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The link of socioeconomic importance to the conservation status of the Mediterranean endemic plants in Egypt

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Abstract. *Shaltout K, Bedair H, El-Khalafy MM, Keshta A, Halmy MWA. 2023. The link of socioeconomic importance to the conservation status of the Mediterranean endemic plants in Egypt. Nusantara Bioscience 15: 189-211.* Mediterranean Basin is the second world's richest hotspot and one of the most critical spots on the planet for endemic species. Therefore, the present study aimed at screening the Mediterranean endemics and evaluating the uses of recorded taxa quantitively through developing new indices and updating the existing ones. Indeed, Semi-structured interviews were used with 43 informants. Relative Cultural Importance (RCI), Species Conservation Importance (SCI), and Relative Medicinal Importance (RMI) indices were applied to determine the most valuable taxa. A preliminary list of 65 Mediterranean endemic species belonging to 49 genera and 22 families in Egypt was compiled from the available literature. Fifty-seven (87.7%) species have at least one aspect of the potential or actual economic value. The most represented use category was the medicinal value (39 taxa: 69.6%). *Thymbra capitata* (L.) Cav. was mentioned in the highest use categories (NU: 5). *Veronica syriaca* Roem. & Schult. attained the maximum ethnobotanical Relative Importance (RI) index value. It is crucial to shed light on the cultural value of Mediterranean endemics to guide future management planning to support the conservation and sustainable use of these critical species.

Keywords: Conservation index, Cultural Importance Index, endemism, Mediterranean Basin, quantitative ethnobotany

INTRODUCTION

Lopez-Alvarado and Farris (2022) reported that the Mediterranean region is the world's second-largest biodiversity hotspot. It includes more than 25,000 species of flowering plants worldwide (Zahran 2010). Being the meeting ground between Europe, Asia, and Africa makes the Mediterranean basin surrounded by temperate, arid, and tropical biogeographical regions in comparison to the more homogeneous areas to the north and south (Zahran 2010). Consequently, the Mediterranean basin's edaphic, climatic, and topographical intricacy makes it exceptionally rich in biodiversity (Thompson 2020). Many Mediterranean species are restricted to a single or few localities in sandy areas, isolated mountain ranges, or islands of unusual soils or rocky grounds; thus, this region is characterized by a high degree of endemism compared to other regions (Zahran 2010). Generally, coastal sectors and subsectors are more affluent in plant endemism than inland areas in Egypt (Abdelaal et al. 2020).

Endemism is an integral component in the Mediterranean region of plant diversity (Fois et al. 2022). A characteristic element of this endemism is that of all the species endemic to the Mediterranean region, 60% are narrow endemic species, i.e., they have a single well-defined area distribution restricted within a small part of the Mediterranean region (Thompson 2020). The Mediterranean flora is thus replete with narrow endemic taxa. This region's spatial isolation is a characteristic feature, with several islands, peninsulas, and high mountains (Vargas 2020; Bedair et al. 2023a). Across the Mediterranean Basin, over 10,000 islands and islets are distributed. The largest islands in the region are Sicily and Sardinia, followed by Cyprus, Crete, Aegean Islands, Corsica, and Balearic Islands (Médail 2022).

Species extinction has increased tremendously in the last few decades. Efforts for plant species conservation have been the focus of many scientists to combat species extinction and to control invasive species. Integrating local indigenous knowledge was among various methods for the sustainable conservation of natural resources (Hanazaki et al. 2018)-especially for plants with medicinal uses and applications. Uses and applications of traditional folk medicine are widely common worldwide and among rural populations of Mediterranean regions (Emre et al. 2021). The knowledge collection on plant species and their various uses is of great importance for preserving cultural heritage and conserving plant diversity (Janaćković et al. 2022). The culture of using wild plants for medicinal purposes in the Mediterranean area is well established, especially among rural communities. Preserving the traditional knowledge of using wild plants for medicinal application has been a top priority in Mediterranean and European countries (Varga et al. 2019; Bedair 2023).

Indeed, the term quantitative ethnobotany was coined for the first time by (Prance et al. 1987). It focuses on measuring the usefulness of plants and vegetation to humans. Different approaches to determining the importance of plants have been developed by various researchers (Halmy and Salem 2015; Heneidy et al. 2017; Ahmed et al. 2023; Shaltout et al. 2023). To measure the importance of plant species for humans, (Reyes-García et al. 2006) recommended using an integrated index termed cultural value. It considers the frequency of citation and versatility of the species, and its formula is further explained in this study. Therefore, this study aims to provide an updated dynamic checklist of the Mediterranean endemics distributed along the Mediterranean coast of Egypt and to apply the cultural indices to investigate folk uses and classification of useful Mediterranean endemics to highlight the significance of these endangered taxa to help in management a conservation plan of them in the near future.

MATERIALS AND METHODS

Study area

Delimitation of the Mediterranean floristic region in this study was mainly assessed according to the system of Good (1974). In Egypt, the Mediterranean territory extends about 970 km from Rafah on the Egyptian-Palestinian border to Sallum on the Egyptian-Libyan border, with an average width of 15-20 km in a north-south direction and a limited area of 16,500 km^2. (Facciola 1990) extended the Mediterranean territory in Egypt from Rafah District on the Egyptian-Palestinian border to Sallum on the Egyptian-Libyan border and distinguished between three subsectors for the Mediterranean coastal land: (i) Western (the Mareotis, extending for 550 km between Sallum and Alexandria District, with annual rainfall between 220-150 mm), (ii) middle (Deltaic extending for 180 km between Alexandria and Port Said District with about 12 km wide), and (iii) east (Sinaitic, extending for 220 km between Rafah and Port Said, with annual rainfall between 150-100 mm) (Figure 1).

List justification

In this study, a taxon was considered a Mediterranean endemic if its distribution was confined to the Mediterranean floristic region determined by Good (1974). Undoubtedly, in this study, we focused on only Mediterranean endemics distributed along the Mediterranean coast of Egypt. In this study, we depended on the preliminary list of Mediterranean endemics in Egypt prepared by Bedair et al. (2020).

Additional data were collected from field visits and the herbaria of Real Jardín Botánico de Madrid, Madrid, Spain; Tanta University (TANE), Tanta, Egypt; Alexandria University (ALEX), Alexandria, Egypt; Cairo University (CAI), Cairo, Egypt; Agricultural Research Center (CAIM), Egypt; Desert Research Center (CAIH), Cairo, Egypt; Assiut University (ASTU), Assiut, Egypt; and National Research Centre (CAIRC), Cairo, Egypt.

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

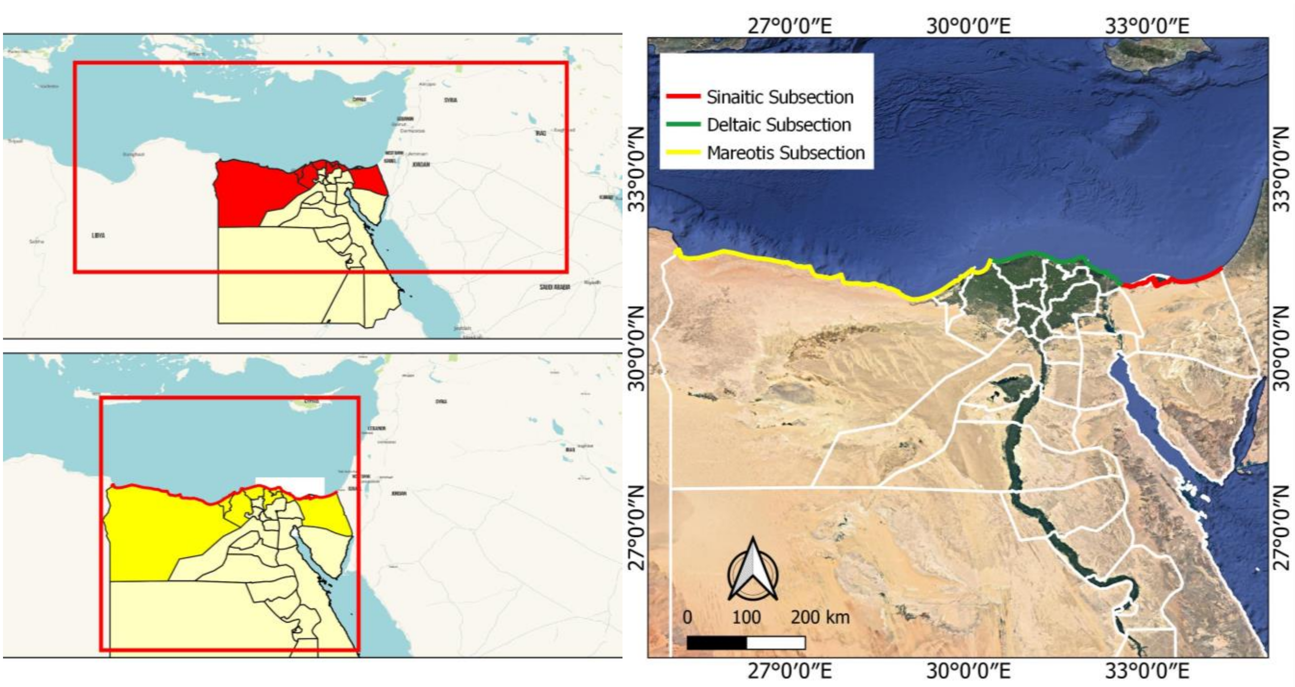


Figure 1. Map of the study area in the Mediterranean territory of Egypt from Rafah to Sallum

Ethnographic data

Data in this study were collected through four different sources:

Literature reviews: included collecting data from (Rizk 1986; Al-Eiswi and Takruri 1989; Rizk and Al-Nowaihi 1989; Belal and Springuel 1996; Chevallier 1996; Ayyad 1998; Ahmed 2009; Shaltout et al. 2010; Bedair 2020; Bidak et al. 2021; Bedair et al. 2022a; Bedair et al. 2022b; Shaltout and Bedair 2022; Shaltout et al. 2023).

Datasets: were collected from (PFAF 2022; Plants 2022; PlantUse 2022).

Open and semi-structured interviews (questionnaires): These interviews were administered to herbalists and local inhabitants, including pre-prepared data sheets of vernacular plant names from the preliminary list. Also, open discussions included some informal questions about the plant's uses, how often it is used, and the best time for using it. Live plants, voucher specimens, and pictures of plant species were provided when possible. They were also asked to fill out the questionnaire identified in Table S1.

Experts: Information was also gathered from researchers and experts familiar with the Mediterranean flora.

Quantitative assessment of the ethnobotanical importance

Indices used for the quantitative assessment of the ethnobotanical, conservation, and medicinal importance of the Mediterranean are described in Table 1. The correlation among the cultural indices was tested using Spearman's simple correlation (r) test. Statistics were computed with the R software (R Core Team 2013) by the "corrgram" package. Both two-way indicator species analysis (TWINSPAN) and non-metric multidimensional scaling (non-metric MDS) were carried out for estimations of the 14 phytochemical classes recorded in 30 Mediterranean endemics (Gauch Jr. and Whittaker 1981) to divide the classes into groups. All the analysis was done using the Community Analysis Package Statistics program (CAP 4).

Table 1. Indices used for the quantitative assessment of the ethnobotanical and medicinal importance of the Mediterranean endemics

Index	Formula	Description/Source
Use-reports (UR_s)	$UR_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_N}^{i_N} UR_{ui}$	It can be calculated in 2 steps: (i) Number of informants who mentioned each use category for the species, and (ii) Sum of all URs of each use category (Kufer et al. 2005).
Relative Frequency of Citation (RFC_s)	$RFC_s = \frac{FC_s}{N} = \frac{\sum_{i=i_1}^{i_N} UR_i}{N}$	It is obtained by dividing the number of informants who reported the use of a species (frequency of citation FC), or the sum of the UR of all informants interviewed for the species without considering the use category, by the total number of informants (Tardío and Pardo-de-Santayana 2008).
Relative Importance (RI_s)	$RI_s = \frac{RFC_{s(\max)} + RNU_{s(\max)}}{2}$	$RFC_{s(max)}$ are obtained by dividing FC_s by the maximum value in all the species [FC_s/max (FC)]. $RNU_{s(max)}$ are obtained by dividing the number of uses of the species by the maximum value in all the species of the survey [NU_s/max (NU)] (Pardo-de-Santayana et al. 2006).
Cultural Value (CV_s)	$CV_s = \left[NU_s / NC \right] \times \left[FC_s / N \right] \times \left[\sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui} / N \right]$	NUs = number of different uses reported for the species. NC = Total use categories reported in the study (Reyes-García et al. 2006).
Cultural Importance (CI_s)	$CI_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui} / N$	Summation of the proportion of informants that mention each species use (Tardío and Pardo-de-Santayana 2008).
Species Conservation Importance (SCI)	$SCI = \frac{\sum_{i=1}^{n} W_i C_i}{10}$	This approach is a function of six criteria (conservation status, abundance, life form, goods, services, and geographic distribution of each species), each scored out of 10, and the weight factor that was given 2 for the conservation status and 1 for the rest of criteria (Halmy and Salem 2015).
Relative Medicinal Importance (RI_i)	$RI_i = \left(\frac{\frac{nCS_i}{NCS_m} + \frac{nP_i}{NP_m}}{2} \right) \times 100$	nCS_i refers to the number of human body systems treated by species i, NCS_m is the maximum number of body systems treated by the most widely used species m; and nP_i refers to the number of healing properties attributed to species i, while NP_m is the maximum number of healing properties attributed to the most widely used species m; (Monteiro et al. 2011).

RESULTS AND DISCUSSION

Taxonomic diversity

There are 73 taxa recorded in this study as Mediterranean endemics in Egypt (a total of 65 species) belonging to 49 genera and 22 families. The *Allium* L. and Fumaria L. (4 taxa), Bellevalia Lapeyr are the most represented genera. (4 taxa), *Muscari* Mill., *Centaurea* L., and *Limonium* Mill. (2 taxa). Any taxon does not represent gymnosperms, while 3 clades represent angiosperms. Monocot families are 4 (Amaryllidaceae, Asparagaceae, Poaceae, and Posidoniaceae), represented by 10 genera and 18 species, while only Papaveraceae represents Eudicots. Core Eudicots are the most represented by 17 families (5 Superrosids and 12 Superasterids). The highly represented families are Asteraceae (13 species), Fabaceae (10 species), Asparagaceae (8 species), and Amaryllidaceae (5 species). On the other hand, 12 families are represented by only one species (Posidoniaceae, Convolvulaceae, Euphorbiaceae, Resedaceae, Apiaceae, Caprifoliaceae, Caryophyllaceae, Rubiaceae, Santalaceae, Solanaceae and Scrophulariaceae) (Table 2).

Ethnobotanical analysis

A total number of 43 informants cited plant uses. Fifty-seven (87.7%) species of the recorded Mediterranean endemics have at least one aspect of the potential or actual economic goods. The offered goods could be arranged in descending order as follows: medicinal (39 taxa: 69.6%), human food (13 taxa: 23.2%), grazing (11 taxa: 19.6%), other uses (11 taxa: 19.6%), timber (6 taxa: 10.7%), then fuel (4 taxa: 7.1%) (Figure 2). Further, fourteen Mediterranean endemics (21.5% of the total taxa) have at least one aspect of the environmental services. The services of the recorded species could be arranged descendingly as follows: soil fertility (8 taxa), sand accumulation (8 taxa), nitrogen fixation (6 taxa), esthetic concerns (3 taxa), wind-breaking (2 taxa), water storage and phytoremediation (one taxon each) (Figure 3). Two Mediterranean endemics have only one service (14.3% of the total environmentally important taxa), 9 taxa have two services (64.3%), and 3 taxa have three services (21.4%) (Figure 4).

The relation between the number of Mediterranean endemics and the number of use categories (NU) they offer approximates an inverse J-shape distribution. Thirty-six taxa have been mentioned in one use category (64.3%) and 16 in two use categories (28.6%), while 3 taxa have been mentioned in three use categories (5.4%). Whereas, *Thymbra capitata* (L.) Cav. has been mentioned in the highest use categories (NU: 5) (Figure 5, Table 3).

The folk species of *T. capitata* (known as *Za'tar* in Egypt) is the most culturally significant according to the CI index (3.6), followed by *Kharshouf* (*Cynara cornigera* Lindl.), which has a CI index value of 1. While 16 species have a low CI index value of 0.02 (e.g., *Centaurea aegialophila* Wagenitz, 1974; *Scilla peruviana* L.; *Silene fruticosa* L.; and *Valerianella petrovitchii* Asch. ex Rohlfs (Table 3). The 16 species with the highest CI index value are perennials. Although the various indices in Table 4 yield appreciable differences in species ranking, all four indices put *T. capitata* in the first ranking. *Allium* sp. (known as *Basal* in Egypt), *T. capitata,* and *C. cornigera* have the highest citation frequency (FC: 43), which means that all the informants mentioned the usefulness of these species.

Table 2. Major taxonomic groups of the Mediterranean endemics in Egypt

Taxonomic clade	Family (F)	Genus (G)	Species (S)	Subspecies (Sub)	Variety (V)	Sub/S	S/G	G/F
Monocots	4	10	18	0	0	0	1.8	2.5
Eudicots	1	1	3	1	0	0.3	3	1
Core Eudicots								
Superrosids	5	13	14	2	0	0.1	1.1	2.6
Superasterids	12	25	30	3	2	0.1	1.2	2.1
Total	22	49	65	6	2	0.5	7.1	8.2

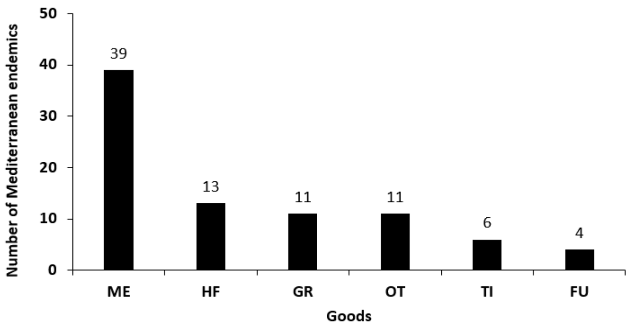


Figure 2. Descending arrangement of the use categories of the Mediterranean endemics in Egypt. Use categories are coded as ME: Medicinal, OT: Other uses, GR: Grazing, FU: Fuelwood, HF: Human food, and TI: Timber

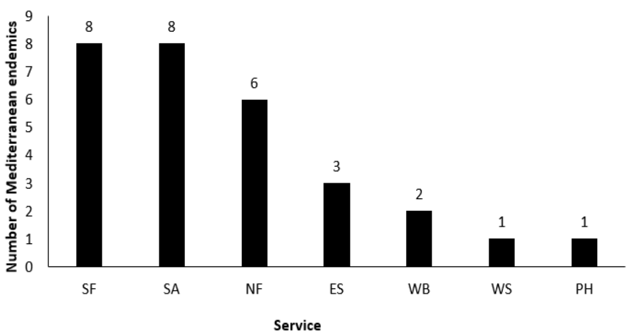


Figure 3. Some Mediterranean endemics in Egypt are concerned with their environmental services. Services are coded as SF: Soil fertility, SA: Sand accumulation, NF: Nitrogen fixation, ES: Esthetic concerns, WB: Wind-breaking, WS: Water storage, and PH: Phytoremediation

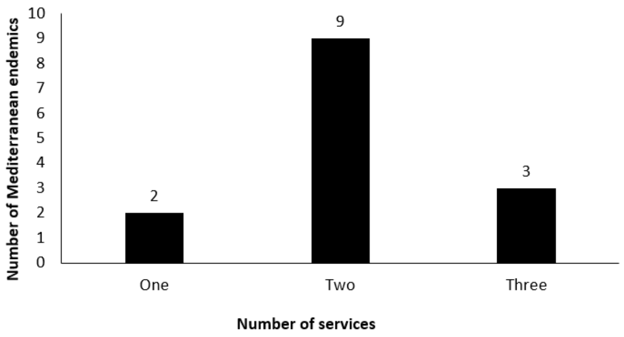


Figure 4. Number of Mediterranean endemics in Egypt concerning the number of ecosystem services

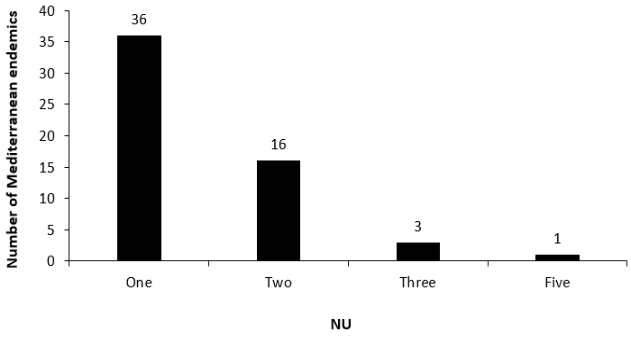


Figure 5. Number of Mediterranean endemics in Egypt concerning the number of use-categories (NU)/goods a species offers

The correlation analysis revealed a strong association between the combinations of the assessed indices (Figure 6). A very high correlation exists between FC and RFC, UR, and CI indices (r = 1). Indeed, CV and NU have the highest correlation with the number of use reports (0.91 and 0.72, respectively). In general, the more multilateral the Mediterranean endemic, the more it has widespread knowledge of usefulness and the more it is mentioned by the informants (Figure 7).

Regarding the species conservation importance (SCI) index, only 2 species attained a value of more than 0.75 (*Ebenus armitagei* Schweinf. & Taub. and *T. capitata*, about 60% of the recorded species are important (attained values of 0.50-0.75). In addition, 6 species have moderate importance (they are *Herniaria cyrenaica* F.Herm., *Muscari albiflorum* (Täckh. & Boulos) Hosni, *C. aegialophila*, *Cynosurus coloratus* Lehm. ex Steud., *Euphorbia parvula* Delile and *Veronica syriaca* Roem. & Schult.). Interestingly, no species has a value lower than 0.25, indicating the importance of Mediterranean endemics in Egypt (Table 5, Table S2).

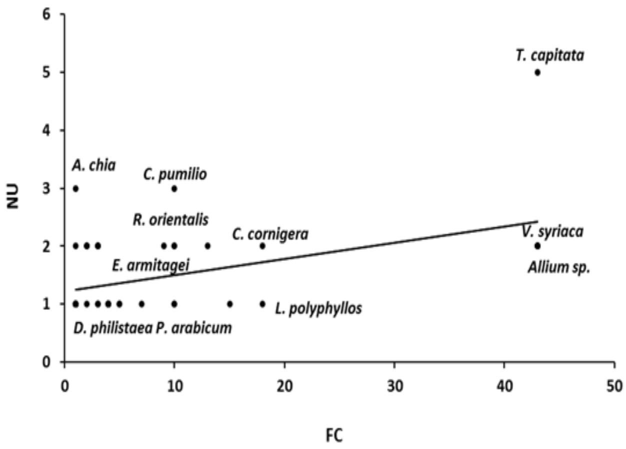


Figure 7. The number of use categories for each species (NU) concerning the frequency of citation (FC) of the useful Mediterranean endemics. Each dot represents one taxon, but only the most useful ones are labeled

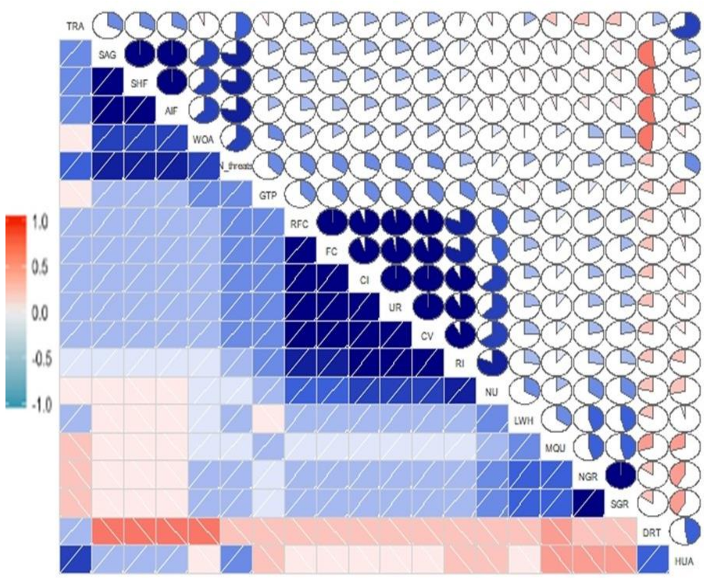


Figure 6. A correlogram representing the relation between the cultural indices and types of threats on the recorded Mediterranean endemics. Threats are abbreviated as HUA: Housing and Urban Areas; TRA: Tourism and Recreation Areas; GTP: Gathering Terrestrial Plants; WOA: Work and Other Activities; DRT: Droughts; LWH: Logging and Wood Harvesting; SAG: Shifting Agriculture; SHF: Small-holder Farming; AIF: Agro-industry Farming; NGR: Nomadic Grazing; SGR: Small-holder Grazing; Ranching or Farming; MQU: Mining & Quarrying

Table 3. Cultural Importance Index (CI) of the 56 useful Mediterranean endemics in Egypt, with the CI component of each use category

Scientific name	Goods						Total CI	Services							Total CI
	ME	HF	GR	OT	FU	TI		SF	SA	NF	ES	WB	WS	PH	
Thymbra capitata	1	1	0.81	0.09	0.7		3.6		0.12		0.07	0.12			0.31
Cynara cornigera	1	1					2								
Allium barthianum	0.23	1					1.23								
Allium blomfieldianum	0.23	1					1.23								
Allium mareoticum	0.23	1					1.23								
Allium trifoliatum subsp. *hirsutum*	0.23	1					1.23								
Veronica syriaca	1	0.23					1.23								
Lotus polyphyllos	0.42		0.42				0.84	0.58	0.23			0.07			0.88
Lycium schweinfurthii var. *aschersonii*	0.58	0.23		0.12			0.58								
Ebenus armitagei	0.3		0.12				0.42	0.07	0.07						0.14
Pancratium arabicum	0.42						0.42		0.23						0.23
Anthemis microsperma	0.2		0.16				0.36		0.07						0.07
Desmazeria philistaea			0.35				0.35								
Centaurea pumilio	0.23				0.07		0.3		0.07		0.07				0.14
Reseda orientalis	0.23			0.02			0.25								
Posidonia oceanica	0.23						0.23								
Trifolium argutum	0.23						0.23	0.07	0.07						0.14
Trigonella berythea		0.16					0.16	0.07	0.07						0.14
Fumaria microstachys	0.07			0.07			0.14								
Hyoseris radiata subsp. *graeca*	0.07		0.07				0.14		0.07				0.07		0.14
Hyoseris scabra	0.07		0.07				0.14		0.07		0.07				0.14
Lathyrus marmoratus	0.07		0.07				0.14								
Lotus cytisoides	0.12						0.12	0.23	0.07						0.3
Thesium humile var. *maritima*			0.12				0.12								
Crepis libyca	0.05	0.05					0.1								
Vicia sinaica	0.05	0.05					0.1	0.07	0.07						0.14
Bellevalia mauritanica	0.09						0.09								
Bellevalia salah-eidii	0.09						0.09								
Bellevalia sessiliflora	0.09						0.09								
Bellevalia warburgii	0.09						0.09								
Leopoldia bicolor	0.09						0.09								
Muscari albiflorum	0.09						0.09								
Muscari parviflorum	0.09						0.09								
Verbascum letourneuxii	0.09						0.09								
Bupleurum nanum	0.05			0.02			0.07								
Fumaria judaica subsp. *judaica*	0.07						0.07								
Limonium sinuatum subsp. *romanum*	0.05			0.02			0.07								

Anthemis chia	0.02	0.02		0.02			0.06								
Heliotropium hirsutissimum	0.05						0.05								
Echinops taeckholmianus	0.02		0.02				0.04								
Centaurea aegialophila	0.02						0.02								
Coronilla repanda	0.02						0.02	0.07	0.07						0.14
Crepis aculeata			0.02				0.02								
Cynosurus coloratus			0.02				0.02								
Euphorbia parvula	0.02						0.02								
Sulla spinossima			0.02				0.02	0.07	0.07					0.02	0.16
Helianthemum crassifolium subsp. *sphaerocalyx*				0.02			0.02								
Helichrysum orientale				0.02			0.02								
Herniaria cyrenaica	0.02						0.02								
Linaria joppensis				0.02			0.02								
Scilla peruviana				0.02			0.02								
Silene fruticosa	0.02						0.02								
Taraxacum minimum		0.02					0.02								
Teucrium brevifolium	0.02						0.02								
Trisetaria koelerioides			0.02				0.02								
Valerianella petrovichii				0.02			0.02								

Note: Goods are coded as ME: Medicinal; OT: Other uses; GR: Grazing; FU: Fuel; HF: Human food; and TI: timber. Services are coded as SF: Soil fertility; SA: Sand accumulation, NF: Nitrogen fixation; ES: Esthetic concerns; WB: Wind-breaking; WS: Water storage; and PH: Phytoremediation

Table 4. Evaluation of useful Mediterranean endemics in Egypt using four quantitative indices and species ranking based on each index

Scientific name	Basic values			Indices				Ranking			
	FC	UR	NU	CI	RFC	RI	CV	CI	RFC	RI	CV
Thymbra capitata	43	155	5	3.6	1	1	2.99	1	1	1	1
Cynara cornigera	43	86	2	2	1	0.7	0.66	2	1	2	2
Allium barthianum	43	53	2	1.23	1	0.7	0.41	3	1	2	3
Allium blomfieldianum	43	53	2	1.23	1	0.7	0.41	3	1	2	3
Allium mareoticum	43	53	2	1.23	1	0.7	0.41	3	1	2	3
Allium trifoliatum	43	53	2	1.23	1	0.7	0.41	3	1	2	3
Veronica syriaca	43	53	2	1.23	1	0.7	0.41	3	1	2	3
Lotus polyphyllos	18	36	2	0.84	0.42	0.41	0.12	4	2	4	4
L. schweinfurthii var. *aschersonii*	10	25	3	0.58	0.23	0.42	0.07	5	4	3	5
Ebenus armitagei	13	18	2	0.42	0.42	0.41	0.06	6	2	4	6
Pancratium arabicum	18	18	1	0.42	0.42	0.31	0.03	6	2	6	7
Anthemis microsperma	9	16	2	0.36	0.2	0.3	0.02	7	5	7	8
Desmazeria philistaea	15	15	1	0.35	0.35	0.28	0.02	8	3	8	8
Centaurea pumilio	10	13	2	0.3	0.23	0.32	0.02	9	4	5	8
Reseda orientalis	10	11	2	0.25	0.23	0.32	0.02	10	4	5	8
Posidonia oceanica	10	10	1	0.23	0.23	0.22	0.009	11	4	11	9
Trifolium argutum	10	10	1	0.23	0.23	0.22	0.009	11	4	11	9
Trigonella berythea	7	7	1	0.16	0.16	0.18	0.004	12	6	13	10
Fumaria microstachys	3	6	2	0.14	0.07	0.24	0.003	13	9	9	11
Hyoseris radiata subsp. *graeca*	3	6	2	0.14	0.07	0.24	0.003	13	9	9	11
Hyoseris scabra	3	6	2	0.14	0.07	0.24	0.003	13	9	9	11
Lathyrus marmoratus	3	6	2	0.14	0.07	0.24	0.003	13	9	9	11
Lotus cytisoides	5	5	1	0.12	0.12	0.16	0.002	14	7	14	12
Thesium humile var. *maritima*	5	5	1	0.12	0.12	0.16	0.002	14	7	14	12
Vicia sinaica	2	4	2	0.1	0.05	0.23	0.002	15	10	10	12
Crepis libyca	2	4	2	0.1	0.05	0.23	0.001	15	10	10	13
Bellevalia mauritanica	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Bellevalia salah-eidii	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Bellevalia sessiliflora	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Bellevalia warburgii	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Muscari albiflorum	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Muscari parviflorum	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Verbascum letourneuxii	4	4	1	0.09	0.09	0.15	0.001	16	8	15	13
Leopoldia bicolor	4	4	1	0.09	0.09	0.15	0.0006	16	8	15	14
Bupleurum nanum	2	3	2	0.07	0.05	0.23	0.001	17	10	10	13
Fumaria judaica subsp. *judaica*	3	3	1	0.07	0.07	0.09	0.001	17	9	18	13
Limonium sinuatum subsp. *romanum*	3	3	1	0.07	0.07	0.09	0.001	17	9	18	13
Anthemis chia	1	3	3	0.06	0.02	0.31	0.001	18	11	6	13
Heliotropium hirsutissimum	2	2	1	0.05	0.05	0.13	0.0004	19	10	16	15
Echinops taeckholmianus	1	2	2	0.04	0.02	0.21	0.0003	20	11	12	16
Centaurea aegialophila	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Coronilla repanda	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Crepis aculeata	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Cynosurus coloratus	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Euphorbia parvula	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Hedysarum spinosissimum	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
H. crassifolium subsp. *sphaerocalyx*	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Helichrysum orientale	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Herniaria cyrenaica	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Linaria joppensis	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Scilla peruviana	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Silene fruticosa	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Taraxacum minimum	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Teucrium brevifolium	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Trisetaria koelerioides	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17
Valerianella petrovichii	1	1	1	0.02	0.02	0.11	0.0001	21	11	17	17

Note: Basic values are coded as FC: Frequency of citation; UR: Number of use-reports; and NU: Number of uses. Quantitative indices are coded as CI: Cultural importance; RFC: Relative frequency of citation; RI: Relative importance; and CV: Cultural value

Table 5. The Species Conservation Index (SCI) values, the corresponding conservation importance category, and the number of species recorded in each category (Halmy and Salem 2015)

SCI index	Conservation Importance Category	Number of species
0.20-0.25	Low importance	0
0.25-0.50	Moderate importance	6
0.50-0.75	Important	48
0.75-1.00	High Importance	2

The medicinal plants were well established for more than 150 therapeutic uses and for treating many human diseases (Table S3). The maximum number of healing properties (NP_m) was attributed to *V. syriaca* (15), followed by *T. capitata* (12) and *Allium* spp. (11). The maximum ethnobotanical relative importance (RI) index value was attained by *T. capitata*, while the minimum value of 11.7 was attained by seven species, namely, *Fumaria judaica* subsp. *judaica*, *Heliotropium hirsutissimum* Grauer, *Hyoseris radiata* subsp. *graeca* Halácsy, *Limonium sinuatum* subsp. *romanum* Täckh. & Boulos, *Lycium schweinfurthii* var. *aschersonii* (Dammer) Feinbrun, *M. albiflorum* and *M. parviflorum*.

Applying TWINSPAN to 14 phytochemical classes recorded in 30 medicinal species led to the recognition of 7 groups at the fifth classification level (Table 6, Figure 8. A). The application of non-metric MDS on the same data set indicates reasonable segregation among these groups (Figure 8. B). The groups are named after the species with the highest number of phytochemical classes: the I- *Taraxacum minimum* Heldr. ex Nyman, 1879 group. This group is constituted of the terpenes class. The highest species are *Echinops taeckholmianus* Amin, *S. fruticosa*, and *H. hirsutissimum*; the II- *E. taeckholmianus* group. This group is constituted of propanoids, lipids, and alkaloids. The highest species are *Pancratium arabicum* Sickenb. and *Posidonia oceanica* (L.) Delile; the III- *H. radiata* subsp. *graeca* group comprised of polyphenols and flavonoids. This group contains 93% of the recorded species. The highest species are *V. syriaca*, *C. cornigera*, and *L. schweinfurthii* var. *aschersonii*; the IV- *P. arabicum* group comprises glycosides, tannins, resins, and carbohydrates. The highest species are *Bellevalia* spp., *F. judaica* subsp. *judaica*, and *Verbascum letourneuxii* Asch. & Schweinf.; V- *P. oceanica* group constituted of steroids. The highest species are *P. arabicum*, *T. minimum*, and *V. syriaca*; the VI- *S. fruticosa* group is the only species in this group and is constituted of vitamins; and the VII- *Allium* species group, which is constituted of saponins and organophosphorus compounds. The highest species are *Allium* species and *P. arabicum*.

The application of TWINSPAN to 10 treatment body systems led to the recognition of 3 groups at the second level of classification: I- This group is constituted of immune, circulatory and cardiovascular, Nervous systems and general pain; II- This group is constituted of respiratory, digestive urinary and renal and exocrine systems; III- This group is constituted of the only reproductive system (Figure 9, Table 7).

Indeed, the arrow length of the CANOCO ordination expresses the relative importance of the phytochemical class. Polyphenols, alkaloids, and organophosphorus compounds are the most effective classes in the recorded Mediterranean endemics. The urinary system (Ur) correlated highly with steroids. Respiratory system (Rs) correlated with a high occurrence of propanoids. The nervous system (Ne) and immune system (Im) correlated with tannins, resins, and carbohydrates (Figure 10).

Table 6. The phytochemical classes were recorded in Mediterranean endemics in Egypt

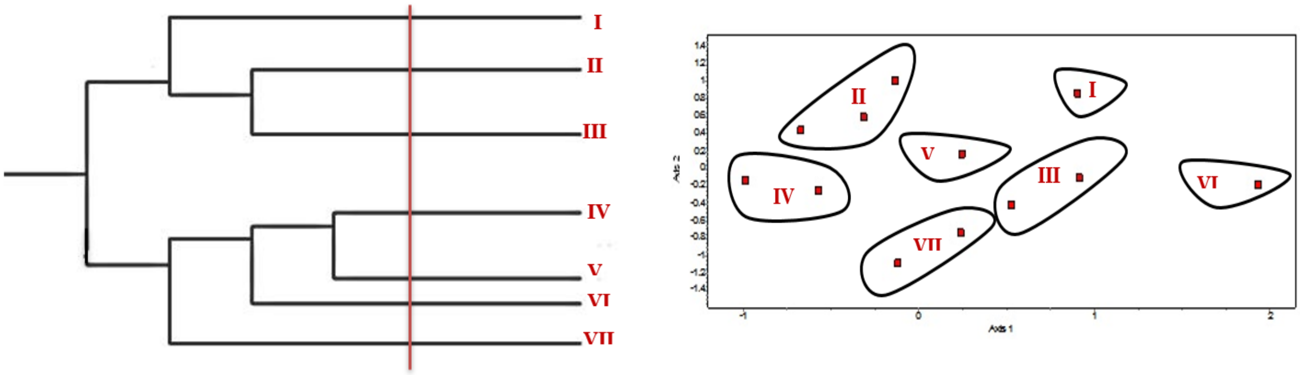
Scientific name	Po	Fl	Pr	St	Te	Sa	Or	Li	Al	Gl	Ta	Re	Ca	Vi	Total
A. barthianum		1				1	1								3
A. blomfieldianum		1				1	1								3
A. mareoticum		1				1	1								3
A. trifoliatum		1				1	1								3
A. chia	1	1													2
B. mauritanica	1														1
B. salah-eidii	1														1
B. sessiliflora	1														1
B. warburgii	1														1
C. aegialophila					1										1
C. pumilio					1										1
C. cornigera	1	1													2
E. taeckholmianus	1	1	1		1			1	1						6
E. parvula					1										1
F. judaica subsp. *judaica*									1						1
H. hirsutissimum	1	1			1			1							4
H. radiata subsp. *graeca*	1	1													2
L. sinuatum subsp. *romanum*	1	1													2
L. polyphyllos	1														1
L. schweinfurthii var. *aschersonii*	1	1													2
M. albiflorum	1														1
M. parviflorum	1														1
P. arabicum		1		1		1	1	1	1	1	1	1	1		10
P. oceanica	1		1	1				1							4
S. fruticosa		1		1	1	1								1	5
T. minimum	1	1		1	1	1				1					6
T. brevifolium					1										1
T. capitata	1														1
V. letourneuxii					1					1					2
V. syriaca	1	1	1	1											4
Total	18	15	3	5	9	7	5	4	3	3	1	1	1	1	

Note: The phytochemical classes are coded as Po: Polyphenols; Fl: Flavonoids; Pr: Propanoids; St: Steroids; Te: Terpenes; Sa: Saponins; Or: Organophosphorus compounds; Li: Lipids; Al: Alkaloids; Gl: Glycosides; Ta: Tannins; Re: Resins; Ca: Carbohydrates; Vi: Vitamins

Table 7. The body systems that Mediterranean endemics treat

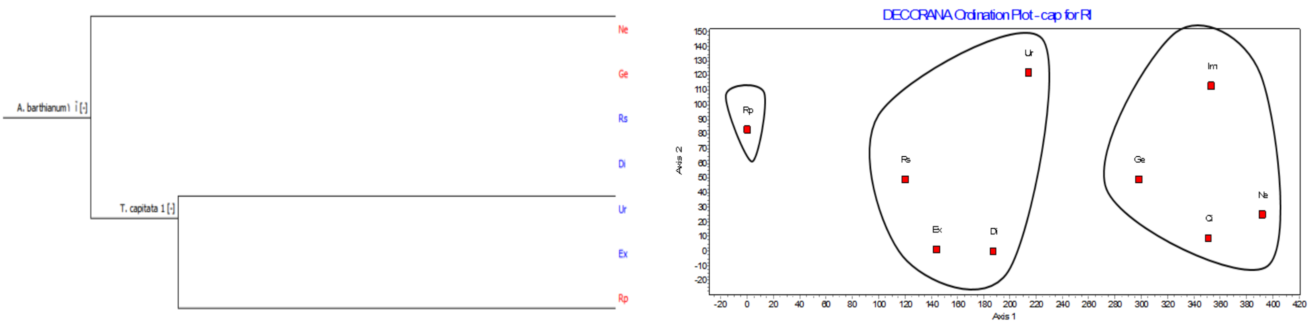
Scientific name	Im	Ci	Rs	Di	Mu	Ne	Ur	Rp	Ge	Ex	Total
A. barthianum	1	1				1			1		4
A. blomfieldianum	1	1				1			1		4
A. mareoticum	1	1				1			1		4
A. trifoliatum	1	1				1			1		4
A. chia									1		1
B. mauritanica									1		1
B. salah-eidii									1		1
B. sessiliflora									1		1
B. warburgii									1		1
C. aegialophila									1		1
C. pumilio									1	1	2
C. cornigera										1	1
E. taeckholmianus			1					1	1		3
E. parvula			1	1		1			1	1	5
F. judaica subsp. *judaica*						1					1
H. hirsutissimum									1		1
H. radiata subsp. *graeca*									1		1
L. sinuatum subsp. *romanum*									1		1
L. polyphyllos									1		1
L. schweinfurthii var. *aschersonii*									1		1
M. albiflorum									1		1
M. parviflorum									1		1
P. arabicum		1				1			1		3
P. oceanica		1		1					1	1	4
S. fruticosa	1						1		1		3
T. minimum							1		1		2
T. brevifolium									1		1
T. capitata		1	1	1			1		1	1	6
V. letourneuxii									1		1
V. syriaca	1		1	1			1		1	1	6
Total	6	7	4	4		7	4	1	28	6	

Note: Body systems are coded as Im: Immune; Ci: Circulatory and cardiovascular; Rs: Respiratory; Di: Digestive; Mu: Muscular and skeletal; Ne: Nervous; Ur: Urinary and renal; Rp: Reproductive; Ge: General pain; and Ex: Exocrine



A B

Figure 8. A. Dendrogram of the 7 groups derived after application of TWINSPAN classification technique at the fifth level, B. Cluster segregation of the 7 groups using non-metric MDS



A B

Figure 9. A. Dendrogram of the 3 groups derived after application of TWINSPAN classification technique at the second level, B. Cluster segregation of the 3 groups using DECORANA. Body systems are coded as Im: Immune, Ci: Circulatory and cardiovascular, Rs: Respiratory, Di: Digestive, Mu: Muscular and skeletal, Ne: Nervous, Ur: Urinary and renal, Rp: Reproductive, Ge: General pain and Ex: Exocrine

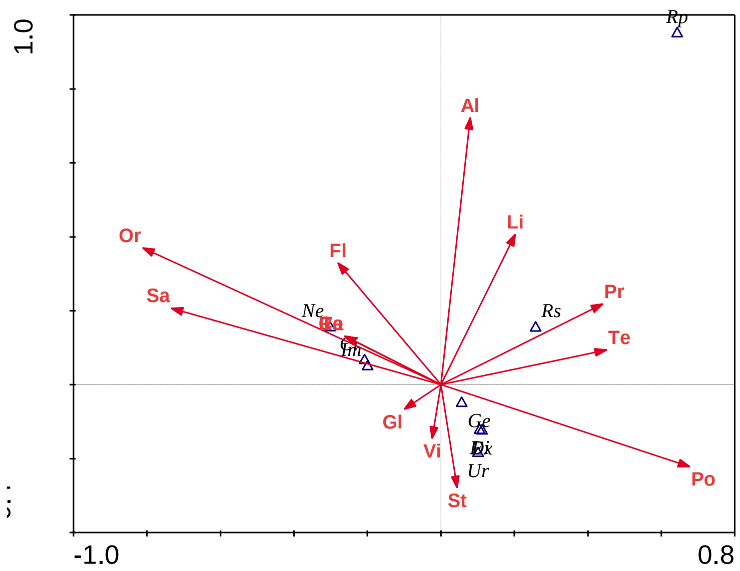


Figure 10. The CCA ordination plot for the phytochemical classes was recorded in Mediterranean endemics (represented by arrows) and their effect on treating different body systems. The phytochemical classes are coded as Po: Polyphenols, Fl: Flavonoids, Pr: Propanoids, St: Steroids, Te: Terpenes, Sa: Saponins, Or: Organophosphorus compounds, Li: Lipids, Al: Alkaloids, Gl: Glycosides, Ta: Tannins, Re: Resins, Ca: Carbohydrates and Vi: Vitamins. Body systems are coded as Im: Immune, Ci: Circulatory and cardiovascular, Rs: Respiratory, Di: Digestive, Mu: Muscular and skeletal, Ne: Nervous, Ur: Urinary and renal, Rp: Reproductive, Ge: General pain and Ex: Exocrine

Discussion

The present study has proved the ethnobotanical uses of Mediterranean endemics in Egypt. The region suffers from huge human impact and is threatened due to the extensive climatic change projections. Consequently, conservation plans are required to conserve these restricted endemic taxa and plant diversity in the Egyptian Mediterranean territory. Many Mediterranean species are restricted to a single or few localities in sandy areas, isolated mountain ranges, or islands of unusual soils or rocky grounds; thus, this region is characterized by a high degree of endemism compared to other regions (Zahran 2010; Radha and Khwarahm 2022). According to UNEP (2022), the Mediterranean is one of the most vulnerable regions in the world to the impacts of global warming. The Mediterranean region's temperature is warming 20% faster than the global average; a 2°C global warming will reduce precipitation by ~10 to 15%.

Further, water temperature is expected to rise between 1.8 and 3.5°C by 2100, with hotspots in the Eastern and northern parts of the Western Mediterranean. Sea level is expected to rise between 0.43 and 2.5 m by 2100. Consequently, these events will result in increased heat waves, coastal erosion, fires, invasive species, floods, acidification of the sea, and the risk of extinction of certain species in the region (UNEP 2022). Unfortunately, over 100 kilometers of Egypt's Mediterranean territory have already been lost due to climate change and human activities, especially the establishment of tourist summer resorts. As a result, it is not easy to find any traces of the natural vegetation reported earlier in this region (El-Hadidi and Hosni 2000; Halmy 2012, 2019). The Mediterranean is vulnerable to climate change impacts in several ways. Water scarcity, the widespread and long-known challenge in many Mediterranean countries, will likely increase in the following decades due to anticipated climate change (Cramer et al. 2019; Bedair et al. 2023b, c; Hama and Khwarahm 2023). In ethnobotanical studies, quantitative analyses serve as a technique for gathering data comparable to that from other studies and drawing valid conclusions from the data gathered. The Mediterranean region in Egypt typically has high rates of human impact, which speeds up the loss of agricultural tradition and ethnobotanical expertise. There is a medium- and long-term danger of irreversible knowledge loss since local inhabitants often learn about ethnobotany from their elderly neighbors and parents (or grandparents). Mediterranean flora offers vast benefits for human beings. About 70% of the recorded taxa have medicinal values. For instance, the marine macrophyte *P. oceanica* was initially intended to treat skin diseases but is now used to treat acne, leg discomfort, colitis, diabetes, hypertension, and respiratory infections (Rizk 2017). In addition, (Farid et al. 2018) assumed that the leaf extract has anticancer activity, while the ball extract showed antivirus activity against the H5N1 virus. Herbalists in the region utilize and sell the plant as a medical plant (e.g., in the Egyptian Center for Herbs and Cross in Alexandria and Tahreer Street in Matrouh District, Egypt) (Bidak et al. 2021). Leaves and flowering branches of *T. capitata* were proven to treat stomach diseases, cough, and throat inflammation (Seif El-Nasr and Bidak 2005).

Moreover, *Fumaria* species have anti-inflammatory, antibacterial, antifungal, antinematode, and antinociceptive effects (Gupta et al. 2012). Common garlic and onions, two economically major *Allium* crop species, play a significant role in the daily diet as vegetables and for therapeutic purposes. Antiviral, antibacterial, antifungal, antidiabetic, anticarcinogenic, antiplatelet, antispasmodic, antiseptic, antihelminthic, antithrombotic, anti-asthmatic, anti-carminative, antioxidant, anti-inflammatory, antihypertensive, hypoglycemic, hypotensive, lithontriptic, and hypocholesterolemic properties are just a few of the health benefits that *Allium* species reported providing (Najeebullah et al. 2021). Further, roots and bulbs of *Bellevalia* species are stated to have anti-rheumatic and anti-inflammatory effects (Savio et al. 2019). *Centaurea pumilio* Hill, 1762, has antimicrobial and antioxidant activities (Naeim et al. 2020). The shoot system extract of *C. cornigera* has been proven to have antimicrobial, antioxidant, and antidiabetic substances. Moreover, in folk medicine in various Mediterranean nations, *C. cornigera* is used to treat several illnesses, including hepatitis, hyperlipidemia, hepatobiliary dysfunction, digestive complaints, irritable bowel syndrome, hyperlipoproteinemia, obesity, dyspeptic disorder, diabetes mellitus, liver complaints, and improving liver regeneration after partial hepatectomy (Ozdenefe et al. 2022).

Moreover, the Phenolic compounds represented in this study by the two most important groups, polyphenols and flavonoids, represent the largest category of phytochemicals and are most widely distributed in the recorded ethnopharmacological species. They have excellent antioxidant activities against radical-mediated disease processes. They also have anti-cancerous, antimicrobial cytotoxicants and vasodilating activities. Terpenoids are the second largest secondary metabolites category in the present study. They comprise nine Mediterranean endemics, such as *T. minimum* and *S. fruticosa*. Terpenoids can have medical effects such as anticarcinogenic, anti-malarial, anti-ulcer, hepaticidal, antimicrobial, or diuretic activity. Examples include perilla alcohol, the anti-malarial medication artemisinin, and the diterpenoid anticancer medicine taxol.

Further, many of them are commercially valuable because of their use as flavors and fragrances in foods and cosmetics (Koche et al. 2016). These results agree with (Koche et al. 2016), who elucidated that phenolics and terpenoids are the two major phytochemical classes occurring as natural products by 45% and 27%, respectively. Interestingly, 7 species, including the 4 recorded *Allium* species, contain Saponins as part of their defense system. They have antifungal and antiviral activities as well as promising agents for the human and animal immune systems (Traore et al. 2000). Furthermore, 5 Mediterranean endemics contain Steroids (*P. arabicum*, *P. oceanica*, *S. fruticosa*, *T. minimum*, and *V. syriaca*). This phytochemical group has antimicrobials, detoxifying agents, strengthners, anti-rheumatics, and anti-malarial,hepaticidal activities (Koche et al. 2016). Indeed, the reason for the linkage between Tannins, Carbohydrates, and Resins in *P. arabicum* is that they can form reversible and irreversible complexes. Plant extracts with tannins are used as astringents to treat and prevent diarrhea, as well as diuretics that are effective against stomach and duodenal cancers and pharmaceuticals that are anti-inflammatory, antiseptic, antioxidant, and homeostatic pharmaceuticals (Koche et al. 2016). Similar to many plant species of the genus *Echinops* L., *E. taeckholmianus* is well known for many plant products (e.g. essential oils) that have wide variety of traditional medical applications, including pain, inflammation, respiratory diseases, aphrodisiac, and removal of renal stones (Bitew and Hymete 2019).

The RI values represented the number of indications assigned to each species, indicating the significance of each species in traditional medicine. The more therapeutic uses for a species, the more significant it is to the local population's overall therapeutic framework and the higher the RI index value. Numerous species had reached RI values above 50.0, indicating an enormous contribution of these species to the regional pharmacopeia. The RI index evaluates the adaptability of medicinal plants in regional pharmacopeia. It can thus be used to compare the function of particular species in the regional pharmacopeia. It can assist in tracking changes in the long-term utilization of significant medicinal species. The RI index can be used to track the evolution of conventional knowledge through time (Bennett and Prance 2000; Monteiro et al. 2011). The *V. syriaca* is the only species with an RI of 100 % due to its broad therapeutic uses in treating many body systems. It treats pharyngitis and laryngitis, respiratory disorders like influenza, digestive and urinary disorders, gout, and rheumatics. It is also applied externally in impaired healing of wounds and skin disorders. In addition, it has antioxidant, anti-inflammatory, analgetic, antimicrobial, cytotoxic, and cholagogic activities (Witkowska-Banaszczak et al. 2016).

Fruits, flowers, and vegetative and underground parts of some Mediterranean endemics provide food sources for the local inhabitants. For example, *Trigonella berythea* Boiss. & C.I.Blanche is a food additive (PFAF 2022). Interestingly, *T. capitata* is widely utilized as a food source and was cited for many edible uses. It is used as a condiment. Spanish oregano oil is an extracted oil from the plant used for flavoring. The leaves are also used as a food additive or for aromatic tea (Facciola 1990). The *C. cornigera* is a wild edible plant in many Mediterranean countries such as Egypt, Libya, and Cyprus. It can be used as a vegetable or boiled with meat (Ozdenefe et al. 2022). Further, the *T. minimum* is a food source (Ahmed 2009). *Vicia sinaica* Boulos is a source of pulse proteins for the human diet. Moreover, *L. schweinfurthii* var. *aschersonii* is a good food source (Bedair 2020).

Some Mediterranean endemics are grazed and browsed by the domestic and wild animals in the region. There is evidence that halophytes (e.g., *Limonium echioides* (L.) Mill.) are preferred by livestock in salt marshes, especially in the dry seasons, for their high water content. Camels, sheep, and goats are the main grazing animals that forage on the species inhabiting salt marshes (Shaltout and Ahmed 2012). The *Lotus polyphyllos* E.D.Clarke and *C. pumilio* are consumed by livestock in the Mediterranean dunes in Egypt (Ahmed et al. 2014). The *T. berythea* and *Sulla spinosissima* (L.) B.H.Choi & H.Ohashi are used as fodder plants because they are rich in high percentages of proteins and vitamins (Haouala et al. 2009). It was reported that the seeds and pods of *E. armitagei* are heavily eaten by insects, especially bruchid beetles *Callosobruchus maculatus* (Fabricius, 1775) (Shaltout et al. 2018). Mediterranean perennials such as *C. pumilio*, *C. cornigera*, *T. capitata*, *S. fruticosa*, and *L. schweinfurthii* var. *aschersonii* are used as timber and fuel. On the other hand, some species have other uses, such as *Reseda orientalis* (Müll.Arg.) Boiss., for manufacturing dyes and perfumes (PFAF 2022). The essential oils obtained from *Helichrysum orientale* (L.) Gaertn. are used in perfume blending (PFAF 2022). In comparison, *Anthemis* L. species is utilized in cosmetics (PFAF 2022). *Fumaria microstachys* (Hausskn.) Pugsley, *Linaria joppensis* Bornm., *V. petrovitchii,* and *L. sinuatum* subsp. *romanum* have esthetic concerns (PFAF 2022). Moreover, *S. peruviana* is an ornamental plant (PFAF 2022). Further, *T. capitata* and *Bupleurum nanum* Poir. have aromatic values and are widely used as good sources of essential oils. Extract of *L. schweinfurthii* var. *aschersonii* can be used as insecticide (Bedair 2020).

The Cultural Importance (CI) index revealed that the *Za'tar* (*T. capitata*) and *Kharshouf* (*C. cornigera*) are the informants in the survey who highly cited the most culturally significant species as their uses. Remarkably, all the informants have emphasized these species' medicinal and nutritional values, which can be attributed to the widespread uses for which the local inhabitants utilize them. The local inhabitants in Mersa Matrouh District collect *Za'tar* and sell it as a food recipe. In addition, it is widely used in folk medicine to treat influenza, cough, diarrhea, respiratory disorders, flu, and asthma. It was proven to have antidiabetic, antimicrobial, antioxidant, antiviral, antiparasitic, and hepatoprotective properties (Bouyahya et al. 2020). Furthermore, four species of *Basal* (*Allium* sp.) were mentioned by all the informants as being used in food and folk medicine.

Interestingly, the 16 species with the highest CI index are all perennials. This can be attributed to the availability of these species in the different seasons, revealing the relation between the prevalence of use, the number of uses for which a species can be utilized, and the availability of the species throughout the year. Consequently, species with higher longevity would have more chance to be widespread, and known to informants is much higher than annuals that die off after only one season. This observation agrees to some extent with (Bennett and Prance 2000; Pardo-de-Santayana et al. 2006; Tardío and Pardo-de-Santayana 2008; Berlin 2014), who assumed that perennials, especially woody perennials, are more likely to be beneficial since they have more number of distinct parts (leaves, roots, flowers, fruits, seeds, bark, wood) that might have a variety of uses.

The *T. capitata* came in the first ranking in all the indices. This result is logical because this species is common and predominant in the western Mediterranean coastal strip and was mentioned by all the informants. There are noticeable differences in species ranking according to all the used indices. For example, RFC puts *P. oceanica* in the 4th position, decreasing to the 11th position based on CI and RI and the 9th rank based on cultural value. The same rankings are obtained for *Trifolium argutum* Banks & Sol. Some extensively used Mediterranean endemics, such as *Allium* sp. and *C. cornigera* (mentioned by all the surveyed 43 informants), but with few uses (folk medicine and human food), are undervalued when using the CV, RI, and CI indices, rising to the first ranking with the RFC index.

The Cultural Value (CV) index gives redundant weight to the diversity of use (Tardío and Pardo-de-Santayana 2008) as it is obtained by multiplying the Relative Frequency of Citation (RFC), Cultural Importance (CI) and Number of Uses (NU/NC). The Relative Importance (RI) index is the mean between the positive correlation of the maximum relative NU and FC (r = 0.5); hence, it overweighs the diversity of uses. The strong correlation between FC and RFC is logical because RFC is obtained by dividing FC by the number of informants participating in the survey. CI index is also strongly correlated with the use reports (UR: r = 1). Therefore, it can be stated that those indices, especially the CI index, are more objective than those depending on use categories.

Further, we can assure that most useful Mediterranean endemics in Egypt have few uses (less than three); only 4 taxa have three uses or more. The positive correlation between FC and NU assures that the more multilateral the Mediterranean endemic, the more it has widespread knowledge of usefulness and the more it is mentioned by the informants. Similar results were obtained by (Tardío and Pardo-de-Santayana 2008) in Northern Spain and by (Shaheen et al. 2017) in Pakistan.

Indeed, ecosystem services are what people obtain from the ecosystem as a whole (Reid et al. 2005). About 21.5% of the recorded endemics offer at least one aspect of environmental services. In the present study, there are 8 sand accumulators (*P. arabicum*, *Anthemis microsperma* Boiss. & Kotschy, *Hyoseris scabra* L., *H. radiata* subsp. *graeca*, *C. pumilio*, *T. capitata*, *L. polyphyllos* and *S. spinosissima*). Most of them are perennials, a finding supported by Seif El-Nasr and Bidak (2005), who elucidated that phanerophytes and chamaephytes can decrease sand drift and increase soil sedimentation effectively. On the other hand, there are 2 windbreaks (*T. capitata* and *L. polyphyllos*), which can reproduce by seeds or running roots (Shaltout and Ahmed 2012). Spectacularly, 8 taxa have a role in soil fertility. All of them belong to the family Fabaceae (*E. armitagei*, *L. polyphyllos*, *L. cytisoides*, *S. spinosissima*, *V. sinaica*, *Coronilla repanda* (Poir.) Guss., *T. argutum* and *T. berythea*). They form a symbiotic association with some species of bacteria (e.g., *Rhizobium* Frank, 1889 and *Bradyrhizobium* Jordan, 1982 species). These bacteria consume nitrogen from the air and fix it into usable form to the legume plant. This fixation occuring in nodules, a specialized roots structures on the plant. After the legume plant roots died and the nodules decompose, nitrogen that the bacteria fixed will be released and become available for subsequent crops (Kebede 2021).

In this study, only *H. radiata* subsp. *graeca* has water storage capability (Shaltout et al. 2010). Water storage has a role in drought avoidance, decreasing competition, and increasing productivity (Hartzell et al. 2017). Moreover, this species is consumed as a vegetable side dish in many countries of the Mediterranean basin. Furthermore, *S. spinosissima* can accumulate toxic metals and thus be used in the phytoremediation of pollutants. According to the data provided in a recent study (Oubohssaine et al. 2022), *S. spinosissima* growing in heavy metal soils is linked to various active bacterial communities that likely support plant growth and tolerance under the current stressful conditions. The superior strains found are excellent candidates for use in rehabilitation programs for chosen plants in contaminated habitats.

The considerable proportion of species (about 60%) attaining SCI values between 0.50-0.75 indicates that the Egyptian flora is rich in critical Mediterranean endemics. The value of the Species Conservation Index reflects the importance of each species not only in terms of its economic and ecological uses but also in terms of its conservation status, rarity, life span, and geographical distribution (Halmy and Salem 2015). Indeed, all species recorded in this study occur in only one global floristic region (i.e., Mediterranean endemics); geographic distribution does not significantly impact the index in this study. Hence, efforts are needed to reduce the pressure on the species in the region by controlling the local inhabitants' grazing and over-collection activities. In addition, controlling the vast habitat loss due to summer resort construction on the western Mediterranean coastal strip is a must. More studies are critically needed for sound conservation management for endemics in the Mediterranean region, where the paucity of information about species composition and vegetation structures curtails conservation efforts. Research that assesses the combined impact of climate change and other human-induced changes, such as land use/land cover changes, will also be valuable.

Limitations of the applied indices

Even though quantification is a relatively old idea in ethnobotany (de Albuquerque and Hanazaki 2009), quantitative methodologies have recently received more attention (Galeano 2000). A quantitative approach is needed to address issues such as threatened species, pressure over natural resources, and impacts of the use of plants. Consequently, the popularity of ethnobotany appears to be linked to recognizing its ethical, biological, and social implications (de Albuquerque and Lucena 2005). These factors have transformed the importance and significance of local knowledge, placing ethnobotany in a privileged position in searching for "solutions to very complex social or environmental problems" (Alexiades 2003). In addition, the lack of appreciation of previous literature is one of the principal weaknesses of many recently published works. Authors often present exciting ideas and describe situations similar to those encountered in other studies, but they do not place their work in the context of or discuss it in terms of the available literature. This may be partly explained by the lack of books/texts on ethnobotany that synthesize current ethnobotanical trends. Indeed, the limitations in building a unifying theory are another weakness of numerous ethnobotanical studies (de Albuquerque and Hanazaki 2009).

In conclusion, In this study, we highlighted the importance of the Mediterranean endemics in Egypt that are critically under threat of extinction and have been neglected for many years. Our findings revealed that the most important species in the region are *T. capitata, Allium* spp., *C. cornigera,* and *V. syriaca*. In addition, we performed a multivariate analysis that revealed that polyphenols, flavonoids, and terpenes are the phytochemical classes with the highest occurrence in these Mediterranean endemics. This study is an alarm for the informants, researchers, and biodiversity conservation organizations of the ethnobiological importance of these threatened taxa. Consequently, taking action to manage a plan for their conservation is crucial.

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Table S1. Example of inquiry about the goods of Mediterranean endemics in Egypt. Goods are coded as: ME: Medicinal, HF: Human food, GR: Grazing, FU: Fuel, TI: Timber, and OT: Other

Name or number: Age: Region:
Specialty: Date:

Scientific name	Common name	Goods					
		ME	HF	GR	OT	FU	TI
Thymbra capitata	زعتر						
Cynara cornigera	خرشوف						
Allium barthianum	بصل						
Allium blomfieldianum	بصل						
Allium mareoticum	بصل						
Allium trifoliatum subsp. *hirsutum*	بصل						
Veronica syriaca	حبق, زهرة الحواشي السورية						
Lycium schweinfurthii var. *aschersonii*	جسوع						
Pancratium arabicum	سوسن						
Anthemis microsperma	أربيان						
Desmazeria philistaea	حلفا						
Centaurea pumilio	مرير						
Reseda orientalis	ذيل الخروف						
Posidonia oceanica	شتنارة						
Trifolium argutum	قضاب						
Trigonella berythea	حندقوق						
Lathyrus marmoratus	جيرحد						
Thesium humile var. *maritima*	حب الكريس						
Vicia sinaica	دحريج						
Bellevalia mauritanica	بصيل						
Bellevalia salah-eidii	بصيل						
Bellevalia sessiliflora	بيلبوش						
Bellevalia warburgii	بصيل						
Leopoldia bicolor	بصيل						
Muscari albiflorum	بصيل						
Muscari parviflorum	بصيل						
Anthemis chia	أربيان						
Echinops taeckholmianus	خشروف						
Centaurea aegialophila	مرير						
Euphorbia parvula	لبين						
Herniaria cyrenaica	أم لبيد						

Table S2. Species Conservation Importance (SCI) of the recorded Mediterranean endemics in the Egyptian flora. IUCN Regional Conservation Status is coded as follows: CR: Critically Endangered, EN: Endangered, RE: Regionally Extinct, EX: Extinct, RA: Rare, IN: Indeterminate, and DD: Data Deficient. Life span is coded as AN: Annual and PE: Perennial. Abundance categories are coded as cc: Very common, c: Common, r: Rare, and rr: Very rare. Goods are abbreviated as GR: Grazing, ME: Medicinal, HF: Human food, FU: Fuel, TI: Timber, and OT: Other uses. Services are coded as WB: Wind-breaking, SA: Sand accumulation, SF: Soil fertility, WS: Water storage, ES: Esthetic concerns, NF: Nitrogen fixation, and PH: Phytoremediation

Binomial	Family	Common name	Regional conservation status	Life span	Abun-dance	Goods	Services	SCI
Thymbra capitata (L.) Cav.	Lamiaceae Martimov	Mediterranean Wild Thyme, Conehead Thyme	EN	PE	c	ME, HF, GR, FU, OT	SA, WB, ES	0.864
Ebenus armitagei Schweinf. & Taub.	Fabaceae Lindl.	-	EN	PE	rr	GR, ME	SF, NF	0.752
Hyoseris scabra L.	Asteraceae	Annual Hyoseris	CR	AN	rr	GR, ME	SA, ES	0.72
Lotus cytisoides L.	Fabaceae Lindl.	Grey Bird´s-foot-trefoil	EN	PE	rr	ME	SF, NF	0.72
Lotus polyphyllos E.D.Clarke	Fabaceae	-	EN	PE	c	GR, ME	SA, WB, SF	0.72
Lycium schweinfurthii var. *aschersonii* (Dammer) Feinbrun	Solanaceae Juss.	Schweinfurth´s Tea-tree	EN	PE		ME, HF, OT (insecticide)		0.72
Sulla spinosissima (L.) BH.Choi & H.Ohashi	Fabaceae Lindl.	Spiny Sulla; Dorniger Sussklee	EN	AN	r	GR	SA, SF, PH	0.72
Vicia sinaica Boulos	Fabaceae Lindl.	-	EX	AN	rr	HF, ME	SF, NF	0.72
Lathyrus marmoratus Boiss. & Blanche	Fabaceae Lindl.	-	EN	AN		HF, ME		0.704
Allium barthianum Asch. & Schweinf.	Amaryllidaceae J.St.-Hil.	Garlic	EN	PE	r	HF, ME		0.688
Allium blomfieldianum Asch. & Schweinf.	Amaryllidaceae J.St.-Hil.	Onions	EN	PE	rr	ME, HF		0.688
Allium mareoticum Bornm. & Gauba	Amaryllidaceae J.St.-Hil.	Onions	EN	PE	rr	ME, HF		0.688
Allium trifoliatum Cirillo	Amaryllidaceae J.St.-Hil.	Pink Garlic, Three-leaved Garlic	RE	PE	rr	HF, ME		0.688
Centaurea pumilio Hill, 1762	Asteraceae Bercht. & J.Presl	-	EN	PE	c	GR, ME, FU	SA, ES	0.688
Coronilla repanda (Poir.) Guss.	Fabaceae Lindl.	Curly Crown Vetch	CR	AN	rr	ME	SF, NF	0.688
Crepis libyca (Pamp.) Babc.	Asteraceae	-	CR	PE	rr	ME, HF		0.688
Cynara cornigera Lindl.	Asteraceae Bercht. & J.Presl	White Artichoke	CR	PE	r	ME, HF		0.688
Echinops taeckholmianus Amin	Asteraceae Bercht. & J.Presl	-	CR	PE	r	GR, ME		0.688
Limonium sinuatum subsp. *romanum* Täckh. & Boulos	Plumbaginaceae Juss.	Wavyleaf sea lavender	CR	PE	rr	ME, OT (Esthetic)		0.688
Pancratium arabicum Sickenb.	Amaryllidaceae J.St.-Hil.	-	EN	PE	r	ME	SA	0.688
Trifolium argutum Banks & Sol.	Fabaceae Lindl.	Sharp-tooth Clover	CR	AN	rr	ME	SF, NF	0.688
Trigonella berythea Boiss. & C.I.Blanche	Fabaceae Lindl.	-	EN	AN	rr	HF	SF, NF	0.688
Bellevalia mauritanica Pomel	Asparagaceae	-	EN	PE	rr	ME		0.656
Bellevalia salah-eidii Täckh. & Boulos	Asparagaceae Juss.	-	EX	PE	rr	ME		0.656
Bellevalia sessiliflora (Viv.) Kunth	Asparagaceae Juss.	-	EN	PE	rr	ME		0.656
Fumaria microstachys (Hausskn.) Pugsley	Papaveraceae Juss.	-	CR	AN	rr	ME, OT (Esthetic)		0.656
Helichrysum orientale (L.) Gaertn.	Asteraceae Bercht. & J.Presl	Eastern Strawflower	CR	PE	rr	OT (perfume blending)		0.656
Hyoseris radiata subsp. *graeca* Halácsy	Asteraceae Bercht. & J.Presl	PE Hyoseris	EN	PE	c	GR, ME	SA, WS	0.656

Muscari parviflorum Desf.	Asparagaceae Juss.	Lesser Grape Hyacinth	CR	PE	rr	ME		0.656
Reseda orientalis (Müll.Arg.) Boiss.	Resedaceae Marti×v	-	CR	AN	rr	ME, OT (dyes and perfumes)		0.656
Scilla peruviana L.	Asparagaceae Juss.	Peru squill	CR	PE	rr	OT (ornamental plant)		0.656
Silene fruticosa L.	Caryophyllaceae	-	CR	PE	rr	ME		0.656
Taraxacum minimum Heldr. ex Nyman, 1879	Asteraceae Bercht. & J.Presl	-	CR	PE	rr	HF		0.656
Teucrium brevifolium Schreb.	Lamiaceae Marti×v	Shortleaf Germander	CR	PE	rr	ME		0.656
Verbascum letourneuxii Asch. & Schweinf.	Scrophulariaceae Juss.	-	EN	PE	r	ME		0.656
Crepis aculeata Boiss.	Asteraceae Bercht. & J.Presl	-	CR	AN	rr	GR		0.624
Desmazeria philistaea (Boiss.) H.Scholz	Poaceae Barnhart	-	CR	AN	rr	GR		0.624
Fumaria judaica subsp. *judaica*	Papaveraceae Juss.	Judean Fumitory	EN	AN	r	ME		0.624
Helianthemum crassifolium subsp. *sphaerocalyx* (Gauba & Janch.) Maire	Cistaceae Juss.	-	EN	PE		OT (wildcard)		0.624
Linaria joppensis Bornm.	Plantaginaceae Juss.	-	CR	AN	rr	OT (Esthetic)		0.624
Thesium humile var. *maritima* (N.D.Simpson) F.M.Saad	Santalaceae R.Br.	Low Bastard Toadflax	EN	AN	r	GR		0.624
Trisetaria koelerioides (Bornm. & Hack.) Melderis	Poaceae Barnhart	-	CR	AN	rr	GR		0.624
Valerianella petrovitchii Asch. ex Rohlfs	Caprifoliaceae Juss.	-	CR	AN	rr	OT (Esthetic)		0.624
Anthemis microsperma Boiss. & Kotschy	Asteraceae Bercht. & J.Presl	-	EN	AN	c	GR, ME	SA	0.592
Heliotropium hirsutissimum Grauer	Boraginaceae Juss.	Hairy Heliotrope	CR	AN		ME		0.592
Bellevalia warburgii Feinbrun	Asparagaceae Juss.	-	RE	PE	rr	ME		0.576
Leopoldia bicolor (Boiss.) Eig & Feinbrun	Asparagaceae Juss.	Taccel Hyacinth	RE	PE	rr	ME		0.576
Bupleurum nanum Poir.	Apiaceae	-	EN	AN	c	ME, OT (Oil)		0.56
Anthemis chia L.	Asteraceae	Chios Chamomile	DD	AN	rr	ME, HF, OT (cosmetics)		0.528
Posidonia oceanica (L.) Delile	Posidoniaceae Vines	Neptune Grass	EN	PE	cc	ME		0.528
Herniaria cyrenaica F.Herm.	Caryophyllaceae Juss.	-	DD	PE	rr	ME		0.496
Muscari albiflorum (Täckh. & Boulos) Hosni	Asparagaceae Juss.	-	DD	PE	rr	ME		0.496
Centaurea aegialophila Wagenitz, 1974	Asteraceae Bercht. & J.Presl	-	DD	AN	rr	ME		0.464
Cynosurus coloratus Lehm. ex Steud.	Poaceae Barnhart	-	DD	AN	rr	GR		0.464
Euphorbia parvula Delile	Euphorbiaceae Juss.	-	DD	AN	rr	ME		0.464
Veronica syriaca Roem. & Schult.	Plantaginaceae Juss.	The Syrian speedwell	DD	AN	rr	ME		0.464

Table S3. Medicinal plants recorded in the study area, their ethnobotanical relative importance (RI), therapeutic uses, parts used, and supporting references

Scientific name	RI	Therapeutic uses	Part used	Major chemical constituents	Reference
Veronica syriaca Roem. & Schult.	100	It treats respiratory disorders like influenza, pharyngitis and laryngitis, digestive and urinary disorders, gout, and rheumatics. It is also applied externally in skin disorders and impaired healing of wounds. It has antioxidant, anti-inflammatory, analgetic, antimicrobial, cytotoxic, and cholagogues activity	Aerial parts	Flavonoid compounds, mainly derivatives of luteolin, apigenin, scutellarein, and isoscutellarein; phenolic compounds, such as derivatives of arbutin, salidroside, and verbascoside; phenylpropanoids, numerous iridoids, derivatives of aucubin and catalpol, as well as phenolic acids and steroid saponosides.	(Witkowska-Banaszczak et al. 2016)
Thymbra capitata (L.) Cav.	90	Heart, liver, respiratory diseases, urinary digestive system, inflammation, Antidiabetic, cough, cold, stomachache, cardiovascular system, eye diseases, infusion as analgesic and vomiting	Aerial parts	Carvacrol, Eucalyptol (1,8-Cineole), β-Caryophyllene, p-Cymene, γ-Terpinene, Borneol, α-Terpineol,	(Gupta et al. 2012)
Euphorbia parvula Delile	71.7	Anticancer, respirational infections, body and skin irritations, digestion complaints, inflammatory infections, body pain, microbial illness, snake or scorpion bites, pregnancy, and sensory disorders.	Whole plant	Polycyclic and macrocyclic diterpenes	(Kemboi et al. 2020)
Allium barthianum Asch. & Schweinf.	70	Chronic diseases, anticancer, preventive cardiovascular and heart diseases, anti-inflammation, antiobesity, antidiabetes, antioxidants, antimicrobial activity, neuroprotective and immunological effects	Leaves	Organosulfur compounds, quercetin, flavonoids, saponins, and others	(Zeng et al. 2017)
Allium blomfieldianum Asch. & Schweinf.	70	Chronic diseases, anticancer, preventive cardiovascular and heart diseases, anti-inflammation, antiobesity, antidiabetes, antioxidants, antimicrobial activity, neuroprotective and immunological effects	Leaves	Organosulfur compounds, quercetin, flavonoids, saponins, and others	(Zeng et al. 2017)
Allium mareoticum Bornm. & Gauba	70	Chronic diseases, anticancer, preventive cardiovascular and heart diseases, anti-inflammation, antiobesity, antidiabetes, antioxidants, antimicrobial activity, neuroprotective and immunological effects	Leaves	Organosulfur compounds, quercetin, flavonoids, saponins, and others	(Zeng et al. 2017)
Allium trifoliatum Cirillo	70	Chronic diseases, anticancer, preventive cardiovascular and heart diseases, anti-inflammation, antiobesity, antidiabetes, antioxidants, antimicrobial activity, neuroprotective and immunological effects	Leaves	Organosulfur compounds, quercetin, flavonoids, saponins, and others	(Zeng et al. 2017)

Posidonia oceanica (L.) Delile	66.7	Treat inflammation and irritation, but also as a remedy for acne, lower limb pain, colitis, sore throat, diabetes, hypertension, and skin problems, prevent respiratory infections	Leaves	Chicoric acid, caftaric, gentisic, chlorogenic, caffeic, ferulic, cinnamic, gallic, p-coumaric acids, quercetin, myricetin, kaempferol, and isorhamnetin. Phenolics such as phloroglucinol, pyrocatechol, pyrogallol, vanillin aldehyde, 4-hydroxybenzaldehyde, 3,4-dihydroxy benzaldehyde, benzoic acid,p-hydroxybenzoic acid,p-anisic acid, vanillic acid, syringic acid, proanthocyanidins, and calchones (as phloretin and phloridzin). Lipids such as palmitic, palmitoleic, oleic, and linoleic acids, as well as the phytosteroids campesterol, stigmasterol, and β-sitosterol	(Vasarri et al. 2021)
Echinops taeckholmianus Amin	45	Anti-inflammation, pain, and fever; ailments related to the respiratory tract, including cough and sore throat; uterus tumor and leucorrhoea	Whole plant	Thiophenes and terpenes. Flavonoids and other phenolic compounds, alkaloids, lipids, and phenylpropanoids	(Bitew and Hymete 2019)
Taraxacum minimum Heldr. ex Nyman, 1879	43.3	Treat cystitis, liver and gastric ailments, hepatic and renal detoxification, and diabetes as an anti-inflammatory and anticarcinogenic, antimicrobial, and antiviral agent	Leaves and roots	Phenolics terpenoids, triterpenoids, steroids, coumarins, phenols, saponins, flavonoids, flavones, flavonols, chalcones, phlobatannins, and cardiac glycosides	(Valenzuela et al. 2018)
Pancratium arabicum Sickenb.	41.7	Reduces blood pressure, treats asthma and malaria, has anticancer, cardiotonic, and hallucinogenic effects	Leaves and bulb	Sterols, tanning chlorides, sulfates, reducing sugars, flavonoids, alkaloids, resins, saponins, carbohydrates, glycosides, and traces of volatile oils	(Morsi et al. 2000)
Silene fruticosa L.	41.7	Antimicrobial, Antiviral, antioxidant, Antitumor, Phagocytic, Immunomodulatory, Hepatoprotection	Whole plant	Phytoecdysteroids, triterpene saponins, terpenoids, benzenoids, flavonoids, N-containing compounds, sterols, vitamins, and others	(Mamadalieva et al. 2014)
Centaurea pumilio Hill, 1762	23.3	Antibacterial and skin diseases	Root and aerial parts	Butanoic acid-2-methyl,2-methyl butyl, Hexyl isovalerate, 5-Methylhexyl 2-Methylbutanoate, α-copaene, β-Caryophyllene, Isogermacrene D, Octacosane	(Mostafa et al. 2019)
Centaurea aegialophila Wagenitz, 1974	21.7	As a diuretic, to treat fever and diabetes, anti-inflammatory activity	Root and aerial parts		(Demir et al. 2011)
Anthemis chia L.	18.3	Antioxidant, antibacterial, antidiabetic activities	Flowers	Chlorogenic acid, quercetin, hyperoside, vanillic acid, protocatechuic acid, caffeic acid, apigenin 7-glucoside and luteolin 7-glucoside	(Sarikurkcu, 2020)
Bellevalia mauritanica Pomel	18.3	Antioxidant, antibacterial, and anticholinesterase activities	Bulbs-roots sh	The ethyl acetate fraction, quinic acid, gallic acid, fumaric acid, malic acid, caffeic acid and others	(Ouelbani et al. 2020)
Bellevalia salah-eidii Täckh. & Boulos	18.3	Antioxidant, antibacterial, and anticholinesterase activities	Bulbs-roots sh	The ethyl acetate fraction, quinic acid, gallic acid, fumaric acid, malic acid, caffeic acid and others	(Ouelbani et al. 2020)
Bellevalia sessiliflora (Viv.) Kunth	18.3	Antioxidant, antibacterial, and anticholinesterase activities	Bulbs-roots sh	The ethyl acetate fraction, quinic acid, gallic acid, fumaric acid, malic acid, caffeic acid and others	(Ouelbani et al. 2020, Abdelsalam et al. 2023)
Bellevalia warburgii Feinbrun	18.3	Antioxidant, antibacterial, and anticholinesterase activities	Bulbs-roots sh	The ethyl acetate fraction, quinic acid, gallic acid, fumaric acid, malic acid, caffeic acid and others	(Ouelbani et al. 2020)
Cynara cornigera Lindl.	18.3	Antibacterial, antioxidant, Antidiabetic activity	Shoot system	Polyphenols, flavonoids	(Ozdenefe et al. 2022)

Lotus polyphyllos E.D.Clarke	15	Anti-inflammatory and cytotoxic activities	Whole plant	3,4-Caffeic acid dimethyl ether and methyl ferulate	(Osman et al. 2015)
Teucrium brevifolium Schreb.	15	Anti-inflammatory and antitumor activities	Aerial parts	Sesquiterpenes include spathulenol, d-cadinene, caryophyllene, caryophyllene oxide, a-humulene, and torreyol	(Menichini et al. 2009)
Verbascum letourneuxii Asch. & Schweinf.	15	Antioxidant and cytotoxic activities	Aerial parts	Catalpol and its 6-O-(α-l-rhamnopyranopranosyl) derivative, aucubin, 6-O-syringoyl ajugol, harpagoside, eukovoside, martynoside, dehydrodiconferyl alcohol-9-O-d-glucopyranoside and its methyl derivative, syringin and coniferin	(Farid et al. 2020)
Fumaria judaica subsp. *judaica*	11.7	Acts as an Acetylcholinesterase (ache) inhibitor and has therapeutic applications in Alzheimer's disease	Whole plant	Anticholinesterase alkaloids, such as physostigmine and galantamine	(Mukherjee et al. 2007)
Heliotropium hirsutissimum Grauer	11.7	Antimicrobial activity	Whole plant	Essential oils (especially thymol), flavonoids (antioxidants), triterpenoids, and other compounds of a phenolic nature or free hydroxyl group, which are classified as active antimicrobial compounds	(Jaradat et al. 2014)
Hyoseris radiata subsp. *graeca* Halácsy	11.7	Antioxidant activities	Whole plant	Phenols, flavonoids	(Shaltout et al. 2010)
Limonium sinuatum subsp. *romanum* Täckh. & Boulos	11.7	Antioxidant activities	Flower		(Xu et al. 2017)
Lycium schweinfurthii var. *aschersonii* (Dammer) Feinbrun	11.7	Antioxidant activity against DPPH and ABTS+ free radicals	Whole plant	Phenolics and flavonoids	(Mamdouh and Smetanska 2022; Shaltout and Bedair 2023)
Muscari albiflorum (Täckh. & Boulos) Hosni	11.7	Antioxidant activities	Flowers and leaves	Phenolics	(Mammadov et al. 2012)
Muscari parviflorum Desf.	11.7	Antioxidant activities	Flowers and leaves	Phenolics	(Mammadov et al. 2012)