African Journal of Ecology

Biogeographical relations of a hyperarid desert flora in eastern Egypt

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Abstract

The floristic composition and geographical elements of the study area were analysed resulted in 328 species representing 206 genera in 55 families. This study confirmed the record of fourteen species, mostly weeds, which can be considered as new additions to the flora of the study area. Therophytes were the dominant life form, while mono- and bi-regional Saharo-Sindian geoelements were the most represented. Ten species showed dominancy with their Q-values ranged between 0.802 and 0.2, where *Zilla spinosa* and *Zygophyllum coccineum* were of common occurrence. Application of cluster analysis and DCA ordination techniques produced four major floristic groups (A–D) comprising seven subgroups. The correlation coefficients (*r*) between the different subgroups revealed high significant correlations ($P = 0.01$) between floristic group (B) and subgroup (C_2) and between subgroups (D_1) and (D_2). Significant correlations ($P = 0.05$) occurred between subgroup (D_1) and both of (A_1) and (C_2). Comparing the floristic similarities between this investigation and other relevant studies were presented and discussed. On the other hand, the low similarity index between the study area and Sinai may be attributed to the geographical position of both deserts where Sinai desert is part of the Irano-Turanian region, while the Eastern Desert is a part of the Saharo-Sindian region.

Key words: chorology, desert vegetation, Egypt, flora, life forms, plant diversity

Résumé

Nous avons analysé la composition floristique et certains éléments géographiques de la zone étudiée et compté 328 espèces représentant 206 genres appartenant à 55 familles. Cette étude a confirmé l'observation de 14 espèces, principalement de petite taille, qui peuvent être considérées comme de nouveaux ajouts à la flore de cette région. Les thérophytes étaient la forme de vie prédominante, et les géo-éléments saharo-sindiens mono- et bi-régionaux étaient les plus représentés. Dix espèces montraient une dominance avec une valeur de Q allant de 0,802 à 0,2, là où *Zilla spinosa* et *Zygophyllum coccineum* sont communes. L'application d'analyses par regroupement et de techniques d'ordination DCA a permis d'obtenir 4 groupes floristiques majeurs (A-D) comprenant 7 sous-groupes. Les coefficients de corrélation (r) entre les différents sous-groupes ont révélé des corrélations très significatives (P=0,01) entre le groupe floristique B et le sous-groupe C_2 et entre les sous-groupes D_1 et D_2. Des corrélations significatives (P=0,05) existaient entre le sous-groupe D_1 et les sous-groupes A_1 et C_2. Des comparaisons entre les similitudes floristiques qui existent entre cette recherche et d'autres études pertinentes furent présentées et discutées. D'autre part, le faible indice de similarité entre la zone de l'étude et le Sinaï pourrait être dû à la situation géographique des deux déserts, le Sinaï faisant partie de la région irano-turanienne alors que le désert oriental fait partie de la région saharo-sindienne.

Introduction

The Eastern Desert of Egypt occupies the area extending from Nile Valley eastward to the Gulf of Suez and Red Sea which is about 223,000 km^2, that is, 21% of the total area of Egypt (Abu Al-Izz, 1971). The inland part of the Eastern Desert can be divided into four main geomorphological and ecological regions, from north to south: (i) Cairo-Suez

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Desert, (ii) Limestone Desert, (iii) Sandstone Desert and (iv) Nubian Desert (Zahran & Willis,1992). Phytogeographically, El Hadidi (1980) divided the Eastern Desert into two main subterritories: (i) Galalah Desert, including Cairo-Suez and the northern limestone plateau and (ii) Arabian Desert, including the southern limestone plateau and the Nubian Sandstone. Ayyad & Ghabbour (1986) considered this desert a part of the hyperarid province of hot desert which covers most of Egypt and extends south to Lat. 21°N in Sudan. Hyperarid provinces are characterized by a mean temperature of over 30°C in the hottest month and a winter rainfall averaging 30 mm^{-1}.

Due to the variations in the flora and vegetation of its wadi ecosystem and the coastal flora along the Red Sea, the Eastern Desert was of extreme interest to botanists from the early beginnings of the last century such as Schweinfurth (1901), Montasir (1938), Hassib (1951), Girgis (1965), Kassas (1952, 1953), Kassas & Girgis (1969, 1970, 1972), Hassan (1987), Salama & Fayed (1989, 1990), Salama & El-Naggar (1991), Abd El-Ghani (1998) and Hassan (2003). Except that of Hassan (1987), most of the previous studies dealt with the different ecological aspect, with less attention to the floristic features of this desert.

Uncontrolled human activities in this desert caused great changes in the distribution, presence and extinction of the Eastern Desert plants, so this study was designed to increase our knowledge about the present status of the floristic diversity of the Eastern Desert of Egypt based on extensive field surveys and the previous herbarium and literature records. To better understand the flora and its biogeographical affinities, the floristic composition and geographical elements of the Eastern Desert were analysed at family and generic levels. The floristic relationships of this desert to its neighbouring desert in Sinai were discussed by comparing the revised floristic inventories and checklists of these regions in this study.

Material and methods

The study area lies between 30°06′ and 24°00′ of the Northern Latitudes (Fig. 1). The Eastern Desert of Egypt consists essentially of a backbone of high, rugged mountains running parallel to and at a relatively short distance from the Red Sea coast. To the west of the Red Sea Mountains (igneous in the south and limestone in the north) lie two broad plateaux, parted by the road of Qift-Qusseir (Lat. 26°N). This desert is greatly dissected by valleys and ravines and that all its drainage is external. Topography, geology, geomorphology and soil of this area have been documented by Said (1962), Abu Al-Izz (1971) and Zahran & Willis (1992).

Climatically, the study area lies within the hyperarid provinces (UNEP, 1992) with a mild winter and a hot summer (mean temperature of the hottest month 20–30°C) covering the Eastern Desert and the north-eastern part of the Western Desert and Gebel Uweinat area. Rainfall occurs only in winter and is due to random cloudbursts, a general feature in arid desert: rain may occur once every several years. The mean annual rainfall ranges from 25 mm in Suez, 4 mm in Hurghada to 3.4 mm in Qusseir and 1.2 mm in Mersa Alam (Table 1). The main bulk of rain occurs in winter, that is, Mediterranean affinity, and summer is, in general, rainless. On daily basis, the mean minimum temperature is high and ranges between 14 and 21.7°C in winter and mean maximum 23.1–46.1°C in summer. Relative humidity ranges from 43% in summer to 65% in winter. The Piche evaporation is higher in summer (13.7–21.5 mm day^{-1}) than in winter (5.2–10.4 mm day^{-1}). Some climatic features in certain stations along the Red Sea coast and the Nile Valley may explain environmental aridity and thermal continentality which increases from north to south (Table 1).

Between 2009 and 2012, 35 field trips were conducted to 500 sites representing 34 geo-referenced sectors covering as much as possible the different landforms in the study area (Fig. 1; Table 2). In each of the studied 34 sectors, presence or absence of plant species is recorded using a number of sites randomly positioned. Due to limited accessibility and rugged topography of some sectors, few sites (6–9) were studied. Taking into account the highly variable abundance of plants (in time and space) in this extreme arid desert environment, the size of sites varied from 10 m × 10 m in dense vegetation cover to 20 m × 20 m in widely spaced shrubs or trees. Field crops and cultivated trees were not included in this survey.

Approximately 164,000 data entries (500 sites × 328 species) were resulted from the present collections. To determine the degree of occurrence of each species in the study area, a Q-value (Danin, Shmida & Liston, 1985) was calculated from the formula: Q = number of entries of a species × total number of species/164,000. Therefore, for each of the collected species, the following data were given: species name, life form, chorology, distribution in sectors, *Q*-value and occurrence symbols (Dom. = dominant,

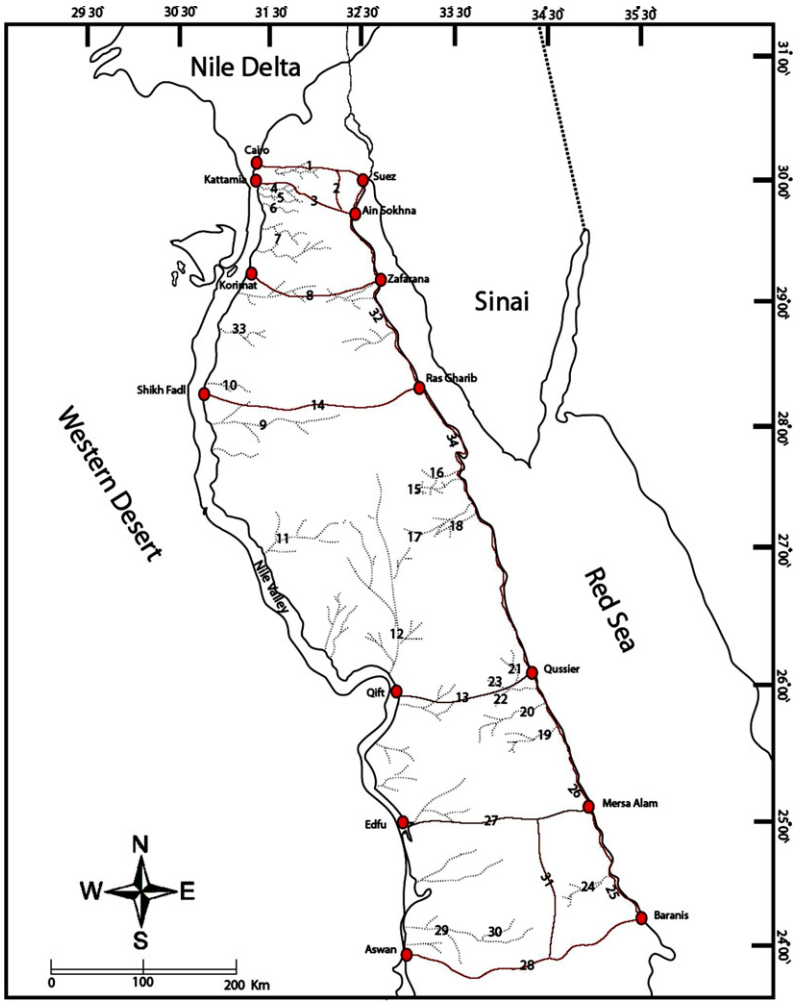

Fig 1 Map of the study area showing the location of the 34 studied sectors

Q-value ≥ 0.2; Very Com. = very common, *Q*-value 0.1–0.199; Com. = common, *Q*-value 0.05–0.099; Occ. = occasional or rare species, *Q*-value 0.01–0.049; and Spo. = sporadic or very rare in the study area, *Q*-value ≤ 0.01). The collected plant species were arranged according to their *Q*-value.

Based on the plant list, the floristic and geographical attributes of the flora of the Eastern Desert were analysed. Patterns of seed plant distribution were quantified at the generic level based on Boulos (1999, 2000, 2002, 2005, 2009). To discuss the floristic similarity and variation as well as biogeographical affinities among the adjacent Sinai Desert, comparisons of floristic composition and geographical elements between the Eastern Desert and Sinai were made using updated checklists of their floras. The checklist of Sinai flora (Danin, Shmida & Liston, 1985) was used for making comparisons.

A floristic data matrix of 97 species and 34 sectors was constructed after the removal of 231 species occurring in less than four sectors (<10%). Based on a binary presence–absence of species and sites, the resultant data matrix was processed by multivariate analysis using the software PAST version 2.11 (Hammer, Harper & Ryan, 2001). For the classification of sectors, cluster analysis using minimum variance as the agglomeration criterion (Orloci, 1978) was applied to a squared Euclidean distance dissimilarity matrix. To assure the robustness of the resultant classification, we devised a second classification

Table 1 Annual average (over 50 years) of some climatic features at nine meteorological stations within the study area. (Max = maximum, Min = minimum)

Station	Temperature (°C)		Rainfall (mm)	Relative humidity (%)	Evaporation (mm day^{-1})
	Max	Min			
Nile land					
Cairo	28.1	15.8	23.8	55.0	10.5
Beni Suef	29.5	12.7	8.6	49.0	12.2
Menya	29.8	15.0	5.08	42.3	10.5
Assiut	30.7	15.3	6.2	30.4	NA
Qena	31.9	14.6	5.3	26.9	17.6
Red Sea coastal land					
Suez	28.1	18.0	25.0	53.1	9.4
Hurghada	27.8	18.6	4.0	46.1	14.1
Quseir	28.0	18.7	3.4	49.8	8.8
Mersa Alam	29.5	22.3	1.2	54.4	NA

using Sørensen similarity coefficient with the group average linkage cluster analysis algorithm using the program Multi-Variate Statistical Package (MVSP) version 3.1 (Kovach, 1999). This produced nearly identical results to the PAST analysis. Søensen's coefficient of floristic similarity (CCs) between the cluster floristic groups is also estimated. Species richness (alpha-diversity) within each separated floristic group was calculated as the average number of species per sector. All the statistical analyses were carried out using SPSS version 10.0 for Windows.

Identification was carried out at the Cairo University Herbarium (CAI), and nomenclature followed Täckholm (1974) which updated by Boulos (1999, 2000, 2002, 2005). Analysis of the phytogeographical ranges was according to Wickens (1976), life-form categories followed Raunkiaer's system of classification (Raunkiaer, 1934), and endemic and near endemic species followed Boulos (2009).

Results and discussion

Floristic analysis

Altogether, 328 species were recorded from various landforms through 34 sectors representing 206 genera in 55 families (Table 3). More than 50% (188 species) of the recorded species belonging to eight families; these are the species-rich families: Asteraceae (41 species), Poaceae (27 species), Fabaceae (34 species), Chenopodiaceae (24 species), Brassicaceae and Zygophyllaceae (eighteen species for each), and Boraginaceae, and Caryophyllaceae (13 species for each). These families represent the most common in the Mediterranean North African flora (Quézel, 1978; Funk *et al.*, 2009). Asteraceae (the largest family in our list) is not only the largest family in the Flora of Egypt (Täckholm, 1974; Shaltout, El-Kady & El-Sheikh, 1999; Boulos, 2002) but also the largest and most widespread of the flowering plants in the world (Good, 1974; Funk *et al.*, 2009). Table (3) shows also that *Astragalus* (ten species), *Plantago* (nine species), *Fagonia* (eight species), *Erodium* (seven species), *Atriplex, Cleome, Heliotropium* and *Zygophyllum* (five species for each) were the largest genera. The highest numbers of species (72, 71 and 68) were recorded in sectors 1, 8 and 3, respectively, while the lowest numbers (10, 8) were in sectors 25 and 34, respectively.

Taking into account the *Q*-values of the recorded species, ten species showed dominancy with their *Q*-values ranged between 0.802 and 0.2 (Table 3). The highest among others were *Zilla spinosa* and *Zygophyllum coccineum* which recorded in more than 65% of the studied sites and spread their dominancy all over the Eastern Desert of Egypt. Their dominance over the communities of the Eastern Desert was documented by many scholars, among others; Montasir (1938), Hassib (1951), Kassas & Imam (1954), Kassas & El-Abyad (1962), Kassas & Girgis (1964), Salama & El-Naggar (1991), Abd El-Ghani (1998) and Galal & Fahmy (2012). In his account on the northern wadies of the Eastern Desert of Egypt, Fossati, Pautou & Peltier (1998) recorded *Zilla spinosa* and *Zygophyllum coccineum* on more than half of his relévés and indicated their wide range of distribution, often on fine calcareous neutral or alkaline substratum. The remaining eight

Table 2 Characteristics of the 34 sectors, together with their names and the total number of studied sites

Symbol	Sector	Total number of sites
T1	Cairo-Suez Road	20
T2	Wadi Hagul	10
T3	Kattamia-Ain Sokhna Road	15
T4	Wadi Degla	20
T5	Wadi Hof	20
T6	Wadi Garawi	10
T7	El-Saff Desert	20
T8	Korimat-Zafarana Road	22
T9	Wadi Tarfa	11
T10	Wadi El-Tahnawi	10
T11	Wadi Assiuty	12
T12	Wadi Qena	21
T13	Qift-Qussier Road	32
T14	Ras Gharib-Shikh Fadl Road	30
T15	Wadi Abu Had	16
T16	Wadi Deb	9
T17	Wadi El-Qattar	16
T18	Wadi Beli	9
T19	Wadi Um Ghig	13
T20	Wadi Assal	12
T21	Wadi El-Nakhil	7
T22	Wadi Karim	6
T23	Wadi El-Hammaria	11
T24	Wadi El-Gemal	20
T25	Mersa Alam-Hammata Road	11
T26	Mersa Alam-Qussier Road	25
T27	Edfu-Mersa Alam Road	26
T28	Aswan- Baranis Road	7
T29	Wadi Kherit	6
T30	Wadi Natash	10
T31	El Shikh Salem Road	6
T32	Suez-Ras Gharib Road	15
T33	Wadi El-Shikh	12
T34	Gharib-Qussier Road	10

dominant species (*Pulicaria undulata*, *Ochradenus baccatus*, *Zygophyllum simplex*, *Acacia tortilis*, *Trichodesma africanum*, *Morettia philaeana*, *Farsetia aegyptia* and *Tamarix nilotica*) showed a regional dominancy over certain sectors. Fifty-six very common and common species with *Q*-values ranged from 0.198 to 0.05 were identified and included *Haloxylon salicornicum*, *Launaea nudicaulis*, *Echinops spinosus*, *Fagonia mollis*, *Atriplex halimus*, *Euphorbia retusa* and *Calotropis procera* (Table 3). Occasional (rare) species were represented by 90 species such as *Zygophyllum decumbens*, *Heliotropium bacciferum*, *Capparis spinosa*, *Centaurea aegyptiaca*, *Launaea spinosa* and *Kickxia aegyptiaca*. Sporadic (very rare) that have *Q*-values <0.01 constituted the main bulk of the recorded flora (172 species, ca. 49.5% of the total species) and included among others; *Cometes abyssinica*, *Helianthemum kahiricum*, *Cleome arabica*, *Halopeplis perfoliata*, *Calendula arvensis* and *Xanthium strumarium*.

Ninety-two historical records (61 perennials, 31 annuals) were documented, and there was no other indication about their presence till to date. These included Schweinfurth's records of *Krascheninnikovia ceratoides* from Wadi El-Abiad and *Galium spurium* from South Galala in 1887; Keller's record of *Echium longifolium* from Wadi Hof in 1904, Simpson's records of *Colchicum cornigerum*, *Heteroderus pusilla*, *Origanum syriacum, Volutaria crupinoides* in 1924; and Simpson's record of *Schimpera arabica* from Wadi Araba in 1928. Of the remarkable records, the stem parasite *Cusuta brevistyle*, and the water-loving species *Ruppia maritima, Veronica anagallis-aquatica* and *V. beccabunga* can be mentioned (full information about these records is ready upon direct request from the authors). The endemic *Fagonia Täeckhomiana* was the only species that reported as extinct by El Hadidi (1979, 2000). The establishment of new settlements and resorts along the Red Sea coast, building new cities beside the old one along the Nile Valley and its expansion to the desert fringes, and the construction of highways that connect the Nile Valley with most of the cities along the Red Sea coast may explain the disappearance of many species and the remarkable changed flora and vegetation occurred in the study area (El Hadidi & Hosni, 2000).

The comparison between the results of this study with that of Hassan (1987) revealed that 270 species were in common of the total of 496 species recorded. The index of similarity (Cs) is therefore 80.9%. This high value can be attributed to the stability of the flora in this area, with limited changes occurred. Seventy-four species characterized the study of Hassan (1987) on the flora of the Eastern Desert, which have not been recorded in this investigation. Forty-eight species in the six largest families: Asteraceae (ten species), Caryophyllaceae (eight species), Chenopodiaceae and Poaceae (seven species for each), Aizoaceae (six species) and Brassicaceae and Lamiaceae (five species for each) formed the major part of the characteristic species. On the other hand, fourteen species, mostly weeds, characterized the present study that neither recorded in previous studies nor in the literature. These may be considered as new additions to the flora of the Eastern Desert of Egypt. Recorded weeds included *Ammi majus, Convolvulus arvensis, Plantago major, Lolium rigidum* and

Table 3 Species composition of the study area arranged according to their Q-values, together with their floristic groups, status, life forms and chorotypes. For status and life form abbreviations, see text

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Aizoaceae	*Mesembryanthemum crystallinum* L.	A1	0.002	Spo.	Th.	Med., Eu-Si
Aizoaceae	*Mesembryanthemum nodiflorum* L.	A2	0.002	Spo.	Th.	Med., Eu-Si, Sa-Si
Aizoaceae	*Trianthema triquetra* Willd.	A1	0.002	Spo.	Th.	Un
Amaranthaceae	*Amaranthus graecizans* L.	C1	0.002	Spo.	Th.	Pal.
Anacardiaceae	*Rhus tripartita* (Ucria) Grande	D2	0.002	Spo.	Ph.	Med., Sa-Si, Ir-Tu
Apiaceae	*Ammi majus* L.	B	0.002	Spo.	Th.	Med.
Apiaceae	*Daucus littoralis* Sm.	B	0.002	Spo.	H.	Eu-Si
Arecaceae	*Hyphaene thebaica* (L.) Mart.	C2	0.002	Spo.	Ph.	Su-Za
Apocynaceae	*Glossonema boveanum* (Decne.) Decne.	D2	0.002	Spo.	H.	Su-Za
Apocynaceae	*Oxystelma esculentum* (L.f.) R. Br.	A2	0.002	Spo.	Ph.	Gu-Co
Apocynaceae	*Periploca aphylla* Decne.	D2	0.002	Spo.	Ph.	Sa-Si
Apocynaceae	*Solenostemma arghel* (Delile) Hayne	D2	0.002	Spo.	Ph.	Sa-Si
Asteraceae	*Achillea santolina* L.	A2	0.002	Spo.	H.	Ir-Tu
Asteraceae	*Bidens pilosa* L.	A1	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Asteraceae	*Calendula arvensis* L.	A1	0.002	Spo.	Th.	Cosm.
Asteraceae	*Cichorium endivia* L.	A1	0.002	Spo.	Th.	Ir-Tu, Med.
Asteraceae	*Limbarda crithmoides* L.	A1	0.002	Spo.	Hel.	Med., Eu-Si
Asteraceae	*Lactuca serriola* L.	C1	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Asteraceae	*Urospermum picroides* (L.) F.W.Schmidt	B	0.002	Spo.	Th.	Med., Sa-Si, Ir-Tu
Asteraceae	*Xanthium strumarium* L.	A2	0.002	Spo.	Th.	Ir-Tu, Med.
Boraginaceae	*Echiochilon fruticosum* Desf.	C1	0.002	Spo.	Ch.	Sa-Si
Boraginaceae	*Echium rauwolfii* Delile	D2	0.002	Spo.	Th.	Su-Za
Boraginaceae	*Heliotropium curassivicum* L.	A2	0.002	Spo.	Ch.	Pan.
Boraginaceae	*Moltkiopsis ciliata* (Forssk.) I.M.Johnst.	A2	0.002	Spo.	Ch.	Sa-Si
Boraginaceae	*Paracaryum intermedium* (Fresen.) Lipsky	A1	0.002	Spo.	Th.	Sa-Si, Ir-Tu
Brassicaceae	*Brassica rapa* L.	B	0.002	Spo.	Th.	Cosm.
Brassicaceae	*Brassica tournefortii* Gouan	A1	0.002	Spo.	Th.	Med., Sa-Si
Brassicaceae	*Coronopus niloticus* (Delile) Spreng.	A2	0.002	Spo.	Th.	Un
Brassicaceae	*Farsetia longisiliqua* Decne.	A2	0.002	Spo.	Ch.	Su-Za
Brassicaceae	*Savignya parviflora* (Delile) Webb	A1	0.002	Spo.	Th.	Sa-Si
Brassicaceae	*Sisybrium irio* L.	A2	0.002	Spo.	Th.	Cosm.
Cannabaceae	*Cannabis sativa* L.	A1	0.002	Spo.	Th.	Cosm.
Capparidaceae	*Maerua crassifolia* Forssk.	D2	0.002	Spo.	Ph.	Su-Za
Caryophyllaceae	*Paronychia sinaica* Fresen	C1	0.002	Spo.	H.	Ir-Tu
Caryophyllaceae	*Silene linearis* Decne.	C1	0.002	Spo.	Th.	Sa-Si
Chenopodiaceae	*Atriplex farinosa* Forssk.	C2	0.002	Spo.	Ph.	Sa-Si

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Chenopodiaceae	*Halocnemum strobilaceum* (Pall.) M.Bieb.	A1	0.002	Spo.	Ch.	Med., Sa-Si, Ir-Tu
Chenopodiaceae	*Halopeplis perfoliata* (Forssk.) Bunge ex Asch.	A1	0.002	Spo.	Ch.	Sa-Si
Cistaceae	*Helianthemum schweinfurthii* Grosser	A2	0.002	Spo.	Ch.	End.
Cleomaceae	*Cleome arabica* L.	A2	0.002	Spo.	H.	Sa-Si
Cleomaceae	*Cleome brachycarpa* DC.	D2	0.002	Spo.	Th.	Sa-Si
Convolvulaceae	*Convolvulus arvensis* L.	A2	0.002	Spo.	Geo.	Pal.
Cucurbitaceae	*Cucumis prophetarum* L.	D2	0.002	Spo.	H.	Sa-Si
Cyperaceae	*Cyperus alopecuroides* Rottb.	A2	0.002	Spo.	Hel.	Un
Cyperaceae	*Cyperus articulata* L.	A2	0.002	Spo.	H.	Pal.
Cyperaceae	*Cyperus conglomeratus* Rottb.	D2	0.002	Spo.	H.	Med., Sa-Si, Su-Za
Ephedraceae	*Ephedra ciliata* Fisch. ex C.A.Mey.	A2	0.002	Spo.	Ph.	Su-Za
Euphorbiaceae	*Chrozophora plicata* (Vahl) Spreng.	A2	0.002	Spo.	Ch.	Med., Sa-Si
Euphorbiaceae	*Euphorbia peplus* L.	A1	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Euphorbiaceae	*Ricinus communis* L.	A1	0.002	Spo.	Ph.	Pal.
Fabaceae	*Acacia saligna* (Labill.) Wendl.f.	B	0.002	Spo.	Ph.	Aus.
Fabaceae	*Cullen plicata* (Delile) C. H. Stirt.	A1	0.002	Spo.	H.	Sa-Si
Fabaceae	*Lotus creticus* L.	A2	0.002	Spo.	Ch.	Med.
Fabaceae	*Sesbania sesban* (L.) Merr.	A2	0.002	Spo.	Ph.	Su-Za
Fabaceae	*Tephrosia purpurea* (L.) Pers.	D2	0.002	Spo.	Ch.	Sa-Si
Frankeniaceae	*Frankenia hirsuta* L.	A1	0.002	Spo.	Ch.	Med., Eu-Si
Frankeniaceae	*Frankenia pulverulenta* L.	A1	0.002	Spo.	Th.	Med., Sa-Si, Ir-Tu
Geraniaceae	*Erodium cicutarium* (L.) L'Her.	A1	0.002	Spo.	Th.	Ir-Tu, Med.
Juncaceae	*Juncus acutus* L.	A2	0.002	Spo.	H.	Ir-Tu, Med.
Molluginaceae	*Glinus lotoides* L.	C1	0.002	Spo.	Th.	Ir-Tu, Med.
Moraceae	*Ficus palmata* Forsk.	A2	0.002	Spo.	Ph.	Sa-Si
Orobanchaceae	*Orobanche ramosa* L.	B	0.002	Spo.	Pa.	Un
Oxalidaceae	*Oxalis corniculata* L.	A1	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago afra* L.	A1	0.002	Spo.	Th.	Med., Sa-Si, Ir-Tu
Plantaginaceae	*Plantago crypsoids* Boiss.	A2	0.002	Spo.	Th.	Near End.
Plantaginaceae	*Plantago exigua* Murray	D2	0.002	Spo.	Th.	Un
Plantaginaceae	*Plantago major* L.	A2	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Poaceae	*Cenchrus ciliaris* L.	A1	0.002	Spo.	H.	Su-Za, Ka-Na, Cape, Sa-Si
Poaceae	*Crypsis schoenoides* (L.) Lam.	A1	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Poaceae	*Dactyloctenium aegyptium* (L.) Willd.	A2	0.002	Spo.	Th.	Pal.
Poaceae	*Desmostachya bipinnata* (L.) Stapf.	A2	0.002	Spo.	Geo.	Sa-Si
Poaceae	*Dichanthium annulatus* (Forssk.) Stapf	A2	0.002	Spo.	H.	Pal.

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Poaceae	*Echinocloa colona* (L.) Link.	C1	0.002	Spo.	Th.	Sa-Si, Ir-Tu
Poaceae	*Hordeum murinum* L.	A1	0.002	Spo.	Th.	Sa-Si, Ir-Tu
Poaceae	*Lolium rigidum* Gaudin	A1	0.002	Spo.	Th.	Ir-Tu, Med.
Poaceae	*Pennisetum setaceum* (Forssk.) Chiov.	A1	0.002	Spo.	H.	Un
Poaceae	*Schismus barbatus* (L.) Thell.	A1	0.002	Spo.	Th.	Med., Ir-Tu, Eu-Si
Poaceae	*Stipa capensis* Thunb.	B	0.002	Spo.	Th.	Sa-Si, Ir-Tu
Polygonaceae	*Rumex cyprius Murb.*	A1	0.002	Spo.	Th.	Sa-Si
Polygonaceae	*Rumex dentatus* L.	A2	0.002	Spo.	Th.	Sa-Si
Polygonaceae	*Rumex simpliciflorus* Murb.	A1	0.002	Spo.	Th.	Sa-Si
Portulacaceae	*Portulaca oleracea* L.	C1	0.002	Spo.	Th.	Cosm.
Primulaceae	*Anagallis arvensis* L.	C1	0.002	Spo.	Th.	Cosm.
Resedaceae	*Reseda decursiva* Forssk.	A1	0.002	Spo.	Th.	Sa-Si
Scrophulariaceae	*Kickxia* acerbiana (Boiss.) Taeckh. & Boulos	D1	0.002	Spo.	Ch.	Sa-Si
Scrophulariaceae	*Lindenbergia indica* (L.) Vatke	C1	0.002	Spo.	Ch.	Sa-Si
Solanaceae	*Datura stramonium* L.	B	0.002	Spo.	Th.	Un
Solanaceae	*Hyoscyamus boveanus* L.	D2	0.002	Spo.	H.	End.
Solanaceae	*Hyoscyamus desertorum* (Aschers. ex Boiss.) Täckholm	A1	0.002	Spo.	H.	Med.
Solanaceae	*Withania somnifera* (L.) Dunal	B	0.002	Spo.	Ch.	Ir-Tu, Med.
Sterculiaceae	*Glossostemon bruguieri* Desf.	A1	0.002	Spo.	Th.	Ir-Tu
Thymelaeaceae	*Thymelaea hirsuta* (L.) Endl.	A1	0.002	Spo.	Th.	Sa-Si
Urticaceae	*Urtica urens* L.	B	0.002	Spo.	Th.	Med., Eu-Si
Zygophyllaceae	*Zygophyllum propinqum* Decne.	A2	0.002	Spo.	Ch.	Sa-Si
Amaranthaceae	*Amaranthus viridis* L.	A1,C1	0.004	Spo.	Th.	Cosm.
Asteraceae	*Asteriscus pygmaeus* (DC.) Coss. & Durieu	A2	0.004	Spo.	Th.	Sa-Si
Asteraceae	*Atractylis mernephthae* Asch.	A1	0.004	Spo.	Th.	Sa-Si
Asteraceae	*Filago desertorum* Pomel	A1	0.004	Spo.	Th.	Sa-Si, Ir-Tu
Asteraceae	*Iphiona scabra* DC.	D2	0.004	Spo.	Ch.	Sa-Si
Asteraceae	*Senecio flavus* (Decne.) Sch. Bip.	D2	0.004	Spo.	Th.	Sa-Si
Asteraceae	*Seriphidium herba-album* (Asso) Soják	A2	0.004	Spo.	Ch.	Sa-Si, Ir-Tu
Avicenniaceae	*Avicennia marina* (Forssk.) Vierh.	C2	0.004	Spo.	Hy.- Hel.	Sa-Si
Boraginaceae	*Arnebia hispidissima* (Lehm.) A. DC.	B	0.004	Spo.	Th.	Sa-Si
Boraginaceae	*Heliotropium ramosissimum* (Lehm.) Sieb. ex A. DC.	A1	0.004	Spo.	Ch.	Sa-Si, Ir-Tu
Caryophyllaceae	*Sclerocephalus arabicus* Boiss.	D1	0.004	Spo.	Th.	Sa-Si
Chenopodiaceae	*Atriplex lindleyi* Moq.	A1	0.004	Spo.	Ch.	Med., Sa-Si
Chenopodiaceae	*Salsola villosa* Delile ex Schult.	C2	0.004	Spo.	Ch.	Sa-Si, Ir-Tu

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Chenopodiaceae	*Suaeda monoica* Forssk. ex J. Gmelin	A1	0.004	Spo.	Ph.	Sa-Si, Su-Za
Convolvulaceae	*Convolvulus lanatus* Vahl	A1,A2	0.004	Spo.	Ch.	Sa-Si
Convolvulaceae	*Cressa cretica* L.	A1	0.004	Spo.	H.	Cosm.
Convolvulaceae	*Cuscuta pedicellata* Ledeb	A2	0.004	Spo.	Pa.	Sa-Si
Fabaceae	*Astragalus spinosus* (Forssk.) Muschl.	A2	0.004	Spo.	Ch.	Ir-Tu
Fabaceae	*Senna holocericea* (Fressn.) Greuter	C1	0.004	Spo.	H.	Af-Mo
Juncaceae	*Juncus rigidus* Desf.	A1,C1	0.004	Spo.	Hel.	Med., Sa-Si, Ir-Tu
Lamiaceae	*Lavandula pubescens* Decne.	A2	0.004	Spo.	H.	Med., Sa-Si
Plantaginaceae	*Plantago ciliata* Desf.	A1	0.004	Spo.	Th.	Sa-Si, Ir-Tu
Poaceae	*Aeluropus lagopoides* (L.) Trin. ex Thwaites	A1	0.004	Spo.	H.	Med., Ir-Tu, Eu-Si,Sa-Si
Poaceae	*Bromus madritensis* L.	A1,A2	0.004	Spo.	Th.	Med., Sa-Si, Ir-Tu
Poaceae	*Leptochloa fusca* (L.) Kunth	A1,C1	0.004	Spo.	H.	Pal.
Poaceae	*Lolium perene* L.	A1,B	0.004	Spo.	H.	Med., Ir-Tu, Eu-Si
Polygonaceae	*Polygonum equisetiforme* Sm.	A1	0.004	Spo.	Ch.	Med., Sa-Si, Ir-Tu
Solanaceae	*Solanum nigrum* L.	A2,C2	0.004	Spo.	Th.	Cosm.
Zygophyllaceae	*Peganum harmala* L.	A1	0.004	Spo.	H.	Med., Ir-Tu, Eu-Si,Sa-Si
Zygophyllaceae	*Tribulus bimucronatus* Viv.	A2,D1	0.004	Spo.	Th.	Su-Za
Zygophyllaceae	*Tribulus megistopterus* Kralik	A1,C1	0.004	Spo.	Th.	Sa-Si
Arecaceae	*Phoenix dactylifera* L.	A2,C2,D1	0.006	Spo.	Ph.	Sa-Si
Asteraceae	*Atractylis carduus* (Forssk.) Christens.	A1,A2	0.006	Spo.	H.	Sa-Si
Boraginaceae	*Lappula spinocarpos* (Forssk.) Asch. ex Kuntze	A1	0.006	Spo.	Th.	Sa-Si, Ir-Tu
Caryophyllaceae	*Herniaria hemistemon* J. Gay	A1,A2	0.006	Spo.	Th.	Sa-Si, Ir-Tu
Chenopodiaceae	*Chenopodium album* L.	A1,A2	0.006	Spo.	Th.	Cosm.
Convolvulaceae	*Convolvulus pilosellifolius* Desr.	A1,B	0.006	Spo.	H.	Sa-Si, Ir-Tu
Fabaceae	*Astragalus annularis* Forssk.	A1	0.006	Spo.	Th.	Sa-Si, Ir-Tu
Fabaceae	*Astragalus schimperi* Boiss.	A1,D2	0.006	Spo.	Th.	Sa-Si
Fabaceae	*Lotus glinoides* Delile	A1	0.006	Spo.	Th.	Sa-Si
Fabaceae	*Lotus halophilus* Boiss. & Spruner	A1,A2	0.006	Spo.	Th.	Med., Sa-Si, Ir-Tu
Fabaceae	*Lupinus digitatus* Forssk.	C1	0.006	Spo.	Th.	Med.
Fabaceae	*Melilotus indica* (L.) All.	B	0.006	Spo.	Th.	Cosm.
Lamiaceae	*Salvia aegyptiaca* L.	A2,B	0.006	Spo.	Ch.	Sa-Si, Ir-Tu
Menispermaceae	*Cocculus pendulus* (J.R. & G. Forst.) Diels	A2	0.006	Spo.	Ph.	Sa-Si
Orobanchaceae	*Cistanche tubulosa* (Schenk) Hook.f.	A1	0.006	Spo.	Pa.	Sa-Si, Ir-Tu
Poaceae	*Aeluropus littoralis* (Gouan) Parl.	C2	0.006	Spo.	H.	Sa-Si
Poaceae	*Avena sterilis* L.	A1,B	0.006	Spo.	Th.	Ir-Tu, Med.
Poaceae	*Phlaris paradoxa* L.	A1,B	0.006	Spo.	Th.	Ir-Tu, Med.
Polygonaceae	*Emex spinosa* (L.) Campd.	A1,A2	0.006	Spo.	Th.	Ir-Tu, Med.

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Resedaceae	*Caylusea hexagyna* (Forssk.) M.L. Green	A1,A2	0.006	Spo.	Th.	Sa-Si
Rhamnaceae	*Ziziphus spina-christi* (L.) Desf.	A2	0.006	Spo.	Ph.	Sa-Si
Solanaceae	*Hyoscyamus albus* L.	A1,D1	0.006	Spo.	H.	Med.
Typhaceae	*Typha domengensis* (Pers.) Poir. ex Steud.	A1,A2,B	0.006	Spo.	Hy.- Hel.	Pan.
Asteraceae	*Anthemis melampodina* Delile	A1	0.008	Spo.	Th.	Sa-Si, Ir-Tu
Asteraceae	*Centaurea scoparia* Sieber ex Spreng.	A1,C1	0.008	Spo.	Ch.	Sa-Si
Asteraceae	*Conyza bonariensis* (L.) Cronquist	A1	0.008	Spo.	Th.	Un
Asteraceae	*Echinops galalensis* Schweinf.	A2	0.008	Spo.	H.	Near End.
Asteraceae	*Phagnalon barbeyanum* Asch. & Schweinf.	A1,A2	0.008	Spo.	Ch.	Sa-Si
Caryophyllaceae	*Cometes abyssinica* R. Br.	D2	0.008	Spo.	Ch.	Af-Mo
Caryophyllaceae	*Spergularia diandra* (Guss.) Boiss.	A1,A2	0.008	Spo.	Th.	Med., Sa-Si, Ir-Tu
Chenopodiaceae	*Chenopodium ficifolium* Sm.	A1,A2,B	0.008	Spo.	Th.	Un
Cistaceae	*Helianthemum kahiricum* Delile	A2	0.008	Spo.	Ch.	Sa-Si
Cistaceae	*Helianthemum lipii* (L.) Dum. Cours.	A1,A2,B	0.008	Spo.	Ch.	Sa-Si
Cleomaceae	*Cleome chrysantha* Decne.	C1,D1,D2	0.008	Spo.	H.	Sa-Si
Ephedraceae	*Ephedra aphylla* Forssk.	A1	0.008	Spo.	Ph.	Sa-Si
Fabaceae	*Astragalus sieberi* DC.	A1,D1	0.008	Spo.	Ch.	Sa-Si
Fabaceae	*Astragalus tribuloides* Delile	A1,A2	0.008	Spo.	Th.	Sa-Si, Ir-Tu
Fabaceae	*Astragalus trigonus* DC.	A1	0.008	Spo.	Ch.	Sa-Si
Fabaceae	*Hippocrepis constricta* Knuze	A1,C1	0.008	Spo.	Th.	Med.
Fabaceae	*Lotononis platycarpos* (Viv.) Pichi-Serm.	A1,C1,D1	0.008	Spo.	Th.	Su-Za
Geraniaceae	*Erodium malacoides* (L.) L'Hér.	A1	0.008	Spo.	Th.	Ir-Tu, Med.
Geraniaceae	*Erodium touchyanum* Delile	A1,B	0.008	Spo.	Th.	Sa-Si
Orobanchaceae	*Orobanche cernua* Loefl.	A2	0.008	Spo.	Pa.	Med., Sa-Si, Ir-Tu
Poaceae	*Avena fatua* L.	A1,B,C2	0.008	Spo.	Th.	Cosm.
Zygophyllaceae	*Fagonia scabra* Forssk.	A1,A2,B	0.008	Spo.	Chas.	Sa-Si
Zygophyllaceae	*Tribulus terrestris* L.	A1,B,C1	0.008	Spo.	Th.	Pan.
Asteraceae	*Artemisia monosperma* Delile	A1	0.01	Occ.	Ch.	Sa-Si
Brassicaceae	*Eruca sativa* Miller	A1,B,C1	0.01	Occ.	Th.	Sa-Si, Ir-Tu
Capparidaceae	*Capparis cartilaginea* Decne.	D1,D2	0.01	Occ.	Ph.	Sa-Si
Capparidaceae	*Capparis decidua* (Forssk.) Edgew.	D2	0.01	Occ.	Ph.	Su-Za
Euphorbiaceae	*Euphorbia granulata* Forssk.	A1,C1	0.01	Occ.	Th.	Sa-Si
Fabaceae	*Astragalus bombycinus* Boiss.	A1	0.01	Spo.	Th.	Sa-Si, Ir-Tu
Geraniaceae	*Erodium arborescens* (Desf.) Willd.	A2	0.01	Occ.	H.	Sa-Si
Aizoaceae	*Aizoon canariense* L.	A1	0.012	Occ.	Th.	Su-Za

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Asteraceae	*Pluchea dioscoridis* (L.) DC.	A1,A2	0.012	Occ.	Ph.	Sa-Si, Su-Za, Ka-Na
Fabaceae	*Acacia ehrenbergiana* Hayne	C1	0.012	Occ.	Ph.	Sa-Si
Fabaceae	*Medicago laciniata* (L.) Mill.	A1	0.012	Occ.	Th.	Sa-Si
Geraniaceae	*Monosonia nivea* (Decne.) Webb	B,C1,D1	0.012	Occ.	H.	Sa-Si
Orobanchaceae	*Orobanche crenata* Forssk.	A1,A2,B	0.012	Occ.	Pa.	Med., Sa-Si, Ir-Tu
Plantaginaceae	*Plantago amplexicaulis* Cav.	A1,D2	0.012	Occ.	Th.	Med., Sa-Si, Ir-Tu
Plantaginaceae	*Plantago cylindrica* Forssk.	A1,A2,C1,D1	0.012	Occ.	Th.	Sa-Si
Poaceae	*Imperata cylindrica* (L.) Raeusch.	A1,B,C1	0.012	Occ.	H.	Med., Sa-Si, Ir-Tu
Poaceae	*Stipagrostis ciliata* (Desf.) De Winter	A1,B,C1	0.012	Occ.	H.	Sa-Si, Ka-Na, Cape
Aizoaceae	*Mesembryanthemum forsskalei* Hochst.	A1	0.014	Occ.	Th.	Sa-Si
Brassicaceae	*Pseuderucaria clavata* (Boiss. & Reut.) O.E. Schulz	A1,A2	0.014	Occ.	Th.	Sa-Si
Caryophyllaceae	*Spergularia marina* (L.) Griseb.	A1,A2	0.014	Occ.	Th.	Med., Ir-Tu, Eu-Si
Chenopodiaceae	*Chenopodium murale* L.	A1,A2,B,C1	0.014	Occ.	Th.	Cosm.
Convolvulaceae	*Convolvulus hystrix* Vahl	A1,C1,C2,D1,D2	0.014	Occ.	Ch.	Sa-Si
Fabaceae	*Taverniera aegyptiaca* Boiss.	A1,D1,D2	0.014	Occ.	Ch.	Near End.
Lamiaceae	*Stachys aegyptiaca* Pers.	A2	0.014	Occ.	H.	Sa-Si
Resedaceae	*Reseda arabica* Boiss.	A1,A2	0.014	Occ.	Th.	Sa-Si
Rutaceae	*Haplophyllum tuberculatum* (Forssk.) Juss.	A1,A2,D2	0.014	Occ.	Ch.	Sa-Si
Scrophulariaceae	*Scrophularia deserti* Delile	A1,A2	0.014	Occ.	H.	Sa-Si
Caryophyllaceae	*Polycarpaea repens* (Forssk.) Asch. & Schweinf.	A2,C1,C2	0.016	Occ.	Th.	Sa-Si
Caryophyllaceae	*Pteranthus dichotomus* Forssk.	A1,A2	0.016	Occ.	Th.	Sa-Si
Chenopodiaceae	*Atriplex dimorphostegia* Kar. & Kir.	A1,A2,C1	0.016	Occ.	Th.	Ir-Tu
Euphorbiaceae	*Chrozophora oblongifolia* (Delile) Spreng.	A1,D1	0.016	Occ.	Ch.	Med., Sa-Si
Malvaceae	*Althaea ludwigii* L.	A1	0.016	Occ.	Th.	Sa-Si
Plantaginaceae	*Plantago ovata* Forssk.	A1,A2	0.016	Occ.	Th.	Med., Sa-Si, Ir-Tu
Plumbaginaceae	*Limonium axillare* (Forssk.) Kuntze	C1,C2	0.016	Occ.	H.	Sa-Si
Chenopodiaceae	*Suaeda vermiculata* Forssk. ex J.F.Gmel.	A2	0.018	Occ.	Ch.	Sa-Si
Fabaceae	*Trifolium alexandrinum* L.	A1,A2,B	0.018	Occ.	Th.	Sa-Si
Geraniaceae	*Monsonia heliotropoides* (Cav.) Boiss.	C1,D2	0.018	Occ.	H.	Sa-Si
Poaceae	*Polypogon monspeliensis* (L.) Desf.	A1,C1,C2	0.018	Occ.	Th.	Cosm.
Acanthaceae	*Blepharis edulis* (Forssk.) Pers.	D1	0.02	Occ.	H.	Sa-Si

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Chenopodiaceae	*Traganum nudatum* Delile	A1,A2	0.02	Occ.	Ch.	Sa-Si
Geraniaceae	*Erodium oxyrhynchum* M.Bieb.	A1,A2	0.02	Occ.	H.	Sa-Si
Moringaceae	*Moringa peregrina* (Forssk.) Fiori	D2	0.02	Occ.	Ph.	Su-Za, Gu-Co
Plantaginaceae	*Plantago coronopus* L.	A1,B	0.02	Occ.	Th.	Med., Sa-Si, Ir-Tu
Brassicaceae	*Farsetia stylosa* R. Br.	C1,D2	0.022	Occ.	Ch.	Su-Za
Salvadoraceae	*Salvadora persica* L.	D1,D2	0.022	Occ.	Ph.	Sa-Si
Zygophyllaceae	*Fagonia tristis* Sickenb.	A1	0.022	Occ.	Ch.	Sa-Si
Asteraceae	*Launaea capitata* (Spreng.) Dandy	A1,B,C1	0.024	Occ.	Th.	Sa-Si
Boraginaceae	*Anchusa hispida* Forssk.	A1,A2	0.024	Occ.	Th.	Sa-Si, Ir-Tu
Chenopodiaceae	*Arthrocnemum macrostachyum* (Moric.) K. Koch	A1,C2	0.024	Occ.	Ch.	Med., Sa-Si
Liliaceae	*Asphodelus tenufolius* Cav.	A1,C1,D2	0.024	Occ.	Th.	Med., Sa-Si, Ir-Tu
Caryophyllaceae	*Paronychia arabica* (L.) DC.	A1,A2,B	0.026	Occ.	Th.	Sa-Si, Ir-Tu
Chenopodiaceae	*Suaeda altissima* (L.) Pall.	A1,A2,C1,C2	0.026	Occ.	Th.	Med., Ir-Tu, Eu-Si
Fabaceae	*Astragalus hamosus* L.	A1,B,C1	0.026	Occ.	Th.	Med.
Zygophyllaceae	*Fagonia thebaica* Boiss.	C1	0.026	Occ.	Ch.	Sa-Si
Asteraceae	*Ifloga spicata* (Forssk.) Sch.-Bip.	A1,A2,C1	0.028	Occ.	Th.	Med., Sa-Si, Ir-Tu
Fabaceae	*Senna italica* Mill.	A1,C1,D2	0.028	Occ.	H.	Su-Za
Neuradaceae	*Neurada procumbens* L.	A1,B	0.028	Occ.	Th.	Sa-Si
Plumbaginaceae	*Limonium pruinosum* (L.) Kuntze Charz.	A2	0.028	Occ.	H.	Sa-Si
Asteraceae	*Volutaria lippii* (L.) Cass. ex Maire	A1,A2,B	0.03	Occ.	Th.	Med., Sa-Si
Chenopodiaceae	*Atriplex leucoclada* Boiss.	A1,A2,C1	0.03	Occ.	Ch.	Sa-Si, Ir-Tu
Ephedraceae	*Ephedra alata* Decne.	A1,A2,D1	0.03	Occ.	Ph.	Med., Sa-Si
Asteraceae	*Pulicaria incisa* (Lam.) DC.	A1,C1,D2	0.032	Occ.	H.	Sa-Si,Gu-Co
Boraginaceae	*Heliotropium arbainense* Fresen.	A2,B,C2	0.032	Occ.	Ch.	Ir-Tu
Lamiaceae	*Lavandula coronopifolia* Poir.	A1,A2,D2	0.032	Occ.	Ch.	Sa-Si
Apiaceae	*Deverra triradiata* Hochst. ex Boiss.	A2,B	0.034	Occ.	Ch.	Sa-Si
Asteraceae	*Nauplius graveolens (*Forssk.) Wiklund	A1,A2	0.034	Occ.	H.	Sa-Si
Chenopodiaceae	*Agathophora alopecuroides* (Delile) Fenzl ex Bunge	A1,A2	0.034	Occ.	Ch.	Sa-Si
Chenopodiaceae	*Bassia indica (*Wight) A.J.Scott	A1,B,C2	0.034	Occ.	Th.	Sa-Si, Ir-Tu
Geraniaceae	*Erodium crassifolium* L'Her.	A1,A2,B,D2	0.034	Occ.	Geo.	Sa-Si
Malvaceae	*Malva parviflora* L.	A1,B,C1,C2	0.034	Occ.	Th.	Med., Ir-Tu, Eu-Si
Poaceae	*Cynodon dactylon* (L.) Pers.	A1,A2,B,C1	0.034	Occ.	Geo.	Cosm.
Zygophyllaceae	*Fagonia arabica* L.	A1,A2,B,C1	0.034	Occ.	Ch.	Sa-Si
Zygophyllaceae	*Fagonia glutinosa* Delile	A1,A2	0.034	Occ.	H.	Sa-Si
Apocynaceae	*Cynanchum acutum* L.	A1,A2	0.036	Occ.	Ch.	Sa-Si

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Caryophyllaceae	*Gypsophila capillaris* (Forssk.) C.Chr.	A1,A2	0.036	Occ.	H.	Med., Sa-Si
Fabaceae	*Crotalaria aegyptiaca* Benth.	A1,A2,C1,C2	0.036	Occ.	H.	Sa-Si
Tamaricaceae	*Tamarix tetragyna* Ehrenb.	A1,A2,C1,C2, D1,D2	0.036	Occ.	Ph.	Med., Sa-Si, Ir-Tu
Zygophyllaceae	*Balanites aegyptiaca* (L.) DC.	D1,D2	0.036	Occ.	Ph.	Sa-Si, Su-Za
Asteraceae	*Launaea spinosa* (Forssk.) Sch. Bip.	A1,A2,D2	0.038	Occ.	Ch.	Sa-Si
Caryophyllaceae	*Polycarpaea robbairea* (Kuntze) Greuter & Burdet	A1,C1,D1,D2	0.038	Occ.	Th.	Sa-Si
Fabaceae	*Astragalus eremophilus* Boiss.	A1,C1	0.038	Occ.	Th.	Sa-Si
Geraniaceae	*Erodium glaucophyllum* (L.) L'Hér.	A1,A2,B	0.038	Occ.	H.	Sa-Si
Scrophulariaceae	*Kickxia aegyptiaca* (Dum.) Nabelek	A1,A2,B	0.038	Occ.	Ch.	Sa-Si
Asteraceae	*Centaurea aegyptiaca* L.	A1,A2,B	0.04	Occ.	H.	Sa-Si
Fabaceae	*Alhagi graecorum* (DC.) Alef.	A1,A2,C1,C2	0.04	Occ.	H.	Sa-Si, Ir-Tu
Asteraceae	*Reichardia tingitana* (L.) Roth	A1,A2,B	0.042	Occ.	Th.	Med., Sa-Si, Ir-Tu
Boraginaceae	*Heliotropium bacciferum* Forssk.	A1,A2,D1,D2	0.042	Occ.	Ch.	Sa-Si
Capparidaceae	*Capparis spinosa* L.	A1,A2,C2	0.042	Occ.	Ch.	Med., Sa-Si, Ir-Tu
Poaceae	*Lasiurus scindicus* Henrard	A1,A2,B,C2	0.044	Occ.	H.	Sa-Si
Zygophyllaceae	*Zygophyllum decumbens* Delile	A1,A2	0.046	Occ.	Ch.	Sa-Si
Poaceae	*Phragmites australis* (Cav.) Trin. ex Steud.	A1,A2,B,C1,C2,D1	0.048	Occ.	Hy.- Hel.	Pan.
Resedaceae	*Oligomeris linifolia* (Vahl) Macbr.	A1,A2,B,C1,C2	0.05	Com.	Th.	Sa-Si
Asteraceae	*Centaurea calcitrapa* L.	A1,A2,C2	0.052	Com.	H.	Med., Sa-Si, Ir-Tu
Chenopodiaceae	*Bassia muricata* (L.) Murr.	A1,A2,B	0.052	Com.	Th.	Sa-Si, Ir-Tu
Poaceae	*Pennisetum divisum* (Forssk. ex J. F. Gmel.) Henrard	A1,A2,C2	0.052	Com.	H.	Sa-Si
Solanaceae	*Hyoscyamus muticus* L.	A1,A2,B,D1,D2	0.052	Com.	H.	Sa-Si, Ir-Tu
Boraginaceae	*Heliotropium digynum* (Forssk.) Asch.	A1,A2,B,C1,C2	0.054	Com.	Ch.	Sa-Si
Nitrariaceae	*Nitraria retusa* (Forssk.) Asch.	A1,A2,C2	0.054	Com.	Ph.	Sa-Si
Asteraceae	*Sonchus oleraceus* L.	A1,A2,B,C1	0.056	Com.	Th.	Cosm.
Brassicaceae	*Anastatica hierochuntica* L.	A1,A2,B	0.056	Com.	Th.	Sa-Si
Chenopodiaceae	*Cornulaca monacantha* Delile	A1,A2,B,C2,D1	0.06	Com.	Ch.	Sa-Si
Fabaceae	*Acacia seyal* Delile	A1,C1,C2	0.06	Com.	Ph.	Un
Apocynaceae	*Calotropis procera* (Ait.) Ait. f.	A1,A2,B,C1,C2,D2	0.062	Com.	Ph.	Sa-Si
Brassicaceae	*Eremobium aegyptiacum* (Spreng.) Asch. & Schweinf. ex Boiss	A1,A2,B,C1	0.064	Com.	Th.	Sa-Si
Zygophyllaceae	*Zygophyllum album* L.f.	A1,A2,C2	0.066	Com.	Ch.	Sa-Si, Ir-Tu
Euphorbiaceae	*Euphorbia retusa* Forssk.	A1,A2,B	0.068	Com.	H.	Sa-Si

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Brassicaceae	*Schouwia purpurea* (Forssk.) Schweinf.	B,C1	0.07	Com.	Th.	Sa-Si
Fabaceae	*Astragalus vogelii* (Webb) Bornm.	A1,C1,C2,D1,D2	0.07	Com.	Th.	Sa-Si
Orobanchaceae	*Cistanche phelypaea* (L.) Cout.	A1,A2,C1,D1	0.07	Com.	Pa.	Med., Sa-Si, Ir-Tu
Polygonaceae	*Calligonum polygonoides* L.	A1,B,C1	0.07	Com.	Ch.	Med., Sa-Si
Asteraceae	*Achillea fragrantissima* (Forssk.) Sch. Bip.	A1,A2	0.072	Com.	Ch.	Sa-Si, Ir-Tu
Tamaricaceae	*Tamarix aphylla* (L.) H. Karst.	A1,A2,C1,C2,D1,D2	0.072	Com.	Ph.	Sa-Si
Zygophyllaceae	*Fagonia indica* Burm.f.	A1,C1,D1,D2	0.072	Com.	Ch.	Sa-Si
Chenopodiaceae	*Anabasis articulata* (Forssk.) Moq.	A1,A2,C1	0.074	Com.	Ch.	Sa-Si, Ir-Tu
Cleomaceae	*Cleome droserifolia* (Forssk.) Delile	A1,A2,C1,C2,D1,D2	0.074	Com.	H.	Sa-Si
Amaranthaceae	*Aerva javanica* (Burm. f.) Spreng.	A1,C1,D1,D2	0.076	Com.	Ch.	Sa-Si
Asteraceae	*Artemisia judaica* L.	A1,A2,B,C1,C2,D2	0.076	Com.	Th.	Sa-Si
Solanaceae	*Lycium shawii* Roem. & Sch.	A1,A2,C2	0.078	Com.	Ph.	Sa-Si
Asteraceae	*Launaea mucronata* (Forssk.) Muschl.	A1,A2,B,C1,D1,D2	0.082	Com.	H.	Sa-Si
Cleomaceae	*Cleome amblyocarpa* Barratte & Murb.	A1,A2,B,C1	0.082	Com.	Th.	Sa-Si, Su-Za
Brassicaceae	*Matthiola livida* (Delile) DC.	A1,A2,B,C1	0.09	Com.	Th.	Sa-Si
Fabaceae	*Retama raetam* (Forssk.) Webb & Berthel.	A1,A2,C1,C2	0.09	Com.	Ph.	Sa-Si
Asteraceae	*Senecio glaucus* L.	A1,A2,B	0.092	Com.	Th.	Med., Sa-Si, Ir-Tu
Fabaceae	*Trigonella stellata* Forssk.	A1,A2,B	0.092	Com.	Th.	Sa-Si, Ir-Tu
Apocynaceae	*Leptadenia pyrotechnica* (Forssk.) Decne.	A1,A2,B,C1,C2,D2	0.094	Com.	Ph.	Sa-Si
Tamaricaceae	*Reaumuria hirtella* Jaub. & Spach	A1,A2,B,D1	0.094	Com.	Ch.	Sa-Si
Caryophyllaceae	*Gymnocarpos decandrum* Forssk.	A1,A2,B	0.098	Com.	Ch.	Sa-Si
Poaceae	*Panicum turgidum* Forssk.	A1,A2,B,C1, C2,D2	0.104	V. Com.	Geo.	Med., Sa-Si, Ir-Tu
Polygonaceae	*Rumex vesicarius* L.	A1,A2,B,C1	0.108	V. Com.	Th.	Sa-Si, Ir-Tu
Urticaceae	*Forsskaolea tenacissima* L.	A1,A2,C1,D1,D2	0.108	V. Com.	H.	Sa-Si, Su-Za
Fabaceae	*Lotus hebranicus* Brand	A1,C1,C2,D1,D2	0.11	V. Com.	H.	Near End.
Asteraceae	*Iphiona mucronata* (Forssk.) Asch. & Schweinf.	A1,A2,C1	0.112	V. Com.	Ch.	Sa-Si
Asteraceae	*Cotula cinerea* Delile	A1,A2,B,C1	0.114	V. Com.	Th.	Sa-Si
Brassicaceae	*Diplotaxis acris* (Forssk.) Boiss.	A1,A2,B,C1	0.114	V. Com.	Th.	Sa-Si
Brassicaceae	*Diplotaxis harra* (Forssk.) Boiss.	A1,A2	0.114	V. Com.	H.	Sa-Si
Resedaceae	*Reseda pruinosa* Delile	A1,A2,C1,D1,D2	0.116	V. Com.	Th.	Sa-Si
Apocynaceae	*Pergularia tomentosa* L.	A1,A2,B,C1,C2,D1,D2	0.118	V. Com.	Ch.	Sa-Si
Apiaceae	*Deverra tortuosa* (Desf.) DC.	A1,A2,C2	0.132	V. Com.	Ch.	Sa-Si

Table 3 *(continued)*

Family	Species	Floristic group	Q-Value	Status	Life form	Chorotype
Chenopodiaceae	*Anabasis setifera* Moq.	A1,A2,C1	0.134	V. Com.	Ch.	Sa-Si, Ir-Tu
Chenopodiaceae	*Atriplex halimus* L.	A1,A2,B,C2	0.142	V. Com.	Ph.	Med., Sa-Si, Ir-Tu
Zygophyllaceae	*Fagonia mollis* Delile	A1,A2,B,D1,D2	0.146	V. Com.	Ch.	Near End.
Asteraceae	*Echinops spinosus* L.	A1,A2,B,C2	0.156	V. Com.	Ch.	Sa-Si, Ir-Tu
Asteraceae	*Launaea nudicaulis* (L.) Hook. f.	A1,A2,B,C1,C2,D1	0.16	V. Com.	H.	Sa-Si, Ir-Tu
Cucurbitaceae	*Citrullus colocynthis* (L.) Schrad.	A1,A2,C1,C2,D1,D2	0.17	V. Com.	H.	Med., Sa-Si, Ir-Tu
Chenopodiaceae	*Haloxylon salicornicum* (Moq.) Bunge ex Boiss.	A1,A2,B,C2,D1	0.188	V. Com.	Ch.	Sa-Si, Ir-Tu
Chenopodiaceae	*Salsola imbricata* Forssk.	A1,A2,B,C1,C2, D1,D2	0.198	V. Com.	Ch.	Sa-Si
Zygophyllaceae	*Fagonia brugieri* DC.	A1,A2,C1,D1,D2	0.198	V. Com.	H.	Sa-Si, Ir-Tu
Tamaricaceae	*Tamarix nilotica* (Ehrenb.) Bge	A1,A2,B,C1,C2,D1,D2	0.2	Dom.	Ph.	Sa-Si, Ir-Tu
Brassicaceae	*Farsetia aegyptia* Turra	A1,A2,B	0.202	Dom.	Ch.	Sa-Si
Brassicaceae	*Morettia philaeana* (Delile) DC.	C1,D1,D2,C1	0.21	Dom.	H.	Sa-Si
Boraginaceae	*Trichodesma africanum* (L.) R. Br.	A1,A2,B,C1,C2,D1,D2	0.214	Dom.	Ch.	Sa-Si, Su-Za, Gu-Co
Fabaceae	*Acacia tortilis* (Forssk.) Hayne	A1,A2,B,C1,C2,D1,D2	0.244	Dom.	Ph.	Sa-Si, Su-Za
Zygophyllaceae	*Zygophyllum simplex* L.	A1,A2,B,C1,C2,D1,D2	0.308	Dom.	Th.	Sa-Si, Ka-Na
Resedaceae	*Ochradenus baccatus* Delile	A1,A2,B,C1,C2,D1,D2	0.336	Dom.	Ph.	Sa-Si
Asteraceae	*Pulicaria undulata* (L.) Kostel	A1,A2,B,C1,C2,D1,D2	0.348	Dom.	Ch.	Sa-Si
Zygophyllaceae	*Zygophyllum coccineum* L.	A1,A2,B,C1,C2,D1,D2	0.696	Dom.	Ch.	Sa-Si
Brassicaceae	*Zilla spinosa* (L.) Prantl	A1,A2,B,C1,C2,D1,D2	0.802	Dom.	Ch.	Sa-Si

Med, Mediterranean; Eu-Si, Euro-Siberian; Sa-Si, Saharo-Sindian; Ir-Tu, Irano-Ruranian; Su-Za, Sudano-Zambezian; Pal., Palaeotropical; Pan., Pantropicl; Cosm., Cosmopolitan; Af-Mo, Afro-Montane; Aus., Australian; End., Endemic; Near End., Near Endemic; Ka-Na, Karoo-Namib; Gu-Co, Guiano-Congo; Un, Undetermined.

Rumex dentatus, which are among the most common weeds of Egyptian arable lands (El Hadidi & Kosinová, 1971; Abd El-Ghani & Amer, 1990; Abd El-Ghani & El-Sawaf, 2004; Abd El-Ghani *et al.*, 2011). Reclamation of the desert appears natural due to population growth and increased congestion in the so-called old lands in the Nile Valley and the Delta. Since the early 1960s, vast areas in the Egyptian deserts (Western, Eastern and Sinai) were subjected to land reclamation. Not surprisingly, 61% of the priority reclaimable land through the Nile waters is located on the fringes of the Valley and Delta regions where soil, in parts of these areas, is loamy in nature; cultivation can be relatively successful (Biswas, 1993). In the study area, agricultural processes were practiced in the deltaic parts of several wadis such as wadi El-Assiuty, W. Qena, W. Kherit, W. Natash and W. El-Shikh. The land reclamation processes entail an almost complete change in the environmental factors. Thus, weeds find the new conditions favourable for their growth. Close to the boundaries of the desert in this study, xerophytic species naturally grow among the weeds of the cultivation. This indicated that these species are native to the natural desert vegetation and can remain after the reclamation process. Therefore, the reclaimed areas of this study can be considered as transitional areas of the succession process between the old cultivated lands and that of the desert (Bennoba, 2011).

The floristic similarities between the two adjacent deserts (the Eastern and Sinai) resulted in 141 species in common of the total of 1378, with an index of similarity of about 20.5%. This low similarity may be attributed to the

geographical position of both deserts where Sinai desert is part of the Irano-Turanian region, while the Eastern Desert is a part of the Saharo-Sindian region. Notably, 335 species were consistent to the Sinai desert, while the Eastern Desert characterized by 64 species. The similarities in the flora of the Eastern Desert and Sinai accounted for 56.5% at the family level and 64.6% at the generic level.

Biological spectrum and chorological affinities

Regarding the life-form spectra (Fig. 2), therophytes was the predominant life form and constituted 40.12% of total recorded species, followed by chamaephytes (21.37%), hemicryptophytes (18.95%), while phanerophytes (8.67%) and the remaining life forms formed 10.89%. In this study, the dominance of therophytes, phanerophytes and chamaephytes over other life forms seems to be a response to the hot dry climate, topographical variations and human and animal interferences (Abd El-Ghani & Abdel-Khalik, 2006).

According to Wickens (1976), the study area lies within the Saharo-Sindian region from Boreo-Subtropical zone of the Tropical Kingdom. This area affected by its boundaries of Mediterranean, Sudano-Zambezian and Irano-Turanian regions. These facts were appeared clearly from the analysis of the phytogeographical origin of the recorded species (Fig. 2). More than the half of the recorded species were of Saharo-Sindian origin (40% mono-regional, 12% bi-regional and 1% pluri-regional). The dominance of Sahro-Sindian element in the study area is coinciding with the results of El Hadidi (1993), El-Demerdash, Hegazy & Zilay (1994), Fossati, Pautou & Peltier (1998), Abd El-Ghani (1998) and Hassan (2003). The Saharo-Sinadian elements followed by Mediterranean elements (3% mono-regional, 4% bi-regional and 12% pluri-regional) and Irano-Turanian (3% mono-regional and 5% bi-regional). Cosmopolitan elements were 4%, endemic and near endemic species constituted 4% of the total. The remaining chorotypes formed 10% and another 2% were of unknown origin.

Spatial distribution patterns of species

The application of cluster analysis and detrended correspondence analysis (DCA; results not shown) produced four major floristic groups (A–D) at the 2nd level of

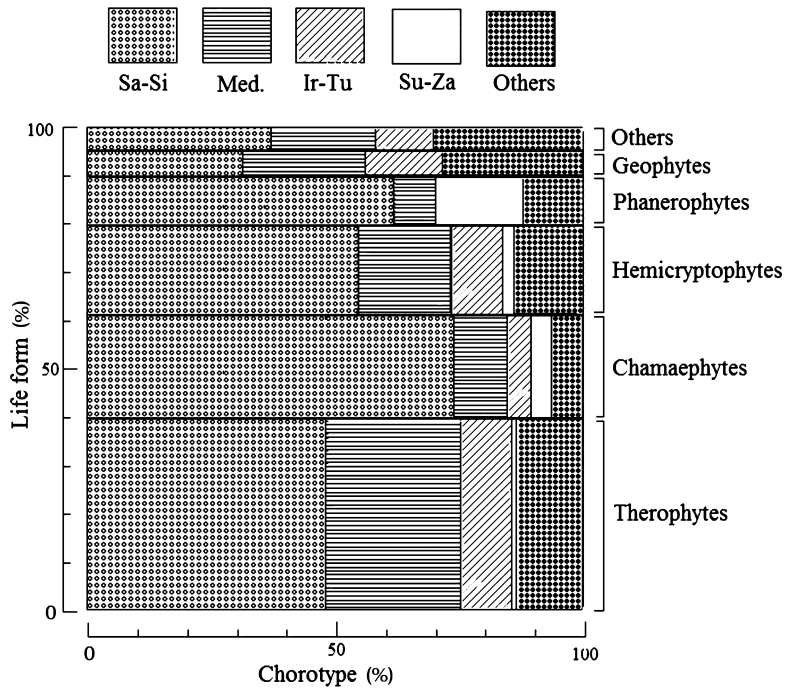

Fig 2 Chorotype spectrum and layer diagram of the study area. Chorotype abbreviations: Sa-Si, Saharo-Sindian; Med., Mediterranean; Ir-Tu, Irano-Turanian; Su-Za, Sudano-Zambezian

classification, and yielded seven subgroups at the 3rd level. The total number of species varied from one subgroup to another. Floristic group (A) dominated by *Zilla spinosa* and *Zygophyllum coccineum*, comprised of ten sectors (Fig. 3) representing the northern part (Lat. 30°05′- 28°18′N) of the study area. *Zygophyllum coccineum-Z. spinosa* communities were among widespread communities within the limestone habitat with different floristic composition. It is plentiful in the affluent of the drainage systems and in the parts of the main channels where the deposits are shallow and coarse. It is less common in the basement complex and is absent from the sandstone habitat (Zahran & Willis, 1992). This first group can be divided into two subgroups; the first (A_1) comprised of six desert roads in the northern part of the Eastern Desert (Cairo-Suez road, Kattamia-Ain Sokhna road, Korimat-Zafarana Road, Shikh Fadl Road-Ras Gharib, Suez-Ras-Gharib Road) and Wadi Hagul. It was the most diversified subgroup (92 species), dominated by 23 species (P = 100%) including: *Atriplex halimus*, *Farsetia aegyptia*, *Ochradenus baccatus*, *Pergularia tomentosa* and *Trichodesma africanum*. Other associates of remarkable presence included *Anabasis articulata*, *Citrullus colocynthis*, *Echinops spinosus* and *Iphiona mucronata* (Table 3). The second subgroup (A_2) included the flora of the northern wadis of the Eastern Desert (Wadi Degla, W. Hof, W. Garawi and El-Saff desert). It comprised of 80 species, with sixteen species dominated with 100% presence value such as *Anabasis setifera, Deverra tortuosa*, *Echinops spinosus,* and *Retama raetam*. Nineteen species were recorded in only one sector of this subgroup with 20% presence value included *Centaurea calcitrapa*, *Cleome drsoerifolia*, *Ifloga spicata*, *Leptadenia pyrotechnica* and *Suaeda altissima*.

Floristic group (B) consisted of 53 species that dominated by *Calligonum polygonoides* and *Diplotaxis acris* representing the desert vegetation in three sectors in the riverine zone (close to the Nile) of Minya-Assiut area of the Eastern Desert. Twenty species shared the dominance, among others; *Cornulaca monacantha*, *Rumex vesicarius*, *Zygophyllum coccineum* and *Zygophyllum simplex*. Other associates included: *Centaurea aegyptiaca*, *Fagonia indica*, *Pergularia tomentosa*, *Salsola imbricata* subsp. *imbricata* and *Schouwia purpurea*.

Citrullus colocynthis and *Zygophyllum coccineum* dominated floristic group (C) that included seven sectors representing the southern zone and Red Sea coastal land (Lat. 27°24′- 24°00′N). Two subgroups can be identified; the first (C_1, 59 species) included six sectors and dominated by *Citrullus colocynthis* associated with *Astragalus vogelii*, *Cotula cinerea*, *Lotus hebranicus*, *Morettia philaeana*, *Zilla spinosa* and *Zygophyllum simplex* (P = 85%). Among sporadic species, *Artemisia judaica*, *Heliotropium digynum*, *Ifloga spicata*, *Oligomeris linifolia* and *Reseda pruinosa* can be noted. The second subdgroup (C_2, 42 species) included four sectors that dominated by *Zygophyllum coccineum* and *Zygophyllum album*. Notably, *Nitraria retusa* and *Salsola imbricata* subsp. *imbricata* were the most represented associates (P = 75%). Other associates included *Atriplex halimus*, *Haloxylon salicornicum*, *Panicum turgidum*, *Suaeda altissima*, *Tamarix nilotica* and *Tamarix aphylla*.

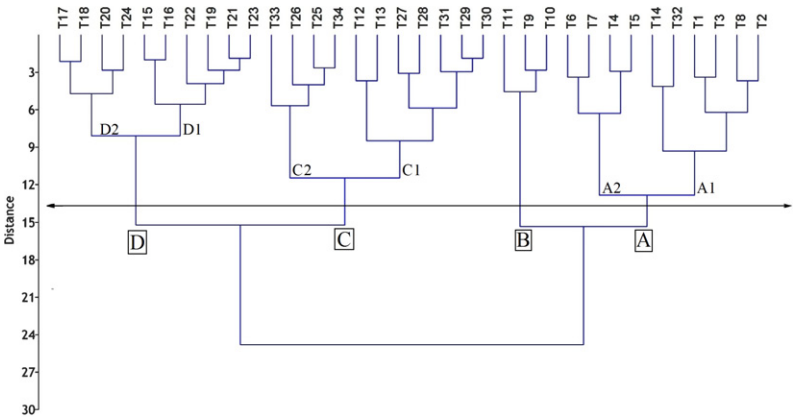

Fig 3 Dendrogram showing the four major floristic groups (A–D) at the 2nd level of classification, and their subgroups (3rd level of classification) resulting from the cluster analysis of the 34 sampled sectors

Floristic group (D) was dominated by *Aerva javanica* and *Zilla spinos*, and can be identified as the Red Sea highlands zone of the study area. Two subgroups can be recognized; the first (D_1) dominated by nine species such as *Acacia tortilis*, *Fagonia mollis*, *Pulicaria undulata*, *Zilla spinosa* and *Zygophyllum coccineum*. Occasional species included *Heliotropium bacciferum*, *Hyoscyamus muticus*, *Launea mucronata* and *Tamarix aphylla*. Ten species shared the dominancy of the second subdivision (D_2), including *Aerva javanica*, *Cleome droserifolia*, *Leptadenia pyrotechnica* and *Ochradenus baccatus*. It can be noted that *Forsskaolea tenacissima*, *Lotus hebranicus* and *Trichodesma africanum* were of remarkable presence (P = 75%). Both subgroups comprised of approximately the same number of species (37 for D_1 and 38 for D_2). The correlation coefficients (r) between the different subgroups revealed high significant correlations (P = 0.01) between floristic group (B) and subgroup (C_2) and between subgroups (D_1) and (D_2). Significant correlations (P = 0.05) occurred between subgroup (D_1) and both of (A_1) and (C_2).

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(*Manuscript accepted 07 July 2013*)

doi: 10.1111/aje.12102