

FIRST REPORT ON THE FLORA OF DAMS AND WATER BREAKERS IN AN ARID DESERT OF THE UNITED ARAB EMIRATES

TAMER MAHMOUD*, HATEM A. SHABANA AND SANJAY GAIROLA

Seed Bank and Herbarium, Sharjah Research Academy, University City, 60999 Sharjah, UAE

*Corresponding author's email: tamer_mahmed@yahoo.com

Abstract

This paper provides the first comprehensive checklist of vascular plant flora of dams and water breakers in hyper-arid desert habitats of the United Arab Emirates (UAE). Surveys in 66 dams and water breakers were conducted to explore flora of these areas. A total of 248 plant species belonging 170 genera distributed in 50 families were recorded. Among these, two regionally endemic species *Pulicaria edmondsonii* and *Schweinfurthia imbricata*, in addition to 34 rare species, were recorded from the study area. The chorological analysis showed that the floristic composition is dominated by Saharo-Arabian elements, with 149 species. The life form spectrum indicated that therophytes were the most represented (46%) and Helophytes was the least represented life form group. Analysis of plant growth form shows that the occurrence of annual plants was high, followed by the perennials.

Key words: Arid desert, Chorology, Dams, Floristic composition, Water breakers, UAE.

Introduction

The United Arab Emirates (UAE) is a part of the Arabian Peninsula and occupies an area about 83600 km² including a bunch of islands. The country consists of seven emirates in which six of them form together the Northern Emirates (i.e. Dubai, Sharjah, Ajman, Umm Al Quwain, Ras Al Khaimah and Fujairah) and they occupy together about 8.2% of the country's area. Abu Dhabi is the capital and the biggest emirate. The UAE has a diverse landscape as a result of geologic processes that have occurred during the Earth's history (Jordan & Sadooni, 2007). The main landforms in the area are the Hajar Mountains, alluvial plains including fans, plains and wadis, dunes including ridges, sand veneer, rising dunes and coastal forms (Pain & Abdelfattah, 2015). The UAE is characterized by hot and dry climate, throughout most of the year, to be classified as hyper-arid area according to the UNEP classification of drylands (Middleton & Thomas, 1997). In such hyper-arid climatic conditions, water is the scarcest resource of particular concern and is the focus of national strategies to promote water conservation. During the last few decades, dams and water breakers were built in different region of the country to conserve rain water and recharge the water table.

Despite its aridity, the UAE has a relatively rich flora, especially in regions that retain some moisture during the precipitation months, including some microhabitats of mountainous regions, wadis and silt pans in front of dams. On the other hand, plants in the region are adapted to live and survive in adverse environmental conditions including high temperature, salinity and drought stress. UAE has about 830 plant species however, detailed studies of the vegetation and plant communities of the country are scarce and data are often lacking. Hence, it is important to understand the distribution of biological diversity in areas where it is most concentrated. Plant surveys and inventories provide the essential baseline data for monitoring change caused by habitat fragmentation and climate

change, and for determining biodiversity conservation priorities. There are some reports about the flora of UAE by pioneer investigators and researchers, however, Jongbloed (2003) and Karim & Fawzi (2007) produced comprehensive guide books that generated increased interest and facilitated further botanical studies. In addition, Feulner (2011) published an annotated checklist of the flora of the Ru'us al-Jibal, adding 17 species not previously recorded in Eastern Arabia. There has been good progress extending and enriching our knowledge of the flora of UAE, resulting new plant records from different region of the country (Gairola *et al.*, 2017, and references therein).

Plant species of dams and water breakers are relatively less studied and there is no plant species inventory for these regions. Therefore, the aim of this study is to provide a checklist of vascular plant species that have been recorded from the dams and water breaks in UAE.

Materials and Methods

Study area and site selection: The study area is situated between (N: 26.032618, E: 56.115121) and (N: 24.783709, E: 56.114088) in the northern east part of the UAE along with the Hajar mountains where dams and water breakers were set up to reserve rain water that drain from the mountainous areas towards the coasts (Fig. 1). A total of 387 hectares area was surveyed representing 66 dams and water breakers distributed through six emirates. The surveyed dams' elevation ranges from 25m above sea level (a.s.l.) (Al Badyyah, Fujairah) to 400m a.s.l. (Hatta, Dubai). There were 39 dams covering around 60% of the study area and their elevation was below 250 m a.s.l. Moreover, 36 dams reserve collected water from Hajar mountains basins in the eastern side towards the Gulf of Oman and 30 dams in the western side towards the Arabian Gulf. On the emirates level, the studied dams are located in six emirates (i.e. Abu Dhabi-1, Ajman-5, Dubai-5, Sharjah-7, Ras Al Khaimah-23 and Fujairah-25 dams).

Field survey and data collection: Systematic surveys of plant species were conducted in the dams' areas during the period from January 2016 to July 2017. In the sites, the survey covered the area from the dam body to 500-1000 m towards the upstream (flood origin). Each site was traversed on foot to cover all the vegetation wherever possible and names of plant species were recorded to prepare an inventory. Plant taxonomic characters including habit of each species were also recorded. The identity of each recorded species was cross-checked with specimens housed in Sharjah herbarium of the Sharjah Research Academy (SRA) and based on field characters with the aid of existing flora for the country (Karim & Fawzi, 2007; Jongbloed, 2003) and other taxonomic literature on the plants of Arabian Peninsula. Information on parameters such as elevation, aspect, GPS coordinates and habitat were also gathered from each site. Plant materials collected from the field were deposited in the Sharjah herbarium for future reference and records. The chorotype of the recorded species is based on Zohary (1973) and Takhtajan (1986), and recent relevant references were also used for this purpose (e.g., Masrahi *et al.*, 2012; Salama *et al.*, 2012; Barakat *et al.*, 2014; Iliadou *et al.*, 2014; Osman *et al.*, 2014; Moawed, 2016). Raunkiaer classification (Raunkiaer, 1934) was used to describe the life form spectrum of the recorded plants.

Results and Discussion

Overview: The vegetation survey and detailed inventory of the 66 dams and water breakers revealed presence of 248 plant species belonging to 170 genera distributed in 50 families (Table 1). UAE has a total of about 830 plant species and the surveyed area comprises almost 30% of the vascular plants of UAE. So, these areas can be considered important areas based on species richness and diversity of elements in addition to be an important soil seed bank. During the surveys of this study, *Glinus lotoides* L. (Molluginaceae) was newly recorded for the flora of the UAE. This is the only representative species of the genus *Glinus* in the UAE (Mahmoud *et al.*, 2016). A total of 34 rare species were recorded from the study area. The occurrence of these rare species in the study area will help to delimit the species range and update their distribution in country's flora.

The dominant families in terms of high species richness in the study area were Fabaceae (30 species), Poaceae (23 species), Asteraceae (17 species) and Brassicaceae (11 species). Floristic data indicates that 58% of the total recorded species belong to ten dominating families (Fig. 2). In the study area, herbaceous growth forms were dominant, followed by shrubs, grasses and sedges and trees (Fig. 3). *Tephrosia apollinea* was the dominant species in 12 sites followed by *Asphodelus tenuifolius* and *Calotropis procera* (6 sites each).

Habitats represented: In all the studied dams, species composition represented by floral elements from all nearby habitats. For example, a considerable number of species from mountainous habitats and wadis were represented in dams' flora which clearly indicates that the propagules of these species traveled from that habitats and deposited in dam basin. Moreover, many plants belonged to quite far habitats, like saline habitats or sand dunes, were recorded in the dams' areas. The survey results

revealed the dams' areas were good pools for aggregation of propagules from diverse habitats. Overall, dams' flora comprise 67 species (27% of total species) mainly pertaining to the mountainous flora, 46 (18.5%) wadis, 46 (18.5%) sandy plains and 39 (15.5%) plantations (Fig. 4).

Rarity and endemism: According to Feulner (2016), the UAE has no nationally endemic plant species, however, he recorded a total of eight species which are considered endemic to the Hajar mountains of the UAE and the Northern Oman. *Pulicaria edmondsonii* and *Schweinfurthia imbricata*, two of the eight endemic species, were recorded in dams' areas. According to Jongbloed (2003) classification, the results revealed presence of 34 rare plants in the dams' areas. Among these, *Asterolinon linum-stellatum*, *Pallenis hierochuntica*, *Nanorrhinum macilentum*, *Polycarphaa robbairea* and *Verbascum cedreti* were recorded only once. On the other hand, the most frequent rare plant in the dams' area was *Heliotropium curassivicum*, which was recorded from 8 dams.

Life form: Plant life-form reflects the plant adaptation strategy to the environmental factors especially climatic condition (Roshan & Hedary, 2014). The life form spectrum of the dams' plants was classified into eight groups. Therophytes was the highest represented group comprising 45.6% of the total recorded species. *Aizoon canariense* was recorded in 27 dams to be the most frequent therophyte. Chamaephytes represented 28.6% and *Tephrosia apollinea* was the most recorded element of chamaephytes in 46 dams. Hemicryptophytes represented by 13.5% and *Citrullus colocynthis* was the most frequent element in 27 dams. Phanerophytes formed 7.5% from the total species and *Acacia tortilis* was the most frequent element in 55 dams. The other groups were Geophytes 3%, Parasite 1%, Hydrophytes 0.4%, and Helophytes 0.4%, (Fig. 5). According to Carvalho *et al.*, (2007), the predominance of therophyte reflects an effective strategy for avoiding water losses due to humidity extremes and water deficiencies. Therophytes are characteristic of desert climate (Malik *et al.*, 2007). Therefore, the dominance of therophytes in the study area may be an outcome of the unfavorable environmental conditions like harsh weather and high aridity in the region. The high percentage of chamaephytes may be related to their ability to resist to the drought, salinity, and sand accumulation (El-Bana *et al.*, 2002).

Chorology: The composition of geographical elements in the studied flora showed four groups. Uniregional was the most represented group by 95 species (38%). Biregional was represented by 80 species (32%). Pluriregional, where we considered all species that have 3 or more but not all phytogeographical regions, was represented by 40 species (16%). Cosmopolitan (COSM) was the least represented group by 20 species (8%) (Fig. 6a). Moreover, the study indicated that Saharo-Arabian (SA) elements were the most represented chorotype with 149 species (60%) followed by Irano-Turanian (IT) 64 species (26%); Sudano-Zambezian (SZ) 55 species (22.2%); Mediterranean (ME) by 45 species (18%) and Tropical (TR) by 22 species (9%) (Fig. 6b).

Table 1. Checklist of plant species recorded in the study area.

Family /Species	Type	Status	Life form	Chorotype	Common habitat
Acanthaceae					
<i>Blepharis ciliaris</i>	Herb	C	Ch	IT SA SZ	Mountains
Aizoaceae					
<i>Aizoon canariense</i>	Herb	C	Th	SA SZ	Compact sand, roadsides
<i>Sesuvium verrucosum</i>	Herb	R	He	SA SD	Saline sand
<i>Zaleya pentandra</i>	Herb	NC	He	SZ	Sand
Amaranthaceae					
<i>Aerva javanica</i>	Shrub	C	Ch	TR	Wadis, alluvial plains
<i>Amaranthus albus</i>	Herb	R	Th	PAL	Compact sand
<i>Amaranthus graecizans</i>	Herb	C	Th	COSM	Plantations
<i>Amaranthus hybridus</i>	Herb	NC	Th	COSM	Plantations
<i>Amaranthus viridis</i>	Herb	C	Th	COSM	Plantations
Apocynaceae					
<i>Rhazya stricta</i>	Shrub	C	Ch	SA SZ	Gravel plains, wadis
Asclepiadaceae					
<i>Calotropis procera</i>	Shrub	C	Ph	SZ	Sandy plains, wadis
<i>Leptadenia pyrotechnica</i>	Shrub	C	Ch	SA SZ	Sandy plains
<i>Pentatropis nivalis</i>	herb	NC	Ph	SS	Wadis, plantations
<i>Pergularia tomentosa</i>	Shrub	NC	Ch	SZ	Low mountains, wadis
Asphodelaceae					
<i>Asphodelus tenuifolius</i>	Herb	C	Th	ME SA	Sand
Asteraceae					
<i>Atractylis carduus</i>	Herb	NC	Th	ME	Sand
<i>Centaurea sinaica</i>	Herb	C	Th	SA	Sandy plains
<i>Conyza bonariensis</i>	Herb	LC	Th	TR	Plantations
<i>Echinops spinosissimus</i>	Herb	NC	Ch	IT ME	Hillsides
<i>Eclipta prostrata</i>	Herb	R	Th	Pluri	Plantations
<i>Filago desertorum</i>	Herb	NC	Th	IT ME	Mountains
<i>Ifloga spicata</i>	Herb	NC	Th	SS	Wadis, sandy plains
<i>Iphiona aucheri</i>	Herb	LC	Ch	SS	Low mountains
<i>Iphiona scabra</i>	Shrub	NC	Ch	SA	Hillsides
<i>Launaea capitata</i>	Herb	C	Th	SA	Compact sand
<i>Launaea massauensis</i>	Herb	NC	He	SS	Wadis, hillsides
<i>Launaea mucronata</i>	Herb	C	He	ME SA	Sandy plains
<i>Launaea procumbens</i>	Herb	C	He	IT SA SZ	Compact sand
<i>Pallenis hierochuntica</i>	Herb	R	Th	SA	Mountains
<i>Pluchea dioscoridis</i>	Shrub	NC	Ph	SA SZ	Wastelands
<i>Pulicaria arabica</i>	Shrublet	NC	Ch	ME TR	Wetlands
<i>Pulicaria edmondsonii</i>	Shrublet	E	Ch	RE	Hillsides
<i>Pulicaria glutinosa</i>	Shrublet	C	Ch	UN	Gravel plains
<i>Reichardia tingitana</i>	Herb	C	Th	ME SA	Mountains
<i>Sonchus oleraceus</i>	Herb	C	Th	ES IT ME	Plantations
<i>Vernonia arabica</i>	Shrub	NC	Th	COSM	Mountains
<i>Zoegea purpurea</i>	Herb	NC	Th	IT SS	Low mountains
Boraginaceae					
<i>Anchusa hispida</i>	Herb	NC	Th	IT SA	Gravel plains
<i>Arnebia hispidissima</i>	Herb	C	Th	SA SZ	Sandy plains
<i>Heliotropium calcareum</i>	Shrublet	C	Ch	IT SA	Sandy plains
<i>Heliotropium curassivicum</i>	Herb	R	Ch	TR	Wetlands, plantations
<i>Heliotropium digynum</i>	Shrublet	NC	Ch	SA	Sandy dunes

Table 1. (Cont'd.).

Family /Species	Type	Status	Life form	Chorotype	Common habitat
<i>Heliotropium lasiocarpum</i>	Herb	NC	Ch	IT SA	Sandy soil
<i>Heliotropium ramosissimum</i>	Herb	C	Ch	SA	Coastal regions
<i>Trichodesma africanum</i>	Herb	NC	Th	ME SA	Mountains, wadis
<i>Trichodesma enetotrichum</i>	Herb	C	Th	SA SD	Wadis
Brassicaceae					
<i>Anastatica hierochuntica</i>	Herb	NC	Th	SA	Limestone hills
<i>Brassica tournefortii</i>	Herb	NC	Th	ME SA TR	Plantations, sand
<i>Diploaxis harra</i>	Herb	C	He	IT SA	Low mountains
<i>Eremobium aegyptiacum</i>	Herb	C	Th	SA	Sandy plains, dunes
<i>Erucaria crassifolia</i>	Herb	C	Th	ME	Sandy soil
<i>Erucaria hispanica</i>	Herb	C	Th	IT ME SS	Low mountains
<i>Farsetia linearis</i>	Shrublet	R	Ch	UN	Sandy plains
<i>Farsetia longisiliqua</i>	Shrublet	R	Ch	SA SZ	Mountains
<i>Farsetia stylosa</i>	Herb	C	Ch	SA SZ	Sand
<i>Lepidium sativum</i>	Herb	R	Th	COSM	Roadsides
<i>Morettia parviflora</i>	Herb	C	Ch	SZ	Wadis
<i>Notoceras bicorne</i>	Herb	LC	Th	SA SS	Wadis, mountains
<i>Physorhynchus chamaerapistrum</i>	Shrublet	C	Ch	IT SA SD	Wadis, low mountains
<i>Sisymbrium erysimoides</i>	Herb	C	Th	ME SA	Plantations
Capparaceae					
<i>Capparis spinosa</i>	Shrub	NC	Ph	Pluri	Hillsides
<i>Cleome amblyocarpa</i>	Herb	C	Th	SA SZ	Sand, gravel
<i>Cleome austroarabica</i>	Herb	NC	Ch	UN	Low mountains
<i>Cleome brachycarpa</i>	Herb	C	He	SA	Limestone hills
<i>Cleome fimbriata</i>	Herb	LC	Th	SS	Gravel plains
<i>Cleome gynandra</i>	Herb	R	Th	SZ	Plantations
<i>Cleome rupicola</i>	Shrublet	C	Ch	SA SD	Low mountains
<i>Cleome scaposa</i>	Herb	NC	Ch	TR	Low mountains
<i>Dipterygium glaucum</i>	Shrublet	C	He	SZ	Sand
Caryophyllaceae					
<i>Polycarpha repens</i>	Herb	C	Th	SZ	Compact sand
<i>Polycarpha robbairea</i>	Herb	R	Th	SA SZ	Wadis
<i>Sclerocephalus arabicus</i>	Herb	C	Th	SA	Gravel
<i>Spergula fallax</i>	Herb	C	Th	SA	Sandy soil, plantations
<i>Spergularia marina</i>	Herb	NC	Th	IT SA	Plantations
Ceratophyllaceae					
<i>Ceratophyllum demersum</i>	Herb	NC	HH	COSM	Fresh or brackish water
Chenopodiaceae					
<i>Bassia muricata</i>	Herb	C	Th	IT SA	Sand
<i>Chenopodium album</i>	Herb	C	Th	COSM	Plantations
<i>Chenopodium murale</i>	Herb	C	Th	COSM	Plantations
<i>Hammada salicornica</i>	Shrub	C	Ch	IT	Sandy plains
<i>Salsola imbricata</i>	Shrub	C	Ch	SA SZ	Saline sand
<i>Suaeda aegyptiaca</i>	Shrub	C	Ch	SA	Saline sand
Cistaceae					
<i>Helianthemum lippii</i>	Shrublet	C	Ch	SS SZ	Hillsides, stony areas
Convolvulaceae					
<i>Convolvulus arvensis</i>	Herb	C	Ph	TR	Plantations
<i>Convolvulus cephalopodus</i>	Herb	NC	Ch	SA	Sandy dunes
<i>Convolvulus glomeratus</i>	Herb	R	Ch	SZ	Mountains

Table 1. (Cont'd.).

Family /Species	Type	Status	Life form	Chorotype	Common habitat
<i>Convolvulus pilosellifolius</i>	Herb	C	He	IT SS	Gravel plains
<i>Convolvulus prostratus</i>	Herb	C	Ch	SA	Compact sand
<i>Convolvulus virgatus</i>	Shrublet	C	Ch	IT SS	Wadis
<i>Cressa cretica</i>	Herb	NC	He	IT ME	Plantations
<i>Cuscuta planiflora</i>	Herb	LC	P	IT ME SA	Gravel
Cucurbitaceae					
<i>Citrullus colocynthis</i>	Herb	C	He	SA	Sand
<i>Cucumis prophetarum</i>	Herb	NC	He	SA SZ	Hillsides
Cyperaceae					
<i>Bolboschoenus maritimus</i>	Sedge	R	He	COSM	Wetlands
<i>Cyperus arenarius</i>	Sedge	LC	G	COSM	Saline sand
<i>Cyperus conglomeratus</i>	Sedge	C	G	SA	Sandy dunes
<i>Cyperus laevigatus</i>	Sedge	LC	He	IT ME SA	Wetlands
<i>Cyperus rotundus</i>	Sedge	C	G	COSM	Sand, plantations
Euphorbiaceae					
<i>Andrachne telephioides</i>	Herb	R	Th	IT ME SS	Silt between rocks
<i>Chrozophora oblongifolia</i>	Herb	C	Ch	IT ME SA	Wadis, gravel plains
<i>Euphorbia arabica</i>	Herb	NC	Th	SA	Gravel in low mountains
<i>Euphorbia granulata</i>	Herb	C	Th	SA SZ	Gravel plains, wadis
<i>Euphorbia hirta</i>	Herb	NC	Th	IT SA	Plantations
<i>Euphorbia larica</i>	Shrub	C	Ch	SS	Mountains
<i>Euphorbia serpens</i>	Herb	LC	Th	TR	Plantations
<i>Phyllanthus rotundifolius</i>	Herb	C	Th	COSM	Plantations
<i>Ricinus communis</i>	Shrub	NC	Ph	SZ TR	Plantations
Fabaceae					
<i>Acacia nilotica</i>	Tree	NC	Ph	SZ	Wadis, plantations
<i>Acacia tortilis</i>	Tree	C	Ph	IT SZ	Wadis
<i>Argyrolobium roseum</i>	Herb	NC	Th	IT SS	Low mountains
<i>Astragalus eremophilus</i>	Herb	NC	Th	SS	Compact sand
<i>Astragalus hauarensis</i>	Herb	NC	Th	SS	Sand
<i>Astragalus tribuloides</i>	Herb	NC	Th	IT SA	Compact sand
<i>Astragalus vogelii</i>	Herb	NC	Th	SA	Sand
<i>Crotalaria aegyptiaca</i>	Shrub	C	He	SZ	Gravel plains
<i>Hippocrepis areolata</i>	Herb	NC	Th	ME SA	Sandy soil
<i>Hippocrepis constricta</i>	Herb	NC	Th	IT ME SA	Sandy soil
<i>Indigofera arabica</i>	Shrub	NC	Ch	SA	Gravel plains, mountains
<i>Indigofera coerulea</i>	Shrublet	NC	Ch	SA SZ	Low mountains
<i>Indigofera oblongifolia</i>	Shrublet	R	Ch	SZ	Gravel
<i>Lotononis platycarpa</i>	Herb	NC	Th	SA SZ	Wadis
<i>Lotus garcinii</i>	Shrublet	LC	He	SS	Saline soil
<i>Lotus halophilus</i>	Herb	C	Th	ME SS	Sandy plains
<i>Medicago laciniata</i>	Herb	C	Th	IT SA	Gravel plains
<i>Melilotus indicus</i>	Herb	C	Th	IT SA	Plantations
<i>Prosopis cineraria</i>	Tree	C	Ph	SS	Sandy plains, wadis
<i>Prosopis juliflora</i>	Small tree	C	Ph	SA	Disturbed soil
<i>Pseudolotus villosus</i>	Herb	NC	Th	UN	Wadis
<i>Rhynchosia minima</i> var. <i>memnonia</i>	Shrublet	C	Ch	SA SD	Sandy plains
<i>Rhynchosia schimperii</i>	Shrublet	C	Ch	SS	Wadis, roadsides
<i>Senna italica</i>	Shrublet	C	Ch	IT SA SZ	Sand
<i>Sesbania</i> sp.	Shrub	R	Ph	UN	Wadis

Table 1. (Cont'd.).

Family /Species	Type	Status	Life form	Chorotype	Common habitat
<i>Taverniera cuneifolia</i>	Shrublet	C	Ch	IT SA SD	Low mountains, wadis
<i>Tephrosia apollinea</i>	Shrublet	C	Ch	SZ	Gravel plains, wadis
<i>Tephrosia nubica</i>	Shrublet	NC	Ch	SA	Gravel plains, wadis
<i>Trigonella hamosa</i>	Herb	NC	Th	SA	Plantations
<i>Trigonella stellata</i>	Herb	R	Th	SZ	Mountains, wadis
Frankeniaceae					
<i>Frankenia pulverulenta</i>	Herb	LC	Th	Pluri	Wadis, coastal sand
Geraniaceae					
<i>Erodium laciniatum</i>	Herb	NC	Th	IT ME SS	Sand, loamy soils
<i>Geranium mascatense</i>	Herb	NC	Th	TR	Hillsides, wadis
<i>Monsonia nivea</i>	Herb	C	Th	SA SZ	Sandy plains
Illeceberaceae					
<i>Cometes surattensis</i>	Herb	LC	Th	SZ	Mountains
<i>Gymnocarpus decandrus</i>	Shrub	C	Ch	SS	Mountains
<i>Herniaria hemistemon</i>	Herb	NC	Th	IT ME SS	Compact sand, mountains
<i>Paronychia arabica</i>	Herb	C	Th	SA	Wadis
Juncaceae					
<i>Juncus rigidus</i>	Shrub	NC	Ch	IT ME SA SZ	Salt marshes, wetlands
<i>Juncus socotranus</i>	Shrub	NC	G	IT SA	Wetlands
Lamiaceae					
<i>Lavandula subnuda</i>	Shrub	C	Ch	UN	Hillsides
<i>Leucas inflata</i>	Shrub	C	Ch	UN	Hillsides
<i>Mentha sp.</i>	Herb	R	Ch	ES	Wadis
<i>Salvia aegyptiaca</i>	Shrublet	NC	Ch	SA SZ	Hillsides
<i>Salvia spinosa</i>	Herb	NC	He	ME SA	Hillsides
<i>Teucrium stocksianum</i>	Shrublet	C	Ch	IT	Hillsides
Lythraceae					
<i>Lawsonia inermis</i>	Shrub	C	Ph	IT ME SA	Plantations
Malvaceae					
<i>Abutilon pannosum</i>	Shrub	NC	Ch	TR	Wadis, wastelands
<i>Hibiscus micranthus</i>	Shrublet	R	Ch	TR	Hillsides
<i>Malva parviflora</i>	Herb	C	Th	IT ME	Disturbed soil
Molluginaceae					
<i>Gisekia pharnacioides</i>	Herb	NC	Th	COSM	Sandy dunes
<i>Glinus lotoides</i> Loefl.	Herb	R	Th	IT ME TR	Dams
<i>Limeum obovatum</i>	Herb	NC	Th	UN	Sandy plains
Moraceae					
<i>Ficus cordata</i> ssp. <i>salicifolia</i>	Tree	NC	Ph	TR	Wadis
Neuradaceae					
<i>Neurada procumbens</i>	Herb	C	Th	COSM	Sandy plains
Nyctaginaceae					
<i>Boerhavia elegans</i>	Herb	C	Ch	SS	Hillsides, wadis
<i>Boerhavia repens</i>	Herb	NC	Ch	TR	Disturbed soil
Orobanchaceae					
<i>Orobanche cernua</i>	Herb	NC	P	ME SA	Plantations, wadis
Palmae					
<i>Phoenix dactylifera</i>	Tree	C	Ph	SA	Plantations
Plantaginaceae					
<i>Nanorrhinum macilentum</i>	Herb	R	Ch	SA SZ	Hillsides
<i>Nanorrhinum ramosissimum</i>	Herb	R	Th	UN	Wadis

Table 1. (Cont'd.).

Family /Species	Type	Status	Life form	Chorotype	Common habitat
<i>Schweinfurthia imbricata</i>	Herb	E	Th	SA	Gravel plains, wadis
<i>Schweinfurthia papilionacea</i>	Herb	LC	He	SS	Gravel plains, wadis
<i>Plantago afra</i>	Herb	NC	Th	ME	Mountains
<i>Plantago amplexicaulis</i>	Herb	NC	Th	IT ME SS	Hillsides
<i>Plantago boissieri</i>	Herb	NC	Th	SS	Sandy dunes
<i>Plantago ciliata</i>	Herb	NC	Ch	IT SA SZ	Compact sand
<i>Plantago ovata</i>	Herb	R	Th	IT ME SS	Mountains
<i>Misopates orontium</i>	Herb	NC	Th	SA	Mountains
<i>Nanorrhinum hastatum</i>	Herb	NC	Th	SA SD	Hillsides
Poaceae					
<i>Aeluropus lagopoides</i>	Grass	C	Th	SZ	Saline soil
<i>Aristida abnormis</i>	Grass	NC	Th	SA SD	Sand
<i>Aristida adscensionis</i>	Grass	NC	Th	IT SA SZ	Sand
<i>Cenchrus ciliaris</i>	Grass	C	He	IT SA SZ	Sand
<i>Cenchrus setigerus</i>	Grass	NC	He	IT SA SZ	Sand
<i>Centropodia forsskalii</i>	Grass	C	Ch	IT SA	Sand
<i>Cymbopogon commutatus</i>	Grass	C	He	SA	Mountains
<i>Cynodon dactylon</i>	Grass	C	G	COSM	Sandy soil
<i>Dactyloctenium aegyptium</i>	Grass	C	Th	TR	Plantations
<i>Dactyloctenium scindicum</i>	Grass	NC	Th	TR	Plantations, wadis
<i>Dichanthium annulatum</i>	Grass	NC	He	TR	Roadsides
<i>Echinochloa colona</i>	Grass	NC	Th	IT ME TR	Disturbed soil
<i>Eragrostis barrelieri</i>	Grass	C	Th	ME SA	Sand
<i>Eragrostis cilianensis</i>	Grass	NC	Th	IT SA	Sand, Plantations
<i>Panicum antidotale</i>	Grass	NC	He	SA SD	Plantations
<i>Phragmites australis</i>	Reed	LC	Hel	COSM	Wetlands
<i>Polypogon monspeliensis</i>	Grass	LC	Th	ES IT ME	Plantations
<i>Saccharum ravennae</i>	Shrubby Grass	NC	G	IT ME	Wetlands
<i>Setaria verticillata</i>	Grass	C	Th	COSM	Plantations
<i>Sporobolus spicatus</i>	Grass	C	G	SA SZ	Saline sand
<i>Stipagrostis plumosa</i>	Grass	C	He	IT SA SZ	Sandy plains
<i>Tragus racemosus</i>	Grass	NC	Th	SA SZ	Plantations
<i>Tricholaena teneriffae</i>	Grass	R	He	SA SZ	Wadis, mountains
Polygalaceae					
<i>Polygala erioptera</i>	Herb	C	Th	SA	Compact sand
Polygonaceae					
<i>Emex spinosa</i>	Herb	C	Th	ME SS	Compact sand
<i>Rumex dentatus</i>	Herb	R	Th	ME SS	Plantations
<i>Rumex vesicarius</i>	Herb	C	Th	SA	Hillsides
Portulacaceae					
<i>Portulaca oleracea</i>	Herb	C	Th	Pluri	Plantations
<i>Portulaca quadrifida</i>	Herb	NC	Th	COSM	Plantations
Primulaceae					
<i>Anagallis arvensis</i>	Herb	C	Th	Pluri	Plantations
<i>Asterolinon linum-stellatum</i>	Herb	R	Th	ME	Mountains
Resedaceae					
<i>Ochradenus arabicus</i>	Shrub	LC	He	SA	Hillsides
<i>Ochradenus aucheri</i>	Shrub	C	He	SA	Low mountains
<i>Oligomeris linifolia</i>	Herb	NC	Th	IT ME	Compact sand
<i>Reseda aucheri</i>	Herb	C	He	IT SS	Mountains
<i>Reseda muricata</i>	Herb	NC	Th	IT SS	Gravel plains

Table 1. (Cont'd.).

Family /Species	Type	Status	Life form	Chorotype	Common habitat
Rhamnaceae					
<i>Ziziphus spina-christi</i>	Tree	C	Ph	Pluri	Wadis
Rubiaceae					
<i>Galium setaceum</i>	Herb	NC	Th	IT ME	Hillsides
<i>Galium sp.</i>	Herb	R	Th	ME IT ES	Hillsides
<i>Plocama aucheri</i>	Shrub	C	Ch	SS	Low mountains
<i>Plocama calycoptera</i>	Shrublet	R	Ch	IT ME SA	Mountains
Rutaceae					
<i>Haplophyllum tuberculatum</i>	Herb	C	He	IT SA	Hillsides, wadis
Salvadoraceae					
<i>Salvadora persica</i>	Shrub	NC	Ph	SS	Hillsides
Scrophulariaceae					
<i>Anticharis glandulosa</i>	Herb	R	Th	SS	Gravel plains
<i>Scrophularia arguta</i>	Herb	NC	Ch	ME SA	Mountains
<i>Scrophularia deserti</i>	Herb	NC	He	SS	Hillsides
<i>Verbascum cedreti</i>	Herb	R	Th	ME	Mountains, plantations
Solanaceae					
<i>Datura stramonium</i>	Herb	R	Th	COSM	Wadis
<i>Hyoscyamus muticus</i>	Herb	NC	Ch	IT SA	Hillsides, Wadis
<i>Lycium shawii</i>	Shrub	C	Ch	IT SA SZ	Hillsides
<i>Physalis minima</i>	Herb	NC	Th	TR	Plantations
<i>Solanum nigrum</i>	Herb	NC	Ch	COSM	Plantations
<i>Solanum virginianum</i>	Herb	NC	He	UN	Disturbed soil
Tamaricaceae					
<i>Tamarix aphylla</i>	Shrub	R	Ph	SZ	Wadis
<i>Tamarix nilotica</i>	Small Tree	C	Ph	ME SA SZ	Saline sand
Tiliaceae					
<i>Corchorus depressus</i>	Herb	NC	Ch	ME SA	Gravel plains
<i>Corchorus trilocularis</i>	Herb	NC	Th	TR	Plantations
Typhaceae					
<i>Typha domingensis</i>	Herb	R	Ch	PAL TR	Wetlands
Urticaceae					
<i>Forsskaolea tenacissima</i>	Herb	C	Ch	SA SZ	Wadis, mountains
<i>Freirea alsinaefolia</i>	Herb	NC	Th	IT SS	Hillsides
Verbenaceae					
<i>Phyla nodiflora</i>	Herb	NC	He	IT ME TR	Plantations
Violaceae					
<i>Viola cinerea</i>	Herb	NC	Th	IT SA SD	Hillsides
Zygophyllaceae					
<i>Fagonia bruguieri</i>	Shrublet	C	Ch	IT SA	Hillsides
<i>Fagonia indica</i>	Shrublet	NC	Ch	IT SA	Wadis, roadsides
<i>Fagonia ovalifolia</i>	Herb	LC	Th	SA SZ	Sandy plains
<i>Seetzenia lanata</i>	Herb	NC	Th	SZ	Mountains, sandy plains
<i>Tetraena qatarensis</i>	Shrublet	NC	Ch	SA	Saline sand
<i>Tetraena simplex</i>	Herb	C	Th	PAL SA SZ	Saline sand
<i>Tribulus arabicus</i>	Shrublet	C	Ch	SA SD	Sandy plains
<i>Tribulus macropterus</i>	Herb	NC	He	SZ	Compact sand
<i>Tribulus pentandrus</i>	Herb	R	Ch	SA	Sand

Status (C: Common, LC: Locally common, NC: Not common, R: rare, E: Endemic); Life-form (Ch: Chamaephytes, G: Geophyte, He: Hemicyptophytes, Hel: Helophytes, HH: Hydrophytes, P: Parasite, Ph: Phanerophytes, Th: Therophytes); Chorotype (COSM: Cosmopolitan, ES: Euro-Siberian, IT: Irano-Turanian, ME: Mediterranean, Pluri: Pluriregional, PAL: Paleotropic, SA: Saharo-Arabian, RE: Regionally endemic, SD: Sudano-Deccanian, SS: Saharo-Sindian, SZ: Sudano-Zambeian, TR: Tropical, UN: Unknown)

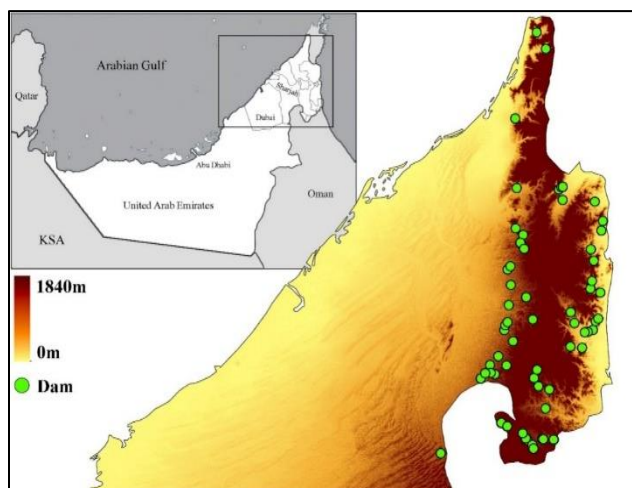


Fig. 1. Location of study area.

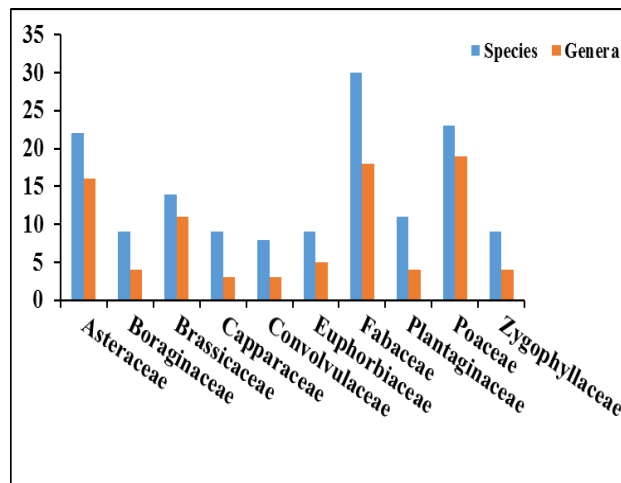


Fig. 2. Genera / species richness of top ten families.

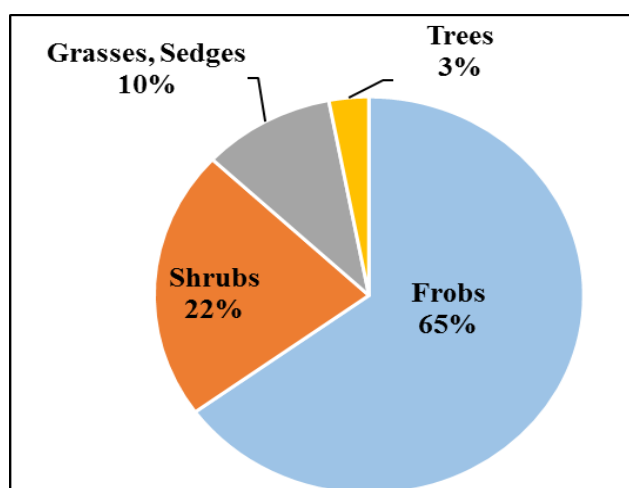


Fig. 3. Plant growth form represented in the study area.

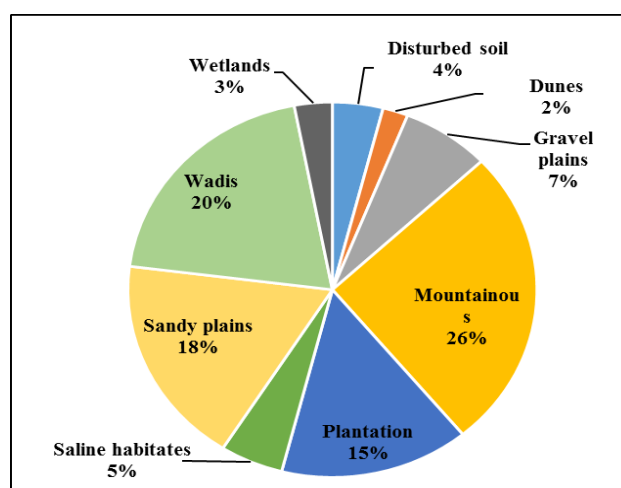


Fig. 4. Plants from different habitats represented in dams' areas.

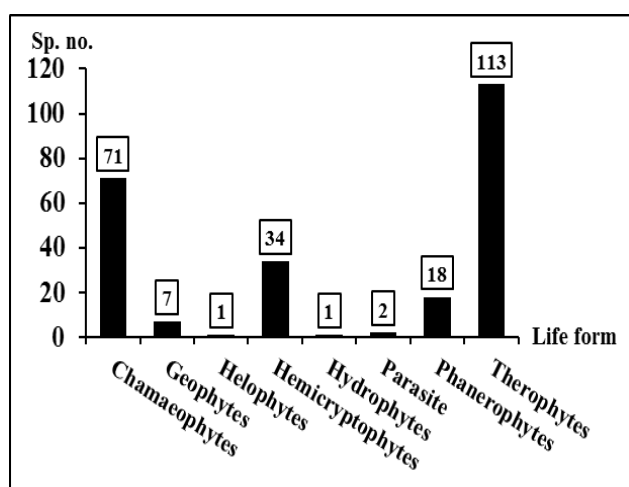


Fig. 5. Life form spectra of the dams' areas with species number.

The majority of recorded species belongs to the Saharo-Arabian chorotype and this pattern is recognized as a good indicator for desert environmental conditions. Similar chorological patterns were also observed for the desert flora elsewhere (e.g., Danin & Plitman 1987; Salama *et al.*, 2013). In addition, Al Shareif *et al.*, (2013) studied

the floristic composition at Khulais region of Western Saudi Arabia, and found that Saharo-Arabian and Sudanian elements constitute majority (ca. 43.6%) of the total recorded flora. It has been reported that there are few endemic species represented in Saharo-Arabian phytogeographic region (Wickens 1977; Boulos, 1997) so, the presence of regionally endemic taxa, like *P. edmondsonii* and *S. imbricata* indicates special ecological and biogeographic importance of the area.

Conclusion

Flora of dams' areas differs from a dam to the other and in the dam, itself, from season to season according to the received amount of water and the timing of rain. Since the dams' basins receive water from the wadis, gorges and mountains, the propagules can be transported from high elevation areas to the lowland areas of dams' lakes. Relatively high water content due to the water reservation, in the form of surface or underground water, strongly helps those propagules to survive. Therefore, the plant list can be used as a taxonomic baseline for studies of the geographical distribution of such species which are recorded growing in their new ranges. Appearance of many species which pertain to different habitats, call for

revision for the floral diversity of these habitats and restudy its driving factors. Due to cryptic nature and the seasonal growth cycles of some plants in unpredictable arid deserts conditions, ecological surveys are sometimes unable to detect all species present at particular sites, such as in flooded habitats. So, emergence of extensive vegetation following natural flooding would help to document maximum floristic diversity of the temporarily inundated areas. We hope this checklist will inspire further botanical exploration in the dams and water breakers areas of the country to add the plant diversity that we have been unable to document.

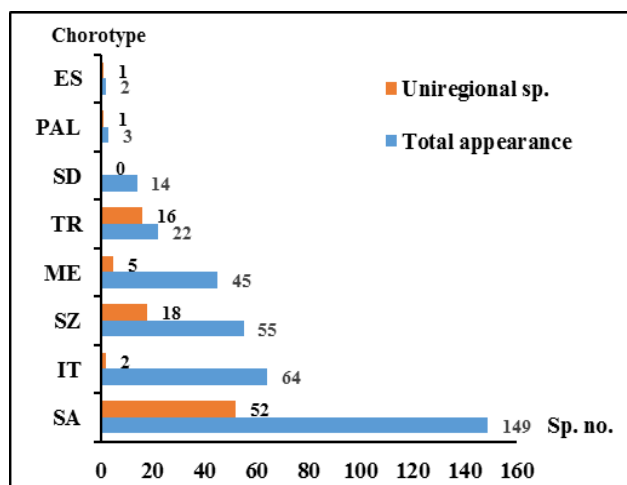
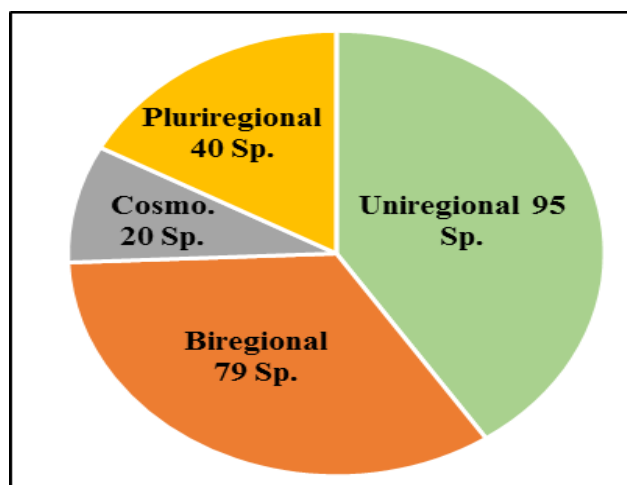


Fig. 6. a, b Chorotype spectra represented in the dams' areas.

Acknowledgements

The authors would like to thank SSBH staff members Reena Cordeiro, Mohamed Fiaz and Mohamed Hassan for their assistance as well as taxonomists of the Royal Botanic Gardens, Kew, UK, for helping in plant identification.

References

- Al Shareif, E., A. Ayesh and S. Rawi. 2013. Floristic composition, life form and chorology of plant life at Khulais region, Western Saudi Arabia. *Pak. J. Bot.*, 45(1): 29-38.
- Barakat, N.A.M., A.M.A. El-Gawad, V. Laudadio, H.F. Kabieli, V. Tufarelli and E. Cazzato. 2014. A contribution to the ecology and floristic

- markers of plant associations in different habitats of Sinai Peninsula, Egypt. *Rend. Lincei*, 25(4): 479-90. doi:10.1007/s12210-014-0329-6.
- Boulos, L. 1997. Endemic flora of the Middle East and North Africa. In: (Ed.): Barakat, H.N. and Hegazy, A.K. (Ed.), reviews in ecology: desert conservation and development. *Metropole, Cairo*, pp. 229-245.
- Carvalho, R., F.S. De Arau and L.W. Lima-verde. 2007. Flora and life-form spectrum in an area of deciduous thorn woodland (caatinga) in northeastern, Brazil. *J. Arid Environ.*, 68: 237-247. doi:10.1016/j.jaridenv.2006.06.003.
- Danin, A. and U. Plitman. 1987. Revision of the plant geographical territories of Israel and Sinai. *Plant Syst. Evol.*, 156: 43-53
- El-Bana, M.I., A.A. Khedr, P. Van Hecke and J. Bogaert. 2002. Vegetation composition of a threatened hypersaline lake (Lake Bardawil), north Sinai. *Plant Ecol.*, 163: 63-75.
- Feulner, G.R. 2011. The flora of the Ru'us al-Jibal-the mountains of the Musandam peninsula: an annotated checklist and selected observations. *Tribulus*, 19: 4-153.
- Feulner, G.R. 2016. The flora of wadi Wurayah national park, Fujairah, United Arab Emirates. *Tribulus*, 24: 4-84.
- Gairola, S., T. Mahmoud, H. Shabana and A. El-Keblawy. 2017. Growing knowledge about the floral diversity of United Arab Emirates: new additions and conservation through seed banking. *Tribulus*, 24: 136-143.
- Iliadou, E., M. Panitsa, T. Raus and P. Dimopoulos. 2014. Flora and factors affecting species diversity in protected "Natura 2000" sites of the Ionian area: the echinades islet group (Greece). *Willdenowia*, 44: 121-136. doi:10.3372/wi.44.44315
- Jongbloed, M.V.D. 2003. The comprehensive guide to the wild flowers of the United Arab Emirates. *ERWDA*, Abu-Dhabi, UAE.
- Jordan, B.R. and F. Sadooni. 2007. Geologic features of the United Arab Emirates. UAEU, Al Ain, UAE.
- Karim, F. and N. Fawzy. 2007. Flora of the United Arab Emirates. UAEU, Al Ain, UAE.
- Mahmoud, T., S. Gairola, H. Shabana and A. El-Keblawy. 2016. Contribution to the flora of United Arab Emirates: *Glinus lotoides* L. (Molluginaceae) and *Senna occidentalis* L. (Fabaceae) two new records. *Biodivers J.*, 7: 223-228.
- Malik, Z.H., F. Hussain and N.Z. Malik. 2007. Life form and leaf size spectra of plant communities Harboring Ganga Chotti and Bedori Hills During 1999-2000. *Int. J. Agric. Biol.*, 9: 833-838.
- Masrahi, Y.S., T.A. Al-Turki and O.H. Sayed. 2012. Geographical distribution and chorology of grasses in the Arabian Peninsula. *Flora*, 207: 250-256. doi:10.1016/j.flora.2011.11.007
- Middleton, N.J. and D.S.G. Thomas. 1997. World atlas of desertification. edward arnold: london, 182.
- Moawed, M.M. 2016. Plant flora of Alaqaan region, Tabuk province, Saudi Arabia, Egypt. *J. Exp. Biol.*, 12: 107-113.
- Osman, A.K., F. Al-Ghamdi and A. Bawadekji. 2014. Floristic diversity and vegetation analysis of wadi arar: A typical desert wadi of the northern border region of Saudi Arabia. *Saudi J. Biol. Sci.*, 21: 554-565. doi:10.1016/j.sjbs.2014.02.001
- Pain, C.F. and M.A. Abdelfattah. 2015. Landform evolution in the arid northern United Arab Emirates: impacts of tectonics, sea level changes and climate. *Catena*, 134: 14-29. doi:10.1016/j.catena.2014.09.011
- Raunkiaer, C. 1934. The lifeforms of plants and statistical plant geography. Oxford university press, oxford.
- Roshan, S.A. and M. Heydari. 2014. Flora, life form and chorological study of *Quercus brantii* habitat in Emamzadeh Abdullah woodland, Iran. *Biodiversitas*, 15: 245-250. doi:10.13057/biodiv/d150219
- Salama, F.M., M.K. Ahmed, N.A. El-Tayeh and S.A. Hammad. 2012. Vegetation analysis, phenological patterns and chorological affinities in wadi qena, eastern desert, Egypt. *Afr. J. Ecol.*, 50: 193-204. doi:10.1111/j.1365-2028.2011.01313.x.
- Salama, F.M., M.M. Abd El-Ghani and N. El-Tayeh. 2013. Vegetation and soil relationships in the inland wadi ecosystem of central Eastern Desert, Egypt. *Turk. J. Bot.*, 37: 489-498.
- Takhtajan, A. 1986. Floristic regions of the world. University of California Press, Berkeley.
- Wickens, G.E. 1987. Some of the phytogeographical problems associated with Egypt. *Cairo Univ. Herb. Public.*, 7-8: 223-230.
- Zohary, M. 1973. Geobotanical foundations of the Middle East. 2Vols, Gustav Fisher Verlag, Stuttgart.