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Phytosociological Survey of Mediterranean Endemic Plants in Egypt

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IN TERMS of plant diversity, the Mediterranean Basin is the world's second-richest hotspot and one of the most important spots on the planet for endemic species. Henceforth, we aim in the present study to provide a phytosociological overview of Mediterranean endemic vegetation based on an extensive database and formal classification. We further aim to describe the vegetation communities and provide information on their distribution and soil variables affecting their distribution. We built a comprehensive database utilizing all available vegetation plots and soil data of the study area from the meta-data of Tanta Ecology Group and our field surveys. We performed a cluster analysis (TWINSPAN). We visualized the results by detrended correspondence analysis (DECORANA) for the observed vegetation communities. The more associated species with Mediterranean endemic taxa were selected depending on the highest chi-squared values. A Canonical Correspondence Analysis (CCA) was performed to estimate the relationship between the soil variables and Mediterranean endemics distribution. Indeed, we distinguished five classes representing Mediterranean endemic vegetation in Egypt: *Cyperus capitatus*, *Echium angustifolium* subsp. *sericeum*, *Asparagus stipularis*, *Zygophyllum album* and *Fumaria judaica* subsp. *judaica*. In addition, the most effective variables in the distribution of Mediterranean endemics in Egypt were calcium carbonate, sand, silt, and pH, while the organic matter was the least effective variable. pH values showed that most of the soils are alkaline and non-saline. Most soils in the study area had sandy to loamy sandy textures and very low content of organic matter. We present a common classification of Mediterranean endemic vegetation based on cutting-edge methods. Our study forms an important basis for decision-making in nature conservation, global change issues, and further in-depth studies on Mediterranean endemic vegetation.

Keywords: DECORANA, Soil, Syntaxonomy, TWINSPAN, Vegetation classification.

Introduction

According to Myers et al. (2000), the Mediterranean basin is one of the world's top 25 biodiversity hotspots. It is regarded as the second-largest biodiversity hotspot in the world, according to Lopez-Alvarado & Farris (2022). It comprises important terrestrial habitats such as rainforests, maquis, garrigues, pastures, marshes, coastal regions, and transitional to desert zones and spans more than 30 states. Also, it contains more than 25,000 species of flowering plants worldwide (Zahran, 2010; Bedair et al., 2023a, b). In contrast to the more homogeneous regions to the north and south, the Mediterranean basin is bordered by temperate, desert, and tropical biogeographical regions since it is the meeting place for Europe, Asia, and Africa (Zahran, 2010). As a result, the Mediterranean basin has an extraordinarily high level of biodiversity due to its complex topography, climate, and edaphic features (Thompson, 2020). Moreover, roughly 63.5% of species, according to the Med-Checklist, are endemic to the area (Heywood, 2002). Because many Mediterranean species are confined to a single or small number of locations,

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such as rocky or unusually fertile islands, isolated mountain ranges, or sandy plains, this region is distinguished by a higher degree of endemism than other regions (Zahran, 2010).

The Mediterranean region's plant diversity depends heavily on endemism (Fois et al., 2022). This endemism is characterized by the fact that 60% of all species native to the Mediterranean region are narrow endemic species, meaning that their range is constrained to a single well-defined location within a relatively small portion of the Mediterranean region (Thompson, 2020). Hence, the flora of the Mediterranean is abundant in small, indigenous taxa. This area's geographic isolation is characterized by several islands, peninsulas, and tall mountains (Vargas, 2020). There are more than 10,000 islands and islets scattered throughout the Mediterranean Basin. The two largest islands in the area, Sicily and Sardinia, are good instances of this (Médail, 2022). They are followed by Cyprus, Crete, the Aegean Islands, Corsica, and the Balearic Islands. Species isolation at high altitudes is also impressive. Because of the gradual changes in many parameters, such as temperature, precipitation, and soil properties with the changes in altitude, mountain environments provide good opportunities to study how plant species richness fluctuates in response to environmental conditions within geographically confined areas (Di Biase et al., 2021).

The Mediterranean is one of the regions in the globe that is most vulnerable to the consequences of global warming, according to UNEP (2022). In actuality, the Mediterranean is warming 20% more quickly than the rest of the world. Precipitation will decrease by 10 to 15% if global warming is 2°C. Furthermore, hotspots in the Eastern Mediterranean and northern regions of the Western Mediterranean are predicted to experience increases in water temperature of between 1.8°C and 3.5°C by 2100. By 2100, the sea level is projected to rise by 0.43 to 2.5 meters. As a result, the region will see more heat waves, coastal erosion, fires, invasive species, floods, sea acidification, and a higher probability of species extinction (UNEP, 2022). The extensive human activity in the region, together with the intimate connections between its primary landscape, flora, and human activities, have shaped and altered the fauna and flora over many thousands of years. Unfortunately, several factors, including population growth and economic development, are currently causing the Hotspot to undergo fast anthropogenic change (Bedair et al., 2023c).

In the current period of large-scale decline in biodiversity, excessive land use and exploitation, and climate change, we urgently need an overview of the status and diversity of ecosystems. Our study updates earlier studies, including the work of Bidak et al. (2013). More precisely, we answer the following questions: (a) what are the vegetation communities of Mediterranean endemic vegetation; (b) where do they occur; and (c) what is the relationship between the soil variables and Mediterranean endemic distribution? The results of our study may serve as an improved basis for decision-making in the Mediterranean region's nature conservation and environmental policy, and further in-depth studies on Mediterranean endemic vegetation.

Materials and Methods

Study area

The assessment covers the Mediterranean endemics whose distribution is confined to the Mediterranean floristic region determined by Good (1974) and distributed along the Mediterranean coast of Egypt as described by Zahran et al. (1985). In the present study, we depended on the checklist previously published by Bedair et al. (2022, 2023c). (Appendix 1).

In Egypt, the Mediterranean territory extends for about 970km from Sallum on the Egyptian-Libyan border to Rafah on the Egyptian-Palestinian border with an average width of 15-20km in a north-south direction and a limited area of 16500km^2. It is subdivided into 3 subsectors: i) western (the Mareotis, extending for 550 km between Sallum and Alexandria, with annual rainfall between 220-150mm), ii) middle (Deltaic extending for 180km between Alexandria and Port Said with about 12km wide), and iii) east (Sinaitic, extending for 220km between Port Said and Rafah, with annual rainfall between 150-100mm) (Fig. 1).

Associated species

The more associated species with Mediterranean endemic taxa were determined depending on the highest chi-square values. These values were conducted using the Community Analysis Package (CAP 4) Statistics program.

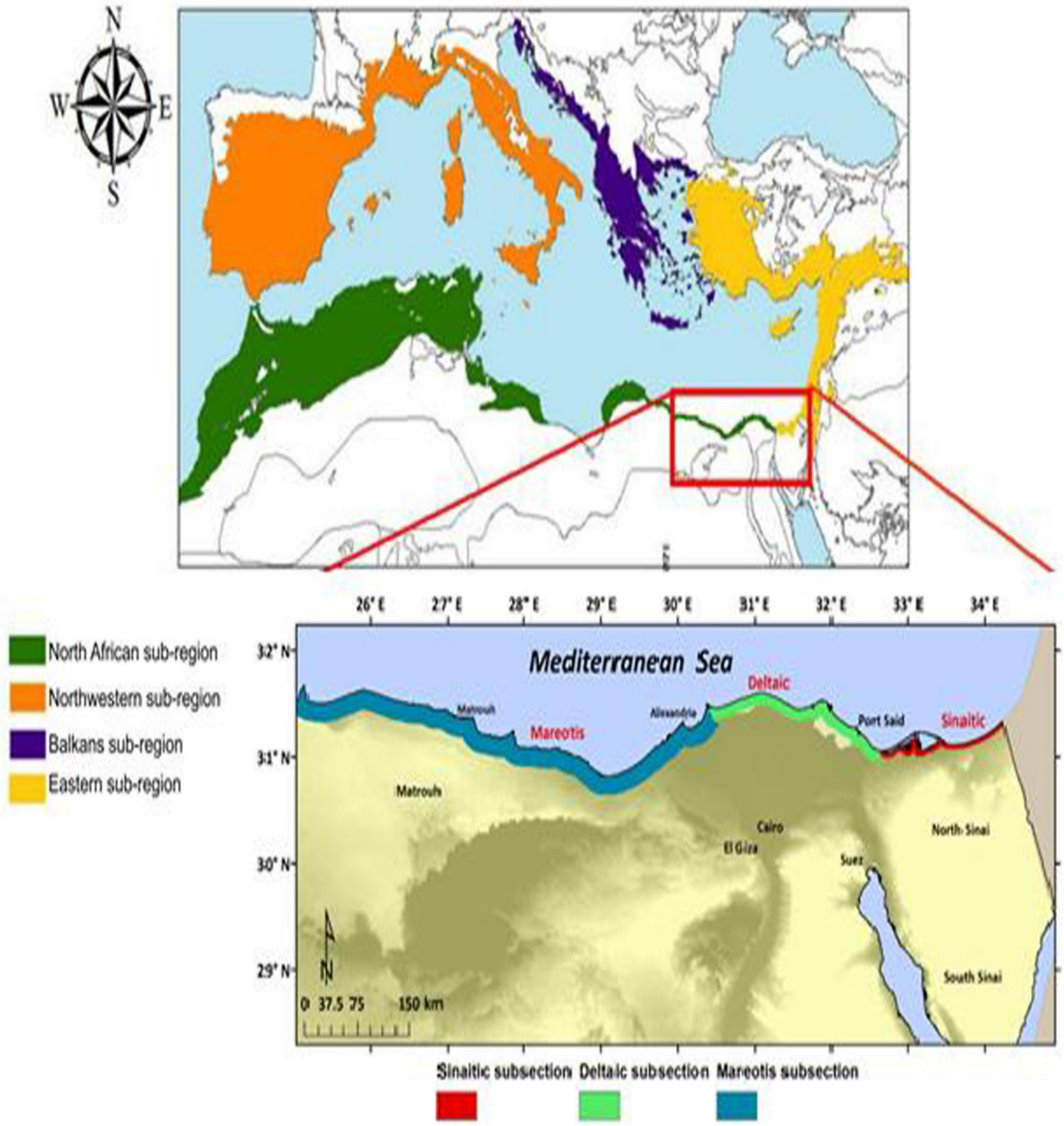

Fig. 1. Map of the study area indicating the Mediterranean floristic region delimitation and the sub-divisions of the Mediterranean region in Egypt.

Multivariate analysis

Two trends of multivariate analysis were applied in the present study: classification and ordination. Both trends have their merits in helping to understand vegetation and environmental phenomena. Both two-way indicator species analysis (TWINSPAN), as a classification technique, and detrended correspondence analysis (DECORANA), as an ordination technique were carried out for estimations of the 900 species recorded in 216 stands in the Mediterranean region in Egypt (Gauch & Whittaker, 1981) (Table 1). All the analysis was carried out using the Community Analysis Package (CAP 4) Statistics program.

Relationship between the soil variables and Mediterranean endemics distribution

Meta-data of soil texture, pH, electric conductivity (EC), organic matter, calcium carbonate and soluble cations (Ca^{++}, Na^{+}, K^{+}) of different soils of the Mediterranean endemics distributed along the Mareotis, Deltaic and Sinaitic subsectors were gathered from available literature such as Al-Sodany (1992), Hassan (2002), Bidak et al. (2013) and El-Khalafy (2023). A Canonical Correspondence Analysis (CCA) was performed by CANOCO 4.5.

TABLE 1. Distribution of the plots in the study area according to the locality and habitat types

Locality	Habitat types	Number of plots	Reference
I- Mareotis subsector			
Lake Mariut transect	Around the lake, sandy soil, cultivated lands	3	Shaltout et al. (2005), Ahmed (2009)
Burg El-Arab transect	Sandy soil and coastal sands	38	Ammar (1970), Hilmy (1971)
Omayed transect	Coastal sand dunes, wadis, inland ridges, saline and non-saline depressions	28	Mahmoud (1975), Razik (1976), Shaltout & Al-Sodany (2002), Bidak et al. (2013), Ahmed et al. (2015a), El-Khalafy (2023)
Al-Alamein transect	Coastal sand dunes, roadsides	3	Bidak et al. (2013), Shaltout (1983)
Dabaa transect	Coastal sand dunes, rocky lands, cultivated lands	9	Bidak et al. (2013), El-Khalafy (2023)
Mersa Matrouh transect	Wadis, sand dunes, roadsides, rocky lands	56	Migahid et al. (1971), Migahed (1983), Hammouda (1988), Kamal & El-Kady (1993), Turki & El Shayeb (2005), El-Zanaty et al. (2010), Osman et al. (2015), El-Amier (2016), Abdelaal et al. (2019)
Maktala transect	Limestone ridges, coastal sand dunes	2	Ahmed (2009), Bidak et al. (2013)
Barrani transect	Wadis, sand dunes	15	Bidak et al. (2013)
Sallum transect	Rocky coastal ridges, gravel sand flats, consolidated dunes	5	Bidak et al. (2013)
II- Deltaic subsector			
Rashid transect	Highways, wastelands, sand flats	8	Shaltout et al. (2010), Al-Sodany (1992)
Idku transect		1	Al-Sodany (1998)
Burullus transect	Coastal dunes	14	Al-Sodany (1992), Shaltout & Al-Sodany (2000), Shaltout & Galal (2006)
Qalabshu transect	Inland ridges, Inland plateaus	11	Al-Sodany (1992), Shaltout et al. (2018)
Baltim-Gamasa transect	Coastal sand dunes, sandy soils	15	Al-Sodany (1992), El-Khalafy (2023)
III- Sinaitic subsector			
Bir El-Abd transect	Sandy soils	1	Heneidak (2008)
El-Arish transect	Mobile dunes, sandy soil	2	Danin et al. (1985), Gibali (1988), Kamel et al. (2008)
Sheikh Zuwayed transect	Sandy soils	1	Heneidak (2008)
Rafah transect	Sandy soils	4	Danin et al. (1985), Gibali (1988)

Results

The phytosociology of Mediterranean endemics and associated taxa

Associated species with Mediterranean endemics

The more associated species with Mediterranean endemic taxa were selected depending on the highest chi-squared values. *Allium mareoticum* was highly associated with *Ajuga iva* (12.4), *Allium barthianum* and *Allium blomfieldianum* with *Allium aschersonianum* (37.7 and 5.0, respectively), *Anthemis microsperma* with *Anacyclus alexandrinus*

(134.4), *Anthyllis vulneraria subsp. maura* with *Urginea maritima* (25.6), *Apium crassipes* with *Pluchea dioscoridis* (117.4), *Bellevalia sessiliflora* with *Alcea acaulis* (26.2), *Bupleurum nanum* with *Ammochloa palaestina* (29.7), *Centaurea pumilio* and *Helianthemum crassifolium* subsp. *sphaerocalyx* with *Calligonum polygonoides* (61.9 and 71, respectively), *Coronilla repanda* with *Chenopodium vulvaria* (79.5), *Crepis aculeata* with *Achillea biebersteinii* (26.2), *Cynara cornigera* and *Filago mareotica* with *Asphodelus fistulosus* (105.3 and 63.4, respectively), *Ebenus armitgei* with *Asparagus aphyllus* (91.7), *Echinops taeckholmianus* with *Astragalus sieberi* (117.4), *Fumaria gaillardotii* with *Epilobium hirsutum* (117.4), *Fumaria judaica* subsp. *judaica* with *Apium leptophyllum* (117.4), *Hyoseris radiata* subsp. *graeca* with *Heliotropium bacciferum* (144.9), *Hyoseris scabra* with *Atractylis prolifers* (50.1), *Lathyrus marmoratus* with *Erucaria pinnata* (53.9), *Limonium echoides* with *Arthrocnemum glaucum* (165.4), *Lotus cytisoides* with *Anthemis pseudocotula* (169.2), *Lotus polyphyllos* with *Crucianella maritima* (159), *Lycium schweinfurthii var. aschersonii* with *Lotus palustris* (127.9), *Muscari parviflorum* with *Anacyclus alexandrinus* (3.7), *Pancratium arabicum* with *Launea mucronata* (137.9), *Posidonia oceanica* with *Launea resedifolia* (5), *Sulla spinosissima* with *Anthemis retusa* (52), *Teucrium brevifolium* with *Polypogon maritimus* (52), *Thesium humile* var. *maritima* with *Diplotaxis simplex* (336.5), *Thymbra capitata* with *Teucrium polium* (93.6), *Trigonella berythea* with *Tanacetum santolinoides* (52), *Trisetaria koelerioides* with *Farsetia aegyptiaca* (16.8), *Valantia columella* with *Anthemis pseudocotula* (169.2), *Linaria joppensis* with *Anagalis arvensis* var. *arvensis* (53.2), *Leopoldia bicolor* with *Ambrosia maritima* (53.2), *Muscari salah-eidii* with *Allium ampeloprasum* (120.2) and *Verbascum letourneuxii* with *Peganum harmala* (110.5) (Table 2).

Multivariate analysis of the sampled stands

A total of 900 species (39 Mediterranean endemic species and 861 species associated with them) were recorded. The application of TWINSPAN on the cover-abundance of these species in 216 stands led to the recognition of 5 vegetation groups at the 3rd level of classification (Fig. 2).

Allium, Astragalus, and Euphorbia were the most represented genera (each of 16 taxa = 1.8%), then *Silene* and *Erodium* (each of 12 taxa = 1.3%). The application of DECORANA on the same set of data indicates reasonable segregation among these groups along the ordination plane of axes 1 and 2 (Fig. 3). The vegetation groups are named after the first and occasionally the second dominant species (the species that have the highest presence percentage) as follows: I, II, III, IV and V. The following is a brief description of these vegetation groups (Table 3).

Group I: *Cyperus capitatus*. It comprises 16 stands (7.4% of the total stands) and 57 species including 4 Mediterranean endemics (*Centaurea pumilio*, *Lathyrus marmoratus*, *Echinops taeckholmianus* and *Pancratium arabicum*). It represents the stands of coastal sand dunes in the Deltaic Mediterranean (Baltim-Gamasa transect). The dominant species are *Cyperus capitatus* (P= 87.5%), *Pancratium maritimum*, *Alhagi graecorum* and *Rumex pictus* (each of P= 68.8%).

Group II: *Echium angustifolium* subsp. *sericeum*. It comprises 28 stands (13% of the total stands) and 55 species including 2 Mediterranean endemics (*Lycium schweinfurthii* and *Centaurea pumilio*). It represents the stands of the maritime sandy soils and limestone ridges of the whole Deltaic Mediterranean (Rashid, Idku, Burullus, Qalabshu, and Baltim-Gamasa transects). The dominant species are *Echium angustifolium* subsp. *sericeum* (P= 100%), *Ononis serrata*, *Rumex pictus*, *Silene gallica* and *Setaria geminata* (each of P= 96.4%).

Group III: *Asparagus stipularis*. It comprises 70 stands (32.4 % of the total stands) and 741 species including 31 Mediterranean endemics. It represents the stands of Sinaitic subsector (Bir El-Abd, El-Arish, Sheikh Zuwayid, and Rafah transects), Mareotis subsector (Burg El-Arab, Dabaa, Omayed, and 2 Matrouh wadis; Wadi Habis and Wadi Hashem) and stands of *Apium crassipes* in Rosetta. The dominant species are *Asparagus stipularis*, *Paronychia arabica*, *Peganum harmala*, *Avena fatua,* and *Onopordum alexandrinum* (each of P= 85.7%).

TABLE 2. Most associated species with Mediterranean endemics depending on chi-square value (χ^2). All values are significant at P≤ 0.005

Mediterranean endemic species	Associated species	χ^2
Allium barthianum	*Allium aschersonianum*	37.7
	Limonium tubiflorum	12.4
Allium blomfieldianum	*Allium aschersonianum*	5.0
	Allium barthianum	3.5
Allium mareoticum	*Ajuga iva*	12.4
	Aegilops kotschyi	3.7
Anthemis microsperma	*Anacyclus alexandrinus*	134.4
	Ammochloa palaestina	31.2
Anthyllis vulneraria subsp. *maura*	*Urginea maritima*	25.6
	Tamarix nilotica	16.8
Apium crassipes	*Pluchea dioscoridis*	117.4
	Bassia indica	57.7
Bellevalia sessiliflora	*Alcea acaulis*	26.2
	Allium sphaerocephalon	26.2
Bupleurum nanum	*Ammochloa palaestina*	29.7
	Anchusa hispida	21.6
Centaurea pumilio	*Calligonum polygonoides*	61.9
	Asparagus horridus	61.9
Coronilla repanda	*Chenopodium vulvaria*	79.5
	Allium ampeloprasum	79.5
Crepis aculeata	*Achillea biebersteinii*	26.2
	Aegilops longissima	26.2
Cynara cornigera	*Asphodelus fistulosus*	105.3
	Asteriscus spinosus	105.3
Ebenus armitgei	*Asparagus aphyllus*	91.7
	Bellevalia species	45.8
Echinops taeckholmianus	*Astragalus sieberi*	117.4
	Cyperus capitatus	10
Filago mareotica	*Asphodelus fistulosus*	63.4
	Cynara cornigera	41
Fumaria gaillardotii	*Epilobium hirsutum*	117.4
	Diplotaxis acris	117.4
Fumaria judaica subsp. *Judaica*	*Apium leptophyllum*	117.4
	Atriplex dimorphostegia	117.4
Helianthemum crassifolium subsp. *sphaerocalyx*	*Calligonum polygonoides*	71.0
	Helianthemum kahiricum	46.3
Hyoseris radiata subsp. *Graeca*	*Heliotropium bacciferum*	144.9
	Helianthemum crassifolium subsp. *sphaerocalyx*	144.9
Hyoseris scabra	*Atractylis prolifers*	50.1

TABLE 2. Cont.

Mediterranean endemic species	Associated species	χ^2
	Ammphila arenaria	40.1
Lathyrus marmoratus	*Erucaria pinnata*	53.9
	Lathyrus aphaca	24.6
Leopoldia bicolor	*Ambrosia maritima*	53.2
	Asphodelus viscidulus	53.2
Limonium echoides	*Arthrocnemum glaucum*	165.4
	Frankenia revoluta	133.2
Linaria joppensis	*Anagalis arvensis* var. *arvensis*	53.2
	Aegilops longissima	53.2
Lotus cytisoides	*Anthemis pseudocotula*	169.2
	Ferula marmarica	169.2
Lotus polyphyllos	*Crucianella maritima*	159
	Elymus farctus	109.9
Lycium schweinfurthii var. *aschersonii*	*Lotus palustris*	127.9
	Carex divisa	77.3
Muscari parviflorum	*Anacyclus alexandrinus*	3.7
	Hordeum marinum	2.2
Muscari salah-eidii	*Allium ampeloprasum*	120.2
	Amaranthus blitoides	120.2
Pancratium arabicum	*Launea mucronata*	137.9
	Erodium laciniatum	67.2
Posidonia oceanica	*Launea resedifolia*	5.0
	Lygos raetam	3.0
Sulla spinosissima	*Anthemis retusa*	52.0
	Plantago cylindrica	52.0
Teucrium brevifolium	*Polypogon maritimus*	52.0
	Brassica rapa	52.0
Thesium humile var. *maritima*	*Diplotaxis simplex*	336.5
	Asphodelus ramosus	280.5
Thymbra capitata	*Teucrium polium*	93.6
	Globularia arabica	59.1
Trigonella berythea	*Tanacetum santolinoides*	52.0
	Stachys aegyptiaca	52.0
Trisetaria koelerioides	*Farsetia aegyptiaca*	16.8
	Panicum turgidum	16.8
Valantia columella	*Anthemis pseudocotula*	169.2
	Lotus cytisoides	169.2
Verbascum letourneuxii	*Peganum harmala*	110.5
	Dactylis glomerata	70.6

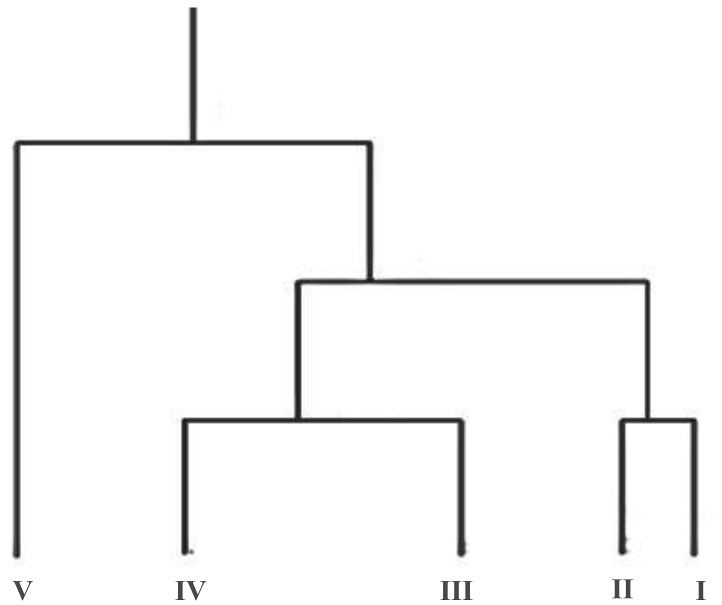

Fig. 2. Cluster analysis, in the form of a dendrogram, represents the classification of the five vegetation groups. I: *Cyperus capitatus*, II: *Echium angustifolium* subsp. *sericeum*, III: *Asparagus stipularis*, IV: *Zygophyllum album* and V: *Fumaria judaica* subsp. *judaica*

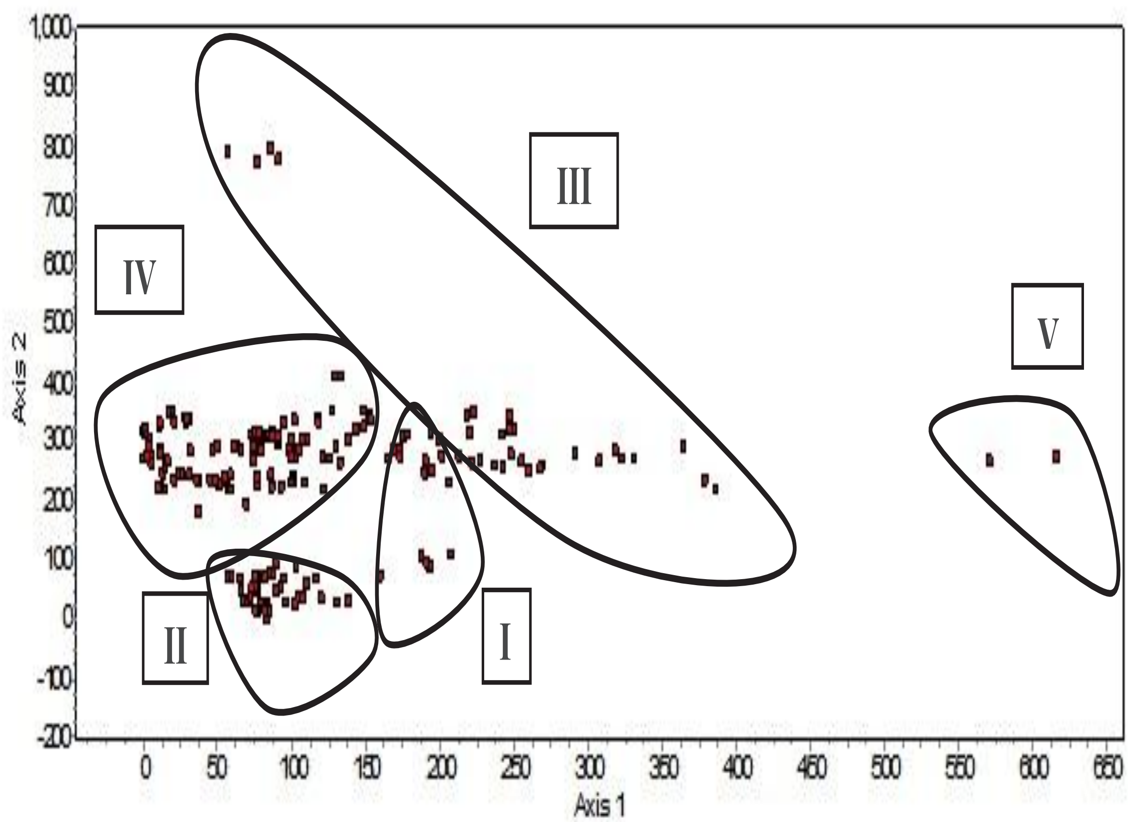

Fig.3. Ordination and classification of the studied Mediterranean endemics and their associated species in the Egyptian flora. I: *Cyperus capitatus*, II: *Echium angustifolium* subsp. *sericeum*, III: *Asparagus stipularis*, IV: *Zygophyllum album* and V: *Fumaria judaica* subsp. *judaica*

TABLE 3. Characteristics of the 5 vegetation groups (I- V) derived after application of TWINSPAN

G	Transect	Habitat	First dominant	P (%)	Second dominant	P (%)
I	Baltim-Gamasa	Coastal sand dunes	*Cyperus capitatus*	87.5	*Pancratium maritimum*	68.8
II	Rashid, Idku, Burullus, Qalabshu and Baltim-Gamasa	Maritime sandy soils and limestone ridges	*Echium angustifolium* subsp. *sericeum*	100	*Ononis serrata*	96.4
III	Bir El-Abd, El-Arish, Sheikh Zuwayid and Rafah (Sinaitic), and Burg El-Arab, Dabaa and Omayed (Mareotis)	Multi-habitats, mainly wadis	*Asparagus stipularis*	85.7	*Paronychia arabica*	85.7
IV	Multi-transects of Mareotis	Coastal sand dunes, rocky coastal ridges, gravel sand flats roadsides, wadis, inland ridges, saline and non-saline depressions	*Zygophyllum album*	100	*Cakile maritima*	100
V	Lake Mariut	Lakeshores	*Fumaria judaica* subsp. *judaica*	100	*Trifolium alexandrinum*	100

Group IV: *Zygophyllum album*. It is the largest vegetation group. It comprises 99 stands (45.8% of the total stands) and 392 species including 22 Mediterranean endemics. It occupies multi-habitats in multi-transects of the Mareotis subsector. The dominant species are *Zygophyllum album*, *Cakile maritima*, *Anacyclus monanthos* subsp. *monanthos*, *Carthamus eriocephalus*, *Eryngium campestre*, *Salicornia fruticosa*, *Sporobolus pungens* (P= 81.8%) and *Haloxylon scoparium* and *Convolvulus lanatus* (each of P= 100%).

Group V: *Fumaria judaica* subsp. *judaica*. It comprises 2 stands (0.9% of the total stands) and 36 species including 2 Mediterranean endemic species (*Fumaria judaica* subsp. *judaica* and *Fumaria gaillardotii*). It represents the stands of Lake Mariut, Alexandria. The dominant species are *Fumaria judaica* subsp. *judaica*, *Trifolium alexandrinum*, and *Cuscuta campestri* (each of P= 100%).

Relationship between the soil variables and Mediterranean endemics distribution

The arrow length of the CANOCO ordination expresses the relative importance of a certain soil variable. Indeed, the most effective variables in the distribution of Mediterranean endemics in Egypt are calcium carbonate, sand, silt, and pH, while organic matter is the least effective variable (Fig. 4). *Thymbra capitata* (r), *Hyoseris scabra* (h) and *Bellevalia sessiliflora* (v) are correlated with high gradients of calcium carbonate. *Thesium humile* var. *maritima* (p) correlated with moderate gradients of calcium carbonate and pH, while *Posidonia oceanica* (o) highly with pH. *Centaurea pumilio* (d) correlated with high gradients of sand fraction, while *Lycium schweinfurthii* (m) with clay and *Lotus polyphyllos* (l) with silt.

pH values showed that most of the soils are alkaline and non-saline, where pH ranges from 9.4 in soils of *Leopoldia bicolor* to 7.3 in soils of *Lycium schweinfurthii*. EC reached the maximum value in soils of *Centaurea pumilio*, while its minimum value was recorded in soils of *Bellevalia sessiliflora*. Moreover, sodium cation had a maximum value in *Lathyrus marmoratus* and minimum value in *Hyoseris scabra* and *Lotus polyphyllos*. Soils of *Centaurea pumilio* are characterized by a high value of K^+, while those of *Pancratium arabicum* are characterized by a high value of Ca^{+2}. Most soils in the study area had sandy to loamy sandy textures. The percentage of sand fraction ranges from 48.6-99%, that of silt from 0-40%, and clay from 0.5-19.1%. Soil samples are characterized by very low content of organic matter. It ranged from 0.03% in soils of *Leopoldia bicolor* to 13.6% in soils of *Centaurea pumilio*. Spectacularly, the study area is characterized by a high content of $CaCO_3$. It reached its maximum value in soils of *Thymbra capitata*, while its minimum value was recorded in soils of *Leopoldia bicolor* (Table 4).

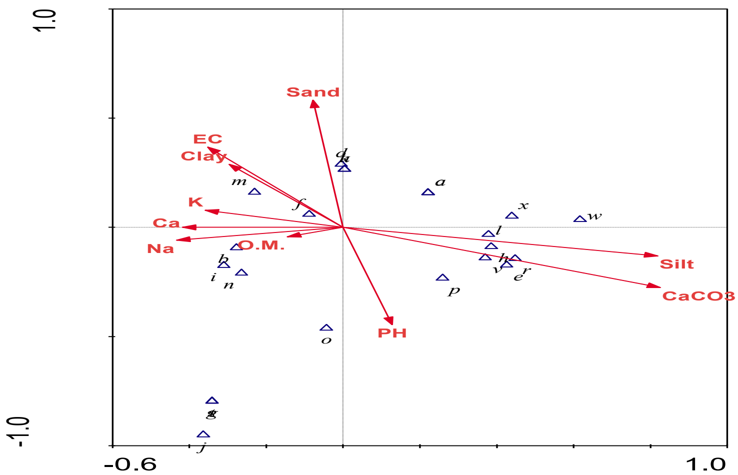

Fig. 4. CANOCO ordination plot for the edaphic variables (represented by arrows). The Mediterranean endemics are coded as: a: *Allium blomfieldianum*, b: *Allium mareoticum*, d: *Centaurea pumilio*, e: *Ebenus armitgei*, f: *Echinops taeckholmianus*, h: *Hyoseris scabra*, i: *Lathyrus marmoratus*, l: *Lotus polyphyllos*, m: *Lycium schweinfurthii*, n: *Pancratium arabicum*, o: *Posidonia oceanica*, p: *Thesium humile* var. *maritima*, r: *Thymbra capitata*, v: *Bellevalia sessiliflora*, w: *Verbascum letourneuxii* and x: *Bupleurum nanum*

TABLE 4. Edaphic variables of the recorded Mediterranean endemics. EC: Electric conductivity

Species	Particle size distribution (%)			Organic matter	$CaCO_3$	pH	EC (dS m^{-1})	Soluble salts (meq^{-1})		
	Clay	Silt	Sand					Na^+	K^+	Ca^{++}
Bellevalia sessiliflora	6.2	18.3	75.5	0.2	23.6	8.6	0.2	0.6	0.1	1.0
Posidonia oceanica	9.0	11.0	80.0	0.2	33.1	8.4	0.9	0.9	0.2	7.0
Hyoseris scabra	8.0	13.1	78.9	0.2	14.2	8.4	2.8	9.8	0.4	19.0
Thymbra capitata	4.7	15.1	80.2	0.2	36.2	8.9	2.6	6.5	0.3	16.0
Lotus polyphyllos	8.1	15.4	76.5	0.1	36.3	9.3	0.6	2.1	0.2	2.9
Verbascum letourneuxii	6.2	18.3	75.5	0.3	55.6	7.5	4.6	2.4	2.5	1.0
Bupleurum nanum	12.2	10.3	77.5	0.2	75.0	7.8	1.0	0.1	0.1	1.4
Lotus cytisoides	7.0	17.8	75.2	0.2	48.3	8.0	6.4	6.9	1.0	6.3
Ebenus armitgei	8.2	17.1	74.4	0.2	37.6	8.6	1.4	0.3	0.1	1.2
Allium mareoticum	4.5	9.3	86.2	0.2	52.4	7.8	0.8	0.7	0.3	2.0
Centaurea pumilio	7.0	17.8	75.2	0.3	47.3	8.9	0.9	0.3	0.1	2.7
Valantia columella	4.2	13.4	82.4	0.2	45.2	8.0	0.8	0.4	0.1	2.2
Pancratium arabicum	6.8	0.3	92.9	0.1	2.3	7.6	70.0	12.5	2.5	12.5
Lycium schweinfurthii	9.2	0.0	90.8	0.2	1.9	7.7	65.0	22.5	5.0	4.7
Lathyrus marmoratus	7.5	0.3	92.2	0.4	2.2	8.2	1.9	3.3	6.5	16.5
Trisetaria koelerioides	19.1	0.0	80.9	0.5	2.1	0.0	0.0	112.5	27.5	27.5
Echinops taeckholmianus	1.0	2.0	97.0	0.5	2.5	8.2	0.9	3.5	1.4	3.4
Trigonella berythea	0.5	0.5	99.0	0.1	12.6	8.2	2.2	16.0	0.7	3.2
Allium blomfieldianum	2.0	3.0	95.0	0.7	4.6	8.0	1.9	7.5	7.0	9.0
Anthemis microsperma	2.0	1.0	97.0	2.7	2.8	7.9	4.7	20.0	1.7	23.0
Sulla spinosissima	6.2	1.2	48.6	2.0	11.2	8.9	0.5	57.0	16.0	172.0
Thesium humile var. *maritima*	8.2	17.1	74.4	0.1	17.3	8.9	0.9	1.3	0.2	1.0
Leopoldia bicolor	5.1	2.1	54.1	0.0	0.2	9.4	0.4	63.0	12.0	169.0

Discussion

Different aspects of the vegetation structure could be determined by classification and ordination analysis. The present study is considered quite different from most of the previous studies because it is only related to Mediterranean endemics along the whole Mediterranean region and their associated species. The vegetation composition of Mediterranean endemics in Egypt was classified by TWINSPAN classification into five vegetation groups (VGs): I: *Cyperus capitatus*, II: *Echium angustifolium* subsp. *sericeum*, III: *Asparagus stipularis*, IV: *Zygophyllum album* and V: *Fumaria judaica* subsp. *judaica*.

Indeed, El-Khalafy (2023) classified the endemic taxa of Egypt and their associated species into 8 vegetation groups at the 4th level of classification. VG I in the present study coincided with him in VG I that represents coastal sand dunes in the Baltim-Gamasa transect and co-dominated by *Cyperus capitatus*, *Pancratium maritimum*, *Alhagi graecorum* and *Rumex pictus*. In addition, the present study agreed with him in communities of *Allium mareoticum* at El-Dabaa, *Pancratium arabicum* at Keliopatra, Matrouh, and *Thesium humile* var. *maritima* at Ajeeba, Matrouh. Further, VG IV in the present study coincided with VG D in Bidak et al. (2013) who studied the status of the wild medicinal plants in the western Mediterranean coastal region of Egypt and recognized 5 vegetation groups at the 3rd level of the classification. This VG occupied multi-habitats in multi-transects and was co-dominated by *Zygophyllum album*, *Cakile maritima*, *Anacyclus monanthos* subsp. *monanthos*, *Carthamus eriocephalus*, *Eryngium campestre*, *Salicornia fruticosa*, *Sporobolus pungens* (P=81.8%) and *Haloxylon scoparium* and *Convolvulus lanatus*.

Shaltout et al. (2010) identified eight associations in the three sand formations: sand dunes, sand hummocks, and sand flats. These associations are named after the dominant species as follows: *Aeluropus lagopoides*, *Pancratium maritimum*, *Echium angustifolium* subsp. *sericeum*, *Echinops spinosus*, *Ononis serrata*, *Thymelaea hirsuta*, *Lycium schweinfurthii* and *Silene succulenta*. VG II in the present study coincided with *Echium angustifolium* subsp. *sericeum* and *Lycium schweinfurthii* associations. Furthermore, our study agreed with Shaltout et al. (2010) in 2 communities of *Apium crassipes*; one of them inhabited the highways and was dominated by *Cornulaca monacantha,* and the other inhabited wastelands and was dominated by *Chenopodium mural*e at Rosetta. The relationships between plant communities and the environment along the international coastal route from Port-Said to Abu-Qir were described by El-Amier & Abd El-Gawad (2017). They identified four communities (*Hordeum murinum-Senecio glaucus*, *Cakile maritima-Senecio glaucus*, *Silybum mariannum*, and *Mesembryanthemum crystalinum*), but the current study identified only one community (*Echinops taeckholmianus*) along the same road. The present study coincided with Al-Sodany (1998) in only one community of Lathyrus marmarotus at Idku and dominated by *Malva parviflora*, and Al-Sodany (1992) in communities of *Lycium schweinfurthii* and *Centaurea pumilio*.

Ahmed et al. (2015b) studied the flora and vegetation of different habitats of the Mareotis subsector and yielded 6 vegetation groups. This study agreed with the present study in communities of *Fumaria gaillardotii* and *Fumaria judaica* subsp. *judaica* at Lake Mariut that represent VG V of the present study. Abdelaal et al. (2019) studied floristic patterns of sand dune ecosystem along the Mediterranean coast of Egypt and coincided with the present study in 4 groups comprising *Lotus polyphyllos* inhabiting the embryonic and transition dunes and dominated by *Elymus farctus*; *Anthemis microsperma* and *Pancratium arabicum* inhabiting the stabilized dunes and dominated by *Echinops spinosissimus*; and *Centaurea pumilio* and *Thymbra capitata* inhabiting the foredunes and dominated by *Ammophila arenaria*. Moreover, Osman et al. (2015) studied the floristic features of Wadi Hashem of the Mareotis subsector. Indeed, the present study harmonized with them in 6 communities representing Mediterranean endemics *Anthemis microsperma*, *Cynara cornigera*, *Filago mareotica*, *Thymbra capitata* and *Verbascum letourneuxii*, *Bupleurum nanum*, *Lathyrus marmarotus* and *Allium barthianum* and are dominated by *Daucus syrticus*, *Amaranthus graecizans*, *Sonchus oleraceous*, *Allium neapolitanum*, *A. roseum,* and *Noaea mucronata*. In addition, our study matched with Turki & El Shayeb (2005) on Wadi Um Rakham of the Mareotis subsector in 3 groups that include endemics Allium blomfieldianum, *Allium barthianum*, *Cynara cornigera* and *Verbascum letourneuxii* and are dominated by *Atriplex halimus*, *Gymnocarpos decandrum* and *Deverra tortuosa*. Kamal & El-Kady (1993) studied vegetation of Wadi Washka and Wadi Nethely of the Mareotis subsector and agreed with the present study in 5 communities of *T. capitata* and dominated by *Hammada scoparia*, *Scorzonera alexandrina*, *Suaeda pruinosa*, *Salsola tetragona* and *Scorzonera alexandrina*. Danin et al. (1985) recorded one vegetation group in the Sinaitic Mediterranean that includes 4 associations of Mediterranean endemics *Crepis aculeata*, *Trigonella berythea*, *Trisetaria koelerioides* and *Coronilla repanda* and are dominated by *Artemisia herba-alba*, *Farsetia aegyptiaca* and *Anabasis articulata*. Indeed, VG III in the present study matched with Heneidak (2008) in communities of *Crepis aculeata*, *Coronilla repanda*, *Lathyrus marmarotus*, *Linaria joppensis*, *Pancratium arabicum*, *Bellevalia sessiliflora*, *Leopoldia bicolor* and *Muscari Salah-eidii*.

Indeed, for the existence and dispersion of plants, soil has been crucial. Distributions of plant communities are frequently greatly influenced by soil properties. Physical, chemical, and mineralogical investigations have been used to establish soil criteria to identify the relevance of soil to species distribution (Guo et al., 2003; Bedair, 2023). The striking variations in plant cover frequently seen for various soil types in nearby locations have naturally led to explanations based on the chemical or physical characteristics of the soil or the physiological characteristics of the plants (Bárcenas-Argüello et al., 2013). Moreover, to establish the evolutionary hypothesis of endemic taxa and areas of endemism, edaphological characteristics are crucial. Indeed, edaphic endemics, or plant species that are unique to an area, are frequently found in edaphically harsh conditions (Raven, 1964; Bedair, 2020; Bedair et al., 2020). For instance, several authors (Gervais & Shapiro, 1999) stated that there are about five endemic or ecologically limited butterflies, most of which are connected to serpentine soils. The edaphic constraint of their host plants severely restricts some species. These provide stronger justification for preserving biodiversity.

Calcium carbonate is a key indicator of Mediterranean endemics distribution in Egypt (Shaltout & Bedair, 2022, 2023). In the present study, soils of Mareotis and Deltaic Mediterranean endemic taxa are represented by high gradients of calcium carbonate (Bedair et al., 2023d). These findings agreed to Al-Sodany (1992), Zahran et al. (2013) and El-Khalafy (2023). A significant portion of the North Coastal region of Africa is covered in calcareous soils. Derivation from calcareous parent rocks may be to blame for this. In Egypt, the calcareous soils constitute 3 million acres in the Northwestern Coastal zone (about 25-30% of the total area) according to Ministry of Agriculture estimation (Taalab et al., 2019). In contrast, soils of the Sinaitic Mediterranean region (especially Bir El-Abd transect) are characterized by very low total calcium carbonate content. It is mostly of secondary origin, mainly attributed to the weathering of parent material which composes these soils (Hassan, 2002; Shaltout et al., 2023). Furthermore, the soil salinity in the Sinaitic Mediterranean soils is classified between non-saline and moderately saline in the surface and profile samples. These soil solutions contain chlorides and sulphates, which are the cause of the salinization. These soils' sand deposit parent materials may be the cause of the low electrical conductivity values (salinity status). The low concentration of cations and anions in the soil extract from the Sinaitic Mediterranean soils may be reflected by the status of the parent material (sand deposits) transported by wind action. Spectacularly, soils of the Deltaic Mediterranean are characterized by the highest values of the EC. This is due to the black sand from the Nile River that builds up on beaches as sediments or sand dunes because of the Nile water's collision with the Mediterranean Sea and is rich in minerals. Further, the sand dune habitat is affected by the leached salts from the salt marshes located to the south, and the waterways crossing the sand dunes leading to the salinization of the soil. Salt sprays have a paramount effect on this habitat. It lies on the leeward side, where there is a chance for the precipitation of salty droplets due to the decrease in wind velocity (Batanouny, 1999).

The water-holding capacity of the soil, the rate of infiltration, the amount of moisture available to plants, and ultimately plant nutrition are all factors that the soil texture may have an impact on (Eltaher et al., 2019). The highly significant correlation between Mediterranean endemics and the sand fraction and low organic matter agreed with studies of Waisel (1972), Ayyad & El-Ghareeb (1982), and Zahran et al. (2013). This is due to most of these species being restricted to Mediterranean sand dunes near the seashore. The high values of organic matter content in El-Arish and Lake Mariut compared to other Mediterranean transects may be due to residues of plant roots from natural vegetation or crops, while low values in soils of the rest transects may be due to virgin soils and climate effect (arid conditions). In the meantime, Zuo et al. (2008) elucidated that the amount of soil organic matter and total nitrogen were lower in the grazed sand dunes.

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Authors' contributions: Heba Bedair contributed to data collection, analysis, interpretation and wrote the original draft. Kamal Shaltout, Yassin Al-Sodany and Marwa Halmy contributed to research conceptualization and revised the final draft.

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References

Abdelaal, M., Ahmed, D., Fois, M., Fenu, G., Bacchetta, G. (2019) Floristic patterns and ecological drivers of sand dune ecosystem along the Mediterranean coast of Egypt. *Arid Land Research and Management*, **33**(4), 388-411.

Ahmed, D. (2009) Current situation of the flora and vegetation of the Western Mediterranean Desert of Egypt. *Ph.D. Dissertation*. Botany Department, Faculty of Science, Tanta University, Tanta, Egypt. 424p.

Ahmed, D.A., Fawzy, M., Saeed, N.M., Awad, M.A. (2015a) Effect of the recent land use on the plant diversity and community structure of Omayed Biosphere Reserve, Egypt. *Global Ecology and Conservation*, **4**, 26-37.

Ahmed, D., Shaltout, K., Hosni, H., El-Fahar, R. (2015b) Flora and vegetation of the different habitats of the western Mediterranean region of Egypt. *Taeckholmia*, **35**(1), 45-76.

Al-Sodany, Y. (1992) Vegetation analysis of the northern part of Nile Delta region. *M. Sc. Dissertation*. Tanta University, Tanta, Egypt.

Al-Sodany, Y. (1998) Vegetation analysis of the canals drains and lakes of the northern part of Nile Delta. *Ph.D. Dissertation.* Botany Department, Faculty of Science, Tanta University, Tanta, Egypt.

Ammar, M. (1970) An analytical study of the effect of microenvironmental variations on the distribution of vegetation of rocky ridges at Burg El-Arab. *M. Sc. Dissertation.* Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Ayyad, M.A., El-Ghareeb, R. (1982) Salt marsh vegetation of the westernMediterranean desert of Egypt. *Journal of Vegetation*, **49**, 3-19.

Bárcenas-Argüello, M.L., del Carmen Gutiérrez-Castorena, M., Terrazas, T. (2013) The role of soil properties in plant endemism–A revision of conservation strategies. In: "*Soil Processes and Current Trends in Quality Assessment*", pp. 381-398, 1st ed., Intech. DOI:10.5772/53056

Batanouny, K.H. (1999) The Mediterranean coastal dunes in Egypt: An endangered landscape. *Estuarine, Coastal and Shelf Science*, **49**, 3-9.

Bedair, H. (2020) Composition and pattern of wild trees and shrubs in the Egyptian flora, *M. Sc. Thesis.* Botany Department, Faculty of Science, Tanta University, Tanta, Egypt.

Bedair, H. (2023) Assessing the impact of anthropogenic activities on the Mediterranean endemic species in Egypt. *Ph.D. Thesis*, Botany Department, Faculty of Science, Tanta University, Egypt.

Bedair, H., Shaltout, K., Ahmed, D., Sharaf El-Din, A., El-Fahhar, R. (2020) Characterization of the wild trees and shrubs in the Egyptian Flora. *Egyptian Journal of Botany,* **60**(1), 147-168.

Bedair, H., Shaltout, K.H., El-Din, A.S., El-Fahhar, R., Halmy, M.W. (2022) Characterization of Mediterranean endemics in the Egyptian flora. *Anales del Jardín Botánico de Madrid,* **79**(2), e130

Bedair, H., Alghariani, M.S., Omar, E., Anibaba, Q.A., Remon, M., Bornman, C., et al. (2023a) Global warming status in the African continent: Sources, challenges, policies, and future direction. *International Journal of Environmental Research*, **17**(3), 45. doi: https://doi.org/10.1007/s41742-023-00534-w

Bedair, H., Anibaba, Q.A., Ghosh, S., Rady, H.A., Omar, E., Remon, M., Alghariani, M.S. (2023b) Funding African-led climate initiatives. *Nature Climate Change,* **13**, 493–494.

Bedair, H., Shaltout, K., Halmy, M.W.A. (2023c) A critical inventory of the mediterranean endemics in the egyptian flora. *Biodiversity and Conservation*, **32**(4), 1327-1351.

Bedair, H., Shaltout, K., Halmy, M.W.A. (2023d) Stacked machine learning models for predicting species richness and endemism for Mediterranean endemic plants in the Mareotis subsector in Egypt. *Plant Ecology*. DOI : 10.1007/s11258-023-01366-6.

Bidak, L. M., Heneidy, S.Z., Shaltout, K.H., Al-Sodany, Y. (2013) Current status of the wild medicinal plants in the Western Mediterranean coastal region, Egypt. The *Journal of Ethnobiology and Traditional Medicine*, **120**, 566-584.

Danin, A., Shmida, A., Liston, A. (1985) "*Contributions to the Flora of Sinai*", III. Checklist of the species collected and recorded by the Jerusalem team 1967-1982. *Willdenowia*, pp. 255-322.

Di Biase, L., Pace, L., Mantoni, C., Fattorini, S. (2021) Variations in Plant Richness, Biogeographical Composition, and Life Forms along an Elevational Gradient in a Mediterranean Mountain. *Plants*, **10**(10), 2090-3010.

El-Amier, Y.A. (2016) Vegetation structure and soil characteristics of five common geophytes in desert of Egypt. *Egyptian Journal of Basic and Applied Sciences*, **3**(2), 172-186.

El-Amier, Y.A., Abd El-Gawad, A.M. (2017) Plant communities along the international coastal highway of Nile Delta, *Egypt. Journal of Scientific Agriculture*, **1**, 117-131.

El-Khalafy, M. (2023) Biodiversity characteristics of endemic taxa in Egyptian flora. *Ph.D. Dissertation*. Botany Department, Faculty of Science, Tanta University, Tanta, Egypt. pp. 482.

Eltaher, G.T., Ahmed, D.A., El-Beheiry, M., El-Din, A.S. (2019) Biomass estimation and heavy metal accumulation by *Pluchea dioscoridis* (L.) DC. in the Middle Nile Delta, (Egypt): Perspectives for phytoremediation. *South African Journal of Botany*, **127**, 153-166.

El-Zanaty, R.I.A., Abdel-Hafez, A.A., Abdel-Gawad, K.I., El-Morsy, M.H.M., Abusaief, H.M.A. (2010) Effect of location and growth season on the productivity and quality of some range plants in Wadi Halazien in the Northwestern Coast in Egypt. *Nature and Science*, **8**(7), 50 -70.

Fois, M., Farris, E., Calvia, G., Campus, G., Fenu, G., Porceddu, M., Bacchetta, G. (2022) The endemic vascular flora of Sardinia: A dynamic checklist with an overview of biogeography and conservation status. *Plants*, **11**(5), 601-619.

Gauch, Jr. H.G., Whittaker, R.H. (1981) Hierarchical classification of community data. *The Journal of Ecology,* **69**, 537-557.

Gervais, B.R., Shapiro, A.M. (1999) Distribution of edaphic-endemic butterflies in the Sierra Nevada of California. *Global Ecology and Biogeography*, **8**(2), 151-162.

Gibali, M. (1988) Studies on the flora of northern Sinai. *M. Sc. Dissertation*. Botany Department, Faculty of Science, Cairo University, Cairo, Egypt.

Good, R. (1974) "*The Geography of Flowering Plants*", 4th ed. Longman, London, 452p.

Guo, Y., Gong, P., Amundson, R. (2003) Pedodiversity in the United States of America. *Geoderma*, **117**(1-2), 99-115.

Hammouda, S. (1988) A study of vegetation and land-use in the western Mediterranean desert of Egypt. *Ph.D. Dissertation*. Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Hassan, M.A. (2002) Environmental studies on coastal zone soils of the north Sinai Peninsula (Egypt) using remote sensing techniques. *Ph.D. Dissertation*, Zugl.: Braunschweig, Univ., Diss., 2002).

Heneidak, S. (2008) Plant diversity, economic and ecological uses of plants from El-Qantra Sharq to Rafah, northern Sinai. *Taeckholmia*, **28**, 131-168.

Heywood, V. (2002) The future of floristics in the Mediterranean region. Israel *Journal of Plant Sciences*, **50**(Sup1.), 5–13.

Hilmy, S. (1971) An ecological study on *Asphodelus microcarpus* Viv. *M. Sc. Dissertation*. Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Kamal, S.A., El-Kady, H.F. (1993) Vegetation analysis of some wadis in the Egyptian Mediterranean desert with 2 figures and 3 tables. *Feddes Repertorium*, **104**(7-8), 537-545.

Kamel, W., Zaghloul, M., El-Wahab, A., Moustafa, A.R. (2008) Current status of the flora of North Sinai: Losses and Gains. Catrina: *The International Journal of Environmental Sciences*, **3**(1), 11-26.

Lopez-Alvarado, J., Farris, E. (2022) Ecology and Evolution of Plants in the Mediterranean Basin: Perspectives and Challenges. *Plants,* **11**(12), 1584 -1586.

Mahmoud, R. (1975) A study of the vegetational complex of saline and marshy habitats on the northwestern coast of Egypt. *Ph.D. Dissertation.* Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Médail, F. (2022) Plant biogeography and vegetation patterns of the Mediterranean islands. *The Botanical Review*, **88**(1), 63–129.

Migahid, A.M., Batanouny, K.H., Zaki, M.A.F. (1971) Phytosociological and ecological study of a sector in the Mediterranean coastal region in Egypt. *Vegetatio*, **23**, 113-134.

Migahid, M. (1983) Vegetation and environmental variations along transects through coastal and inland ecosystems of the western Mediterranean desert of Egypt. *M. Sc. Dissertation*. Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Myers, N., Mittermeier, R., Mittermeier, C., Da Fonseca, G., Kent, J. (2000) Biodiversity hotspots for conservation priorities. *Nature*, **403**(6772), 853–858.

Osman, A. K., El Garf, I. A., Nasr, H. (2015) Studies on the shallow wadies of the Mareotis sector of the Mediterranean coastal land of Egypt: Floristic features of Wadi Hashem. *Flora Mediterranea*, **25**, 57-71.

Raven, P.H. (1964) Catastrophic selection and edaphic endemism. *Evolution*, **18**(2), 336-338.

Razik, M. (1976) A study on the vegetation composition, productivity and phenology in a Mediterranean desert ecosystem at Omayed, Egypt. *M. Sc. Dissertation*. Botany Department, Faculty of Science, Alexandria University, Alexandria, Egypt.

Shaltout, K.H. (1983) An ecological study of *Thymelaea hirsuta* (L.) Endl. in Egypt. *Ph. D. Thesis*, Tanta Univ., Tanta. 165 pp.

Shaltout, K.H., Al-Sodany, Y.M. (2000) Flora and vegetation of Lake Burullus area. Mediterranean West Coast Project, Egyptian Environmental Affairs Agency, Cairo, Egypt.

Shaltout, K.H., Al-Sodany, Y.M. (2002) Phytoecology of Omayed Site. Mediterranean West Coast Project, Egyptian Environmental Affairs Agency, Cairo, Egypt.

Shaltout, K.H., Galal, T.M. (2006) Comparative study on the plant diversity of the Egyptian northern lakes. *Egyptian Journal of Aquatic Research,* **32**(2), 254-270.

Shaltout, K., Bedair, H. (2022) Diversity, distribution and regional conservation status of the Egyptian tree flora. *African Journal of Ecology*, **60**, 1155-1183.

Shaltout, K., Bedair, H. (2023) Perennial shrubs in Egypt: Current status and updated red data list. *Phytotaxa*, **585**(3), 167-192.

Shaltout, K.H., Hassan, L.M., Galal, T.M. (2005) Habitat and vegetation of lake Mariut, Egypt. *Assiut University Journal of Botany*, **34**(2), 309-337.

Shaltout, K., Sharaf El-Din, A., Ahmed, D. (2010) "*Plant Life in the Nile Delta*". Tanta University Press, 232p.

Shaltout, K., El-Din, A., El-Fahar, R., Beshara, H. (2018) Associated species and threats upon Lycium schweinfurthii var. schweinfurthii in the Deltaic Mediterranean coast, Egypt. *Taeckholmia*, **38**(1), 107-122.

Shaltout, K., Bedair, H., El-Khalafy, M.M., Keshta, A., Halmy, M.W. (2023) The link of socioeconomic importance to the conservation status of the Mediterranean endemic plants in Egypt. *Nusantara Bioscience*, **15**(2), 189-211.

Taalab, A.S., Ageeb, G.W., Siam, H.S., Mahmoud, S.A. (2019) Some characteristics of calcareous soils. A review. *Middle East Journal,* **8**(1), 96-105.

Thompson, J. (2020) "*Plant Evolution in the Mediterranean: Insights for Conservation*". Oxford University Press, USA.

Turki, Z.A., El Shayeb, F.M. (2005) Floristic and ecological studies of the Western Mediterranean coastal land in Egypt,(Wadi Um Rakham). *Flora Mediterraea*, **15**, 331-341.

UNEP (2022) United Nations Environment Program. Website: https://www.unep.org/unepmap/resources/factsheets/climate–change [Accessed 29 December 2022].

Vargas, P. (2020) The Mediterranean floristic region: high diversity of plants and vegetation types .In: "Encyclopedia of the World's Biomes", Goldstein M.I. & DellaSala D.A. (Eds.), Vol. 3, pp. 602–616. Elsevier, Ashland.

Waisel, Y. (1972) "*Biology of Halophytes*". Academic Press. New York and London; 395p.

Zahran, M. (2010) Afro–Asian Mediterranean coastal lands. In: "Climate–Vegetation", Gilbert F (Ed.), pp. 1–103. Springer, Dordrecht.

Zahran, M.A., Ahmed, A.M., Abd El-Gawad, A.M., Shawky, R.A. (2013) Vegetation-soil relationship in Sidi Abd El-Rahman Sector, Western Mediterranean Coast, Egypt. *Egyptian Journal of Botany*, **53**(2), 385- 398.

Zahran, M., El-Demerdash, M., Mashaly, I. (1985) On the ecology of the Deltaic coast of the Mediterranean Sea, Egypt. General survey. *Proceeding of Fourth Egyptian Botanical Society*, **4**, 1392–1407.

Zuo, X., Zhao, H., Zhao, X., Zhang, T., Guo, Y., Wang, S., Drake, S. (2008) Spatial pattern and heterogeneity of soil properties in sand dunes under grazing and restoration in Horqin Sandy Land, Northern China. *Soil and Tillage Research*, **99**(2), 202-212.

دراسة المجتمعات النباتية المصاحبة للنباتات مقتصرة التوزيع في منطقة البحر الأبيض المتوسط بمصر

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تعد منطقة حوض البحر الأبيض المتوسط ثاني أغنى نقطة ساخنة في العالم من حيث التنوع النباتي وواحدة من أهم المواقع على هذا الكوكب للأنواع مقتصرة التوزيع. تهدف هذه الدراسة إلى وصف المجتمعات النباتية المصاحبة للنباتات مقتصرة التوزيع في منطقة البحر الأبيض المتوسط بمصر وتوفير معلومات عن توزيعها ومتغيرات التربة المؤثرة على توزيعها. حيث قمنا ببناء قاعدة بيانات شاملة باستخدام جميع البيانات المتاحة بوحدة بحوث البيئة بكلية العلوم جامعة طنطا. أدى تطبيق التحليل الدليلي ثنائي الإتجاه على وفرة 39 نوعًا مستوطنًا في البحر المتوسط و 861 نوعًا مرتبطًا بها في 216 موقعًا إلى التعرف على 5 مجموعات نباتية في المستوى الثالث من التصنيف على النحو التالي: I: السِعد، II: الكحلة، III: عاقول الجبل، IV: الرطريط، و V:الزيتا. علاوة على ذلك، تم تحديد البيانات الوصفية لقوام التربة، ودرجة الحموضة، والتوصيل الكهربائي، والمواد العضوية، وكربونات الكالسيوم، والكاتيونات الذائبة (الكالسيوم والصوديوم والبوتاسيوم) لأنواع مختلفة من التربة موزعة على طول قطاعات مريوط والدلتا وسيناء. أظهرت قيم الأس الهيدروجيني أن معظم الترب قلوية وغير مالحة. كانت غالبية الترب في منطقة الدراسة ذات قوام رملي إلى طيني. تتميز عينات التربة بمحتوى منخفض جدًا من المواد العضوية ومحتوى عالٍ من كربونات الكالسيوم. تشكل دراستنا أساسًا هامًا لصناع القرار في مجال الحفاظ على الطبيعة، وقضايا التغير المناخي، والمزيد من الدراسات المتعمقة حول النباتات مقتصرة التوزيع في منطقة البحر الأبيض المتوسط.