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Evaluation of Conservation status of the Egyptian endemic plants along the Mediterranean coastal strip region

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Abstract

The IUCN Red List, which provides data on distribution, ecology and habitats, population size, economic uses, threats and conservation actions, is a critical indicator of the status of the world's biodiversity and will assist in informing a necessary conservation decision. The Mediterranean region is characterized by a heavy endemism of plant diversity, where the majority of its species are narrow endemic species. The current investigation aims at evaluating the conservation status, degree of extinction of Mediterranean endemic plants in Egypt and their changes over the recent climate changes. Twenty Field trips were conducted from February 2017 to March 2023, investigating different regions in the coastal Mediterranean strip in Egypt. In addition, all the previous studies performed in the investigated area, scientific literature, and different herbaria have been taken into consideration. Coordinates, main habitats and threats for 15 Mediterranean endemic taxa were conducted during visits to evaluate their level of conservation depending on IUCN categories. The current investigation indicated that nine taxa were found to be threatened (7 endangered, 2 critically endangered). In addition, four taxa were believed to be extinct, while two species were recorded as Data Deficient. Climate changes (drought and excessive temperature) and human impacts (urbanization and tourism) are the most effective threats on the taxa in this region. The present investigation is the pioneer study for completely evaluation of these taxa according to IUCN criteria.

Keywords IUCN assessment · Conservation · Endemism · Mediterranean · Extinction · Biodiversity

Introduction

Species extinction becomes an urgent global issues laid at the basis of biodiversity conservation (Burbidge and Manly 2002). Over the last 100 years, the trends in plant biodiversity loss have been a major source of concern (e.g., Le Roux et al. 2019; Knapp et al. 2020). Despite the great efforts for conserving biodiversity over the last decades, biodiversity possess significant challenges and appears to be lost when it comes to adopting rates at the global level (Pimm et al. 1995; Le Roux et al. 2019). Even though the levels of extinction nowadays are almost known, extinction quantification still vital in order to know the exact rates of extinction and prediction (Ladel 2019). The lack of data about the location of taxa in numerous nations is very clear (Meyer et al. 2016; Sporbert et al. 2019), due to bias in species collection, inappropriate techniques for sampling, lack of facilities for research, and species identification and definition difficulties (Ceballos et al. 2015). It is believed that over 40% of the world's plants are exposed to extinction (Nic Lughadha et al. 2020). Numerous scientists have stated that the Planet is directed to the sixth extinction wave (Pievani 2018; Youngsteadt et al. 2019). The restricted geographic distribution is an important indicator for the degree of extinction in terrestrial plants (Knapp et al. 2020).

An endemic taxa is restricted to confined geographic area due to parameters like isolation, or other abiotic conditions. The knowledge about endemicity is necessary for offsetting conservation priorities (Lima et al. 2020). The restricted geographical distribution of the endemic taxa generally indicates greater vulnerability than other taxa, so it's used as surrogate for identifying the conservation priorities (Mehrabian et al. 2020).

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The Mediterranean basin is one of the world's top 25 biodiversity hotspots. It is regarded as the second-largest biodiversity hotspot (Myers et al. 2000; Lopez-Alvarado and Farris 2022). It includes various terrestrial habitats like rainforests, marshes, pastures, maquis, garrigues, coastal regions, and transitional to desert zones and spans. In addition, it has a higher degree of endemism than other regions and is home to over 25,000 taxa of flowering plants worldwide (Zahran 2010). The Mediterranean region's plant diversity mainly depends on endemism (Fois et al. 2022). It is reported that 60% of the Mediterranean endemics are narrow species, which means that their range is limited to a single, well-defined location within a relatively small portion of the region (Thompson 2020). This area's geographic isolation is characterized by a number of peninsulas, islands and tall mountains (Vargas 2020).

The Mediterranean regions in the globe are most exposed to the consequences of global warming, according to United Nations Environment Program (UNEP 2022). In actuality, the Mediterranean is warming 20% more quickly than other regions in the planet. Precipitation will decrease by 10–15% if global warming is 2 °C. Furthermore, the north section of the Western Mediterranean and Eastern Mediterranean contain hotspots that are predicted to experience increases in water temperature of between 1.8–3.5 °C and the sea level is projected to rise by 0.43 to 2.5 m by 2100. Thus, the region will see more heat waves, coastal erosion, fires, invasive species, floods, sea acidification, and a greater chance of organism's extinction (UNEP 2022). The extensive human activity in the region, together with the intimate connections between its primary landscape, and flora, have shaped and altered the fauna and flora over many thousands of years. Unfortunately, several factors, including population growth and economic development, are currently causing the hotspot to undergo fast anthropogenic change.

Endemic taxa are critical constituents in the flora of most regions, where these taxa have become exposed to extinction within the previous years (El-Khalafy et al. 2021b). Many different resources reported on the number of endemics in Egypt: Boulos (2009) reported 60 endemics**;** Hosni et al. (2013) increased the number to 76 taxa; while Abdelaal et al. (2018) reduced it to 48 taxa. According to El-khalafy et al. (2021a), Egypt is home to 41 endemics distributed in 20 families and 36 genera and. Among them, 36.6% (15 taxa) are home to the Mediterranean basin.

Recently, a huge activities has been performed in numerous countries for the publication of Red Lists depending on the International Union for Conservation of Nature (IUCN) protocol (Stroh et al. 2014; Qin et al. 2017). The IUCN Red List are widely considered the most authoritative available method for assessing the worldwide danger of species extinction (Mace et al. 2008**;** IUCN 2019). Red List data (including habitat characteristics, threats, and conservation measures) may be help in identifying and development of recovery and conservation strategies plans for plants which require special conservation measures (Vié et al. 2008). The IUCN red list methodology uses criteria based on population size, rate and possible causes of decline, and distribution area to assign species to categories of relative extinction risk (IUCN 2019).

Depending on IUCN categories, 13 Mediterranean endemics were threatened (86.7% of the assessed endemics). The high amount of threatened endemics in Mediterranean basin is alarming an wide spread in numerous Mediterranean countries. Orsenigo et al. (2018) evaluated 1340 species of Italian endemic plants. Six taxa were categorized as Extinct. A risk category has been assigned to 300 plants (22.4%). Moreover, 218 plants (16.3%) have been evaluated as Near Threatened (NT) and 560 (41.8%) as Least Concern (LC). Because the available information did not allow a reliable assessment, 247 taxa (18.4%) are assessed as Data Deficient (DD). In addition, Romeiras et al. (2016) evaluated 94 endemics in Cape Verde. Their results showed that 78% of the evaluated endemic plants (92 taxa) were categorized as threatened taxa: 27 as critically endangered, 38 as endangered and seven as vulnerable. In addition, eight taxa were evaluated as near threatened, one as least concern and five as data deficient. Six taxa (6.5%) were Not Evaluated (NE). Besides the 92 assessed endemics, two taxa were listed as Extinct (EX).

Endemic plants are an essential component in the Mediterranean flora which is rich in these endemic taxa. Numerous of these endemics are already extinct, while the others become very rare and exposed severely to extinction because of great threats, especially overcollection, overgrazing and construction activities (El-Khalafy et al. 2023). Therefore, the aims of the current investigation are to increase evaluation of endemics in Mediterranean regions by 1-confirming their existence or extinction; 2- IUCN assessment with determination of ecological, conservation conditions, and risk degree; and 3- species new assessments proposed in the current investigation and the previous ones.

Material and Methods

Study area

The northwestern portion of Egypt is a considerably diversified area with an extension Mediterranean coast for about 1000 km. It is classified into three different geomorphologic regions (Fig. 1): the western region, which is defined as the western North Coast with a length of 550 km; the middle region represents the coast of Delta with a length of 250 km; the eastern region extends for 200 km in North Sinai. The Mediterranean Sea is comparatively large, and includes sand dunes, lakes and lagoons, deltaic sediments,, mud flats, plateaus and rocky beaches (Hereher 2013).

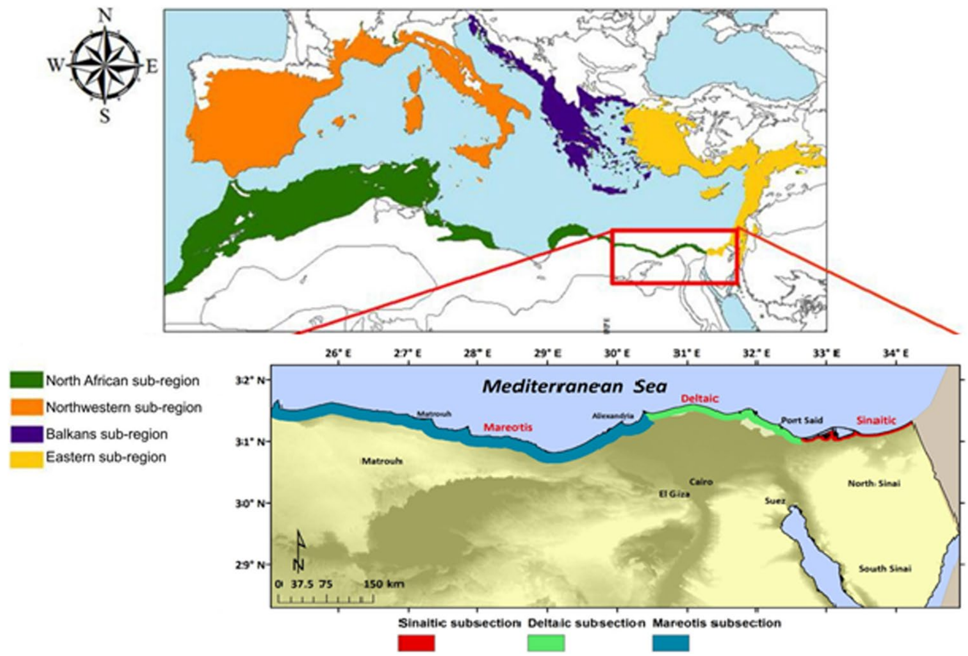


Fig. 1 Map indicating the study area (Bedari et al. 2023)

Field trips

Twenty Field trips have been performed between February 2017 till March 2023 to different locations in the Mediterranean basin (e.g. Demiatta, Gamasa, Baltim, Rashid, Edku, Alexandria, Burg-Elarab, Alamine, Omayed El-Dabaa, Ras El-Hekma, Sidi Abdel-Rahman, El-Zaytona, Matrouh). The target of these field trips is to confirm the existence of these endemics in their own habitats, evaluation of the previous studies in the research area, and scientific literature. In addition, different herbaria were visited (e.g., Cairo (CAI), Tanta (TANE), Alexandria (ALEX), Aswan (ASW) and Assiut (ASTU) Universities Herbaria. The endemic species' specimens gathered from various sites. Furthermore, seed samples as possible were gathered. Identification and synonyms were selected depending on Täckholm (1974), Boulos (1999–2005, 2009) and (https://powo.science.kew.org/).

IUCN assessment

IUCN Red Criteria: Version 3.1 was utilized for evaluating the current conservation and ecological conditions of the studied plants (IUCN 2012), and its guidelines (IUCN 2019). The current investigation included a comparative analysis between the previously prepared assessment and the updated List. Criterion B "Geographic range: B1 (extent of occurrence) AND/OR B2 (area of occupancy)" are used for gathering the following information:

Geographic range

Using ArcGIS 10.4.1., the study locations were plotted. Depending on IUCN Standards and Petitions Committee (IUCN 2019), Occurrence extent (EOO), Area of Occupancy (AOO), and quantity of locations where the species was found were assessed. The EOO and AOO were calculated and mapped using the Geospatial Conservation Assessment Tool (http://www.geocat.Kew.org). In the current study, the phytogeographic regions are detected according to Wickens (1977).

Population Characteristics and habitat

In accordance with the IUCN Standards and Petitions Committee (IUCN 2019), the total number of mature individuals was counted to evaluate the estimate of studied taxa subpopulations and populations. The IUCN Habitats Classification Scheme ver. 3.1 (https://www.iucnredlist.org/resources/classificationschemes) is the ideal tool for documentation of its habitats.

Threats

All the threats which impacted the target species were documented in the field (over-collecting, overgrazing, drought, construction processes and others) (Assi 2007). Threat characteristics were determined according to the IUCN Threats Classification Scheme ver. 3.2 (https://www.iucnredlist.org/resources/classificationschemes).

Red list category and Conservation strategies

Species are assigned to a category if they meet the appropriate quantitative threshold for one of five criteria at least (IUCN 2019). Version 3.1 Categories and Criteria were used. Moreover, IUCN Classification Scheme was used to propose conservation requirements, and activities, needed to save these threatened species.

Soil analysis

Soil sampling and analysis

Three randomly distributed composite soil samples were collected as profiles (0–50 cm depth) from the zones of active roots of different plants, brought to the laboratory in plastic containers, spread over paper sheets for air drying, passed through 2 mm sieve to separate gravel and debris, and packed in plastic containers until analysis. Soil texture was detected using the Bouyqucous hydrometer method, whereby the percentages of clay, silt and sand were calculated (Allen et al. 1986). Soil extracts were prepared as 1:5 (w/v) soil / distilled water extract to measure Electrical Conductivity (EC), pH, carbonates, bicarbonates, chloride, sulphates, nitrates, nitrites, phosphorus, calcium, magnesium, sodium and potassium. Soil reaction (pH) was estimated using a glass electrode pH-meter (Jenway 3020, Cole-Parmer, Staffordshire, UK). EC (dSm^{-1}) and total dissolved salts (TDS) (ppm) were assessed using a direct indicating conductivity bridge using a conductivity meter. Total organic matter was determined by loss on ignition at 550OC (Parkinson and Quarmby 1974), and calcium carbonate was calculated using Bernard's calcimeter (Betremieux 1948). Carbonates and bicarbonates were estimated by titration against 0.01N HCl using phenolphthalein and methyl orange as indicators, respectively (Allen et al. 1986). Sulphates were determined using the gravimetric with the ignition of residue method (Harrison and Perry 1986). Chlorides were estimated by direct titration against silver nitrate using 5% potassium chromate as the indicator (Kolthoff and Stenger 1947; APHA 1981; Hazen 1989). Ca + 2 and Mg + 2 were measured by titration, while Na + and K + were determined using a flame photometer (Corning 410 BWB, Sherwood Scientific Ltd., Cambridge, UK). For the determination of some available nutrients, soil extracts using 2.5% v/v glacial acetic acid were prepared. Total nitrogen was determined using Micro-Kjeldahl apparatus (VELP UDK 130, VELP Scientifica Srl, Usmate Velate, Italy). Molybdenum blue and Indo-phenol blue were used for the estimation of P and N by Spectrophotometer at 700 nm and 660 nm, respectively. Fe, Zn, Mn, and Cu concentrations were determined using atomic absorption (GBC 932 AA, GBC Scientific Equipment Ltd., Dandenong, Australia). A flame photometer was used for estimation of K. All these procedures are outlined by Jackson (1960), Bear (1975) and Allen et al. (1986).

Results

Floristic analysis

Fifteen taxa (11 species, 2 varieties, 2 subspecies) belonging to 14 genera and 9 families were assessed. Asteraceae has the highest percentage (4 taxa), then Asparagaceae (3 taxa), and Amaryllidaceae (2 taxa), while other families contain one taxon only (Table 1).

IUCN assessment

The fifteen taxa are home to Mediterranean basin, extending from El-Sallum to Al-Arish and Rafah in the eastern part. Depending on the present study, four species are believed to be extinct (*Bellevalia salah-eidii*, *Limonium sinuatum* subsp. *romanum*, *Muscari salah-eidii* and *Vicia sinaica*), while data deficient category are represented by two species (*Fumaria microstachys* and *Muscari albiflorum*), as no information is available about their area of occupancy, the extent of occurrence, population characteristics, soil characteristics, ecology, and habitat. There are 15 Mediterranean endemics that defined in the current investigation. To summarize, 13 taxa of the regionally assessed plants are subjected to extinction (about 86.7% of the evaluated endemics). They include 7 species (46.7%) evaluated as Endangered and 2 species (13.3%) listed as Critically Endangered. An additional 4 species (26.7%) are recorded as Extinct. Further, 2 species (13.3%) are classified in the category Data Deficient (Fig. 2, Table 2). The following is a detailed evaluation of these taxa:

Allium mareoticum Bornm. & Gauba

Allium mareoticum is a bulbous geophyte, used as medicinal plant and human food sources. It is home to the Mediterranean strip from Alexandria to Matrouh at El-Dabaa region near the sea shore and Omayed region (Fig. 3–1). This taxon is usually present near water. This taxon was considered extinct for a long time, but recently, it is found in two locations (El-Dabaa region and Omayed region). Its extent of occurrence (EOO) is 125.2 km^2, and its area of occupancy (AOO) is 20 km^2 (Table 2). It qualifies as endangered (EN) under criteria EN B1ab (i, iii, v) + 2ab (i, iii, v); CR C2a(i). The estimated population size during the field trips was 25 individuals. The expected total population size of between 25 and 100 mature individuals. There are separate subpopulations, with mature individuals in each one ranging from 2–5. *A. mareoticum* is distributed in desert spots in rocky sandy regions. During the field study, this

Table 1 Properties of the Red List evaluation of the studied endemic taxa according to IUCN categories. The life forms are coded as follows: CH: chamaephyte, HE: hemicryptophyte, GH; geophyte-helophyte, TH: therophyte, and Ge: geophyte. The collected species is denoted with *. The uses are: *Md*: medicinal, *Hf*: human food, *Gr*: Grazing, *Fu*: fuel and *Et*: Ethetic uses

Scientific name	Life form	Flowering time	Pop. Size in the field	Expected Total Pop. Size (ind.)	Mat. Individuals in large subpop.	Pop. trend	System	Habitat	Soil	Uses	Associated Species
Amaryllidaceae											
*Allium mareoticum**	GH	March–May	25	25- 100	2–5	Decreasing	terrestrial	Desert areas	Rocky sandy near the sea shore	Md, Hf	*Ajuga iva*, *Adonis dentata*
*Pancratium arabicum**	GH	May–June, Aug.-Sep	75	50–200	3–15	Decreasing	terrestrial	Coastal sandy dunes	Sandy	Md, Hf	*Pancratium maritimum, Aegilops bicornis, Cakile maritima, Lotus pollyphyllos, Ammophila arenaria*
Asteraceae											
*Anthemis microsperma**	TH	Feb.-May	100	75–300	5–30	Decreasing	terrestrial	Desert areas	Rocky sandy	Md, Gr	*Anabasis articulata*, *Abutilon longicuspe*, *Aeluropus lagopoides* and *Aerva javanica*
Atractylis carduus var. *marmarica**	TH	March-Aug	250	200–500	10–75	Decreasing	terrestrial	Desert areas	Rocky sandy	Md, Gr, Fu	*Asphodelus macrocarpus*, *Aegilops kotschyi*, *Ajuga iva*, *Allium roseum*
*Echinops taeckholmianus**	HE	June-July, March–April	1200	1000–3000	100–500	Decreasing	terrestrial	Sandy areas	Sand dunes near the sea	Md, Gr	*Alhagi graeco*rum, *Astragalus sieberi* and *Echinops spinossimus*
*Sonchus macrocarpus**	CH	March–May	600	500–2000	10–50	Decreasing	terrestrial	moist ground and canal banks	Sandy	Md, Hf, Fu	*Lysimachia arvensis, Sonchus oleraceous, Arthrocnemum macrostachyum, Symphyotrichum squamatum*
Plantaginaceae											

Table 1 (continued)

Scientific name	Life form	Flowering time	Pop. Size in the field	Expected Total Pop. Size (ind.)	Mat. Individuals in large subpop.	Pop. trend	System	Habitat	Soil	Uses	Associated Species
Veronica anagalloides subsp. *taeckholmiorum**	TH	March–May	65	40–100	2–5	Decreasing	terrestrial	irrigation canals and ditches	Loamy sandy	Md, Gr	*Amaranthus lividus*, *Veronica anagallis-aquatica*, *Chenopodium murale*, *Chenopodium album*
Poaceae											
*Bromus aegyptiacus**	TH	March–May	50	25–100	2–10	Decreasing	terrestrial	sandy areas	Sandy soil	Md, Gr	*Coincya tournefortii*, *Bassia indica*, *Atriplex semibaccata*, *Atriplex turcomanica*
Santalaaceae											
Thesium humile var. *maritima**	TH	Feb.-April	30	50–100	3–10	Decreasing	terrestrial	coastal sandy regions	Loamy sandy	Md, Gr	*Helianthemum lippi*, *Allium roseum* var. *tourneuxii*, *Artemisia herba-alba* and *Aegilops kotschyi*
Asparagaceae											
Bellevalia salaheidii	GH	-		-	-	-	terrestrial	Desert areas	sandy	Md, Hf	-
Muscari albiflorum	GH	-		-	-	-	terrestrial	Desert areas	sandy	Md, Hf	-
Muscari salaheidii	GH	-		-	-	-	terrestrial	Desert areas	sandy	Md, Hf	-
Fabaceae											
Vicia sinaica Boulos	TH	-		-	-	-	terrestrial	Desert areas	Sandy plains	-	-
Fumariaceae											
Fumaria microstachys	TH	-		-	-	-	terrestrial	Cultivated lands	Cultivated land	Md, Et	-
Plumbaginaceae											
Limonium sinuatum subsp. *romanum*	HE	-		-	-	-	terrestrial	moist ground	-	Md, Et	-

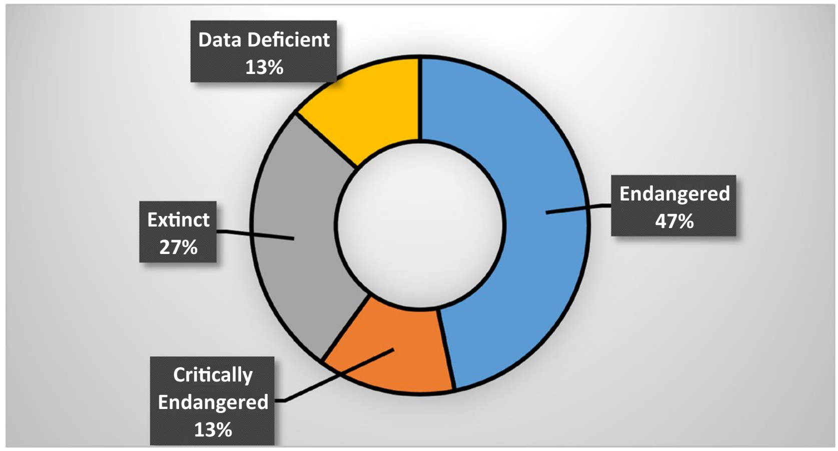


Fig. 2 Global Red List status of the studied taxa

species was primarily restricted to rocky sandy regions near the sea shore associated with *Ajuga iva* and *Adonis dentata* (Table 2). *A. mareoticum* is found on sandy soils with 97% sand, 1% silt and 2% clay. This taxa occupied soils that have high contents of K^+ and P (1.7 meq l^{-1} and 27 ppm, respectively) (Table 3).

Anthemis microsperma Boiss. & Kotschy

Anthemis microsperma is annual herb, used as medicinal plant and grazing source. Depending on the field surveys, Herbarium specimens and literature reviews, this species is home to Mediterranean strip (Matrouh to Al-Arish and Rafah). It was more concentrated in Burg El-Arab & El-Alamin (Omayed), E-Dabaa-Matrouh and very rare in other locations (Rafah-Al-Arish) (Fig. 3–2). This species was also present in the Sinai region, but no specimens were collected from North Sinai for a long time. Its EOO is 174.26 km^2, and an AOO of 36 km^2 (Table 2). It qualifies as endangered (EN) under criteria EN B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i). The estimated population size during the field trips was 100 individuals. The expected total population size of between 75 and 300 mature individuals. The number of mature individuals in each subpopulation ranges from 5–30 in the largest one. *A. microsperma* is distributed in desert spots in rocky sandy regions. During the field study, this species was found to be primarily restricted to rocky sandy regions in high-elevation plateaus and road sides associated with *Anabasis articulate*, *Abutilon longicuspe*, *Aeluropus lagopoides* and *Aerva javanica* (Table 2). *A. microsperma* is found on sandy soils with 95% sand, 3% silt and 2% clay. This species is occupied soils that have high contents of P (26 ppm) (Table 3).

Atractylis carduus var. *marmarica* Täckh. & Boulos

Atractylis carduus var. *marmarica* is perennial herb, used as medicinal plant, grazing source and fuel. It is home to Mediterranean strip (from Alexandria to Matrouh) and Libyan Desert (Fig. 3–3). It is concentrated in four locations: Burg El-Arab & El-Alamin, Sidi Abdelrahman-Eldabaa, Matrouh-Sallum and Libyan Desert Locations. It is more concentrated in Mediterraneanstrip. Its EOO is 1693.3 km^2, and an AOO of 48 km^2 (Table 2). It qualifies as endangered (EN) under criteria EN B1ab (i,ii,iv,v) + 2ab (i,ii, iv,v); C2a(i). The total population size recorded in the field was 250 individuals. The expected total population size of between 200 and 500 mature individuals. The number of mature individuals in each subpopulation ranges from 10–75 in the largest one. *Atractylis carduus* var. *marmarica* is distributed in desert spots in rocky sandy regions. This species was primarily restricted to rocky sandy regions in high-elevation plateaus associated with *Asphodelus macrocarpus*, *Aegilops kotschyi*, *Ajuga iva*, *Allium roseum*, *Anabasis articulata* and *Asphodelus microcarpus* (Table 2). *Atractylis carduus* var. *marmarica* is found on sandy soils with 99% sand, 0.5% silt and 0.5% clay. This species occupied soils that have high contents of sand (99%), and low contents of $so4^{--}$, silt, clay, organic matter, $caco^3$ (1.0 meq l^{-1}, 0.5%, 0.5%, 0.1% and 1.7, respectively) (Table 3).

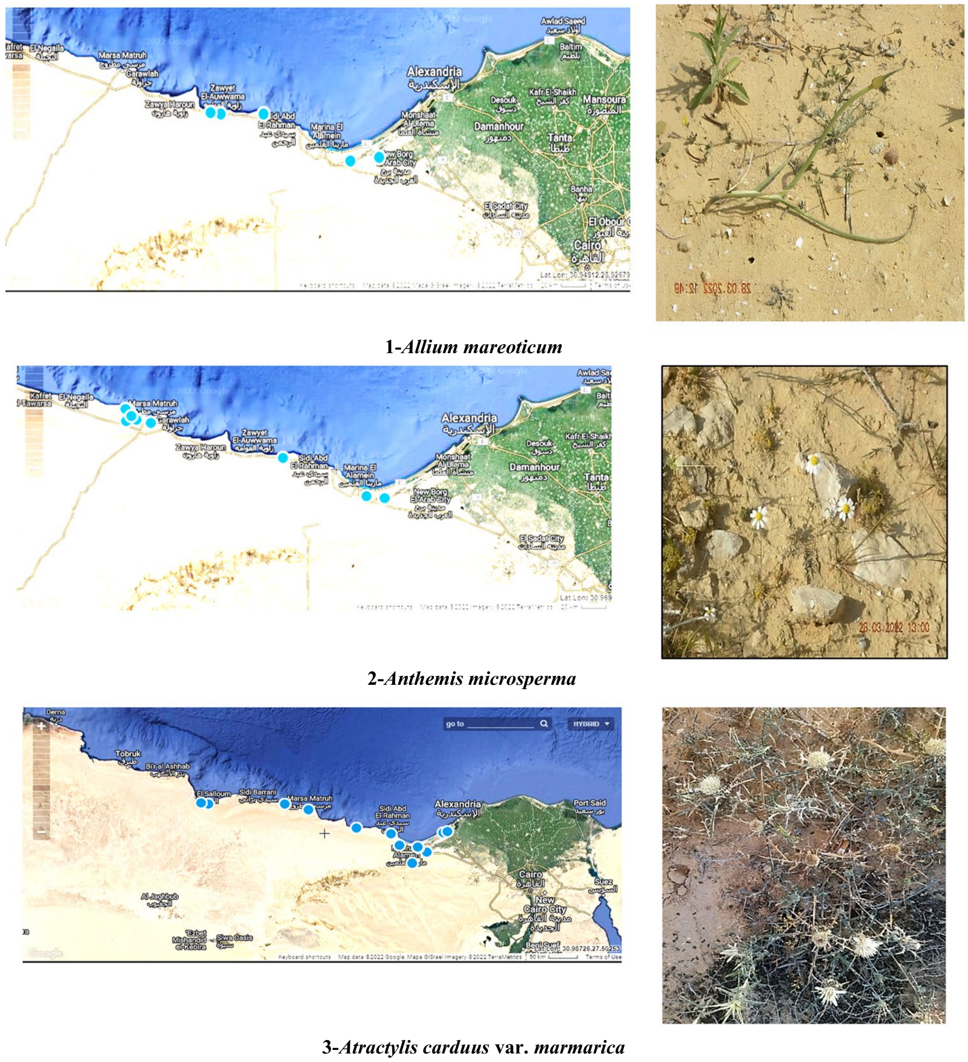
Bromus aegyptiacus Tausch

Bromus aegyptiacus is annual herb, used as medicinal plant, grazing and food sources. Depending on the field surveys, Herbarium specimens and literature reviews, this species is endemic to Mediterranean strip (from Rosetta to Alexandria), Nile region and Eastern Desert (Fig. 3–4). Recently, this taxon become very rare and much threatened. Its EOO is about 54.787km^2, and an AOO of 16 km^2 (Table 2). It qualifies as critically endangered under criteria CR B1ab (i,ii,iii,iv,v); C2a(i). The estimated population size during the field trips was 50 individuals. The expected total population size of between 25 and 100 mature individuals. The number of mature individuals in each subpopulation ranges from 2–10 in the largest one. *Bromus aegyptiacus*

Table 2 Comparison of the Red List evaluation of the studied taxa in the present study with three previous studies according to IUCN categories. These studies are coded as: I: Hosni et al. (2013), II: EL-Hadidi and Hosni (2000), and III: IUCN (1998). The conservation categories are coded as follows: *EN*: endangered, *VU*: vulnerable, *LC*: least concern, *RA*: rare, *IN*: indeterminate, *CR*: critically endangered, *EX*: extinct, *DD*: data deficient and *NE*: non-evaluated. *AOO*: Area of occupancy and *EOO*: Extent of occurrence

Scientific name	Previous studies			Present study	IUCN criteria	Justification		No. of locations	Sector
	I	II	III			EOO (km^2)	AOO (Km^2)		
Amaryllidaceae									
Allium mareoticum	CR	EN	NE	EN	B1ab (i,iii,v) + 2ab (i,iii,v); CR C2a(i)	125.2	20	2	El-Dabaa, Omayed
Pancratium arabicum	EN	EN	NE	EN	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i)	2766	64	6	Matrouh, El-Dabaa-Ras El-Hekma, Alexandria, Rashid-Idku, Baltim-Gamasa and Rafah-Al-Arish
Asparagaceae									
Bellevalia salah-eidii	EX	EN	EN	EX	-	-	-	1	El-Hammam
Muscari albiflorum	CR	-	EN	DD	-	-	-	1	Sallum
Muscari salah-eidii	EX	EN	RA	EX	-	-	-	2	Rafah, Alexandria
Asteraceae									
Anthemis microsperma	VU	-	NE	EN	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i)	174.3	36	3	Burg El-Arab & El-Alamin (Omayed), E-Dabaa-Matrouh, Rafah-Al-Arish
Atractylis carduus var. *marmarica*	EN	-	NE	EN	B1ab (i,ii,iv,v) + 2ab (i,ii, iv,v); C2a(i)	1693.3	48	4	Burg El-Arab & El-Alamin, Sidi Abdelrahman-Eldabaa, Matrouh and Libyan desert Locations
Echinops taeckholmianus	EX	IN	NE	EN	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i)	962.5	20	3	Baltim-Idku (El-Hammad village), Alexandria and El-Dabaa
Sonchus macrocarpus	VU	RA	NE	EN	B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v)	3146.1	36	6	Matrouh (El-Negela), Mariut Lake, Alexandria, Rashid-Idku, Baltim-Gamasa and Kafrelsheikh
Fabaceae									
Vicia sinaica Boulos	EX	IN	RA	EX	-	-	-	1	Al-Arish
Fumariaceae									
Fumaria microstachys	CR	RA	NE	DD	-	-	-	1	Matrouh
Plantaginaceae									
Veronica anagalloides subsp. *taeckholmiorum*	-	-	NE	CR	B2ab (i,iv,v); C2a(i)	124.9	8	2	Kafrelsheikh and Mariut lake
Plumbaginaceae									
Limonium sinuatum subsp. *romanum*	EX	-	NE	EX	-	-	-	1	Matrouh
Poaceae									
Bromus aegyptiacus	VU	-	NE	CR	B1ab (i,ii,iii,iv,v); C2a(i)	54.8	16	1	Lake Mariut
Santalaceae									
Thesium humile var. *maritima*	VU	-	NE	EN	B1ab (i,iii,v) + 2ab (i,iii,v)	491.1	40	5	Alexandria, Alamin-Burg Elarab, Sidi Abdelrahman-El-Dabaa, Matrouh and Sidi-Baranni-Sallum

Fig. 3 Distribution range and photos of nine recorded Mediterranean Egyptian endemics in their own habitats



is distributed in sandy regions associated with *Coincya tournefortii*, *Bassia indica*, *Atriplex semibaccata*, *Atriplex turcomanica*, *Atriplex halimus*, *Amaranthus viridis* and *Apium graveolens* (Table 2). It is found on sandy soils with 90% sand, 6% silt and 4% clay. This species is occupied soils that have high contents of k^+ and Hco_3^- (1.7 meq l^{-1} and 8.8 meq l^{-1}, respectively) (Table 3).

Echinops taeckholmianus Amin

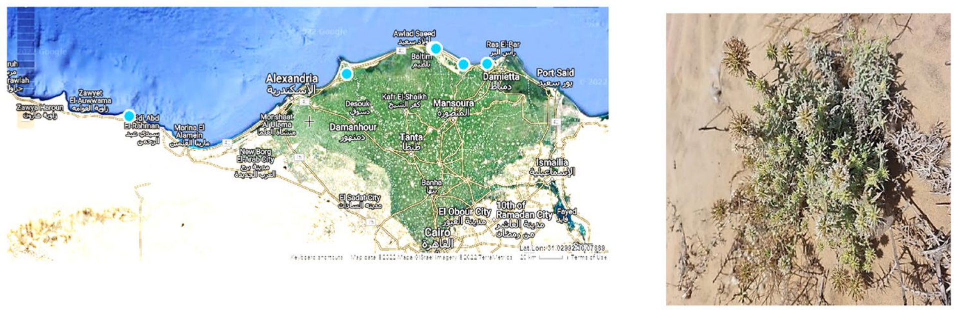
Echinops taeckholmianus is perennial herb, used as medicinal plant and grazing source. It is endemic to Mediterranean strip (From Baltim to Matrouh) and Deltaic sector of Mediterranean. It is concentrated in three main locations: Baltim-Idku, Alexandria and El-Dabaa Locations. It was more concentrated in the Eastern portion (Blatim) and very rare in the Western portion and Delta. This taxon is usually present in sandy soil near the sea. It was more concentrated on the littoral sand dunes and their nearby cultivations of Idku, Baltim and El-Dabaa (Fig. 3–5). Its EOO is about 962.465 km^2, and an AOO of 20 km^2 (Table 2). It qualifies as endangered under category EN B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i). The estimated population size during the field trips was 1200 individuals. The expected total population size of between 1000 and 3000 mature individuals. The number of mature individuals in each subpopulation ranges from 100–500 in the largest one. *E. taeckholmianus* is distributed in dunes near the sea (Fig. 9b) associated with *Alhagi graecoru*m, *Astragalus sieberi* and *Echinops spinossimus* (Table 2). It is found on sandy soils with 97% sand, 2% silt and 1% clay. This species is occupied soils that have low values of EC (0.9 dS m^{-1}) (Table 3).

Pancratium arabicum Sickenb

Pancratium arabicum is a perennial bulb, used as medicinal plant, and food source. It is concentrated in Mediterranean strip from Matrouh reaching Al-Arish and Rafah (Fig. 3–6).

Fig. 3 (continued)

4-*Bromus aegyptiacus*



5-*Echinops taeckholmianus*

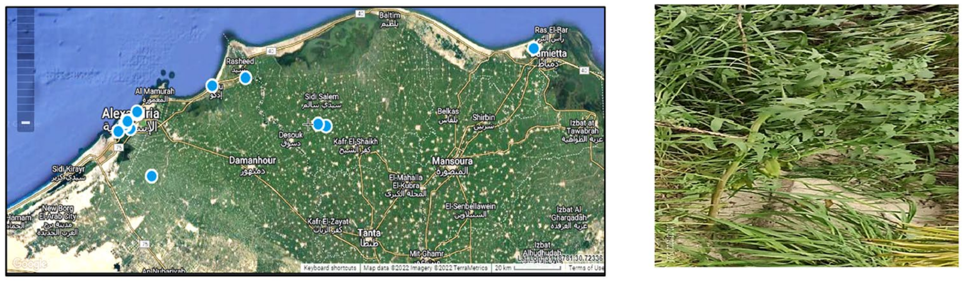
6-*Pancratium arabicum*

It was distributed in six locations: Matrouh, El-Dabaa-Ras El-Hekma, Alexandria, Rashid-Idku, Baltim-Gamasa and Rafah-Al-Arish locations. Recently, it is observed along the road between Baltim and Gamasa. Also, it was gathered from Kom El-Aqula (between Baltim and Rashed). Its EOO is about 2766 km^2, and its AOO is 64 km^2 (Table 2). It qualifies as Endangered (EN) under criteria EN B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v); C2a(i). The estimated population size during the field trips was 75 individuals. The expected total population size of between 50 and 200 mature individuals. The number of mature individuals in each subpopulation ranges from 3–15 in the largest one. *Pancratium arabicum* is distributed in coastal sandy dunes associated with *Pancarium maritimum, Aegilops bicornis, Cakile maritima, Lotus pollyphyllos, Ammophila arenaria* and *Zygophyllum album* (Table 2). It is found on sandy soils with 99% sand, 0.5% silt and 0.5% clay. This plant is occupied soils that have high contents of cl$^-$ and sand (13.7 meq l^{-1} and 99%, respectively), and low contents of silt, clay, organic matter and Zn (0.5%, 0.5%, 0.1% and 0.11 ppm, respectively) (Table 3).

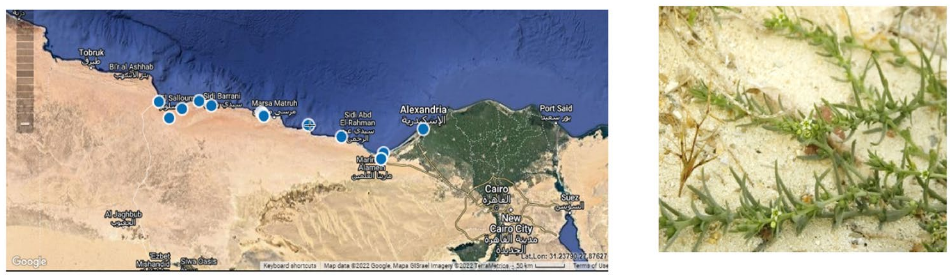
Sonchus macrocarpus Boulos & C.Jeffrey

Sonchus macrocarpus is annual or short-lived perennial herb, used as medicinal plant, grazing and food sources. Depending on the field surveys, Herbarium specimens and literature reviews, this species is endemic to the Nile Delta, Mediterranean Coast and Eastern desert regions (Fig. 3–7). Recently**,** it was showed that this species is more concentrated in Alexandria, but very rare in the Nile area. In addition, No recent record of this taxon in the eastern desert. It was distributed in six locations: Matrouh (El-Negela), Mariut Lake, Alexandria city, Rashid-Idku, Baltim-Gamasa and Kafrelsheikh city locations. Its EOO is about 3146.135 km^2, and its AOO is 36 km^2 (Table 2). It qualifies as endangered

Fig. 3 (continued)



7-***Sonchus macrocarpus***



8-*Thesium humile* var. *maritima*

9-*Veronica anagalloides* subsp. t*aeckholmiorum*

(EN) under criteria EN B1ab (i,ii,iii,iv,v) + 2ab (i,ii,iii,iv,v). The estimated population size during the field trips was 600 individuals. The expected total population size of between 500 and 2000 mature individuals. The number of mature individuals in each subpopulation ranges from 10–50 in the largest one. *Sonchus macrocarpus* is distributed in moist ground and canal banks associated with *Lysimachia arvensis, Sonchus oleraceous, Arthrocnemum macrostachyum, Aster squamatus, Bromus rubens* and *Bassia indica*. Recently, it is recorded along roadsides in different regions in Alexandria (Table 2). It is found on sandy soils with 98% sand, 0.5% silt and 1.5% clay. This species is occupied soils that have high contents of k^+ (1.7 meq l^{-1}), and low contents of pH, Mg + +, silt, and Cu (7.7, 0.6 meq l^{-1}, 0.5%, and 0.04 ppm, respectively) (Table 3).

Thesium humile var. *maritima* (N. D. Simpson) Sa'ad

Thesium humile var. *maritima* is semi-parasite annual herb, used as medicinal plant, and grazing human sources. Depending on the field surveys, Herbarium specimens and literature reviews, this species is endemic to the Mediterranean strip from Alexandria to Matrouh. (Fig. 3–8). This taxon become very rare and disappeared from different locations. It is observed in five locations (Alexandria, Alamin-Burg Elarab, Sidi Abdelrahman-El-Dabaa, Matrouh and Sidi-Baranni-Sallum). Recently, it was observed only in Alamin-Burg Elarab and Matrouh locations. Its EOO is about 4919.116 km^2, and its AOO is 40 km^2 (Table 2). It qualifies as endangered (EN) under criteria **EN B1ab (i, iii, v) + 2ab (i, iii, v)**. The estimated population size during the field trips was 30 individuals. The expected total population size of between 50 and 100 mature individuals. The number of mature individuals in each subpopulation ranges from 3–10 in the largest one. *Thesium humile var. maritima* is distributed coastal sandy regions associated with *Helianthemum lippi*, *Allium roseum*, *Artemisia herba-alba* and *Aegilops kotschyi* (Table 2). It is found on loamy sandy soils with 74.4% sand, 17.1% silt and 8.2% clay. This species is occupied soils that have high contents of pH, silt, and $Caco_3$ (8.9, 17.1%, and 17.3, respectively), and low contents of most soil parameters (Table 3).

Table 3 Soil analysis of the recorded endemic taxa. *EC*: electric conductivity, *SP*: saturation percentage, *SAR*: sodium absorption value, *TDS*: Total dissolved salts, *OM*: organic matter. The highest values are in bold, while the lower ones are underlined

Sample No	pH	EC (dS m^{-1})	Soluble salts (meq l^{-1})							SAR	TDS (ppm)	Texture			OM (%)	$CaCO_3$	Available levels of nutrients (p.p.m)						
			Anions				Cations																
			Ca^{++}	Mg^{++}	Na^{+}	K^{+}	HCO_3^{-}	Cl^{-}	SO_4^{--}			Sand	Silt	Clay			N	P	K	Fe	Zn	Mn	Cu
Allium mareoticum	7.9	4.7	23.0	5.0	20.0	**1.7**	2.0	3.6	44.0	5.3	3027	97.0	1.0	2.0	2.7	2.8	1.6	**26.0**	116.0	0.88	0.41	0.07	0.12
Anthemis microsperma	8.0	1.9	9.0	0.8	7.5	0.7	7.0	9.0	2.0	3.4	1235	95.0	3.0	2.0	0.7	4.6	2.1	**26.0**	120.0	1.87	0.43	0.19	0.21
Atractylis carduus var. *marmarica*	7.9	1.3	5.4	0.8	4.4	0.8	5.0	5.4	1.0	2.5	838	**99.0**	0.5	0.5	0.1	1.7	2.0	18.0	120.0	0.23	0.23	0.08	0.21
Bromus aegyptiacus	7.8	1.9	9.0	1.8	4.7	**1.7**	**8.8**	3.6	4.7	2.0	1184	90.0	6.0	4.0	1.7	3.7	3.1	21.0	112.0	1.65	0.32	0.04	0.21
Echinops taeckholmianus	8.2	0.9	3.4	1.0	3.5	1.4	5.0	2.7	1.6	2.3	570	97.0	2.0	1.0	0.5	2.5	2.4	18.0	121.0	0.32	0.54	0.10	0.23
Pancratium arabicum	8.2	2.2	3.2	1.4	16.0	0.7	2.0	**13.7**	5.6	10.6	1389	**99.0**	0.5	0.5	0.1	12.6	1.5	21.0	119.0	1.10	0.11	0.22	0.07
Sonchus macrocarpus	7.7	1.8	14.2	0.6	3.2	**1.7**	7.8	4.3	7.6	1.2	1152	98.0	0.5	1.5	1.1	8.9	1.6	24.0	121.0	1.60	0.22	0.32	0.04
Thesium humile var. *maritima*	**8.9**	0.9	1.0	2.3	1.3	0.2	1.4	1.6	1.8	5.4	640	74.4	17.1	8.2	0.1	**17.3**	1.4	23.0	110.0	0.64	0.31	0.04	0.11
Veronica anagalloides subsp. *taeckholmiorum*	7.9	**12.6**	**43.0**	**24.0**	**80.3**	0.4	1.0	14	**132.8**	**13.9**	**10,064**	74.0	12.0	**14.0**	**5.3**	3.1	**4.6**	9.0	**431.0**	**3.60**	**2.43**	**1.32**	**0.76**

Veronica anagalloides subsp. *taeckholmiorum* Chrtek & Osb. -Kos

Veronica anagalloides subsp. *taeckholmiorum* is annual herb, used as medicinal plant, and grazing source.. Depending on the field surveys, Herbarium specimens and literature reviews, this species is endemic to Nile and Mediterranean regions (Fig. 3–9). Recently, during field visits, it was cleared that this taxa is more concentrated in Nile Delta and very rare in Mediterranean region. It was distributed in two locations: Kafrelsheikh and Rashid-Alexandria locations. Its EOO is about 124.9 km^2, and its AOO is 8 km^2 (Table 2). It qualifies as critically endangered (CR) under criteria CR B2ab (i,iv,v); C2a(i). The estimated population size during the field trips was 65 individuals. The expected total population size of between 40 and 100 mature individuals. The number of mature individuals in each subpopulation ranges from 2–5 in the largest one. It is distributed in irrigation canals and ditches associated with *Amaranthus lividus*, *Veronica anagallis-aquatica*, *Chenopodium murale*, *Chenopodium album* and *Pluchea dioscoridis* (Table 2). It is found on sandy loamy soils with 74% sand, 12% silt and 14% clay. This species is occupied soils that have high contents of most soil parameters, and low contents of Hco_3^-, sand, and P (1 meq l^{-1}, 74%, and 9.0 ppm, respectively) (Table 3).

Extinct taxa

Muscari salah-eidii is a perennial bulb and was distributed in sandy soil. Depending on the field surveys, Herbarium specimens and literature reviews, this species is restricted to North Sinai. It is believed to be **extinct,** as it is not collected from the field since 1967. In addition, no recent herbarium specimens were recorded in the different herbaria allover Egypt. It was collected in 1965 in Rafah by Salah Eid who planted it in his garden in Alexandria. In addition, *Vicia sinaica* is an annual or perennial herb. It was distributed in sandy soil. It is believed to be extinct because it has not been collected throughout the last 60 years. In addition, no recent herbarium specimens were recorded in the different herbaria all over Egypt. This species is restricted to North Sinai. It was collected in 1955 in Al-Arish by Loutfy Boulos. Moreover, *Limonium sinuatum* subsp. *romanum* is a perennial herb. It was distributed in moist ground and believed to be **extinct,** as it is not collected from the field since 1949. In addition, no recent herbarium specimens were recorded in the different herbaria all over Egypt. This species is restricted to the Western Mediterranean Coast. It was collected in 1949 in Bir Romani in Matrouh and wasn't collected again till now. Moreover, *Bellevalia salah-eidii* is believed to be **extinct** it is not collected from the field since 1966. It is a perennial bulb and is distributed in sandy areas. No recent herbarium specimens were recorded in the different herbaria all over Egypt. This species is restricted to the Mediterranean coastal strip (Hammam).

Data deficient taxa

Muscari albiflorum is a perennial bulb and is known only from the type locality. It is assessed as data deficient, as there is no information about its distribution, number of populations in the field for a long time, ecological preferences, population size, trends, and possible threats depending on the field surveys, Herbarium specimens and literature reviews. In addition, no specimens were seen in different herbaria all over Egypt. It is restricted to Western Mediterranean (Sallum) in sandy soils. It was collected in 1965 in Salum by Salah Eid and wasn't collected again till now. In addition, *Fumaria microstachys* is an annual herb which hasn't been collected from the filed since 1989. It is restricted to the Mediterranean coastal strip (Matrouh region) and distributed in weeds of cultivation near water.

Major threats impacted the studied taxa

The most obvious threats that Egypt's Mediterranean endemics faced, depending on IUCN Classification Scheme of Threats, is presented in Fig. 4 and Table 4. Most evaluated species are exposed to residential and commercial development, which constitutes the most obvious impact on all Mediterranean taxa. For instance, gathering terrestrial plants for human food or medicinal use constitutes a major threat to all Mediterranean endemics in Egypt. Housing and urban activities have caused irreversible habitat destruction of 11 Mediterranean endemics. Moreover, Climate fluctuations and severe Weather, especially an increasing frequency of droughts is another widely distributed threat, which has a direct effect on the size and quality of the habitats for all Mediterranean endemics. Additionally, land use changes associated with human agricultural expansion, grazing by livestock, and conversion to pastureland, are also key threats contributing to the decline of the populations of these taxa (Fig. 5).

Conservation actions

For these endemic taxa, no real conservation efforts were conducted, but several actions must be taken into consideration as listed in IUCN-CMP conservation actions (Table 5).

Discussion

IUCN assessment

Knowledge of spatial patterns of endemism is essential for conservation strategies (Ferrier 2002), particularly in the

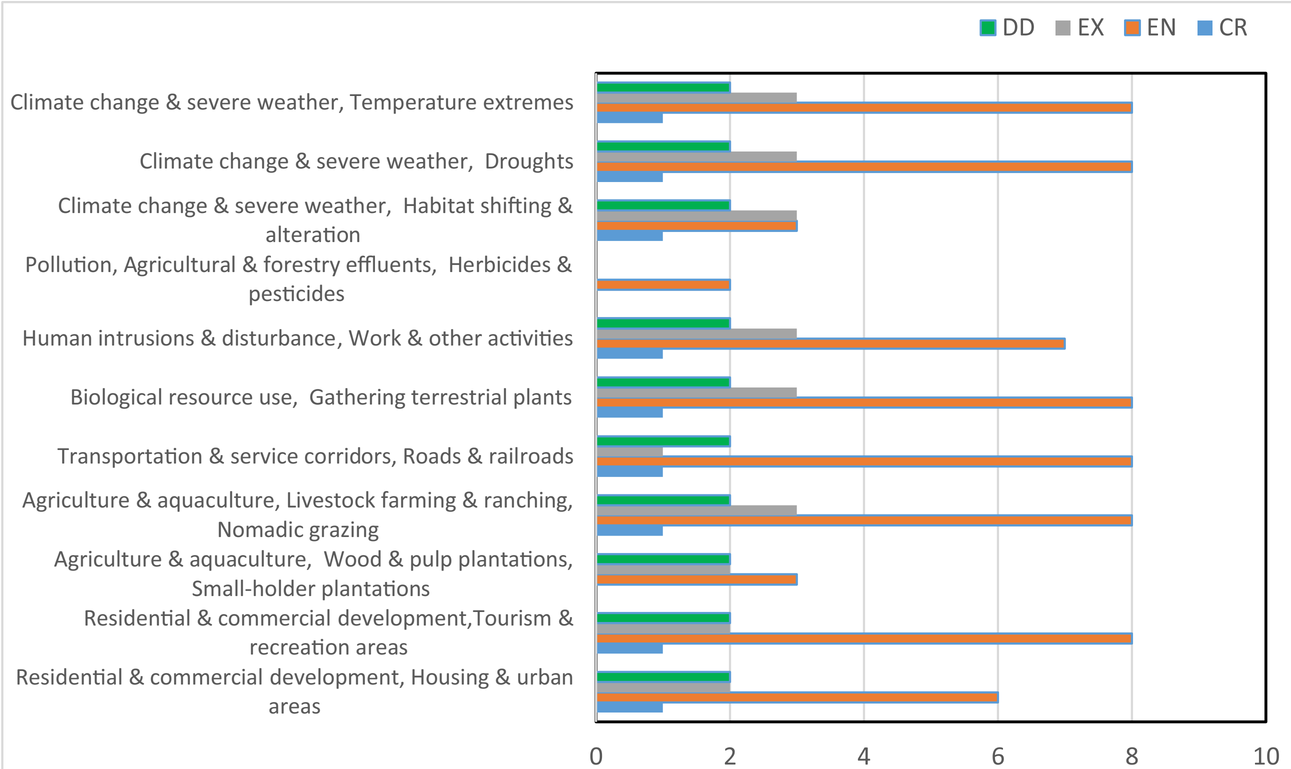


Fig. 4 Summary of major threats to all Mediterranean endemics evaluated in Egypt

Table 4 Summary of major threats to the studied taxa based on the IUCN Threats Classification Scheme

Threat	Timing	Scope	Severity	Impact score
1.1. Housing & urban areas	ongoing	whole (> 90%)	very rapid declines	High impact:9
1.3. Tourism & recreation areas	ongoing	whole (> 90%)	very rapid declines	High impact:9
2.2.1 Small-holder plantations	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
2.3.1. Nomadic grazing	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
4.1. Roads & railroads	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
5.2. Gathering terrestrial plants	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
6.3. Work & other activities	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
9.3.3. Herbicides & pesticides	ongoing	Minority (< 50%)	rapid declines	Moderate impact:6
11.1 Habitat shifting & alteration	ongoing	whole (50–90%)	very rapid declines	High impact:8
11.2. Droughts, 11.3. Temperature extremes	ongoing	Minority (< 50%)	slow but significant declines	Low impact:5

face of continuous landscape transformation (Foley et al. 2005) and environmental fluctuations (Thomas et al. 2004). Endemic plants are those which exhibited restricted geographical distribution and habitat (Olivieri et al. 2015). Endemics could have a small ecological niche (Williams et al. 2009). The concentration of endemism in Egypt is below the normal average, when compared to other Mediterranean countries like Tunisia and Palestine; while Turkey, Morocco, Italy and Spain contain the highest concentrations of endemism (Hegazy and Lovett-Doust 2016). This trend is like the one related to the total flora. However, neighboring countries like Saudi Arabia, Sudan, and Libya showed a similar trend of endemics (Hegazy and Lovett- Doust 2016).

The Mediterranean basin is considered an important hotspot for plant biodiversity, and a region prone to several anthropic pressures, besides being more susceptible to climate fluctuations compared to other regions. In this basin, that has a high amount of rare and endangered species, significant practical conservation actions have been carried out to save many plants from extinction, or to improve their conservation status (Fenu et al. 2023). All the endemics

Fig. 5 Major threats to the studied taxa

Table 5 Conservation actions needed for the studied endemic species based on the IUCN scheme (http://www.iucnredlist.org/technical-documents/classification-schemes)

Conservation action needed
1.1. Site/area protection
1.2. Resource & habitat protection
2.1. Site/area management
2.3. Habitat & natural process restoration
3.1.3. Limiting population growth
3.2. Species recovery
3.4.1. Captive breeding/artificial propagation
3.4.2. Genome resource bank
4.1. Formal education, 4.2. Training, 4.3. Awareness & communications
5.1. Legislation, 5.1.2. National level
5.2. Policies and regulations
5.4. Compliance and enforcement, 5.4.1. International level
5.4. Compliance and enforcement, 5.4.2. National level
7.3. Conservation finance

suffer from one pattern of threats at least. Most endemics are overharvested by local people, herbalists, and researchers who do excessive cutting and collecting. There are no laws regulating the gathering of wild plants for trade. The most dangerous part of this activity is that it typically targets localized, rare and threatened flora, causing destruction to it (Seif El-Nasr and Bidak 2005; Shaltout et al. 2023). Indeed, habitat deterioration is one of the most obvious threats that impacted numerous endemics, particularly in Mediterranean sector (El-Khalafy et al. 2021a,b). In addition, agriculture process, urban areas, tourism, construction processes, mining and quarrying are significant threats that causing disturbance in the ecology of most Mediterranean areas due to the complete removal and destruction of the vegetation (Baidak et al. 2015).

The current investigation is considered an significant update for the conservation strategy of Mediterranean endemics in Egypt. The evaluation of the conservation of endemics is a key challenge because of their limited geographical range and high vulnerability to threats, mainly due to the loss or alteration of their habitats (Caujapé-Castells et al. 2010). In the present study, Geographical range (criterion B) in the form of extent of occurrence (B1: EOO) and/or area of occupancy (B2: AOO) was the widely used criteria. The data required for IUCN assessment (distribution, population characteristics, habitats, ecological characters, threats, conservation measures, and any other relevant data) are considered a strong input into filling gaps in conservation programs (Rodrigues et al. 2006).

Sonchus macrocarpus (Eoo = 3146.1km2, Aoo = 36 km2, 6 fragmented locations) was evaluated as endangered in the current study, but vulnerable by Hosni et al. (2013), rare by El-Hadidi and Hosni (2000) and data deficient by Ali (2010). The gradation and difference in the evaluation of the status of species indicate the continuous change in plant occurrence. Depending on IUCN criterion D, *Abies nebrodensis* was evaluated as CR in Italy (i.e. lower than 50 mature individuals in the plant population). Even though a significant genetic variability has been detected, the low sexual performance of adult plants and the low health of the seedlings and samplings grown in the tree nurseries should be viewed as issues of a bottle-neck effect due to the limited population size (Pasta et al. 2017). The major threats to this species were habitat degradation, grazing, and the trampling of young individuals by introduced herbivores. Additionally, it may be impacted by global warming both directly by decreasing its chances of survival and indirectly by an increase in the frequency of wildfires (Pasta et al. 2017).

S. ***macrocarpus*** species is highly affected by urbanization and the construction of new housing areas that lead to the removal of a large number of individuals and the destruction of its habitats. Moreover, agriculture processes by local people, particularly in the Delta caused destruction to its habitats and completely disappear in several localities. Additionally, drought and climatic fluctuations affect its status and cause death to numerous populations (Heneidy et al. 2021; El-khalafy et al. 2021a,b). As climate fluctuations and water Scarcity play an important role in the inhibition of the growth of many species (Shaltout et al. 2015).

Allium mareoticum (EOO = 125.2 km^2, and AOO = 20 km^2, 2 fragmented locations) was assessed as endangered in the current investigation and El-Hadidi and Hosni (2000), but it was evaluated as critically endangered by Hosni et al. (2013)**.** It is home to Mediterranean sector, so it was severely impacted by habitat destruction as a result of urban areas and tourism activities, agriculture processes and construction actions (Seif El-Nasr and Bidak 2005; El-Khalafy et al. 2021a,b). Thus, numerous habitats nearby have been severely degraded and destroyed.

Echinops taeckholmianus (EOO = 962.465 km^2, AOO = 20 km^2, 3 fragmented locations) was assessed as endangered in the current study, but extinct **by** Hosni et al. (2013) and indeterminate by El-Hadidi and Hosni (2000). The occurrence of this plant is very restricted with a low number of individuals and impacted by numerous threats (El-Khalafy et al. 2021a,b). The population is severely fragmented, and there is obvious decline in its habitat quality. Moreover, climatic changes, especially excessive temperatures and drought are main threats which impacted this taxon. In addition, it was cleared that this species is threatened by human and construction activities in the area. Clearance for agriculture by the Bedouins who reside near the species area, has also been recorded. Human activities lead to extensive disturbance of this taxon. Tourism activities, overgrazing, and uncontrolled scientific research are major human activities which impacted this species (El-Khalafy 2023**)**.

Pancratium arabicum **(**EOO = 1219.5 km^2, AOO = 52 km^2, 6 fragmented locations) was assessed as endangered in the current investigation like Hosni et al. (2013) and El-Hadidi and Hosni (2000)**.** This species is home to sand dunes near the sea shores. Construction of tourist villages on the seashores caused death of large individuals of this taxon and destruction of its habitats. Numerous roads are also constructed though the sand dunes (ex: Matrouh area) which cause disturbance in its existence (El-Khalafy et al. 2021a,b; Ahmed et al. 2014). Moreover, the development of summer resorts at Deltaic sector of Mediterranean has destroyed numerous habitats of natural ecosystems. For example, the construction of Marina Delta lagoons and new gas stations along the shoreline has destroyed large regions of sand dunes that are inhabited by *Echinops taeckholmianus* and *Pancratium arabicum*. In addition, new buildings (Delta University and New Mansoura University), new Mansoura city and the industrial city of Gamasa that occupy the coastline between Baltim and Gamasa have contributed to the degradation of extensive regions of natural ecosystems nearby (Nafea 2019).

Anthems microsperma (EOO = 174.3 km^2, AOO = 36 km^2, 3 fragmented locations) and ***Thesium humile*** var. ***maritima*** (EOO = 4919.1 km^2, AOO = 40 km^2, 5 fragmented locations) were evaluated as endangered in the curent study, while vulnerable by Hosni et al. (2013). The two plants are home to Mediterranean sector, so it was severely stressed by habitat loss due as result of urban areas and tourism, agriculture processes and construction activities (Seif El-Nasr and Bidak 2005; El-Khalafy et al. 2021a,b). These activities cause removal of their habitats.

Atractylis carduus* var. *marmarica (EOO = 1693.3 km^2, AOO = 48 km^2, 3 fragmented locations) was evaluated as endangered in the current investigation, but vulnerable by Hosni et al. (2013)**.** Recently, the amount of its populations and mature individuals has declined. It is more concentrated in Mediterranean sector which is highly impacted by severe human impacts which cause destruction to its habitats and the death of a large number of their individuals (El-Khalafy et al. 2021a,b). In addition, the locals gather it for fuel and traditional treatment (Shaltout and Ahmed 2012).

Four taxa are evaluated as extinct. ***Bellevalia salah-eidii*** was believed to be extinct in the current investigation and Hosni et al. (2013), but endangered by El-Hadidi and Hosni (2000) and IUCN (1998). ***Muscari salah-eidii*** was believed to be extinct in the current study and Hosni et al. (2013), but endangered by El-Hadidi and Hosni (2000) and rare by IUCN (1998). ***Vicia sinaica*** was exposed to be extinct in the current investigation and Hosni et al. (2013), but indeterminate by El-Hadidi and Hosni (2000) and rare by IUCN (1998)**.** In addition, *Limonium sinuatum* subsp. *romanum* was believed to be extinct in the current investigation like Hosni et al. (2013). *Limonium sinuatum* subsp. *romanum*, *Muscari salah-eidii* and *Bellevalia salah-eiddi* are known only from a type locality or a single gathering. They were not collected from the field throughout the last 60 years (Hosni et al. 2013). Although *Muscari salah-eidii* was recorded at Rafah, North Sinai by Heneidak (2008), no herbarium specimens that assure their current occurrence. Moreover, *Vicia sinaica* has not been gathered throughout the last 50 years (Hosni et al. 2013).

Two taxa are evaluated as data deficient. ***Fumaria microstachys*** was evaluated as data deficient in the current investigation, but critically endangered by Hosni et al. (2013), and rare by El-Hadidi and Hosni (2000). Moreover, *Muscari albiflorum* was evaluated as data deficient in the current investigation, but critically endangered by Hosni et al. (2013), and endangered byIUCN (1998)**.** The two taxa were assessed as data deficient as there is no information about their distribution and number of populations in the field for a long time. So, no adequate data for making an accurate assessment based on its distribution and or population status.

Threats

The Mediterranean sector is considered important hotspot for biological diversity, it may be considered main center of endemism, and it represents remarkable bio-region for its large number of species exposed to extinction. It is remarked by rapid human population growth, which generates manifold pressures on the environment, since the leading development and consumption models are not ecologically sustainable. Whereas at the beginning of the1960s, most countries had an ecological footprint that was less than or scarcely greater than their capacity for ecological regeneration of natural resources, the current situation is much worse, with most of the Mediterranean countries in "ecological deficit", except for Montenegro (Drius et al. 2019). The Mediterranean sector, an important center of plant biodiversity and a global biodiversity hotspot (Cañadas et al. 2014), faces serious threats from a variety of anthropogenic and natural factors that have caused a high level of natural habitat fragmentation. The Mediterranean strip has given rise to some of the world's most powerful civilizations over the past 4,000 years, which has led to overuse of the soil and the conversion of a large portion of the pristine vegetation into agricultural landscapes (Vogiatzakis et al. 2016). In this region, the tourism industry is expanding in the coastal sector. There are conflicts arising from competing uses of the space and resources shared by this and other human activities along the coastline. Furthermore, excessive use of natural resources damages and exhausts coastal habitats, which has a negative feedback effect on all human impacts. Hence, in order to strike a compromise that will protect natural resources over time, both tourism and other human impacts must take into account their reliance on coastal ecosystem services and take technical and policy measures (Drius et al. 2019).

Recommendations

Since many tourist attractions are centered around the diversity of species, habitats, and landscapes, protecting nature is essential to the tourism industry's long-term viability, which aims to preserve the equilibrium of the environmental, economic, and sociocultural spheres (Drius et al. 2022). According to the extreme importance of endemic species in our study, it is necessary to control the risks that threaten these species in this specific region of the world, and to impose protection for these species and enact laws for that. This concept is embedded in the sustainable tourism approach: "tourism that takes full account of its current and future economic, social and environmental impacts, addressing the needs of visitors, the industry, the environment and host communities" (UNEP/UNWTO 2005; Drius et al. 2022).

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Declarations

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