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Phytosociological Studies on the Associated Species of *Balanites aegyptiaca* in the Eastern and Western Egyptian Deserts

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THE CURRENT study offers quantification of soil, vegetation structure, and species distribution in 44 samples related to *Balanites aegyptiaca* in the Egyptian Deserts (the Eastern and Western Deserts). Egypt's Deserts were very dry. Throughout the research sites, 132 different plant species were counted. They belonged to 105 genera and 43 different families, and they were made up of 49 annuals and 83 perennials. The three largest families by the number of documented species are Asteraceae, Poaceae, and Fabaceae, which account for 33.33% of all recorded species. The most prevalent species, which represent a typical spectrum of desert life forms, were therophytes, phanerophytes, and chamaephytes. Six distinct vegetation groups, each with a distinct floristic composition, were identified after the classification of the vegetation was studied using the TWINSPAN technique. Detrended correspondence analysis (DCA) revealed that the first two DCA axes could distinguish these groups. Redundancy analysis (RDA) could also be used to effectively interpret and explain them. Sand, clay, water content, organic matter, sodium, potassium, calcium, and magnesium contents all closely correlated with the first four redundancy axes and accounted for 76.1% of the species-environment relationships among the studied stands. The vegetation pattern in the study areas was clearly demonstrated by classification and ordination. Because this area of study seemed to have a simple xerophytic floristic composition with Saharan Arabian elements, it was relatively unaffected by human disturbances.

Keywords: *Balanites aegyptiaca*, Climatic factors, Egypt, Egyptian deserts, Multivariate analysis, Plant communities.

Introduction:

Balanites aegyptiaca (L.) Delile, a member of the Zygophyllaceae (Balanitaceae) family, is also known as the "desert date" (Heiglige in Arabia) (Hall & Waljer, 1991) with several uses in folk medicine (Eisawi et al., 2022). It is a multibranched, thorny shrub or tree that can reach a height of nearly 10 m. It is a perennial tropical evergreen tree that tolerates drying (Yadav & Panghal, 2010; Chothani & Vaghasiya, 2011). *Balanites aegyptiaca* has a short trunk, branching often from near the base. The ecological distribution of this tree is extensive. It is indigenous to the Arabian Peninsula and other dry and semi-arid regions of Africa, the Middle East, and South Asia (Arbonnier, 2004). However, it is more common in Africa and South Asia (Hall & Waljer, 1991; Ndoye et al., 2004; Hammouda et al., 2005; Chothani & Vaghasiya, 2011; Okia et al., 2011; Al-Thobaiti & Abu Zeid, 2018).

The Sahara, which includes the Egyptian Deserts (Eastern, Western, and Sinai), makes up nearly 95% of the country's total land area. The Western Desert of Egypt makes up over two-thirds of Egypt's total area (about 681,000km^2). Shifting sand is an inconvenience in an oasis because it not

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only overwhelms homes, farms, and wells but also settles wherever conditions are stabilized, such as by vegetation, boosting the level. In Baris Oasis, it is common to see dunes creeping upon some trees, such as *Balanites aegyptiaca* and *Hyphaene thebaica*. Consecutive belts of *Saccharum officinarum*, *Eucalyptus, Lagonychium*, and *Acacia* are used to protect the farms of this oasis. The type and location of its water sources are other distinguishing characteristics of the Western Desert (Said, 1962). According to the availability of groundwater, the Western Desert of Egypt is regarded as a key region for growth.

The term «Oasis» is frequently used to describe a location with a sustainable way of life that has been positioned within harsh environmental conditions. These are depressions in desert areas that contain springs, wells, and trees, revealing the beauty, allure, and variety of the natural world.

The New Valley Governorate makes up one-third of Egypt›s total size and is one of the nation›s most significant geographic regions. The Kharga Oasis is the final oasis on the ring before the Nile Valley; it is a large depression that spans the entirety of southern Egypt, with the exception of the region that is next to the Red Sea and stretches across an area of 220km from the north to the southwest of the Nile.

The Eastern Desert of Egypt covers an area of around 223,000km^2, approximately 21% of Egypt's total land area, running from the eastward Nile Valley to the Suez Gulf and the Red Sea. A dried river in a desert region is referred to as a wadi, and it is one of the desert's main habitats. Roux et al. (1982) defined the wadi as an extreme example of hydro-systems, which are described as both terrestrial and aquatic ecosystems connected to rivers and impacted by their floods. Wadis create a habitat for plants as they're able to store a little more water than the adjacent desert (Hillel & Tadmor, 1962; Ayyad & Ghabbour, 1986). Following heavy rain, a wadi could be turned into a momentary water course. A wadi contains a main canal as well as tributaries that branch out from it. A wadi's water supply is many times greater than any recorded rainfall. Wadi El Gemal is located 40 kilometers south of Marsa Allam, Egypt. In 2003 A.D., it became a protectorate. It belongs to the largest wadi in Egypt›s Eastern Desert, with a total surface area of about 7,000 square kilometers that includes land and sea. Thin layers of fine sand and silty soil build up in isolated places; these are typically where windblown debris collects. These loci›s placement appears to be influenced by variations in coarse and the direction of such changes. The wadi›s name, Wadi El Gemal, or «valley of camels,» is likely derived from its exceedingly arid features, which are mirrored in the vegetation that can only be grazed by camels. There are nomads from the widely dispersed tribe «Bashariya» who reside in this wadi and others to the south who live relatively well in Sudan (El-Sharkawi et al., 1982). The wadi is also home to a variety of plant species, including acacia trees, the well-known medicinal herb *Balanites aegyptiaca, Tamarix aphylla, Anastatica hierochuntica*, and more. The majority of Egypt's phytogeographic regions have been impacted by human activities in recent decades, including the establishment of new cities and roadways, the construction of factories and quarries, the cultivation of the deltaic portion of wadis, and the concentrated collection of plant species for their uses as fuel, medicines, fibers, and other commodities. These activities change the distribution of plants in certain places and have an impact on the local natural flora. This has significant implications for the distribution, species richness, and extinction of the flora of the Egyptian Desert. The study of plant communities in Egypt's Deserts has a long heritage (Zahran & Willis, 1992) and has recently been continued by Salama et al. (2019) and (2021) for the Kharga and Dakhla Oases, respectively, and Hussein et al. (2021) in hyper-arid desert habitats.

With *Balanites aegyptiaca* serving as the characteristic species, this study was created to: (1) reevaluate the distribution of species in the Egyptian Deserts (Baris oasis in the Western Desert and Wadi El-Gemal in the Eastern Desert); (2) evaluate the impact of various soil factors on the distribution and composition of the weed flora in the study areas; and (3) use multivariate analysis to examine the vegetation and species diversity in relation to the current environmental conditions.

The climatic data of the studied locations fall within the categories of arid and hyperarid climates (Ayyad & Ghabbour, 1986). Through the past six years, there have been annual fluctuations in the highest and lowest air temperatures (°C), mean rainfall (mm), and humidity (%) in the Western and Eastern Deserts. Both the winter and summer are hot. According to the data, 20°C was recorded as the average lowest minimum temperature for the past six years (2017–2022), while 37°C was the average highest maximum temperature, both in the Western Desert. The Eastern Desert recorded the highest mean relative humidity of 52% in 2020, while the Western Desert recorded the lowest mean relative humidity of 20% in 2021. Rainfall is sporadic; over the past six years, the Eastern Desert has had both minimum and maximum amounts (0.1 and 0.4mm) of precipitation (Table 1).

Study area

The research location lies in the southern portion of Kharga Oasis, one of the major oases in Egypt's Nubian Desert, which is located in the Western Desert (El-Hadidi, 2000). Its approximate total area is 59,664 km^2, which is located between 24° 40' and 26° N and 30° 07' and 30° 47' E (Fig. 1). The depression's non-fossiliferous brown sandstone floor, which covers a significant portion of the lower-lying areas of the floor with an arid soil type, is between 300 and 400 meters below the surrounding plateau (Hermina, 1990). Nubian sandstone makes up the depression's floor, but a lot of it is enveloped with blown sand. The depression's highest point is 115 meters above sea level, and its lowest point is approximately at sea level (ASL). Two distinct strata of water-bearing sandstone that is separated by a border of impermeable grey shale are where the oasis' wells get their water from. One of the lovely oases within the New Valley Region is Baris Oasis (or Paris), which is around 90 kilometers from Kharga Oasis, the New Valley's capital. Baris city and eight local rural units make up the center of Baris: Jeddah, Gormchin, Baghdad, Aden, Al-Qasr Al-Qibli, Al-Max Al-Qibli, Darb Al-Arba'een I, and Darb Al-Arba'een II. The area of the city and center of Baris is approximately 59,664km^2 or 13.5% of the province's overall area.

TABLE 1. Meteorological data from New Valley station in the Western Desert and Marsa Alam station in the Eastern Desert indicating the maximum, and minimum temperatures (°C), average rainfall (mm), and average humidity (%) through 2017-2022

Year	Western Desert				Eastern Desert			
	Temperature °C		Humidity%	Rainfall mm	Temperature °C		Humidity%	Rainfall mm
	max	min			max	min		
2017	34	20	24	-	29	24	49	0.0
2018	34	23	23	0.2	29	25	48	0.4
2019	33	21	23	0.2	28	22	45	0.1
2020	35	21	25	0	28	23	52	0.4
2021	36	22	20	-	28	25	51	0.0
2022	37	22	21	-	27	24	51	0.0

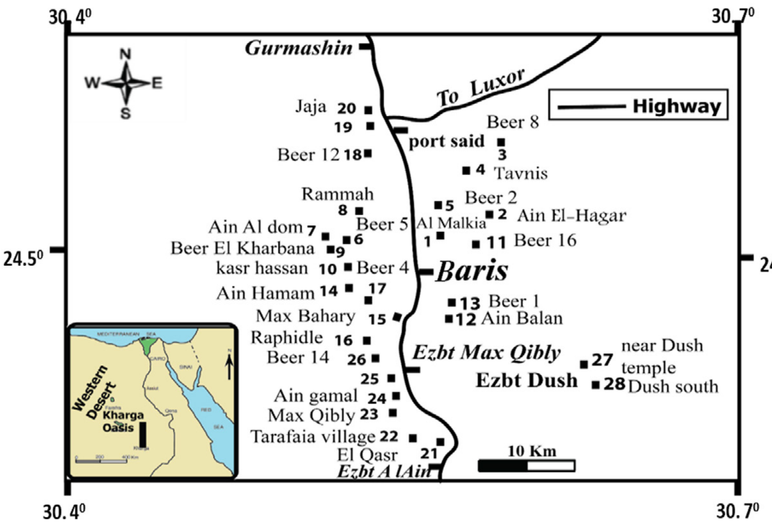

Fig. 1. Location map of stands studied in Baris Oasis

The study area, in the Eastern Desert, is a section of Wadi El-Gemal's main channel and a deltaic plain. Latitudes 24°39'25.84″N and 35°05'34.86″E are its boundaries (Fig. 2). A low plain, ranging in width from a few hundred meters to three kilometers, is formed by the Red Sea's coastline south of Qusseir port. This plain is made up of modern sands and gravels that are occasionally broken up by two gravelly terraces from the Pleistocene. The terraces continue to the west, where they merge with the upper Cretaceous-Pliocene sedimentary succession that borders the major Red Sea Basement Ridge, which runs parallel to the shore in an NW-SE orientation. The washes that drain the desert into the Red Sea cut through this basement ridge as well as the sedimentary succession to the east (Said 1962). There have been few geomorphological investigations on Wadi El-Gemal, but the most significant ones are those by El-Sharkawi et al. (1982), Hegazy (1984), Akawy (1999), Ahmed (2001), Barakat (2003), Khaleal et al. (2005) and Tarek & Fahmy (2012). Wadi El-Gemal and its tributaries make up the main valley, and each of them has numerous tributaries. In cross-section, they have a U shape, though some of one's tributaries have a V shape. Due to the great resistivity of the wall-forming rocks, the valleys' slopes are steep. The Wadi El-Gemal upstream is close to the Hafafit climax. In Wadi El-Gemal Basin (WGB), ridges are prevalent, particularly in the eastern region where foliated metamorphic rocks are found. These ridges generally trend in an NW-SE direction. Wadi El-Gemal vegetation is characterized by arid circumstances and protracted dry seasons. High air humidity and high temperatures are usual. In these circumstances, vegetation is restricted to the wadis, where runoff water is collected and kept in wadi-fill sediments. The most common plants in Wadi El-Gemal are *Avicennia marina* (mangrove), which grows close to the coast; *Pheonix dactylifera*, which grows only near beaches; *Tamarix* sp., which grows along the wadi's lower 15km; and *Salvadora persica*, which grows on remote islands along the wadi. Along the wadi, *Balanites aegyptiaca* grows abundantly. It is used as a diabetes treatment (Khaleal et al., 2008).

Materials and Methods

Soil analysis

At a depth of 0–50 cm, four soil samples were taken from each stand. Thereafter, these four samples were combined into one composite sample, air-dried, and thoroughly mixed. The texture of the soil was determined according to Piper (1950) and Ryan et al. (1996). Organic matter (OM) was determined according to Sparks et al., (1996). According to Jackson (1967), soil water extracts were made at a ratio of 1:5 to assess electrical conductivity (EC), total soluble salts (TSS), and pH values of the clear soil filtrate. The soil reaction of the collected samples was determined using an electric pH meter. Water-soluble ions, the cations (sodium and potassium), were determined using the Williams & Twine (1960) method, whereas calcium and magnesium were determined according to Johnson & Ulrich (1959). Anions (chlorides, sulfates, and phosphates) were determined based on Woods & Mellon (1941), Jackson (1958) and Black et al. (1965).

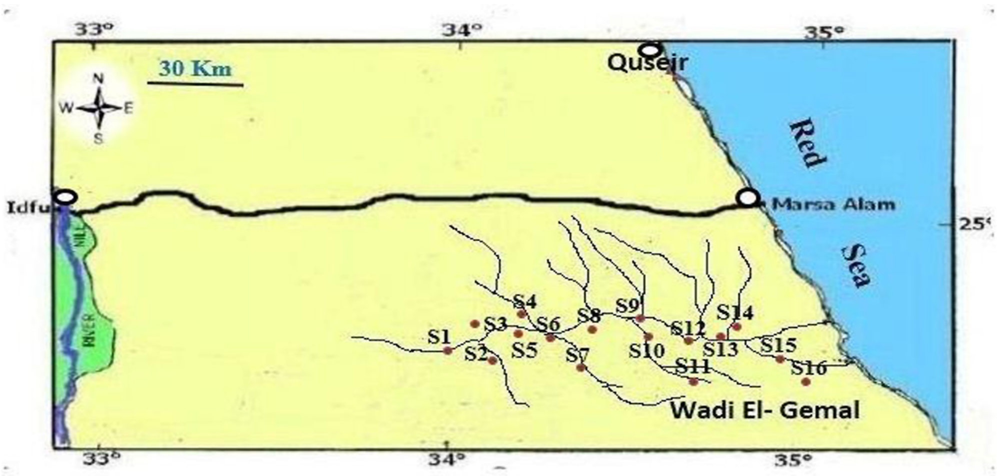

Fig. 2. Location map of the Wadi El- Gemal area

Floristic analysis

Life forms were recognized using Raunkiær's (1937) scheme and floristic categories based on many authors cited by Ahmed (2003). Analysis of the phytogeographical distribution of each species follows Zohary (1966, 1972, 1978). A chorotype can reveal the geographic region where species groups may occur (Báez et al., 2005). Annual and perennial species at every stand were noted.

Täckholm (1974) established the taxonomic nomenclature, which Boulos (1999, 2000, 2002, 2009) and El-Hadidi & Fayed (1995) modified. Each species' voucher specimens were gathered and identified in the Assiut University (ASU) Herbarium, where they are kept.

Data analysis

Based on the occurrence of *Balanites aegyptiaca* in the study locations, forty-four stands were chosen. About 25 x 25m worth of samples were used (the minimal area of the plant communities). During multiple trips to the Egyptian Desert in the years 2021 and 2022, a quantitative study of the surrounding vegetation was conducted. Stands were chosen based on either dense vegetation with *Balanites aegyptiaca* or a change in species diversity close to *Balanites aegyptiaca*. To avoid disturbing the flora, the sampling stands were located 150–200 meters (m) or more away from the motorable road. From each stand, species presence and absence were noted, and a presence percentage (P%) for each species was determined. Both classification and ordination approaches were used to acquire a good study of the vegetation and associated environmental variables. The number of groups at each division is doubled using the divisive hierarchical classification approach known as TWINSPAN (positive and negative groups are formed at each dichotomy). The procedures directly classify both samples and species at the same time, constructing an ordered two-way table to show the relationship between them as clearly as possible (Hill, 1979; Økland, 1990).

For all ordinations, the computer program CANOCO 4.5 (Ter Braak, 1987–1992) was utilized. Detrended correspondence analysis (DCA) was used in preliminary analyses to determine the degree of change in species diversity along the first ordination axis. The associations between vegetation composition and environmental factors were determined using RDA. (Hill & Gauch, 1980). Ter Braak (1986) suggests combining DCA and RDA to determine how much variation in species records is explained by environmental data. Sixteen soil parameters were included: electric conductivity (EC), total soluble salts (TSS), soil reaction (pH), gravel, sand, silt, and clay; water content (WC); organic matter (OM); sodium (Na), potassium (K); calcium (Ca); magnesium (Mg); chlorides (Cl); sulfates (SO_4); and phosphates (PO_4). The variables in the RDA biplots were represented by arrows with lengths proportional to the rate of change. The direction of each arrow establishes the axis on which the species points can be projected. When quadrate points have been projected perpendicular to the (prolonged) arrows, their order roughly represents the ranking of weighed averages in relation to the values of the factors involved.

Results

Floristic Composition and Species Diversity

According to the floristic makeup of the species, 132 plant species related to Balanites aegyptiaca were discovered in the study locations. They belonged to 105 genera and 43 different families, and they were made up of 49 annuals and 83 perennials (Table 2). The two largest families had 17 species each: Asteraceae and Poaceae. Following that was the Fabaceae family, which contained 10 species. Zygophyllaceae follows, with 8 species. Amaranthaceae, Brassicaceae, and Mimosiaceae (each with 5 species). Five families each had four species (Asclepiadaceae, Boraginaceae, Chenopodiaceae, Convolvulaceae, and Euphorbiaceae). Caryophyllaceae, Cyperaceae, Polygonaceae, and Solanaceae exhibited the same number of recorded species (3 for each). Only two species are present in six families (Arecaceae, Caesalpinaceae, Malvaceae, Plantaginaceae, Primulaceae, and Tamariceae). Other families had only one species each.

Life forms

Figure 3 depicts the life forms of the 132 plant species connected to *Balanites aegyptiaca* in the study locations according to Raunkiær (1937). Seven different life forms are represented by the associated species. Therophytes (36.36%) have the greatest number of species (48 species). Phanerophytes have 27 species and account for approximately 20.45% of the vegetation, Chamaephytes came in third with a 19.69% share, including 26 species. A total of 14 species of Hemicryptophytes comprise around 10.6 percent of the flora. There are ten species that make up the geophytes (7.57%). There are six species that make up the Hydrophytes (4.54%). One species, *Cuscuta campestris*, is represented parasite (0.75%).

TABLE 2. Species composition of the study area of Egyptian Deserts classified according to the different families, together with their chorology types [Choro= Chorology type (Am= American, SA= Saharo-Arabian, SZ= Sudano-Zambezian, M= Mediterranean, IT= Irano-Turanian, Cosm = Cosmopolitan, Pan = Pantropical, SU= Sudanian PAL= Paltropical and ES= Euro–Siberian). LF = Life forms (Th: Therophytes, H: Hydrophytes, He: Hemicryptophytes, Ch: Chamaephytes, G: Geophytes and Ph: Phanerophytes)]

Families and species	Dur	LF	Choro
Acanthaceae			
Blepharis ciliaris	Per	Ch	SA+SZ
Amranthaceae			
Amaranthus graecizans	Ann	Th	M+IT
Amaranthus viridis	Ann	Th	M+IT
Suaeda aegyptiaca	Per	Ch	SA
Suaeda fruticosa	Per	Ch	M+SA
Aerva javanica	Per	Ch	SA+SZ
Apiaceae			
Ammi majus	Ann	Th	M+IT
Arecaceae			
Hyphaene thebaica	Per	Ph	SA+SZ
Phoenix dactylifera	Per	Ph	SA+SZ
Asclepiadaceae			
Calotropis procera	Per	Ph	SA+SZ
Leptadenia pyrotechnica	Per	Ph	SA+SZ
Solenostemma arghel	Per	Ph	SA
Pergularia tomentosa	Per	Ch	SA+SZ
Asteraceae			
Ambrosia maritima	Ann	He	M+SA
Bidens pilosa	Ann	Th	PAN
Calendula arvensis	Ann	Th	M+SA+IT
Cichorium endivia subsp. divaricatum	Ann	Th	M+IT
Conyza bonariensis	Per	Th	Am
Launaea mucronata	Ann	Th	SA
Pluchea dioscoridis	Per	Ph	SA+SZ
Sonchus oleraceus	Ann	Th	Cosm
Lactuca serriola	Ann	Th	M+IT
Achillea fragrantissima	Per	Ch	SA+IT
Artemisia Judaica	Per	Ch	SA
Cotula cinerea	Ann	Th	SA
Launaea spinosa	Per	H	SA
Iphiona mucronata	Per	Ch	SA+SZ
Iphiona scabra	Per	Ch	SA+ SZ
Pulicaria incisa	Per	Ch	SA+IT
Pulicaria undulata	Per	Ch	SA+SZ
Avicinniaceae			
Avicennia marina	Per	Ph	SA

TABLE 2. Cont.

Families and species	Dur	LF	Choro
Boraginaceae			
Cordia myxa	Per	Ph	PAL
Cordia sinensis	Per	Ph	SU
Trichodesma africanum	Ann	Th	SA
Arnebia hispidissma	Ann	Th	SA+IT
Brassicaceae			
Farsetia aegyptia	Per	Ch	SA + SZ
Farsetia longisiliqua	Per	Ch	SA+SZ
Zilla spinosa	Per	Th	SA
Anastatica hierochuntica	Ann	Th	SA
Brassica tournefortii	Ann	Th	M+SA
Caesalpinaceae			
Senna italica	Per	Ch	SA+SZ
Senna alexandrina	Per	Ch	SU
Capparaceae			
Capparis dcidua	Per	Ph	SA+SU
Caryophyllaceae			
Stellaria pallida	Ann	Th	M+ES
Vaccaria hispanica subsp. Hispanica	Ann	Th	M+ES+IT
Silene linearis	Ann	Th	SA
Chenopodiacea			
Bassia indica	Ann	Th	SA+IT
Chenopodium album	Ann	Th	Cosm
Chenopodium murale	Ann	Th	Cosm
Salsola imbricata	Per	Ch	SA
Cleomeaceae			
Cleome droserifolia	Per	Ch	SA+IT
Convolvulaceae			
Convolvulus arvensis	Per	G	PAL
Convolvulus fatmensis	Per	G	SA
Cressa cretica	Per	H	M+IT
Cuscuta campestris	Ann	Par	Am
Cucurbitaceae			
Citrullus colocynthis	Per	He	M+SA
Cyperaceae			
Cyperus laevigatus	Per	He	Cosm
Scirpus litoralis	Per	He	PAL
Scirpus maritimus	Per	He	M+IT
Ephedraceae			
Ephedra alata Decne.	Per	Ch	SA
Euphorbiaceae			
Euphorbia helioscopia	Ann	Th	M+IT+ES
Euphorbia hirta	Ann	Th	PAN
Euphorbia peplus	Ann	Th	Cosm
Ricinus communis	Per	Ph	PAN

TABLE 2. Cont.

Families and species	Dur	LF	Choro
Fabaceae			
Crotalaria aegyptiaca	Per	Ch	SA
Alhagi graecorum	Per	H	PAL
Dalbergia sissoo	Per	Ph	PAL
Lathyrus hirsutus	Ann	Th	M+IT
Medicago polymorpha	Ann	Th	Cosm
Medicago sativa	Per	H	M+IT+ES
Melilotus messanensis	Ann	Th	M+IT
Sesbania sesban	Per	Ph	SZ
Trifolium resupinatum var. resupinatum	Ann	Th	M+IT+ES
Trigonella hamosa	Ann	Th	M+SA+SZ
Juncaceae			
Juncus rigidus	Per	G	M+IT+ES
Lamiaceae			
Mentha longifolia	Per	He	PAL
Malvaceae			
Hibiscus trionum	Ann	Th	PAL
Malva parviflora	Ann	Th	M+IT+ES
Mimosiaceae			
Acacia farnesiana	Per	Ph	Am
Acacia nilotica	Per	Ph	SA
Acacia ehrenbergiana	Per	Ph	SU
Acacia tortilis subsp. raddiana	Per	Ph	SA + SZ
Acacia tortilis subsp.tortilis	Per	Ph	SA+ SZ
Nitrariaceae			
Nitraria retusa	Per	Ph	SA+SZ
Nyctaginaceae			
Boerhavia repens sub.viscosa	Per	H	PAL
Oleaceae			
Olea europaea	Per	Ph	M
Oxalidaceae			
Oxalis corniculate	Per	G	Cosm
Plantaginaceae			
Plantago amplexicaulis	Ann	Th	SA
Plantago lagopus	Ann	Th	M+IT
Plumbaginaceae			
Limonium pruinosum	Per	He	SA
Poaceae			
Aeluropus littoralis	Per	He	M+IT
Panicum turgidum	Per	G	SA+ IT
Avena fatua	Ann	Th	PAL
Brachiaria mutica	Ann	H	PAN
Cynodon dactylon	Per	G	PAN
Dactyloctenium aegyptium	Ann	Th	PAL
Desmostachya bipinnata	Per	He	M+SA+IT
Dichanthium annulatum	Per	He	PAL

TABLE 2. Cont.

Families and species	Dur	LF	Choro
Digitaria sanguinalis	Ann	Th	PAL
Echinochloa colona	Ann	Th	PAN
Imperata cylindrica	Per	G	PAL
Leptochloa fusca	Per	G	PAL
Lolium rigidum	Ann	Th	M+IT+ES
Panicum repens	Per	G	PAN
Phalaris minor	Ann	Th	M+SA+IT
Phragmites australis	Per	He	PAL
Sorghum halepens	Per	G	PAN
Polygonaceae			
Emex spinose	Ann	Th	M+SA
Polygonum bellardii	Ann	Th	M+IT
Polygonum equisetiforme	Per	Ch	M+IT
Portulacaceae			
Portulaca oleracea	Ann	Th	Cosm
Primulaceae			
Anagallis arvensis	Ann	Th	Cosm
Anagallis arvensis spp. *arvensis*	Ann	Th	Cosm
Resedaceae			
Ochradenus baccatus	Per	Ph	SA+SZ
Rhamnaceae			
Ziziphus spina-christi	Per	Ph	SA+SZ
Salvadoraceae			
Salvadora persica	Per	Ph	SA+SZ
Solanaceae			
Hyoscyamus muticus	Per	He	SA+IT
Solanum nigrum	Per	Ch	Cosm
Lycium shawii	Per	Ph	SA+SZ+IT
Tamaricaceae			
Tamrix aphylla	Per	Ph	SA+IT
Tamrix nilotica	Per	Ph	SA+IT
Tiliaceae			
Corchorus trilocularis	Ann	Th	PAN
Typhaceae			
Typha domingensis	Per	He	PAN
Urticaceae			
Forsskaolea tenacissima	Per	He	SA+ SZ
Zygophyllaceae			
Balanites aegyptiaca	Per	Ph	SA+SZ
Tribulus pentandrus	Ann	Th	SA+SZ
Zygophyllum coccineum	Per	Ch	M+SA+SZ
Fagonia arabica	Per	Ch	SA+IT
Fagonia indica	Per	Ch	SA+IT
Fagonia mollis	Per	Ch	SA+IT
Zygophyllum album	Per	Ch	M+SA+IT
Zygophyllum simplex	Ann	Th	SA

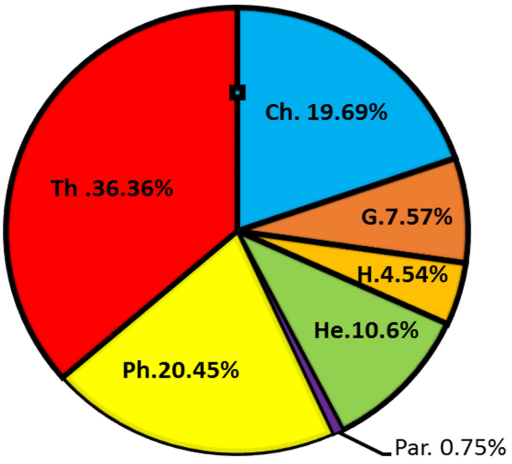

Fig. 3. The life forms of the recorded plant species in the study areas

Chorological affinities

The overall chorological analysis of the investigated flora, as shown in Fig. 4, revealed that 27 species, or 20.45% of all reported species, belonged to Monoregional regions. There were 67 species identified as Saharo-Arabian (50.75%). A total of 55 species are bioregional elements, accounting for 41.67% of all species recorded. Pluri-regional taxa with a wide geographical range are represented by 14 recorded species (10.60% of all recorded species). Ten species, or 7.57% of the species identified, represent the pantropical floristic zone. 8.33% of the species that were recorded, or 11 species, were classified as Cosmopolitan taxa. Fifteen species, or 11.36% of the species recorded, are from the paleotropical floristic zone.

Vegetation structure

Classification of vegetation

The floristic presence-absence data matrix from the research area was classified using vegetation analysis, and six vegetation categories were produced (Fig. 5). One dominant species with a high presence percentage (P%) that was present in all of these groups and was a companion to *Balanites aegyptiaca* was *Tamrix nilotica*. *Zygophyllum coccineum* (B, C, D, E, and F groups) and *Tamrix aphylla* (A, B, C, D, and E groups) are the two species documented in five groups, respectively. *Balanites aegyptiaca* was the species recorded in four groups (A, B, D, and E). Four species show consistency in group F: *Blepharis ciliaris, Pergularia tomentosa, Avicennia marina,* and *Limonium pruinosum*. Eight species show consistency in group E: *Farsetia aegyptia* has the highest presence percentage (75%). Group D has 11 species, which shows consistency with a low presence percentage (11.1–22.22%), whereas *Fagonia indica* has the highest presence percentage (77.77%). Three species show consistency in group C, with a 100% presence percentage; these species are *Nitraria retusa, Aeluropus littoralis,* and *Zygophyllum album*. Twelve species with low P% (6.25–18.75) show consistency with group B. A large number of species (33 species) are consistent with group A. Notably, 35 species are shared between groups A and B, while 9 species are present in groups D and E (Table 3).

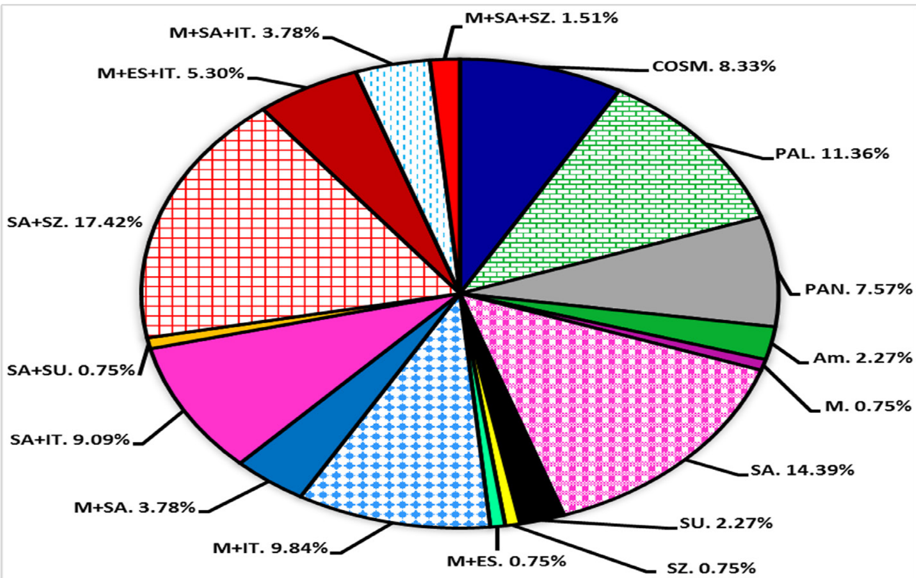

Fig. 4. The chorological analysis of the recorded plant species in the study areass

TABLE 3. Floristic composition of the vegetation groups (A- F) with the presence values (P%) of each species

Vegetation groups	**A**	**B**	**C**	**D**	**E**	**F**
Total number of stands	**12**	**16**	**2**	**9**	**4**	**1**
Total number of species	**75**	**58**	**13**	**30**	**26**	**12**
Species present in 6 groups (%)						
Tamrix nilotica	58.33	56.3	100	66.7	50	100
Species present in 5 groups (%)						
Tamrix aphylla	33.33	6.25	100	22.2	50	
Zygophyllum coccineum		6.25	100	66.7	75	100
Species present in 4 groups (%)						
Balanites aegyptiaca	100	100	0	100	100	
Species present in 3 groups (%)						
Phoenix dactylifera	100	81.3	100			
Imperata cylindrica	25	37.5	50			
Phragmites australis	58.33	43.8	100			
Cotula cinerea				33.3	75	100
Zilla spinosa				55.6	100	100
Fagonia mollis				88.9	100	100
Citrullus colocynthis		6.25		33.3	25	
Calotropis procera	83.33	25		22.2		
Acacia tortilis subsp. *raddiana*			50	66.7		100
Species present in 2 groups (%)						
Amaranthus viridis	8.33	6.25				
Conyza bonariensis	8.33	18.8				
Launaea mucronata	25	12.5				
Pluchea dioscoridis	16.66	18.8				
Sonchus oleraceus	58.33	6.25				
Cordia myxa	8.33	6.25				
Stellaria pallida	25	12.5				
Vaccaria hispanica subsp. *Hispanica*	16.66	12.5				
Bassia indica	41.66	12.5				
Salsola imbricata	8.33	18.8				
Convolvulus arvensis	16.66	12.5				
Convolvulus fatmensis	41.66	12.5				
Cressa cretica	25	6.25				
Cyperus laevigatus	8.33	6.25				
Scirpus litoralis	8.33	6.25				
Euphorbia hirta	8.33	6.25				
Alhagi graecorum	66.66	62.5				
Dalbergia sissoo	8.33	6.25				
Sesbania sesban	50	25				
Mentha longifolia	8.33	6.25				
Cynodon dactylon	83.33	50				
Dichanthium annulatum	75	56.3				
Echinochloa colona	25	18.8				
Leptochloa fusca	16.66	6.25				
Lolium rigidum	25	6.25				
Phalaris minor	8.33	6.25				
Sorghum halepens	75	18.8				

TABLE 3. Cont.

Vegetation groups	A	B	C	D	E	F
Emex spinosa	8.33	6.25				
Polygonum equisetiforme	25	12.5				
Portulaca oleracea	8.33	6.25				
Anagallis arvensis spp. *arvensis*	16.66	18.8				
Ziziphus spina-christi	8.33	6.25				
Hyoscyamus muticus	16.66	18.8				
Typha domingensis	8.33	12.5				
Tribulus pentandrus	33.33	6.25				
Juncus rigidus		12.5	100			
Hyphaene thebaica		75	50			
Zygophyllum simplex			50			100
Aerva javanica				88.9	75	
Leptadenia pyrotechnica				55.6	100	
Artemisia judaica				44.4	25	
Launaea spinosa				44.4	100	
Pulicaria undulata				22.2	50	
Cleome droserifolia				11.1	50	
Acacia tortilis subsp.*tortilis*				11.1	75	
Salvadora persica				22.2	25	
Fagonia arabica				22.2	50	
Iphiona scabra					25	100
Species present in 1 group (%)						
Amaranthus graecizans	8.33					
Suaeda fruticosa	8.33					
Ammi majus	25					
Calendula arvensis	8.33					
Cichorium endivia subsp. *divaricatum*	33.33					
Lactuca serriola	8.33					
Brassica tournefortii	33.33					
Chenopodium album	8.33					
Chenopodium murale	50					
Cuscuta campestris	33.33					
Scirpus maritimus	8.33					
Acacia farnesiana	16.66					
Acacia nilotica	33.33					
Lathyrus hirsutus	16.66					
Medicago polymorpha	8.33					
Medicago sativa	8.33					
Melilotus messanensis	16.66					
Trifolium resupinatum var. *resupinatum*	16.66					
Hibiscus trionum	41.66					
Malva parviflora	33.33					
Boerhavia repens sub.viscosa	16.66					
Olea europaea	33.33					
Plantago amplexicaulis	16.66					
Plantago lagopus	25					

TABLE 3. Cont.

Vegetation groups	**A**	**B**	**C**	**D**	**E**	**F**
Avena fatua	58.33					
Brachiaria mutica	16.66					
Dactyloctenium aegyptium	16.66					
Desmostachya bipinnata	8.33					
Digitaria sanguinalis	16.66					
Polygonum bellardii	16.66					
Anagallis arvensis	25					
Solanum nigrum	25					
Corchorus trilocularis	41.66					
Suaeda aegyptiaca		18.8				
Ambrosia maritima		6.25				
Bidens pilosa		6.25				
Cordia sinensis		18.8				
Trichodesma africanum		6.25				
Euphorbia helioscopia		6.25				
Euphorbia peplus		6.25				
Ricinus communis		6.25				
Senna italica		12.5				
Trigonella hamosa		6.25				
Oxalis corniculata		6.25				
Panicum repens		6.25				
Nitraria retusa			100			
Aeluropus littoralis			100			
Zygophyllum album			100			
Achillea fragrantissima				22.2		
Iphiona mucronata				11.1		
Pulicaria incisa				11.1		
Anastatica hierochuntica				11.1		
Senna alexandrina				11.1		
Capparis dcidua				11.1		
Ephedra alata Decne.				11.1		
Crotalaria aegyptiaca				22.2		
Acacia ehrenbergiana				11.1		
Lycium shawii				11.1		
Fagonia indica				77.8		
Solenostemma arghel					50	
Arnebia hispidissma					25	
Farsetia aegyptia					75	
Farsetia longisiliqua					50	
Silene linearis					25	
Panicum turgidum					25	
Ochradenus baccatus					50	
Forsskaolea tenacissima					50	
Blepharis ciliaris						100
Pergularia tomentosa						100
Avicennia marina						100
Limonium pruinosum						100

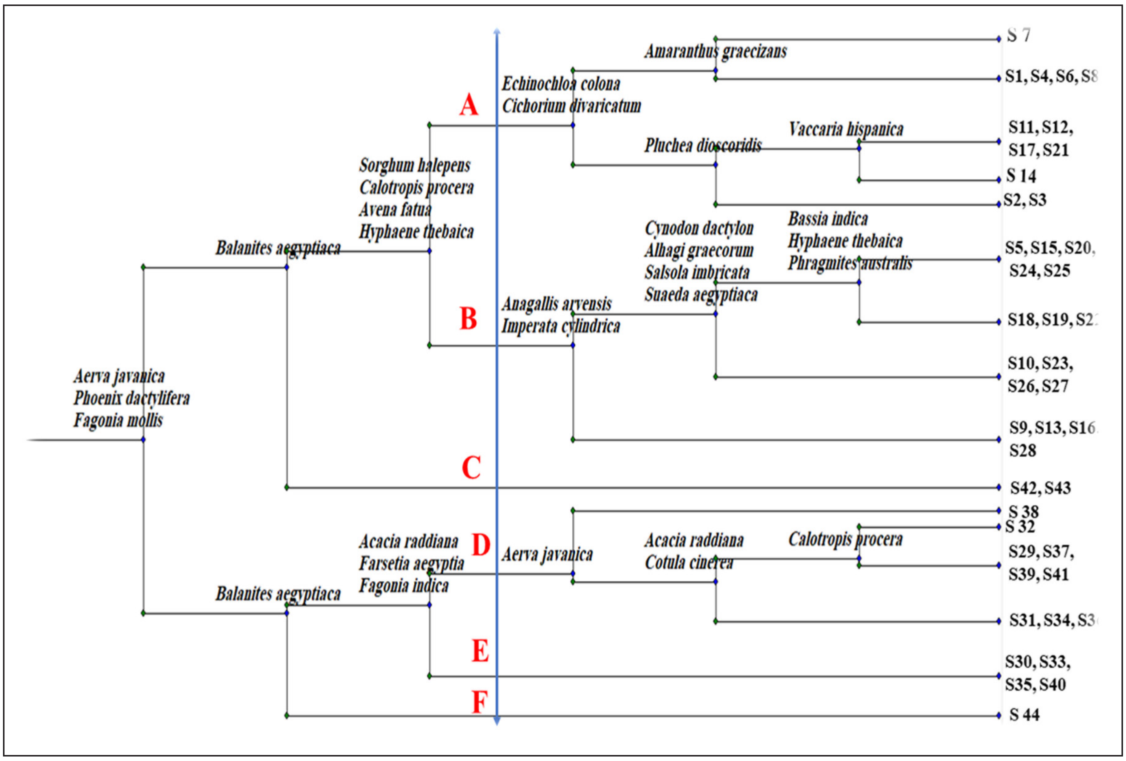

Fig. 5. Dendrogram indicating the four TWINSPAN groups (A-F), together with their indicator species resulted from the classification of the 44 stands

Group (A)

The Western Desert's Group A contained the largest variety of the other groups, with 75 species being reported from 12 stands (Fig. 5). Co-dominant species included *Calotropis procera, Cynodon dactylon, Dichanthium annulatum*, and *Sorghum halepens*. The dominant species were *Balanites aegyptiaca* and *Phoenix dactylifera*. There were 23 species of sporadic species, and their P% was 8.33. (Table 3). This group's soil was distinguished by having the highest levels of phosphates and organic matter and the lowest levels of gravel and calcium ions. Group A had the highest value of each species richness, equaling 20.83 species stands^{-1}, while H' equaled 2.99 (Table 4).

Group (B)

Balanites aegyptiaca dominated (P = 100%) the 16 stands (58 species) of this group sampled from the Western Desert, with the lowest species richness of 10.81 species stand^{-1} and the lowest H' of 2.30. *Phoenix dactylifera* and *Hyphaene thebaica* were co-dominant species. There were 28 sporadic species (P = 6.25%; Fig. 5; Table 3). This group's soil contained the highest content of sand. It did, however, have the lowest content of gravel and silt (Table 4).

Group (C)

Tamarix nilotica, Tamrix aphylla, Zygophyllum coccineum, Phoenix dactylifera, Phragmites australis, Juncus rigidus, Nitraria retusa, Aeluropus littoralis, and *Zygophyllum album* dominated the two stands of group C, which were collected from the Eastern Desert near the Red Sea Coast (Fig. 5, Table 3). H' equaled 2.40, and the species richness was 11 species stands^{-1}. Most soil variables (silt, EC, TSS, Na^{+}, K^{+}, Ca^{+2}, Mg^{+2}, and Cl^{-}) were highest in this group's soil. On the other hand, it had the lowest pH content (Table 4).

Group (D)

Balanites aegyptiaca (dominant species) characterized the 9 stands of this group (30 species) sampled from the Eastern Desert, *with Fagonia mollis*, *Aerva javanica*, and *Fagonia indica* as co-dominant species. Ten sporadic species were present, with a presence percentage of 11.11%. (Fig. 5, Table 3). The gravel content was the highest among the other groups. H' was 2.39, and the species richness was 10.89 species stand^{-1} (Table 4).

TABLE 4. Mean values, standard deviations, and ANOVA values of the soil variables in the study area's vegetation groups (A-F) [= P< 0.01, * = P< 0.05]**

Soil variables		Vegetation groups						F value	*P*
		A	B	C	D	E	F		
Gravel	(%)	0.00±0.00	0.00±0.00	1.77±2.50	9.73±7.95	6.34±6.44	8.68±0.00	8.82**	0.000
Sand	(%)	72.44±6.97	79.53±7.59	50.60±8.88	50.68±13.50	45.31±15.10	72.98±0.00	16.22**	0.000
Silt	(%)	4.62±3.95	3.59±3.75	22.17±12.67	13.26±5.03	17.97±8.27	8.02±0.00	11.96**	0.000
Clay	(%)	22.94±7.11	16.88±6.08	25.46±1.28	26.33±19.67	30.38±14.15	10.32±0.00	1.64	0.172
OM	(%)	5.32±2.42	4.36±1.64	4.24±2.50	1.94±1.33	1.47±0.62	1.32±0.00	5.54**	0.001
WC	(%)	1.54±1.51	1.79±3.10	3.70±1.05	0.27±0.22	0.23±0.17	0.31±0.00	1.38	0.252
TSS		0.67±0.53	2.40±3.45	2.61±2.23	0.22±0.33	0.07±0.02	0.38±0.00	1.81	0.135
pH		7.85±0.27	7.74±0.24	7.04±0.23	8.44±0.65	8.32±0.56	8.69±0.00	7.18**	0.000
EC (mS cm^{-1})		1.05±0.83	3.74±5.40	4.08±3.49	0.34±0.51	0.11±0.03	0.59±0.00	1.81	0.135
Na	(mg.g^{-1} d wt soil)	0.05±0.01	0.06±0.03	0.43±0.35	0.04±0.05	0.02±0.01	0.09±0.00	13.76**	0.000
K	(mg.g^{-1} d wt soil)	0.07±0.03	0.09±0.03	0.11±0.11	0.06±0.05	0.01±0.01	0.03±0.00	3.93**	0.006
Ca	(mg.g^{-1} d wt soil)	0.48±0.59	0.93±0.94	17.25±14.74	1.86±3.17	0.55±0.15	1.07±0.00	12.47**	0.000
Mg	(mg.g^{-1} d wt soil)	0.28±0.21	0.49±0.40	5.66±6.35	0.34±0.66	0.10±0.03	0.26±0.00	8.86**	0.000
Cl	(mg.g^{-1} d wt soil)	1.29±1.21	5.17±8.51	11.52±12.08	0.38±0.29	0.29±0.03	1.00±0.00	2.13	0.083
SO_4	(mg.g^{-1} d wt soil)	1.02±0.85	2.18±1.86	0.09±0.07	0.01±0.01	0.01±0.01	0.02±0.00	4.78**	0.002
PO_4	(mg.g^{-1} d wt soil)	0.86±0.35	0.71±0.34	0.14±0.07	0.02±0.02	0.01±0.00	0.01±0.00	14.04**	0.000
SR		20.83±6.60	10.81±4.40	11.00±1.41	10.89±1.05	14.75±3.30	12.00±0.00	7.79**	0.000
Shannon_H (H')		2.99±0.34	2.30±0.42	2.40±0.13	2.39±0.10	2.67±0.23	2.49±0.00	6.61**	0.000

Group (E)

Group E included 26 species collected from 4 stands in the Eastern Desert. *Balanites aegyptiaca, Zilla spinosa, Fagonia mollis, Leptadenia pyrotechnica,* and *Launaea spinose* were the dominant species, while *Zygophyllum coccineum, Cotula cinerea, Aerva javanica, Acacia tortilis* subsp. *tortilis,* and *Farsetia aegyptia* were the co-dominant species (Table 3). The soil of this group was richer in clay content than the other groups, but it showed the lowest concentration in most soil variables than the others (sand, WC, EC, TSS, Na^+, K^+, Mg^{+2}, Cl^-, and PO_4^{-3}). Species richness was 14.75 species stand-1, where H' was 2.67 (Table 4).

Group (F)

This *vegetation* group was the least diverse of the other groups (12 species) and consists of a single strand (separated from the others in the TWINSPAN dendrogram) collected from the Eastern Desert. This group's soil has the highest concentration of pH values and Na content, while clay and organic matter have the lowest concentrations. H' was 2.49, and the species richness was 12 species stand^{-1} (Fig. 5; Table 4).

Ordination: DCA and RDA

DCA results

The 44 stands' floristic data were analyzed using detrended correspondence analysis (DCA), and the data were shown along axes 1 and 2 in Fig. 6. The resulting TWINSPAN clusters were aggregated into six vegetation groups (A, B, C, D, E, and F). The six TWINSPAN groups were separated along the first (eigenvalue = 0.77) and second (eigenvalue = 0.229) DCA axes. Higher eigenvalues of the first DCA axis indicated that it captured a greater proportion of the variation in species composition among stands. The four DCA axes account for 17.7%, 22.9%, 27.0%, and 30.4% of the total variation in species data, respectively. This high percentage of variance explained by the axes is attributed to the many presence values (one value) in the vegetation data set. The stands of group (A) and group (B) were separated towards the negative end of DCA axis 1, while the stands of group (C) and group (D) were separated out along the positive end of DCA axis 1. The lengths of gradients were relatively short: 2.0 for the first axis and 1.5 for the second. Stands of group (A) and group (B) were separated towards the negative end of DCA axis 1, while stands of group (D), (E), and (F) were separated out along the other end, and those of group (C) were transitional in their composition between the other groups.

Soil-vegetation relationships

Most of the soil contents (gravels, sand, silt, OM, pH, Na^{+1}, K^{+1}, Ca^{+2}, Mg^{+2}, SO_4, and PO_4) showed highly significant differences, whereas other variables showed non-significant differences among the 6 groups (Table 4).

The relationship between the vegetation and soil variables was studied using redundancy analysis (RDA). Figure 7 shows the RDA ordination biplot with TWINSPAN groups (A–F) and the examined soil variables. The species–environment correlations were higher for the first four axes, explaining 71.0% of the cumulative variance (Table 5). The 14 soil variables contributed independently to the overall ordination since none of the inflation variables reached higher scores than 49.85. From the intra-set correlations of the soil factors with the first four axes of RDA (Table 5), it can be inferred that the first axis was negatively correlated with silt (r = -0.6188) and positively correlated with PO_4 (r = 0.7287). The second axis was defined by sand (r = -0.465) and SR contents (r = 0.6624). RDA axis 3 was highly positively correlated with Ca (r = 0.6048) and highly negatively correlated with SO_4 (r = -0.2926) (Ca-So_4 gradient). While RDA axis 4 was highly positively correlated with OM (r = 0.4758) and highly negatively correlated with SR (r = -0.1856) (OM-SR gradient). A test for significance with an unrestricted Monte Carlo permutation test (499 permutations) found the F-ratio for the eigenvalue of axis 1 and the trace statistic to be significant (p = 0.002). The ordination diagram produced by RDA (Fig. 7) showed a similar pattern to the floristic DCA ordination (Figure 6), with most of the stands remaining in their respective TWINSPAN vegetation groups. It can be noted that the stands of groups (A) and (B) occupied the right side of the ordination plane and were affected by several soil factors, including SR, H′, $PO_{4,}$ sand, K, OM, $SO_{4,}$ Na, and chloride ions. On the other hand, the remaining vegetation groups (C, D, E, and F) occupied the left side of the plane and were affected by pH, gravel, silt, calcium, and magnesium ions.

Species diversity

Both estimated species diversity indices (species richness and Shannon-Wiener index) showed significant variations among the separated TWINSPAN groups (Table 5). However, Pearson correlation coefficients (r) between the examined soil variables and diversity indices exhibited insignificant correlations (results not shown). In addition, group (A) had the highest species richness (20.83±6.60 species $stand^{-1}$) and Shannon-Wiener index (2.99±0.34), while group (D) had the lowest diversity records.

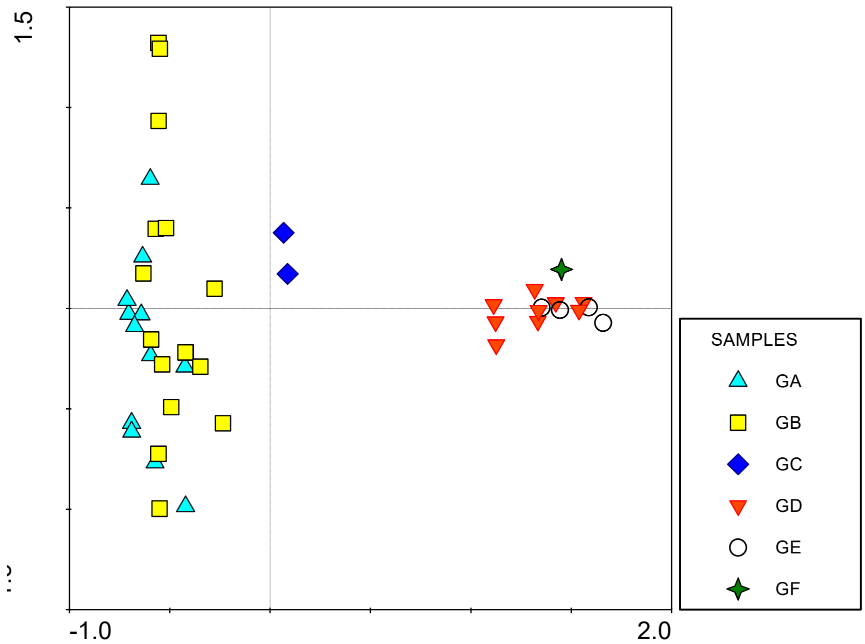

Fig. 6. DCA ordination diagram for 44 stands on axes 1 and 2, with the four TWINSPAN groups

TABLE 5. Intersect correlation of the soil variables together with eigenvalues and species–environment correlations along the first 4 RDA axes

RDA Axes		AX1	AX2	AX3	AX4
Species– environment correlations		0.972	0.956	0.918	0.84
% Cumulative variance of species data		44.1	58.1	65.6	71.0
Eigenvalues		0.202	0.064	0.034	0.025
Gravels	(%)	-0.6076	0.1985	0.0392	-0.0034
Silt	(%)	**-0.6188**	0.1787	0.3224	0.2398
Sand	(%)	0.6171	**-0.465**	-0.2921	-0.1668
OM		0.6064	-0.0147	-0.0293	**0.4758**
pH		-0.4087	0.4266	-0.2631	-0.0489
Na		0.0079	-0.3643	0.5973	0.149
K		0.3129	-0.403	-0.0815	0.1109
Ca	($mg.g^{-1}$ d.wt soil)	-0.1421	-0.2884	**0.6048**	0.1217
Mg	($mg.g^{-1}$ d.wt soil)	-0.0425	-0.3017	0.5486	0.161
Cl	($mg.g^{-1}$ d.wt soil)	0.038	-0.4102	0.1252	-0.0197
SO_4	($mg.g^{-1}$ d.wt soil)	0.3173	-0.3395	**-0.2926**	0.0589
PO_4		**0.7287**	-0.1197	-0.2815	0.1032
SR		0.5712	**0.6624**	0.2297	**-0.1856**
H’		0.4736	0.6206	0.2472	-0.1602

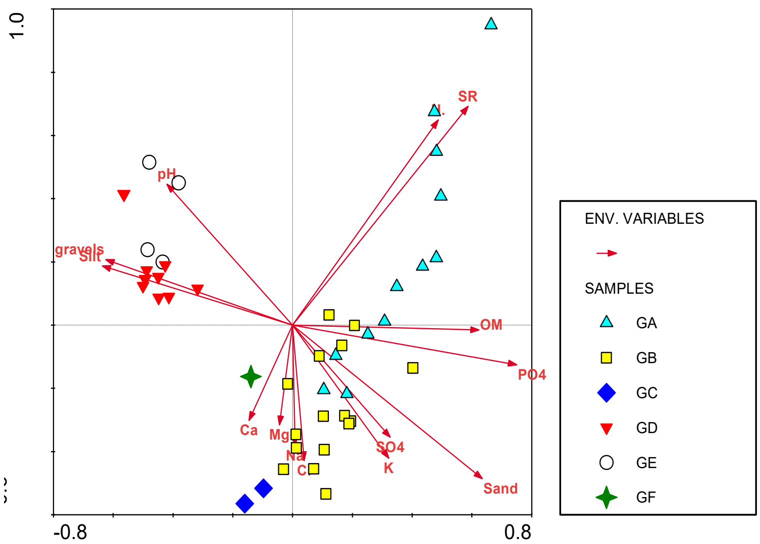

Fig. 7. Redundancy Analysis (RDA) biplot along axes 1 and 2, showing the distribution of the 44 stands and their correlations with the environmental variables and vegetation groups (A-F)

Discussion

There are numerous habitats, soil types and climatic conditions where *Balanites aegyptiaca* can grow (Varshncy & Vyas, 1982; Sarker et al., 2000; Pandey, 2005). According to El Amin (1990), trees can grow in a variety of soil types, including alluvial soil, sandy soil, dark cracked clay soil, garden soil, riverside soil, and food slopes of rocky soil. The tree has great strategies to grow and thrive under combined water and salinity conditions, as reported by Maksoud & El-Hadidi (1988). In studied stands of Egyptian Deserts linked with *Balanites aegyptiaca*, a total of 132 species from 105 genera and 43 various families were found. The life form evolved as a result of climatic and environmental adaptation (Hegazy et al., 2012; Salama et al., 2019). Similar climatic conditions throughout different regions indicate similar micro- and macroclimates (Duran & Hamzaoglu, 2002). They contain 83 perennials (68.03%) of the total recorded species and 49 annuals (37.12%). The current study's prevalence of perennials agrees with the findings of Marie (2000), Zahran & Willis (2009) and Abdelaal (2016), and, most recently, Bedair et al. (2021) on Wadi Hagul in the Eastern Desert. The families Poaceae, Asteraceae, and Fabaceae make up the majority of the flora, which is associated with *Balanites aegyptiaca*; the same families were the most numerous with Alshamy (2016) on some oasis in the Western Desert. These families were reported to be the most common in other parts of Egypt's reclaimed areas, including Soliman (1989) in Tahrir, Shehata & El-Fahar (2000) in Salhiya, Shaheen (2002) in newly farmed lands along Egypt's southern border, Mustafa (2002) in Upper Egypt farmlands, Abd El-Ghani & Fawzy (2006) in the Oasis agro-ecosystems, and Mashaly et al. (2011) in the Nile Delta reclaimed areas. Poaceae, Fabaceae, Asteraceae, and Brassicaceae made up the majority of the species composition of various habitats in Egypt (Salama et al., 2018). On the other hand, the highest families and most prevalent in the Mediterranean and North African flora are Asteraceae, Zygophyllaceae, Fabaceae, Chenopodiaceae, and Brassicaceae (Amro et al., 2021). The Asteraceae family was reported to be the most common in other parts of the Eastern Desert (Wadi Asyouti and Wadi Habib) (Salama et al., 2014). Asteraceae make up the majority of Egypt's floristic composition; according to Täckholm (1974) and Boulos (2002), there are 234 species and 98 genera that make up its representation. Rainfall has a close relationship with the life forms of desert flora (Danin & Orshan, 1990), topography, and landforms (Kassas & Girgis, 1965; Orshan, 1986; Zohary, 1973; Shaltout et al., 2010).

The prevailing life forms in plant communities growing under a given climatic regime can be used to characterize climate types, with the number of species within each life form expressed as a proportion of the total amount of species found in the investigated area (Carvalho da Costa et al., 2007). Müller-Dombois & Ellenberg (1974) have developed alternative life-form systems. The species that were identified belonged to seven different life forms. They were therophytes, phanerophytes, hemicryptophytes, geophytes, chamaephytes, hydrophytes, and parasites. Therophytes made up the majority of the entire flora, accounting for 36.36 percent of it, which was explained by their brief life cycle, the availability of water, and the prevailing climatic circumstances (Shaltout & El-Fahar, 1991; Salama et al., 2021a). The presence of therophytes in the current study area is also related to human activities, as agreed upon (Barbero et al., 1990; Salama et al., 2021b). Similar habitats have been identified in the Wadi El-Natrun Depression agroecosystem (Abd El-Ghani et al., 2015). Phanerophytes act (20.45%), Chamaephytes (19.69%), and the lowest life form was Parasites (0.75%). These patterns of the life-form spectrum are strikingly similar to those observed by Amro et al. (2021) in Egypt's hyper-arid coastal desert. According to Hussein et al. (2021), chamaephytes were the most abundant family, followed by therophytes, hemicryptophytes, and phanerophytes in hyper-arid desert environments. Plant distribution is influenced by a species' ability to adapt to its habitat and its living conditions (Esmailzadeh et al., 2006; Najafi et al., 2007).

Another aspect of floristic research is chorological affinity, which pertains to regional distributions and plant responses to environmental changes. Each plant has a specific ecological range and can withstand a given geographical environmental state. The living conditions and ecological adaptation of a species affect how widely distributed a plant is (Esmailzadeh et al., 2006; Najafi et al., 2007). An important source of information for biogeography, habitat needs models, threatened species conservation, areas of provenance for plant genetic resources, and plant selection for environmental rebuilding is plant distribution (González & Martin, 2006). The chorological analysis of the associated vegetation showed that 20.45% of the species are mono-regional, 41.67% are bi-regional, and 10.60% of the species are pluri-regional. Due to the presence of inter-zonal habitats such as anthropogenic or hydro, halo, and psammophilous sites, inter-regional species (bi-, tri-, and pluriregional) dominate mono-regional ones, Zohary (1973). The Saharo-Arabia species are abundant in the research locations, which is a good indicator of a hot, dry climate and may be related to their strong tolerance for the harsh circumstances of the desert. Using the application of multivariate analysis techniques, correlations between soils and plants in diverse habitats were examined in the majority of dry regions. In the desert ecosystem, García-Novo et al. (2004), Enright et al. (2005), Salama et al. (2016), van Etten & Fox (2017), and El-Tayeh et al. (2020) acted in this manner. The distributional variation was influenced by the heterogeneity of microclimatic conditions and local topography. RDA was used to conduct direct gradient analysis (Ter Braak & Prentice, 1988) and to identify relationships between vegetation data and environmental factors (Jean & Bouchard, 1993). Multivariate analysis was used in the research region to examine the 132 species linked to estimations of *Balanites aegyptiaca* cover found in 44 examined stands in the Egyptian Deserts. The TWINSPAN technique was used to classify stands, and the results were six vegetation groups at level 3, named after their dominant species:

(A) *Balanites aegyptiaca* and *Phoenix dactylifera*

(B) *Balanites aegyptiaca*

(C) *Tamraix nilotica, Tamarix aphylla, Zygophyllum coccineum, Phoenix dactylifera, Phragmites australis, Juncus rigidus, Nitraria retusa, Aeluropus littoralis,* and *Zygophyllum album*

(D) *Balanites aegyptiaca*

(E) *Balanites aegyptiaca, Zilla spinosa, Fagonia mollis, Leptadenia pyrotechnica,* and *Launaea spinosa*

(F) Contains only one stand, which is distinguished by having the highest concentrations of sodium (Na), a high pH, the lowest concentrations of clay and organic matter, and a consistent presence of some species, such as *Avicenna marina*, a mangrove species that is highly resistant to harsh environmental conditions like high salinity, high temperatures, strong winds, and anaerobic soil (ElDohaji et al., 2020) and Das et al. (2016), and *Limonium pruinosum*, a member of the Plumbaginaceae family, is particularly typical of saline muddy places or sub-desert areas of tropical and warm parts of Africa, America, and Asia (Botineau, 2010).

Tamarix nilotica was always present with *Balanites aegyptiaca* and covered the entire study area. According to Abbas et al. (2016), *T. nilotica* has been the most widely distributed species in Wadi El Rayan and can be regarded as the most successful plant in the research region because it grows in a variety of environments and ecosystems (e.g., desert regions, edges of wetlands, and saline marshes). In this study region, organic matter and PO_4 appear to be important factors; as a group (A), it contains the most OM and PO_4 of any group; it also has the maximum species richness (20.83 species stand^{-1}) and Shannon-Wiener index (2.99). One important element influencing the soil fertility of certain Egyptian Desert ecosystems is organic matter (Sharaf El-Din & Shaltout, 1985; Abd El-Ghani, 1998, 2000), and the soils of arid terrain have small levels of organic matter and a pH that is somewhat alkaline at the surface (Dregne, 1976). Henkin et al. (2006) observed a substantial positive connection between the phosphorus in the soil and the diversity of species in Israeli annual legumes. Salinity levels in the soil have an impact on the species diversity of the plants (Kumar, 1996; Abbadi & El Sheikh, 2002), pH, calcium, and organic matter (Abd El-Ghani, 1998). In the two deserts under investigation, different distribution forms of annuals and perennials were found. Groups A and B (Western Desert) had more annuals like *Sonchus oleraceus, Bassia indica, Echinochloa colona, Lolium rigidum, and Tribulus pentandrus* species than the other groups, C, D, and E (Eastern Desert), in which the largest number of species were perennials. This could be due to the fact that groups A and B have the highest water content, OM, and PO_4 content. Group C, which was close to the Red Sea Coast, had the highest content of most soil variables (silt, EC, TSS, Na^+, K^+, Ca^{+2}, Mg^{+2}, and Cl^-). Group C is also distinguished by the dominance of salt-tolerant species such as *Zygophyllum coccineum, Tamrix* nilotica, *Tamrix aphylla, Phragmites australis, Zygophyllum album, Nitraria retusa, Aeluropus littoralis, and Juncus rigidus*. According to McIntyre et al. (1995) and Sternberg & Shoshany (2001), a system's high percentage of annual plants denotes a higher degree of disturbance. The predominance of perennial plants in a desert habitat determines the enduring characteristics of the vegetation. This could be explained by the insufficient rainfall for the growth of many annuals, according to Hosni & Hegazy (1996) and Abd El-Ghani et al. (2015), the precipitation affords a better chance for a substantial number of annuals to emerge, giving the vegetation a distinctive physiognomy. Annuals may contribute more and perform better because of their short life cycles, high resource allocation to the sexual organs, and productivity of flowers early in their lifecycle to assure seed output in a short amount of time (Sans & Masalles, 1995). Redundancy Analysis (RDA) showed that gravels, sand, silt, pH, PO4, OM, K, and Cl were the key factors impacting species distribution patterns. Yet, according to El-Khouly & Shawky (2017) and Amro et al. (2021), gravel, coarse sand, silt, and clay had an impact on the pattern of species distribution. The differences in soil properties, substrate discontinuities, and the allelopathic influence of one or more invasive species, depending on their relative dominance among other associated species, may be responsible for the changes in species richness and diversity (James et al., 2006). Local differences in soil characteristics around specific plants would result in a high amount of species variety because heterogeneous environments allow several plants within a community to have their needs met (Whittaker & Levin, 1977).

Conclusion

This study was carried out in the Eastern and Western Deserts of Egypt to investigate the effect of environmental factors on the floristic composition and vegetation associated with Balanitis aegyptiaca. Human activity threatens the native communities that live in desert ecosystems by negatively affecting them. It is imperative to reduce as much as possible the severity of the dangerous effects of the floristic composition. Our findings may be helpful in identifying plant variations in these areas. Conflict of Interest: The authors declare that they have no conflicts of interest.

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دراسات إجتماعية نباتية للنباتات المصاحبة لنبات بلح الصحراء في صحاري مصر الشرقية و الغربية

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يهدف هذا البحث الي دراسة تركيب الغطاء النباتي ، وتوزيع الأنواع المصاحبة لنبات بلح الصحراء ، والتركيب الكمي للتربه في 44 موقعا في الصحاري المصرية (الصحراء الشرقية والغربية). كانت صحارى مصر جافة جدًا في جميع المواقع المبحوثه ، تم تسجيل 132 نوعًا نباتيًا ينتمون إلى 105جنسا و 43 عائلة مختلفة ، منهم 49 نباتًا حوليًا و 83 نباتًا معمرًا. أكبر ثلاث عائلات من حيث عدد الأنواع الموثقة هي العائلة المركبة و العائلة النجيلية و العائلة البقلية (Asteraceae و Poaceae وFabaceae) ، والتي تمثل 33.33٪ من جميع الأنواع المسجلة. كانت الأنواع الأكثر انتشارًا ، والتي تمثل مظهرًا نموذجيًا من أشكال الحياة الصحراوية ، هي الحوليات، والنباتات الشجرية، والجنبات. تم تحديد 6 مجموعات نباتية متميزة، كل منها بتركيبة نباتية مميزة، بعد دراسة تصنيف الغطاء النباتي باستخدام برنامج التصنيف والتسلسل ثنائي الأتجاه (TWINSPAN). كشف برنامج تحليل التطابق العكسي (DCA) أن هذه المجموعات فصلت بوضوح علي أول محورين. أيضًا تم استخدام برنامج تحليل التطابق الكنسي (RDA) لأظهار العلاقة بين الغطاء النباتي والتربة لتفسيرها وشرحها بشكل فعال. محتويات الرمل والطين ومحتوى الماء والمواد العضوية والصوديوم والبوتاسيوم والكالسيوم والمغنيسيوم كلها مرتبطة ارتباطًا وثيقًا بمحاور التكرار الأربعة الأولى وتمثل 76.1 ٪ من العلاقات بين الأنواع والبيئة في المواقع المدروسة. تم توضيح نمط الغطاء النباتي في مناطق الدراسة بوضوح من خلال التصنيف والتنسيق. نظرًا لأن هذا المجال من الدراسة يبدو أنه يحتوي على تركيبة نباتية بسيطة من الحوليات التي تمثل الصحراء العربية، التي لم تتأثر نسبيًا بالاضطرابات البشرية.