value between brackets) of the importance values (out of 200) of indicator and preferential weedy species in the different vegetational groups resulting from TWINSPAN classification of the stands of canal and drain banks in Damietta Governorate

Species Group	A	B	C	D
Adiantum capillus-veneris	0.16(2.50)	1.38(6.34)	-	-
Alhagi graecorum	-	0.55(5.69)	-	-
Alternanthera sessilis	-	0.40(3.30)	-	-
Amaranthus graecizans	0.27(2.44)	-	-	-
Amaranthus hybridus	0.86(2.45)	-	-	-
Amaranthus lividus	9.65(1.34)	0.86(3.58)	-	-
Anagallis arvensis var. *caerula*	-	0.02(6.50)	-	-
Apium graveolens	-	3.00(2.97)	4.02(2.92)	-
Arthrocnemum macrostachyum	-	0.58(6.28)	37.06(1.08)	11.59(1.20)
Aster squamatus	-	2.75(2.33)	-	8.83(1.73)
Atriplex portulacoides	-	-	15.15(1.50)	44.99(1.73)
Atriplex prostrata	-	-	0.12(3.75)	7.24(1.73)
Bassia indica	-	0.55(3.75)	-	6.62(1.03)
Beta vulgaris	0.67(2.45)	-	-	-
Bidens pilosa	0.74(2.45)	-	-	-
Cakile maritima	7.45(1.64)	-	-	-
Carex extensa	-	0.10(6.20)	-	-
Centaurea calcitrapa	5.10(2.45)	1.55(6.34)	-	-
Centaurium pulchellum	-	0.06(6.17)	0.76(3.72)	-
Chenopodium album	5.01(1.53)	0.31(5.26)	-	-
Chenopodium ambrosioides	0.93(2.46)	-	-	-
Chenopodium glaucum	-	3.40(4.14)	-	-
Chenopodium murale	0.23(2.48)	1.51(3.32)	-	3.12(1.73)
Cichorium endivia	0.67(2.43)	0.19(6.26)	-	-
Convolvulus arvensis	-	0.79(3.70)	-	-
Conyza aegyptiaca	0.47(1.64)	3.59(1.93)	0.26(3.65)	-
Conyza bonariensis	0.40(2.45)	2.06(2.79)	-	-
Corchorus olitorius	0.30(2.43)	0.15(5.53)	-	-
Coronopus didymus	0.87(1.83)	0.68(6.34)	-	-
Coronopus squamatus	-	0.11(6.09)	-	-
Cressa cretica	-	1.06(6.32)	1.85(3.45)	-
Cynanchum acutum	-	0.23(6.35)	2.14(2.20)	-
Cynodon dactylon	52.80(0.63)	13.90(1.50)	5.19(3.10)	-
Cyperus alopecuroides	-	2.95(3.73)	1.20(3.73)	-
Cyperus articulata	-	6.45(2.95)	-	-
Cyperus laevigatus	-	0.15(4.47)	0.31(3.71)	7.89(1.73)
Cyperus rotundus	8.87(0.82)	3.20(2.97)	-	-
Dactyloctenium aegyptium	-	1.65(4.45)	-	-
Echinochloa colona	1.41(1.60)	0.74(5.07)	-	-
Echinochloa crus-galli	0.27(2.44)	0.79(3.05)	-	-
Echinochloa stagnina	-	8.14(2.34)	-	-
Eclipta alba	0.80(2.46)	1.32(2.63)	-	-
Eleusine indica	-	0.21(6.19)	-	-
Elymus elongatus	-	-	1.02(3.73)	-
Ethulia conyzoides	-	2.05(3.66)	-	-
Gnaphalium luteo-album	0.13(2.38)	0.92(3.11)	-	-
Halocnemum strobilaceum	-	-	-	15.58(1.21)
Hordeum marinum	-	-	-	0.61(1.72)
Imperata cylindrica	13.85(2.09)	8.38(2.63)	-	7.16(1.73)
Inula crithmoides	-	1.71(4.49)	10.80(1.14)	-
Ipomoea carnea	-	2.16(3.73)	-	-
Juncus acutus	-	1.20(3.86)	4.75(2.38)	-
Juncus rigidus	-	0.56(5.70)	9.72(2.04)	9.00(1.33)
Juncus subulatus	-	-	11.36(2.10)	-
Lathyrus hirsuta	0.20(2.50)	-	-	-
Leersia hexandra	-	4.47(3.25)	-	-
Leptochloa fusca	-	3.96(4.71)	0.99(3.48)	-
Limonium narbonense	-	-	6.22(2.60)	-
Lolium perenne	0.20(2.40)	0.13(5.96)	-	-
Lotus glaber	-	0.16(4.56)	0.30(2.53)	-
Ludwignia stolonifera	-	0.81(4.64)	-	-
Malva parviflora	4.22(2.08)	0.06(6.33)	-	-
Medicago intertexta	0.58(2.45)	0.08(6.38)	-	-
Melilotus indicus	1.15(1.66)	0.54(3.39)	0.64(3.77)	-
Mentha longifolia	11.31(1.59)	5.37(3.11)	-	-
Mesembryanthemum crystallinum	1.23(2.45)	-	-	-
Mesembryanthemum nodiflorum	3.04(1.92)	0.03(5.33)	-	13.07(1.73)
Oxalis corniculata	0.36(2.47)	1.25(4.42)	-	-
Panicum repens	3.52(2.16)	0.85(4.76)	6.92(3.38)	-
Paspalidium geminatum	-	7.31(2.47)	-	-
Paspalum distichum	-	2.31(4.39)	-	-
Persicaria lapathifolia	-	2.56(6.33)	-	-
Persicaria salicifolia	-	6.07(2.30)	-	-

Species group	A	B	C	D
Persicaria senegalensis	-	0.69(6.29)	-	-
Phragmites australis	-	28.29(1.06)	33.33(0.76)	32.52(0.59)
Phyla nodiflora	16.55(2.45)	4.37(3.59)	-	-
Plantago major	-	0.49(3.12)	-	-
Pluchea dioscoridis	-	12.38(1.36)	3.44(1.60)	2.29(1.73)
Polygonum equisetiforme	8.24(1.77)	0.07(6.29)	-	2.24(1.73)
Polypogon monspeliensis	-	8.36(2.33)	4.54(2.10)	-
Polypogon viridis	-	1.82(3.46)	-	-
Portulaca oleracea	17.21(1.41)	0.49(3.41)	-	-
Ranunculus sceleratus	-	-	0.06(3.50)	-
Rorripa islandica	0.30(2.40)	0.03(6.67)	-	
Rumex dentatus	2.80(1.34)	6.24(1.40)	-	
Saccharum spontaneum	5.89(2.45)	4.49(2.95)	-	-
Salsola kali	2.61(2.44)	-	-	-
Scripus litoralis	-	-	5.74(2.81)	-
Scirpus maritimus	-	2.17(4.16)	8.91(1.53)	-
Senecio glaucus	-	0.10(6.44)	-	8.26(1.73)
Setaria verticillata	1.80(2.44)	-	-	-
Setaria viridis	-	0.11(4.65)	-	-
Solanum nigrum	1.11(2.44)	0.09(4.11)	-	-
Sonchus macrocarpus	-	0.10(6.23)	-	-
Sonchus oleraceus	-	1.35(2.39)	0.10(3.70)	-
Spergularia marina	-	0.54(4.13)	5.95(2.21)	-
Suaeda maritima	-	0.48(5.73)	6.60(2.35)	4.41(1.64)
Suaeda pruinosa	-	0.68(6.32)	-	-
Suaeda vera	-	-	-	12.33(1.04)
Tamarix nilotica	-	0.93(3.84)	0.79(3.73)	10.03(1.12)
Torilis arvensis	1.10(2.45)	0.56(4.98)	-	-
Trifolium resupinatum	4.68(1.78)	0.17(6.35)	-	-
Typha domingensis	-	4.62(2.68)	9.61(3.39)	3.65(1.73)
Urospermum picroides	-	0.04(7.00)	-	-
Verbena supina	-	6.35	-	-
Veronica anagallis aquatica	-	0.33(4.73)	-	-
Vicia sativa	-	0.02(5.50)	-	-
Vigna luteola	-	0.84(5.33)	-	-
Zygophyllum aegyptium	-	-	-	*21.74(0.64)*

Table 2: Mean and standard error of the different soil variables in the stands representing the different vegetational groups obtained by TWINSPAN classification of canal and drain bank habitats in Damietta Governorate

Soil variable Group	A	B	C	D
Sand (%)	93.69 ± 1.18	87.72 ± 1.17	92.32 ± 1.69	93.04 ± 1.24
Silt (%)	6.37 ± 1.48	11.73 ± 1.09	6.58 ± 1.34	6.02 ± 1.21
Clay (%)	0.20 ± 0.07	0.40 ± 0.17	0.88 ± 0.46	0.49 ± 0.10
Moisture content (%)	13.44 ± 5.19	28.32 ± 2.63	34.12 ± 4.96	14.25 ± 3.46
W.H.C. (%)	48.13 ± 6.98	64.30 ± 3.01	44.28 ± 3.60	41.07 ± 4.52
$CaCO_3$ (%)	12.14 ± 2.28	9.75 ± 1.04	9.86 ± 2.38	5.50 ± 0.44
Organic carbon (%)	0.60 ± 0.11	1.18 ± 0.08	0.78 ± 0.14	0.51 ± 0.20
pH	7.79 ± 0.06	7.92 ± 0.04	8.13 ± 0.07	7.91 ± 0.08
EC (μmhos/cm)	580.00 ± 121.68	2087.50 ± 487.90	2653.57 ± 642.62	7212.50 ± 2428.25
Cl^- (%)	0.03 ± 0.01	0.16 ± 0.05	0.29 ± 0.07	0.73 ± 0.29
SO_4^{--} (%)	0.10 ± 0.02	0.16 ± 0.03	0.10 ± 0.02	0.20 ± 0.06
CO_3^{--} (%)	0.0 ± 0.0	0.001 ± 0.006	0.005 ± 0.002	0.0 ± 0.0
HCO_3^- (%)	0.10 ± 0.01	0.10 ± 0.005	0.10 ± 0.01	0.10 ± 0.01
Na^+	28.65 ± 7.30	143.69 ± 37.74	145.02 ± 25.63	514.05 ± 179.99
K^+ | mg/100 g dry soil	11.59 ± 4.25	19.44 ± 4.12	18.69 ± 2.31	42.41 ± 5.93
Ca^{++}	5.50 ± 2.01	20.24 ± 3.60	10.49 ± 2.52	44.13 ± 6.7

Abbrviations : W.H.C: Water holding capacity, EC: Electrical coductivity

Table 3. Pearson-moment correlation (r) between the different soil variables in the stands surveyed of canal and drain banks in Damietta Province.

Sand	1.000														
Silt	-0.980***	1.000													
Clay	-0.565***	0.404***	1.000												
M.C.	-0.128	0.138	-0.042	1.000											
W.H.C.	-0.115	0.210	-0.377**	0.478***	1.000										
$CaCO_3$	0.118	-0.071	-0.251*	0.061	0.267*	1.000									
O. carbon	0.048	0.020	-0.345**	0.489***	0.740***	0.271*	1.000								
PH	-0.074	0.050	0.136	0.406***	0.163	0.088	0.159	1.000							
EC	-0.044	0.066	-0.071	-0.097	-0.050	-0.044	-0.168	-0.091	1.000						
Cl^-	-0.029	0.044	-0.053	-0.104	-0.086	-0.037	-0.196	-0.081	0.984***	1.000					
SO_4^-	-0.001	0.023	-0.101	-0.095	-0.115	-0.020	-0.030	-0.394***	0.410***	0.373**	1.000				
CO_3^{--}	0.273*	-0.268*	-0.140	0.253*	0.046	0.338**	0.222	0.550***	-0.021	-0.013	-0.082	1.000			
HCO_3^-	0.162	-0.165	-0.061	-0.006	0.048	-0.025	0.160	0.121	-0.028	-0.088	0.211	0.103	1.000		
Na^+	-0.035	0.058	-0.076	0.125	0.078	0.029	-0.021	-0.053	0.842***	0.832***	0.335**	-0.054	-0.053	1.000	
K^+	-0.142	0.143	0.069	-0.137	-0.132	-0.106	-0.054	0.056	0.424***	0.367**	0.283*	0.130	0.128	0.276*	1.000
Ca^{++}	0.120	-0.097	-0.178	-0.137	0.028	-0.099	0.015	-0.223	0.708***	0.619***	0.477***	-0.066	0.224	0.617***	0.515***	1.000
	Sand	Silt	Clay	M.C.	W.H.C	$CaCO_3$	O. carbon	pH	EC	Cl^-	SO_4^-	CO_3^{--}	HCO_3^-	Na^+	K^+	Ca^{++}

Explanation: * = Significant at P ≤ 0.05; ** = Significant at P ≤ 0.07; *** = Significant at P ≤ 0.001.
M.C: Moisture content, W.H.C: Water holding capacity, O.C: Organic carbon, E.C: Electrical conductivity

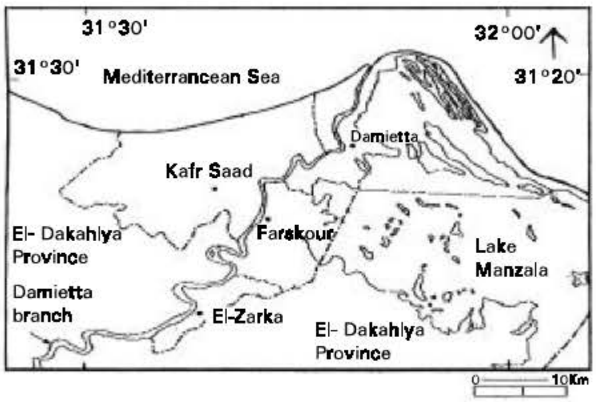

Fig. 1: Map of Damietta province showing different districts (•) of the study area.

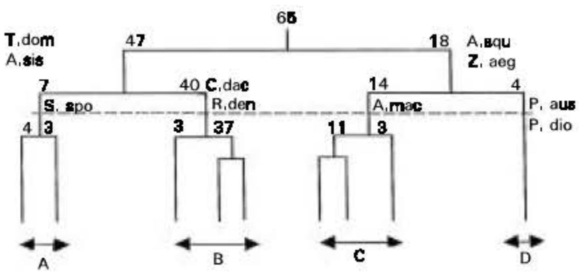

Fig. 2: TWINSPAN dendrogram of 65 stands based on the importance values of the weed species in canal and drain bank habitat of Damietta province. The indicator species are abbreviated to the first letter of the genus and the first three letters of species name

Table 3. Several edaphic variables are significantly correlated with each other such as: fine fractions (silt & clay), water-holding capacity, calcium carbonate, organic carbon, pH, chloride, sulphate, soluble carbonate, sodium, potassium and calcium. While, soil variables such as: moisture content, electrical conductivity and bicarbonate have no significant correlations with any of the other soil variables.

Relationship between vegetation and environment: The correlation between vegetation and environment is indicated on the ordination diagram produced by canonical correspondence analysis (CCA) of the biplot of species-environment (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, within the set of the samples measured. The angle between an arrow and each axis is a reflection of its degree of correlation with the axis. By dropping a perpendicular to the arrow from each "species-point" an indication is provided of the relative position of species along the environmental gradient. As shown in Fig. 4, it is clear that the percentage of chloride, sodium cation, electrical conductivity, clay, sulphate, organic carbon content, calcium and potassium cations as well as moisture content are the most effective environmental variables which have high significant correlations with the first and second axes. The dominant species of group A *Cynodon dactylon* and the indicator species *Saccharum spontaneum* which are separated at the lower right side of the CCA biplot diagram show a close relationship with high percentage of clay. In group B the dominant species *Phragmites australis* and the indicator species *Rumex dentatus* and *Cynodon dactylon* which are also separated at the upper right side of the CCA biplot diagram show a close relationship with high percentage of chloride, electrical conductivity, sodium, calcium and potassium cations. On the other hand, at the upper left side of CCA biplot diagram the dominant and indicator species of group C: *Arthrocnemum macrostachyum* and *Juncus acutus*

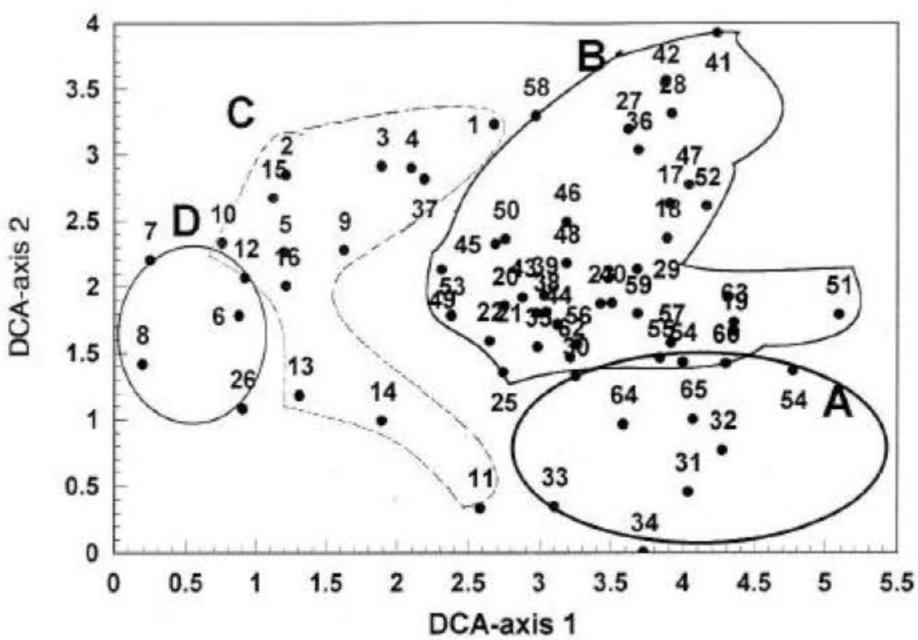

Fig. 3: DCA erdination of 65 stands of weeds in the canal and drain bank habitat of Damiella Province

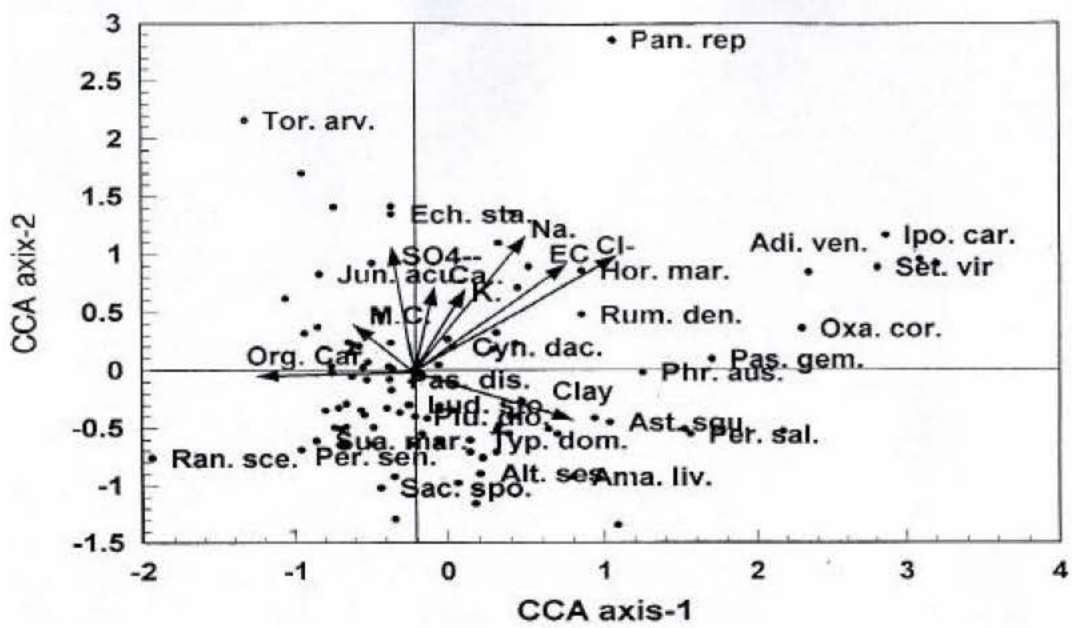

Fig. 4: Canonical correspondence analysis (CCA) ordination of weedy species in canal and drain bank habitat along the gradient of environmental variable (arrows) in Damietta province. The indicator and preferential species are indicated by the first three letters of genus and species respectively

are separated and exhibit a strong relation with high contents of sulphate, soil moisture and organic carbon. However, at the lower left side of CCA biplot diagram, the indicator species of group D: *Zygophyllum aegyptium* and *Pluchea dioscoridis* are segregated and show a reltionship with organic carbon content.

Discussion

The phytosociological studies reveal that, the vegetation of canal and drain banks are classified by TWINSPAN classification into four groups. Each group comprises a number of stands which are similar in terof vegetation and characterized by dominant and/or codominant species as well as by a number of indicator and/or preferential species. The recognized vegetational groups named after their dominants or codominants are: *Cynodon dactylon* (group A), *Phragmites australis* (group B), *Arthrocnemum macrostachyum-Phragmites australis* (group C) and *Phragmites australis* (group D).

It is of interest to mention that, Simpson (1932) has classified the vegetation of irrigation channels in Egypt, from the functional viewpoint, into five classes: aquatic, invading, bank retainers, weed controllers and sand controllers. In the Nile region (Nile Delta and Valley) of Egypt, Hassib (1951) has enumerated several unlisted plant associations (9 in uncultivated lands, 25 in marshlands, 12 in aquatic habitats, and 8 halophytic communities). Some of these associations and communities are comparable to the vegetation groups of the canal and drain banks in this study.

According to Braun-Blanquet's floristic association system, the identified vegetation groups in the canal and drain banks in the present study can be categorized into two classes: *Arthrocnemetea* and *Phragmitetea*.The first class (*Arthrocnemetea*) occupies a median position along the moisture gradient. The characteristic species in the present study which may be related to the first class are: *Arthrocnemum macrostachyum, Phragmites australis, Atriplex portulacoides, Juncus subulatus, Inula crithmoides, Zygophyllum aegyptium, Halocnemum strobilaceum, Mesembryanthemum nodiflorum* and *Suaeda vera*.

The communities belonging to the second class (*Phragmitetea*) are adapted to a wide moisture gradient extending from canal and drain banks. This class may include most of the communities in the ruderal habitats (e.g., roadsides, waste grounds, abandoned fields) in the Nile Delta region. The characteristic species which may be related to the second class are: *Phragmites australis, Cynodon dactylon, Portulaca oleracea, Phyla nodiflora, Pluchea dioscoridis, Imperata cylindrica, Mentha longifolia, Rumex dentatus, Polypogon monspeliensis, Echinochloa stagnina* and *Persicaria salicifolia*. Under second class, three alliances could be distinguished; these are:

1 *Imperata cylindrica*, this alliance mostly occupies the arid part of moisture gradient of *Phragmitetea*. The characteristic species which associated under this alliance are *Imperata cylindrica* and *Phragmites australis*.
2 *Panicetion repeni*, this alliance occupies, in most cases the medium positions along the moisture gradients of *Phragmitetea*. The characteristic species which associated under this alliance are: *Panicum repens, Cynodon dactylon, Polypogon monspeliensis, Chenopodium murale* and *Phragmites australis*.
3 *Echinochlion stagnini*, this alliance occupies the moist positions along the moisture gradients of the shallow canal and drain banks. The characteristic species which associated under this alliance are: *Echinochloa stagnina, Cynodon dactylon, Pluchea dioscoridis, Persicaria salicifolia* and *Cyperus alopecuroides*.

Comparing the two syntaxa (*Arthrocnemetea* and *Phragmitetea*) identified in canal and drain bank habitat type with the previous related studies, it has been found that, the class *Phragmitetea* in the present study does not resemble the *Phragmitetea* described by Van Groenendael *et al.* (1983) in their study on water bodies in Europe. Moreover it is not similar to either *Phragmitetea* or *Phragmitetalia segetalia* (belongs to *Panicetea hydro-segetalia*) described by Zohary

(1973). In recent studies, the class *Phragmitetea* is not similar to the class *Phragmitetea* described by Al-Sodany (1992) but, it may be comparable with the class *Phragmitetea* described by El-Sheikh (1989). On the other hand, comparison between the class *Arthrocnemetea* in the present study with the previous studies, led to the finding that, this class (*Arthrocnemetea*) may be related to the classes described by Montasir (1937),Zahran *et al.*(1990) and Al-Sodany (1992). The relationship between specific conductance (salinity) and plant distribution, indicates that, the relatively higher soil salinity values in the soil of banks of canals and drains may be related to the evaporation process. The increase in soil salinity of drain banks as compared with those of canals is related to the fact that, the drainage water that passes through drains is usually more saline than the irrigation water that passes through canals (El-Sheikh, 1989). The most important soil gradients which correlate with the distribution of vegetation as recognized by Shaltout and Sharaf El-Din (1988), El-Sheikh (1989) and Al-Sodany (1992) are: soil salinity (EC), moisture gradient, soil fertility (organic carbon and phosphorus contents), alkalinity, $CaCO_3$, soil texture (sand, silt & clay), pH value and nitrogen content. In this study, the application of canonical correspondence analysis (CCA biplot) indicates that, the most important soil variables which correlated with the distribution of weed vegetation in canal and drain banks are: fine fraction (clay), chloride, soil salinity (EC), sodium, sulphate, soil fertility (organic carbon), potassium, calcium and moisture content.

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