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Characterization of Mediterranean endemics in the Egyptian flora

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Abstract. The Mediterranean Basin is the world's second richest hotspot, and one of the most important locations on the planet for endemic taxa. However, there is no available up-to-date list of Mediterranean endemics. Available data are frequently insufficient or outdated. Therefore, this study aimed at delimiting the Mediterranean floristic region in Egypt, screening its Mediterranean endemics, and determining their habitats, life forms, flowering periods, dispersal types and phyto-geographical distribution. From a list of 275 Mediterranean endemic taxa in Egypt compiled from literature, this study reduced it to 57 taxa (including species, subspecies and varieties; 20.7%) belonging to 46 genera and 22 families. Fifteen major habitats harbored Mediterranean endemics in Egypt, with coastal dunes (17 taxa = 29.8%) and non-saline depressions (16 taxa = 28.1%) being the most represented. Moreover, the Mareotis (west) subsector was the richest (46 taxa = 80.7%). The largest number of taxa was recorded in North African sub-region (52 taxa = 91.2%), followed by Eastern (levant) sub-region (36 taxa = 63.2%). Therophytes were the most recorded life form, while ballochory was the most represented dispersal type. In conclusion, it is crucial to shed the light on Mediterranean endemics and provide an up-to-date documented database to help future management plan that support their conservation and sustainable use.

Keywords. Conservation planning, distribution, endemism, floristic regions, Mediterranean basin.

Resumen. La cuenca Mediterránea es el segundo hotspot más rico del mundo y uno de los lugares más importantes del planeta en taxones endémicos. Sin embargo, no existe una lista actualizada de taxones endémicos mediterráneos. Los datos disponibles son frecuentemente insuficientes o están desactualizados. Por tanto, nuestro objetivo fue delimitar la región florística mediterránea en Egipto, seleccionar sus plantas endémicas mediterráneas y determinar sus hábitats, formas de vida, periodos de floración, tipos de dispersión y distribución fitogeográfica. Partiendo de una lista preliminar de 275 taxones endémicos del Mediterráneo presentes en Egipto recopilada de la bibliografía, este estudio redujo ese número a 57 taxones (incluyendo especies, subespecies y variedades; 20.7%) pertenecientes a 46 géneros y 22 familias. Las plantas endémicas mediterráneas de Egipto viven en quince hábitats principales, siendo los más representativos las dunas costeras (17 taxones = 29.8%) y las depresiones no salinas (16 taxones = 28.1%). El subsector Mareotis (al oeste) fue el más rico (46 taxones = 80.7%), mientras que el mayor número de taxones se registró en la subregión del norte de África (52 taxones = 91.2%), seguida de la subregión del este (levante) (36 taxones = 63.2%). Los terófitos fueron la forma vital más registrada y la balocoria el tipo de dispersión más común. En conclusión, es crucial arrojar luz sobre las plantas endémicas del Mediterráneo y proporcionar una base de datos documentada y actualizada que ayude a planificar una gestión futura que promueva su conservación y uso sostenible.

Palabras clave. Cuenca mediterránea, distribución, endemismos, planificación de la conservación, regiones florísticas.

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INTRODUCTION

Myers (1990) has recognized the Mediterranean basin as one of the richest biodiversity hotspots in the world. In fact, it is currently considered the world's second largest Biodiversity Hotspot (IUCN 2022). Geographically, it extends over more than 30 nations and encompasses important terrestrial habitats including coastal dunes, temperate forests, garrigue, maquis, grasslands, wetlands, and semi-desert zones. Its position at the crossroads between Africa, Asia and Europe has contributed to the diversity of ecosystems in the Mediterranean basin spanning arid, temperate and tropical biogeographical regions, distinguishing the basin from the more homogeneous areas to the north and south (Blondel & Aronson 1999; Zahran 2010). Consequently, the edaphic, climatic and topographical intricacy of the Mediterranean basin makes it exceptionally rich in biodiversity. It has been reported to include more than

25,000 species of flowering plants (Lihová & al. 2004; Zahran 2010; Vargas 2020).

Endemism is an integral component of plant diversity in the Mediterranean region. According to the Med-Checklist (2016), about 63.5% of the recorded native species are endemic to the region (Greuter 1991; Heywood 2002). A main feature of endemism in the Mediterranean basin is that 60% of the endemic species are narrow endemics, i.e., they have a restricted distribution to one particular area well-defined within a small part of the basin (Thompson & al. 2005). Many of them are restricted to a single or a few localities in sandy areas, isolated mountain ranges, or islands of unusual soil or rocky ground, therefore the Mediterranean flora is brimming with narrow endemic taxa compared to other regions (Blondel & al. 2010; Zahran 2010).

Generally, islands (Whittaker & Fernández-Palacios 2007; Kier & al. 2009) and coastal ecosystems are richer in plant endemism than inland areas (Abdelaal & al. 2020). A characteristic feature of this region is the spatial isolation, where there are several islands, peninsulas, and high mountains (Vargas 2020). Over 10,000 islands (and islets) are distributed across the Mediterranean Basin. Good examples are Sicily and Sardinia, which are the largest islands in the region, followed by Cyprus, Crete, Aegean Islands, Corsica, and Balearic Islands. Altitudinal taxa isolation is also remarkable. Hence, plate collisions between the three main peninsulas (Iberian, Italian, and Balkan) and the European plate in the Tertiary period resulted in mountains rising to around 2000 m elevation over southern Europe (Heywood 2002; Vargas 2020). In addition, the region encompasses the Atlas, the largest mountain range in north Africa, which was uplifted in the Miocene as a result of orogenic movements (Babault & al. 2008). Further, with the exception of land proximity on the straits of Gibraltar and Tunisia-Sicily, the Mediterranean Sea's east-west orientation itself has been a substantial geographical barrier for plant dispersal between north Africa and Europe (Rodríguez-Sánchez & Arroyo 2011; Vargas 2020). Consequently, most narrow endemics are found in southern Europe and north Africa either on islands or medium-high mountains (Vargas 2020). Most parts of the Mediterranean basin have a high-level of rare and endemic taxa with small populations, the majority of which are endangered by many threats including fire, land use changes, habitat conversion and degradation (Cowling & al. 1996; Rundel & al. 2018). In fact, climatic instability and long-term change may also play roles in generating endemism, both by creating novel ecological opportunities for speciation and by producing shifting patterns of habitat fragmentation that are conducive to allopatric speciation, followed in some cases by secondary contact and hybridization (Harrison & Noss 2017 and references therein).

The borderlines of the Mediterranean coastal strip in Egypt were modified by Boulos (1999-2005) to be stretched from the border with Libya, near Sallum, to Port Said. However, to the authors' best knowledge, very few publications are available in the literature addressing the presence of a Mediterranean territory from Rosetta to Rafah. The last two decades witnessed intensive studies in the west Mediterranean coastal land, to cope with the devastation associated with the urbanization in this coastal strip (e.g., Halmy 2012; Halmy & al. 2015a, 2015b; Halmy & Gessler 2015; Halmy 2019; Halmy & al. 2019). It is unfortunate to report that Egypt had already lost over one hundred kilometers of its Mediterranean territory due to climate change, and human activities, especially the establishment of tourist summer resorts. As a result, it is now difficult to find any traces of the natural vegetation reported earlier in this region (El-Hadidi & Hosni 2000; Halmy 2012; Halmy & al. 2015a, 2015b; Halmy 2019; Halmy & al. 2019).

Djamali & al. (2012) indicated that Egypt is not part of the Mediterranean climate nor of the Mediterranean biogeographic region, due to the lack of any native arboreal Mediterranean taxa in Egypt. However, Wickens (1977) argued for the possibility of the presence of steppe maquis vegetation of the Ceratonia-Pistacion lentisci alliance (described by Zohary 1973) along the Egyptian Mediterranean coast, which is considered an evidence of the presence of a Mediterranean territory in Egypt. Moreover, Egypt is so close to floristically Mediterranean rich areas both to the west (Cyrenaic) and to the east, which could be an interesting place to study the interaction among the Mediterranean, the Tropical and the Saharo-Sindic floristic contingents. Therefore, it would play an interesting role as a melting pot among three (if not four if we consider also the Turanic contingent) floristic regions. The currently available data provide enough evidence for extending the Mediterranean territory in Egypt from Sallum, on the Egyptian-Libyan border, to Rafah, on the Egyptian-Palestinian border, as was elucidated by Zahran & al. (1985).

Egypt has a long history in vegetation research, dating back to 1930s. Several regional studies on vegetation communities and floristic composition have been conducted. However, a compiled complete classification overview and a vegetation map of the Mediterranean region are still lacking. Consequently, this study aims to provide an authenticated database of the Mediterranean endemic plants of Egypt, analyze the checklist in terms of floristic diversity, geographical distribution, life forms, growth forms, flowering times and dispersal types.

MATERIAL AND METHODS

Dataset and study area delimitation

The biogeographical regionalization of the study area was defined within Geographical Information Systems

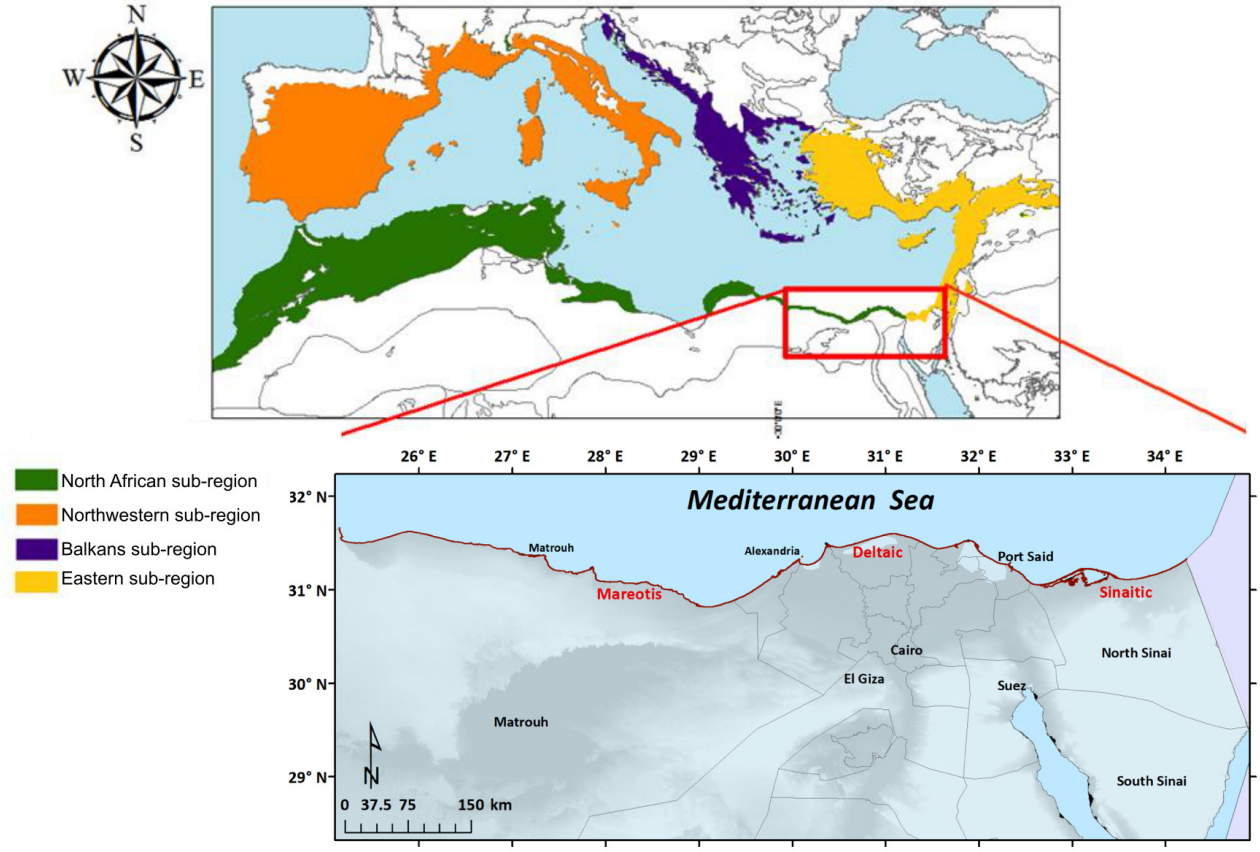

Fig. 1. Map of the study area indicating the Mediterranean floristic region delimitation and the sub-divisions of the Mediterranean region in Egypt.

(GIS) framework using ArcMap 10.1 software (ESRI 2012), where a vector file of the biogeographical regionalization of the study area was created by converting the already published map by Good (1974) into a polygon vector shapefile to enhance the quality of future analyses. The process was performed in 3 steps: 1) the original map of Good (1974) was scanned and converted into TIFF format, then it was georeferenced using a previously georeferenced shapefile; 2) polygons defining the boundaries and the geographic locations of the sub-regions across the study area were created; and 3) attributes and information related to each of the defined provinces were added and linked to the shapefile (Fig. 1).

Delimitation of the Mediterranean region in this study was mainly assessed according to the system of Good (1974). It is necessary to keep in mind that regions are separated from each other not by lines, but by belts inhabited by taxa belonging to the contiguous regions. According to Vargas (2020), there is principally a consensus for recognizing five vegetation belts in the Mediterranean region: (1) thermo-Mediterranean vegetation belt (coastal scrub: maquis/garrigue/phrygana) and conifer-oak woodlands on inland hills; (2) meso-Mediterranean (sclerophyll woodland on plains and piedmont); (3) supra-Mediterranean (oak and pine woodlands up to the altitudinal timberline); (4) oro-Mediterranean (high-altitude bush communities); and (5) cryoro-Mediterranean (alpine communities of herbs). In fact, only the thermo-Mediterranean vegetation belt is present in Egypt.

The chorionomic boundary of the Mediterranean region coincides with the boundary of the typical Mediterranean forests of *Quercus ilex* L. and the primary area of *Olea europaea* L. subsp. *europaea* cultivation. The Mediterranean region can be subdivided into: North-western sub-region, North African sub-region, Eastern sub-region (levant) and Balkans sub-region (Fig. 1).

Regarding Egypt, the Mediterranean territory extends for about 970 km from Sallum, on the Egyptian-Libyan border, to Rafah, on the Egyptian-Palestinian border, with an average width 15–20 km in north-south direction and a limited area of ca. 16,500 km^2. The Mediterranean phytogeographical region was divided into three main sub-sectors: 1) western *a.k.a.* the Mareotis, with mean annual rainfall between 220–150 mm and stretching for 550 km between Sallum and Alexandria; 2) middle *a.k.a.* Deltaic, stretching for 180 km between Alexandria and Port Said,

with width of about 12 km; and 3) east *a.k.a.* Sinaitic, with an annual rainfall between 150–100 mm and extending for 220 km between Port Said and Rafah (Zahran & al. 1985; Zahran & Willis 2008).

List justification

A preliminary list of Mediterranean endemics in Egypt was prepared based on Täckholm (1974), Greuter & al. (1984– 1989), Boulos (1999– 2005), Greuter & von Raab-Straube (2008), Ahmed (2009), Shaltout & al. (2010), and El-Khalafy (2018).

Authentication of the taxa was assessed depending on floras of countries of Mediterranean basin such as Quézel & Santa (1962–1963), Tutin & al. (1964–1980), Davis (1965–1985), Zohary (1966, 1987), Mouterde (1966–1984), Beck-Mannagetta (1967– 1983), Franco (1971–1983), Zangheri (1976), Haslam & al. (1977), Feinbrun-Dothan (1978, 1986), Jafri & El-Gadi (1977–1988), Duvigneaud (1979), Pottier-Alapetite (1979–1981), Meikle (1977–1985), Guinochet & Vilmorin (1973–1984), Smythies (1984–1986), Castroviejo & al. (1986–2021), Davis & al. (1988), and Güner & al. (2000).

The following databases were also consulted to check the recorded plants: Hassler (2004–2022), Flowers in Israel (2005–2022), Euro+Med (2006), Danin & Fragman-Sapir (2016), Med-Checklist (2016), Dimopoulos & al. (2020), eflora Maghreb (2021), African Plant Database (2022), Chikhali (2022), EPPO (2022), Flora of Cyprus (2022), Flora of Libya (2022), Flora of Turkey (2022), GBIF (2022), JSTOR (2022), POWO (2022), VicFlora (2022), and WCSP (2022). Data were also collected from field visits and collection research including the following herbaria: Real Jardín Botánico, Madrid (MA), Tanta University (TANE), Alexandria University (ALEX), Cairo University (CAI), Assiut University (ASTU), Agricultural Research Center (CAIM), Desert Research Center (CAIH), National Research Centre (CAIRC), and National Registry for Egyptian Herbaria (2022). Information was also compiled from available literature (papers, books, M.Sc. and Ph.D. theses, and scientific reports).

The recorded taxa were arranged alphabetically according to Angiosperm Phylogeny Group system (APG IV: Byng & al. 2016). The accepted names followed International Plant Names Index (IPNI 2022), World Flora Online (WFO 2022), World Checklist of Selected Plant Families (WCSP 2022), and Plants of the World Online (POWO 2022).

Species traits

General characteristics of the recorded plants such as habitats, geographical distribution, growth and life forms, sex forms, flowering period and dispersal types were determined from the following publications: Täckholm & Drar (1950–1969), Zohary (1966, 1987), Täckholm (1974), Jafri & El-Gadi (1977–1988), Feinbrun-Dothan (1978, 1986), Boulos (1999–2005, 2009), El-Hadidi & Hosni (2000), Seif El-Nasr & Bidak (2006a, 2006b), Ahmed (2009), Shaltout & al. (2010), El-Khalafy (2018), Bedair (2020), Mushtaq & al. (2020), Bedair & al. (2020), Ghosh & al. (2021), Bedair & al. (2022 a & b), Ghosh & al. (2022), Abdelsalam & al. (2022) and Shaltout & Bedair (2022). The dispersal type of the collected diaspores of many of the recorded taxa was assessed according to Dansereau & Lems (1957) (Table 1). The main assigned sex forms were bisexual (i.e. hermaphrodite) having both male and female sex organs in the flower, or unisexual, either monoecious (each plant has both male and female flowers) or dioecious (the male and female blossoms appear on separate plants), and polygamous.

Life forms follow the system of Raunkiaer (1937). This system which is designed for the northern temperate zone and based on the location of renewal buds was coded and identified as follows:

Phanerophytes: plants with permanent buds borne at height > 25 cm. They are subdivided into: mega-phanerophyte (over 30 m); meso-phanerophyte (8–30 m); micro-phanerophyte (2–8 m); and nano-phanerophyte (under 2 m).

Table 1. Scheme of the ten dispersal types of Dansereau & Lems (1957).

Dispersal type	Description
Autochore	Diaspora without obvious adaptations to any external agent.
Barochore	Diaspora characterized mainly by their weight and the lack of any other feature.
Pyrenochore	Diaspora lacks distinctive adaptations, too heavy to be carried by breeze (0.5–0.999 mg).
Microsclerochore	Diaspora lack distinctive adaptations, too heavy to be carried by breeze (0.005–0.449 mg).
Ballochore	Diaspora forcibly ejected from parent plant.
Auxochore	No disarticulating from parent plant before diaspora is deposited at a site of further development.
Heterochore	Diaspora either with appendages or extremely light or provided with fleshy outer layers.
Cyclochore	Diaspora largely consisting of accessory parts, forming a voluminous spherical frame.
Pterochore	Diaspora with scarious wing like or plumose appendages.
Pogonochore	Diaspora with long, hair like or plumose appendages.
Desmochore	Diaspora with short, stiff, spring, glandular or hooked appendages adhering to rough surface.
Sporochore	Diaspore very minute, can be carried by breeze (0.001–0.004 mg).
Sarcochore	Diaspore with soft and fleshy outer layers.

Epiphytes: these plants cling to other plants for support; they are not attached to the soil.

Stem succulents: plants with succulent stems and without proper foliage leaves.

Chamaephytes: plants with permanent buds borne above the soil surface till a height < 25 cm. This group is subdivided into active chamaephytes (with shoots diageotropic and persistent throughout their whole length); passive chamaephytes (with weak stems which lie on the ground); suffruticose chamaephytes (the perennating parts remain on the surface of the ground after the herbaceous parts have died away oil the approach of the critical season); and cushion plants (a reduced form of active chamaephytes).

Hemicryptophytes: plants with permanent buds borne close to soil surface. This category is further divided into protohemicryptophytes (with only stem leaves); partial rosette plants (with both stem and basal rosette leaves); and rosette plants (with only basal rosette leaves).

Cryptophytes: with permanent buds borne under soil surface in case of geophytes, in the mud overlain by water in case of helophytes or in the water in case of hydrophytes.

Therophytes: plants complete their life-cycle within a single favourable season.

Parasites: these plants live on or in the host which provides them with nutriment.

Phytogeographical sectors in this study were assigned according to Zahran & al. (1985). Besides, the global distribution of the recorded taxa (i.e. floristic regions) was assigned following the system of Good (1974), which divided the globe into six kingdoms, three subkingdoms and thirty nine floristic regions. Distribution of the recorded taxa in countries of Mediterranean was also checked in some databases such as Hassler (2004–2022), Euro+Med (2006), Med-Checklist (2016), Flora of Libya (2022), POWO (2022), WCSP (2022), GBIF (2022), and JSTOR (2022).

Rarity forms of the recorded taxa were assessed depending on the national geographical range, habitat specificity and local abundance according to Rabinowitz (1981). The eight rarity forms are coded and explained in Table 2.

RESULTS

List justification

A preliminary list of 275 Mediterranean endemic taxa in Egypt was prepared. Boulos (1999–2005) recorded 275 Mediterranean endemic taxa in the Egyptian flora. Of these, 106 (38.5%) Mediterranean endemics were recorded in the western Mediterranean region of Egypt by Ahmed (2009). Indeed, the present study has reduced this number to be 57 (20.7%) Mediterranean endemic taxa in Egypt (Appendices 1 and 2). Taxonomic authorities are ommitted from the names of taxa mentioned in the text below; they are included in the taxon lists of Appendices 1 and 2.

Taxonomic diversity

There were 57 Mediterranean endemic taxa, including species, subspecies and varieties, recorded in this study belonging to 46 genera and 22 families. The most represented genera were *Allium* and *Fumaria* (4 taxa each); *Bellevalia* (3 taxa); *Muscari*, *Centaurea* and *Limonium* (2 taxa each). Gymnosperms were not represented by any taxon, while angiosperms were represented by 2 clades (Table 3).

Four monocot families were recorded (Amaryllidaceae, Asparagaceae, Poaceae and Posidoniaceae), with 10 genera and 17 species, while eudicots were the most represented with 18 families. The highly represented families were Asteraceae (10 taxa), Fabaceae and Asparagaceae (8 taxa each), and Amaryllidaceae (5 taxa) (Fig. 2). On the other hand, 12 families were represented by only 1 taxon (Posidoniaceae, Convolvulaceae, Euphorbiaceae,

Table 2. Typology of rare species based on three characteristics: geographical range, habitat specificity (specific habitats vs. several habitats) and local population size according to Rabinowitz (1981) [A: abundant; L: large; N: narrow; Na: non abundant; S: small; W: wide].

Local population size	Geographical range, habitat specificity			
	Wide	Narrow	Wide	Narrow
Large (L), abundant somewhere (A)	Locally abundant over a large range in several habitats (LWA)	Locally abundant over a large range in a specific habitat (LNA)	Locally abundant in several habitats but restricted geographically (SWA)	Locally abundant in a specific habitat but restricted geographically (SNA)
Small (S), non abundant (Na)	Constantly sparse over a large range and in several habitats (LWNa)	Constantly sparse over a large range in a specific habitat (LNNa)	Constantly sparse and geographically restricted in several habitats (SWNa)	Constantly sparse and geographically restricted in a specific habitat (SNNa)

Table 3. Numbers of the major taxonomic groups of the Mediterranean endemics in Egypt.

Clade	Families (F)	Genera (G)	Species (S)	Subspecies (Sub)	Varieties (V)	Sub/S	S/G	G/F
Monocots	4	10	17	0	0	0	1.7	2.5
Eudicots	18	36	40	5	2	0.1	1.1	2
Total	22	46	57	5	2	0.1	2.8	4.5

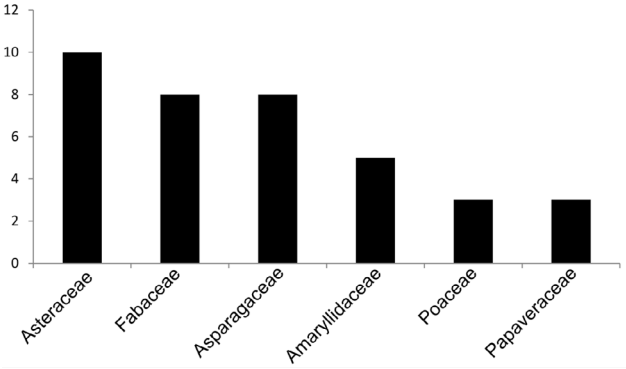

Fig. 2. Families having more than three (> 3) Mediterranean endemic taxa in the Egyptian flora.

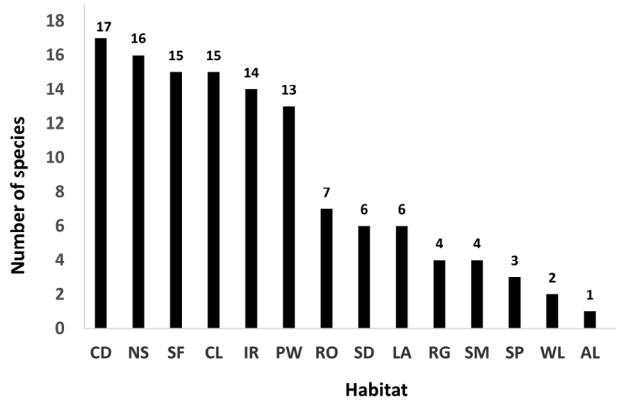

Fig. 3. Number of the Mediterranean endemics in Egypt in relation to their habitat [AL: alluvial soils; CD: coastal dunes; CL: cultivated lands; IR: inland ridges; LA: lake Mariut; NS: non-saline depressions; PW: plains and wadis; RG: rocky ground; RO: roadsides; SD: saline depressions; SF: sand formations; SM: salt marshes; SP: Sallum plateau; WL: waste lands].

Resedaceae, Apiaceae, Caprifoliaceae, Caryophyllaceae, Rubiaceae, Santalaceae, Solanaceae and Scrophulariaceae) (Appendix 1). The diversity of the major taxonomic groups indicated that the eudicots were the most diverse in terms of families, genera, species, subspecies and varieties, whereas monocots were the least. The ratio of genus to family (G/F) had a maximum value in monocots (2.5) and a minimum in eudicots (2). The ratio of species to genus (S/G) had a maximum in monocots (1.7) and a minimum in eudicots (1.1), while the subspecies to species ratio was very low in all the major taxonomic groups (Table 3).

Habitats

Fourteen major habitats harbour the Mediterranean endemics in Egypt: 10 were natural habitats and 4 were anthropogenic habitats. The most represented habitats were the coastal dunes (17 taxa = 29.8%), followed by non-saline depressions (16 taxa = 28.1%), whereas alluvial soils (only one taxon: *Bellevalia warburgii*) and waste lands (2 taxa = 3.5%) were the least represented habitats (Fig. 3).

Geographical distribution

National geographic distribution.—The Mareotis (west) subsector was the richest of the three subsectors with 46 taxa (= 80.7%; e.g. *Allium mareoticum, Muscari albiflorum* and *Scilla peruviana*), followed by the *Sinaitic* (east) subsector with 15 taxa (26.3%; e.g., *Bellevalia warburgii, Coronilla repanda,* and *Vicia sinaica*), whereas, the Deltaic (middle) subsector had the least Mediterranean endemics with only five taxa (8.8%).

Global geographical distribution.—All the recorded taxa belonged to the Mediterranean region in the Boreal kingdom, which is divided into four sub-regions: North African sub-region (52 taxa = 91.2%), Eastern (levant) sub-region (36 taxa = 63.2%), Balkans sub-region (21 taxa = 36.8%) and North-western sub-region (16 taxa = 28.1%). The Mediterranean endemics in Egypt were recorded in 21 Mediterranean basin countries out of 25 (Table 4). The greatest number of taxa was recorded in Libya (29 taxa = 50.9%), followed by Palestine (24 taxa = 42.1%), then Syria and Lebanon (22 taxa each = 38.6%), while the lowest number (one taxon = 1.8%) was reported in San Marino, Slovenia and Bosnia and Herzegovina. On the other hand, no taxa were recorded in Malta, Monaco, and Holy See (Vatican City) (Fig. 4). Interestingly, 47 Mediterranean endemics (82.5%) were recorded in Egypt (excluding Sinai Peninsula that belongs to North African sub-region), and 15 (26.3%) in Sinai Peninsula belonging to Eastern sub-region.

Furthermore, there were 11 steno-endemics recorded only in Egypt (19.3% of the total Mediterranean endemics). They were *Allium mareoticum*, *Anthemis microsperma*, *Bellevalia salah-eidii*, *Echinops taeckholmianus*, *Fumaria microstachys*, *Limonium sinuatum* subsp. *romanum*, *Muscari albiflorum*, *Pancratium arabicum*, *Thesium humile* var. *maritima*, *Muscari salah-eidii* and *Vicia sinaica*. In addition, nine near-endemic taxa were recorded in Egypt and Libya (*Allium barthianum*, *Allium blomfieldianum*,

Table 4. Distribution of Mediterranean endemics in countries/territories of the Mediterranean basin [AG: Algeria; AL: Albania; BK: Bosnia and Herzegovina; CY: Cyprus; EG: Egypt (excluding Sinai); FR: France; GR: Greece; HR: Croatia; IS: Israel; IT: Italy; LE: Lebanon; LY: Libyan Arab Jamahiriya; MJ: Montenegro; MO: Morocco; PO: Portugal; SI: Sinai; SL: Slovenia; SM: San Marino; SP: Spain; SY: Syrian Arab Republic; TS: Tunisia; TU: Turkey].

Taxon	North African					Eastern sub-region (levant)						Balkans sub-region						North-western sub-region					Total
	EG	LY	TS	AG	MO	PL	SY	LE	CY	TU	SI	GR	AL	HR	MJ	BK	SL	IT	FR	SP	PO	SM	
Allium barthianum Asch. & Schweinf.	+	+																					2
Allium blomfieldianum Asch. & Schweinf.	+	+																					2
Allium mareoticum Bornm. & Gauba	+																						1
Allium trifoliatum Cirillo	+					+	+	+	+	+		+						+	+				9
Anchusa undulata subsp. *hybrida* (Ten.) Cout.	+	+	+	+		+	+	+	+	+		+	+					+	+				13
Anthemis microsperma Boiss. & Kotschy	+																						1
Apium crassipes (W.D.J. Koch ex Rchb.) Rchb.f.	+		+	+														+					4
Bellevalia salah-eidii Täckh. & Boulos	+																						1
Bellevalia sessiliflora (Viv.) Kunth	+	+									+												3
Bellevalia warburgii Feinbrun						+	+	+			+												4
Centaurea aegialophila Wagenitz	+	+							+	+		+											5
Centaurea pumilio L.	+	+				+						+											4
Convolvulus humilis Jacq.	+	+	+	+	+	+	+	+	+									+		+	+		12
Coronilla repanda (Poir.) Guss.		+	+	+	+	+			+		+	+						+			+		10
Crepis aculeata Boiss.						+	+	+			+												4
Cynara cornigera Lindl.	+	+							+			+											4
Cynosurus coloratus Lehm. ex Steud.	+	+	+			+	+	+	+			+											8
Desmazeria philistaea (Boiss.) H.Scholz	+	+	+			+	+	+															6
Ebenus armitagei Schweinf. & Taub.	+	+																					2
Echinops taeckholmianus Amin	+																						1
Euphorbia parvula Delile	+	+																					2
Filago mareotica Delile	+	+	+	+					+											+			6
Fumaria gaillardotii Boiss.	+	+	+	+		+	+	+	+	+	+	+	+	+				+		+			15
Fumaria judaica Boiss. subsp. *judaica*	+	+				+	+	+	+			+	+	+				+					10
Fumaria microstachys Kralik ex Hausskn.	+																						1
Sulla spinosissima (L.) B.H.Choi & H.Ohashi	+	+	+	+	+	+	+	+	+	+	+	+						+	+	+			15
Helianthemum crassifolium subsp. *sphaerocalyx* (Gauba & Janch.) Maire	+	+																					2
Helichrysum orientale (L.) Gaertn.	+									+		+											3

Table 4. Cont'd.

Taxon	North African					Eastern sub-region (levant)						Balkans sub-region						North-western sub-region					Total
	EG	LY	TS	AG	MO	PL	SY	LE	CY	TU	SI	GR	AL	HR	MJ	BK	SL	IT	FR	SP	PO	SM	
Heliotropium hirsutissimum Grauer	+	+				+	+	+	+	+		+											8
Herniaria cyrenaica F.Herm.	+	+																					2
Hyoseris radiata subsp. *graeca* Halácsy	+	+		+								+											4
Lathyrus marmoratus Boiss. & Blanche	+					+	+	+		+	+												6
Leopoldia bicolor (Boiss.) Eig & Feinbrun	+					+	+	+			+												5
Limonium echioides (L.) Mill.	+	+	+	+	+				+	+		+						+	+	+	+		12
Limonium sinuatum subsp. *romanum* Täckh. & Boulos	+																						1
Linaria joppensis Bornm.						+					+												2
Lotus cytisoides L.	+		+	+	+	+	+	+	+	+		+	+	+	+			+	+	+			16
Lycium schweinfurthii var. *aschersonii* (Dammer) Feinbrun	+					+																	2
Muscari albiflorum (Täckh. & Boulos) Hosni	+																						1
Muscari parviflorum Desf.	+		+	+		+	+	+	+	+		+		+	+	+		+				+	14
Muscari salah-eidii (Täckh. & Boulos) Hosni											+												
Pancratium arabicum Sickenb.	+																						1
Posidonia oceanica (L.) Delile	+	+	+	+	+				+	+	+	+	+	+	+		+	+	+	+			16
Reseda orientalis (Müll.Arg.) Boiss.		+				+	+	+	+	+	+												7
Scilla peruviana L.	+	+	+	+	+													+		+	+		8
Taraxacum minimum (Brig. ex Guss.) N.Terracc.	+						+	+	+	+		+						+	+	+	+		10
Teucrium brevifolium Schreb.	+	+			+					+		+											5
Thesium humile var. *maritima* (N.D.Simpson) F.M.Saad	+																						1
Thymbra capitata (L.) Cav.	+	+	+	+	+	+	+	+	+	+		+	+	+	+			+		+	+		17
Trifolium argutum Sol.	+					+	+	+	+	+		+											7
Trigonella berythea Boiss. & Blanche	+					+	+	+	+		+												6
Trisetaria koelerioides (Bornm. & Hack.) Melderis						+	+	+			+												4
Valantia columella (Ehrenb. ex Boiss.) Bald.	+	+																					2
Valerianella petrovitchii Asch.	+	+																					2
Verbascum letourneuxii Asch.	+	+																					2
Veronica syriaca Roem. & Schult.	+					+	+	+		+													5
Vicia sinaica Boulos											+												1
Total	**47**	**29**	**15**	**14**	**9**	**24**	**22**	**22**	**21**	**18**	**15**	**21**	**6**	**6**	**4**	**1**	**1**	**15**	**7**	**10**	**6**	**1**	

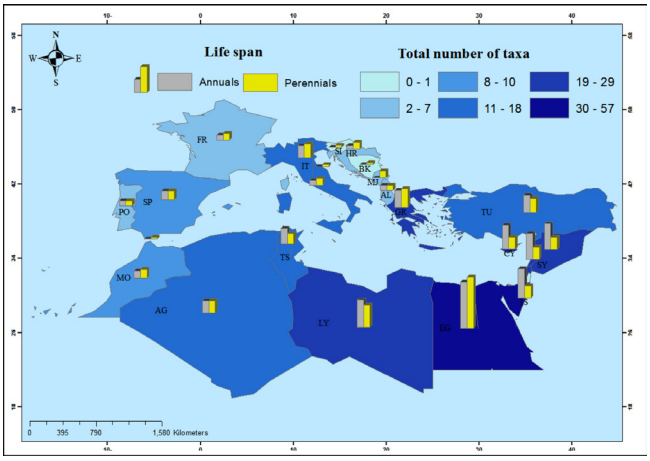

Fig. 4. Total number of the recorded Egypt Mediterranean endemics in each country of the Mediterranean basin [AG: Algeria; AL: Albania; BK: Bosnia and Herzegovina; CY: Cyprus; EG: Egypt; FR: France; GR: Greece; HR: Croatia; IS: Israel; IT: Italy; LE: Lebanon; LY: Libyan Arab Jamahiriya; MJ: Montenegro; MO: Morocco; PO: Portugal; Sl: Slovenia; SM: San Marino; SP: Spain; SY: Syrian Arab Republic; TS: Tunisia; TU: Turkey].

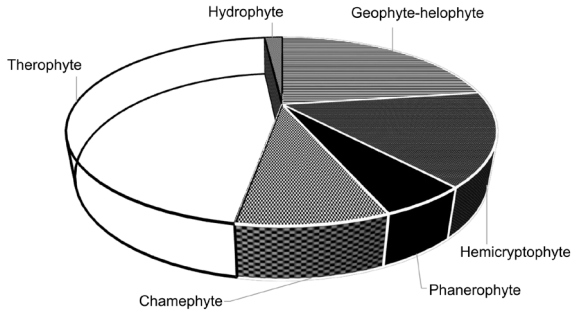

Fig. 5. Life form spectrum of the Mediterranean endemics in Egypt.

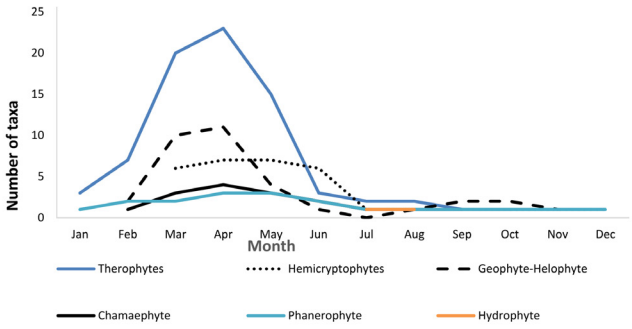

Fig. 6. Monthly variation in the number of the Mediterranean endemics in the flowering stage in relation to their life forms in Egypt.

Ebenus armitagei, *Euphorbia parvula*, *Helianthemum crassifolium* subsp. *sphaerocalyx*, *Herniaria cyrenaica*, *Valantia columella*, *Valerianella petrovitchii* and *Verbascum letourneuxii*), while two taxa (*Lycium schweinfurthii* var. *aschersonii* and *Linaria joppensis*) were recorded in Egypt and Palestine. Besides, *Thymbra capitata*, *Posidonia oceanica* and *Lotus cytisoides* were widely distributed in the Mediterranean basin. Regarding the life span, the perennials dominated the annuals.

Growth, life and sex forms

Regarding the growth forms of the recorded taxa, the highest percentage of them were perennials (31 taxa = 54.4% of the total taxa), while annuals were represented by 26 taxa (45.6%). The life form determination indicated that therophytes (26 taxa = 45.6%) constituted the highest percentage of Mediterranean endemics, followed by geophyte-helophytes (13 taxa = 22.8%), hemicryptophytes (nine taxa = 15.8), and chamaephytes (five taxa = 8.8%). *Posidonia oceanica* was the only represented hydrophyte, while phanerophytes were represented by *Ebenus armitagei*, *Helichrysum orientale* and *Lycium schweinfurthii* var. *aschersonii* (Fig. 5). The sex form of Mediterranean endemics was arranged ascendingly as follows: monoecious (three taxa = 5.3%) and hermaphrodite (54 taxa = 94.7%).

Flowering period

Analysis of the flowering time indicated a gradual increase in the frequency of the flowered taxa from December (two taxa = 3.5%) till reaching a maximum in April (48 taxa = 84.2%) and March (41 taxa = 71.9%) forming positively skewed curve. Generally, the period from March to May was characterized by the highest flowering peak, while the period from September to December was characterized by the lowest (Fig. 6). In relation to life forms therophytes had maximum values followed by hemicryptophytes and geophyte-helophytes. It's obvious that all the recorded life forms had maximum values in March and April. Surprisingly, only phanerophytes stay flowered all the year (Fig. 6).

Dispersal types

Determination of dispersal types indicated that the ballochores (21 taxa = 36.8% of the total plant taxa) were the most represented dispersal type, followed by the pogonochores (11 taxa = 19.3%), then the sarcochores (nine taxa = 15.8%) and microsclerochores (six taxa = 10.5%) (Fig. 7). On the other hand, cyclochores, desmochores and sporochores were the least represented dispersal types (only one taxon each = 1.8%).

Rarity forms

The relation between the number of Mediterranean endemics and the rarity forms indicated that SNN was the

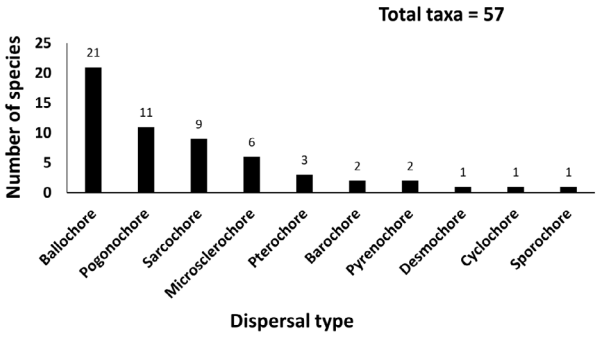

Fig. 7. Dispersal type spectrum of the Mediterranean endemics in Egypt.

most represented (60 taxa = 92.3%), followed by SNA (four taxa = 6.2%). On the contrary, SWN was the least represented by only one taxon (*Verbascum letourneuxii*).

DISCUSSION

List justification

In the present study, 218 taxa were excluded from the preliminary list of Mediterranean Egyptian endemism. For example, *Tripodion tetraphyllum* was recorded in the Netherlands (JSTOR 2022) and inner Anatolia (Hassler 2004–2022). Although *Leiotulus alexandrinus* is a Mediterranean element, it was collected along Gulf of Suez, eastern desert, Egypt (Abd El-Ghani & al. 2017; Hassler 2004–2022). Therefore, it was excluded from Mediterranean endemics list in this study. Although the endemic *Brassica deserti* was recorded by Kamel & al. (2008) only in the Mediterranean coast of Sinai, it was indicated by El-Khalafy & al. (2021) in Gebel Igma, southern Sinai. Hence, it was excluded from the present study. The same status is noticed for *Convolvulus palaestinus* that was collected from southern Sinai by El-Husseini & al. (2008).

Notably, some Mediterranean elements were excluded for their extension to adjacent regions. For example, *Aegilops longissima*, *Astragalus trimestris*, *Ononis natrix* subsp. *stenophylla* and *Trigonella maritima* extend into adjacent territories of the Saharo-Arabian region as mentioned by Feinbrun-Dothan (1978, 1986) and Zohary (1966, 1987). Even though *Trisetaria koelerioides* was recorded in Suadi Arabia in POWO (2022) and Hassler (2004–2022), it is recorded as Mediterranean endemic in the present study. It does not exist in Chaudhary (1999–2001). In addition, identification of *T. koelerioides* in the literature could have been mistaken with *Trisetaria chaudharyana* H.Scholz (Eflora of the Kingdom of Saudi Arabia 2020).

Indeed, *Heliotropium hirsutissimum* was recorded in Suadi Arabia in Hassler (2004–2022), but Chaudhary (1985) elucidated that most reports of this species from Suadi Arabia could possibly be a misidentification of *H. arbainense* Fresen. Consequently, it can be considered as an east Mediterranean endemic. The endemic *Anthemis microsperma* was recorded by Täckholm (1974) in only the western Mediterranean region, but Boulos (1999–2005) recorded it from northern Sinai. There are no authentically identified collected specimens supporting its occurrence in Sinai. It might have been observed there only one time and then disappeared or was misidentified with another similar taxa. The same case holds for *Anchusa undulata* subsp. *hybrida* that was recorded in Nile region in Boulos (1999–2005) in error.

Region delimitation and characterization

As a result of climate change, the Mediterranean region's borders with the Euro-Siberian region to the north (Europe) and the Saharan region to the south (Africa) have been fluctuating over millions of years (Vargas 2020). However, the northern and southern boundaries of the region are overall relatively decipherable, and disagreement among authors appears only in relation to comparatively small areas (mainly the Iberian and Balkan Peninsulas). In contrast, the establishment of both the western and eastern boundaries particularly is not generally agreed upon (Takhtajan 1986).

On the national scale, along the years, there have been some problems associated with the delimitation of phytogeographical regions, especially the Mediterranean floristic region in Egypt. Muschler (1912), Täckholm & Drar (1950–1969), Hassib (1951) and Täckholm (1956, 1974) demonstrated that the Mediterranean region in Egypt comprises two subregions: the Western Mediterranean coastal region (which stretches from Sallum to Alexandria, including Rosetta) and the Eastern Mediterranean coastal region (which stretches from Port Said to Rafah). Further, Zohary (1973) clarified that Mediterranean coast of Egypt harboured vegetation of the "Batha" type as well as the order *Ballotelia undulatae* belonging to the class *Quercetia calliprini* of the Eu-Mediterranean vegetation.

Zohary (1973) and Takhtajan (1986) proposed that there were two gaps in the Mediterranean territory along the North African sub-region: first gap in northern Egypt from Omayed to Rafah, and the second one in Libya along the Great Syrte between Tripoli and Benghazi. Hence the Saharo-Arabian vegetation advances quite close to the coast. Wickens (1976) restricted the North African gap to be only in Sinai (between Port Said and Rafah).

It is sad to report that Egypt had already lost over one hundred kilometers of its Mediterranean territory due to climate change, human activities, especially tourist summer resorts. As a result, it is now difficult to find any trace

of the natural vegetation reported earlier in this region (El-Hadidi & Hosni 2000; Halmy 2012; Halmy & al. 2015a, 2015b; Halmy 2019; Halmy & al. 2019). Nevertheless, the current available data provide enough evidence for extending the Mediterranean territory in Egypt from Sallum, on the Egyptian-Libyan border, to Rafah, on the Egyptian-Palestinian border, with 3 subsectors: western (from Sallum to Alexandria), middle (between Alexandria and Port Said) and eastern (between Port Said and Rafah) as elucidated by Zahran & al. (1985). The Mareotis (western) subsector of Mediterranean coastal belt in Egypt is by far the richest part in Mediterranean endemics because it receives a higher amount of rainfall (Zahran 2010). One other study, to our knowledge, has shown that about 60% of the Mediterranean taxa in Egypt do exist in the Mareotis subsector (El-Hadidi & Hosni 2000).

The Mediterranean coastal land of Egypt is characterized by outstanding physiographic variations which leads to the differentiation of several types of habitats. The predominance of coastal dunes vegetation found in this study agrees to some extent with Batanouny (1999) and Ahmed & al. (2015) who stated that the majority of the Mediterranean coast in Egypt is bordered by sand dunes which represent a landscape with special characteristics and features. In fact, there are different types of dunes: (1) the mobile dunes that are characterized by loose, mobile sand and specialized plant species that are usually sand binders, which can tolerate the burial of their shoot systems in sand and the exposure of their roots. These plants are capable of producing adventitious roots from the buried vegetative part (such as *Hyoseris radiata* subsp. *graeca*, *Centaurea pumilio* and *Pancratium arabicum*); and (2) the consolidated dunes, characterized by phreatophytes that send deep roots which penetrate into the dunes to make use of the deep-sited fresh water (such as *Helianthemum crassifolium* subsp. *sphaerocalyx* and *Lotus polyphyllos*).

Furthermore, non-saline depressions occupy the major part of the land surface between the coastal ridges parallel to the coast such as the Abu Sir Depression, between the coastal and Abu Sir ridges; and the frontal plain, between the Gebel Mariut ridge and the Mariut tableland (Ayyad 1976). They are inhabited by Mediterranean endemics such as *Anthemis microsperma*, *Muscari parviflorum*, *Verbascum letourneuxii*, and *Cynara cornigera*.

The term ‘life form’ is distinct from the term ‘growth form’. The hereditary transmitted growth form is the morphology of the individual’s stem, whereas the environmentally influenced life form is the overall appearance of the plant community (Glime 2017). One spectacular phenomenon, to be noticed here, is the prevalence of perennials over annuals in the Mediterranean basin. This finding agrees to some extent with Zohary (1973) who assumed that predominance of sclerophyllous evergreen perennials is a characteristic trait that distinguishes this subsector from the adjacent ones. Therophytes flower during the rainy season, giving the coastal belt a temporary flush as a grassland desert. Whilst, woody shrubs and perennial herbs dominate during the longer dry periods giving the scrub vegetation of the area, which is scattered sparsely and grouped in patches (Zahran 2010). The prevalence of hemicryptophytes can be due to the widespread degradation of ecological conditions as a result of human activity and climate change (Habib & al. 2020). Phanerophytes came in the next order, a result that agrees with Kadi-Hanifi (2003), who elucidated that the aridity and openness of the environment reduce the number of phanerophytes.

In Mediterranean climates, the climatic factors most important in determining vegetation structure and composition appear to be the total amount of water available (in relation to potential losses) and the amount available in summer. In more continental Mediterranean areas, winter temperature also plays an important role. Reduced total water availability (in relation to evaporation) results in dominance by smaller plant forms. On the other hand, increased summer water stress results in smaller and harder leaves. The most striking feature of Mediterranean vegetation is its potential diversity of plant forms (Box 1982).

Flowering plants show a variety of sex forms (Barrett 2002). Only 6% of angiosperms are polygamous individuals, whereas hermaphrodites are the most represented (Tomaszewski & al. 2018). In the present study, most of the recorded species presented bisexual flowers (95.9%). Bisexual taxa are superior all over the world (Lewis 1941). Accordingly, they have variable possible chances of cross and self-pollination by autogamy (including cleistogamy) and geitonogamy giving many new individuals (Peedia, 2017). Bisexual flowers have parts such as bracts and pedicels that aid in insect attraction or organs that facilitate precipitation and uptake of pollen grains during animal pollination (Bawa & Beach 1981). Bram & Quinn (2000) reported that dioecy is rare angiosperms. The low number of dioecious taxa could be interpreted in the view that these taxa suffer a reproductive handicap, because their populations contain fewer seed-producing individuals (Queenborough & al. 2009).

Most Mediterranean endemics flower from May to March, while a low percentage flower from August to January. In Egypt, plants start to grow from November when temperatures and evaporation are low, and humidity is high enough to make soil water content suitable

for plant growth till reaching flowering stage in March and April (Heneidy 2010).

Croteau (2010) described the role of movement factors like wind, water or animals in the passive dispersal of diaspores (i.e., seeds, spores or fruits) of flowering plants. These disseminules (i.e., diaspores) have some metamorphosis that help in transporting them from the parent plant to a new site. The predominance of ballochoric taxa (diaspores forcibly ejected from parent plant) may be due to the dry climate in Egypt. They are able to shatter when exposed to drought (El-Sheikh 1996). The commonness of pogonochoric taxa (diaspores with long hairs) reflects the suitability for wind dispersal in Egypt. The wide distribution of sarcochores (soft and fleshy diaspores) in the present study indicates that the principal mode of dissemination is the sarcochory by animals (i.e., zoochory).

Regarding the rarity forms, 60 taxa (92.3% of the total Mediterranean endemics) in the present study belonged to SNN cell, which means that these taxa are threatened. Chen & al. (2014) attributed the rarity of plants to internal causes such as genetic drift, pollination failure or unfeasibility of diaspores; or external causes such as human impacts or environmental factors like climate, soil or pathogens. Human impacts, roads, resorts or cultivation may be causes of habitat loss (Ahmed 2009). On the other hand, four Mediterranean endemics (*Anthemis microsperma*, *Bellevalia sessiliflora*, *Filago mareotica* and *Thymbra capitata*) belonged to the SNA cell. One of the recorded taxa (*Verbascum letourneuxii*) was the only Mediterranean endemic belonged to SWN; their population numbers are decreasing leading to habitat reduction, which in turn may cause the taxon to be extinct and move to one of the rare cells (SNA or SNN) (Rabinowitz 1981; Ahmed 2009). High percentage of rare taxa (SNN, SNA and SWN), whereas absence of common taxa (LNA, LNN and LWA) are indicators that support a management plan to conserve Mediterranean endemics in Egypt.

CONCLUSION

We report 57 Mediterranean endemic species in the Egyptian flora, the majority of which are found in the Mareotis subsector of the North African Mediterranean sub-region. We show that the most hospitable habitats for Egypt's Mediterranean endemics are the coastal dunes and non-saline depressions. Therophytes make up for the majority of the endemic species and hermaphrodites are the most represented among sex forms. The majority of taxa have the highest flowering peak in April. Among dispersal types, ballochory is the most prevalent. Finally, the most frequent rarity type is SNN (small geographic range-narrow habitat-non abundant), indicating that most of the species are rare and very restricted, and they should be taken into consideration for conservation plans in the near future.

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Appendix 1. Main characteristics of the recorded Mediterranean endemics in the Egyptian flora [Abundance (cc: very common; c: common; r: rare; rr: very rare); Sex form (b: bisexual; m: monoecious); Life spam (a: annual; p: perennial)].

Scientific name	Vernacular name	Abundance	Life form	Life span	Sex form	Dispersal type	Flowering time
Amaryllidaceae							
Allium barthianum Asch. & Schweinf.	بصل	r	Geophyte-Helophyte	p	b	Ballochore	Mar-May
Allium blomfieldianum Asch. & Schweinf.	بصل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-Apr
Allium mareoticum Bornm. & Gauba	بصل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-May
Allium trifoliatum Cirillo	بصل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-Apr
Pancratium arabicum Sickenb.	سوسن	r	Geophyte-Helophyte	p	b	Barochore	Aug-Oct
Apiaceae							
Apium crassipes (W.D.J.Koch ex Rchb.) Rchb.f.	-	rr	Chamaephyte	p	b	Ballochore	Apr-Jun
Asparagaceae							
Bellevalia salah-eidii Täckh. & Boulos	بصيل	rr	Geophyte-Helophyte	p	b	Pterochore	Feb-Apr
Bellevalia sessiliflora (Viv.) Kunth	بيلبوش	rr	Geophyte-Helophyte	p	b	Ballochore	Feb-Apr
Bellevalia warburgii Feinbrun	بصيل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-May
Leopoldia bicolor (Boiss.) Eig & Feinbrun	بصيل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-Apr
Muscari albiflorum (Täckh. & Boulos) Hosni	بصيل	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-Apr
Muscari parviflorum Desf.	-	rr	Geophyte-Helophyte	p	b	Ballochore	Sep-Nov
Scilla peruviana L.	-	rr	Geophyte-Helophyte	p	b	Ballochore	Apr-Jun
Muscari salah-eidii (Täckh. & Boulos) Hosni	-	rr	Geophyte-Helophyte	p	b	Ballochore	Mar-Apr
Asteraceae							
Anthemis microsperma Boiss. & Kotschy	أربيان	c	Therophyte	a	b	Microsclerochore	Mar-May
Centaurea aegialophila Wagenitz	مرير	rr	Therophyte	a	m	pogonochore	Apr-May
Centaurea pumilio L.	مرير	c	Hemicryptophyte	p	m	pogonochore	Mar-Jun
Crepis aculeata Boiss.	-	rr	Therophyte	a	b	pogonochore	Apr-Jul
Cynara cornigera Lindl.	خرشوف	r	Chamaephyte	p	b	pogonochore	Mar-Jun
Echinops taeckholmianus Amin	خشروف	r	Hemicryptophyte	p	b	pogonochore	Jun-Jul
Filago mareotica Delile	-	c	Therophyte	a	b	pogonochore	Mar-May
Helichrysum orientale (L.) Gaertn.	-	rr	Phanerophyte	p	b	pogonochore	Apr-Jun
Hyoseris radiata subsp. *graeca* Halácsy	-	c	Hemicryptophyte	p	b	pogonochore	Mar-Jun
Taraxacum minimum (Brig. ex Guss.) N.Terracc.	-	rr	Hemicryptophyte	p	b	pogonochore	Aug-Jan
Boraginaceae							
Anchusa undulata subsp. *hybrida* (Ten.) Cout.	قلحك	r	Therophyte	a	b	Sarcochore	Mar-May
Heliotropium hirsutissimum Grauer	-	r	Therophyte	a	b	Sarcochore	May-Oct
Caprifoliaceae							
Valerianella petrovitchii Asch.	-	rr	Therophyte	a	b	Desmochore	Mar-Apr

Appendix 1. Cont'd.

Scientific name	Vernacular name	Abundance	Life form	Life span	Sex form	Dispersal type	Flowering time
Caryophyllaceae							
Herniaria cyrenaica F.Herm.	أم لبيد	rr	Hemicryptophyte	p	b	Microsclerochore	Mar-Jun
Cistaceae							
Helianthemum crassifolium subsp. *sphaerocalyx* (Gauba & Janch.) Maire	-	r	Chamaephyte	p	b	Ballochore	Feb-Apr
Convolvulaceae							
Convolvulus humilis Jacq.	-	rr	Therophyte	a	b	Sarcochore	Mar-May
Euphorbiaceae							
Euphorbia parvula Delile	لبين	rr	Therophyte	a	m	Sarcochore	Mar-May
Fabaceae							
Coronilla repanda (Poir.) Guss.	-	rr	Therophyte	a	b	Barochore	Mar-May
Ebenus armitagei Schweinf. & Taub.	-	rr	Phanerophyte	p	b	pogonochore	Feb-May
Hedysarum spinosissimum L.	-	r	Therophyte	a	b	pogonochore	Mar-Apr
Lotus cytisoides L.	-	rr	Hemicryptophyte	p	b	Ballochore	Mar-Jun
Trifolium argutum Sol.	قضاب	rr	Therophyte	a	b	Pterochore	Feb-Apr
Trigonella berythea Boiss. & Blanche	حندقوق	rr	Therophyte	a	b	Sarcochore	Mar-Apr
Vicia sinaica Boulos	دحريج	rr	Therophyte	a	b	Ballochore	-
Lathyrus marmoratus Boiss. & Blanche	جيرحد	r	Therophyte	a	b	Ballochore	Feb-Apr
Lamiaceae							
Teucrium brevifolium Schreb.	-	rr	Chamaephyte	p	b	Microsclerochore	Mar-May
Thymbra capitata (L.) Cav.	زعتر	c	Chamaephyte	p	b	Microsclerochore	Jul-Sep
Papaveraceae							
Fumaria judaica Boiss. subsp. *judaica*		r	Therophyte	a	b	Sarcochore	Jan-Apr
Fumaria microstachys Kralik ex Hausskn.	-	rr	Therophyte	a	b	Microsclerochore	Mar-May
Fumaria gaillardotii Boiss.	-	r	Therophyte	a	b	Sporochore	Feb-May
Plantaginaceae							
Linaria joppensis Bornm.	-	rr	Therophyte	a	b	Ballochore	Mar-Apr
Veronica syriaca Roem. & Schult.	حبق، زهرة الحواشي السورية	rr	Therophyte	a	b	Ballochore	Jan- Apr
Plumbaginaceae							
Limonium echioides (L.) Mill.	-	rr	Therophyte	a	b	Sarcochore	Apr-Jun
Limonium sinuatum subsp. *romanum* Täckh. & Boulos	-	rr	Hemicryptophyte	p	b	Ballochore	Mar-Jun
Poaceae							
Cynosurus coloratus Lehm. ex Steud.	-	rr	Hemicryptophyte	a	b	Pterochore	Mar-May
Desmazeria philistaea (Boiss.) H.Scholz	حلفا	rr	Therophyte	a	b	pyrenochore	Mar-Apr, Aug
Trisetaria koelerioides (Bornm. & Hack.) Melderis	-	rr	Therophyte	a	b	pyrenochore	Mar-May
Posidoniaceae							
Posidonia oceanica (L.) Delile	شتنارة	cc	Hydrophyte	p	b	cyclochore	Jul-Aug
Resedaceae							
Reseda orientalis (Müll.Arg.) Boiss.	ذيل الخروف	rr	Therophyte	a	b	Sarcochore	Jan-Feb
Rubiaceae							
Valantia columella (Ehrenb. ex Boiss.) Bald.	-	r	Therophyte	a	b	Ballochore	-

Appendix 1. Cont'd.

Scientific name	Vernacular name	Abundance	Life form	Life span	Sex form	Dispersal type	Flowering time
Santalaceae							
Thesium humile var. *maritima* (N.D.Simpson) F.M.Saad	حب الكريس	r	Therophyte	a	b	Microsclerochore	Feb-May
Scrophulariaceae							
Verbascum letourneuxii Asch.	-	r	Hemicryptophyte	p	b	ballochore	Apr-May
Solanaceae							
Lycium schweinfurthii var. *aschersonii* (Dammer) Feinbrun	جسوع	r	Phanerophyte	p	b	Sarcochore	All year round

Appendix 2. Updated list of Mediterranean endemics in Egypt in the present study compared to the three previous related studies coded as A, B, C, D [A: Boulos (1999–2005); B: Med-Checklist (Greuter & al. 1984–1989, Greuter & von Raab-Straube 2008); C: Ahmed (2009); D: this study; ×: excluded as a Mediterranean endemism; √: recorded as Mediterranean endemic; DI: Libyan desert; IR-TR: Irano-Turanian; SA-RA: Saharo-Arabian].

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Amaranthaceae							
Agathophora alopecuroides (Delile) Fenzl ex Bunge var. *alopecuroides*	Iran, Iraq, Pakistan, Saudi Arabia	5, 6, 11	POWO (2022)	×	√	×	×
Anabasis syriaca Iljin	Deserts of Palestine, Isthmic desert of Egypt	6, 11	Danin & Fragman- Sapir (2016), CAI, CAIRC, Boulos (1999–2005)	√	√	×	×
Atriplex leucoclada var. *inamoena* (Aellen) Zohary	AfghanistanIran, Iraq, Kazakhstan, Kuwait, Oman, Pakistan, Saudi Arabia, Transcaucasus, Turkmenistan, Uzbekistan, Yemen	2, 5, 6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Bassia arabica (Boiss.) Maire & Weiller	Gulf States, Saudi Arabia	6, 11	POWO (2022)	×	√	×	×
Haloxylon negevensis (Iljin & Zohary) L.Boulos	Central Sinai, Deserts of South Israel	6, 11	POWO (2022), Hassler (2004–2022)	√	√	×	×
Haloxylon schmittianum Pomel	Saudi Arabia, absent in Egypt and reported in Egypt in Med-Checklist (2016) in error	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Haloxylon tamariscifolium (L.) Pau	Mauritania, Western Sahara, absent in Egypt and reported in Egypt in Med-Checklist (2016) in error	6, 12	POWO (2022), Boulos (1999–2005)	×	√	×	×
Salsola longifolia Forssk.	Western Sahara, Gulf States, Mauritania, Arabian Peninsula	6, 11, 12	POWO (2022), Hassler (2004–2022)	√	√	×	×
Salsola schweinfurthii Solms	Gulf States, Oman, Saudi Arabia	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Salsola villosa Schult.	India, Saudi Arabia	6, 11, 19	POWO (2022), Boulos (1999–2005)	×	√	×	×
Suaeda altissima (L.) Pall.	Xinjiang and Afghanistan	5, 6	POWO (2022)	√	×	×	×
Suaeda pruinosa Lange	Djibouti	6, 12	POWO (2022), GBIF (2022)	√	√	√	×
Amaryllidaceae							
Allium aschersonianum Barbey	West IR-TR	5	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Allium barthianum Asch. & Schweinf.		6		√	×	×	√
Allium blomfieldianum Asch. & Schweinf.		6		√	×	√	√

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Allium curtum subsp. *palaestinum* Feinbrun	IR-TR	5	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Allium curtum Boiss. & Gaill. subsp. *curtum*	IR-TR	5	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Allium mareoticum Bornm. & Gauba		6		√	×	√	√
Allium roseum var. *tourneuxii* Boiss.	Saharo Sindian	5, 11	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Allium sphaerocephalon subsp. *arvense* (Guss.) Arcang.	Canary Islands, IR-TR Anatolia of Turkey, Central Europe	2, 5, 6, 7	Euro+Med (2006), eflora Maghreb (2021), Hassler (2004–2022)	√	×	×	×
Allium trifoliatum Cirillo		6		√	×	√	√
Pancratium arabicum Sickenb.		6		√	×	√	√
Apiaceae							
Ammoides pusilla (Brot.) Breistr.	Desert Oases in Egypt (Dakhla oases), Suadi Arabia, introduced to Germany	6, 11	Boulos (1999–2005), CAI, Hassler (2004–2022), Euro+Med (2006), Roskov & al. (2019)	√	×	×	×
Apium crassipes (W.D.J.Koch ex Rchb.) Rchb.f.		6		√	×	×	√
Bupleurum nanum Poir.	Mediterranean extending to deserts (SA-AR), Western desert in Egypt	6, 11	GBIF (2022)	√	×	×	×
Bupleurum nodiflorum Sm.	Extends to IR-TR parts of Syria (Jbel Druze), Turkey (Anatolia) and Israel	5, 6	Hassler (2004–2022)	√	×	√	×
Daucus syrticus Murb.	Europe, West Asia, North America, Australia	2, 6, 8, 9, 10, 11, 34, 35, 36	Hassler (2004–2022), Laínz (1981)	√	√	√	×
Leiotulus alexandrinus Ehrenb.	Extends to north African deserts (Eastern Desert, Great Southwestern Desert of Egypt)	6, 11	Hassler (2004–2022), Abd El-Ghani & al. (2017)	√	×	√	×
Ridolfia segetum (L.) Moris	Canary Islands, Arabian Peninsula.	6, 7, 11	POWO (2022)	√	×	×	×
Stoibrax dichotomum (L.) Raf.	Suadi Arabia, North African deserts of Algeria and Morocco	6, 11	GBIF (2022), African Plant Database (2022)	√	×	×	×
Tordylium aegyptiacum (L.) Poir.	Central Iraq	5, 6	POWO (2022)	×	×	√	×
Apocynaceae							
Caralluma europaea (Guss.) N.E.Br.	Extends to SA-AR deserts of Israel	6, 11	Danin & Fragman- Sapir (2016), Flowers in Israel (2005–2022)	√	√	√	×
Rhazya greissii Täckh. & Boulos	Desert Oases in Egypt (Kharga oases)	6, 11	POWO (2022), GBIF (2022), Euro+Med (2006)	×	√	×	×
Araceae							
Biarum olivieri Blume	East SA-AR	11	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Aristolochiaceae							
Aristolochia maurorum L.	Mesopotamian, inner and east Anatolia, Iran, Iraq	5, 6	Hassler (2004–2022), Euro+Med (2006), Med-Checklist (2016), POWO (2022), GBIF (2022)	×	√	×	×
Asparagaceae							
Asparagus aphyllus L.	Arabian Peninsula	6, 11	POWO (2022), Ahmed 2009	√	×	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Bellevalia mauritanica Pomel	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	×	√	×
Bellevalia romana (L.) Sweet	Netherlands	2, 6	GBIF (2022), JSTOR (2022), Hassler (2004–2022)	√	×	√	×
Bellevalia salah-eidii Täckh. & Boulos		6		√	×	√	√
Bellevalia sessiliflora (Viv.) Kunth		6		√	×	√	√
Bellevalia trifoliata (Ten.) Kunth	Baharia oases, eastern desert, IR-TR part of Palestine, SA-AR part of N Africa and Turkey	5, 6, 11	CAI, CAIM, Danin & Fragman-Sapir (2016), GBIF (2022), Euro+Med (2006)	√	×	√	×
Bellevalia warburgii Feinbrun		6		√	×	×	√
Leopoldia bicolor (Boiss.) Eig & Feinbrun		6		√	√	×	√
Muscari albiflorum (Täckh. & Boulos) Hosni		6		√	×	√	√
Muscari parviflorum Desf.		6		√	×	√	√
Muscari salah-eidii (Täckh. & Boulos) Hosni		6		√	×	×	√
Ornithogalum arabicum L.	Sudan	6, 12	POWO (2022)	√	×	√	×
Ornithogalum narbonense L.	Iran, Iraq	5, 6	POWO (2022), Ahmed 2009	√	×	×	×
Scilla peruviana L.		6		√	×	×	√
Asteraceae							
Ambrosia maritima L.	Arabian Peninsula, Tropical Africa	6, 11, 12	POWO (2022)	√	×	√	×
Anacyclus monanthos subsp. *monanthos* (L.) Thell.	Western desert, SA-AR part of Sinai, SA-AR part of Algeria	6, 11	CAI, Hatim & al. (2021), GBIF (2022)	√	√	√	×
Anthemis bornmuelleri Stoj. & Acht.	SA-AR parts of Syria (Jbel Druze), Saudi Arabia	5, 6, 11	POWO (2022), Hassler (2004–2022), Chikhali (2022)	×	×	×	×
Anthemis chia L.	Netherlands, Croatia, Austria	2, 6	GBIF (2022), JSTOR (2022)	√	×	√	×
Anthemis indurata Delile	Arabian Peninsula	6, 11	POWO (2022)	√	×	×	×
Anthemis microsperma Boiss. & Kotschy		6		√	√	√	√
Anthemis scrobicularis subsp. *fungosa* Yavin	Douptfully present in Egypt	11	Yavin (1972), Frumin & Shammash (2008), Greuter & von Raab-Straube (2008), Euro+Med (2006)	×	√	×	×
Artemisia inculta Sieber ex DC.	Douptfully present in Egypt	6, 11	Täckholm (1974)	×	√	×	×
Asteriscus aquaticus (L.) Less.	Central Europe	2, 6	POWO (2022)	√	×	×	×
Atractylis boulosii Täckh.	Central Sinai	6, 11	POWO (2022)	√	√	×	×
Atractylis phaeolepis Pomel	Central and South Sinai, deserts of Israel	6, 11	Hassler (2004–2022)	×	√	×	×
Atractylis prolifera Boiss.	SA-AR	11	Jafri & El-Gadi (1977–1988)	×	√	×	×
Atractylis serratuloides Sieber ex Cass.	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	×	×
Carduus argentatus L.	Pakistan	5, 6	POWO (2022)	×	√	×	×
Carlina involucrata Poir.	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	√	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Carthamus glaucus subsp. *alexandrinus* (Boiss. & Heldr.) Hanelt	Ukraine, Krym, Caucasus and Iran	2, 5, 6	POWO (2022)	√	√	×	×
Carthamus mareoticus Delile	Western desert in Egypt	6, 11	Boulos (1999–2005)	√	√	×	×
Carthamus tenuis subsp. *foliosus* (Boiss.) Hanelt	Nile valley, Oases, deserts of Egypt	6, 11	Boulos (1999–2005), CAI	√	√	×	×
Centaurea aegialophila Wagenitz		6		√	×	×	√
Centaurea alexandrina Delile	Chad, Mali	6, 12	POWO (2022)	√	√	×	×
Centaurea bimorpha Viv.	Western Sahara, deserts of Algeria and Tunisia	6, 11	POWO (2022), African Plant Database (2022)	√	√	×	×
Centaurea damascena Boiss.	Absent in Egypt and recorded in Egypt in Med-Checklist (2016) in error	6, 11	Danin A & Fragman-Sapir (2016), Flowers in Israel (2005–2022)	×	√	×	×
Centaurea furfuracea Coss. & Durieu	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	×	×
Centaurea glomerata Vahl	Extends to SA-AR Great Southwestern Desert, Nile Valley and southern Sinai	6, 11	GBIF (2022), TANE, CAI	√	√	√	×
Centaurea lanulata Eig	Deserts of Palestine, absent in Egypt and recorded in Egypt in Med-Checklist (2016) in error	6, 11	Danin & Fragman- Sapir (2016), Flowers in Israel (2005–2022)	×	√	×	×
Centaurea postii Boiss.	South Sinai and Syrian deserts	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Centaurea procurrens Sieber ex Spreng.	South Sinai and Syrian deserts	6, 11	Hassler (2004–2022), POWO (2022)	√	√	×	×
Centaurea pullata L.	Douptfully present in Egypt	6	El-Beheiry & al. (2020)	√	√	√	×
Centaurea pumilio L.		6		√	√	√	√
Chlamydophora tridentata (Delile) Ehrenb. ex Less.	SA-AR	11	Zohary (1966, 1987)	√	√	×	×
Crepis aculeata Boiss.		6		√	√	×	√
Crepis clausonis (Pomel) Batt. & Trab.	Douptfully present in Egypt	6	Boulos (1999–2005), GBIF (2022), JSTOR (2022), Euro+Med (2006), Hassler (2004–2022)	√	√	×	×
Crepis libyca (Pamp.) Babc.	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	×	×
Crepis nigricans Viv.	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	×	×
Cynara cornigera Lindl.		6		√	√	×	√
Daveaua anthemoides Mariz	Not recorded in Egypt in Egyptian flora books, herbaria or literature	6	Boulos (1999–2005), Täckholm (1974), GBIF (2022)	×	√	×	×
Dittrichia viscosa subsp. *angustifolia* (Bég.) Greuter	Nile Delta, South Sinai, Anatolia of Turkey, European Turkey, deserts of Israel, Jbel Druze of Syria	2, 5, 6, 11	Boulos (1999–2005), Hassler (2004–2022)	√	√	√	×
Echinops spinosissimus Turra	Cameroon, Mauritania, Western Sahara	6, 12	POWO (2022)	√	×	√	×
Echinops philistaeus Feinbrun & Zohary	Not recorded in Egypt in Egyptian flora books or herbaria or literature	6	Boulos (1999–2005), Täckholm (1974), Hassler (2004–2022), POWO (2022)	×	√	×	×
Echinops taeckholmianus Amin		6		√	√	×	√
Filago mareotica Delile		6		√	√	×	√

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Gnomophalium pulvinatum (Delile) Greuter	Arabian Peninsula, Indian Subcontinent to SE Tibet	5, 6, 11, 12, 19	Boulos (1999–2005), POWO (2022)	×	√	×	×
Helichrysum orientale (L.) Gaertn.		6		√	√	×	√
Helichrysum stoechas subsp. *barrelieri* (Ten.) Nyman	Arabian Peninsula	6, 11	POWO (2022)	√	×	×	×
Hyoseris radiata subsp. *graeca* Halácsy		6		√	√	√	√
Hyoseris scabra L.	Netherlands, Sweden, Germany	2, 6	Euro+Med (2006), JSTOR (2022), Hassler (2004–2022)	√	×	√	×
Ifloga spicata subsp. *hadidii* (Fayed & Zareh) Greuter	Eastern desert, South Sinai	11	Boulos (1999–2005)	×	√	×	×
Iphiona mucronata (Forssk.) Asch. & Schweinf.	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Jurinea staehelinae (DC.) Boiss.	Not recorded in Egypt in Egyptian flora books or herbaria or literature, IR-TR region of Jordan, Lebanon, Syria and Palestine	5, 6	Boulos (1999–2005), Täckholm (1974), Hassler (2004–2022), POWO (2022)	×	√	×	×
Leontodon tuberosus L.	Sweden, Macedonia, EU-SR and IR-TR parts of Turkey	2, 6	JSTOR (2022), Hassler (2004–2022)	√	√	√	×
Mantisalca salmantica (L.) Briq. & Cavill.	Macaronesia, Europe	2, 6, 7	POWO (2022), Euro+Med (2006)	√	×	×	×
Onopordum alexandrinum Boiss.	West IR-TR, East SA-AR	5, 11	Feinbrun-Dothan (1978, 1986), Ahmed (2009)	√	√	×	×
Onopordum carduiforme Boiss.	Reported in Egypt as casual alien in Med-Checklist (2016) and Euro+Med (2006) in error	6	Boulos (1999–2005), El-Beheiry & al. (2020)	×	√	×	×
Phagnalon rupestre (L.) DC.	Iran and Arabian Peninsula.	5, 6, 11	POWO (2022)	√	×	√	×
Picris amalecitana (Boiss.) Eig	Not recorded in Egypt in Egyptian flora books or herbaria or literature	6	Boulos (1999–2005), Täckholm (1974)	×	√	×	×
Picris asplenioides L.	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Picris rhagadioloides (L.) Desf.	Central Europe, not recorded in Egypt in Egyptian flora books	2, 6	POWO (2022), Boulos (1999–2005), Täckholm (1974)	×	√	×	×
Picris sulphurea Delile	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Pseudopodospermum undulatum (Vahl) Zaika, Sukhor. & N.Kilian	Arabian Peninsula, not recorded in Egypt in Egyptian flora books	6, 11	POWO (2022), Boulos (1999–2005), Täckholm (1974)	×	√	×	×
Reichardia picroides (L.) Roth	Absent in Egypt but reported in error	6	Euro+Med (2006), Med-Checklist (2016), Boulos (1999–2005)	√	×	√	×
Scorzonera drarii V.Tackh.	Isthmic desert	6, 11	Täckholm (1974)	×	√	×	×
Scorzoneroides hispidula (Delile) Greuter & Talavera	Iran and Southwest Asia	5, 6	Boulos (1999–2005), Täckholm (1974),	×	√	×	×
Scorzoneroides simplex (Viv.) Greuter & Talavera	Mauritania	6, 12	POWO (2022)	√	√	√	×
Senecio aegyptius L.	Tropical Africa	6, 12	POWO (2022)	√	√	×	×
Senecio belbeysius Delile	Nile Delta, Nile Valley	6, 11	Hassler (2004–2022), Boulos (1999–2005)	√	√	×	×
Senecio glaucus L. subsp. *glaucus*	Eastern Desert, Great Southwestern Desert	6, 11	Hassler (2004–2022), Boulos (1999–2005)	√	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Sonchus macrocarpus Boulos & C.Jeffrey	Eastern desert	6, 11	El□Khalafy & al. (2021), Boulos (1999–2005)	×	√	√	×
Taraxacum minimum (Brig. ex Guss.) N.Terracc.		6		√	√	√	√
Boraginaceae							
Alkanna tinctoria Tausch subsp. *tinctoria*	Central Europe	2, 6	POWO (2022)	√	×	√	×
Anchusa humilis (Desf.) I.M.Johnst.	Chad, Mauritania	6, 12	POWO (2022)	√	√	×	×
Buglossoides incrassata (Guss.) I.M.Johnst.	Canary Islands, central Europe, W Iran	2, 5, 6, 7	POWO (2022)	√	√	×	×
Echiochilon fruticosum Desf.	Arabia	6,11	POWO (2022), Boulos (1999–2005), Ahmed (2009)	×	√	×	×
Echium longifolium Delile	Yemen, Ethiopia, Suadi Arabia	6, 11, 12	(GBIF (2022), Dubaie & Al□Khulaidi (1993), Boulos (1999–2005)	×	√	×	×
Heliotropium rotundifolium Sieber ex Lehm.	Deserts of Palestine, deserts of Egypt	6, 11	Danin & Fragman-Sapir (2016), Boulos (1999–2005), CAI	√	√	×	×
Nonea vivianii DC.	Wadi El-Arbaeen (south Sinai)	6, 11	CAIA	×	√	×	×
Podonosma galalensis Schweinf. ex Boiss.	Deserts of Palestine, deserts of Egypt	6, 11	Danin & Fragman-Sapir (2016), Boulos (1999–2005), CAI	×	√	×	×
Trichodesma ehrenbergii Schweinf.	Sudan and Arabian Peninsula	6, 11, 12	POWO (2022)	×	√	×	×
Anchusa undulata subsp. *hybrida* (Ten.) Cout.		6		√	√	×	√
Echium angustifolium subsp. *sericeum* (Vahl) Klotz	Yemen, Arabia	6, 11	GBIF (2022), Dubaie & Al-Khulaidi (1993), Boulos (1999–2005)	×	√	√	×
Echium angustifolium Mill. subsp. *angustifolium*	Extends to SA-AR deserts of Egypt and Libya and IR-TR part of Turkey and Israel, and Turkey in Europe (EU-SR)	2, 5, 6, 11	Boulos (1999–2005), Euro+Med (2006), Hassler (2004–2022), GBIF (2022), African Plant Database (2022), Rabei & Elgamal (2021), Davis (1965-1985)	√	√	√	×
Echium glomeratum Poir.	Russia, IR-TR part of Turkey (inner and north Anatolia), SA-AR central Syrian and Lebanon deserts	3, 5, 6, 11	GBIF (2022), Hassler (2004–2022), El-Husseini & al. (2008)	√	√	×	×
Echium rubrum Forssk.	Hungary, Ukraine, Georgia, Romania, Czechia, United Kingdom, Russia	2, 3, 6	GBIF (2022), JSTOR (2022)	√	√	√	×
Echium sabulicolum var. *tenue* (Roth) Hadidy in Boulos	Absent in Egypt but reported in error, Netherlands	2, 6	Med-Checklist (2016), POWO (2022), Hassler (2004–2022), GBIF (2022)	√	√	×	×
Heliotropium hirsutissimum Grauer		6		√	√	√	√
Brassicaceae							
Arabis verna (L.) W.T.Aiton	Crimea, Russia	3, 6	POWO (2022), Hassler (2004–2022),	×	√	×	×
Biscutella didyma var. *depressa* (Willd.) El Naggar	Austria, Bulgaria, Germany, Hungary, Switzerland	2, 6	POWO (2022)	×	√	×	×
Brassica deserti Danin & Hedge	Gebel Igma, southern Sinai	6, 11	El-Khalafy & al. (2021)	√	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Crucihimalaya kneuckeri (Bornm.) Al-Shehbaz, O'Kane & R.A.Price	Saudi Arabia	6, 11	POWO (2022)	×	√	×	×
Didesmus aegyptius (L.) Desv.	Luxor, south Egypt	6, 11	GBIF (2022), Täckholm (1974)	√	√	√	×
Didesmus bipinnatus (Desf.) DC.	Netherlands, Kuwait; Saudi Arabia	2, 6, 11	JSTOR (2022), Hassler (2004–2022)	√	×	√	×
Diplotaxis muralis subsp. *simplex* (Viv.) Jafri	North African deserts (SA-AR)	6, 11	African Plant Database (2022), GBIF (2022), Jafri & El-Gadi (1977–1988)	√	√	×	×
Enarthrocarpus strangulatus Boiss.	SA-AR, Belgium	2, 6, 11	Flowers in Israel (2005–2022), GBIF (2022)	√	√	×	×
Erucaria microcarpa Boiss.	SA-AR	11	Flowers in Israel (2005–2022), Danin & Fragman-Sapir (2016)	√	√	√	×
Lobularia arabica (Boiss.) Muschl.	Mauritania, Saint Katherine and deserts of Palestine	6, 11, 12	Rabei & Elgamal (2021), Danin & Fragman-Sapir (2016), GBIF (2022), CAI, SCUI	√	√	×	×
Matthiola longipetala subsp. *bicornis* (Sm.) P.W.Ball	Germany, Canada, Sweden, USA, SA-AR region of Sinai	2, 6, 8, 9, 10, 11	GBIF (2022), Rabei & Elgamal (2021)	×	√	×	×
Matthiola longipetala subsp. *hirta* (Conti) Greuter & Burdet	SA-AR region of Sinai	6, 11	Rabei & Elgamal (2021)	×	√	×	×
Nasturtiopsis coronopifolia subsp. *arabica* (Boiss.) Greuter & Burdet	Deserts of Israel	6, 11	Flowers in Israel (2005–2022), Danin & Fragman-Sapir (2016)	×	√	×	×
Ochthodium aegyptiacum (L.) DC.	Absent in Egypt but reported in error	6	Med-Checklist (2016), Euro+Med (2006), GBIF (2022)	√	√	×	×
Pseuderucaria clavata subsp. *clavata* (Boiss. & Reut.) O.E.Schulz	Deserts of Israel	6, 11	Flowers in Israel (2005–2022), Danin & Fragman-Sapir (2016)	×	√	×	×
Pseuderucaria teretifolia (Desf.) O.E.Schulz	USA	6, 8, 9, 10	GBIF (2022)	×	√	×	×
Ricotia lunaria (L.) DC.	South Sinai	6, 11	Täckholm (1974)	√	√	×	×
Rorippa integrifolia Boulos	Maghara mountain	6, 11	POWO (2022)	√	√	×	×
Sinapis arvensis subsp. *allionii* (Jacq.) Baillarg.	Recorded in UK, the Netherlands, Eretria, Denmark, Russia, Australia	2, 3, 6, 34, 35, 36	World Plants, Complete List, JSTOR (2022), GBIF (2022), El□Khalafy & al. (2021)	√	√	√	×
Sisymbrium polyceratium L.	Switzerland, Germany, USA	2, 6, 8	JSTOR (2022), POWO (2022), Hassler (2004–2022)	×	√	×	×
Zilla spinosa subsp. *biparmata* (O.E.Schulz) Maire & Weiller	North Africa deserts	6, 11	CAI, Hassler (2004–2022)	√	√	×	×
Campanulaceae							
Asyneuma rigidum subsp. *sinai* (A. DC.) Damboldt	South Sinai mountains	6, 11	Täckholm (1974)	√	√	×	×
Capparaceae							
Capparis spinosa var. *inermis* Turra	Tanzania, W Asia to India, Arabian Peninsula, W Indian Ocean	6, 11, 15, 19	POWO (2022), Ahmed (2009)	√	×	×	×
Capparis spinosa var. *canescens* Coss.	Arabian Peninsula, West and Central Asia to India	5, 6, 11, 19	POWO (2022)	×	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Caprifoliaceae							
Cephalaria syriaca (L.) Schrad. ex Roem. & Schult.	Central Asia and Pakistan	5, 6	POWO (2022)	×	√	×	×
Lomelosia aucheri (Boiss.) Greuter & Burdet	Iraq, not recorded in Egyptian flora books	5, 6	POWO (2022), Täckholm (1974), Boulos (1999–2005)	×	√	×	×
Lomelosia prolifera (L.) Greuter & Burdet	Absent in Egyptian flora books and reported in Egypt in Med-checklist (2016) in error	6	POWO (2022), Dobignard & Chatelain (2012), Boulos (1999–2005), Täckholm (1974), Med-Checklist (2016)	×	√	×	×
Pterocephalus arabicus Boiss.	Central Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Pterocephalus sanctus Decne.	Suadi Arabia	6, 11	POWO (2022)	×	√	×	×
Scabiosa eremophila Boiss.	Extends to deserts recorded in eastern desert and deserts of Palestine	6, 11	Abd El-Ghani & al. (2017), Danin & Fragman-Sapir (2016)	√	√	×	×
Valerianella petrovitchii Asch.		6		√	×	×	√
Caryophyllaceae							
Arenaria deflexa Decne.	Arabian Peninsula	6, 11	POWO (2022)	√	√	√	×
Bolanthus hirsutus (Labill.) Barkoudah	South Sinai mountains	6, 11	Täckholm (1974)	√	√	×	×
Dianthus guessfeldtianus Muschl.	Galala desert	11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Dianthus sinaicus Boiss.	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Gypsophila capillaris (Forssk.) C.Chr.	Iran, Iraq, Kuwait, Saudi Arabia	5, 6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Gypsophila coelesyriaca (Boiss. & Hausskn.) F.N.Williams	Iran, Iraq	5, 6	POWO (2022)	×	√	×	×
Herniaria cyrenaica F.Herm.		6		√	√	×	√
Minuartia mediterranea (Ledeb. ex Link) K.Malý	Mediterranean, slightly extending to adjacent regions (European Turkey, Switzerland, Iran), doubtfully present in Egypt	2, 5, 6	Zohary (1966, 1987), Hassler (2004–2022), GBIF (2022), JSTOR (2022)	√	√	×	×
Paronychia arabica subsp. *longiseta* Batt.	Sahara to Iraq and Arabian Peninsula	5, 6, 11, 12	POWO (2022), Boulos (1999–2005)	×	√	×	×
Paronychia capitata (L.) Lam.	Canary Islands, Yemen, Eritrea, North African deserts of Morocco and Algeria	6, 7, 11, 12	POWO (2022), Hassler (2004–2022), eflora Maghreb (2021), African plant database (2022)	√	√	√	×
Paronychia sinaica Fresen.	Suadi Arabia	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Petrorhagia arabica (Boiss.) P.W.Ball & Heywood	Central and South Sinai, Deserts of Israel	6, 11	CAI, Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Petrorhagia illyrica subsp. *angustifolia* (Poir.) P.W.Ball & Heywood	Turkmenistan, Romania, North African deserts of Morocco	2, 5, 6, 11	JSTOR (2022), GBIF (2022), eflora Maghreb (2021), African plant database (2022)	√	√	√	×
Polycarpon succulentum J.Gay	Iraq, Arabian Peninsula	5, 6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Silene biappendiculata Ehrh. ex Rohrb.	South Sinai	11	POWO (2022), Täckholm (1974), Boulos (1999–2009)	×	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Silene fruticosa L.	Netherlands, Austria	2, 6	GBIF (2022), JSTOR (2022)	√	√	√	×
Silene leucophylla Boiss.	Saint Catherine, South Sinai	6, 11	POWO (2022), CAI	√	√	×	×
Silene linearis Decne.	Arabian Peninsula	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Silene palaestina Boiss.	Central Sinai (Isthmic desert)	6, 11	Täckholm (1974)	√	√	×	×
Silene pseudoatocion Desf.	Victoria, Norway, Sweden, Germany	2, 6, 34	GBIF (2022), VicFlora (2022)	√	√	×	×
Silene schimperiana Boiss.	Yemen, Arabian Peninsula	6, 11	POWO (2022), Hassler (2004–2022), GBIF (2022)	√	√	×	×
Silene succulenta Forssk. subsp. *succulenta*	Saudi Arabia, Transcaucasus	2, 6, 11	POWO (2022)	√	×	√	×
Silene vivianii Steud. subsp. *vivianii*	Arabia, Iraq	5, 6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Cistaceae							
Fumana thymifolia (L.) Webb	Krym, Isthmic desert of Sinai	5, 6, 11	POWO (2022), Täckholm (1974)	√	√	√	×
Helianthemum crassifolium subsp. *sphaerocalyx* (Gauba & Janch.) Maire		6		√	√	×	√
Helianthemum kahiricum Delile	Gulf States, Iraq, Kuwait, Oman, Saudi Arabia	5, 6, 11	POWO (2022), Boulos (1999–2005), Ahmed (2009)	×	√	×	×
Helianthemum schweinfurthii Grosser	Gebel Shalufa (eastern desert)	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Helianthemum vesicarium Boiss.	West IR-TR, with extensions to the adjacent Mediterranean coastland	5, 6	Zohary (1966, 1987), Ahmed 2009	√	×	×	×
Convolvulaceae							
Convolvulus cneorum L.	New Zealand, absent in Egypt and reported in Egypt in Med-Checklist (2016) in error	6, 37	Boulos (1999–2005), Täckholm (1974), POWO (2022)	×	√	×	×
Convolvulus dorycnium L.	Central Asia	5, 6	POWO (2022)	√	×	×	×
Convolvulus humilis Jacq.				√	√	√	√
Convolvulus oleifolius Desr.	Liberia, Inland areas of Sinai	6, 11, 14	GBIF (2022), Kamel & al. (2008), CAI	√	√	√	×
Convolvulus palaestinus Boiss.	South Sinai	6, 11	El-Husseini & al. (2008)	√	√	×	×
Convolvulus prostratus Forssk.	Sahara, Arabian Peninsula to India	6, 11, 12, 19	POWO (2022), Boulos (1999–2005)	×	√	×	×
Convolvulus secundus Desr.	absent in Egypt and reported in Egypt by Täckholm (1974) in error	6	Boulos (1999–2005), POWO (2022), Med-Checklist (2016), Euro+Med (2006)	√	√	×	×
Convolvulus spicatus Peter ex Hallier f.	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Crassulaceae							
Rosularia lineata (Boiss.) A.Berger	Deserts of South Sinai, Syria and Israel	6, 11	Hassler (2004–2022), CAI, CAIM	√	√	×	×
Cucurbitaceae							
Bryonia cretica L.	Belgium, Bulgaria, Czechoslovakia, Germany, Great Britain, Hungary, Kazakhstan, Netherlands, Sardegna, Sicilia, Switzerland, Tadzhikistan, Uzbekistan	2, 5, 6	POWO (2022), GBIF (2022), JSTOR (2022)	√	√	√	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Bryonia syriaca Boiss.	South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Elatinaceae							
Elatine macropoda Guss.	Germany, Canada, Siberia, Jbel Druze of Syria, El-Khanka, Nile Valley, South Egypt	2, 5, 6, 11	GBIF (2022), CAI, Boulos (1999–2005), Hassler (2004–2022)	×	√	×	×
Ephedraceae							
Ephedra foeminea Forssk.	Tropical Africa, Arabian Peninsula	6, 11, 12	POWO (2022)	×	√	×	×
Ephedra pachyclada subsp. *sinaica* (Riedl) Freitag & Maier-St.	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Euphorbiaceae							
Euphorbia arguta Banks & Sol.	Sudan, Nile Valley	6, 11, 12	POWO (2022), CAI	√	√	×	×
Euphorbia chamaepeplus Boiss. & Gaill.	Iran, Iraq & Arabian Peninsula	5, 6, 11	POWO (2022)	×	√	×	×
Euphorbia dendroides L.	Canary Islands, United Kingdom	2, 6, 7	POWO (2022), GBIF (2022), JSTOR (2022)	√	√	√	×
Euphorbia hierosolymitana Boiss.	W Transcaucasus	2, 6	POWO (2022)	√	√	×	×
Euphorbia obovata Decne.	South Sinai	6, 11	POWO (2022), Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Euphorbia oxyodonta Boiss.	Iraq and IR-TR Jbel Druze (Syria), and Anatolia (Turkey)	5, 6	GBIF (2022), Hassler (2004–2022)	√	√	×	×
Euphorbia parvula Delile		6		√	√	×	√
Euphorbia pterococca Brot.	Canary Islands	6, 7	POWO (2022)	√	×	×	×
Euphorbia punctata Delile	Azerbajan, Ecuador	5, 6, 30	GBIF (2022), JSTOR (2022)	√	√	√	×
Euphorbia terracina L.	Macaronesia, Hungary, Arabian Peninsula	2, 6, 7, 11	POWO (2022)	√	×	√	×
Fabaceae							
Anthyllis vulneraria subsp. *maura* (Beck) Maire	Mauritania	6, 12	GBIF (2022)	√	√	√	×
Argyrolobium uniflorum (Decne.) Jaub. & Spach	Mauritania, Pakistan, Saudi Arabia	5, 6, 11, 12	POWO (2022), Boulos (1999–2005)	×	√	×	×
Astracantha echinus (DC.) Podlech	Suadi Arabia	6, 11	POWO (2022), Hassler (2004–2022)	√	√	×	×
Astragalus amalecitanus Boiss.	Saint Katherine protectorate, South Sinai	6, 11	Rabei & Elgamal (2021)	√	√	×	×
Astragalus asterias subsp. *radiatus* (Batt.) Greuter	Iran, Iraq, Pakistan, Saudi Arabia, Transcaucasus	2, 5, 6, 11	POWO (2022), Boulos (1999–2005), Ahmed (2009)	×	√	×	×
Astragalus camelorum Barbey	Isthmic desert, Sinai	6, 11	CAI, Täckholm (1974)	√	√	×	×
Astragalus cretaceus Boiss. & Kotschy	Iraq	5, 6	POWO (2022), National Registry for Egyptian Herbaria (2022)	√	×	×	×
Astragalus fresenii Decne.	South Sinai	6, 11	CAI, Täckholm (1974)	√	√	×	×
Astragalus fruticosus Forssk.	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Astragalus intercedens Sam. ex Rech.f.	Suadi Arabia	6, 11	POWO (2022), Hassler (2004–2022)	√	√	×	×
Astragalus kralikii Coss. ex Batt.	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Astragalus macrocarpus DC. subsp. *macrocarpus*	Isthmic desert, Sinai	6, 11	Täckholm (1974)	√	√	×	×
Astragalus mareoticus Delile	Canary Islands, Arabian Peninsula	6, 7, 11	POWO (2022)	√	×	×	×
Astragalus palaestinus Eig	El-Bustan, South Sinai	6, 11	Täckholm (1974)	√	√	×	×
Astragalus peregrinus Vahl	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Astragalus sanctus Boiss.	Isthmic desert, Sinai	6, 11	Täckholm (1974)	√	√	×	×
Astragalus sinaicus Boiss.	Arabian Peninsula	6, 11	POWO (2022), GBIF (2022), Med-Checklist (2016) + Euro+Med (2006)	√	√	×	×
Astragalus trigonus DC.	Chad, Mali, Mauritania, Niger, Sudan	6, 12	POWO (2022), GBIF (2022)	√	√	×	×
Astragalus trimestris L.	SA-AR with extensions into the Mediterranean coastal plain	6, 11	Zohary (1966, 1987)	√	√	×	×
Bituminaria flaccida (Nábelek) Greuter	Suadi Arabia	6, 11	POWO (2022), Hassler (2004–2022)	×	√	×	×
Ceratonia siliqua L.	Iran	5, 6	POWO (2022), Hassler (2004–2022)	√	√	×	×
Colutea istria Mill.	Irano-Turanian	5	Flowers in Israel (2022)	√	√	×	×
Coronilla repanda (Poir.) Guss.		6		√	√	×	√
Ebenus armitagei Schweinf. & Taub.		6		√	√	√	√
Hedysarum coronarium L.	Australia and New Zealand	34, 35, 36, 37	Euro+Med (2006), GBIF (2022)	√	√	√	×
Hedysarum spinosissimum L.		6		√	√	√	√
Hippocrepis ciliata Willd.	Absent in Egypt but reported in Täckholm (1974) error, Ukraine	5, 6	Euro+Med (2006), Med-Checklist (2016), Boulos (1999–2005), GBIF (2022)	×	√	×	×
Hippocrepis cyclocarpa Murb.	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Lathyrus hierosolymitanus Boiss.	Afghanistan, Iraq, Iran to central Asia	5, 6	GBIF (2022), Boulos (1999–2005)	×	√	×	×
Lathyrus marmoratus Boiss. & Blanche		6		√	√	√	√
Lathyrus setifolius L.	Canary Islands	6,7	POWO (2022)	√	×	×	×
Lotus tetragonolobus L.	Netherlands, Ukraine, Canary Islands, New South Wales, Victoria, Georgia, China	2, 4, 6, 7	JSTOR (2022), POWO (2022), Hassler (2004–2022)	√	×	√	×
Lotus creticus L.	Canary Islands	6, 7	POWO (2022)	√	×	√	×
Lotus cytisoides L.		6		√	√	√	√
Lotus edulis L.	Netherlands, extends to EU-SR, IR-TR of Turkey	2, 5, 6	JSTOR (2022), Euro+Med (2006), Hassler (2004–2022)	√	√	×	×
Lotus hebranicus Hochst. ex Brand	Eritrea, Sudan	6, 12	POWO (2022), Boulos (1999–2005)	×	√	×	×
Lotus longisiliquosus R.Roem.	Absent in Egypt but reported in error	6	Boulos (1999–2005), POWO (2022), GBIF (2022), Hassler (2004–2022)	×	√	×	×
Lotus peregrinus L.	Netherlands, extends to IR-TR of Turkey (Anatolia) and Syria, SA-AR desert Oases and St. Catherine mountains in Egypt	5, 6, 11	JSTOR (2022), Euro+Med (2006), Hassler (2004–2022), Rabei & Elgamal (2021)	√	√	√	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Lotus polyphyllos Clarke	SA-AR	11	Jafri & El-Gadi (1977–1988)	√	√	√	×
Lupinus digitatus Forssk.	Senegal, Western Sahara	6, 12	POWO (2022)	×	√	×	×
Lupinus palaestinus Boiss.	Central Sinai	6, 11	POWO (2022), Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Medicago granadensis Willd.	Mediterranean, elsewhere adentive, Afghanistan	5, 6	Zohary (1966, 1987), GBIF (2022)	√	√	×	×
Medicago hypogaea E. Small	Iraq	5, 6	POWO (2022), WCSP (2022)	√	√	√	×
Medicago polyceratia (L.) Trautv.	Mauritania	6, 12	POWO (2022)	√	√	×	×
Melilotus elegans Ser.	Djibouti, Ethiopia	6, 12	POWO (2022)	√	×	×	×
Melilotus segetalis (Brot.) Ser.	Liberia	6, 14	POWO (2022)	√	√	×	×
Melilotus serratifolius Täckh. & Boulos	Dakhla oasis	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Ononis natrix subsp. *stenophylla* (Boiss.) Sirj.	Mediterranean with extensions into adjacent territories of the SA-AR region	6, 11	Zohary (1966, 1987)	√	√	×	×
Ononis vaginalis Vahl	W IR-TR with extensions into SA-AR	5, 11	Zohary (1966, 1987)	√	√	×	×
Ononis variegata L.	Canary Islands	6, 7	POWO (2022), GBIF (2022)	√	√	×	×
Pisum fulvum Sm.	Germany, United Kingdom, Russia	2, 3, 6	Hassler (2004–2022), GBIF (2022) herbarium sheets	√	√	×	×
Retama monosperma subsp. *bovei* (Spach) Maire	Sahara of Morocco, absent in Egypt	6, 11	Euro+Med (2006) + Ahmed (2009), eflora Maghreb (2021), POWO (2022), GBIF (2022), WSCSP (2022)	√	×	×	×
Retama raetam (Forssk.) Webb & Berthel. subsp. *raetam*	Saudi Arabia, Sudan, Western Sahara	6, 11, 12	POWO (2022)	√	×	×	×
Trifolium argutum Sol.		6		√	√	√	√
Trifolium constantinopolitanum Ser.	Great Britain, Ireland, Bulgaria, Belgium, absent in Egypt and reported in Egypt in Med-Checklist (2016) in error	2, 6	Boulos (1999–2005), POWO (2022), GBIF (2022), Hassler (2004–2022)	×	√	×	×
Trifolium dichroanthum Boiss.	Armenia, USA	2, 6, 8, 9, 10	GBIF (2022), JSTOR (2022)	√	√	×	×
Trifolium landuliferum var. *nervulosum* (Boiss. & Heldr.) Zohary	North Albania, European Turkey (Euro-Siberian)	2, 6	POWO (2022), Hassler (2004–2022)	√	√	×	×
Trifolium philistaeum Zohary	Isthmic desert, Sinai	6, 11	Täckholm (1974)	√	√	×	×
Trifolium purpureum var. *desvauxii* (Boiss. & Blanche) Post	West Asia, Australia, United states of America	6, 8, 9, 10, 11, 34, 35, 36	GBIF (2022)	×	√	×	×
Trigonella arabica Delile	SA-AR	11	Danin & Fragman- Sapir (2016), Flowers in Israel (2005–2022)	√	√	×	×
Trigonella berythea Boiss. & Blanche		6		√	√	√	√
Trigonella cylindracea Desv.	Iran, Suadi Arabia	5, 6, 11	POWO (2022)	×	√	×	×
Trigonella maritima Poir.	Mediterranean, extending to adjacent deserts	6, 11	Zohary (1966, 1987)	√	√	√	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Trigonella media Delile ex Urb.	Cairo (eastern desert)	6, 11	POWO (2022), Boulos (1999–2005)	×	√	×	×
Trigonella occulta Delile ex Ser.	India, Pakistan, Bhutan and Nepal	4, 5, 6, 19	IPNI (2022), GBIF (2022)	√	√	√	×
Trigonella schlumbergeri Boiss.	Deserts of Syria, Israel and Central Sinai	6, 11	Hassler (2004–2022)	√	√	×	×
Tripodion tetraphyllum (L.) Fourr.	Netherlands, IR-TR Anatolia	2, 5, 6	JSTOR (2022), Hassler (2004–2022)	√	√	√	×
Vicia articulata Hornem.	Iraq	5, 6	POWO (2022)	√	×	√	×
Vicia ervilia (L.) Willd.	Central Asia	5, 6	POWO (2022)	√	×	√	×
Vicia sinaica Boulos		6		√	√	×	√
Vicia villosa subsp. *microphylla* (d'Urv.) P.W.Ball	Canary Islands, Europe to Central Asia and Afghanistan	2, 5, 6, 7	Boulos (1999–2005), POWO (2022)	×	√	×	×
Gentianaceae							
Centaurium malzacianum Maire	Saudi Arabia	6, 11	POWO (2022)	×	√	×	×
Geraniaceae							
Erodium arborescens (Desf.) Willd.	Deserts of Egypt and Palestine	6, 11	CAI, CAIRC, Danin & Fragman-Sapir (2016)	×	√	×	×
Erodium chium (L.) Willd.	Western Sahara and Eritrea	6, 12	POWO (2022)	√	×	√	×
Hypericaceae							
Hypericum lanuginosum Lam.	South Sinai, Anatolia of Turkey and Central Syrian deserts	5, 6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Hypericum sinaicum Hochst. ex Boiss.	Saudi Arabia, South Sinai	6, 11	POWO (2022), Hassler (2004–2022), Täckholm (1974)	×	√	×	×
Iridaceae							
Moraea mediterranea Goldblatt	SA-AR regions of Palestine (Negev Desert), Great Southwestern Desert and central Sinai Peninsula of Egypt	6, 11	Pokorný & Pokorná (2009-2010), Danin & Fragman-Sapir (2016), Flowers in Israel (2005–2022), Hassler (2004–2022)	√	×	×	×
Lamiaceae							
Ballota pseudodictamnus (L.) Benth.	Great Britain	2, 6	GBIF (2022)	√	×	×	×
Phlomis floccosa D.Don	Russia	3, 6	GBIF (2022) herbarium sheet	×	√	√	×
Prasium majus L.	Macaronesia	6, 7	Euro+Med (2006), POWO (2022)	√	×	√	×
Teucrium brevifolium Schreb.		6		√	√	×	√
Thymbra capitata (L.) Cav.		6		√	√	√	√
Ballota kaiseri Täckh.	South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Ballota saxatilis Sieber ex C.Presl subsp. *saxatilis*	Saudi Arabia, South Sinai	6, 11	POWO (2022), World Plants (Complete List), Täckholm (1974)	√	√	×	×
Ballota undulata (Sieber ex Fresen.) Benth.	Saudi Arabia, South Sinai	6, 11	POWO (2022), Hassler (2004–2022), Täckholm (1974)	×	√	×	×
Marrubium alysson L.	Deserts of Egypt and Palestine, Netherlands	2, 6, 11	JSTOR (2022), Danin & Fragman-Sapir (2016), Hassler (2004–2022)	√	√	×	×
Micromeria graeca (L.) Benth. ex Rchb.	Absent in Egyptian flora books and reported in Egypt in Med-checklist (2016) in error	6	Med-Checklist (2016), Boulos (1999–2005), Täckholm (1974)	×	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Micromeria microphylla (d'Urv.) Benth.	USA, absent in Egyptian flora book and reported in Egypt in Med-checklist (2016) in error	6, 8	Med-Checklist (2016), Boulos (1999–2005), Täckholm (1974), GBIF (2022)	×	√	×	×
Micromeria nervosa (Desf.) Benth.	SA-AR region in south Sinai (Egypt) and IR-TR Anatolia (Turkey)	5, 6, 11	Hassler (2004–2022), Täckholm (1974), Flora of Turkey (2022), Davis (1965-1985)	√	√	√	×
Micromeria serbaliana Danin & Hedge	Gebel Serbal, Saint Catherine, South Sinai	6, 11	Boulos (1999–2005), POWO (2022)	×	√	×	×
Nepeta septemcrenata Ehrenb. ex Benth.	Iran, Suadi Arabia	5, 6, 11	GBIF (2022), JSTOR (2022)	×	√	×	×
Origanum isthmicum Danin	Halal mountain, Central Sinai	6, 11	CAI, POWO (2022)	√	√	×	×
Origanum syriacum L. subsp. *sinaicum*	South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Origanum syriacum L. subsp. *syriacum*	Saudi Arabia, not recorded in Egyptian flora books and recorded in Egypt Med-Checklist (2016) in error	6, 11	Boulos, Täckholm (1974), POWO (2022), Hassler (2004–2022)	×	√	×	×
Phlomis fruticosa L.	Transcaucasus, not recorded in Egyptian flora books and recorded in Egypt Med-Checklist (2016) in error	2, 6	Boulos (1999–2005), Täckholm (1974), POWO (2022)	×	√	×	×
*Pseudodictamnus damascenus (*Boiss.) Salmaki & Siadati	Deserts of Egypt and Syria	6, 11	CAIM, TANE, Hassler (2004–2022)	×	√	×	×
Salvia dominica L.	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Satureja cuneifolia Ten.	Iraq, absent in Egyptian flora book and reported in Egypt in Med-checklist (2016) in error	5, 6	Täckholm (1974), Boulos (1999–2005), POWO (2022)	×	√	×	×
Stachys aegyptiaca Pers.	Saudi Arabia	6, 11	POWO (2022)	×	√	×	×
Teucrium leucocladum Boiss.	Saudi Arabia	6, 11	POWO (2022)	×	√	×	×
Thymus bovei Benth.	Deserts of Egypt, Arabia	6, 11	CAI, CAIRC, GBIF (2022), Boulos (1999–2005)	×	√	×	×
Thymus decussatus Benth.	Suadi Arabia	6, 11	POWO (2022), Hassler (2004–2022), Boulos (1999–2005)	×	√	×	×
Linaceae							
Linum decumbens Desf.	Canary Islands	6, 7	POWO (2022)	√	×	×	×
Malvaceae							
Alcea acaulis (Cav.) Alef.	Saint Catherine	6, 11	Rabei & Elgamal (2021)	√	√	×	×
Alcea apterocarpa (Fenzl) Boiss.	South Sinai	6, 11	Täckholm (1974)	√	√	×	×
Molluginaceae							
Glinus runkewitzii Täckh. & Boulos	Luxor, south Egypt	6, 11	Boulos (1999–2005)	×	√	×	×
Oleaceae							
Olea europaea subsp. *europaea* var. *sylvestris* (Mill.) Lehr	Western desert in Egypt, introduced to Angola, Argentina Northeast, Ascension, Bermuda, Canary Is., China South-Central, China Southeast, Corse, Egypt, France, Hainan, Hawaii, Iran, Iraq, Korea, Krym, Lebanon-Syria, Marianas, Mexico Southwest, New Zealand North, Taiwan, Tibet	6, 11	POWO (2022), Boulos (1999–2005), CAI	√	×	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Orobanchaceae							
Orobanche minor var. *grisebachii* (Reut.) Hadidy	Saint Catherine	6, 11	Rabei & Elgamal (2021)	√	√	×	×
Orobanche ramosa var. *schweinfurthii* (Beck) Hadidy	Nile islands at Beni-Suef, middle Egypt	6, 11	Amer & al. (2015)	×	√	√	×
Papaveraceae							
Fumaria gaillardotii Boiss.		6		√	√	√	√
Fumaria judaica Boiss. subsp. *judaica*		6		√	√	√	√
Fumaria microstachys Kralik ex Hausskn.		6		√	√	√	√
Hypecoum aegyptiacum (Forssk.) Asch. & Schweinf.	South Egypt	6, 11	GBIF (2022)	√	√	×	×
Hypecoum aequilobum Viv.	Isthmic desert of Sinai	6, 11		×	√	×	×
Hypecoum imberbe Sm.	Transcaucasus, Iraq	2, 5, 6	POWO (2022)	√	√	×	×
Hypecoum littorale Wulfen	Iraq, Kuwait, Saudi Arabia	5, 6, 11	Boulos (1999–2005), POWO (2022)	×	√	×	×
Hypecoum procumbens L. subsp. *procumbens*	Iraq	5, 6	Boulos (1999–2005), POWO (2022)	×	√	×	×
Papaver humile Fedde	Deserts of Egypt and Israel SA-AR	6, 11	Hassler (2004–2022), Flowers in Israel (2005–2022)	√	√	×	×
Plantaginaceae							
Linaria joppensis Bornm.		6		√	√	×	√
Plantago albicans L.	Canary Islands, Mauritania, Iran, NE Tropical Africa, Arabian Peninsula	5, 6, 7, 11, 12	POWO (2022)	√	×	×	×
Plantago crassifolia Forssk.	South Africa, USA, Canada	2, 6, 8, 9, 10, 16	JSTOR (2022), GBIF (2022), SANBI (2010-2012), Tropicos (2022)	√	×	√	×
Plantago crypsoides Boiss.	SA-AR region of Egypt (central Sinai) and deserts of Israel, Suadi Arabia, Bahrain, Kuwait, Iran	5, 6, 11	GBIF (2022), Hassler (2004–2022)	×	√	×	×
Plantago macrorhiza Poir.	Absent in Egypt but reported in error	6	Med-Checklist (2016), Euro+Med (2006), African Plant Database (2022)	√	×	×	×
Plantago phaeostoma Boiss. & Heldr.	Canary Islands, Deserts of Egypt, central Sinai and deserts of Israel	6, 7, 11	GBIF (2022), Hassler (2004–2022)	×	√	×	×
Plantago sinaica (Barnéoud) Decne.	South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Plantago squarrosa Murray	SA-AR region in central Sinai and eastern desert of Egypt, and IR-TR Anatolia (Turkey), USA	5, 6, 8, 9, 10, 11	JSTOR (2022), Boulos (1999–2005), Hassler (2004–2022)	√	√	√	×
Veronica syriaca Roem. & Schult.		6		√	×	×	√
Plumbaginaceae							
Limoniastrum guyonianum Durieu ex Boiss.	South Morocco, South Algeria	6, 11	GBIF (2022), Hassler (2004–2022)	√	√	×	×
Limoniastrum monopetalum (L.) Boiss.	Mauritania, Canary Islands	6, 7, 12	JSTOR (2022), Hassler (2004–2022)	√	√	√	×
Limonium sinuatum subsp. *romanum* Täckh. & Boulos		6		√	√	√	√

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Limonium sinuatum subsp. *bonduellei* (Lestib.) Sauvage & Vindt	Mauritania, Chad	6, 12	POWO (2022)	√	×	√	×
Limonium sinuatum (L.) Mill. subsp. *sinuatum*	W Sahara and W Caucasus	2, 6, 12	POWO (2022)	√	×	√	×
Limonium avei (De Not.) Brullo & Erben	Absent in the Egyptian flora books and reported in Egypt in Med-checklist (2016) and Euro+Med (2006) in error	6	Täckholm (1974), Boulos (1999–2005), Hassler (2004–2022)	×	√	×	×
Limonium echioides (L.) Mill.		6		√	√	√	√
Limonium narbonense Mill.	Euro Siberian Azores Islands	2, 6	Hassler (2004–2022), GBIF (2022)	√	√	√	×
Limonium sibthorpianum (Guss.) Kuntze	Absent in the Egyptian flora books and reported in Med-Checklist and Euro+Med (2006) in error	6	POWO (2022), Täckholm (1974), Boulos (1999–2005)	×	√	×	×
Limonium tubiflorum (Delile) Kuntze var. *tubiflorum*	Extends to the Libyan desert (DI)	6, 11	CAI, Boulos (1999–2005)	×	√	×	×
Limonium tubiflorum var. *zanonii* (Pamp.) Maire	Extends to the Libyan desert (DI)	6, 11	CAI, Boulos (1999–2005)	×	√	×	×
Poaceae							
Aegilops longissima Schweinf. & Muschl.	East Mediterranean extending into SA-AR	6, 11	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Avena longiglumis Durieu	SA-AR	11	Feinbrun-Dothan (1978, 1986)	√	×	×	×
Cutandia maritima (L.) Barbey	Canary Islands	6, 7	POWO (2022)	√	×	√	×
Cynosurus coloratus Lehm. ex Steud.		6		√	×	×	√
Desmazeria philistaea (Boiss.) H.Scholz		6		√	√	√	√
Holcus annuus Salzm. ex C.A.Mey.	Transcaucasus	2, 6	Euro+Med (2006), POWO (2022)	√	×	×	×
Lagurus ovatus L.	Macaronesia, Arabian Peninsula	6, 7, 11	POWO (2022), Euro+Med (2006)	√	×	×	×
Parapholis filiformis (Roth) C.E.Hubb.	absent in Egypt but reported in error, Belgium, Netherlands, UK	2, 6	Boulos (1999–2005), POWO (2022), Euro+Med (2006), GBIF (2022), JSTOR (2022)	√	×	×	×
Phalaris aquatica L.	Transcaucasus, Canary Islands	2, 6, 7	Euro+Med (2006), POWO (2022)	√	×	×	×
Rostraria berythea (Boiss. & Blanche) Holub	Iran, Iraq, Inner Anatolia, SA-AR regions of Jordon, Israel	5, 6, 11	POWO (2022), Hassler (2004–2022)	×	×	×	×
Rostraria hispida (Savi) Dogan	Kuwait and United Arab Emirates, doubtfully present in Egypt	6, 11	Boulos (1999–2005), POWO (2022), Euro+Med (2006), Med-Checklist (2016)	√	×	×	×
Trisetaria koelerioides (Bornm. & Hack.) Melderis		6		√	×	×	√
Polygalaceae							
Polygala sinaica Botsch. var. *sinaica*	South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Polygonaceae							
Persicaria obtusifolia (Täckh. & Boulos) Greuter & Burdet	Nile valley, south Egypt	6, 11	CAI	×	√	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Polygonum equisetiforme Sm.	Macaronesia, Western Sahara to Central Asia	2, 5, 6, 12	POWO (2022)	×	√	×	×
Rumex aegyptiacus L.	Russia, Nile Valley, south Egypt	3, 6, 11	GBIF (2022), JSTOR (2022), CAI, CAIM	×	√	×	×
Rumex pictus Forssk.	Arabian Peninsula	6, 11	POWO (2022)	×	√	×	×
Posidoniaceae							
Posidonia oceanica (L.) Delile		6		√	×	√	√
Primulaceae							
Coris monspeliensis L.	Somalia, Switzerland	2, 6, 13	POWO (2022), GBIF (2022)	√	√	√	×
Primula boveana Decne. ex Duby	Saint Catherine, South Sinai	6, 11	Hassler (2004–2022), Täckholm (1974)	√	√	×	×
Ranunculaceae							
Adonis dentata Delile	Pakistan, Arabian Peninsula	5, 6, 11	POWO (2022)	×	√	×	×
Delphinium ambiguum L.	Central Europe, South Asia, Australia, USA and Canary Islands	2, 7, 8, 9, 10, 19, 34, 35, 36	POWO (2022), GBIF (2022), Hassler (2004–2022)	√	√	×	×
Delphinium bovei Decne.	Isthmic desert of Sinai	6, 11	Täckholm (1974)	√	√	×	×
Nigella arvensis subsp. *taubertii* (Brand) Maire	Ukraine, Europe, Southwest Asia	2, 6, 11	Euro+Med (2006), (Boulos 1999, 2005)	×	√	×	×
Nigella deserti Boiss.	Iran, Iraq	5, 6	POWO (2022)	√	×	×	×
Ranunculus millefolius Banks & Sol.	Iran, Iraq	5, 6	POWO (2022)	√	√	×	×
Ranunculus sphaerospermus Boiss. & Blanche	China and South Africa	4, 6, 16	POWO (2022)	√	×	×	×
Resedaceae							
Reseda odorata L.	India, South Africa, Netherlands, doubtfully present in Egypt	6, 16, 19	Med-Checklist (2016), Euro+Med (2006), POWO (2022), Täckholm (1974), Boulos (1999–2005), GBIF (2022), JSTOR (2022), El-Beheiry & al. (2020)	×	√	×	×
Reseda orientalis (Müll.Arg.) Boiss.		6		√	√	×	√
Reseda phyteuma L.	Madeira, E Central Europe and S Transcaucasus	2, 6, 7	POWO (2022), Ahmed 2009	√	×	×	×
Reseda lutea L.	Canary Islands, Central Asia and Arabian Peninsula, S Africa	5, 6, 7, 11, 16	POWO (2022), Boulos (1999–2005)	×	√	×	×
Reseda pruinosa Delile	Ethiopia, Sudan	6, 12	POWO (2022)	×	√	√	×
Reseda urnigera Webb	Deserts of Egypt and Israel	6, 11	Hassler (2004–2022)	×	√	√	×
Rhamnaceae							
Rhamnus lycioides subsp. *graeca* (Boiss. & Reut.) Tutin	Absent in Egypt and recorded in Egypt in Med-Checklist (2016) in error	6	POWO (2022), Boulos (1999–2005), Täckholm (1974)	×	√	×	×
Rhamnus lycioides subsp. *oleoides* (L.) Jahand. & Maire	Arabian Peninsula	6, 11	POWO (2022)	√	√	×	×
Rubiaceae							
Crucianella aegyptiaca L.	Arabian Peninsula	6, 11		√	×	×	×
Crucianella maritima L.	Sweden, Canary Islands, SAAR deserts and Oases of Egypt	2, 6, 7, 11	JSTOR (2022), African Plant Database (2022)	√	√	√	×
Galium canum Req. ex DC.	Arabian Peninsula	6, 11	POWO (2022)	√	×	×	×

Appendix 2. Cont'd.

Scientific name	Reason for exclusion	Chorotype (Good 1974)	Source	A	B	C	D
Galium verticillatum Danthoine ex Lam.	Macaronesia, Iran, Somalia	5, 6, 7, 13	POWO (2022)	√	×	√	×
Valantia columella (Ehrenb. ex Boiss.) Bald.		6		√	×	×	√
Santalaceae							
Thesium humile Vahl var. *humile* Vahl	Canary Islands, W Iran and Arabian Peninsula	5, 6, 7, 11	POWO (2022), Euro+Med (2006), GBIF (2022), Hassler (2004–2022)	×	×	√	×
Thesium humile var. *maritima* (N.D.Simpson) F.M.Saad		6		√	×	√	√
Scrophulariaceae							
Verbascum letourneuxii Asch.		6		√	×	×	√
Solanaceae							
Lycium europaeum L.	southwest Asia, Canary Islands	6, 7, 11	Boulos (1999–2005), Euro+Med (2006)	×	×	√	×
Lycium schweinfurthii var. *aschersonii* (Dammer) Feinbrun		6		√	√	√	√
Lycium schweinfurthii var. *schweinfurthii* Dammer in Engl.	Mauritania, Canary Islands	6, 7, 12	GBIF (2022), Hassler (2004–2022)	√	√	√	×
Solanum sinaicum Boiss.	Macaronesia, N Africa to Eritrea and Mozambique, Europe to China and Arabian Peninsula, Indian Subcontinent	2, 4, 5, 6, 7, 11, 12, 13, 15, 19	POWO (2022)	√	×	×	×
Zygophyllaceae							
Zygophyllum aegyptium Hosny	Wadi sudr, sinai	6, 11	Morsy & al. (2015)	√	×	√	×