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Factors affecting the spatial distribution of plant species in Nile islands of mid Egypt

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ABSTRACT

Altogether 152 species of vascular plant species were recorded, belonged to 49 families and 117 genera in 15 islands of the Nile at mid Egypt. The distribution of species showed high variability, the highest was 107 species in canal banks followed by the waste lands, 99 species; while the lowest was 27 species in onion farmlands. The application of Twinspan and Canonical Correspondence Analysis (CCA) resulted in the division of the monitored islands into 2 clear sets, submerged temporary and unsubmerged permanent islands that were subdivided into 4 subgroups. The correlation of these subgroups to the soil variables prevailing in the area of study was discussed. The islands of group A were highly correlated with sand and phosphates; group B was correlated with sand, nitrogen, organic matter and phosphates; while group C was affected by pH, electric conductivity, magnesium, and bicarbonates but islands of group D were affected by silt and organic matter. The interset correlation of the soil variables showed that CCA axis 1 was highly positively correlated with the electric conductivity (0.6465) and highly negatively (-0.4574) correlated with sand content of the soil. While, CCA axis 2 was highly positively (0.2557) correlated with the electric conductivity and highly negatively (-0.3891) correlated with organic matter. The ten different habitats-farmlands were divided into 4 different groups: Group A, comprised the orchards; group B, comprised the winter crops; the waste lands and canal banks were in group D and corn as the only monitored summer crop in Group C.

Keywords: Flora, Agro ecosystem, Weed-soil relationships, Statistical analyses, Sociological ranges.

1. INTRODUCTION

Egypt is an oasis created by the river in a region that was otherwise barren desert [1]. And today it renders fertile the only parts of Egypt which are productive of wealth; called the Nile valley and the delta of the Nile [2]. According to Rzoska [3], the Nile valley began to from 5.5 million years ago, during the Miocene period.

Before reaching the Mediterranean Sea, the Nile flows for about 6700 km through ten countries in north-eastern Africa [4]. Meister proposed that the source of the Nile is the Kagara River in Burundi [5]. It flows through lakes Victoria, Lyoga, Albert and Nasser, and its mouth is in Egypt at Mediterranean Sea. In 2008 El-Abassery and Hassan [6] cited that the length of the Nile in Egypt is about 1200 km from the southern border at Aswan to the Mediterranean coast. The Nile system has been subjected to large scale schemes of river control, as barrages and dams which have been built across the Nile. These have segmented the natural hydro biological system with undoubted effect on biota [7]. The construction of Aswan High Dam during 1960s affected the river morphology including islands formation and types [8].

El-Abassery and Hassan [6] cited that all of the islands are wetlands which are considered as a reservoir for the biodiversity and have special importance in the life of migratory birds, also all islands are surrounded by aquatic plants like *Phragmites* and Acacia trees (*Acacia nilotica*) which are considered good habitat for birds.

The earliest phytosociological study on weed in Egypt carried out by Tadros and Atta [9] who described the communities of rain fed barely fields in the western Mediterranean coastal region. Then, many studies have been carried out in the Nile region but most of them are floristic [10-14].

Hassib [15] cited that the flora of the Nile in Egypt comprises about 534 species (excluding algae), about 25% of the flora of the country. Many studies of the flora of the Nile have been carried out, particularly after the establishment of Aswan High Dam [16-37]. According to these studies, the vascular fresh water weed flora of Egypt includes 87 species of flowering plants in 45 genera representing 25 families: 12 are Dicotyledons and 13 are Monocotyledons in addition to 3 Pteridophytes's species (*Azolla filiculoides*, *Marsilea egyptiaca* and *M. capensis*).

El-Abassery and Hassan [6] proposed that there are some 500 islands in the main stream of the Nile and its Rosetta and Damietta branches. In addition, El-Hadidi and Hosni [38] indicated that these islands have great diversity in origin, size and structure; 144 of them have been designated in 1996 as protected areas and spread over 16 governorates; 27 of these protected islands are located at Aswan [39]. Moustafa [40] showed that Beni-Suef governorate has 46 islands that differ in length, width and space from each other with a total space of about 4500.12 Fadden (Fadden = c. 4200 m²).

Few studies were concerned with the plant life-forms of the riverian islands in the upper Nile valley in Egypt. Springuel [41] studied the natural vegetation of the islands of the first Cataract at Aswan, and El-Khatib [42] defined the current and past vegetation types of Kraman islands in the Nile at Sohag governorate. Mohamed and Hassan [43] described the plant life-forms of sedimentary islands in Minya governorate, while Hamada [44] studied the plant life-forms of seven islands at Aswan governorate. Recently Hamed et al. [45] worked on some riverian islands at Qena governorate. Also Abd El-Ghani [46] stated that the studies on the vegetation of aquatic ecosystems on the Nile islands have received little attention.

In a study of the species migration route in Nile islands in the same area, Amer et al. [47] confirmed that the most species rich families were Poaceae, Asteraceae, Fabaceae and Brassicaceae that made up almost 44.4% of the total flora. On the other hand, 28 families were very poor and represented by only one species each. Also, the life forms of the collected flora were dominated by the therophytes, 86 species with average of c. 57% followed by the hydrophytes (17.8%) and geophytes (7.2%). Chaemophytes and hemicryptophytes were equally represented by 7 species each, or about 4.6% of the total flora of the area. Nano-phanerophytes were represented by relatively considerable number of species (9 species, c. 6%), in comparison to meso- and microphanerophytes that were represented by only one species each.

The analyses of spatial variation in multi-species weed communities with environmental factors could be useful as a tool to develop a sustainable long-term weed control and soil management strategy [48]. At the same soil condition, some species thrive well [49] in addition the probability of finding these species growing together might be great, even though other factors also influence their abundance, as climate, ability for competition, seed production, capacity and geographic distribution. Because of their ecological requirements, weeds of Egyptian croplands differ from season to another. Several studies [50, 51] indicate that weeds can be grouped into 3 main categories according to their seasonal performance: 1) summer weeds, which are mostly restricted to the warmer months of the year; 2) winter weeds, which are more mostly restricted to the cooler months of the year; and 3) all-year weeds, which are present and active biologically throughout the year.

Application of numerical methods, as correlation and cluster analyses, and multivariate techniques such as canonical correspondence analysis, can be useful to understand the relationships between weed species and crops. The application of multivariate analysis techniques in weed studies was conducted in Egypt by several researchers in the Nile delta [28, 52-54]; in southern Sinai [55] and in Nile valley [56].

The aims of this work are: a) studying the floristic composition of representative Nile islands in mid Egypt, b) studying the factors that affect the spatial distribution of the flora in the Nile islands, c) studying the affinity between weeds and crops in the selected islands, d) to assess the influence of some environmental factors on weed species composition and distribution.

2. MATERIALS AND METHODS

The studied area, Beni-Suef Governorate, is located at road distance of about 90 km south of Cairo and consists of seven districts namely from south to north: El-Fashn, Somosta, Ehnasya, Beba, Beni-Suef, Nasser and El-Wasta (Fig. 1). It embraces three main terrestrial habitats; desert, fallow land and cultivated land. The rainy season stretches from November to April with a total annual rainfall of about 7.8 mm. The mean temperature values varies between 12.2°C and 29.1°C in January and July respectively. The mean relative humidity ranges between 35% in May and 57% in December [57].

2.1. Selected islands

Fifteen out of 46, the total number of Nile islands at Beni-Suef Governorate, were subjected to almost seasonal visits between 2009 and 2013 (Fig. 1). The selected 15 islands were classified into 7 inhabited permanent (unsubmerged) islands that were cultivated throughout the whole year, another 7 uninhabited submerged islands that were cultivated only in months of low Nile water level from November to June in most years and 1 uninhabited submerged and uncultivated island throughout the year. The islands that were covered with water in summer months, from July to October, are called temporary or submerged islands.

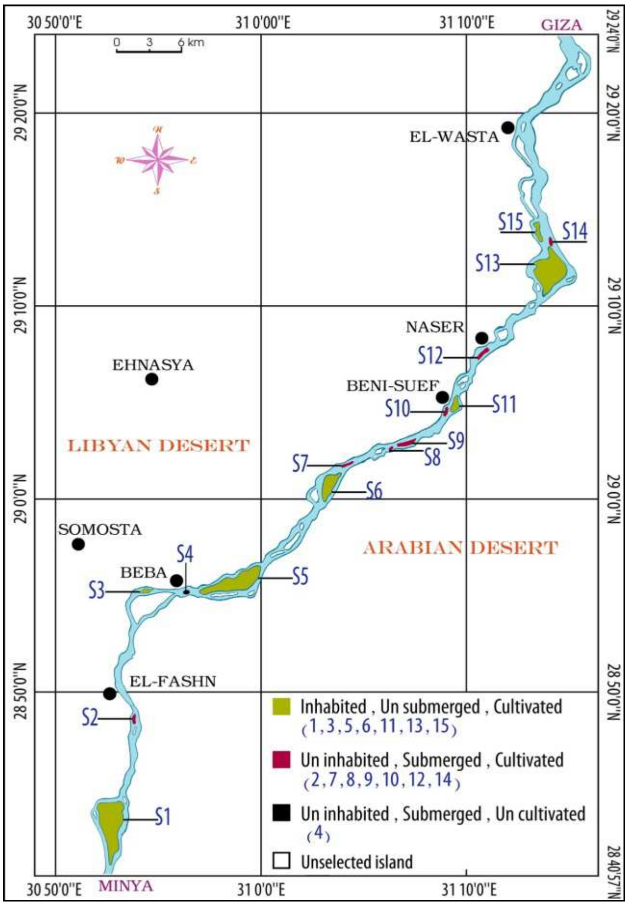

Fig. 1. Investigated islands along the Nile River at Beni-Suef governorate. S1 - Zawet El gedamy, S2 - Awlad Shaker, S3 - El-Foqaey, S4 - Al Shoqr, S5 - Beba, S6 - Sannor, S7 - Bani-Soliman, S8 - Tall El-Nayrouze, S9 - Beni-Suef, S10 - Abu Selem, S11 - El-Alalma, S12 - Mansheyat Al-Sherka, S13 - Al Koraymate, S14 - BaniHeder, S15 - Baget Saleh.

2.2. Soil sampling

To give an overview of the effect of the soil variables on the distribution of the flora in the area, fifteen samples were collected, each represented an island (site). Each sample was a composite sample collected from the monitored stands in each site. These were collected from each stand at a depth of 5-50 cm. The samples of the stands of each site were then pooled, forming one composite sample, air-dried, passed through a 2 mm. sieve to remove gravel and debris, and then packed in paper thoroughly mixed and bags ready for physical and chemical analysis. Three replicates were analyzed for each sample measurement. Fifteen soil variables (physical and chemical) were investigated namely: soil reaction (pH), electric conductivity (EC), organic matter (OM), sand, silt, clay, bicarbonates (HCO^{3-}), chloride (Cl^-), sulfates (SO_4^{2-}), nitrates (NO^{3-}), phosphates (PO_4^{3-}), Ca^{2+}, Mg^{2+}, Na^+ and K^+.

2.3. The selected species

The specimens were collected, identified and checked at Cairo University herbarium (CAI). The identification and nomenclature are mainly based on [17, 58-63]. Voucher specimens were kept at Cairo herbarium (CAI).

2.4. Floristic sampling

Seventy seven stands have been chosen to cover the variations of habitats in the selected islands. The stands were: 15 canal banks, 11 waste lands and 51 cultivated lands. The latter were subdivided into 42 crop farmlands: 13 wheat, 14 clover, 7 corn, 4 onion and 4 lupin stands; in addition to 9 orchards: 2 mango, 5 banana and 2 orange stands. The size of the stand was 20 × 100 m, which approximates the minimal area of weed associations in the study area. Such size was adopted by some other authors [55, 56, 64, 65].

Frequency of occurrence (f%) of species was calculated as the number of stands where the species was recorded divided by the total number of stands at each site (island). The presence performance (P%) of each species was then calculated as the number of stands where the species was recorded divided by the total number of stands.

The frequency of occurrence of the recorded species were organized into five categories: 1) Species recorded in 13-15 sites; 2) Species recorded in 10-12 sites; 3) Species recorded in 7-9 sites; 4) Species recorded in 4-6 sites and 5) Species recorded in 1-3 sites.

2.5. Multivariate analyses of the data

Both classification and ordination techniques were employed. Unicates of the total flora were estimated from the data set to avoid noise and summarize redundancy [66]. A floristic presence/ absence data matrix consists of 15 sites (islands) and identified 152 species was classified by Two-Way Indicator Species Analysis (TWINSPAN) using the default setting of the computer program CAP for windows (Community Analysis Package, version 1.2). The sites were ordered first by divisive hierarchical clustering, and then the species were clustered based on the classification of sites. An ordered two-way table that expresses succinctly the relationships of the samples and species within the data set was constructed [67, 68]. To assure the robustness of the resultant classification matrix with minimum variance (also called Ward's method) as agglomeration criterion [69] of Multi-Variate Statistical Package for windows (MVSP) version 3.13g [70] was used. A dendrogram was elaborated according to TWINSPAN analysis.

The basic goal of ordination is to summarize the community patterns, and to compare these with the environmental information. In this study, the default option of the computer program CANOCO software version 4.51 [71] was used for ordination. The direct gradient analysis was undertaken using Canonical Correspondence Analysis CCA [72].

Preliminary analysis were made by applying the default options of the DCA [73] in the CANOCO program, to check the magnitude of change in species composition along the first ordination axis (i.e., gradient length in standard deviation units). DCA estimated the compositional gradient in the floristic data of the present study to be more than 4 S.D. units for most subset analysis, thus Canonical Correspondence Analysis (CCA) is the appropriate ordination method to perform direct gradient analysis [74].

A Monte Carlo permutation test (499 permutations; [75]) was used to test for significance of the eigenvalues of the first canonical axis. The use of canonical coefficients in determining the significance of environmental variable is undesirable because they can be unstable. Inter-set correlations from the CCA's were therefore used to assess the importance of the environmental variables. All data variables were assessed for normality (SPSS for window version 20) prior to the CCA analysis, and appropriate transformations were performed when necessary to improve normality according to [76].

The TWINSPAN floristic groups were subjected to ANOVA (one-way analysis of variance) based on soil variables to find out whether there were significant variations among groups. The similarities between each pair of the studied ten habitats, 3 orchards, 5 croplands, canal banks and waste lands were estimated by using the linear correlation coefficients. Application of the cluster analysis to the presence percentage of species in each crop was elaborated and then was separated along the first two axes of the scatter plot of non-metric multidimensional analysis based on Gower similarity measure of species in the ten habitats.

3. RESULTS

3.1. General distribution

Appendix 1 shows the spatial distribution of the plant species recorded in the surveyed area. It is evident that the number of the species and their presence performance varied from site to site. In unsubmerged islands (sites), the total number of recorded species ranged from 68 to 79 species except for El-Foqaey island (S3) and Baget Saleh island (S15) where they recorded 54 and 46 species respectively. At the contrary, in the submerged islands, the total number of species ranged between 33 and 53 species except for Bani-Soliman island (S7) that included 68 species. The uncultivated submerged island, Al Shoqr island (S4), included only 36 species.

The species were grouped in generalized five categories (I-V) of presence performance. Category V, species recorded in 13-15 sites, had the widest ecological amplitude, included 13 species (c. 8.5 % of the total recorded species). Among these, six species, namely *Cynodon dactylon* (L.) Pers., *Chenopodium album* L., *Senecio aegyptius* L. var. *discoideus* Boiss., *Cyperus rotundus* L. var. *rotundus*, *Rumex dentatus* L. subsp. *dentatus* and *Vossia cuspidata* (Roxb.) Griff. were recorded in all sites with presence performances ranged between 98.7 and 23.4%. Of these, *Cynodon dactylon* had the widest ecological amplitude with the highest performance, P = 98.7 %. In addition, five species were recorded in 14 sites with presence values ranged between 26% and 37.7%. These were 2 winter weeds, *Malva parviflora* L. and *Sonchus oleraceus* L.; and 3 canal bank species, *Pluchea dioscoridis* (L.) DC., *Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis* and *Rorippa palustris* (L.) Besser. Two species, namely *Persicaria lapathifolia* (L.) Gray and *Solanum nigrum* L. var. *nigrum*, were recorded in 13 sites with presence values 29.9% and 39 % respectively.

Category IV, species recorded in 10-12 sites, included 18 species (c. 11.8%). The presence performance values ranged between 36.4% and 15.6%. Seven species were collected from 12 sites; six species were recorded in 11 sites and five species from 10 sites. Except for the 4 winter weeds, *Chenopodium murale* L., *Dactyloctenium aegyptium* (L.) Willd., *Capsella bursa-pastoris* (L.) Medik. and *Cichorium endivia* L. subsp. *divaricatum* Schousb. and the 3 summer weeds, *Echinochloa colona* (L.) Link, *Portulaca oleracea* L. and *Amaranthus viridis* L., the rest 11 species were canal bank species.

Category III, species recorded in 7-9 sites, included 20 species or 13.2 % of the total collected species. The presence performance values ranged between 33.8% and 11.7%. Seven species were recorded in 9 sites, four in 8 sites and 9 in 7 sites. Of these, two species showed high presence values in definite sites as *Ludwigia stolonifera* (Guill. & Perr.) P.H.Raven that recorded 100% in site 4 (Al Shoqr island) and *Polypogon monspeliensis* (L.) Desf. that recorded 80% in site 6 (Sannor island).

Category II, species recorded in 4-6 sites, included 39 species; ten species in 6 sites, 21 species in 5 sites and eight species in 4 sites with presence performances ranged between 20.8% and 5.2%.

Category I, species recorded in 1-3 sites, included 62 species (c. 40.8% of the total recorded species). These species represented the most narrow-spread species. Eleven species were collected from three sites, 16 species were recorded in two sites and 35 species were confined to only one site. Of these, 24 of species were recorded in the permanent islands especially in Al Koraymate island (S13) that included 10 species. Also the records showed that the presence values of these species ranged between 1.3 and 9.1%. Again, some species might show high performances in definite sites as the hydrophyte *Myriophyllum spicatum* L. that recorded 60% in site 9 (Beni-Suef island), the canal bank *Silybum marianum* (L.) Gaertn. var. *marianum* that recorded 57.1% in site 5 (Beba island) and *Orobanche crenata* Forssk. that recorded 50% in site 2 (Awlad Shaker submerged temporary island).

3.2. Crop-weed relationships (Sociological range)

The floristic composition differed from one habitat (orchard, farmland, canal bank and waste land) to another, also the presence performances of the species. Moreover, the distribution of species among different habitats showed high variability, the highest was 107 species in canal banks followed by the waste lands, 99 species, while the lowest was 27 species in onion farmlands. The total number of species ranged between 32 and 60 in orchards and between 27 and 60 in crop farmlands. Appendix 2 summarized the presence performance of each species within the studied ten habitats. Category 1 (widest sociological range of species) included one species; *Cynodon dactylon* that was recorded in all 10 habitats with high performance (P = 97.4%).

Category 2 included four species that existed in 9 habitats with presence performances ranged between 39% and 64.9%. But, the behavior of the species differed from habitat to another. For instance, the four species recorded their high performances (P = 100%) in mango orchards, *Chenopodium album* recorded high performances in wheat and onion farmlands while *Cyperus rotundus* var. *rotundus* and *Malva parviflora* recorded that in lupin farmlands and orange orchards respectively.

Category 3 included 11 species that recorded in 8 habitats with presence performance values ranged between 15.6% and 59.7%. The canal bank species, *Senecio aegyptius* var. *discoideus*, *Pseudognaphalium luteoalbum* (L.) Hilliard & B. L. Burttand and *Pluchea dioscoridis* performed better in waste lands and canal banks than in other habitats. While, the mesophytic species like *Amaranthus viridis*, *Chenopodium murale*, *Convolvulus arvensis* L. and *Oxalis corniculata* L. performed better in orchards than in other habitats.

Category 4, existed in 7 habitats, included 10 species with presence performance values ranged between 10.4% and 32.5%. Among these, five species performed better or might record P = 100% in orchards whereas monitored in other habitats with very low performances. These were *Echinochloa colona*, *Portulaca oleracea*, *Euphorbia helioscopia* L., *Euphorbia peplus* L. and *Bidens pilosa* L. On the other hand, *Melilotus indicus* (L.) All. performed better in stands of clover, onion and waste lands than in other habitats.

Category 5 (species present in six habitats) included 10 species with presence performance values ranged between 7.8% and 39%. *Echinochloa stagnina* (Retz.) P. Beauv., *Capsella bursa-pastoris* (L.) Medik., *Mentha longifolia* (L.) Huds. subsp. *typhoides* (Briq.) Harley, *Stellaria pallida* (Dumort.) Murb. and *Dactyloctenium aegyptium* recorded the highest presence (P = 100%) in mango orchards. On the other hand, *Eclipta prostrate* (L.) L., *Persicaria lapathifolia* (L.) Gray and *Cyperus alopecuroides* Rottb. showed certain consistency in the canal bank with high performance ranged between 53.3% and 93.3%.

Category 6 included 19 species with presence performances ranged between 7.8% and 26%. Only 3 species recorded the highest presence performance (P = 100%) in certain habitats. These were the annuals *Amaranthus hybridus* L. subsp. *hybridus*, *Paspalidium geminatum* (Forssk.) Stapf and *Digitaria ciliaris* (Retz.) Koeler in mango orchards. Whereas, *Phragmites australis* subsp. *australis* showed high performance in canal bank (P = 93.3%) and *Cichorium endivia* subsp. *divaricatum* recorded 71.4% in clover farmlands.

Category 7 included 13 species that presented in four habitats with presence performances ranged between 5.2% and 23.4%. *Phalaris paradoxa* L. was the only species that recorded performance of 100% in mango orchards. Also, *Glinus lotoides* L., *Persicaria lanigera* (R. Br.) Soják, *Leptochloa fusca* (L.) Kunth, *Potentilla supina* L. and *Homognaphalium pulvinatum* (Delile) Fayed & Zareh preferred existence in waste lands with P values ranged between 63.6% and 36.4%. *Euphorbia heterophylla* L. had its highest P values in orchards.

Category 8 included 15 species with presence performances ranged between 3.9% and 14.3%. *Urtica urens* L. was the only species that recorded P = 100% in mango and orange orchards. Also, *Corchorus olitorius* L. recorded showed high presence performance in banana orchards (P = 80%). *Avena fatua* L. recorded only in some winter crops, wheat and clover, and achieved P value 46.2% in wheat farmland.

Category 9 included 32 species with presence performances ranged between 2.6% and 23.4%. Among these, 13 species were confined to waste lands and canal banks. The most prominent species were *Vossia cuspidata*, *Cyperus articulatus*, *Ludwi-*

gia stolonifera and *Tamarix nilotica* (Ehrenb.) Bunge with performance values ranged between 27.3% and 100%.

Category 10 included 37 species that were confined to only one weed assemblage (narrowest sociological range) distributed as follows: 16 species in canal banks, 6 species in waste lands, 7 species in crop farmlands, 8 species in orchards.

3.3. Multivariate analyses

3.3.1. Ordination and clustering of the islands

The dendrogram resulting from TWINSPAN (Figure 2) of the 15 studied islands based on their floristic composition showed that two main groups were separated and the border line species was *Cyperus articulatus*. The first represented the unsubmerged (permanent) islands and was dominated by *Melilotus indicus*. This group was further differentiated into two subgroups (C and D), at the subsequent levels of classification. The second one comprised the submerged (temporary) islands; *Panicum coloratum* was the indicator species of this group. Also this group was differentiated into two subgroups (A and B) at the subsequent levels of classification.

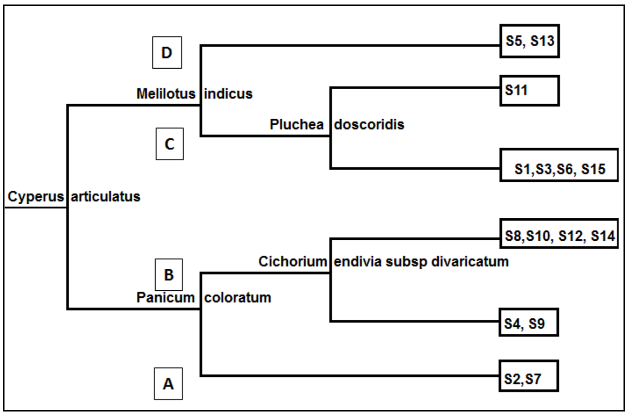

Fig. 2. TWINSPAN dendrogram of the 15 studied sites based on their species presence values. A-D are the 4 separated TWINSPAN floristic groups.

3.3.2. Similarity coefficient between the investigated islands

Analysis of the floristic composition of the investigated sites carried out by IBM SPSS correlated the distances between each two islands. The floristic correlation, similarities and dissimilarities, between the islets were expressed in Table 1. It was evident that even neighboring islands showed remarkable differences in their floristic composition, or had a small number of species in common.

Table 1. Similarity coefficient between the investigated islands (S1 – S15). For abbreviations, see Figure 1.

	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15
S1	100														
S2	39.7	100													
S3	60.4	43.9	100												
S4	36.9	49.2	31	100											
S5	47.1	14.7	43.7	29.4	100										
S6	45	21.8	54.5	39.4	48.8	100									
S7	43	73.9	44.7	52.6	25.8	31.1	100								
S8	42.9	61.6	46.1	51	23.1	36.9	68.3	100							
S9	52.5	58.4	47	48	24	41	58.3	59.7	100						
S10	44.1	43.1	46.3	44.9	41.3	55.6	50.3	66.6	52	100					
S11	51.6	25.8	64.2	31.5	50.7	52.5	28.5	27.1	32	38	100				
S12	43.6	62.1	47.2	45	30.5	31.1	62.6	60.3	44.9	50.4	28.8	100			
S13	49.9	15.5	59.7	25.5	60.3	53.3	17.9	32.2	19.2	43.7	55	26.1	100		
S14	45.6	54.6	53.2	48.3	31.6	35.4	63.3	70.7	52.3	64.2	27.6	71.8	35	100	
S15	58.3	40.6	56	43.1	57.8	60.6	46.9	48	47.6	70.9	49	45.7	63.5	57.3	100

Table 2. Mean values ± standard errors of the soil variables in the 15 selected islands representing the floristic groups A-D obtained by TWINSPAN. EC = electric conductivity, OM = organic matter. Significant (*P< 0.05), highly significant (**P< 0.01)

	TWINSPAN floristic groups					
	A	**B**	**C**	**D**	**F- ratio**	**P**
No. of sites	**2**	**5**	**6**	**2**		
Sand	91.0 ± 1.41	68.5 ± 14.05	64.4 ± 29.94	65.5 ± 2.12	0.874	0.004**
Silt	6.5 ± 0.71	19.17 ± 7.88	19.8 ± 14.82	20.5 ± 0.71	0.927	0.461
Clay	2.5 ± 0.71	12.33 ± 6.22	15.8 ± 15.07	13.5 ± 2.12	0.848	0.149
pH	8.15 ± 0.21	8.2 ± 0.27	8.16 ± 0.22	8.31 ± 0.43	0.172	0.917
EC	0.5 ± 0.71	1.00 ± 2.00	5.2 ± 6.3	6.5 ± 7.78	1.302	0.003**
OM	0.11 ± 0.08	2.42 ± 3.04	0.56 ± 0.64	3.1 ± 0.57	1.393	0.002**
HCO_3	1.71 ± 1.82	0.75 ± 0.67	1.44 ± 1.23	4.06 ± 4.02	2.182	0.064*
Cl	4.6 ± 3.68	6.02 ± 11.76	48.88 ± 58.24	52.49 ± 65.92	1.444	0.052*
SO_4	2.0 ± 0.00	3.17 ± 5.85	10.0 ± 12.06	20.5 ± 24.75	1.456	0.283
Ca	1.89 ±1.25	2.20 ± 3.12	9.5 ± 11.05	20.96 ± 25.66	1.873	0.091*
Mg	1.00 ± 0.00	1.00 ± 2.00	6.20 ± 7.98	11.50 ± 14.85	1.543	0.265
Na	4.07 ± 2.95	6.84 ± 12.75	43.91 ± 52.31	41.96 ± 51.97	1.314	0.046*
K	1.00 ± 1.41	0.33 ± 0.52	0.80 ± 0.84	2.50 ± 2.12	2.448	0.121
NO_3	0.43 ± 0.30	0.30 ± 0.33	0.09 ± 0.05	0.20 ± 0.02	1.159	0.073*
PO_4	0.00 ± 0.00	0.33 ± 0.52	0.00 ± 0.00	0.00 ± 0.00	1.1	0.392

The similarity values differed. In permanent islands the lowest similarity value was 45% recorded between Zawet Elgedamy island (S1) and Sannor island (S6) and the highest value was 64.2% recorded between El-Foqaey island (S3) and El-Alalma island (S11), while this might reach 73.9% as in between the submerged islands (S2; Awlad Shaker island and S7; Bani-Soliman island). On the contrary, these values were remarkably low, in between the submerged and unsubmerged islands that might reach 14.7% or 15.5% as in the correlation between S2 with either S5 or S13 respectively. Unexpectedly, the similarity coefficient between the unsubmerged island Baget Saleh (S15) showed relatively high consistency values even with the submerged islands ranged between 40.6% and 70.9%.

3.3.3. Species-soil relationships

Based on the resultant TWINSPAN 4 groups A-D, the investigated 15 soil parameters were checked to understand the effect of soil variables on the distribution of the species among the monitored islands. Table 2 indicates that the sand content of the soil, electric conductivity (EC) and organic matter (OM) were highly significant. In addition, 5 variables namely, HCO_3, NO_3, Cl, Ca and Na were significant. Moreover, it was evident that sites of groups A (*Panicum coloratum* was the leading dominant species) and C (*Pluchea dioscoridis* was the leading dominant species) were correlated with the high sand content of the soil that might record 92.41% and 95.34% respectively. While the sites of group B (*Cichorium endivia* subsp. *divaricatum* was the leading the dominant species) was affected by the organic matter of the soil. Group D (*Melilotus indicus* was the leading dominant species) was correlated with the bicarbonates, calcium and magnesium contents of the soil.

The relation between the flora and soil variables was indicated on the ordination diagram produced by Canonical Correspondence Analysis (CCA). 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.

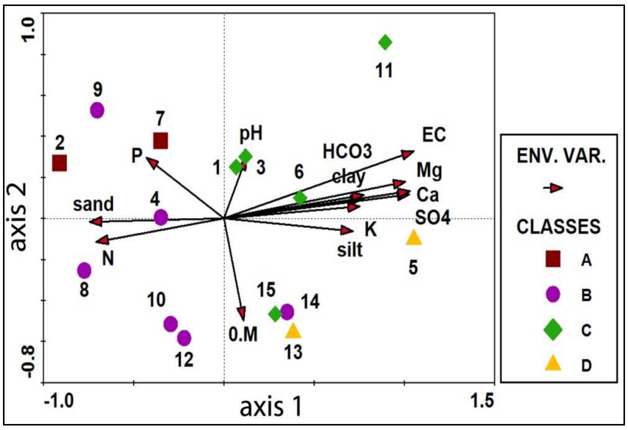

Fig. 3. CCA biplot of axis 1 and 2 showing the distribution of the 15 sites with their TWINSPAN floristic groups (A-D) in relation to the soil variables.

CCA ordination biplot with floristic groups (A-D) and the examined soil variables were shown in Figure 5. Preliminary analysis revealed high inflation factors for 3 soil variables (clay, chlorides and sodium) which should be excluded from the analysis. So, this analysis is based on 12 soil parameters: sand, silt, organic matter, pH, electric conductivity, sulfates, bicarbonates, phosphates, nitrates, calcium, magnesium and potassium contents.

It can be noticed that sites of group A were highly correlated with sand and phosphates; group B was correlated with sand, nitrogen, organic matter and phosphates; while group C was affected by pH, electric conductivity, magnesium, and bicarbonates but sites of group D were affected just by silt and organic Matter. These results revealed an association between floristic composition and the measured soil variables.

Table 3 showed the interset correlation of the soil variables along the 4 axes of the CCA biplot ordination. It is obvious that CCA axis 1 was highly positively correlated with the electric conductivity (0.6465) and highly negatively (-0.4574) correlated with sand content of the soil. This axis can be called electric conductivity - sand axis. Also, CCA axis 2 was highly positively (0.2557) correlated with the electric conductivity and highly negatively (-0.3891) correlated with organic matter. Thus, this axis can be interpreted as the electric conductivity - organic matter axis.

3.3.4. Ordination of habitats

By using the ordination of the Community Analysis Package (CAP), the ten different habitats-crop farmlands were clustered in 4 groups (Figure 4). Group A comprised the orchards, group B comprised the winter crops, group C comprised the summer crop and group D comprised the habitats of the canal banks and waste lands.

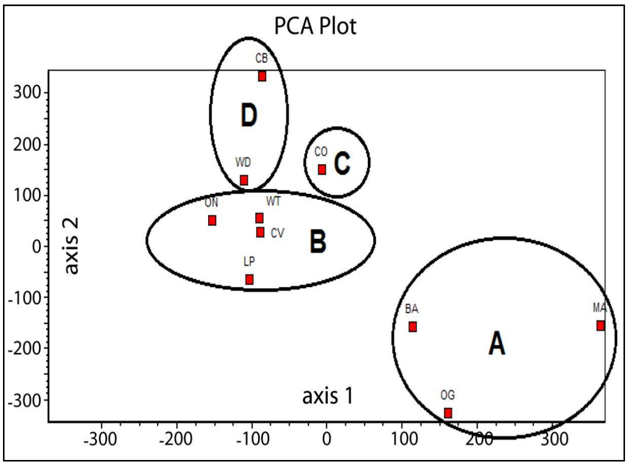

Fig. 4. PCA ordination of the investigated ten habitats. A-D are the groups that resulted from cluster analysis. For abbreviations, see Table 4.

3.3.5. Similarity coefficient of habitats

Table 4 showed the similarity coefficient between each pair of the investigated ten habitats-farmlands. The lowest values were between orange orchards and both waste lands and canal banks where they recorded 10% and 10.9% respectively. Also, the affinity coefficients recorded 11.1 % between Mango orchards and each of Onion farmlands and waste lands. On the other hand the highest values (74.4%) were between wheat and clover, both were winter crops. This was the case also in the correlation between banana and orange orchards (72.5%).

Table 3. The interset correlations of the soil variables along the 4 axes of the CCA biplot ordination, eigenvalues and species-environmental correlation coefficients.

	AX1	AX2	AX3	AX4
Eigenvalues	**0.2257**	**0.03**	**0.0914**	**0.1067**
species-environmental correlation coefficient	**0.9362**	**0.9968**	**0.9994**	**0.9939**
sand	-0.4574	-0.0127	0.4764	0.2452
silt	0.4389	-0.049	-0.48	-0.231
clay	0.472	0.0761	-0.4679	-0.2573
OM	0.0668	-0.3891	-0.1224	0.1499
pH	0.0763	0.235	-0.2483	0.4373
EC	0.6465	0.2557	-0.1728	0.0562
HCO_3	0.4763	0.0897	0.1768	0.4641
SO_4	0.6311	0.0919	-0.1133	0.2498
Ca	0.634	0.1031	-0.065	0.3424
Mg	0.6173	0.1395	-0.1234	0.2734
K	0.4624	0.0454	0.2763	0.456
NO_3	-0.4355	-0.0895	0.2848	-0.089
PO_4	-0.264	0.231	-0.43	0.5524

Table 4. The similarity coefficient between each pair of the investigated habitats by using the correlation of SPSS program. MA = Mango, BA = Banana, OG = Orange, WT = Wheat, CV = Clover, CO = Corn, ON = Onion, LP = Lupin, CB = Canal banks and WD = Waste lands.

	MA	BA	OG	WT	CV	CO	ON	LP	CB	WD
MA	100									
BA	63.5	100								
OG	52.6	72.5	100							
WT	30.5	43.6	30.7	100						
CV	31.3	46.8	31	74.4	100					
CO	48.9	58.1	50.4	20.4	29.4	100				
ON	11.1	20.6	3.9	62	63.4	16.5	100			
LP	30.2	39.4	29	50.8	66	43	61.4	100		
CB	17.5	26.1	10.9	36.9	38.1	34.5	40	45.1	100	
WD	11.1	25.9	10	46.9	54.3	29.9	53.7	55.7	67.1	100

4. DISCUSSION

In this study, altogether 152 species belonging to 117 genera in 49 families of the vascular plants were recorded. It was evident that the number of species and also the presence performance varied from site (island) to another. It was obvious that even neighboring islands showed remarkable differences in their floristic composition, or had small number of species in common. When the total number of species might reach 79 species in permanent (unsubmerged) islands, it might decrease to be 33 species in temporary islands and this was not surprising considering that the unsubmerged islands were subjected to land cultivation through the whole year while the submerged islands were only cultivated in winter months when the Nile water level was convenient, from November to June in most years. Kim et al. [77] revealed that anthropogenic disturbance of natural sites, here was the extensive cultivation in unsubmerged islands than submerged ones, had a considerable effect on species richness. This is in accordance with the investigation on the flora of Berlin [78-80], central Europe [81] and Thienemann's principle that "the more variable the habitat condition, the higher the diversity in a biocoenosis" [82]. The ecological amplitude of species varied, some showed broad while others were confined to special type of islands with very narrow amplitude. Six species, namely *Cynodon dactylon*, *Chenopodium album*, *Senecio aegyptius* var. *discoideus*, *Cyperus rotundus* var. *rotundus*, *Rumex dentatus* subsp. *dentatus* and *Vossia cuspidata* were recorded in all islands with different presence performance values ranged between 23.4% and 98.7% and had the broadest ecological amplitude. This result was also conducted by Shaheen [83] who cited that these weeds were ubiquitous, or as mentioned by Shaltout and Sharaf El-Din [84] who revealed that the species with large amplitude as *Cynodon dactylon* was often caused by phenotypic plasticity and heterogeneity. In addition, Abd El-Ghani [46] cited that the abundance of Vossia cuspidata in the sites of his surveyed area (islands of the Nile valley, Egypt) might be attributed to its position at the opposite ends of environmental gradients as mentioned by Muller-Dumbois and Ellenberg [85]. On the other hand, weeds of moderate occurrence might be related to the need for special habitats "thermic preferability" [83]. The existence of some species in a few sites as Myriophyllum spicatum might be related to the fluctuations of the water level, cleaning practices and human activities as fishing and boating [86]. Also the restriction of some species to special one site of the studied area as *Najas marina* subsp. *armata* in site 9 might be related to the spread of extensive agricultural practices that represent an acute loss of habitats for these species and therefore may be replaced by *Myriophyllum spicatum*. This is the same result that was reported by Agami and Wise [87], or to the allelopathic effect of *Myriophyllum spicatum* [88, 89].

Using of twinspan technique gave a clear cut between the submerged and unsubmerged permanent islands. It divided the studied islands into 2 groups depending on the floristic composition. Our results indicated an important role of habitat diversity in shaping floral diversity patterns in most species subsets. The similarity coefficient between the floristic compositions of each pair of the islands indicated the high correlation between the submerged islands that might reach 73.9% and between the unsubmerged islands that might reach 64.2%, while it recorded 14.7% between the submerged and unsubmerged islands. This might be related to the length of cultivation time. Unsubmerged permanent islands are cultivated through the whole year in contrary to the habitat loss in the submerged islands during the un-cultivation time. The strong correlation of plant species richness with habitat diversity had been documented by many authors [90-92].

One of the most important gradients in weed species composition in this study is the type of crop. This is confirmed by many authors [93-95]. In Egypt, 2 crops are usually grown in a seasonal sequence: a winter crop and a summer crop. It results that a crop rotation is accompanied by a weed-flora rotation [12]. The agro-ecosystem of the studied area can be differentiated into orchards and croplands. As demonstrated by the ordination of the species of the different habitats, 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 crop, for instance *Orobanche* sp. with clover or because the weed requirements to a definite exudates secreted by the roots of its host as *Orobanche crenata* with *Vicia faba* [96]. Some species are more abundant in certain crops with which they exhibit similarity morphologically and phenologically (e.g., *Avena fatua* L. in wheat crop) such similarity makes the recognition of the weed species from the crop plants very difficult and consequently hinders its control [57]. The dominance of the weed species with discoid stems such as *Cichorium endivia* L. subsp. *divaricatum* Schousb. in clover could be related to the fact that this crop undergoes three to five cuts during its growth period. This is supported by Abd El-Ghani and El-Bakry [51]. Moreover, the protection given by the tree foliage of the orchards affects the environment of weeds. The orchards exhibit 2 different microhabitats according to light conditions: the shaded areas below the crowns of trees support the growth of shade-loving species such as *Poa annua*, *Stellaria pallida* and *Urtica urens* whereas the sunny microhabitats support the growth of other species belonging to croplands. Moreover, canal bank species such as *Mentha longifolia* subsp. *typhoides*, *Phragmites australis* subsp. *australis* and *Imperata cylindrical* can grow in the moist microhabitats produced by the shade of the crowns of trees. These findings were also confirmed [56, 97, 98] that such environmental microheterogeneity promotes the diversity.

The weed species vary in their sociological range, ecological aggressiveness and seasonal preference. Sociological range and ecological performance seem to be linked; most species in the first category (present in all assemblages) are also the species with higher performance values. Species with narrow sociological range present in a few assemblages often have low scores of performance values [56]. Species richness varied from one crop to another. The winter weeds represent the main bulk of the recorded species within each crop, this may be attributed to differences in the weed control methods of the two winter and summer crops, this is in agreement with Hegazy et al. [57]. On comparing orchards with field crops, it can be recorded that orchards have a relatively large number of perennials weeds and rhizomatous species than that of field crops, this can be attributed to different cultivation practices that orchards are rarely ploughed. The same result was achieved by Abd El-Ghani et al. [56] in their studies on olive orchards. Also, in the plantation of sugarcane in Ethiopia, attributed that to the wider spacing between trees rows, a long growth cycle and constant moist conditions due to irrigation, which might have created conductive conditions for the growth of weeds [99].

Most species that are dominant in the habitats of canal banks and waste lands are perennials as *Vossia cuspidata* (Roxb.) Griff., *Cyperus articulatus* L., *Ludwigia stolonifera* (Guill. & Perr.) P.H.Raven, *Tamarix nilotica* (Ehrenb.) Bunge, *Salix mucronata* Thunb., *Phoenix dactylifera* L. and *Juncus bufonius* L. This is supported by Shaltout [100] who mentioned that 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. These all support the view that increasing habitat heterogeneity increases species diversity [101]. The species that are confined to canal banks or water loving species or even hydrophytes as *Typha domingensis* (Pers.) Poir. ex Steud., *Azolla caroliniana* Willd., *Ceratophyllum demersum* L., *Plantago major* L. and *Myriophyllum spicatum* L. or restricted to salinized waste land habitats such as *Cyperus difformis* L., *Fimbristylis bisumbellata* (Forssk.) Bubaniand and *Polycarpon prostratum* (Forssk.) Asch. & Schweinf. can be attributed to habitat preference phenomenon. Abd El-Ghani and Fawzy [102] postulated this phenomenon in the farmlands of the Egyptian Oases.

The ordination carried out by MVSP followed by CAP classified the 10 habitats-farmlands into distinct 4 groups: the first included the orchards (orange, banana and mango), the second included the winter crop farmlands (wheat, clover, lupin and onion), the third group included the canal banks and waste land habitats and the corn cultivations, a summer crop, stood alone in the fourth group. In addition, highly significant correlations were recorded between individuals of each group. This result is in line with what reported in the studies of Abd El-Ghani et al. [56] in the reclaimed lands along the northern sector of the Nile valley in Egypt. Also, this assures the differentiation of the Egyptian weeds into 3 main categories according to their seasonal performance: winter, summer and all-year-weeds postulated by several authors [50, 51]. Moreover, it showed that the differences in weed species were mainly affected by type of crop, seasonal preference, and ecological factors.

The edaphic characteristics of the soil were among the most delimiting factors in the distribution of the flora in any particular area. It was found that the sand contents of the soil, electric conductivity, and organic matter were highly significant ($p < 0.01$) in addition to bicarbonates, chlorides, calcium, sodium and nitrogenous contents of the soil were also significant ($p < 0.05$) among the prevalent floristic groups of the area of study. The resultant Twinspan 4 floristic groups were affected by the soil variables. Groups A (*Panicum coloratum* was the leading dominant species) and C (*Pluchea dioscoridis* was the leading dominant species) were correlated with sand content of the soil, group B (*Cichorium endivia* subsp. *divaricatum* was the leading dominant species) was correlated with the organic matter while group D (*Melilotus indicus* was the leading dominant species) was correlated with the bicarbonates, calcium and magnesium contents of the soil. Even within same soil condition, same floristic group, some species thrive well [49], in addition the probability of finding these species growing together might be great, even though other factors also influence their abundance, as climate, ability for competition, seed production, capacity and geographic distribution.

The application of Canonical Correspondence Analysis (CCA) on the matrix of species against the different habitats of the present study demonstrated the effect of soil variables on the spatial distribution of weed communities in the study area. It was obvious that the first axis of CCA biplot was positively correlated with the electric conductivity and negatively correlated with sand content of the soil. This axis can be interpreted as the electric conductivity - sand axis. Also, the second axis was positively affected by electric conductivity and negatively correlated with the organic matter thus can be interpreted as the electric conductivity - organic matter axis. The application of ordination and clustering by using Twinspan and Canonical Correspondence Analysis (CCA) summarized the large complex data and compared that with the environmental information [103]. This resulted in the division of the monitored islands into 2 clear sets. One included the submerged and the other included the unsubmerged islands which were subdivided into 2 subgroups. Also, it correlated these subgroups to the soil variables prevailing in the area of study [75, 104].

AUTHORS' CONTRIBUTION

All authors contributed in all stages of this work except for writing the manuscript which had been written by AS. The final manuscript has been read and approved by all authors.

TRANSPARENCY DECLARATION

The authors declare no conflicts of interest.

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Appendix 1. The general distribution of the recorded species in the surveyed 15 sites. Sites are shown in Figure 1. Values are the average frequency percentages (f%) of each species in the site

Sites	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	SUM	
Species / Number of stands	**7**	**4**	**6**	**2**	**7**	**5**	**6**	**5**	**5**	**5**	**6**	**4**	**6**	**3**	**6**	**77**	**%**
Species that recorded in 13-15 sites																	
Cynodon dactylon	100	100	100	100	100	100	100	100	80	100	100	100	100	100	100	76	98.7
Chenopodium album	29	100	67	50	14	60	67	100	80	100	50	50	50	100	100	50	64.9
Senecio aegyptius var. discoideus	57.1	100	66.7	100	57.1	20	83.3	80	40	40	50.	100	33.3	100	33.3	46	59.7
Cyperus rotundus var. rotundus	71.4	25	16.7	50	71.4	40	50	60	80	60	16.7	25	50	66.7	66.7	39	50.6
Rumex dentatus subsp. dentatus	28.6	25	50	50	42.9	60	33.3	40	40	40	33.3	50	66.7	33.3	66.7	34	44.2
Vossia cuspidata	14.3	50	16.7	50	14.3	20	33.3	40	20	20	16.7	25	16.7	33.3	16.7	18	23.4
Malva parviflora	57.1	50	50	100	14.3	20	33.3	60	40	40	50	50	16.7	33.3		29	37.7
Sonchus oleraceus	42.9	50	33.3	50	14.3		33.3	20	40	40	33.3	25	16.7	33.3	33.3	23	29.9
Pluchea dioscoridis	42.9	75	16.7	50	14.3	20	33.3	60	40	20		25	16.7	33.3	16.7	22	28.6
Phragmites australis subsp. australis	28.6	50	16.7	50	28.6	20	33.3	20	20	20	33.3	25	16.7		33.3	20	26
Rorippa palustris	14.3	75	16.7	50	14.3	20	33.3	20	40	40	16.7	50	16.7	33.3		20	26
Persicaria lapathifolia	14.3	75	50		14.3	20	33.3	60	60	40		100	16.7	100	50	30	39
Solanum nigrum var. nigrum	28.6	75	33.3	100	14.3	20	33.3		40	20	33.3	25	33.3		33.3	23	29.9
Species that recorded in 10-12 sites																	
Echinochloa colona	14.3		16.7	50	85.7	40		20	20	40	50	25	50		50	25	32.5
Portulaca oleracea	28.6		16.7	50	57.1	40			20	40	33.3	25	50	33.3	33.3	22	28.6
Glinus lotoides	28.6	50	16.7	50	.	20	33.3	40	40	40		50		33.3	16.7	19	24.7
Eclipta prostrata	14.3	50	.	100	14.3	20	16.7	40	40	60		25	16.7		16.7	18	23.4
Persicaria senegalensis		25	16.7		14.3	20	33.3	20	40	20	16.7	25	16.7	33.3		14	18.2
Bidens pilosa	14.3	25		50	14.3		16.7	20	20	20	16.7	25	16.7	33.3		12	15.6
Dactyloctenium aegyptium	14.3			50	14.3	20	16.7	20	20	20	16.7	25	.	33.3	16.7	12	15.6
Pseudognphalium luteoalbum	71.4		50		57.1			20	20	40	50	25	66.7	33.3	50	28	36.4
Amaranthus viridis	42.9	75	16.7		.	20	50	40	80		50	75	16.7	33.3		25	32.5
Cyperus alopecuroides	14.3	50		50	57.1	40	33.3			20	33.3	50	50		33.3	22	28.6
Chenopodium murale	28.6		16.7		42.9	40			60	40	16.7	25	16.7	33.3	33.3	19	24.7
Persicaria salicifolia	14.3			100	14.3	40	16.7	40	40	40			16.7	66.7	16.7	17	22.1
Oxalis corniculata	28.6	25		50	14.3	20	33.3	40	40	20	16.7		16.7			15	19.5
Trifolium resupinatum var. resupinatum	42.9	50	33.3		42.9	20			60	20	50	25			16.7	20	26
Persicaria lanigera	28.6	50	16.7	100	14.3	20	33.3	20				75		66.7		17	22.1
Echinochloa stagnina	28.6		.	100	.	60	16.7	40	40	20			16.7	33.3	33.3	17	22.1
Capsella bursa-pastoris	14.3		16.7	100	28.6	20	33.3	20	60	20					16.7	15	19.5
Cichorium endivia subsp. divaricatum					28.6	40	16.7	20		80	16.7	25	16.7	33.3	16.7	15	19.5
Species that recorded in 7-9 sites																	
Polypogon monspeliensis	28.6		16.7	50	57.1	80				60	66.7		50		66.7	26	33.8
Melilotus indicus	42.9	50	33.3		.	60	33.3		60	40	33.3				16.7	20	26
Poa annua	14.3		16.7		57.1	60	16.7			40	16.7		33.3		50	18	23.4
Polypogon viridis	28.6	25	16.7	50	14.3	20					16.7		33.3		33.3	12	15.6
Mentha longifolia subsp. typhoides		50	16.7	50			16.7	20				75	16.7	33.3	16.7	11	14.3
Ludwigia stolonifera	14.3	25		100	.	20		20		20	16.7	25		33.3		10	13
Corchorus olitorius		25		50	14.3			20	20	20	16.7	25			16.7	9	11.7
Convolvulus arvensis	57.1		33.3		42.9	20		20			50		66.7		16.7	19	24.7
Conyza bonariensis			33.3		42.9	20		20		20	33.3		50	33.3		14	18.2
Potentilla supina		50		50	28.6		33.3	20	20	20			16.7			11	14.3
Paspalidium geminatum	14.3	50		50		20	33.3		20			50			16.7	11	14.3

Amaranthus hybridus subsp. hybridus	57.1									40	16.7	25	50	33.3	66.7	16	20.8
Cyperus articulatus	42.9		16.7		42.9	40					33.3		66.7		16.7	16	20.8
Euphorbia peplus	28.6		33.3			40				20	33.3		33.3		16.7	12	15.6
Ceratophyllum demersum	42.9		33.3		.	20	16.7		40		33.3	25				12	15.6
Lamium amplexicaule					28.6		16.7	40		60		25	16.7	33.3		11	14.3
Vicia sativa subsp. Sativa	14.3		16.7		28.6	20					16.7		66.7		16.7	11	14.3
Chenopodium ambrosioides	28.6			50	14.3	40			40		16.7		33.3			11	14.3
Stellaria pallida			16.7	50	.	40		20	20		33.3		33.3			10	13
Digitaria ciliaris	14.3					20	16.7	40		20		50	16.7			9	11.7
Species that recorded in 4-6 sites																	
Euphorbia helioscopia	28.6		66.7		42.9	40					33.3		50			16	20.8
Amaranthus biltum subsp. emerginatus					57.1	60					16.7	25	33.3		16.7	12	15.6
Imperata cylindrica	28.6		16.7		42.9	20					16.7		33.3			10	13
Leptochloa fusca	14.3	50					16.7	40	60	20						10	13
Panicum coloratum	28.6	25			28.6		33.3				16.7				16.7	9	11.7
Ranunculus sceleratus	42.9		16.7		14.3						16.7		16.7		16.7	8	10.4
Ricinus communis	28.6	25				20		20		40					16.7	8	10.4
Brachiaria reptans	28.6	25					16.7	40				25	16.7		.	8	10.4
Datura stramonium		25		50	28.6		33.3		20						16.7	8	10.4
Homognaphalium pulvinatum							16.7	40	20	40		25	16.7			8	10.4
Eichhornia crassipes	42.9				42.9		16.7					75		33.3		11	14.3
Polygonum equisetiforme	28.6	100					33.3	40	20							11	14.3
Tamarix nilotica	28.6		33.3			20					33.3		33.3			9	11.7
Amaranthus graecizans				50	28.6		16.7		20		66.7					9	11.7
Potamogeton nodosus	14.3							40		40			33.3	33.3		8	10.4
Paspalum distichum						20	16.7	40		40		50				8	10.4
Riccia	14.3		16.7		14.3	20					50					7	9.1
Salix mucronata	14.3		16.7		.	60	16.7				16.7					7	9.1
Coronopus didymus			16.7		.	40		20		20	33.3					7	9.1
Emex spinosa	14.3				42.9	20					16.7		16.7			7	9.1
Euphorbia prostrata	14.3		33.3		14.3	20			40							7	9.1
Phalaris minor		25			28.6			20			16.7		33.3			7	9.1
Phalaris paradoxa	14.3			50	14.3						50		16.7			7	9.1
Phyla nodiflora	14.3		16.7		28.6	20							16.7			6	7.8
Euphorbia heterophylla	14.3		16.7		28.6						16.7		16.7			6	7.8
Cynanchum acutum subsp. acutum		25					16.7			20		25		33.3		5	6.5
Desmostachya bipinnata			16.7		14.3	20				20			16.7			5	6.5
Phoenix dactylifera	.	25					16.7	20	20		16.7					5	6.5
Polycarpon tetraphyllum	14.3			50			16.7	20	20							5	6.5
Populus euphratica	14.3		16.7		14.3	20					16.7					5	6.5
Sesbania sesban	14.3		16.7			20			20				16.7			5	6.5
Trigonella hamosa			50			20					50		50			10	13
Avena fatua	28.6				57.1		16.7								16.7	8	10.4
Xanthium strumarium	14.3					20							33.3		16.7	5	6.5
Avena barbata subsp. barbata					14.3			20	40		16.7					5	6.5
Potamogeton perfoliatus					14.3	40					16.7	25				5	6.5
Sorghum virgatum			.		28.6						16.7		16.7		16.7	5	6.5
Anagallis arvensis subsp. arvensis var. caerulea	14.3		16.7				16.7						16.7			4	5.2
Galinsoga parviflora	14.3		16.7		14.3	20										4	5.2

Species that recorded in 1-3 sites																	
Myriophyllum spicatum	42.9					20			60							7	9.1
Silybum marianum var. marianum	14.3				57.1								16.7			6	7.8
Cyperus michelianus subsp. pygmaeus						20	16.7	60								5	6.5
Anagallis arvensis subsp. arvensis var. arvensis	28.6					20				20						4	5.2
Adiantum capillus-veneris						20				20	16.7					3	3.9
Azolla caroliniana		25					16.7							33.3		3	3.9
Cyperus difformis					14.3		16.7				16.7					3	3.9
Fimbristylis bisumbellata		25					16.7			20						3	3.9
Juncus bufonius	14.3									20		25				3	3.9
Juncus hybridus						20		20			16.7					3	3.9
Setaria verticillata					14.3								16.7		16.7	3	3.9
Typha domingensis	28.6		.								33					4	5.2
Alternanthera sessilis			16.7										33.3			3	3.9
Orobanche cernua							33.3				16.7					3	3.9
Orobanche crenata		50							20							3	3.9
Veronica anagalloides subsp. taeckholmionum	28.6								20							3	3.9
Vicia sativa subsp. nigra		25					16.7									2	2.6
Alhagi graecorum							16.7				16.7					2	2.6
Enarthrocarpus lyratus							16.7							33.3		2	2.6
Fumaria parviflora	14.3														16.7	2	2.6
Gnaphalium polycaulon							16.7						16.7			2	2.6
Lolium rigidum							16.7				16.7					2	2.6
Medicago sativa subsp. sativa					14.3		16.7									2	2.6
Oldenlandia capensis var. capensis		25					16.7									2	2.6
Oxystelma esculentum	.	25					16.7									2	2.6
Polycarpon prostratum	14.3						16.7									2	2.6
Tagetes minuta	14.3						16.7									2	2.6
Cenchrus echinatus													33.3			2	2.6
Amaranthus hybridus subsp. cruentus													16.7			1	1.3
Ammi majus													16.7			1	1.3
Bromus catharticus													16.7			1	1.3
Eleusine indica													16.7			1	1.3
Nothoscordum gracile													16.7			1	1.3
Plantago major													16.7			1	1.3
Senna alexandrina													16.7			1	1.3
Trianthema portulacastrum													16.7			1	1.3
Verbena supina													16.7			1	1.3
Spergularia marina												25				1	1.3
Sphaeranthus suaveolens var. abyssinicus												25				1	1.3
Urtica urens											50					3	3.9
Citrullus colocynthis											16.7					1	1.3
Leersia hexandra											16.7					1	1.3
Lemna gibba											16.7					1	1.3
Spirodela polyrhiza										20						1	1.3
Brassica nigra									20							1	1.3
Najas marina subsp. armata									20							1	1.3
Vicia narbonensis var. narbonensis									20							1	1.3

Veronica anagallis-aquatica							33.3									2	2.6
Brassica juncea							16.7									1	1.3
Lotus arabicus							16.7									1	1.3
Potamogeton pectinatus							16.7									1	1.3
Potamogeton crispus						20										1	1.3
Eragrostis cilianensis					28.6											2	2.6
Vicia monantha					28.6											2	2.6
Withania somnifera					14.3											1	1.3
Leptochloa panicea					14.3											1	1.3
Sinapis allionii					14.3											1	1.3
Eruca sativa			16.7													1	1.3
Nymphaea caerulea			16.7													1	1.3
Orobanche ramosa var. schweinfurthii		50														2	2.6
Medicago polymorpha var. vulgaris	14.3															1	1.3
Acacia nilotica subsp. nilotica	14.3										.					1	1.3
	79	45	54	37	70	68	68	49	51	53	69	45	74	33	46		

Appendix 2. Sociological range of the recorded species in the 10 different habitats. P% = presence performance. For abbreviations, see Table 4.

	Orchards			**Crop farmlands**					**CB**	**WD**	**Sum**	
Type of habitats	**MA**	**BA**	**OG**	**WT**	**CV**	**CO**	**ON**	**LP**				
Species / Number of stands	**2**	**5**	**2**	**13**	**14**	**7**	**4**	**4**	**15**	**11**	**77**	**%**
Species present in all 10 habitats												
Cynodon dactylon	100	100	100	100	100	100	50	100	100	100	75	97.4
Species present in 9 habitats												
Chenopodium album	100	40		100	71.4	42.9	100	25	53.3	63.6	50	64.9
Cyperus rotundus var. *rotundus*	100	60	50		42.9	85.7	50	100	60	63.6	40	51.9
Rumex dentatus subsp. *dentatus*	100	60	50	53.8	78.6		50	50	26.7	36.4	36	46.8
Malva parviflora	100	60	100	46.2	57.1	28.6		50	20	18.2	30	39
Species present in 8 habitats												
Senecio aegyptius var. *discoideus*		40	50	69.2	50		100	50	73.3	90.9	46	59.7
Pseudognphalium luteoalbum	50	40		30.8	21.4		25	25	53.3	81.8	29	37.7
Polypogon monspeliensis	100	20		38.5	50		75	75	26.7	27.3	28	36.4
Amaranthus viridis	100	100	100	7.7	28.6	85.7			26.7	9.1	25	32.5
Pluchea dioscoridis		20		15.4	7.1	14.3	25	25	73.3	45.5	23	29.9
Solanum nigrum var. *nigrum*	100	40			35.7	14.3	25	25	40	45.5	23	29.9
Trifolium resupinatum var. *resupinatum*		40	50	38.5	35.7		25	25	13.3	27.3	20	26
Chenopodium murale	100	60	100	23.1	35.7			25	6.7	18.2	19	24.7
Convolvulus arvensis	100	60	100	15.4	7.1	42.9			26.7	18.2	19	24.7
Oxalis corniculata	100	80	50	7.7	7.1	28.6			26.7	9.1	16	20.8
Vicia sativa subsp. *sativa*		40	50	23.1	14.3		25	25	6.7	9.1	12	15.6
Species present in 7 habitats												
Echinochloa colona	100	60	100			100		25	46.7	27.3	25	32.5
Sonchus oleraceus	100	80		38.5	35.7	28.6			20	27.3	24	31.2
Portulaca oleracea	100	60	100	.	.	100		25	20	36.4	22	28.6
Melilotus indicus		40		23.1	42.9		50	25	13.3	45.5	21	27.3
Poa annua	100	20	100	38.5	28.6				13.3	18.2	18	23.4

Euphorbia helioscopia	50	80	100	15.4	21.4				13.3	18.2	16	20.8
Euphorbia peplus	100	60	50	15.4	14.3				6.7	18.2	13	16.9
Bidens pilosa	100	40	50	7.7	14.3	14.3			20		12	15.6
Polygonum equisetiforme		20	50	15.4	7.1			25	20	18.2	11	14.3
Datura stramonium	50	20	50	7.7		14.3			13.3	9.1	8	10.4
Species present in 6 habitats												
Persicaria lapathifolia				53.8	50		50	25	53.3	45.5	30	39
Cyperus alopecuroides					7.1	14.3	25	25	93.3	36.4	22	28.6
Eclipta prostrata	50				7.1	.	25	25	60	45.5	18	23.4
Echinochloa stagnina	100	20			7.1	14.3			53.3	36.4	17	22.1
Capsella bursa-pastoris	100	40	50	46.2	21.4					9.1	15	19.5
Conyza bonariensis	50	40		23.1				25	26.7	9.1	12	15.6
Mentha longifolia subsp. *typhoides*	100	40	50	15.4	7.1				20		11	14.3
Stellaria pallida	100	60	100	7.7	.				13.3	9.1	11	14.3
Dactyloctenium aegyptium	100	40			.	28.6	25		6.7	18.2	10	13
Euphorbia prostrata	50	20	50		7.1	14.3			6.7		6	7.8
Species present in 5 habitats												
Phragmites australis subsp. *australis*	50	20		15.4					93.3	18.2	20	26
Rorippa palustris		20		7.7	50				33.3	54.5	20	26
Persicaria salicifolia		20		38.5	7.1				46.7	27.3	17	22.1
Amaranthus hybridus subsp. *hybridus*	100	20			14.3	57.1			46.7		16	20.8
Cichorium endivia subsp. *divaricatum*				7.7	71.4	.	25	25	.	9.1	14	18.2
Persicaria senegalensis				15.4	7.1	.	25		53.3	18.2	14	18.2
Paspalidium geminatum	100			7.7		28.6			13.3	45.5	12	15.6
Chenopodium ambrosioides	50	60			7.1				26.7	18.2	11	14.3
Lamium amplexicaule	50	20		23.1	28.6				13.3		11	14.3
Trigonella hamosa				15.4	28.6		50		6.7	18.2	11	14.3
Imperata cylindrica	50	40		7.7					26.7	9.1	9	11.7
Panicum coloratum		20	50			28.6			13.3	27.3	9	11.7
Digitaria ciliaris	100	40				28.6		25	6.7		8	10.4
Paspalum distichum				7.7	7.1	14.3			13.3	27.3	8	10.4
Brachiaria reptans		40	50			28.6			6.7	9.1	7	9.1
Coronopus didymus		20	50	7.7	21.4				6.7		7	9.1
Emex spinosa	50	40	50	7.7					13.3		7	9.1
Phalaris minor		20		15.4	7.1			25	.	18.2	7	9.1
Xanthium strumarium	50	20	50	7.7					13.3		6	7.8
Species present in 4 habitats												
Glinus lotoides					21.4			50	40	63.6	18	23.4
Persicaria lanigera		20			21.4				46.7	54.5	17	22.1
Polypogon viridis				38.5	28.6				26.7	18.2	15	19.5
Leptochloa fusca							25	25	33.3	36.4	11	14.3
Potentilla supina	50				14.3				20	45.5	11	14.3
Amaranthus graecizans					14.3	14.3			20	18.2	8	10.4
Homognaphalium pulvinatum				15.4			25		6.7	36.4	8	10.4
Phalaris paradoxa	100	20		23.1					13.3		8	10.4
Phyla nodiflora	50					14.3			13.3	27.3	7	9.1
Euphorbia heterophylla	50	60	50		7.1						6	7.8
Avena barbata subsp. *barbata*		20		15.4			25			9.1	5	6.5
Silybum marianum var. *marianum*	50			7.7					6.7	18.2	5	6.5
Cynanchum acutum subsp. *acutum*					7.1	14.3			6.7	9.1	4	5.2

Species present in 3 habitats												
Amaranthus biltum subsp. *emerginatus*					21.4				26.7	36.4	11	14.3
Ranunculus sceleratus					14.3				33.3	18.2	9	11.7
Ricinus communis					7.1				33.3	27.3	9	11.7
Avena fatua				46.2	7.1					9.1	8	10.4
Corchorus olitorius		80	50			28.6					7	9.1
Desmostachya bipinnata							25		13.3	18.2	5	6.5
Sorghum virgatum				15.4					6.7	18.2	5	6.5
Urtica urens	100	20	100								5	6.5
Anagallis arvensis subsp. *arvensis* var. *caerulea*	50	20			14.3						4	5.2
Galinsoga parviflora	50								13.3	9.1	4	5.2
Vicia sativa subsp. *nigra*				15.4	7.1				.	9.1	4	5.2
Adiantum capillus-veneris	50	20			.				6.7		3	3.9
Orobanche cernua					7.1		25			9.1	3	3.9
Populus euphratica		20							6.7	9.1	3	3.9
Veronica anagalloides subsp. *taeckholmiorum*				7.7					6.7	9.1	3	3.9
Species present in 2 habitats												
Vossia cuspidata									100	27.3	18	23.4
Cyperus articulatus									60	54.5	15	19.5
Ludwigia stolonifera									46.7	27.3	10	13
Tamarix nilotica									33.3	45.5	10	13
Riccia aegyptica									13.3	54.5	8	10.4
Salix mucronata									26.7	36.4	8	10.4
Cyperus michelianus subsp. *pygmaeus*									6.7	36.4	5	6.5
Phoenix dactylifera									20	9.1	4	5.2
Alternanthera sessilis									6.7	18.2	3	3.9
Juncus bufonius									13.3	9.1	3	3.9
Alhagi graecorum									6.7	9.1	2	2.6
Enarthrocarpus lyratus									6.7	9.1	2	2.6
Tagetes minuta									6.7	9.1	2	2.6
Polycarpon tetraphyllum		20								36.4	5	6.5
Sesbania sesban						14.3			26.7		5	6.5
Anagallis arvensis subsp. *arvensis* var. *arvensis*					21.4					9.1	4	5.2
Juncus hybridus							25		13.3		3	3.9
Orobanche crenata					14.3					9.1	3	3.9
Setaria verticillata	100							25			3	3.9
Brassica nigra	50									9.1	2	2.6
Cenchrus echinatus	50								6.7		2	2.6
Eragrostis cilianensis						14.3			6.7		2	2.6
Eruca sativa	50			7.7							2	2.6
Fumaria parviflora		20			7.1						2	2.6
Gnaphalium polycaulon	50									9.1	2	2.6
Medicago polymorpha var. *vulgaris*				7.7						9.1	2	2.6
Oldenlandia capensis var. *capensis*					7.1					9.1	2	2.6
Orobanche ramosa var. *schweinfurthii*					7.1					9.1	2	2.6
Sinapis allionii				7.7					6.7		2	2.6
Veronica anagallis-aquatica		20								9.1	2	2.6
Vicia monantha				7.7						9.1	2	2.6
Withania somnifera				7.7					6.7		2	2.6

Species present in canal bank												
Typha domingensis									33.3		5	6.5
Acacia nilotica subsp. *nilotica*									6.7		1	1.3
Azolla caroliniana									6.7		1	1.3
Ceratophyllum demersum									6.7		1	1.3
Eichhornia crassipes									6.7		1	1.3
Lemna gibba									6.7		1	1.3
Myriophyllum spicatum									6.7		1	1.3
Najas marina subsp. *armata*									6.7		1	1.3
Plantago major									6.7		1	1.3
Senna alexandrina									6.7		1	1.3
Potamogeton crispus									6.7		1	1.3
Potamogeton nodosus									6.7		1	1.3
Potamogeton pectinatus									6.7		1	1.3
Potamogeton perfoliatus									6.7		1	1.3
Spergularia marina									6.7		1	1.3
Spirodela polyrhiza									6.7		1	1.3
Species present in waste lands												
Cyperus difformis										27.3	3	3.9
Fimbristylis bisumbellata										18.2	2	2.6
Lolium rigidum										18.2	2	2.6
Polycarpon prostratum										18.2	2	2.6
Lotus arabicus										9.1	1	1.3
Sphaeranthus suaveolens var. *abyssinicus*										9.1	1	1.3
Species present in crop farmlands												
Brassica juncea				7.7							1	1.3
Medicago sativa subsp. sativa					7.1						1	1.3
Citrullus colocynthis						14.3					1	1.3
Nymphaea caerulea							25				1	1.3
Vicia narbonensis var. *narbonensis*							25				1	1.3
Leptochloa panicea								25			1	1.3
Oxystelma esculentum								25			1	1.3
Species present in orchards												
Ammi majus	50										1	1.3
Bromus catharticus	50										1	1.3
Eleusine indica	50										1	1.3
Nothoscordum gracile											1	1.3
Trianthema portulacastrum	50										1	1.3
Verbena supina	50										1	1.3
Amaranthus hybridus subsp. *cruentus*	50										1	1.3
Leersia hexandra			50								1	1.3
Total number of species	58	60	32	56	60	31	27	29	107	99		