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Vegetation diversity in natural and agro-ecosystems of arid lands

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Key words: Desert, Diversity, Egypt, Vegetation, Weeds.

Abstract: Vegetation in natural desert and agro-ecosystems was investigated in the middle sector of Egypt. The vegetation was classified by the Two Way Indicator Species Analysis technique (TWINSPAN) into nine vegetational groups representing seven habitat types: desert, fallow land, winter crops of old cultivated land, summer crops of old cultivated land, *Citrus* orchards, winter crops of reclaimed land, and summer crops of reclaimed land. Detrended Canonical Correspondence Analysis (DCCA) demonstrates that soil factors especially soil texture, $CaCO_3$, organic carbon and electric conductivity contribute significantly to the distribution of species. In all habitat types, species diversity is higher in winter than in summer season. The weed species diversity is greater in the reclaimed areas compared to the old cultivated land and in winter crops than in summer ones.

Abbreviations: TWINSPAN - Two Way Indicator Species Analysis, DCA - Detrended Correspondence Analysis, DCCA - Detrended Canonical Correspondence Analysis.

Nomenclature: Täckholm (1974) and Boulos (1995, 1999, 2000 and 2002).

Introduction

The patterns of water availability produced by horizontal redistribution (Kassas 1953, Wondzell et al. 1996) or by differences in soil texture (Fossati et al. 1999) often determine the distribution of vegetation in desert regions. Desert vegetation is a complex dynamic phenomenon, deserves to be classified (Mucina 1997) and described.

We focus on the "wadis" (valleys), the most important ecosystems in the mountainous desert landscape of the world (Monod 1992), where the water supply is many times the recorded rainfall of the region as the wadi collects water from the surrounding often extensive catchment area. The moisture advantage is counterbalanced by two destructive factors: torrents and, since wadis contain vegetation richer than the other types of desert habitats (Kassas and Imam 1954), overgrazing.

The increase in the human population of Egypt necessitates the expansion of the cultivated land wadis. This was achieved by the reclamation of many desert areas during the past few decades. This human interference causes the weedy species to replace the natural plants in these reclaimed areas (El-Bakry 1982), which are considered as transitional habitats between the old cultivated land and desert.

The vegetation of wadis of the Egyptian deserts has been studied by such authors as Kassas (1952), Migahid et al. (1959), Kassas and Zahran (1962 and 1965), El-Sharkawi et al. (1982), El-Sharkawi and Ramadan (1983, 1984 and 1986), Springuel et al. (1986), El-Ghareeb and Shabana (1990), Dargie and El-Demerdash (1991), Mashaly (1996), Farghali (1998), Fossati et al. (1998) and Emad El Deen and Waly (2000). Yet, studies on the vegetation of the reclaimed land in Egypt are very limited. The most recent study by Shehta and El-Fahar (2000) is concerned with the vegetation of the reclaimed areas northeast of the Nile Delta. It has been estimated that the farm management practices such as application of herbicides (Hegazy 1994, Légere and Samson 1999, Leeson et al. 2000), crop rotation (Haas and Streibig 1982, Derksen et al. 1994), tillage (Derksen et al. 1993, Thomas and Frick 1993) and use of fertilizers (Hume 1982, Andersson and Milberg 1998) contribute significantly to the expansion of the weed community. Each management practice exerts a different selection pressure on weed species (Grime 1988). The many factors involved in the formation of the weed community make it difficult to evaluate the relative importance of each individual factor (Pysek and Lepš 1991). Selection of a limited number is in order.

Furthermore, weed communities diversity, important as is, has little been investigated (Précsényi and Pozsgai 1985, Horváth 1990) and most of the diversity studies on weeds focus on the impact of the management practices on the weed community diversity (e.g., Clements et al. 1994, Stevenson et al. 1997, Doucet et al. 1999). The extension into phytosociological studies can provide weed biologists with the quantitative information required in developing comprehensive weed community management strategies and also supply baseline information for measuring changes in the weed flora in the future (Frick and Thomas 1992). Such studies are still limited in Egypt (Shaltout et al. 1992, El-Demerdash et al. 1997).

In specific terms, the objective of the present study is to delineate the different plant communities in relation to habitat types, and in relation to these to estimate and discuss plant species diversity in desert sites, cultivated and transitional.

Study area

The study area, Beni-Suef governorate (latitudes 28^{o} 36’ to 29^{o} 26’ N and longitudes 30^{o} 36’ to 31^{o} 21’ E), is located about 120 km south of Cairo (Fig. 1). It consists of seven districts namely: El-Wasta, Nasser, Beni-Suef, Ihnasya, Beba, Somosta and El-Fashn. Beni-Suef governorate includes three main terrestrial habitats; desert, fallow land and cultivated land. The total annual rainfall is 7.8 mm with the rainy season stretching from November to April. The mean monthly air temperature ranges between 12.2 C$^{\circ}$ during January and 29.1 C$^{\circ}$ during July. The mean relative humidity varies between 35% during May and 57% during December.

Materials and methods

Vegetation analysis

A total of 120 stands were located over two growing seasons (1998–1999 and 1999–2000). The stands covered the different habitat types in six sites of the study area. The number and distribution of the stands through the different habitats are shown in Table 1.

Stands and sites were selected so as to represent the variation of vegetational, climatic and edaphic characteristics prevalent in the area. In selecting each stand, care was taken to ensure reasonable degree of physiographic and physiognomic homogeneity of both habitat and vegetation.

For every stand, a floristic list and plant counts were taken within 10 quadrats from which the mean relative density and relative frequency of species (Hegazy et al. 1998) were calculated as follows:

Density = (number of individuals / area sampled)

Relative density = (density for a species) / (total density for all species) x 100

Frequency = (number of sampled quadrats in which species occurs) / (total number of quadrats sampled)

Relative frequency = (frequency value for a species) / (total of frequency values for all species) x 100

Individual plants in every quadrat were measured for height and cover (Ohtsuka and Ohsawa 1994, Hegazy 1996). To evaluate the height performance of each species, the relative height (*RH*) was calculated by the equation:

$$RH = 100\ H / PH$$

where H is the measured height and PH is the potential height of each species based on the maximum height measured in all quadrats investigated and in the surrounding area. The relative cover (*RC*) of each species was calculated by the equation:

$$RC = (RH \times C \text{ of the species} / \text{sum of } RH \times C \text{ of all species}) \times 100$$

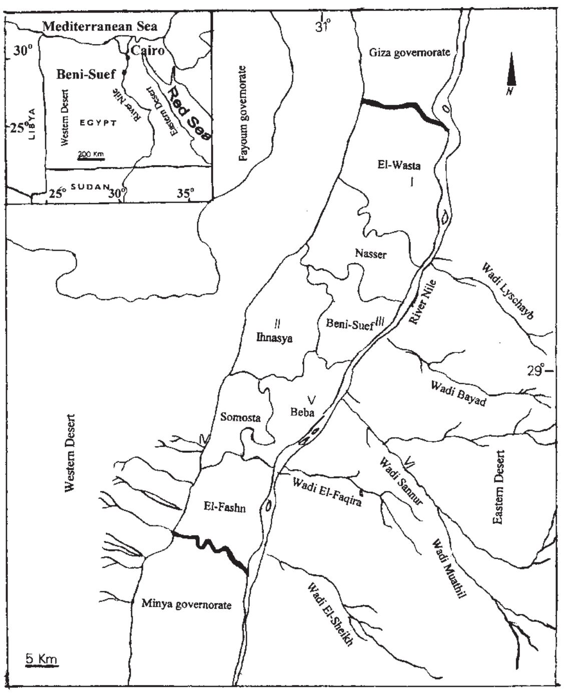

Figure 1. Map of the study area indicating the locations.

Table 1. The distribution of the sampled stands in the different habitat types of the study area. I = El-Wasta, II = Ihnasya, III = Beni-Suef, IV = Somosta, V = Beba, VI = Wadi Sannur.

Habitat			Site	Number of stands
Desert			VI	23
Fallow land			II & III	8
Cultivated land	Old cultivated land	Wheat	I, III & V	9
		Broad bean	I, III & V	9
		Egyptian clover	I, III & V	7
		Cotton	I, III & V	9
		Maize	I, III &V	8
		Citrus orchards	I, III & V	10
	Reclaimed land	Wheat	IV	12
		Onion	IV	9
		Maize	IV	10
		Pea nut	IV	6

where C is the cover of the species calculated as percentage of ground surface by the line intercept method (Mueller–Dombois and Ellenberg 1974). Four line intercept transects were randomly placed within every quadrat.

Relative density, relative frequency and relative cover were summed up for each species to give the importance value (IV) out of 300 in each stand. The size of the quadrat was 5 x 5 m in desert, 2 x 2 m in fallow land and 1 x 1 m in cultivated land.

Species diversity

The Shannon–Wiener index (H') and Shannon–evenness index ($E1$) (Ludwig and Reynolds 1988, Orlóci 1991, He and Orlóci 1993) were determined for the different habitats in both winter and summer seasons as follows:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \ ,$$

where $p_i = n_i/N$ = proportional abundance of species i in a habitat made up of s species, n_i = the number of stands containing species i and $N = \sum n_i$.

The evenness index was calculated as:

$$E1 = H' / \ln s \ .$$

Soil analysis

In each stand, three soil samples were taken along the depth of 0-50 cm. The three samples were pooled together in one composite sample per stand. These samples were air dried, sieved through 2 mm sieve and stored in paper bags until analysis.

For soil texture analysis, the coarse fractions were separated by sieve method. In this method, a known weight of samples were passed through a series of sieves of 2 mm, 0.25 mm and 0.05 mm diameters to separate gravels (>2 mm), coarse & medium sand (2–0.25 mm), fine & very fine sand (0.25–0.05 mm) and silt & clay (<0.05 mm). The amount of each fraction was expressed as percentage of the original weight used. Silt was separated from clay by pipette method (Piper 1944).

The percentage of $CaCO_3$ was estimated by titration against 1N HCl (Jackson 1962). Oxidizable organic carbon was determined by using the Walkely and Black rapid titration method (Black 1979).

Soil–water extracts of 1:5 were prepared and used for determination of electric conductivity (E.C.), soil reaction (pH) and bicarbonate (HCO^{-}_3). Electric conductivity was determined by using electric conductivity meter. Soil reaction was measured by a glass electrode pH meter. Bicarbonate was determined by titration with 0.1 N HCl using methyl orange as indicator (Jackson 1962).

Multivariate analyses and statistical testing

TWINSPAN, Two Way Indicator Species Analysis (Hill 1979), was applied for the classification of stands and species into groups based on the importance value of the species. Detrended Correspondence Analysis (DCA, ter Braak 1987) was used to ordinate stands and species in two–dimensional space using the importance value of species. The Detrended Canonical Correspondence Analysis (DCCA, ter Braak 1987) was applied to relate the different TWINSPAN groups and individual species to the different edaphic factors and to evaluate the relative importance of these factors. Soil data of the TWINSPAN groups were compared by one–way ANOVA (Snedecor and Cochran 1962).

Results

Floristic composition

A total of 150 species belonging to 33 families and 118 genera were recorded. The graminaceous species have the highest contribution to the total flora (32 species) followed by members of Asteraceae (22 species), Fabaceae (17 species) and Brassicaceae (10 species). A total of 105 weed species were recorded (see Appendix). These comprise 54 winter weeds, 24 summer weeds and 27 all-year weeds. Among the all-year weeds, 17 are with winter affinity while the others are with summer affinity. Within the desert habitat, 54 species were recorded. Some species were found to grow both as common weeds in the cultivated land and as desert annuals after winter rains.

Vegetation classification

The application of TWINSPAN based on the importance value of the recorded species in 120 stands produced nine vegetational groups coinciding with habitat type variation. These groups are labeled A, B, C, D, E, F, G, H and I (Fig. 2). Each group comprises a set of stands, which are similar in their vegetation and are characterized by specific indicator species.

Group A represents the desert habitat type and is dominated by *Zygophyllum coccineum* and *Zilla spinosa*. This group is differentiated into subgroups at the subsequent levels of classification dominated by *Pulicaria crispa, Haloxylon salicornicum, Tamarix nilotica, Panicum turgidum* and *Juncus rigidus.*

Group F comprises the stands of the summer crops of the old cultivated land. *Xanthium strumarium* is the indicator species of this group while *Echinochloa colona, Portulaca oleracea, Corchorus olitorius* and *Brachiaria reptans* are the dominant species. *Euphorbia heterophylla, Dinebra retroflexa, Hibiscus trionum, Amaranthus lividus, A. hybridus, Sida alba, Convolvulus arvensis* and *Solanum nigrum* are the important associated species.

Group G includes the habitat type of the winter crops of the old cultivated land. The indicator species of this group is *Ammi majus* while the dominant species are *Anagallis arvensis, Sonchus oleraceus, Coronopus squamatus, Beta vulgaris, Rumex dentatus, Euphorbia helioscopia, Chenopodium murale, Melilotus indicus* and *Phalaris paradoxa.* The associated species are represented by *Capsella bursa-pastoris, Trifolium resupinatum, Medicago polymorpha, Polypogon monspeliensis, Chenopodium album, Poa annua* and *Cichorium endivia.*

Group D comprises stands of *Citrus* orchards. This group is characterized by *Oxalis corniculata* and *Urtica urens* and the dominant *Stellaria pallida, Euphorbia peplus* and *E. helioscopia.*

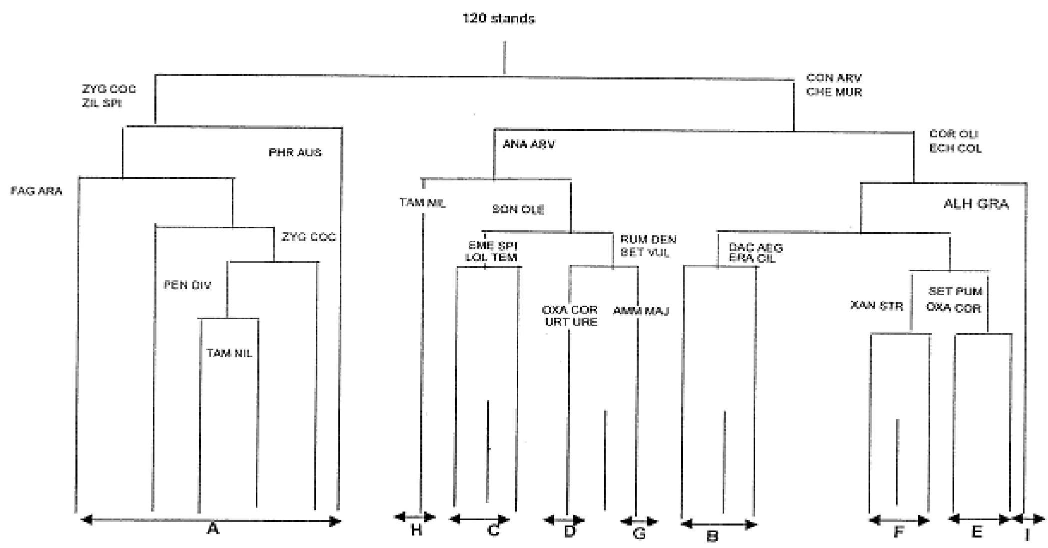

Figure 2. TWINSPAN dendrogram of 120 stands based on the importance value of the species. Indicator species names are abbreviated to the first three letters of both genus and species names.

The rest of the stands of the *Citrus* orchards which are not included in group D are represented by group E. *Cynodon dactylon, Echinochloa colona, Portulaca oleracea, Brachiaria reptans* and *Cyperus rotundus* are dominant.

Some stands of the fallow land constitute group H. *Tamarix nilotica* is the indicator and also dominant species of this group. The associated species include *Hordeum marinum, Phragmites australis* and *Polypogon monspeliensis.*

Group I includes the remaining stands of fallow land not separated by group H. These stands are indicated by *Alhagi graecorum. Pluchea dioscoridis* shares the dominance with *Cynodon dactylon.*

Group B includes the stands of the summer crops of the reclaimed land, indicated by *Dactyloctenium aegyptium, Eragrostis cilianensis* and *Chenopodium album.* The dominant species of this group include *Echinochloa colona, Portulaca oleracea, Corchorus olitorius* and *Brachiaria reptans.*

The habitat type of the winter crops of the reclaimed land is represented by group C. In this group, *Chenopodium murale* co-dominates with *Melilotus indicus, Sonchus oleraceus* and *Emex spinosa.* The important associated species are *Chenopodium album, Malva parviflora, Anagallis arvensis, Polypogon monspeliensis, Phalaris paradoxa, Cynodon dactylon, Trigonella hamosa, Lactuca serriola,* and *Sisymbrium irio.*

DCA ordination

The ordination of the 120 stands given in Figure 3 indicates the segregation of the TWINSPAN groups according to three different habitat types. Stands of group A which represent the desert habitat type are located nearly at the upper right side of the diagram, while stands of

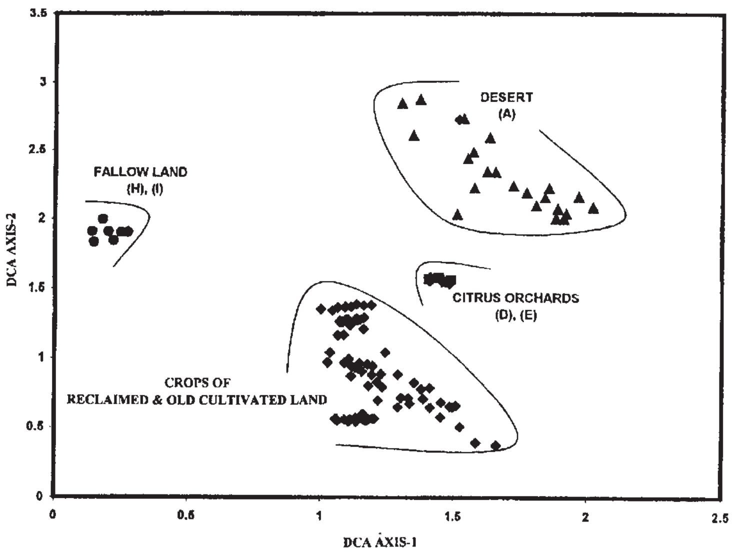

Figure 3. DCA ordination of 120 stands based on the importance value of species with TWINSPAN groups superimposed. Stands of the crops of reclaimed and old cultivated land are further separated in Fig. 4.

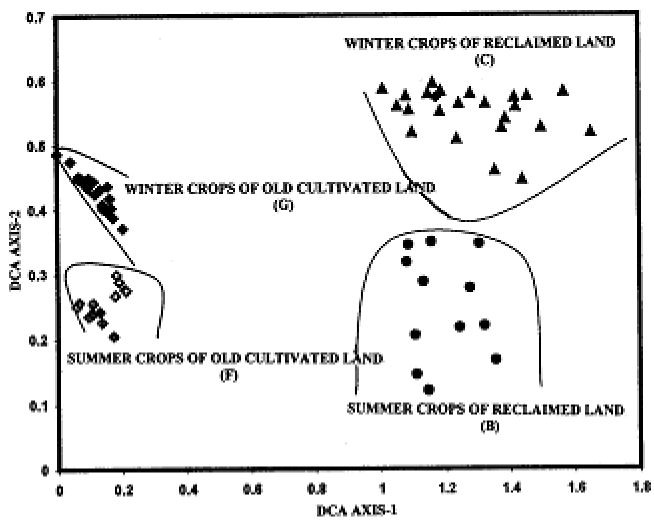

Figure 4. DCA ordination of 39 stands of the crops of reclaimed and old cultivated land based on the importance value of species with TWINSPAN groups superimposed.

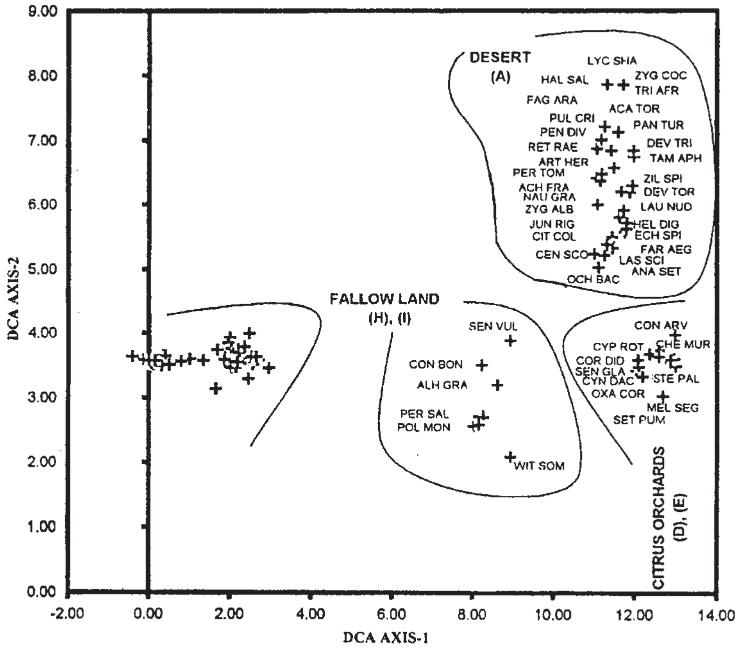

Figure 5. DCA ordination of species in 120 stands with TWINSPAN groups superimposed.

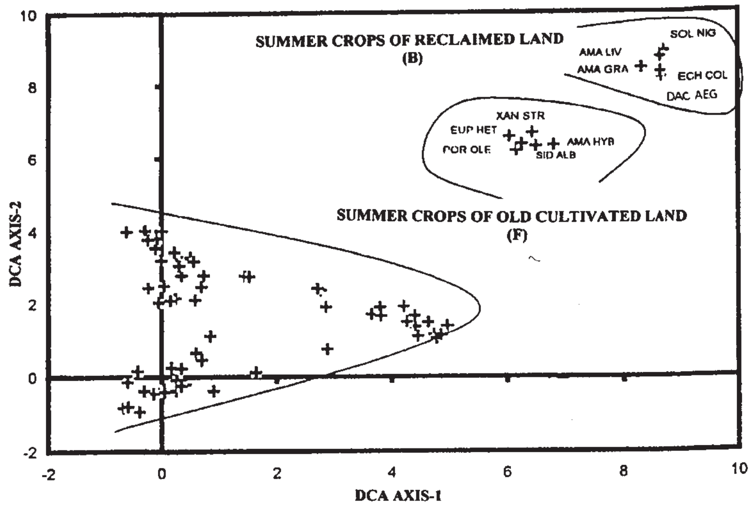

Figure 6. DCA ordination of species in 79 stands representing the crops of reclaimed and old cultivated land with TWINSPAN groups superimposed.

groups H and I of the fallow land are arranged together nearly at the middle of axis 2. Stands of groups D and E for the Citrus orchards are arranged together below group A.

Stands of the other TWINSPAN groups (79 stands) are grouped together nearly at the middle of axis 1. They are not separated from each other in the dimensions shown. These 79 stands which represent the habitat types of winter crops of the old cultivated land, winter crops of the reclaimed land, summer crops of the old cultivated land and summer crops of the reclaimed land are further separated by DCA in Figure 4. This diagram indicates the segregation of four TWINSPAN groups on the ordination plane. Group C of the winter crops of reclaimed land occupies the upper right side of the ordination diagram while the stands of group B which represent the summer crops of the reclaimed land are located at the end of axis 1. The two groups F and G are separated along axis 2.

The DCA ordination of species in all the studied stands (Fig. 5) demonstrates the separation of TWINSPAN groups of three habitat types. Species of group A representing the desert habitat type are located at the upper right side of the diagram, while those of groups D and E for *Citrus* orchards are arranged nearly at the end of axis 1. Groups H and I of the fallow land are arranged nearly at the middle of the ordination diagram.

Species of the other TWINSPAN groups belonging to the crops of reclaimed and the old cultivated land (79 stands) are arranged together forming one group nearly at the middle of axis 2. The DCA ordination of these species (Fig. 6) shows the separation of group B which represents

Table 2. Soil characteristics of the TWINSPAN groups representing the different habitat types in the study area. Values are means followed by standard deviations. *PV* is the significant level according to the LSD-test. ns = not significant. A = desert, B = summer crops of reclaimed land, C = winter crops of reclaimed land, D & E = *Citrus* orchards, F = summer crops of old cultivated land, G = winter crops of old cultivated land, and H & I = fallow land.

Soil properties	TWINSPAN groups									*PV*
	A	B	C	D	E	F	G	H	I	
Organic carbon (%)	0.6±0.2	0.7±0.2	0.6±0.2	2.3±0.7	2.4±0.7	1.7±0.4	1.6±0.3	2±0.4	1.6±0.4	0.05
Ca CO_3 (%)	20.8±7.3	8.5±2.9	7.6±2.4	3.2±0.6	3.1±0.5	3.5±0.7	3±0.3	3.2±0.5	2.7±0.2	0.001
Electric conductivity (ds/m)	1.15±0.1	0.9±0.1	1.3±0.2	0.3±0.05	0.2±0.01	0.4±0.04	0.3±0.02	3.2±0.3	2.8±0.2	0.01
PH	8.1±0.3	7.7±0.3	7.7±0.2	8.2±0.2	8.2±0.2	8.1±0.3	8.1±0.1	7.9±0.4	7.8±0.2	0.05
HCO^-_3(%)	0.1±0	0.03±0	0.1±0	0.1±0	0.1±0	0.1±0	0.1±0	0.1±0	0.1±0	ns
Gravels (%)	26.5±7.5	13.5±5.6	12.6±7.1	0±0	0±0	0±0	0±0	0±0	0±0	0.01
Coarse & medium sand (%)	41.6±8	32.9±4.4	32.9±8.7	0±0	0±0	0±0	0±0	0±0	0±0	0.01
Fine & very fine sand (%)	23.5±5	33.8±4.6	31.3±8.6	38.6±2.2	36.6±3.4	37.5±3.3	35.9±3.6	42±4.7	39±4.5	0.05
Silt (%)	4.2±0.4	9.4±3.8	10.3±3.2	19.6±1	18.2±2	19.6±1.7	19.1±1.5	19.3±1.3	19.3±1	0.01
Clay (%)	4.1±0.4	11.6±4.3	10.4±3.6	41.8±1.7	45.2±5	42.9±3.4	44.6±3.1	41.3±4.8	41.8±5.3	0.001

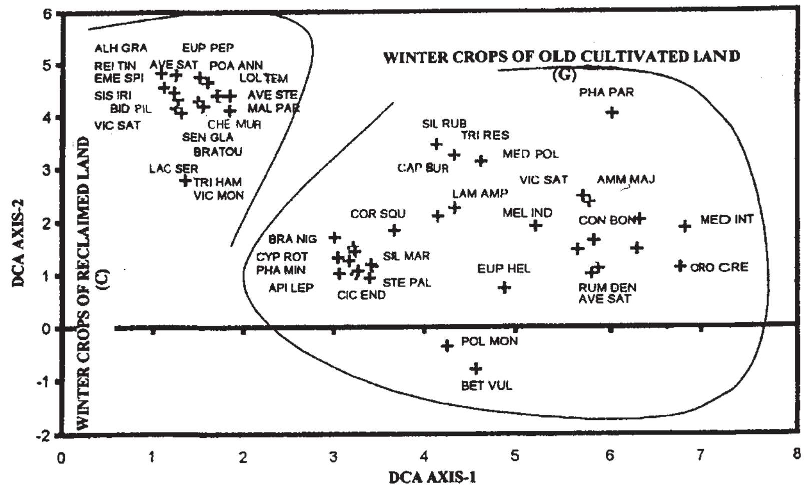

Figure 7. DCA ordination of species in 46 stands of the winter crops of reclaimed and old cultivated land with TWINSPAN groups superimposed.

the summer crops of the reclaimed land and group F for the summer crops of the old cultivated land.

Species of the remaining TWINSPAN groups C and G are clustered together in one group nearly at the origin of the two axes (Fig. 6). Species in the 46 stands which represent the winter crops of the reclaimed and the old cultivated land (groups C and G, respectively) are separated by DCA (Fig. 7). Species of group C are separated along axis 1 while those of group G are separated along axis 2.

Vegetation – soil relationships

The results in Table 2 indicate considerable variation in the edaphic factors among the stands of the different vegetational groups. The percentage of organic carbon attains high values of 2.3% and 2.4% in groups D and E, respectively. In the other vegetational groups, the percentage of organic carbon ranges from 0.6% in groups A and C to 2% in group H. The percentage of $CaCO_3$ is maximum (28.8%) in group A followed by group B (8.5%) and group C (7.6%). The percentage of $CaCO_3$ varies in the remaining groups between 2.7% for group I and 3.5% for group F. Electric conductivity attains high values of 3.2 and 2.8 ds/m in both groups H and I, respectively. Relatively high values of 0.9, 1.15 and 1.3 ds/m are recorded in groups B, A and C, respectively, while electric conductivity of the other groups ranges between 0.2 ds/m in group E and 0.4 ds/m in group F. Soil pH ranges from 7.7 in groups B and C to 8.2 in groups D and E. Non-significant differences are observed between the values of HCO^-_3 of the different TWINSPAN groups.

Significant differences are observed in soil texture among the different vegetational groups. The percentage of gravels attains highest value of 26.5% in group A followed by group B (13.5%) and group C (12.6%). Soils supporting the other vegetational groups are devoid of gravels. The percentage of coarse and medium sand

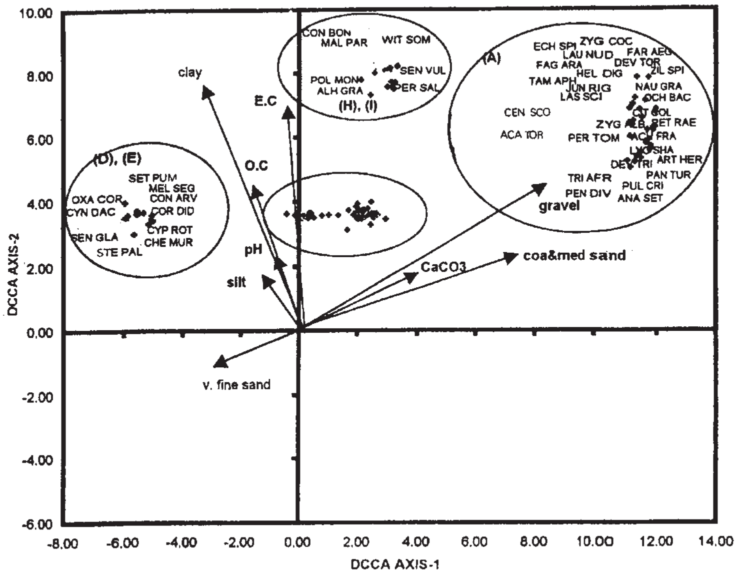

Figure 8. DCCA species-soil variable biplot for 120 stands, with arrows and points indicating the soil factors and species, respectively.

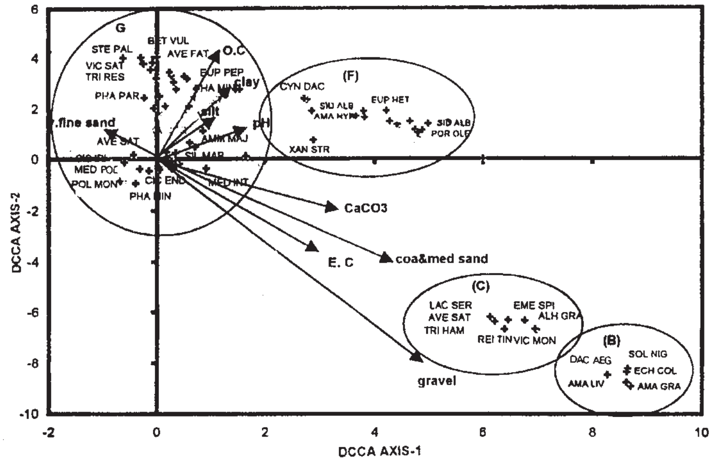

Figure 9. DCCA species-soil variable biplot for 79 stands, representing the crops of reclaimed and old cultivated land, with arrows and points indicating the soil factors and species, respectively.

shows a maximum value of 41.6% in group A followed by a mean value of 32.9% in groups B and C. On the other hand, soils of the other vegetational groups are devoid of coarse and medium sand. The percentage of fine and very fine sand varies between 23.5% for group A and 42% for group H. The percentage of silt shows a maximum value of 19.6% in groups D and F and a minimum value of 4.2% in group A. The percentage of clay exhibits relatively low values of 4.1%, 10.4% and 11.6% in groups A, C and B, respectively. On the other hand, the other vegetational groups show relatively high values, which vary between 41.3% and 45.2% in groups H and E, respectively.

The correlation between vegetation and soil variables is seen in the DCCA ordination biplots (Figs 8 and 9) in which soil variables are represented by arrows. The edaphic variables that have long arrows are more important in the ordination and have most probably important influence on community variation and species distribution. The angle between an arrow and each axis is a reflection of its degree of correlation with that axis.

Figure 8 shows that species in group A (desert) exhibit a close relationship with high percentage of gravel, coarse and medium sand and $CaCO_3$. Species of both groups D and E (*Citrus* orchards) are highly correlated with organic carbon (O.C) and clay. Species of both groups H and I (fallow land) show a close relation with high electrical conductivity (E.C). Figure 9 indicates that species of the two groups B and C (summer and winter crops of the reclaimed land, respectively) are highly correlated with gravels, coarse and medium sand and electrical conductivity. Species in groups F and G (summer and winter crops of old cultivated land, respectively) have strong relations with the high organic carbon, clay and pH value.

The effect of soil on the weed species distribution was also demonstrated by the DCA ordination of the species present in the wheat crops of the reclaimed and the old cultivated land (Fig. 10). In this ordination diagram, spe-

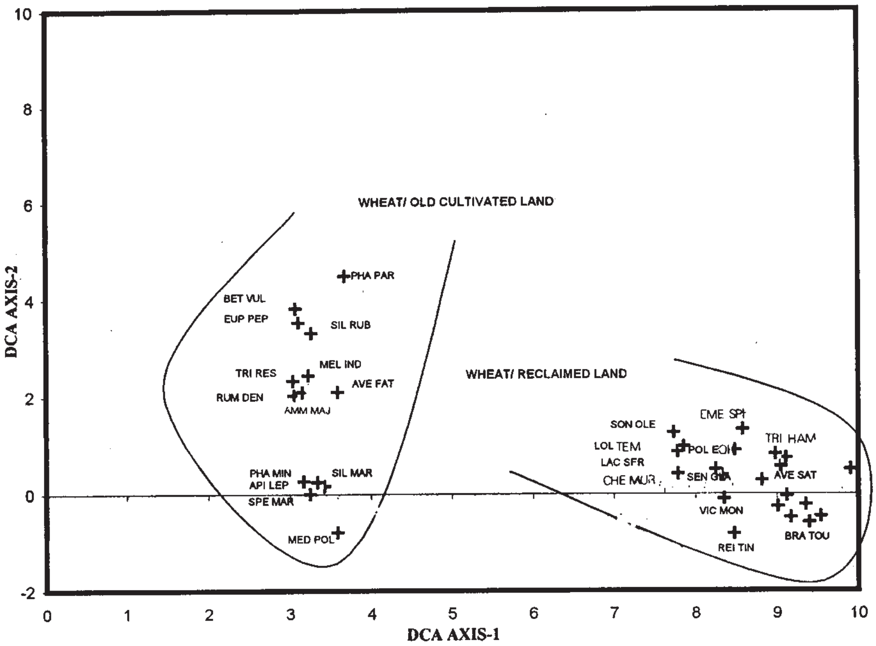

Figure 10. DCA ordination of species in 21 stands, representing the wheat crops of reclaimed and old cultivated land.

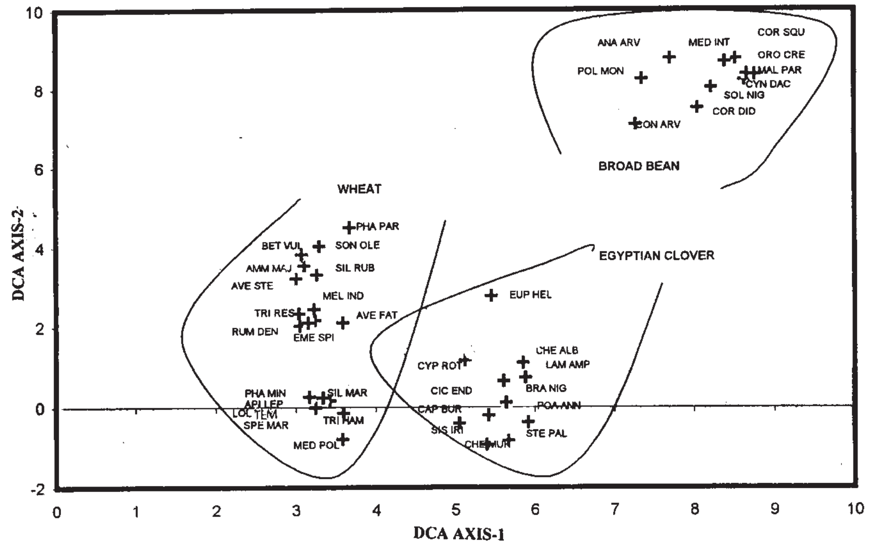

Figure 11. DCA ordination of species in 25 stands of the winter crops of old cultivated land.

cies of old cultivated land are separated from those of the reclaimed land. Among the species that dominate the old cultivated land are *Beta vulgaris, Phalaris paradoxa, Avena fatua* and *Ammi majus,* while *Avena sativa, Emex spinosa, Chenopodium murale* and *Melilotus indicus* dominate the reclaimed land.

Crop – weed relationships

The effect of crop type on the weed species distribution is demonstrated by the DCA ordination (Fig. 11) of the species present in the three studied winter crops of the old cultivated land (wheat, broad bean and Egyptian clover). This ordination diagram demonstrates the segregation of three groups of species. Each of these groups represents the species of one crop. The common weeds of wheat are *Avena fatua, Beta vulgaris* and *Phalaris paradoxa,* while those of Egyptian clover are *Cichorium endivia*, *Brassica nigra* and *Capsella bursa-pastoris.* For broad bean *Coronopus squamatus, Orobanche crenata, Anagallis arvensis* are the common weed flora.

Species diversity

In either the winter or summer season as shown in Figure 12a, the habitat type of the fallow land attains the lowest species diversity as measured by the Shannon-Wiener index. The habitat types of the desert, crops of reclaimed land, crops of old cultivated land and *Citrus* orchards showed non-obvious differences.

In both winter and summer seasons, the evenness value decreases from high to lower values in fallow land,

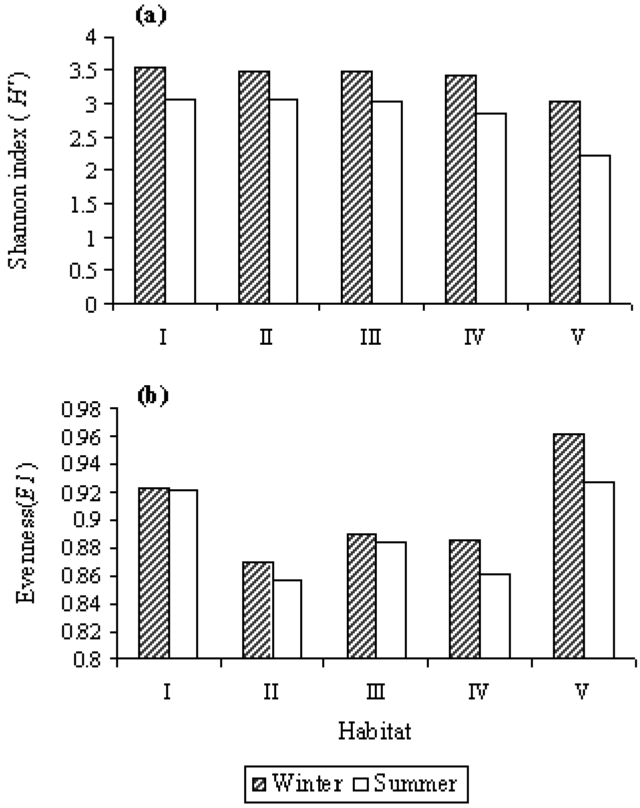

Figure 12. Species diversity in the different habitat types of the study area. I = *Citrus* orchards, II = desert, III = crops of reclaimed land, IV = crops of cultivated land, and V = fallow land.

followed by *Citrus* orchards, crops of the reclaimed land, crops of the old cultivated land and desert (Fig. 12b). In all habitat types, the species diversity is higher in winter than in the summer season.

Discussion

The vegetation of the study area was classified into nine vegetational groups representing seven habitat types, namely desert, fallow land, *Citrus* orchards, winter crops of old cultivated land, summer crops of old cultivated land, winter crops of reclaimed land and summer crops of reclaimed land.

The studied desert habitat type is represented by the first 50 km of Wadi Sannur from the Nile Valley side (see Fig. 1). The first part (1 km) at the downstream of this wadi is characterized by saline soils. This salinized part supports heavy growth of halophytic species such as *Juncus rigidus, Tamarix nilotica* and *Zygophyllum album.* The rest of the studied part of the wadi is dominated by xerophytic perennials including *Zilla spinosa*, *Zygophyllum coccineum, Haloxylon salicornicum, Panicum turgidum, Pulicaria crispa* and *Pergularia tomentosa.* These perennials constitute the permanent vegetation in the wadi. During the rainy season, annual species such as *Schismus barbatus, Rumex vesicarius, Diplotaxis acris* and *Ifloa spicata* form a green plant cover.

The vegetation of Wadi Sannur belongs to the synsystematic alliance of *Zygophyllaeion coccini* which is recorded in the wadis east of Minya province (El-Sharkawi and Ramadan 1983) and in Wadi-Assiuti located in the Eastern desert (Farghali 1998). The higher species diversity of the desert habitat type in winter than in summer season can be related to the winter rains which promote the growth of many annual species.

The vegetation of the old cultivated land is differentiated into two main groups, one representing the vegetation of the winter crops, while the other representing the summer crops. This differentiation between the weed vegetation of the winter and summer crops as demonstrated by the TWINSPAN classification indicates that climate plays an important role in the composition of the weed community (Kosinová 1975).

The crop plant has a major effect on the weed flora (Andersson and Milberg 1998). This effect may be indirect. For example, herbicides, soil management and fertilization regimes may vary depending on the crop type, and these factors influence most weed species (Froud-Williams et al. 1983, Leeson et al. 2000).

As demonstrated by the ordination of the species of the different winter crops of the old cultivated land, the crop type plays an important role in the structure of the weed community. The role of the crop type is indicated by the restriction of the parasitic weed species to specific crops. For example, *Orobanche crenata* with broad bean and *Cuscuta planiflora* with Egyptian clover. Some species are more abundant in certain crops with which they exhibit morphological and phenological similarities (e.g., *Avena* spp. in wheat crop). Such similarities make the recognition of the weed species from the crop plants very difficult and consequently hinder its control. The dominance of the weed species with discoid stems such as *Cichorium endivia* in Egyptian clover can be related to the fact that this crop undergoes three to five cuts during its growth period. This cutting may lead to the disappearance of the weed species other than those with discoid stems (Abd El-Ghani and El-Bakry 1992).

The weed species diversity of the habitat types of the winter crops higher than those of the summer crops can be attributed to differences in the weed control methods of the two groups of crops. Due to the high density of the winter crops (wheat, Egyptian clover and broad bean), weeds are mainly controlled by hand pulling and this occurs nearly once during the growing period of the crop. On the other hand, the summer crops (cotton and maize) are cultivated in relatively widely spaced rows, and this allows the hoeing of the fields two times or more during the growing period of the crop. The more effective methods of weed control in summer crops decrease the diversity of their weeds.

In summer crops, the dominance is restricted to few species, e.g., *Echinochloa colona, Portulaca oleracea, Brachiaria reptans* and *Corchorus olitorius.* On the contrary, in winter crops, the abundance is distributed among a relatively large number of species including *Beta vulgaris, Anagallis arvensis, Coronopus squamatus, Ammi majus, Rumex dentatus, Melilotus indicus, Euphorbia helioscopia* and *Chenopodium murale.* This indicated by the higher evenness values of the habitat types of winter crops than those of the summer crops.

Citrus orchards (monitored only in the old cultivated land) have a relatively large number of perennial weeds when compared to the field crops because they are rarely ploughed. For the same reason, *Citrus* orchards are characterized by the abundance of the rhizomatous species compared to the field crops.

The environment of weeds in *Citrus* orchards is influenced by the protection given by the tree foliage. Two kinds of light conditions occur in *Citrus* orchards, the shaded microhabitat presents below the crowns of *Citrus* trees and the relatively sunny microhabitat presents between trees. This environmental micro-heterogeneity causes the weed community to be fragmented into isolated patches. The shade loving species such as *Oxalis corniculata* and *Stellaria pallida* dominate the shaded areas. On the other hand, the sunny places support the growth of other species growing in the field crops.

The shade effect produced by the *Citrus* trees keeps the soil moisten for longer time than in the open sites. This allows the growth of species characteristic of canal banks such as *Plantago major, Persicaria salicifolia, Gnaphalium luteo-album* and *Mentha longifolia.*

The present study indicates that the habitat type of *Citrus* orchards attains the highest species diversity (as measured by the Shannon–Wiener index) among the studied habitat types. This can be related to the presence of different kinds of light environments in *Citrus* orchards. Such environmental micro-heterogeneity promotes the diversity (Palmer and Maurer 1997, Orlóci et al. 2002).

The habitat type of the fallow land is dominated by perennials especially *Pluchea dioscoridis* and *Tamarix nilotica.* The dominance of these species in the abandoned areas may be attributed to their abilities to cope with the significant substrate alterations, which may inhibit the reestablishment of other long-lived species (Shaltout 1994).

As demonstrated in the present study and in others (e.g., El-Demerdash et al. 1997, El-Halawany 2000), soil factors affect the distribution of weed species. This may explain the differences in community composition between the reclaimed and old cultivated land.

The vegetation of the habitat type of the crops of the reclaimed land consists mainly of the weed species growing in the crops of the old cultivated land in addition to some desert annuals such as *Senecio glaucus, Reichardia tingitana* and *Launaea nudicaulis.* This may lead us to consider the habitat of the crops of the reclaimed land as transitional between the habitat of the crops of the old cultivated land and that of the desert. In the reclaimed land of the present study, the weedy species replace the natural plant communities and this is a widespread phenomenon (Staniforth and Scott 1991, Bazzaz 1996).

The habitat type of the crops of the reclaimed land exhibits higher weed species diversity than that of the crops of old cultivated land. This may be related to: (1) some desert annuals in addition to the weedy species are found to grow in the reclaimed land; (2) the low content of organic carbon and the sandy texture of the soil of the reclaimed land necessitate the addition of large amounts of manure compared to the soil of the old cultivated land and this may increase the diversity (Mt. Pleasant and Schlater 1994) in the reclaimed land because manure usually contain seeds of many weedy species; and (3) owing to the sandy texture of the reclaimed land, their crops are more frequently irrigated than those of the old cultivated land and this will give more chance for the establishment of the weed species in the reclaimed land and thereby increases their weed diversity.

Conclusion

TWINSPAN successfully divided the vegetation into nine vegetational groups closely linked with habitat variation. Ordination indicates that the vegetational groups are generally distinct, but in the dimensions probed some groups cannot be distinguished. The application of the DCCA ordination biplot clarifies that edaphic factors especially soil texture, $CaCO_3$, organic carbon and electric conductivity play a major role in the species distribution. Climate and crop type also contribute in a major way to the sorting of the species among the sites.

The habitat of the reclaimed land can be considered transitional between the the old cultivated land and the desert. This is because it includes, in addition to the weedy species growing in the old cultivated land, some desert annuals which behave as weeds.

The highest species diversity among the studied habitat types is in the *Citrus* orchards. This may be related to the (micro)environmental heterogeneity present in this habitat type. The higher species diversity of the habitat types of the crops of the reclaimed land than those of the crops of the old cultivated land may be attributed to the transitional nature of the reclaimed areas, as well as the differences in the management practices such as manure application which may favour the weed diversity in the reclaimed land.

The weed species diversity in the winter crops is higher than in the summer crops and this can be explained by the differences in the weed control methods between the two groups of crops which are more effective in the summer crops and thereby reduce their weed species diversity.

References

Abd El-Ghani, M.M. and A.A. El-Bakry. 1992. Studies on weed assemblages in croplands, Egypt, II. Egyptian clover fields. *Bull. Fac. Agric. Univ. Cairo* 43:1221-1252.

Andersson, T.N. and P. Milberg. 1998. Weed flora and the relative importance of site, crop, crop rotation, and nitrogen. *Weed Sci.* 46:30-38.

Bazzaz, F.A. 1996. *Plants in Changing Enviroments.* Cambridge University Press, Cambridge.

Black, C.A. 1979. *Methods of Soil Analysis.* American Society of Agronomy. 2:771-1572.

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

Boulos, L. 1999. *Flora of Egypt,* Vol. 1. Azollaceae-Oxalidace. Al Hadara Publishing, Cairo.

Boulos, L. 2000. *Flora of Egypt,* Vol. 2. Geraniaceae-Boraginaceae. Al Hadara Publishing, Cairo.

Boulos, L. 2002. *Flora of Egypt,* Vol. 3. Verbenaceae-Compositae. Al Hadara Publishing, Cairo.

Clements, D.R., S.F. Weise and C.J. Swanton. 1994. Integrated weed management and weed species diversity. *Phytoprotection* 75:1-18.

Dargie, T.C. and M.A. El-Demerdash. 1991. A quantitative study of vegetation-environment relationships in two Egyptian deserts. *J. Veg. Sci.* 2:3-10.

Derksen, D.A., A.G. Thomas, G.P. Lafond, H.A. Loeppky and C.J. Swanton. 1994. Impact of agronomic practices on weed communities: fallow within tillage systems. *Weed Sci.* 42:184-194.

Derksen, D.A., G.P. Lafond, A.G. Thomas, H.A. Loeppky and C.J. Swanton. 1993. Impact of agronomic practices on weed communities: tillage systems. *Weed Sci.* 41:409-417.

Doucet, C., S.E. Weaver, A.S. Hamill and J. Zhang. 1999. Separating the effects of crop rotation from weed management on weed density and diversity. *Weed Sci.* 47:729-735.

El-Bakry, A.A.H. 1982. Studies on plant life in the Cairo – Ismailia region. M. Sc. thesis, Faculty of Science, Cairo University, Egypt.

El-Demerdash, M.A., H.A. Hosni and N. Al-Ashri 1997. Distribution of the weed communities in the north east Nile Delta, Egypt. *Feddes Repert.* 108:219-232.

El-Ghareeb, R. and M.A. Shabana. 1990. Vegetation- relationships in the bed of wadi El-Sheikh of southern Sinai. *Vegetatio* 90: 145-157.

El-Halawany, E.F. 2000. Flora and vegetation of date palm orchards in Nile Delta, Egypt. *Proc. 1st Inter. Conf. Biol. Sci. Fac. Sci. Tanta univ.* 1:266-283.

El-Sharkawi, H.M. and A.A. Ramadan. 1983. Vegetation of inland desert in wadies in Egypt, IV. The wadi systems east of Minya province. *Feddes Repert.* 94:335-346.

El-Sharkawi, H.M. and A.A. Ramadan. 1984. Vegetation of inland desert in wadies in Egypt, V. Edaphic characteristics of plant communities in wadi systems east of Minya province. *Feddes Repert.* 95:547-557.

El-Sharkawi, H.M. and A.A. Ramadan. 1986. Vegetation of inland desert in wadies in Egypt, VII. Ecophysiological characteristics of plant communities in wadi systems east of Minya province. *Feddes Repert.* 97:373-382.

El-Sharkawi, H.M., F.M. Salama and A.A. Fayed. 1982. Vegetation of inland desert in wadies in Egypt, III. Wadi Gimal and Wadi El-Miyah. *Feddes Repert.* 93:135-145.

Emad El Deen, H.M. and N.M. Waly. 2000. Habitat and Floristic diversity in Wadi-Sudr area, south west Sinai. *Proc. 1st Inter. Conf. Biol. Sci. Fac. Sci. Tanta univ.* 1:228-241.

Farghali, K.A. 1998. Vegetation of main tributaries of Wadi El-Assiuti in Eastern Desert of Egypt after rainfall. *Egypt. J. Bot.* 38: 131-144.

Fossati, J., G. Pautou and J.P. Peltier. 1998. Wadi vegetation of the north-Eastern Desert of Egypt. *Feddes Repert.* 109:313-327.

Fossati, J., G. Pautou and J.P. Peltier. 1999. Water as resource and disturbance for wadi vegetation in a hyperarid area (Wadi Sannur, Eastern Desert, Egypt). *J. Arid Environ.* 43:63-77.

Frick, B. and A.G. Thomas. 1992. Weed surveys in different tillage systems in south western Ontario field crops. *Can. J. Plant Sci.* 72:1337-1347.

Froud-Williams, R.J., D.S.H. Drennan and R.J. Chancellor. 1983. Influence of cultivation regime on weed floras of arable cropping systems. *J. Appl. Ecol.* 20:187-197.

Grime, J.P. 1988. The C-S-R model of primary plant strategies-origins, implications and tests. In: L.D. Gottlieb and S.K. Jain (eds), *Plant Evolutionary Biology*. Chapman and Hall, London, pp. 371-393.

Haas, H. and J.C. Streibig. 1982. Changing patterns of weed distribution as a result of herbicide use and other agronomic factors. In: H.M. LeBaron and J. Gressel (eds), *Herbicide Resistance in Plants*. John Wiley & Sons, New York, pp. 57-79.

He, X.S. and L. Orlóci. 1993. Comparative diversity analysis of vegetation. *Abstracta Botanica* 17:79-86

Hegazy, A. K. 1994. Trade-off between sexual and vegetative reproduction of the weedy *Heliotropium curassavicum. J. Arid Environ.* 27:209-220.

Hegazy, A.K. 1996. Effects of cement-kiln dust pollution on the vegetation and seed-bank species diversity in the Eastern Desert of Egypt. *Environ. Conserv.* 23:249-258.

Hegazy, A.K., M.A. El-Demerdash and H.A. Hosni. 1998. Vegetation, species diversity and floristic relations along an altitudinal gradient in south-west Saudi Arabia. *J. Arid Environ.* 38:3 -13.

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

Horváth, K. 1990. Diversity studies on the weed community of a maize field. *Acta Ovariensis* 32:35-43.

Hume, L. 1982. The long-term effects of fertilizer application and three rotations on weed communities in wheat (after 21-22 years at Indian Head, Saskatchewan). *Can. J. Plant Sci.* 62:741- 750.

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

Kassas, M. 1952. Habitat and plant communities in the Egyptian desert, I. Introduction. *J. Ecol.* 40:342-351.

Kassas, M. 1953. Landforms and plant cover in the Egyptian desert. *Bull. Soc. Géog. Egypte* 26:193-205.

Kassas, M. and M. Imam. 1954. Habitat and plant communities in the Egyptian desert, III. The wadi bed ecosystem. *J. Ecol.* 42: 424-441.

Kassas, M. and M.A. Zahran. 1962. Studies on the ecology of the Red Sea coastal land, I. The district of Gebel Ataqa and El-Galala El-Bahariya. *Bull. Soc. Géog. Egypte* 35:129-175.

Kassas, M. and M.A. Zahran. 1965. Studies on the ecology of the Red Sea coastal land, II. The district from El-Galala El-Qibliya to Hurghada. *Bull. Soc. Géog. Egypte* 38:155-193.

Kosinová, J. 1975. Weed communities of winter crops in Egypt. *Preslia* 47:58-74.

Leeson, J.Y., J.W. Sheard and A.G. Thomas. 2000. Weed communities associated with arable Saskatchewan farm management systems. *Can. J. Plant Sci.* 80:177-185.

Légere, A. and N. Samson. 1999. Relative influence of crop rotation, tillage, and weed management on weed associations in spring barley cropping systems. *Weed Sci.* 47:112-122.

Ludwig, J.A. and J.F. Reynolds. 1988. *Statistical Ecology: a Primer on Methods and Computing*. John Wiley & Sons, New York.

Mashaly, I.A. 1996. On the phytosociology of Wadi Hagul, Red Sea coast, Egypt. *J. Environ. Sci.* 12:31-54.

Migahid, A.M., M. Al-Shafei, A.A. Abdel-Rahman and M.A. Hammouda. 1959. Ecological observation in western and southern Sinai. *Bull. Soc. Géog. Egypte* 32:165-205.

Monod, T. 1992. Du désert: Lecon inaugurale de l'enseignement de l'érémologie. *Sécheresse* 3:7-24.

Mt. Pleasant, J. and K. J. Schlater. 1994. Incidence of weed seed in cow (*Bos* sp.) manure and its importance as a weed source for cropland. *Weed Technol.* 8:304-310.

Mucina, L. 1997. Classification of vegetation: past, present and future. *J. Veg. Sci.* 8:751-760.

Mueller-Dombois, D. and H. Ellenberg. 1974. *Aims and Methods of Vegetation Analysis.* John Wiley & Sons, New York.

Ohtsuka, T. and M. Ohsawa. 1994. Accumulation of buried seeds and establishment of ruderal therophytic communities in disturbed habitat, central Japan. *Vegetatio* 110:83-96.

Orlóci, L. 1991. *Entropy and Information. Ecological Computations Series*: Vol. 3. SPB Academic Publishing, The Hague.

Orlóci, L., M. Anand, and V. D. Pillar. 2002. Biodiversity analysis: issues, concepts, techniques. *Community Ecology* 3:217-223.

Palmer, M.W. and T.A. Maurer. 1997. Does diversity beget diversity? A case study of crops and weeds. *J. Veg. Sci.* 8:235-240.

Piper, C.S. 1944. *Soil and Plant Analysis: a laboratory manual of methods for the examination of soils and the determination of inorganic constituents of plants.* A Monograph from the Water and Agriculture Research Institute. University of Adelaide, Adelaide.

Précsényi, I. and J. Pozsgai. 1985. Cukorrépavetés gyomnövényzetének diverzitása. *Növénytermelés* 34:299-304.

Pysek, P. and J. Lepš. 1991. Response of a weed community to nitrogen fertilization: a multivariate analysis. *J. Veg. Sci.* 2:237-244.

Shaltout, K.H. 1994. Post-agricultural succession in the Nile Delta region. *J. Arid Environ.* 28:31-38.

Shaltout, K.H., A. Sharaf El-Din and R.A. El-fahar. 1992. Weed communities of the common crops in Nile Delta region. *Flora* 187:329-339.

Shehta, M.N. and R.A. El-Fahar. 2000. The vegetation of reclaimed areas in Salhya region. *Proc. 1st Inter. Conf. Biol. Sci. Fac. Sci. Tanta univ.* 1:315-332.

Snedecor, G.W. and W.G. Cochran. 1962. *Statistical Methods* (5th ed.). Iowa State College Press, Iowa.

Springuel, I., A.M. Mekki and M. Soghir. 1986. Vegetation of the upstream parts of the wadi in the southern Eastern Desert, Egypt. *Aswan Sci. Tech. Bull.* 7:99-120.

Staniforth, R.J. and P.A. Scott. 1991. Dynamics of weed populations in a northern subarctic community. *Can. J. Bot.* 69:814-821.

Stevenson, F.C., A. Légere, R.R. Simard, D.A. Angers, D. Pageau and J. Lafond. 1997. Weed species diversity in spring barley varies with crop rotation and tillage, but not with nutrient source. *Weed Sci.* 45:798-806.

Täckholm, V. 1974. *Students' Flora of Egypt* (2nd ed.). Cairo University Press, Cairo.

ter Braak, C.J.F. 1987. *CANOCO- A FORTRAN program for canonical community ordination by [partial] [detrended] [canonical] correspondence analysis, principal components analysis and redundancy analysis (ver. 2.1).* TNO Institute of Applied Computer Science, Wageningen.

Thomas, A.G. and B.L. Frick. 1993. Influence of tillage systems on weed abundance in south western Ontario. *Weed Techn.* 7:699-705.

Wondzell, S.M., G.L. Cunningham and D. Bachelet. 1996. Relationships between landforms, geomorphic processes, and plant communities on a watershed in the northern Chihuahuan Desert. *Landscape Ecol.* 11:351-362.

Appendix EA4-4. A list of the species recorded in the study area with their families and the habitats in which they occur as well as the seasonality of the weed species. Downloadable from the web site of this issue at www.akkrt.hu.