Habitat diversity and floristic analysis of Wadi El-Natrun Depression, Western Desert, Egypt

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Abstract. Despite the actual desertification in Wadi El-Natrun Depression nitrated by tourism and overuse by nomads, 142 species were recorded. Sixty-one species were considered as new additions, unrecorded before in four main habitats: (1) croplands (irrigated field plots); (2) orchards; (3) wastelands (moist land and abandoned salinized field plots); and (4) lakes (salinized water bodies). The floristic analysis suggested a close floristic relationship between Wadi El-Natrun and other oases or depressions of the Western Desert of Egypt.

Key words: biodiversity, croplands, human impacts, lakes, oases, orchards, wastelands

Introduction

Wadi El-Natrun is part of the Western (Libyan) Desert adjacent to the Nile Delta (23 m below sea level), located approximately 90 km southwards of Alexandria and 110 km NW of Cairo. It is oriented in a NW–SE direction, between longitudes 30°05'–30°36'E and latitudes 30°29'–30°17'N (King & al. 2009). It is about 50 km long, narrow at both ends (2.6 km in the north and 1.24 km in the south) and wider in the middle, about 8 km. The Depression is characterized by small disconnected lakes at the bottom of the Wadi, aligned along its general axis in the northwesterly direction, except for Lake El-Gaar (Zahran & Willis 1992, 2009).

Wadi El-Natrun is considered one of the important depressions in the Western Desert that lies below sea level and is known for its land reclamation and utilization (Zahran &Willis 2009). However, agriculture in the Wadi follows the Egyptian agriculture of summer and winter crops. Arable lands are cultivated with field crops and orchards. Reclaimed lands include vast areas of the desert lands that have been reclaimed and are under cultivation, irrigated by underground water. Whereas the modern irrigation techniques (such as drip, sprinkle and pivot) are used in the newly reclaimed areas, the older ones follow the inundation type of irrigation (Soliman 1996; Abd El-Ghani & El-Sawaf 2004). Thus the presence of irrigation water as underground water of suitable quality, existence of natural fresh water springs and availability of water contained in the sandy layers above the shallow water table southwest of the Depression are the main reasons for the importance of Wadi El-Natrun.

Integration between life forms and chorological affinities in the floristic studies have contributed significantly to the prevailing climatic conditions and human impact on land use (e.g., agricultural practices, introduction of new cultivars, grazing, construction of new roads, and establishment of new settlements) and vegetation. Some investigations relied on this approach: Batalha & Martins (2002) in Brazilian cerrado sites, Klimeš (2003) in NW Himalayas; Becker & Müller (2007) in semiarid regions of West and South Africa; Gouvas & Theodoropoulos (2007) in Mount Hymettus (C Greece); Carvalho da Costa & al. (2007) in deciduous thorn woodland (caatinga) in Northeast Brazil; Al Sherif & al. (2013) in the arid region of Saudi Arabia.

According to Salem & al. (2003), a SPOT satellite image has divided the land cover of Wadi El-Natrun into two major classes (Fig. 1): the first includes sparse cultivated fields and natural vegetation which contain all the dominant vegetation types of the gravel habitat occupying an area about 83.7 km^2. The second class includes salt marsh vegetation and dense irrigated fields which contain relatively high vegetation cover with a total area of about 6.6 km^2, where salt marshes are the major range areas for most grazing and livestock rearing activities. Date palms (*Phoenix dactylifera* L.) and olives (*Olea europaea* L.) are the principal orchard trees and represent the greatest source of income for the Wadi. Farmlands are represented by arable lands occupied by field crops and orchards. They exhibit the typical ancient pattern of agriculture, where usually a three-year crop rotation is applied. The crop succession during this period is: (1) temporary Egyptian clover (or fallow fields-cotton), (2) wheat-maize (or rice) and (3) permanent Egyptian clover (or broad beans-maize). Alfalfa (*Medicago sativa* L.) is the principal perennial fodder crop cultivated in Wadi El-Natrun. The planting time for the winter crops is September–November, February–March for cotton, and April–May for maize and rice. In Wadi El-Natrun and other oases of the Western Desert, this habitat occupies the lower levels of the cultivated land, where underground water is available (Abd El-Ghani & El-Sawaf 2004). In general, certain species are subjected to severe uncontrolled cutting such as *Tamarix* spp. for fuel and roofing purposes, *Juncus acutus* for making mats, and *Typha* spp. for fuel and for making mats and hats. The destruction of *Typha* leaves bares the dunes and causes their movement towards the lakes. Therefore, protection of *Typha* in Wadi El-Natrun is urgently needed (Zahran & Girgis 1970). Due to continuous destruction of the natural vegetation by establishment of new settlements and resorts, roads construction, population pressure, land reclamation projects, expansion of human demands and economic activities in Wadi El-Natrun Depression, changes in its floristic composition are expected.

Despite the numerous studies on ecology, flora and vegetation of the depressions (oases) in the Western Desert (Bornkamm & Kehl 1990; Abd El-Ghani 2000), little attention has been paid to the vegetation of Wadi El-Natrun Depression and most of the studies concerning it (Stocker 1927; Boulos 1962; El Hadidi 1971; Boulos & al. 1974; Hussein 1980; Taher1999; El-Sawaf & Emad El-Deen 2000) are focused on the lakes found there.

On the basis of recent floristic investigations by the authors in Wadi El-Natrun Depression, the current situation of the floristic composition in various habitats and an analysis of the crop-weed interactions of the agroecosystem are the main goals of this work.

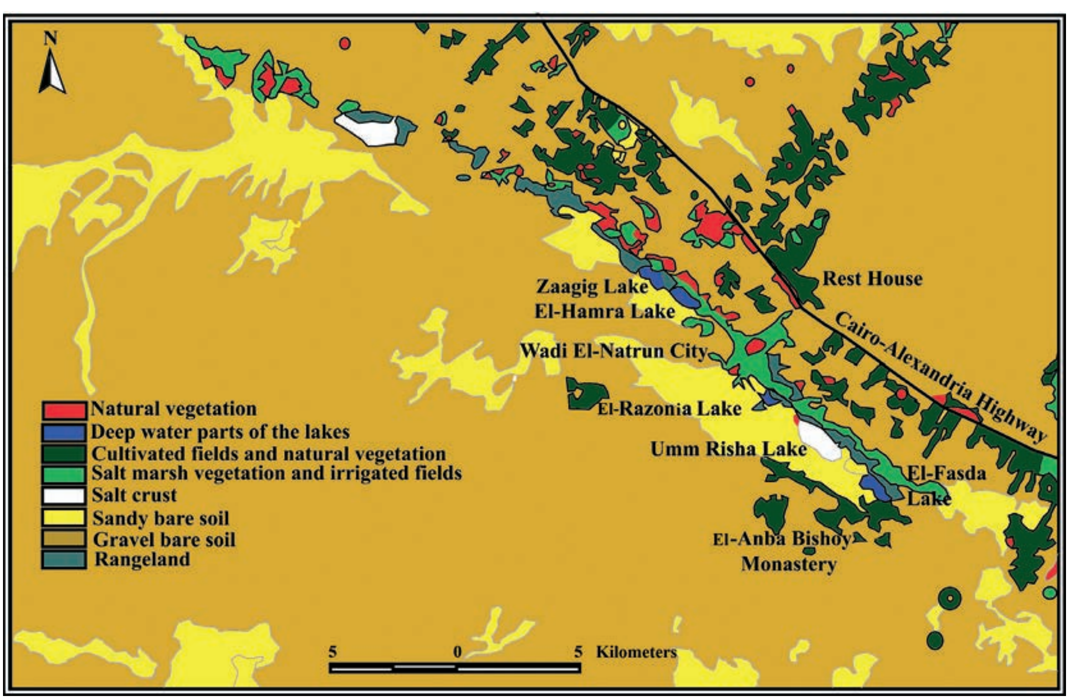

Fig. 1. SPOT satellite image showing the major vegetation types and land cover in Wadi El-Natrun Depression (after Salem & al. 2003).

Material and methods

Vegetation survey and floristic composition

Field data were gathered during intensive field work in 2008-2011, in order to sample the vegetation and floristic composition of the study area. In this study, four main habitats were distinguished in the agroecosystems of Wadi El-Natrun: (1) croplands (irrigated field plots included); (2) orchards (cultivations of fruit trees); (3) wastelands (moist land and abandoned salinized field plots); and (4) lakes (salinized water bodies). One hundred and twenty-two selected stands (Fig. 2) were surveyed, distributed randomly so as to represent as much as possible variation in the vegetation. Having a reasonable degree of physiognomic homogeneity in topography and vegetation type, low levels of vegetation disturbance and changes in habitat types and plant communities were the main criteria in the selection of stands. In each of the studied stands, ecological notes and presence or absence of plant species were recorded. The recorded taxa were classified according to the life-form system proposed by Raunkiaer (1937) and Hassib (1951). Analysis of phytogeographical ranges was carried out after Zohary (1947, 1962) and Abd El-Ghani (1981, 1985). Taxonomic nomenclature was according to Täckholm (1974), Cope & Hosni (1991), Boulos (1995, 2009), and El Hadidi & Fayed (1978, 1995). Specimens of each species were collected and identified at the Herbarium of Cairo University (CAI), where they were deposited.

Crop–weed relationships

Differences in the floristic composition among croplands and orchards were evaluated using their presence percentages (P %). Permanent stands were visited seasonally to record the variation in the floristic composition. Three types of orchard crops (29 stands) were included (*citrus*, date palm, others). Field crops (53 stands) included five winter crops, broad beans (*Faba vulgaris* L.), Egyptian clover (*Trifolium alexandrinum* L.), barley (*Hordeum vulgare* L.), wheat (*Triticum aestivum* L.), and tomato (*Lycopersicon esculentum* L.); one summer crop – maize (*Zea mays* L.); and the perennial alfalfa (*Medicago sativa* L.).

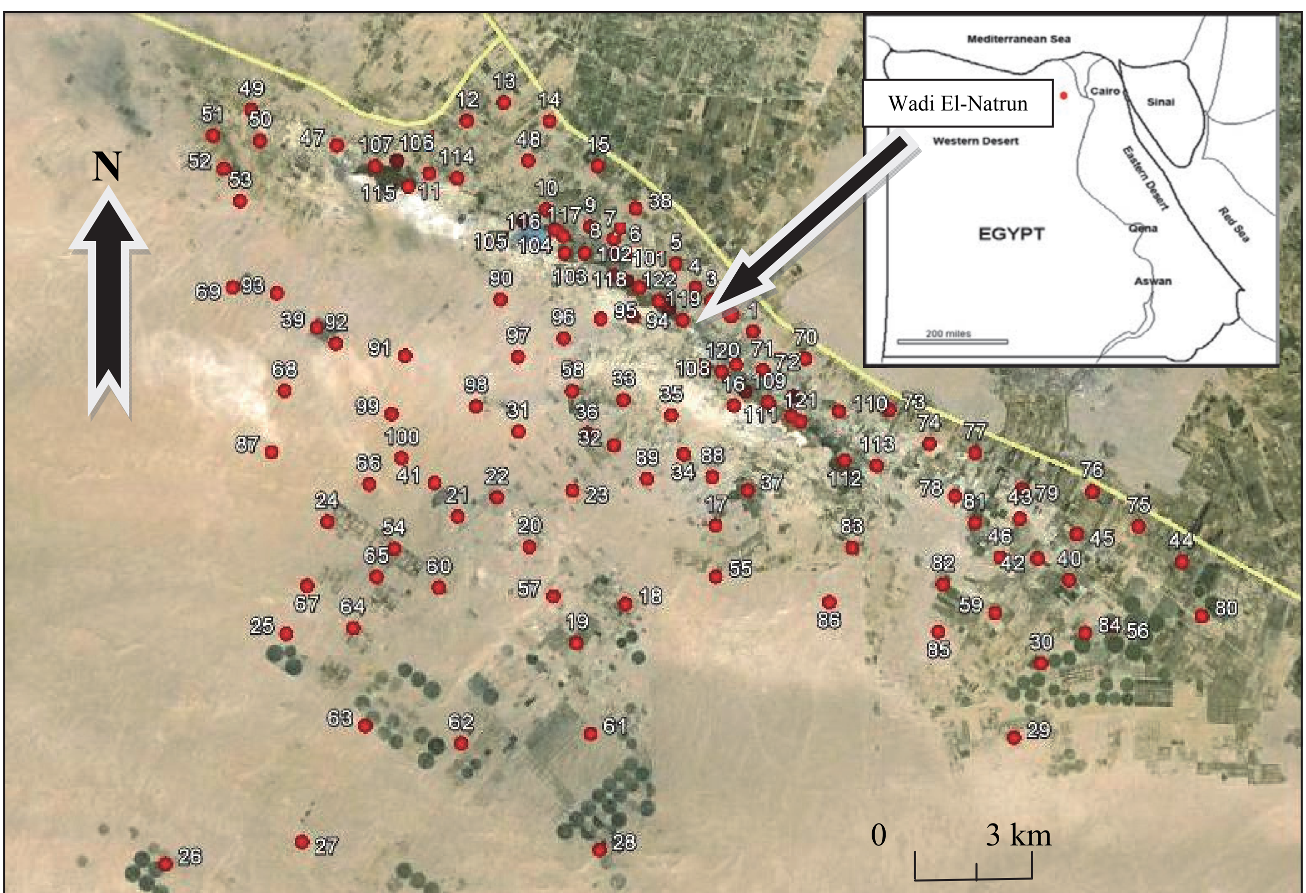

Fig. 2. Distribution of the 122 studied stands in Wadi El-Natrun Depression.

Data analysis

In order to obtain an effective analysis of the vegetation, both classification and ordination techniques were employed. To avoid distortion, species present in 1-5 stands (97 species or 68.3 % of the total flora) were eliminated from the data set. Therefore, a floristic presence/absence data matrix consists of 122 stands and 45 species subjected to cluster analysis by the similarity index (the Czekanowski coefficient; Ludwig & Reynolds 1988). Second, the matrix was analyzed by Bray-Curtis variance regression ordination, using the Sørensen coefficient as the distance measure to check the magnitude of change in species composition along the soil gradients (McCune & Mefford 1999). The Bray-Curtis variance regression ordination was used because it is considered an effective technique for community analyses and for revealing ecological gradients (McCune & Grace 2002).

Results

Floristic composition

A total of 142 species of the vascular plants were identified, belonging to 108 genera in 35 families (Table 1). They consisted of 21 trees and shrubs (14.79 %), 42 perennial herbs (29.58 %) and 79 annuals (55.63 %). The total number of species varied from one habitat to another: 112 species in croplands, 75 species in orchards, 52 species in wastelands, and 25 species in lakes (17.6 % of the total flora).

Comparing our floristic results with the earlier recorded from Wadi El-Natrun, it was found that 61 species have been recorded for the first time and represent new additions to the flora of Wadi El-Natrun (results are not shown, and can be requested from the first author). This comparison also revealed disappearance of 101 species from the flora of the study area, most of which were of xerophytic nature (annuals or perennials), such as *Astragalus peregrinus, A. trigonus, Anabasis articulata, Fagonia arabica, Carduncellus eriocephalus, Euphorbia retusa, Filago desertorum, Helianthemum lippii,* and *Pulicaria arabica.*

Patterns of species distribution in the habitats

Eight ubiquitous species with the broadest ecological range were recorded in all habitats (Table 1). They included *Cynodon dactylon*, *Senecio glaucus* subsp. *coronopifolius* and *Spergularia marina* with the highest values in the croplands (52.8, 39.6 and 18.9 %, respectively), and *Imperata cylindrica*, *Alhagi graecorum*, *Polypogon monspeliensis,* and *Panicum turgidum* in the lakes (40.1, 36.4, 18.2 and 13.6 %, respectively). *Phragmites australis* fared better in the wastelands habitat (38.8 %).

Table 1. List of recorded species in the four habitats of Wadi El-Natrun, along with their life span, life forms and chorotypes.

No.	Taxon	Life span	Life form	Chorotype	Habitats C	O	WL	L
Aizoaceae								
1	**Aizoon canariense* L.	Ann	Th	SA+SZ	2	3	–	–
2	**Mesembryanthemum crystallinum* L.	Ann	Th	MED+ES	2	–	–	–
3	*Mesembryanthemum nodiflorum* L.	Ann	Th	MED+SA+ES	2	–	–	–
4	**Trianthema triquetra* Willd.	Ann	Th	PAL	8	–	6	–
Amaranthaceae								
5	*Amaranthus graecizans* L.	Ann	Th	MED+IT	21	3	–	–
6	*Amaranthus lividus* L.	Ann	Th	COSM	9	17	6	–
7	**Amaranthus* sp.	Ann	Th	MED	2	–	–	–
8	**Amaranthus viridis* L.	Ann	Th	PAL	2	3	–	–
Apiaceae								
9	**Ammi majus* L.	Ann	Th	MED	4	–	–	–
10	*Berula erecta* (Huds.) Coville	Per	HH	MED+ES	–	–	–	5
11	*Deverra tortuosa* (Desf.) DC.	Shr	Ch	SA	2	14	–	–
Apocynaceae								
12	**Cynanchum acutum* L.	Per	Th	MED+IT+ES	25	59	22	–
Asteraceae								
13	*Artemisia monosperma* Delile	Shr	Ch	MED+SA	4	3	6	–
14	**Bidens pilosa* L.	Ann	Th	PAN	2	–	–	–

Table 1. Continuation.

No.	Taxon	Life span	Life form	Chorotype	Habitats			
					C	O	WL	L
15	**Cichorium endivia* L. subsp. *divaricatum* (Schousb.) P.D.Sell	Ann	Th	MED+IT	15	3	–	–
16	**Conyza bonariensis* (L.) Cronquist	Ann	Ph	MED	30	35	22	–
17	*Cotula cinerea* Delile	Ann	Th	SA+SZ	6	10	6	–
18	*Echinops spinosus* L.	Per	H	SA	2	–	–	–
19	**Launaea mucronata* (Forssk.) Muschl. subsp. *cassiniana* (Jaub. & Spach) N. Kilian	Per	Th	SA	2	3	6	–
20	*Launaea mucronata* (Forssk.) Muschl. subsp. *mucronata*	Per	Th	SA	6		6	–
21	*Launaea nudicaulis* (L.) Hook. f.	Per	H	SA+SZ+IT	4	10	17	–
22	**Limbarda crithmoides* (L.) Dumort.	Shr	Th	MED+SA	–	–	6	–
23	**Pluchea dioscoridis* (L.) DC.	Shr	Ph	SA+SZ	11	10	28	–
24	*Pulicaria undulata* (L.) C. A. Mey. subsp. *undulata*	shr	H	SA+SZ	2	3	–	–
25	**Reichardia tingitana* (L.) Roth	Ann	Th	SA+IT	8	–	–	–
26	*Senecio glaucus* L. subsp. *coronopifolius* (Maire) C. Alexander	Ann	Th	MED+IT+ES	40	31	22	9
27	*Sonchus maritimus* L.	Per	Ch	MED+IT	–	3	–	14
28	*Sonchus oleraceus* L.	Ann	Th	COSM	49	38	11	–
29	*Symphyotrichum squamatum* (Spreng.) Nesom	Ann	Th	PAN	4	7	–	–
	Boraginaceae							
30	*Heliotropium bacciferum* Forssk. subsp. *bacciferum*	Per	Ch	SA+IT	2	3	–	–
31	*Heliotropium digynum* (Forssk.) Asch ex C. Chr.	Per	Ch	SA	9	7	6	–
32	*Moltkiopsis ciliata* (Forssk.) I. M. Johnst.	Shr	Ch	MED+SA	–	7	–	–
	Brassicaceae							
33	*Brassica nigra* (L.) Koch	Ann	Th	COSM	–	3	–	–
34	*Brassica tournefortii* Gouan	Ann	Th	MED+IT	6	–	–	–
35	*Cakile maritima* Scop.	Ann	Th	MED+SA	–	3	–	–
36	**Capsella bursa–pastoris* (L.) Medik.	Ann	Th	COSM	2	–	–	–
37	**Coronopus didymus* (L.) Sm.	Ann	Th	COSM	2	–	–	–
38	**Eremobium aegyptiacum* (Spreng.) Asch. & Schweinf. ex Boiss.	Per	Th	SA	–	10	–	–
39	*Farsetia aegyptia* Turra	Shr	Ch	SA+SZ	2	–	–	–
40	*Raphanus sativus* L.	Ann	Th	CULT	6	–	–	–
41	*Sisymbrium irio* L.	Ann	Th	MED+IT+ES	11	3	6	–
	Caryophyllaceae							
42	*Paronychia arabica* (L.) DC.	Ann	Th	SA	–	–	6	–
43	*Polycarpaea repens* (Forssk.) Asch. & Schweinf.	Per	Ch	SA+SZ	–	–	6	–
44	**Silene nocturna* L.	Ann	Th	MED	2	3	–	–
45	**Silene rubella* L.	Ann	Th	MED+IT	4	–	–	–
46	*Spergularia marina* (L.) Griseb.	Per	Th	COSM	19	3	11	18
	Chenopodiaceae							
47	*Agathophora alopecuroides* (Delile) Fenzl ex Bunge	Shr	Ch	SA	2	–	–	–
48	**Atriplex halimus* L.	Shr	Ph	MED+SA	2	–	–	–
49	**Atriplex lindleyi* Moq. subsp. *inflata* (F. Muell.) P. G. Wilson	Per	Ch	MED+IT+ES	2	–	17	–
50	*Bassia indica* (Wight) A.J.Scott	Ann	Ch	SZ+IT	21	41	6	–
51	*Bassia muricata* (L.) Asch.	Ann	Th	SA+SZ	2	3	–	–
52	**Beta vulgaris* L.	Ann	Th	COSM	17	–	–	–
53	*Chenopodium album* L.	Ann	Th	COSM	6	7	–	–
54	*Chenopodium murale* L.	Ann	Th	COSM	64	28	22	–
55	*Cornulaca monacantha* Delile	Shr	Ch	SZ	–	3	–	–
56	*Salsola tetragona* Delile	Shr	Ch	MED+SA	–	–	11	–
57	*Suaeda aegyptiaca* (Hasselq.) Zohary	Ann	Th	SA+SZ	–	–	6	–
	Convolvulaceae							
58	**Convolvulus arvensis* L.	Per	H	PAL	8	7	–	–
59	*Convolvulus lanatus* Vahl	Shr	Ph	SA	2	–	–	–
	Cucurbitaceae							

Table 1. Continuation.

No.	Taxon	Life span	Life form	Chorotype	Habitats			
					C	O	WL	L
60	*Citrullus colocynthis* (L.) Schrad.	Per	H	MED+SA	2	–	–	–
Cuscutaceae								
61	**Cuscuta pedicellata* Ledeb.	Ann	Pa	SA+SZ	4	–	–	–
Cyperaceae								
62	**Cyperus difformis* L.	Ann	Th	PAN	2	–	–	–
63	*Cyperus laevigatus* L. var. *laevigatus*	Per	Geo	PAL	4	–	17	73
64	**Cyperus rotundus* L. var. *fenzelianus* (Steud.) Habashy	Per	Geo	PAN	9	3	–	–
Euphorbiaceae								
65	**Euphorbia helioscopia* L.	Ann	Ph	COSM	4	3	6	–
66	**Euphorbia indica* Lam.	Ann	Th	SA+SZ+IT	–	–	6	–
67	**Euphorbia peplus* L.	Ann	Th	COSM	4	–	–	–
Fabaceae								
68	**Acacia nilotica* (L.) Delile	Tr	Ph	SZ	2	–	–	–
69	*Alhagi graecorum* Boiss.	Per	H	PAL	4	14	28	36
70	*Melilotus indicus* (L.) All.	Ann	Th	PAL	28	10	–	–
71	**Melilotus messanensis* (L.) All.	Ann	Th	MED+IT	2	–	–	–
72	**Trifolium resupinatum* L.	Ann	Th	MED+IT+ES	2	–	–	–
73	*Trigonella hamosa* L.	Ann	Th	MED+SA+SZ	2	–	–	–
Geraniaceae								
74	*Erodium oxyrhynchum* M. Beib subsp. *bryoniifolium* (Boiss) Schönb.–Tem.	Ann	H	SA+IT	2	3	6	–
Juncaceae								
75	*Juncus acutus* L.	Per	HH	MED+IT+ES	–	–	11	86
76	*Juncus rigidus* Desf.	Per	Geo	MED+IT+SA	2	–	17	82
Lamiaceae								
77	**Mentha longifolia* (L.) Huds.	Per	HH	PAL	4	–	–	–
Malvaceae								
78	*Malva parviflora* L.	Ann	Th	MED+IT	38	17	17	–
Neuradaceae								
79	*Neurada procumbens* L.	Ann	Th	SA	2	3	–	–
Nitrariaceae								
80	*Nitraria retusa* (Forssk.) Asch.	Shr	Ch	SA+SZ	–	3	6	–
Orobanchaceae								
81	**Orobanche crenata* Forssk.	Ann	Geo	MED+IT	2	–	–	–
Oxalidaceae								
82	**Oxalis corniculata* L	Per	Geo	COSM	4	–	–	–
Plantaginaceae								
83	**Plantago lagopus* L.	Ann	Th	MED+IT	4	–	–	–
Poaceae								
84	**Aeluropus littoralis* (Gouan) Parl.	Per	H	MED+SA	–	–	17	23
85	*Arundo donax* L.	Per	Geo	NATUR	–	–	–	18
86	*Avena fatua* L.	Ann	Th	COSM	6	3	–	–
87	**Avena sativa* L.	Ann	Th	NATUR	4	–	–	–
88	**Cenchrus biflorus* Roxb.	Per	Th	SA+SZ	15	17	–	–
89	*Centropodia forskaolii* (Vahl) Cope	Per	Geo	SA+IT	–	–	–	5
90	**Chloris virgata* Sw.	Ann	Th	PAL	2	7	–	–
91	*Cynodon dactylon* (L.) Pers.	Per	Geo	PAN	53	45	33	14
92	*Dactyloctenium aegyptium* (L.) Willd.	Ann	Th	PAL	32	14	6	–
93	*Desmostachya bipinnata* (L.) Stapf	Per	Geo	SA+SZ	2	–	–	32
94	*Digitaria sanguinalis* (L.) Scop.	Ann	Th	PAL	21	45	–	5
95	**Dinebra retroflexa* (Vahl) Panz.	Ann	Th	SA+SZ+IT	2	7	–	–
96	*Echinochloa colona* (L.) Link	Ann	Th	PAN	13	17	6	–

Table 1. Continuation.

No.	Taxon	Life span	Life form	Chorotype	Habitats C	O	WL	L
97	**Echinochloa crusgalli* (L.) P. Beauv.	Ann	Th	PAN	–	3	–	–
98	**Eleusine indica* (L.) Gaertn.	Ann	Th	SZ	2	–	–	–
99	**Eragrostis cilianensis* (All.) Vignolo ex Janch.	Ann	Th	PAL	6	3	–	–
100	*Eragrostis pilosa* (L.) P. Beauv.	Ann	Th	PAL	8	–	–	–
101	*Imperata cylindrica* (L.) Raeusch.	Per	H	MED+IT+SA	6	35	28	40
102	**Leptochloa fusca* (L.) Kunth,	Per	Geo	PAL	6	–	6	–
103	*Lolium perenne* L.	Per	Th	COSM	13	3	–	–
104	*Lolium rigidum* Gaudin	Ann	Th	MED+IT+ES	6	–	–	–
105	*Panicum turgidum* Forssk.	Per	Geo	SA+SZ	2	7	11	14
106	*Parapholis incurva* (L.) C. E. Hubb	Ann	H	MED+IT+ES	4	–	–	–
107	**Phalaris minor* Retz.	Ann	Th	MED+IT+SA	2	–	–	–
108	*Phragmites australis* (Cav.) Trin. ex Steud. subsp. *australis*	Per	Ch	PAL	17	28	39	14
109	**Poa annua* L.	Ann	Th	MED+IT+ES	6	3	–	–
110	*Polypogon monspeliensis* (L.) Desf.	Ann	Th	COSM	17	10	17	18
111	**Rostraria rohlfsii* (Asch.) Holub	Ann	Th	SA	–	3	–	–
112	*Setaria verticillata* (L.) P. Beauv.	Ann	Th	COSM	8	31	6	–
113	**Setaria viridis* (L.) P. Beauv.	Ann	Th	COSM	17	35	6	–
114	**Sorghum halepense* (L.) Pers.	Per	Ch	CULT	2	–	–	–
115	**Sorghum virgatum* (Hack.) Stapf	Ann	Th	SZ	2	3	–	–
116	*Sporobolus spicatus* (Vahl) Kunth.	Per	Geo	MED+SA+SZ	–	–	6	5
117	**Stipagrostis hirtigluma* (Steud. ex Trin. & Rupr.) De Winter.	Ann	H	SA+SZ	–	7	–	–
118	*Stipagrostis plumosa* (L.) Munro ex T. Anderson	Per	Geo	SA	–	3	6	–
Polygonaceae								
119	*Emex spinosa* (L.) Campd.	Ann	Th	MED	15	–	–	–
120	**Polygonum bellardii* All.	Ann	Th	MED+IT+ES	2	3	–	–
121	**Rumex dentatus* L.	Ann	Th	MED+IT+SZ	2	3	6	–
Portulacaceae								
122	**Portulaca oleracea* L.	Ann	Th	COSM	26	28	–	–
Primulaceae								
123	*Anagallis arvensis* L.	Ann	Th	COSM	26	3	–	–
124	*Samolus valerandi* L.	Per	H	PAL	–	–	–	5
Solanaceae								
125	**Datura innoxia* Mill.	Ann	Th	PAN	4	3	–	–
126	*Hyoscyamus muticus* L.	Shr	H	SA+SZ	–	3	–	–
127	**Solanum elaeagnifolium* Cav.	Per	Th	PAN	2	3	–	5
128	*Solanum nigrum* L.	Ann	Ch	COSM	11	14	6	–
129	**Withania somnifera* (L.) Dunal	Shr	Ch	SA+SZ	–	3	–	–
Tamaricaceae								
130	*Tamarix aphylla* (L.) H Karst.	Tr	Ph	SA+SZ+IT	–	–	6	–
131	*Tamarix nilotica* (Ehrenb.) Bunge	Tr	Ph	SA+SZ	9	–	6	23
132	**Tamarix tetragyna* Ehrenb.	Tr	Ph	MED+IT+SA	2	–	17	–
Tiliaceae								
133	**Corchorus olitorius* L.	Ann	Th	PAN	9	–	–	–
Typhaceae								
134	*Typha domingensis* (Pers.) Poir. ex Steud.	Per	HH	PAN	2	–	–	50
135	*Typha elephantina* Roxb.	Per	HH	SA+IT	–	–	6	27
Verbenaceae								
136	*Phyla nodiflora* (L.) Greene	Per	Ch	PAL	2	–	–	–
Zannichelliaceae								
137	*Zannichellia palustris* L.	Per	H	COSM	–	–	–	5
Zygophyllaceae								

Table 1. Continuation.

No.	Taxon	Life span	Life form	Chorotype	Habitats C	Habitats O	Habitats WL	Habitats L
138	**Tribulus pentandrus* Forssk.	Ann	Th	SA	6	–	–	–
139	*Tribulus terrestris* L.	Ann	Th	COSM	–	7	–	–
140	*Zygophyllum album* L. f.	Shr	Ch	MED+SA+SZ	2	7	6	–
141	*Zygophyllum coccineum* L.	Shr	Ch	SA+SZ	2	–	6	–
142	*Zygophyllum simplex* L.	Ann	Th	SA+SZ	4	7	–	–

Legend: (+) = recorded, (-) = unrecorded, (*) = new records. Figured are the mean presence percentages (P %) for each species.
Habitats abbreviations: C=croplands, O=orchards, WL=wastelands, L=lakes.
Life span abbreviations: Ann=annuals, Per=perennials.
Life forms abbreviations: Ph=phanerophytes, Ch=chamaephytes. H=hemicryptophytes, Geo=geophytes, HH=helophytes & hydrophytes, Pa=parasites, Th=therophytes.
Chorotypes abbreviations: COSM=cosmopolitan, CULT= cultivated, NATUR=naturalized, ES=Euro-Siberian, IT=Irano-Turanian, MED=Mediterranean, PAL=Palaeotropical, PAN=Pantropical, SA=Saharo-Arabian, SZ=Sudano-Zambezian.

Twenty-two species were recorded in three habitats (croplands, orchards and wastelands). Ten species showed their highest presence in orchards, namely: *Amaranthus lividus, Bassia indica, Conyza bonariensis, Cotula cinerea, Cynanchum acutum, Echinochloa colona, Setaria verticillata, S. viridis, Solanum nigrum* and *Zygophyllum album.* Six species were recorded in croplands: *Chenopodium murale, Dactyloctenium aegyptium, Heliotropium digynum, Malva parviflora, Sisymbrium irio* and *Sonchus oleraceus. Erodium oxyrhynchum*, *Artemisia monosperma, Euphorbia helioscopia, Launaea nudicaulis, Pluchea dioscoridis,* and *Rumex dentatus* fared better in wastelands habitat.

Desert species contributed to the weed assemblages of orchard and cropland habitats and included *Chloris virgata*, *Launaea mucronata* subsp. *cassiniana, Neurada procumbens,* and *Pulicaria undulata* subsp. *undulata*. *Symphyotrichum squamatum* is a biennial which scored 3.77 % in croplands habitat and 6.9 % in orchards habitat. As shown in Table (1), four species were confined to wastelands and lake habitats, and these were the halophytes: *Aeluropus littoralis*, *Juncus acutus, Sporobolus spicatus,* and *Typha elephantina*.

Some species showed a narrow ecological range or much limited sociological presence, as they were confined to only one habitat. Forty species (28.2 % of the total flora) were only recorded in the croplands. *Beta vulgaris, Emex spinosa, Corchorus olitorius*, *Eragrostis pilosa,* and *Reichardia tingitana* showed high presence of 17 %, 15.1 %, 9.43 %, 7.55 %, and 7.55 %, respectively. Twenty-two species were occasionally recorded (1.89 %), including some common desert plants such as *Citrullus colocynthis*, *Convolvulus lanatus, Farsetia aegyptia, Mesembryanthemum crystallinum* and *M. nodiflorum,* whereas others were among the common weeds of Egypt, such as *Capsella bursa-pastoris, Melilotus messanensis, Amaranthus* sp., *Trifolium resupinatum,* and *Bidens pilosa.*

Eleven species were confined to the orchard habitat, with *Eremobium aegyptiacum* showing the highest presence (10.3 %). Lower values of 3.45 % were recorded by the annual weeds *Brassica nigra* and *Echinochloa crusgalli,* desert annuals *Cakile maritime*, *Rostraria rohlfsii*, and desert perennials *Cornulaca monacantha, Hyoscyamus muticus* and *Withania somnifera*. *Centropodia forskaolii, Samolus valerandi*, *Zannichellia palustris, Berula erecta,* and *Arundo donax* showed certain consistency to the lakes habitat; *Suaeda aegyptiaca, Limbarda crithmoides, Tamarix aphylla, Salsola tetragona, Polycarpaea repens, Euphorbia indica,* and *Paronychia arabica* were present in the wastelands.

Biological spectrum of species

Seven life forms were recorded. The proportion of these life forms in the four recognized habitats is shown in Fig. 3. Therophytes were recorded frequently in all habitats, where they scored 80 % in the saline lakes and 50-60 % in the stands of other habitats. Chamaephytes ranked second and were equally present (12-17 %) in the croplands, orchards and wastelands, and very modestly represented (4 %) in the saline lakes habitat. Proportions of phanerophytes were almost equal in all habitats. The saline lakes habitat showed highly significant differences (P=0.001) among the recognized habitats (Table 2).

Classification and ordination of the vegetation

Using cluster analysis, 122 stands were classified into five groups (A-E), representing five different types of

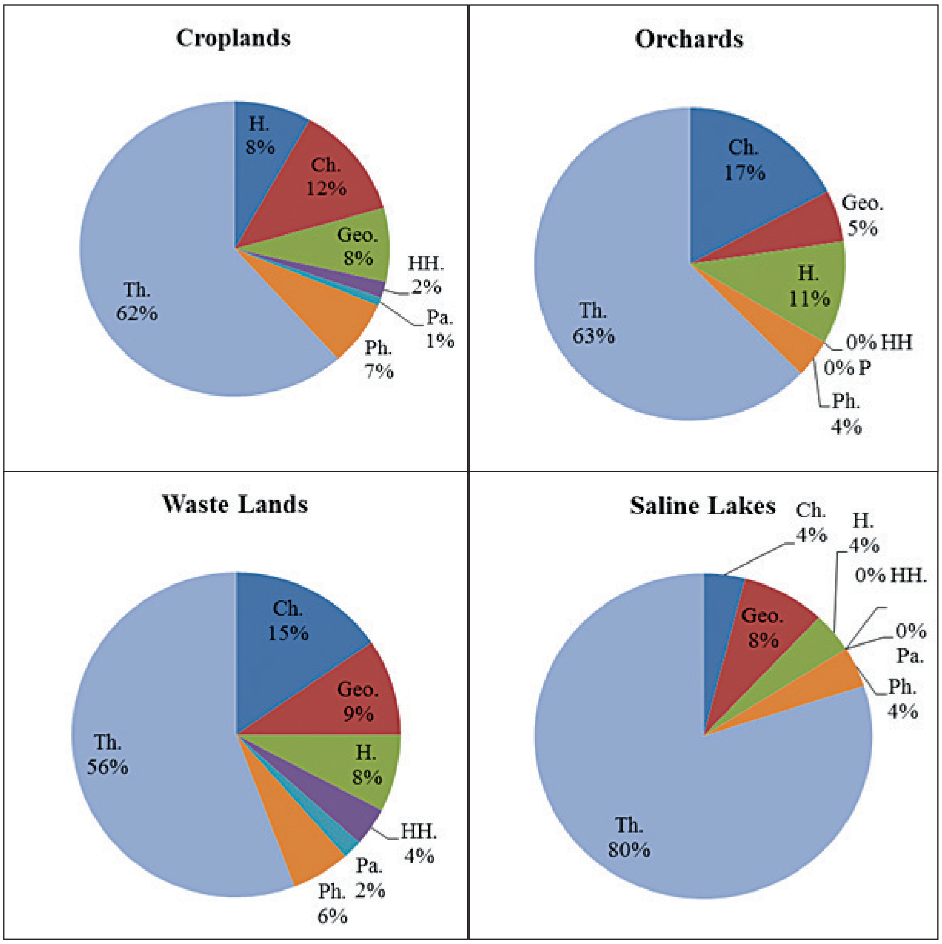

Fig. 3. Distribution of the biological spectra in different habitats. Ph.=phanerophytes, Ch.=chamaephytes. H.=hemicryptophytes, Geo.=geophytes, HH.=helophytes & hydrophytes, Pa=parasites, Th.=therophytes.

Table 2. Mean values, standard errors and ANOVA F-values of the life forms in the recognized habitats of Wadi El-Natrun.

Habitats	Phanerophytes (Ph.)	Chamaephytes (Ch.)	Hemicryptophytes (H.)	Helophytes & hydrophytes (HH.)	Geophytes (Geo.)	Parasites (Pa.)	Therophyes (Th.)	F-ratio	P
Croplands	6.9 ± 9.4	3.8 ± 5.8	2.4 ± 2.5	1.2 ± 1.8	6.5 ± 14.2	4.0 ± 0.0	9.0 ± 14.2	1.50	0.182
Orchards	5.3 ± 11.6	6.5 ± 10.4	5.9 ± 9.5	0.0	4.5 ± 12.4	0.0	4.5 ± 12.4	0.41	0.87
Waste lands	9.4 ± 10.4	5.5 ± 8.9	6.9 ± 10.8	3.4 ± 4.5	7.4 ± 9.9	0.0	7.4 ± 9.9	2.14	0.052
Saline lakes	2.6 ± 7.7	1.3 ± 4.2	7.8 ± 14.2	33.6 ± 35.4	18.7 ± 27.8	0.0	18.7 ± 27.8	10.13	0.001*

*= $P \leq 0.01$.

communities belonging to four habitats: croplands, orchards, wastelands, and saline lakes (Fig. 4). Each floristic group can be designated to one or more of the recognized habitats. While floristic group (A) dominated by *Senecio glaucus* subsp. *coronopifolius-Chenpodium murale-Chenopoium murale* occupied mainly the croplands, group (B) dominated by *Melilotus indicus-Sonchus oleraceus-Digitaria sanguinalis* occupied the croplands and orchards. Floristic group (C) dominated by *Cynodon dactylon-Beta vulgaris-Conyza bonariensis* was found mainly in the orchard habitats, floristic group (D) dominated by *Tamarix nilotica-Cyperus laevigatus-Phragmites australis* prevailed in the wastelands, and group (E) was mainly assigned to the lakes and was dominated by *Juncus rigidus-Desmostachya bipinnata-Typha domingensis*.

Application of the Bray-Curtis ordination indicated reasonable segregation between these habitats (Fig. 5). Floristic group (E) which represented the stands from lake habitats was ordered at the negative end of Axis 1. Whereas stands from wasteland habitats (WL) had a central position on Axis 1, stands from the cropland (C) and orchard habitats (O) were ordered at the other positive end. Therefore, Axis 1 represented the lakes (L) and C-O gradient.

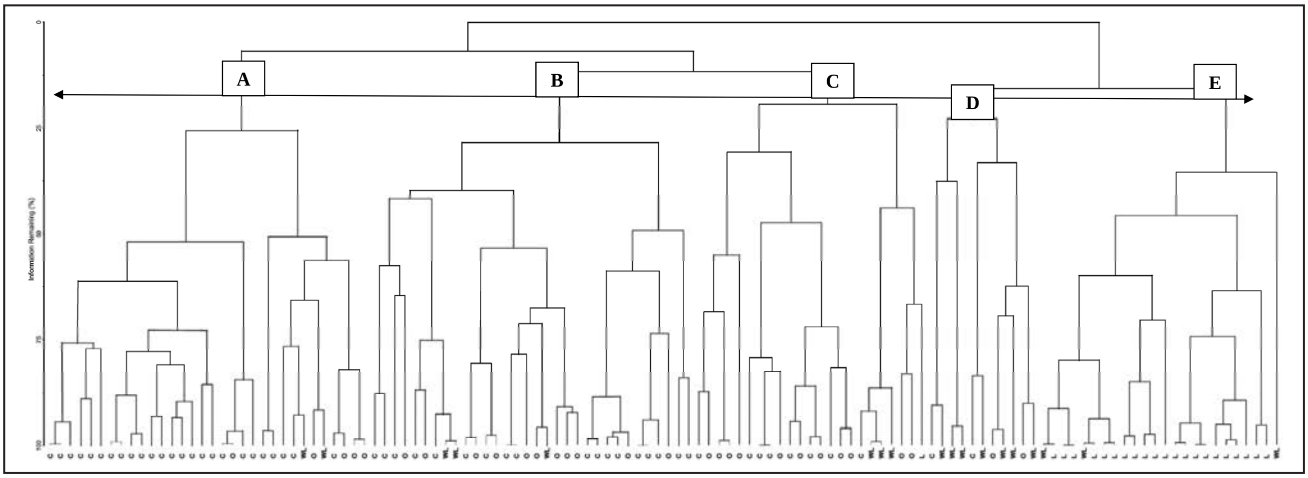

Fig. 4. Relationship between the five floristic groups (A-E) generated after cluster analysis. C=croplands, O=orchard, WL=wastelands, L=lakes.

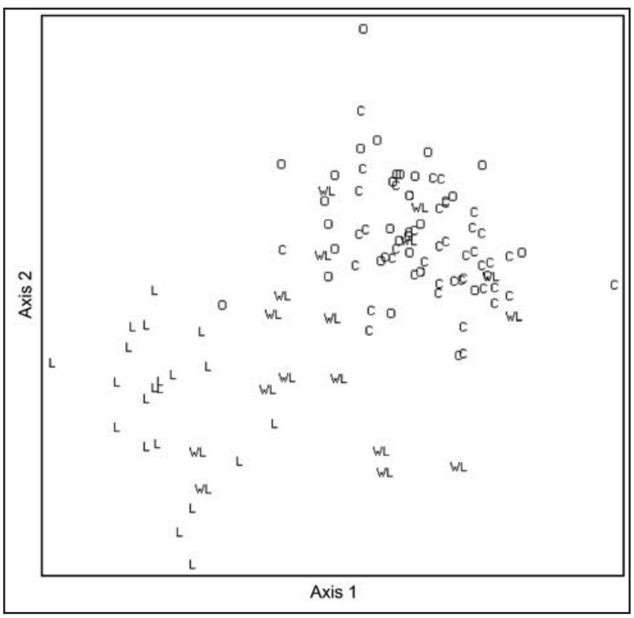

Fig. 5. Bray-Curtis ordination of stands indicating the segregation of the four habitats of Wadi El-Natrun. For abbreviations, see Fig. 4.

Chorological affinities

Chorological analysis revealed that cosmopolitan (22 species), palaeotropical (16 species) and pantropical chorotypes (11 species) have comprised 49 species, or about 34.5 % of the recorded flora (Table 1). The mono-regional chorotype was represented by 22 species (15.4 %), of which 13 species were Saharo-Arabian. On the other hand, the tri-regional chorotype was represented by 23 species (16.2 % of the total flora) formed by combination of the five different phytochoria: Mediterranean, Saharo-Arabian, Sudano-Zambezian, Irano-Turanian, and Euro-Siberian. Only the combination of MED+IT+ES showed apparent importance as it comprised 10 species, while the other combinations were less important, each represented by a small number of species (1-4).

Crop-weed relationship

Table (3) shows the performance of each species within the six studied crops. The total number of species varied among the crops: the highest was 91 species in the winter crops (WC), and the lowest was 29 in the *citrus* orchards (CO). Nine species were recorded in all six crops (the widest sociological ranges of species). Performance (P %) seemed to differ. While *Chenopodium murale* performed better in winter, summer and perennial crops (P=64.3, 58.3 and 71.4 %, respectively), *Phragmites australis* exhibited higher maximum performance in orchards (P=21.4, 37.5 and 28.6 % in FO, CO and DO, respectively). Similar observations pertained to *Cynanchum acutum* in three orchards, and *Malva parviflora* in three crops. Despite their lower presence values, *Launaea amal-aminae* and *Tamarix nilotica* were steady in three crops, and *Eremobium aegyptiacum* and *Moltkiopsis ciliata* in orchards.

Some species showed a certain degree of consistency to one assemblage (narrowest sociological range) and were distributed as follows: 31 in the winter crops (WC), nine in the summer crop, three in the perennial crops, seven in the fruiting orchards, two in the *citrus* orchards, and one in the date palm orchards (Table 3). Apart from *Corchorus olitorius* (P=41.7 %), *Trianthema triquetra* (P=33.3 %) and *Emex spinosa* (P=23.5 %), all members of this category showed low or very low performance. Several desert species were also recorded in the floristic composition of all habitats (e.g., *Hyoscyamus muticus, Cornulaca monacantha, Zygophyllum coccineum, Parapholis incurva, Citrullus colocynthis, Acacia nilotica,* and *Bassia muricata*).

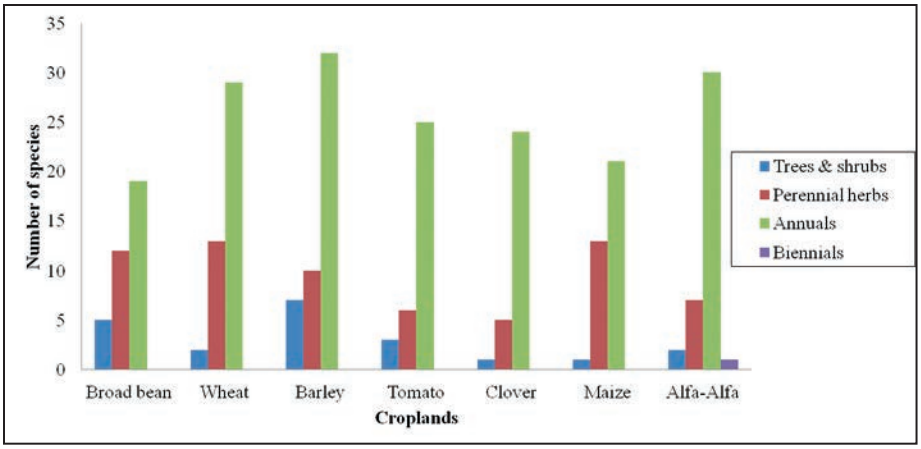

Fig. 6. Distribution of the different growth forms in the studied crops.

Table 3. Species performance in the croplands of Wadi El-Natrun. Figures are the mean presence percentages (P %) for each species.

Species	WC	SC	PC	FO	CO	DO
Total number of fields	34	12	7	14	8	7
Total number of species	91	36	40	58	29	32
Species recorded in six assemblages						
Bassia indica	20.6	8.3	42.9	57.1	12.5	42.9
Chenpodium murale	64.7	58.3	71.4	42.9	12.5	14.3
Conyza bonariensis	35.3	16.7	28.6	21.4	37.5	57.1
Cynodon dactylon	50.0	66.7	42.9	28.6	75	42.9
Digitaria sanquinalis	17.6	25.0	28.6	57.1	12.5	57.1
Phragmites australis	17.6	16.7	14.3	21.4	37.5	28.6
Portulaca oleracea	23.5	25.0	42.9	28.6	12.5	42.9
Setaria viridus	14.7	25.0	14.3	28.6	25	57.1
Sonchus oleraceus	29.9	41.7	42.9	57.1	25	14.3
Species recorded in five assemblages						
Cenchrus ciliaris	17.6		28.6	14.2	12.5	28.6
Cynanchum acutum	32.4	16.7		71.4	50	42.9
Malva parviflora	41.2	33.3	28.6	18.6	12.5	
Senecio glaucus subsp. *coronopifolius*	58.8		14.3	50.0	12.5	14.3
Setaria verticillata	8.8		14.3	42.9	25	14.3
Species recorded in four assemblages						
Alhagi graecorum	2.9	8.3		14.2		28.6
Amaranthus lividus	11.8		14.3	28.6		14.3
Anagallis arvensis	35.3	8.3	14.3			14.3
Chenpodium album	2.9	8.3	14.3	14.2		
Cyperus rotundus var. *fenzelianus*	5.9	16.7	14.3		12.5	
Dactyloctenium aegyptium	20.6	66.7	28.6	28.6		
Imperata cylindrica	11.8			35.7	50	14.3
Pluchea dioscoridis	14.7		14.3		12.5	28.6
Zygophyllum simplex	2.9		14.3	7.1		14.3
Species recorded in three assemblages						
Amaranthus graecizans	14.7	50.0		7.1		
Chloris virgata			14.3	7.1		14.3
Cichorium endivia subsp. *divaricatum*	17.6		28.6	7.1		
Deverra tortuosa	2.9			14.2		28.6
Dinebra retroflexa		8.3		7.1	12.5	
Echinochloa colona	2.9	50.0		35.7		
Euphorbia helioscopia	2.9		14.3	7.1		
Heliotropium digynum	14.7			7.1		14.3
Launaea amal-aminae	2.9	8.3	14.3			
Melilotus indicus	38.2		28.6	21.4		
Panicum turgidum	2.9			7.1	12.5	
Poa annua	5.9		14.3	7.1		
Polypogon monspeliensis	23.5		14.3	21.4		
Sisymbrium irio	11.8		28.6	7.1		
Solanum nigrum	17.6			21.4	12.5	
Spergularia marina	26.5		14.3	7.1		
Symphyotrichum squamatum			28.6	7.1	12.5	
Tamarix nilotica	5.9	16.7	14.3			
Species recorded in two assemblages						
Aizoon canariense	2.9			7.1		
Amaranthus viridus	2.9			7.1		
Artemisia monosperma	5.9					14.3
Avena fatua	8.8					14.3
Bassia muricata	2.9			7.1		
Beta vulgaris	20.6		28.6			
Convolvulus arvensis	11.8				25	
Cotula cineria	8.8			21.4		
Cyperus laevigatus	2.9	8.3				
Datura innoxia	5.9				12.5	
Eragrostis cilianensis	8.8					14.3
Eragrostis pilosa	8.8	8.3				
Eremobium aegyptiacum				14.2		14.3
Erodium oxyrhynchum			14.3	7.1		
Heliotropium bacciferum subsp. *bacciferum*	2.9			7.1		
Launaea mucronata subsp. *cassiniana*		8.3		7.1		
Launaea nudicaulis	5.9			21.4		
Leptochola fusca	5.9	8.3				
Lolium perenne	20.6			7.1		
Moltkiopsis ciliata				7.1		14.3
Neurada procumbens			14.3			14.3
Plantago lagopus	2.9	8.3				
Polygonum bellardii			14.3		12.5	
Pulicaria undulata subsp. *undulata*	2.9					14.3

Table 3. Continuation.

Species	WC	SC	PC	FO	CO	DO
Total number of fields	34	12	7	14	8	7
Total number of species	91	36	40	58	29	32
Rumex dentatus			14.3	7.1		
Silene nocturna	2.9				12.5	
Silene rubella	2.9		14.3			
Solanum eleagnifolium	2.9				12.5	
Sorghum virgatum		8.3				14.3
Stipagrostis hirtigluma				7.1		14.3
Tribulus terrestris				7.1	12.5	
Zygophyllum album	2.9			14.2		
Species recorded in one assemblage						
Acacia nilotica	2.9					
Agathophora alopecuroides	2.9					
Ammi majus	5.9					
Atriplex halimus	2.9					
Avena sativa	5.9					
Brassica tournefortii	8.8					
Citrullus colocynthis	2.9					
Convolvulus lanatus	2.9					
Coronopus didymus	2.9					
Cuscuta pedicellata	5.9					
Cyperus difformis	2.9					
Emex spinosa	23.5					
Euphorbia peplus	5.9					
Farsetia aegyptia	2.9					
Lolium rigidum	8.8					
Melilotus messanensis	2.9					
Mentha longifolia	5.9					
Mesembryanthemum nodiflorum	2.9					
M. crystallinum	2.9					
Orobanche crenata	2.9					
Oxalis corniculata	5.9					
Parapholis incurva	5.9					
Phalaris minor	2.9					
Raphanus sativus	8.8					
Reichardia tingitana	11.8					
Tamarix tetragyna	2.9					
Tribulus pentandrus	8.8					
Trifolium resupinatum	2.9					
Trigonella hamosa	2.9					
Typha domingensis	2.9					
Zygophyllum coccineum	2.9					
Amaranthus albus		8.3				
Atriplex lindleyi subsp. *inflata*		8.3				
Bidens pilosa		8.3				
Corchorus olitorius		41.7				
Desmostachya bipinnata		8.3				
Echinops spinosus		8.3				
Phyla nodiflora		8.3				
Sorghum halepense		8.3				
Trianthema triquetra		33.3				
Capsella bursa-pastors			14.3			
Eleusine indica			14.3			
Juncus rigidus			14.3			
Cakile maritima				7.1		
Cornulaca monacantha				7.1		
Echinochloa crus-galli				7.1		
Nitraria retusa				7.1		
Rostraria rohlfsii				7.1		
Sonchus maritimus				7.1		
Stipagrostis plumosa				7.1		
Withania somnifera					12.5	
Hyoscyamus muticus					12.5	
Brassica nigra						14.3

Legend: WC=winter crops, SC=summer crop, PC=perennial crop, FO=fruiting orchards, CO=*citrus* orchards, DO=date palm orchards.

Discussion

A total of 142 species belonging to 108 genera in 35 families of the vascular plants were recorded in this study. On the basis of the number of species, five major families accounted for 54.9 % of the total flora in the study area, while four of them (*Poaceae, Asteraceae, Fabaceae, Chenopodiaceae*) were also reported as most frequent in the reclaimed areas in other parts of Egypt (Soliman 1989 in Tahrir area; Shehata & El-Fahar 2000 in the reclaimed areas of Salhiya; Shaheen 2002 in the newly farmed lands along the southern border of Egypt; Mustafa 2002 in the farmlands of Upper Egypt; Abd El-Ghani & Fawzy 2006 in the agroecosystems of the oases). Moreover, *Poaceae, Asteraceae* and *Fabaceae* were found to be the most frequent families containing many weed species in other studies of the tropics (Åfors 1994; Becker & al. 1998; Tamado & Milberg 2000). These families represent the most common plants in the Mediterranean and North African flora (Quézel 1978), as well as the most important plants in small-scale farming in highland Peru, Central Mexico and North Zambia (Åfors 1994; Becker& al. 1998; Vibrans 1998).

Therophytes constituted the main bulk of the total flora, which was attributed to the climatic features of Wadi El-Natrun which according to the map of Walter & Leith (1960) is of the extremely arid type.

Frequent occurrence of therophytes may be attributed to their short life cycle, water availability and the prevailing climatic conditions (Shaltout & El-Fahar 1991). The preponderance of therophytes could be related to their high reproductive capacity, ecological, morphological and genetic plasticity under high level of disturbance (Grime 1979). Furthermore, the high proportion of therophytes in this study is also attributed to human activities, according to Barbero & al. (1990). Their range strongly resembles the one reported by Olsvig-Whittaker & al. (1983) from a Negev Desert watershed at Sede Boqer, Israel, and complies also with the observations of Danin & Orshan (1990) for corresponding environments in Israel. The low number of perennials (42 species) and trees (21 species) could be explained by the agricultural processes and vegetative growth structures. Therophytes also dominated many arid and semi-arid study areas, for example, in Northeast Brazil (Carvalho da Costa & al. 2007), Mount Hymettus (Greece) (Gouvas & Theodoropoulos 2007) and Khulais region, West Saudi Arabia (Al Sherif & al. 2013). Abd El-Ghani & Fawzy (2006) recognized five main habitats in the agroecosystems of the major oases of the Western Desert; viz., farmlands, canal banks, reclaimed lands, wastelands, and water bodies. Similar habitats were recognized in the agroecosystem of Wadi El-Natrun Depression.

Like any oasis (depression) of the Western Desert, the vegetation around the saline lakes habitat of Wadi El-Natrun is of the salt-marsh type, where high levels of salinity were encountered (Zahran & Girgis 1970). This may explain the low number of species recorded in this habitat, where a significant relationship between salinity and species richness was reported in other studies too (e.g., Moustafa & Klopatek 1995; Shaltout & al. 1997; Abd El-Ghani 2000; Abd El-Ghani & El-Sawaf 2004).

Chorological analysis indicated that the floristic structure of the study area was relatively simple as compared with other areas of Egypt, being stronger affected by human impacts (Shaltout & El-Fahar 1991; Bakr 2007; Abd El-Ghani & al. 2011), while pure Mediterranean species were very poorly represented and bi- and tri-regional Mediterranean chorotypes constituted 26.7 %. The Saharo-Arabian chorotype, either pure or penetrating into other regions, accounted for 40 % of all recorded flora. Thus, presumably, this chorotype was more effective in the flora of the study area, which can be attributed to migration of some desert species such as *Citrullus colocynthis* to the arable lands (Hamed 2012). Such invasion of the desert plant species can be attributed to urbanization and other human activities, including livestock grazing or other household purposes in addition to fragmentation by road network and urban sprawl in the area. This result agrees with Salem & al. (2003) who have described Wadi El-Natrun as a raw grazing ecosystem for goats, sheep, cows, and camels.

Trees and shrubs were represented best by the Saharo-Arabian chorotype and they are known as a good indicator for desert environmental conditions, while the Mediterranean species stood for more mesic environments. Similar results were reported in the other reclaimed areas across the country, e.g., El-Tahrir area (Soliman 1989), the newly farmed lands along the southern border of Egypt (Shaheen 2002), the farmlands of Upper Egypt (Mustafa 2002), and in the agroecosystems of the oases (Abd El-Ghani & Fawzy 2006).

The present study revealed the disappearance of 101 species from the flora of Wadi El-Natrun. This could be attributed to human activities, urbanization, and land and soil degradation in the Depression. Abd El-Ghani & Fahmy (1998) have reached a similar conclusion during their study of the floristic variations in the course of 60 years in Feiran Oasis of Southern Sinai, Egypt. On the other hand, 61 species were considered new to the flora of Wadi El-Natrun. Of these, seven species were considered new to the floristic structure of the study area. This high number of newly recorded species can be related to the following factors: (1) a very little attention paid to the agroecosystems and various habitats of Wadi El-Natrun, (2) contamination of the crop seeds which were mainly brought for cultivation from the Nile Valley or Delta with other seeds of weedy species, and (3) old commercial relationships between the nomads of Wadi El-Natrun and those of other oases of the Western Desert via several well-known routes.

Among the striking results of this study was the disappearance of *Cyperus papyrus* which has always been recorded as extinct from the Egyptian flora (Täckholm & Drar 1950). In Ancient Egypt, it was the hieroglyphic symbol for Lower Egypt. The roots were used for fuel; pith for paper and the stems were employed for boats and boxes. According to Boulos & al. (1974), *Cyperus papyrus* was a dominant plant in Wadi El-Natrun but it was recorded only in some scattered places (El Hadidi 1968). El Hadidi (1971) reported a population of papyrus at the shore of Um Risha Lake, associated with some water-loving species such as *Berula erecta, Cyperus articulatus, Pycreus mundtii,* and *Lemna gibba*. Boulos & al. (1974) confirmed the absence of *Cyperus papyrus* around El-Rhazonia Lake. This absence can be explained by the fact that in the previous period the lake received a flow of water then slowly its salinity increased and *Cyperus papyrus* disappeared.

Some species such as *Typha elephantina* was confined to Wadi El-Natrun, with no confirmation of its occurrence in any locality outside it. Our results confirmed the occurrence of *T. elephantina* in W. El-Natrun. The presence of this species in Egypt is most interesting from a geographical point of view because it constitutes a link between India and Algeria, and provides a better explanation of its occurrence in the latter country (Boulos 1962). *Typha elephantina* was recorded in Wadi El-Natrun by Général Adréossy in 1823 who was a member of Napoleon's Expedition to Egypt. Then, it was entirely overlooked, and was not mentioned by Ascherson & Schweinfurth (1889). The plant was rediscovered in Wadi El-Natrun by Sickenberger (1901), Muschler (1912), Stocker (1927), Simpson (1930, 1937) Täckholm & al. (1941, (1956). Boulos (1962) identified the presence of *T. elephantina* mixed with *T. domingensis* in dense thickets around the lakes, associated with *Samolus valerandi, Berula erecta, Cyperus laevigatus* var. *laevigatus, Sonchus maritimus,* and *Lemna gibba*.

The wide distribution of some weeds in this study was attributed to their being ubiquitous species with wide amplitude (e.g., *Chenopodium murale* and *Cynodon dactylon*) often caused by phenotypic plasticity and heterogeneity (Shaltout & Sharaf El-Din 1988). Restricted distribution of some weeds, such as *Emex spinosa* in the winter crops (WC), *Corchorus olitorius* in the summer crop (SC), *Capsella bursa-pastoris* in the perennial crops (PC), *Sonchus maritimus* in the fruiting orchards (FO), *Withania somnifera* in the *citrus* orchards, and *Brassica nigra* in the date palm orchards (DO) can be attributed to the habitat preference phenomenon. The type of crop, seasonal preferences and ecological factors may explain the differences in number clearly observed among different crop farmlands.

Abd El-Ghani & Fawzy (2006) discussed the latter phenomenon in the farmlands of the Egyptian Oases as they included five of the identified habitats (farmlands, canal banks, reclaimed lands, wastelands, and water bodies), each with its own preferential species. It can be noted too that Abd El-Ghani & El-Sawaf (2004) reported similar habitats in their reports on the diversity and distribution of plant species in the agroecosystems of Egypt. Similar findings were indicated in this investigation, which may suggest a close floristic relationship between Wadi El-Natrun and other oases or depressions of the Western Desert of Egypt.

Conclusions

As part of the Sahara, the arid climatic features of Wadi El-Natrun Depression have been reflected in the structure and composition of its Mediterranean North African flora. Anthropogeneic activities in this area influenced the species diversity, where land reclamation and other touristic resorts have affected the number of species recorded in each habitat. Also, alteration in climatic conditions in the last seven decades and desertification were among the main reasons for disappearance of many species and several newly recorded ones. Being included in the Western Desert of Egypt, a close floristic relationship was detected between Wadi El-Natrun Depression and the oases of that desert.

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