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Riparian Plant Communities Structure and Diversity Along River Nile, Middle Egypt

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THE RIPARIAN vegetation along the River Nile in Middle Egypt was studied to analyze the composition and structure of plant communities in relation to environmental gradients. Species diversity of plant communities was also determined. Vegetation was sampled in 103 stands distributed along the moisture gradient starting from the edge of the water and ending towards the most rising terrace. The classification of vegetation using the Two Way Indicator Species Analysis (TWINSPAN) recognizes four community types differing in their soil characters, topography and anthropogenic factors. Detrended Correspondence Analysis (DCA) clearly distinguishes these communities by the first two DCA axes. The composition and structure of plant communities are controlled mainly by soil moisture content and soil electrical conductivity. Other important edaphic factors are soil texture and organic carbon. The patterns of the species distribution at both community type and regional levels are unimodal, a pattern in accord with the niche-base model of species distribution. Species richness, Shannon-index of diversity and evenness are higher for communities occupying the slopes of the Nile bank compared to those located along water edge and on the most rising bank terrace. The pattern of species diversity is discussed in view of habitat factors.

Keywords: Core-satellite model, Distribution pattern, Disturbance, Diversity, Soil factors, Niche-based model, Vegetation.

A riparian zone is the interface between land and a flowing surface water body. Plant communities along the river margins are called riparian vegetation. Riparian ecosystems encompass the stream channel between the low- and high-water marks. They also encompass the terrestrial landscape above the high-water mark where vegetation may be influenced by elevated water tables or flooding and by the ability of the soils to hold water (Naiman and Décamps, 1997; Nilsson and Svedmark, 2002). Riparian corridors are diverse, complex, and dynamic and have economic and biological values (Sharitz *et al.*, 1992). These characteristics make them key ecosystems for preserving biodiversity (Naiman *et al.*, 1993). Although progress has been made in understanding the ecological processes which control the biodiversity of riparian vegetation in temperate regions (*e.g.* Hills and Murphy, 1996; Murphy *et al.*, 1994; Robach *et al.*, 1997), there has been less work in this context on tropical and sub-tropical riparian plant communities (Wyant and Ellis, 1990; Murphy *et al.*, 2003).

Vegetation structure along river banks is determined by both abiotic factors and human impact. Abiotic factors include soil pH (Gould and Walker, 1999;

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Decocq, 2002), soil moisture (Springuel, 1990; Gould and Walker, 1999; Decocq, 2002), salinity (Salinas and Casas, 2007), soil texture (Turner *et al.*, 2004), organic matter (Lenssen *et al.*, 2000; Turner *et al.*, 2004), elevation (Gould and Walker, 1999; Salinas and Casas, 2007), and topography (Gould and Walker, 1999; van Coller *et al.*, 2000). Disturbances due to human activities are known to affect the riparian vegetation. Rivers are increasingly fragmented by dams, resulting in disruption of natural dispersal pathways and subsequent changes of riverine communities (Jansson *et al.*, 2000). Embanking, clear-cutting, trenching, and pollution also contribute to damaging riparian habitats (Nilsson and Svedmark, 2002).

Several recent models have been proposed to explain the pattern of species distribution within a region. Among them, the niche-based and the core-satellite models are the currently most accepted models (Collins and Glenn, 1991; Perelman *et al.*, 2001). The niche-based model (Brown, 1984) states that across an entire, environmentally heterogeneous region, most species will be restricted to a relatively reduced number of sites and only a few or none will be found in all samples. In contrast, the core-satellite model (Hanski, 1982) incorporates plant demography and stochastic environmental variation to predict that there is a group of core species that are found in nearly all sites (90–100%) within a region, and a group of satellite species found in only a few sites. The first model may apply to large regions, whereas the second model is apparent within smaller and less heterogeneous areas, where the spatial autocorrelation of environment is relatively high.

The River Nile extends from Lake Tanganyika in Tanzania (Lat. 3° S) to the shore of the Mediterranean Sea (Lat. 31° 15` N) for a length of 6625 km. It drains an area of about 3 million km^2 and connects regions differing in relief, climate, geological structure and soils. It derives its water from the southern lake area of the Sudan basin and from the Ethiopian highlands. In its northward passage, the Nile drains the major interior Sudan basin across the high Nubian area into Egypt and the Mediterranean by way of a series of cataracts (Zahran and Willis, 1992). A series of barrages and dams have been built across the River Nile and its tributaries. These dams and barrages have segmented the natural hydrobiological system with undoubted impact on biota (Kassas, 1971). The riparian vegetation along River Nile has been destroyed in many places as a result of human activities (Springuel, 1990).

The vegetation along the irrigation canals and drains in Egypt, particularly in Nile Delta, have been documented in several studies (*e.g.*, Shaltout and El-Sheikh, 1993; Shaltout *et al.*, 1994; Shaltout *et al.*, 1995; Abu Zaida *et al.*, 2008), though the riparian vegetation along the main stream of River Nile has received little attention (but see Springuel, 1990). The objectives of this paper are (1) analyze the composition and structure of plant communities in relation to environmental gradients, (2) investigate the pattern of species distribution at both community type and regional (entire study area) levels, and (3) determine the species diversity of plant communities.

Material and Methods

Study area

The study area represents the riparian zone of the main stream of River Nile in Egypt located between latitudes 28° 30` and 29° 25` N (Fig. 1). The region is subjected to various degrees of human disturbances which in some instances lead to the destruction of vegetation in some areas. The most important human activities include fire, grazing, trampling, cleaning practices, boating and fishing.

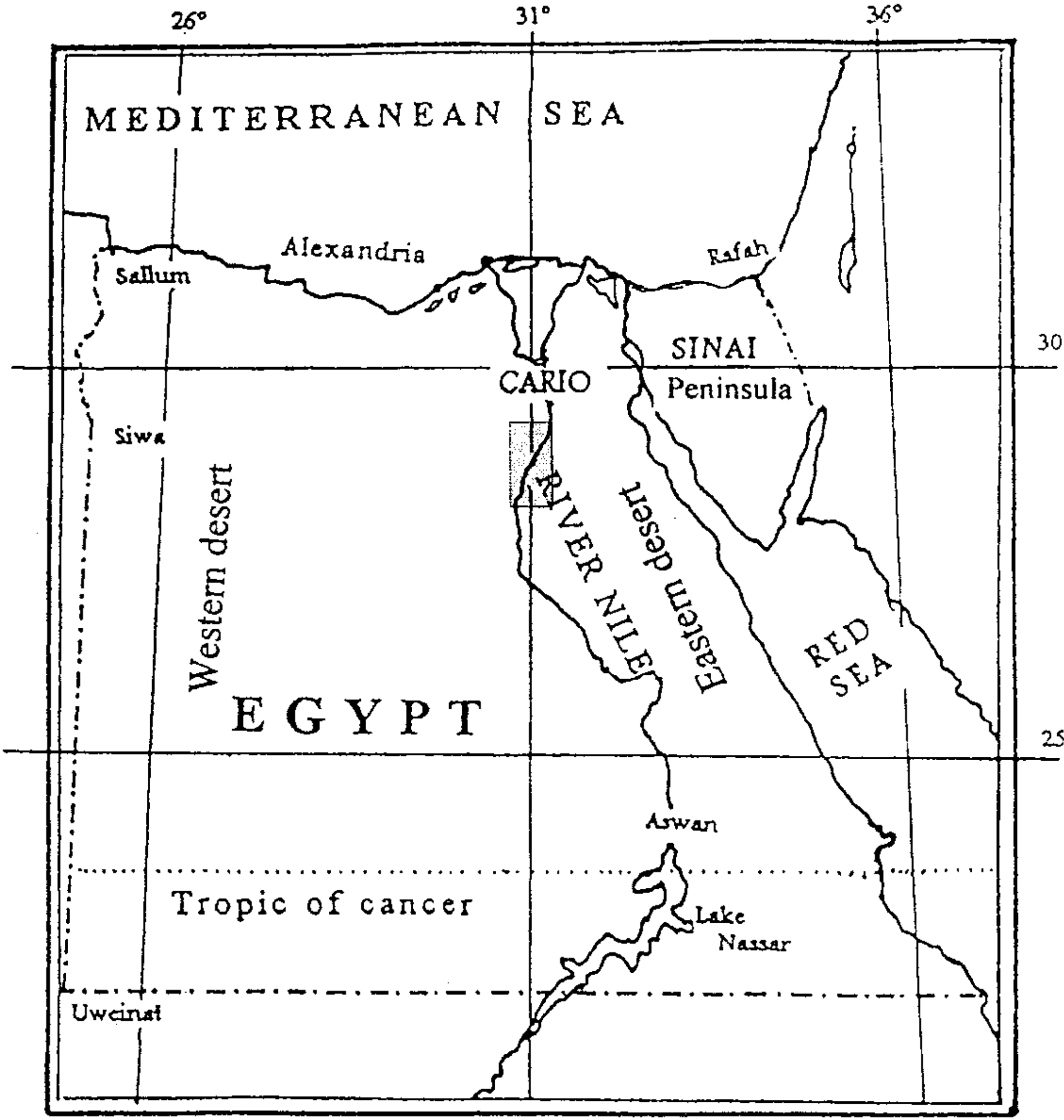

Fig. 1. Map of Egypt indicating the location of the study area (shaded part).

The total annual rainfall is 7.8 mm with the rainy season occurring from November to April. The mean monthly air temperature ranges between 12.2 °C during January and 29.1 °C during July. The mean relative humidity varies between 35% during May and 57% during December. The mean monthly evaporation ranges from 5.5 mm day^{-1} during January to 20.1 mm day^{-1} during June (data from Ministry of Civil Aviation, 1975).

Vegetation sampling

Vegetation was sampled in 103 stands (3 × 10 m each) along the two banks of the River Nile in middle Egypt during February-April 2008. Stands were selected along the moisture gradient starting from the edge of the water and ending towards the most rising terrace. In each stand, the present species were recorded and their cover as percentage of ground surface was evaluated visually. Species identification and nomenclature followed Boulos (1999, 2000, 2002 and 2005)

Soil analysis

For determination of soil variables, three soil samples were taken randomly per stand, from a depth of 0-50 cm. The three samples were pooled together, forming one composite sample for each stand. Soil texture was determined by pipette method (Forster, 1995). The percentage of $CaCO_3$ was estimated using 1N HCl (Jackson, 1967). Oxidizable organic carbon was determined by modified Walkley-Black method (Jackson, 1958). Soil moisture content was measured by drying soil at 105 °C for 24 h. Soil-water extracts of 1:5 were prepared and used for measurement of electrical conductivity (E.C.), soil reaction (pH) and bicarbonate (HCO_3^-). Electrical conductivity and soil reaction were measured using a conductivity and pH meter (Jenway 4330). Bicarbonate was determined by titration with 0.1N HCl using methyl orange as indicator.

Data analysis

TWINSPAN, Two Way Indicator Species Analysis (Hill, 1979a), was applied for the classification of stands into groups (community types) based on the cover values of species. The Detrended Correspondence Analysis– DCA (Hill, 1979b) was used to ordinate stands in two-dimensional space using the cover values of species. Data of the soil variables of the community types identified by TWINSPAN were compared by one-way ANOVA followed by Tukey's post-hoc test. The same analysis was used to compare between the diversity indices of the community types. Linear correlation of soil variables with DCA axes and cover values of the dominant species was made to relate the distribution of plant species and plant communities to edaphic factors. The one-way ANOVA and correlation analyses were conducted using SPSS 12 for Windows. In order to test the niche-based and the core-satellite models of species distribution, the frequency distributions of species presence (proportion of stands in which the species occur) were calculated. The patterns of species distribution were compared at the scales of the entire study area and within each community type.

Three indices were applied for measurement of diversity in each stand (Pielou, 1975; Zhang, 1995):

Species richness: $D = S$

Shannon-index of diversity: $H' = -\sum_{i=1}^{S} pi \ln pi$

Evenness index: $E = (-\sum_{i=1}^{S} pi \ln pi) / \ln S$

where pi is the relative cover species i and S is the number of species present.

Results

Floristic composition

A total of 71 species belonging to 27 families and 60 genera were recorded (Table 1). The species of Poaceae have the highest contribution to the total flora (12 species) followed by members of Fabaceae (10 species), Asteraceae (9 species), Brassicaceae and Polygonaceae (4 species each).

Vegetation classification

The application of TWINSPAN classification technique on the cover values of the recorded species in 103 stands leads to the separation of four community types (A-D; Fig. 2). Each community type comprises a set of stands which are similar in their vegetation. The vegetation composition of these communities is presented in Table 1.

Community type A includes stands dominated by *Phragmites australis* and *Imperata cylindrica.* The important associated species include *Convolvulus arvensis*, *Phyla nodiflora* and *Rumex dentatus*. The indicator species of this community type is *Chenopodium murale. Phragmites australis*, *Pluchea dioscoridis*, *Tamarix nilotica* and *Cynodon dactylon* are the dominant species of community B, while *Ricinus communis*, *Convolvulus arvensis* and *Phyla nodiflora* are the important associated species. This community is indicated by *Ricinus communis*, *Cynodon dactylon* and *Pluchea dioscoridis*. Stands of community type C are dominated by *Cyperus articulatus*, *Phragmites australis*, *Senecio aegyptius* and *Vossia cuspidata*. The common associated species include *Poa annua*, *Gnaphalium luteo-album*, *Echinochloa stagnina*, *Rumex dentatus* and *Persicaria salicifolia.* The indicator species of this community are *Cyperus articulatus* and *Rumex dentatus*. *Vossia cuspidata*, *Echinochloa stagnina* and *Persicaria salicifolia* are the dominant and indicator species of community D, while *Phragmites australis* and *Cyperus articulatus* are the important associated species.

TABLE 1. A list of the species recorded in the study area with their families and mean cover values in the four community types resulted from TWINSPAN technique.

Species	**Community type**			
	A	**B**	**C**	**D**
Acacia nilotica (L.) Delile (Fabaceae)	0.06	—	—	—
Alhagi graecorum Boiss. (Fabaceae)	0.06	—	—	—
Amaranthus hybridus L. (Amaranthaceae)	—	0.01	—	—
Anagallis arvensis L. (Primulaceae)	—	—	0.01	—
Bidens pilosa L. (Asteraceae)	—	—	0.01	—
Capsella bursa-pastoris (L.) Medik. (Brassicaceae)	—	—	0.01	—
Chenopodium album L. (Chenopodiaceae)	0.30	0.06	0.42	0.01
Chenopodium ambrosioides L. (Chenopodiaceae)	—	0.03	—	—
Chenopodium murale L. (Chenopodiaceae)	0.33	0.11	0.06	—
Cichorium endivia L. (Asteraceae)	0.01	—	0.01	—
Convolvulus arvensis L. (Convolvulaceae)	2.85	2.79	—	—
Conyza bonariensis (L.) Cronquist. (Asteraceae)	—	0.01	—	—
Coronopus didymus (L.) Sm. (Brassicaceae)	—	—	0.01	—
Coronopus squamatus (Forssk.) Asch. (Brassicaceae)	—	0.01	—	—
Cynanchum acutum L. (Asclepiadaceae)	0.12	—	—	—
Cynodon dactylon (L.) Pers. (Poaceae)	0.29	7.45	1.23	—
Cyperus alopecuroides Rottb. (Cyperaceae)	—	—	2.89	0.08
Cyperus articulatus L. (Cyperaceae)	0.35	0.32	7.07	1.77
Cyperus rotundus L. (Cyperaceae)	0.01	0.01	0.09	0.01
Dichanthium annulatum (Forssk.) Stapf (Poaceae)	—	—	0.01	—
Echinochloa stagnina (Retz.) P. Beauv. (Poaceae)	—	—	1.92	16.50
Eclipta alba (L.) Hassk. (Asteraceae)	0.01	—	—	—
Emex spinosa (L.) Campd. (Polygonaceae)	—	0.14	—	—
Euphorbia helioscopia L. (Euphorbiaceae)	—	0.01	—	—
Euphorbia peplus L. (Euphorbiaceae)	0.01	—	—	—
Glinus lotoides L. (Molluginaceae)	—	—	0.51	0.27
Gnaphalium luteo-album L. (Asteraceae)	—	—	2.71	0.48
Gnaphalium pulvinatum Delile (Asteraceae)	—	—	1.56	—
Imperata cylindrica (L.) Raeusch (Poaceae)	8.53	0.26	—	—
Juncus bufonius L. (Juncaceae)	—	—	0.36	—
Lathyrus hirsutus L. (Fabaceae)	—	—	0.01	—
Ludwigia stolonifera (Guill. & Perr.) P.H. Raven (Onagraceae)	—	—	0.14	—
Malva parviflora L. (Malvaceae)	—	0.16	—	—
Medicago polymorpha L. (Fabaceae)	—	—	0.01	—
Melilotus indicus (L.) All. (Fabaceae)	—	—	0.01	0.01
Mentha longifolia (L.) Huds. (Lamiaceae)	0.01	—	—	—
Oxalis corniculata L. (Oxalidaceae)	—	0.03	0.01	—
Oxystelma alpini Decne. (Asclepiadaceae)	0.18	0.03	0.01	—
Panicum repens L. (Poaceae)	—	—	—	0.32
Paspalum distichum L. (Poaceae)	—	—	0.22	0.01
Persicaria lanigera (R. Br.) Soják (Polygonaceae)	—	—	0.67	0.32
Persicaria salicifolia (Willd.) Assenov (Polygonaceae)	0.50	0.05	1.36	3.56
Persicaria senegalensis (Meisn.) Soják (Polygonaceae)	—	—	0.01	—
Phalaris minor Retz. (Poaceae)	—	—	0.01	—
Phalaris paradoxa L. (Poaceae)	—	—	0.01	—
Phragmites australis (Cav.) Trin.ex Steud. (Poaceae)	40.00	33.79	4.32	2.42
Phyla nodiflora (L.) Greene (Verbenaceae)	1.18	2.11	0.01	—

TABLE 1. Contd.

Species	Community type			
	A	B	C	D
Plantago major L. (Plantaginaceae)	—	—	0.02	—
Pluchea dioscoridis (L.) DC. (Asteraceae)	—	15.89	1.03	0.29
Poa annua L. (Poaceae)	0.12	0.11	2.58	0.15
Polypogon monspeliensis (L.) Desf. (Poaceae)	—	—	0.01	—
Polypogon viridus (Gouan) Breistr. (Poaceae)	—	—	0.07	—
Ranunculus sceleratus L.(Ranunculaceae)	—	—	0.14	—
Ricinus communis L. (Euphorbiaceae)	0.04	3.84	0.56	—
Rorippa palustris (L.) Besser (Brassicaceae)	—	—	0.67	0.07
Rumex dentatus L. (Polygonaceae)	1.18	0.01	1.92	0.84
Salix subserrata Willd. (Salicaceae)	—	0.53	—	—
Sanguisorba minor Scop. (Rosaceae)	0.18	—	0.02	—
Senecio aegyptius L. (Asteraceae)	—	0.11	4.72	0.81
Sesbania sesban (L.) Merr. (Fabaceae)	0.03	0.01	—	—
Silybum marianum (L.) Gaertn. (Fabaceae)	—	—	—	—
Solanum nigrum L. (Solanaceae)	—	—	0.10	—
Sonchus oleraceus L. (Asteraceae)	0.04	0.03	0.01	—
Stellaria pallida (Dumort.) Pire' (Caryophyllaceae)	—	—	0.01	—
Tamarix nilotica (Ehrenb.) Bunge (Tamaricaceae)	—	6.84	1.03	0.26
Trifolium resupinatum L. (Fabaceae)	—	—	0.15	0.66
Typha domingensis (Pers.) Poir. ex Steud. (Typhaceae)	—	—	0.01	0.65
Urtica urens L. (Urticaceae)	—	—	0.01	—
Veronica anagallis-aquatica L.(Scrophulariaceae)	—	—	0.04	—
Vicia sativa L. (Fabaceae)	—	—	0.01	—
Vossia cuspidata (Roxb.) Griff. (Poaceae)	—	0.53	3.33	22.94

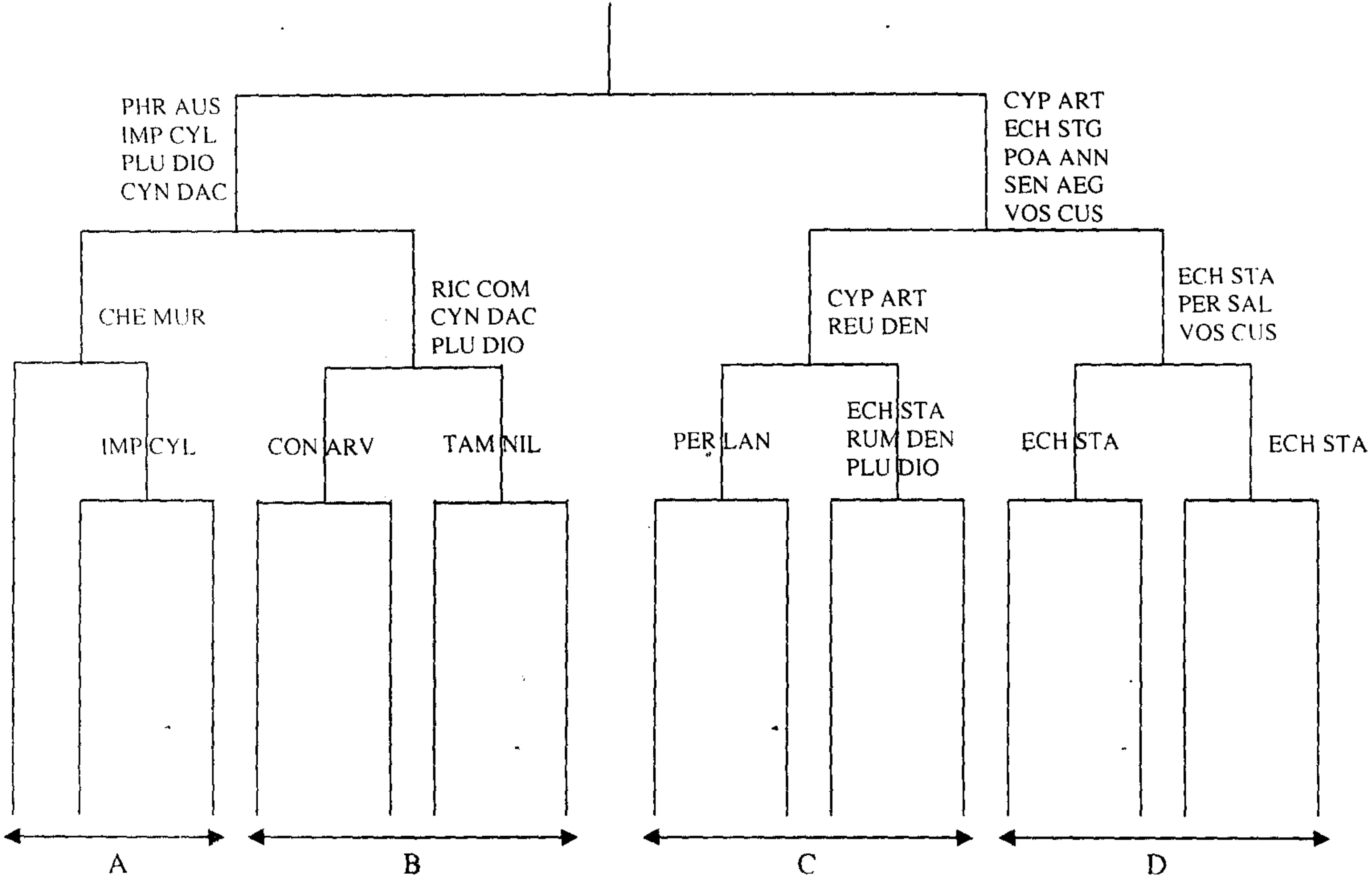

Fig. 2. TWINSPAN dendrogram of the 103 stands based on the cover values of species. Indicator species names are abbreviated to the first three letters of both species and genus names. For complete names, see Table 1.

Community structure and composition in relation to edaphic factors

Ordination of the 103 stands given by DCA (Fig. 3) indicates that the community types produced by TWINSPAN classification are markedly distinguishable and show a clear pattern of segregation on the ordination planes. The community types are distinguished and distributed mainly along axis 1 from left to right in the order: communities D, C, B and A. This distribution pattern shows that DCA axis 1 is mainly a soil moisture gradient with moisture decreasing gradually from left to right. The eigenvalues for the first two DCA axes are 0.842 and 0.544, respectively. The high eigenvalue for DCA axis 1 indicates that it captures the greater proportion of the variation in species composition among stands.

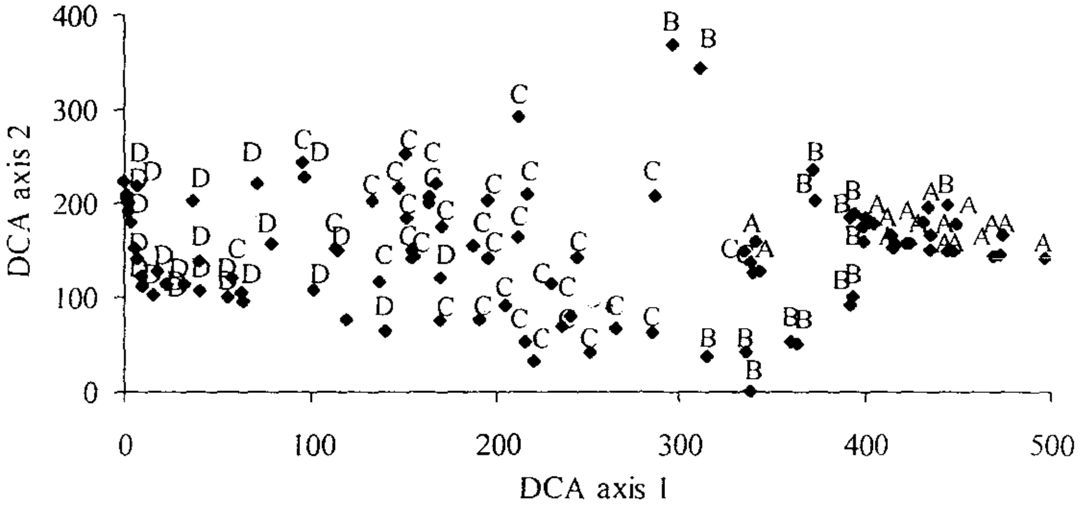

Fig. 3. DCA ordination of the 103 stands based on the cover values of species with the community types resulted from TWINSPAN superimposed.

Correlation analyses confirm that DCA axis 1 is strongly related to soil moisture (Table 2). Moreover, this axis exhibits significant negative correlations with sand and silt, and significant positive correlations with electrical conductivity, organic carbon, $CaCO_3$ and clay. On the other hand, DCA axis 2 does not show any significant correlation with the measured soil parameters.

Edaphic characteristics of the four community types are summarized in Table 3. With the exception of organic carbon, HCO_3^- and pH, the measured soil parameters show significant differences among community types. The highest values of electrical conductivity are recorded in community types A (2.57 mS/cm) and B (2.45 mS/cm), while the lowest values are exhibited by communities C (1.15 mS/cm) and D (0.58 mS/cm). The percentage of $CaCO_3$ varies between 3.32 in community C and 4.20 in community A. The maximum value of soil moisture is recorded in community type D (10.70%), followed by communities C (3.90%), B (0.99%) and A (0.76%). The highest value of sand is exhibited by community D (49.0%), while in the other communities it varies between 37.4% in community C and 38.5% in community B. The percentage of silt ranges from 38.7 in community A to 41.9 in community D. The minimum value of clay is showed by community D (9.1%), while in the other community types it varies from 22.1% in community A to 23.8% in community C.

TABLE 2. Linear correlation coefficients (*r*) between edaphic variables and the first two DCA axes.

Edaphic parameter	**DCA axis**	
	1	**2**
Electrical conductivity (mS/cm)	0.784**	0.188
Organic carbon (%)	0.195*	-0.077
HCO_3^- (%)	0.112	0.177
$CaCO_3$ (%)	0.357**	0.099
pH	0.084	0.043
Soil moisture content (%)	-0.834**	0.081
Sand (%)	-0.557**	0.142
Silt (%)	-0.314**	-0.128
Clay (%)	0.653**	-0.086

*$P<$ 0.05, **$P<$ 0.01

TABLE 3. Means ± SD of edaphic factors of the different community types. Values in a raw sharing the same letter are not significantly different at the 0.05 level.

Edaphic variable	**Community type**			
	A	**B**	**C**	**D**
Electrical conductivity (mS/cm)	2.57^{a} ±0.31	2.45^{a} ±0.90	1.15^{b}±0.82	0.58^{c} ±0.46
Organic carbon (%)	1.09^{a} ±0.16	1.11^{a} ±0.18	0.92^{a} ±0.15	1.03^{a} ±0.57
HCO_3^- (%)	0.039^{a} ±0.004	0.037^{a} ±0.005	0.037^{a} ±0.005	0.037^{a} ±0.005
$CaCO_3$ (%)	4.20^{a} ±0.37	4.17^{a} ±0.51	3.32^{b}±0.57	3.77^{c} ±0.49
pH	8.0^{a} ±0.1	8.0^{a} ±0.1	8.0^{a} ±0.1	7.9^{a} ±0.1
Soil moisture content (%) .	0.76^{a}±0.26	0.99^{a} ±0.56	3.90^{b} ±2.37	10.70^{c}±4.57
Sand (%)	37.6^{a} ±2.1	38.5^{a} ±2.1	37.4^{a} ±10.1	49.0^{b} ±6.0
Silt (%)	38.7^{a} ±7.2	39.3^{ab} ±2.8	40.1^{ab} ±3.0	41.9^{b} ±3.2
Clay (%)	22.1^{a}±2.2	22.7^{a} ±2.2	23.8^{a}±6.8	9.1^{b} ±6.4

The correlations of the cover values of the dominant species with soil variables are shown in Table 4. Most of the dominant species show significant correlations with soil characters. *Cynodon dactylon*, *Imperata cylindrica* and *Phragmites australis* are positively correlated with electrical conductivity and negatively correlated with soil moisture content. *Echinochloa stagnina*, *Persicaria salicifolia* and *Vossia cuspidata* display negative correlations with electrical conductivity and clay, and positive correlations with moisture content and sand. Electrical conductivity is negatively correlated with *Cyperus articulatus* and positively correlated with *Tamarix nilotica*. Organic carbon exhibits positive associations with *Persicaria salicifolia* and *Phragmites australis*.

Patterns of species distribution

The pattern of species distribution in the entire study area is unimodal right-skewed with no signs of the bi-modality (Fig. 4) predicted by the core-satellite model of species distribution. Approximately 80% of the species occur in less than 10% of stands and none species occur in more than 90% of stands. The species distribution within particular community types showed the same unimodal pattern (Fig. 4). Approximately 63%, 55%, 63% and 55% of species are present in less than 10% of stands for community types A, B, C and D, respectively. At community type level, no species occur in more than 90% of sites except for community type A in which only one species (*Phragmites australis*) present in all stands.

Species diversity

Community types show differences in the values of the measured species diversity indices (Fig. 5). Species richness is significantly higher in community type C (6.89 species/stand) than in the remaining three community types (4.26, 3.59 and 3.39 species/stand for communities B, A and D, respectively). Community C attains the highest value of Shannon index (1.4), while the other community types show low values (0.79, 0.73 and 0.51 for communities B, D and A, respectively). The highest evenness value is recorded in community C (0.76) followed by community types D (0.66), B (0.59) and A (0.45).

TABLE 4. Linear correlation coefficients (r) between edaphic variables and the cover of the dominant species in the study area.

Species	Edaphic variable								
	Electrical conductivity (mS/cm)	Organic carbon (%)	HCO_3^- (%)	$CaCO_3$ (%)	pH	Soil moisture content (%)	Sand (%)	Silt (%)	Clay (%)
Cynodon dactylon	0.262**	0.076	0.034	0.099	0.066	-0.294**	-0.168	-0.088	0.213*
Cyperus articulatus	-0.204*	-0.186	-0.066	-0.355**	0.009	0.016	-0.055	-0.029	0.159
Echinochloa stagnina	-0.421**	-0.191	0.119	0.084	-0.135	0.749**	0.564**	0.053	-0.585**
Imperata cylindrica	0.233*	-0.009	0.030	0.110	-0.025	-0.213*	-0.097	-0.307**	0.130
Persicaria salicifolia	-0.207*	0.271**	0.117	-0.002	-0.139	0.290**	0.223*	0.067	-0.269**
Phragmites australis	0.691**	0.226*	0.214*	0.550**	0.050	-0.544**	-0.258**	-0.147	.283**
Pluchea dioscoridis	0.083	0.021	-0.162	0.083	-0.126	-0.201*	-0.046	-0.177	0.141
Senecio aegyptius	0.070	-0.065	-0.068	0.060	-0.012	0.020	-0.009	0.005	0.000
Tamarix nilotica	0.319**	0.051	-0.052	0.088	0.018	-0.123	-0.036	-0.081	0.069
Vossia cuspidata	-0.339**	-0.039	-0.088	0.016	-0.095	0.430**	0.400**	0.335**	-0.580**

*$P < 0.05$, **$P < 0.01$

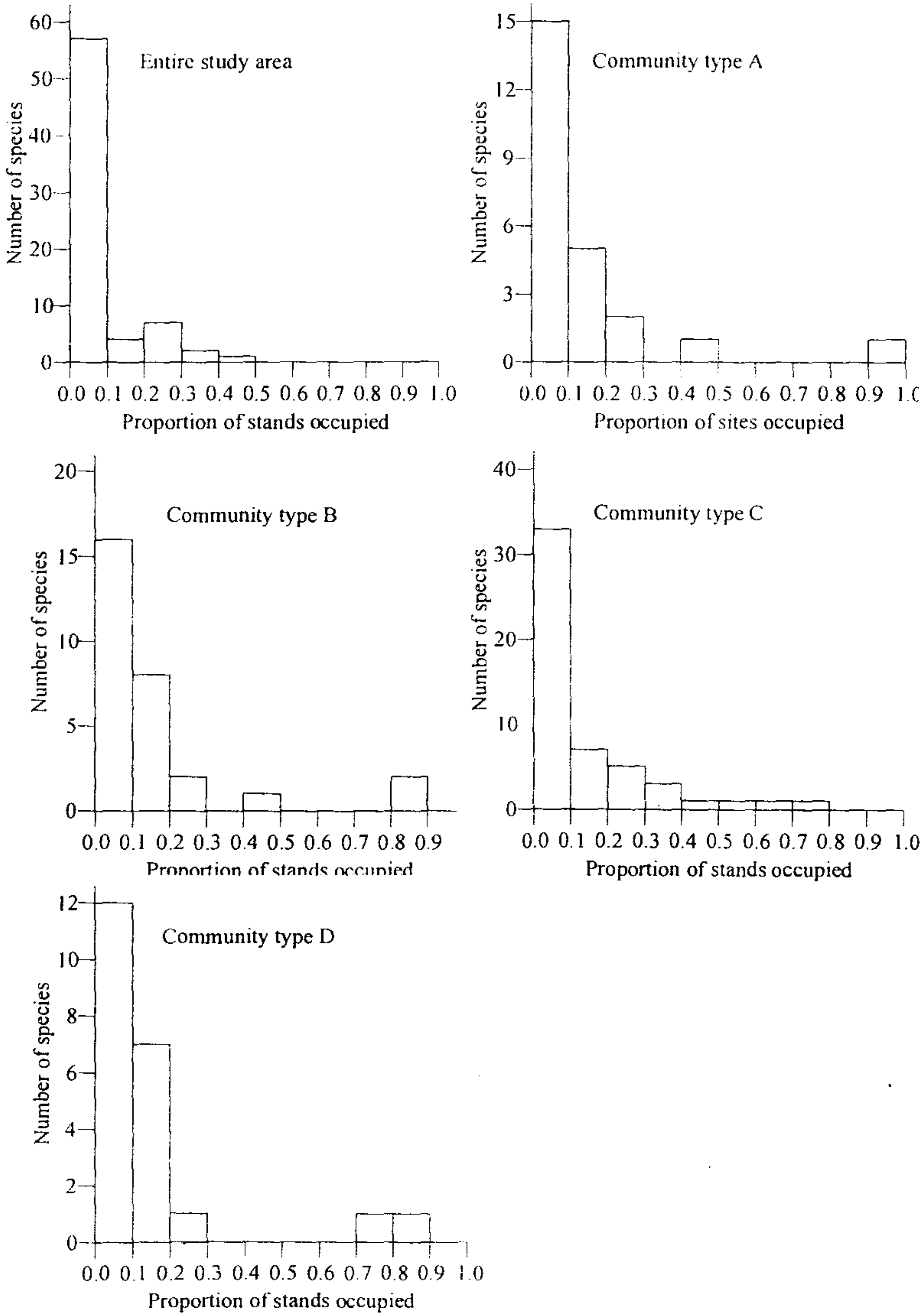

Fig. 4. Distribution of species across sites (stands) at the level of the entire study area and within community types.

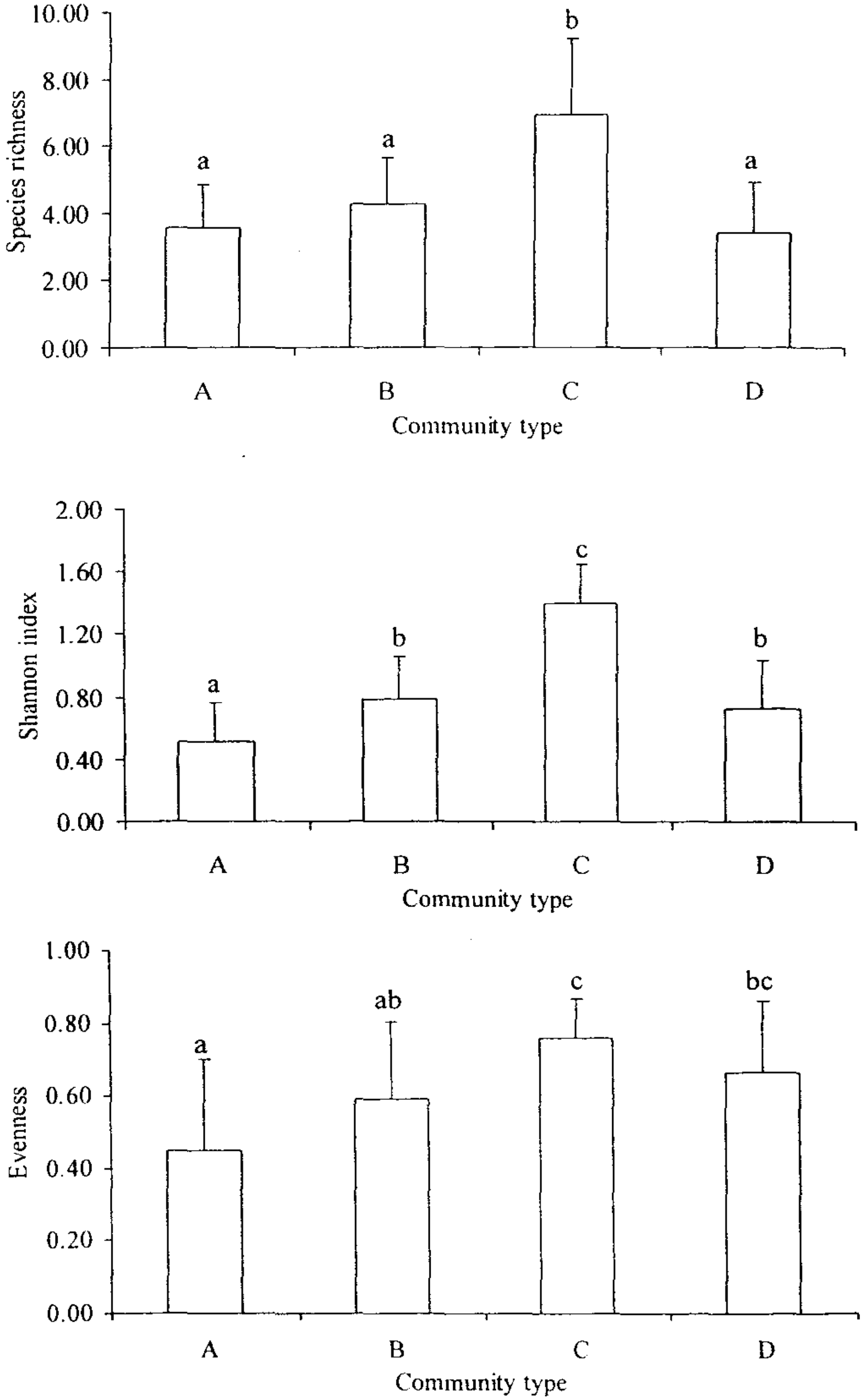

Fig. 5. Species richness, Shannon index and evenness of the four community types. Bars represent 1 SD. Community types sharing the same letter are not significantly different at the 0.05 level.

Discussion

The TWINSPAN classification of vegetation leads to the recognition of four community types differing in their environmental features (soil characters, topography and anthropogenic factors). Community type A represents the vegetation of the most rising bank terrace. *Phragmites australis* is the most dominant species in this community type. It is also one of the dominant species of community types B and C and one of the important associated species in community type D. The wide distribution and the preponderance of this plant in the study area reflect its ability to tolerate a wide range of environmental conditions. Communities dominated by *Phragmites australis* were recorded along banks of River Nile in Upper Egypt (Springuel, 1990) and along the irrigation canals and drains in Nile Delta (Shaltout and El-Sheikh, 1993; Abu Zaida *et al.*, 2008). The habitat of community A is usually subjected to anthropogenic pressures such as fire, cutting and grazing. This may explain the dominance of *Imperata cylindrica* in this community because of its ability to cope with such human disturbances (Springuel, 1990). *Imperata cylindrica* was reported to dominate along water courses in Nile Delta (Shaltout and El-Sheikh, 1993) and in the riparian vegetation of the River Nile in Upper Egypt (Springuel, 1990). Stands of community B also located at the most rising terrace. *Tamarix nilotica* and *Cynodon dactylon* are dominant species in this community. Similar communities were recorded by Springuel (1990) along the Nile banks in Egypt.

The vegetation of community type C covers the slopes of the Nile banks. *Vossia cuspidata* is one of the dominant species in this community. It is one of the "Sudd" grasses never seen in flower in Egypt (El Hadidi and Fayed, 1995). It was not recorded in the floras or accounts dealing with Egyptian grasses before Boulos (1995). Its distribution has been reported throughout tropical Africa and South East Asia (Skerman and Riveros, 1989). Communities dominated by *Vossia cuspidata* were identified in the islands of the River Nile in Egypt (Abd El-Ghani and Fahmy, 2001). *Cyperus articulatus* and *Senecio aegyptius* are among the dominant species in community C. like *Vossia cuspidata*, these two species are recognized by Abd El-Ghani and Fahmy (2001) as dominant plants in the islands of the River Nile in Egypt.

Stands of community D are located along the water edge. This habitat is subjected to high disturbance due to cleaning practices, aquatic weed control and fluctuation of water level. *Echinochloa stagnina* and *Persicaria salicifolia* are among the dominant plants of this community. They are reported to dominate communities located along canals and drains in Nile Delta (Shaltout and El-Sheikh, 1993) and in the Nile islands in Egypt (Abd El-Ghani and Fahmy, 2001).

The results of the present study indicate that soil moisture is very important for the composition of riparian vegetation. Similar results were reported for vegetation along river banks by Springuel (1990), Gould and Walker (1999) and

Decocq (2002) and for vegetation of other water bodies by Shaltout and El-Sheikh (1993) and Ali (2006).

Soil salinity (determined by electrical conductivity) also affects significantly the composition and structure of plant communities in the present study. Our results are consistent with other studies showed that soil salinity is a key determinant of primary production and species distribution in arid- and semiarid-zone riparian ecosystems (Busch and Smith, 1995; Salinas *et al.*, 2000). Dominant species in the study region like *Echinochloa stagnina*, *Persicaria salicifolia* and *Vossia cuspidata* show negative response to salinity. However, high salinity is associated with dense growth of *Tamarix nilotica* and *Phragmites australis*. Similar results were reported for these species by Serag and Khedr (2001) and Abd El-Ghani and Fahmy (2001).

Edaphic factor such as soil texture and organic carbon also contribute to the vegetation composition in the study area. These results are in accord with Turner *et al.* (2004) and Lenssen *et al.* (2000) in their studies on riparian vegetation.

Bimodality is difficult to test statistically (Gotelli and Simberloff, 1987; Gaston and Lawton, 1989). Fortunately, my data of the patterns of species distribution across stands are not obviously bimodal, or at lest they do not have modes at each end of the frequency histogram of proportion of sites occupied, as demanded by the core-satellite model.

The riparian vegetation along the river Nile in middle Egypt lacks a distinct group of core species that tend to be present in most sites, and is particularly rich in satellites species. The absence of a distinct group of core species may be due to the strong habitat heterogeneity of the region. However, the species distribution within particular community types showed the same unimodal pattern. Thus, vegetation heterogeneity of the riparian vegetation follows predictions of the niche-base model of species distribution, even when smaller amount of habitat heterogeneity (community type level) was considered in which the core-satellite species model is more likely to apply (Collins and Glenn, 1991; Brown, 1995). This would suggest that the riparian vegetation in the present study area have either a particularly high habitat heterogeneity or species with particularly narrow niches.

The results of the present study agree with those of Perelman et al. (2001) on Flooding Pampa grassland that predicted unimodality in the regional distribution of species. By contrast, the core-satellite hypothesis has been documented in other vegetation studies (Eriksson *et al.*, 1995; Pärtel *et al.*, 2001).

The highest values of species diversity as measured by species richness, Shannon index and evenness, are exhibited by community type C which occupies the slopes of Nile banks. This may be related to the intermediate position of that community along the prevailing environmental gradients in particular the soil moisture gradient. The moderate soil moisture conditions of community type C allow the germination and growth of a wide range of species compared to the dry conditions in community types A and B and the excessive moisture conditions in community D.

The low species diversity of the zone located along the water edge (community D) may be related to the high disturbance as a result of the fluctuations of water level and cleaning practices. Similar conclusions were given by Shaltout and El-Sheikh (1993) and Shaltout *et al.* (1995) in their studies on the vegetation of the irrigation and drainage canals in Egypt. Vegetation of the most rising bank terrace (community types A and B) is characterized by its low species diversity. This can be attributed to the low soil moil content which inhibits the germination and reduces the growth of many species. Moreover, human disturbances as grazing, trampling and fire may reduce the seedling emergence and the survival of some species and thereby decreases diversity (Salinas and Casas, 2007).

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تركيب وتنوع المجتمعات النباتية على ضفاف نهر النيل فى مصر- الوسطى

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اجريت الدراسة الحالية على الغطاء النباتى الموجود على ضفاف نهر النيل فى منطقة مصر الوسطى ، وذلك لتعيين العلاقه بين تركيب المجتمعات النباتيه و العوامل البيئيه. وتهدف الدراسة ايضاً الى تعيين نمط توزيع الأنواع النباتية على مستوى المجتمع النباتى و مستوى منطقة الدراسه ككل، بالاضافه الى تقدير التنوع الحيوي للمجتمعات النباتية. تمت دراسه الغطاء النباتى فى ١٠٣موقعاً تمثل التدرج فى رطوبة التربه بدءاً من حافة المياه حتى الجسر. أدى إستخدام التحليل الدليلى ثنائى الاتجاه (TWINSPAN) الى تقسيم الغطاء النباتى الى أربعة مجتمعات نباتية رئيسية مختلفة فى خصائص التربة ، الطوبوغرافيا و مدى التدخلات البشريه. وأظهرت الدراسة أن رطوبة التربة و التوصيل الكهربى لمستخلص التربة يؤثران بشكل كبير على تركيب المجتمعات النباتية. كما بينت النتائج ايضا التأثير المهم للكربون العضوى وقوام التربه على تركيب الغطاء النباتى. وأظهرت النتائج أن توزيع الأنواع النباتية على مستوى المجتمع النباتى و مستوى منطقة الدراسة ككل يأخذ نفس النمط حيث أن معظم الأنواع تنتشر فى عدد قليل من المواقع. وتتفق هذه النتائج مع تنبوءات فرضية النيش (الخن) البيئى. تتميز المجتمعات النباتية التى تسود منحدرات نهر النيل بقيم مرتفعة للتنوع الحيوي وذلك عند مقارنتها بالمجتمعات التى تنمو على حواف المياه و الجسور. وتم تفسير التنوع الحيوي للمجتمعات النباتية فى ضوء العوامل البيئية للموئل.