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DIVERSITY AND DISTRIBUTION OF ENDEMIC AND THREATENED PLANT SPECIES IN THE SORKHABAD PROTECTED AREA, ZANJAN, NW IRAN AND IDENTIFICATION OF THE BIODIVERSITY HOTSPOTS IN THE AREA

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Moghanloo, L., Ghahremaninejad, F., Bidarlord, M. & Norastehnia, A.: Diversity and distribution of endemic and threatened plant species in the Sorkhabad Protected Area, Zanjan, NW Iran and identification of the biodiversity hotspots in the area. Nat. Croat., Vol. 32., No. 1, 17-34, 2023, Zagreb.

Protected areas are a mainstay of biodiversity conservation. All over the world, plant biodiversity is at risk and every year the number of threatened species increases dramatically. Many of these species are endemic. Sorkhabad Protected Area is situated in Zanjan Province, NW Iran, and is located in the Irano-Anatolian global biodiversity hotspot. The aim of this study is to investigate endemic and threatened vascular plant species, classify the local rarity of these species and identify hotspots of them in this area. 81 endemic species belonging to 59 genera within 22 families and 116 threatened species belonging to 86 genera within 46 families were collected from the area. Fabaceae with 16 and Asteraceae with 14 endemic species are the two largest families and *Astragalus* L. with 13 endemic species is the largest genus in terms of the number of endemic species. The degree of endemism in the Sorkhabad Protected Area is 15.2 percent. The distribution map of species was prepared using ArcGIS 10.3. The hotspots in terms of endemic and threatened species richness were identified, occupying all told 50,709 ha (41.35%) of the Sorkhabad Protected Area. Identifying the hotspots will help to obtain a proper management program and consequently preserve the biodiversity of this area.

Key words: conservation, elevational distribution, floristic, locally rare taxa, specific species

Moghanloo, L., Ghahremaninejad, F., Bidarlord, M. & Norastehnia, A.: Raznolikost i rasprostranjenost endemičnih i ugroženih biljnih vrsta u zaštićenom području Sorkhabad, Zanjan, SZ Iran, i identifikacija 'vrućih točaka' biološke raznolikosti tog područja. Nat. Croat., Vol. 32., No. 1, 17-34, 2023, Zagreb.

Zaštićena područja temelj su zaštite biološke raznolikosti. U cijelom svijetu biljna raznolikost je ugrožena, a broj ugroženih vrsta dramatično raste. Mnoge od tih vrsta su endemi. Zaštićeno područje Sorkhabad smješteno je u provinciji Zanjan, SZ Iran, u području irano-anatolske 'vruće točke' biološke raznolikosti. Cilj ovog rada je istražiti endemične i ugrožene vaskularne biljne vrste, klasificirati lokalno rijetke vrste i identificirati 'vruće točke' ovog područja. Prikupljeno je ukupno 81 endemična vrsta iz 59 rodova unutar 22 porodice, te 116 ugroženih vrsta iz 86 rodova unutar 46 porodica. Najzastu-

pljenije su porodice Fabaceae sa 16 i Asteraceae s 14 endemičnih vrsta, a od rodova *Astragalus* L. s 13 endemičnih vrsta. Stupanj endemičnosti u zaštićenom području Sorkhabad je 15,2%. Karte rasprostranjenosti vrsta pripremljene su u programu ArcGIS 10.3. Određene su 'vruće točke' za endemične i ugrožene vrste te one zauzimaju ukupno 50,709 ha (41,35%) zaštićenog područja Sorkhabad. Identificiranje tih točaka pomoći će stvoriti plan upravljanja i posljedično očuvati biološku raznolikost ovog područja.

Ključne riječi: zaštita, visinska rasprostranjenost, flora, lokalno rijetke svojte, specifične vrste

INTRODUCTION

All over the world, plant biodiversity is at risk and every year the number of threatened species increases dramatically (Belanger, 2019). Many of these species are endemic, therefore unique, and often only a few and small wild populations resist (Coelho *et al.*, 2020). Endemism is one of the most important concepts in biogeography and the number of endemic species in a biogeographic region is the first step in assessing the conservation situation of that region (Anderson, 1994).

Because of the importance of protected areas in the conservation of biodiversity, it is necessary to carry out floristic research and document endemic and threatened species in these areas. In Zanjan Province and in Iran as a whole, several floristic studies have been conducted to investigate biodiversity in different areas such as the diversity of vascular plants in Damirli mountains (Mahmoodi *et al.*, 2022); geographic distribution of the genus *Astragalus* in Iran (Mahmoodi *et al.*, 2009); the hotspots and conservation gaps of the mega genus *Astragalus* in the Old World (Maassoumi & Ashouri, 2022); plant biodiversity of Golestan National Park (Akhani, 1998); floristic study of Marakan Protected Area (Ghahremaninejad & Nafisi, 2011); plant diversity of Ghorkhod Protected Area (Memariani *et al.*, 2016); floristic study of Lissar Protected Area (Ghahremaninejad *et al.*, 2012); flora of Sarigol National Park (Rahchamani *et al.*, 2014); floristic study of Saldaran Protected Region (Hasanzadeh *et al.*, 2018); the flora of Saluk National Park (Ezazi *et al.*, 2014); a floristic study of Kalmand Bahadoran Protected Area (Mirhosseini *et al.*, 2018) and floristic study of vegetation in Palang Galoun Protected Region (Sadeghipour *et al.*, 2018).

Sorkhabad Protected Area, which has an area of 122,618 hectares is situated in Zanjan Province. The extent, topographic diversity and diverse habitats suggest the hypothesis that there is a large plant diversity in the area; conducting detailed floristic studies and surveying the endemic and threatened species in order to investigate the conservation value of the area in terms of the inventory of plant diversity seem very necessary.

The Irano-Anatolian region and the Caucasus region are two global biodiversity hotspots that intersect with Iran (Noroozi *et al.*, 2019). Sorkhabad Protected Area is located in the Irano-Anatolian global biodiversity hotspot. For practical conservation management and on local or regional scales it is necessary to find hotspots at a higher resolution, so-called "hotspots-within-hotspots" (Canadas *et al.*, 2014).

Because there are an airport, mining operation, many residential regions and agricultural lands within the Sorkhabad Protected Area, it faces various conservation challenges. Accordingly, the investigation of specific species including endemic and threatened species in terms of the checklist, the number of existing populations, their location and the hotspot richness of these species is very important.

The aim of this study, the first of its kind to have been conducted in the area, is to investigate endemic and threatened vascular plant species and identify the hotspot richness of them. Documenting the plant diversity and identifying the hotspots of specific species in the area will help in the assessment of the importance of this protected area, as well in a review of the management programs of the area and the adoption of appropriate conservation plans.

MATERIAL AND METHODS

Study area

Sorkhabad Protected Area, which has an area of122,618 hectares, is situated between the geographical coordinates 36° 44' to 37° 8' N and 48° 4' to 48° 46' E, to the northwest of Zanjan city (Fig. 1). This area is one of several protected areas in the Qezal Ozen river basin, which is defined between the two valleys of the Qezal Ozen and Zanjanrud rivers and includes part of the northwestern heights of the Qaflankoh mountain range. The geomorphology of the area mainly includes mountainous areas, hills and plains, the latter mostly located in the western half. The elevation varies from 400 m to 3000 m and most of the area is located in the 1000 to 2200 m elevation zone. The mountains are mainly composed of volcanic rocks and most of the heights are the continuation of the Alborz mountain range. The soils of the area have great depth and lumen texture with granular gravel and medium strength. The dominant climate in this area is cold semi-arid in the west, northwest, and south and cold semi-humid in the northeast. In the southern and southwestern parts of the area due to the airport and a number of mines and factories, there was no possibility for sampling. The central part, especially in the western half, has a significant reduction in diversity and density of natural ve-

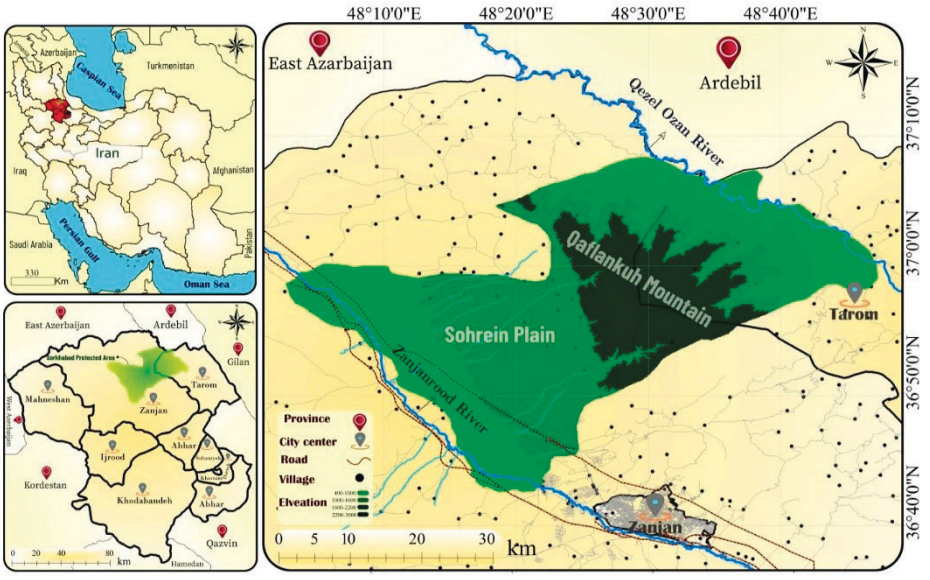


Fig. 1. Map of Sorkhabad Protected Area showing the position of the area in Iran.

getation due to the presence of agricultural and destroyed land. Fig. 2 shows a number of views of habitat diversity in the Sorkhabad Protected Area.

Species diversity and distribution data

The field studies and floristic sampling were carried out between April 2019 and January 2021, in 32 field trips. The specimens of vascular plant species of the Sorkhabad Protected Area were collected in different seasons. The exact locations and altitudes were determined using GPS. Specimens identified according to the Flora of Iran (Assadi, 1988-2021), Flora Iranica (Rechinger, 1963-2015 - vols 1-181), Flora of Turkey (Davis

Fig. 2. Views of habitat diversity in the Sorkhabad Protected Area. Picture "**d**" indicates a semi-natural habitat and the rest of the pictures are views of natural habitats. **a**: a view of plain and hilly areas in the western half of the protected area; **b**: sloping areas with scattered shrubs in the eastern half of the protected area; **c**: Zanjanrood River bank (on the western border of the area); **d**: natural habitat of *Colchicum* population inside a cultivated area in the center of the protected area; **e**: Gezel Ozan River bank (on the eastern border of the area); **f**: moist Alpine area at the heights of Gaflankuh Mountains in the eastern half of the protected area; **g**: dry mountainous area with rocky and sandy slopes in the northeast of the protected area.

1965-1988), Flora of Iraq (Townsend, 1966-1974) and monographs published after these floras (such as *Ornithogalum*, Bidarlord & Ghahremaninejad (2016); *Polygonum*, Hassannejad & Porheidar (2017); *Gagea,* Zarrei *et al.* (2011); *Acantholimon*, Assadi (2006) and Khajoei & Khosravi (2020); *Onosma*, Mehrabian (2015); Fabaceae, Mousavi & Khosravi (2012). The identification of *Astragalus* species was done with reference to Maassoumi (1998, 2003, 2014, 2018) and Podlech (1999), Podlech *et al.* (2001, 2010, 2012). The chorology of species is based on Zohary (1973), Takhtajan (1986), White & Leonard (1999), Flora of Iran (Assadi, 1988-2021), and Maassoumi & Ashuri (2022) about the distribution and hotspot gaps of the genus *Astragalus.* Using the life form system of Raunkiaer, 1934, the following five categories were used: chamaephytes, geophytes, hemicryptophytes, phanerophytes, and therophytes. Endemic species have been indicated according to Flora of Iran (Assadi, 1988-2021), Flora Iranica (Rechinger, 1963-2015) and Biodiversity Plant Species of Iran (Ghahreman & Attar, 1999). The threatened species and the red list category of them have been indicated according to the Red Data Book of Iran (Jalili & Jamzad, 1999) and the IUCN Red List of threatened species (IUCN, 2022). Classification of the local rarity of species is based on Benjamin & Jeffrey (2011) and Akhani (2015). The distribution map of endemic and threatened species was prepared with the use of ArcGIS 10.3 software and based on the geographical locations obtained with GPS for each specimen.

RESULTS

Taxonomic distribution of endemic diversity

Altogether 534 vascular plant taxa were identified in this area. Of these, 81 species (belonging to 59 genera and 22 families) are endemic. The degree of endemism in the Sorkhabad Protected Area is 15.2 percent. *Pseudocamelina* (Boiss.) N. Busch (Brassicaceae) and *Clastopus* Boiss. (Brassicaceae) are two of the endemic genera. Dicots contain 74 endemics, or 91% of all vascular plant endemics and monocots with 7 endemics account for 9% of all vascular plant endemics. Fabaceae with 16 (20% of all endemic species) and Asteraceae with 14 endemic species (17% of all endemic species) are thetwo largest families in terms of the number of endemic species. Lamiaceae with 9 endemics (11% of all endemic species) is the third largest family. Further families are Caryophyllaceae with 6 and Papaveraceae, Brassicaceae with 4 endemic species. Ranunculaceae, Plumbaginacea, Polygonaceae and Boraginaceae have 3 endemic species. Apiaceae, Rosaceae, Iridaceae, and Rubiaceae with 2 endemics are the next families. The rest of the families have only one endemic species (Fig. 3). *Astragalus* L. is the largest genus in the world (Podlech & Zarre, 2013) and also in Iran (Ghahremaninejad *et al.*, 2020; Maassoumi, 2020a, 2020b; Maassoumi internet site: http://astragalusofworld.com); with 13 endemic species it is the largest genus in terms of the number of endemic species.

Phytogeography, Life forms and elevational distribution of endemic species

A considerable number of endemic species (83%) in the area belong to the Irano-Turanian floristic region and 14% of endemic species are shared between the Irano-Turanian and other regions. The Euro-Siberian species have the least frequency (3%) in the phytogeographical spectrum of the area. Both of the endemic genera (*Pseudocamelina*

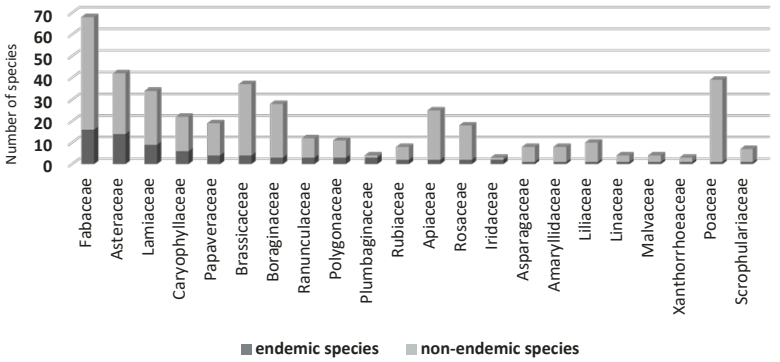


Fig. 3. Number of endemic and non-endemic species in the 22 families of the vascular flora (sorted by number of endemic species).

(Boiss.) N. Busch and *Clastopus* Boiss.) and all 7 monocot endemic species are represented in the Irano-Turanian region.

Among the endemic vascular plant species, hemicryptophytes are the most dominant life form (50%) that followed by chamaephytes (19%), geophytes (15%), therophytes (14%), and phanerophytes (2%). Hemicryptophytes are dominant in both of the phytogeographical regions (Irano-Turanian, Euro-Siberian) whereas chamaephytes and phanerophytes are very poor in the Euro-Siberian region (Fig. 4).

The elevational distributions of endemic vascular plant species are as follows: 20% of endemic species are distributed in the lowlands (400 to 1000 m). 61% are distributed in mid-elevation zones (1000 to 1600 m and 1600 to 2200 m) and 19% are in high elevations (2200 to 3000 m).

Red list of threatened species

Out of the total species collected in this study, 116 threatened species of vascular plant belonging to 86 genera and 46 families were identified from Sorkhabad Protected Area. Of these, 79 were identified according to the Red Data Book of Iran (Jalili &

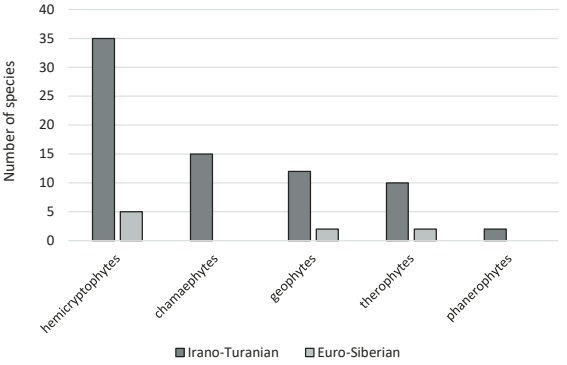


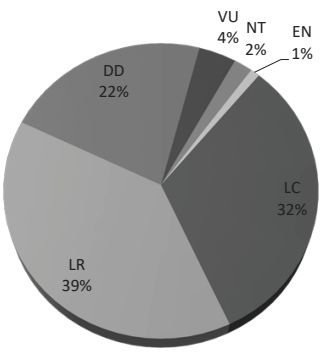
Fig. 4. Life form spectra of the endemic vascular plant species in the phytogeographical regions of Sorkhabad Protected Area.

Jamzad, 1999), and 37 were identified from the IUCN Red List of threatened taxa assessed for the red list in Iran from 2007 to 2019. In total, 21.7% of the plant diversity from the area is threatened and 56 of the threatened species are also endemic and 9 of them belong to genera that have only one species in Iran. In terms of red list category, 39% of all threatened species are LR (Lower Risk), 32% are LC (Least Concern), 22% are DD (Data Deficient), 4% are VU (Vulnerable), 2% are NT (Near Threatened) and 1% are EN (Endangered) (Fig. 5.a). It is noteworthy that 38 species of over 116 threatened species are on the red list in the global scope of assessment.

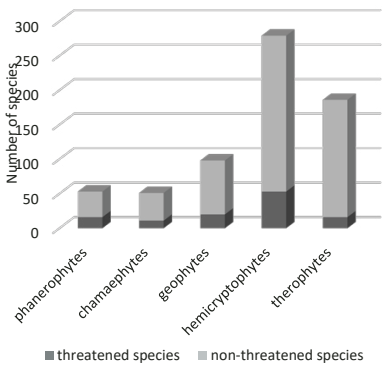
76% of threatened species in this area belong to the Irano-Turanian floristic region and 19% belong to the Euro-Siberian region. 5% of threatened species are Pluriregional and 4% are Sub-Cosmopolitan. The Sahara-Sindian region has the least number (1%) of threatened species. 43% of all phanerophytes of the Sorkhabad Protected Area, 28% of chamaephytes, 26% of geophytes, 23% of hemicryptophytes and 9% of therophytes are on the red list of threatened species (Fig. 5.b).

Locally rare taxa

Locally rare taxa are those that are rare or uncommon within a local geographical boundary but more common outside of that boundary. In addition to the rare taxa identified by global, national, and state/provincial levels, locally rare taxa are important for the preservation of species diversity and ecological processes, and therefore require effective and recognizable conservation status (Benjamin, 2011). Moreover, several endemic and threatened species in this study were uncommon and found with one individual or just a few in one locality or a few localities and they are rare in this area. According to Akhani (2015), 3% of species are very rare = 1 (found only once with one or a few individuals in one locality), 10% are rare = 2 (found with more than 2 and up to 10 individuals in a few localities), 63.5% are fairly common = 3 (found in several places, or in one place with a large number of individuals), 22% are common = 4 (rather common in many parts or locally very frequent) and 1.5% are very common = 5 (found



a.



b.

Fig. 5.a. Categories of threatened species of Sorkhabad Protected Area. LR: Lower Risk, LC: Least Concern, DD: Data Deficient, VU: Vulnerable, NT: Near Threatened, EN: Endangered. b. Comparison of the number of threatened and non- threatened species in the 5 life forms (sorted by percentage of threatened species in each life form).

in many parts of the study area, or forming large communities) (Appendix I). Using the approximate AOO (estimated area of occupancy) of each species, the L-rank categories of them were determined based on Benjamin (2011). Appendix I shows that 29.5% of species are L1 = Critically imperiled (Area < 10 km^2 or fewer than ten 1 km^2 cells), 32% of species are L2 = Imperiled (Area < 50 km^2 or fewer than fifty 1 km2 cells), 21% of species are L3 = Vulnerable to threat or extinction (Area < 250 km^2 or fewer than two hundred fifty 1 km^2 cells), 16 % of species are L4 = Apparently secure (Uncommon but not rare, some cause for long-term concern due to declines or other factors), 1.5% of species are L5 = Demonstrably widespread, abundant and secure (Common; widespread and abundant).

Discussion

Out of 81 endemic species and 116 threatened species, 61 of them are reported for the first time from this area and 9 of them are new records for Zanjan Province (Appendix I). The order of Fabaceae, Asteraceae, Lamiaceae and Caryophyllaceae as the largest families in terms of the number of endemic species is expected and consistent with Iranian vascular flora. Table 1 shows a comparison of area size, total species richness and degree of endemism in the vascular flora of the Sorkhabad Protected Area and of Iran as a whole. According to this comparison, 6.6% of the total species richness and 3.1% of the endemics in Iran have been identified in this area; comparing area sizes, this study revealed the high richness of vascular plant taxa in the Sorkhabad Protected Area. *Astragalus* L. is the largest genus in the world and in Iran. Southwestern and central Asia is the center of diversity for *Astragalus*, and there may be more than 800 species in Iran (Sheikh Akbari Mehr *et al.*, 2012). In a taxonomic study of the genus *Astragalus* L. in Zanjan province (Bagheri *et al.*, 2011, 2017) 62 endemic species were recognized in this province. Out of 13 endemic species of *Astragalus* that were collected in the Sorkhabad Protected Area, 9 species have been reported in the mentioned study and 4 species (*Astragalus biserrula* Bunge, *Astragalus gypsaceus* Beck, *Astragalus lilacinus* Boiss., *Astragalus stenolepis* Fisch.) will be added to the list of endemic species of *Astragalus* L. in the study. Iranian endemic monocots included 152 species (Mehrabian *et al.*, 2021) and 7 species of them were identified in this area, so Sorkhabad Protected Area includes about 5% of endemic monocots in Iran.

About 70% of species in this study were in category 1 or 2 in terms of population status and 82% of species met the area of occupancy criteria for local rarity ranks 1, 2, 3. Therefore 70% to 82% of endemic and threatened species in Sorkhabad Protected Area are locally rare species. Several species such as *Cynanchum acutum*, *Delphinium tuberosum*, *Gagea chomutovae*, *Lamium amplexicaule* var. *allepicum* were found with one or a few individuals in one locality and are very rare in this area.

The order of dominance of life forms of endemic vascular plant species in the Sorkhabad Protected Area is similar to Iran as a whole; however the percentage of geophyte and therophyte endemic species in the Sorkhabad Protected Area is higher than in Iran (Table 1).

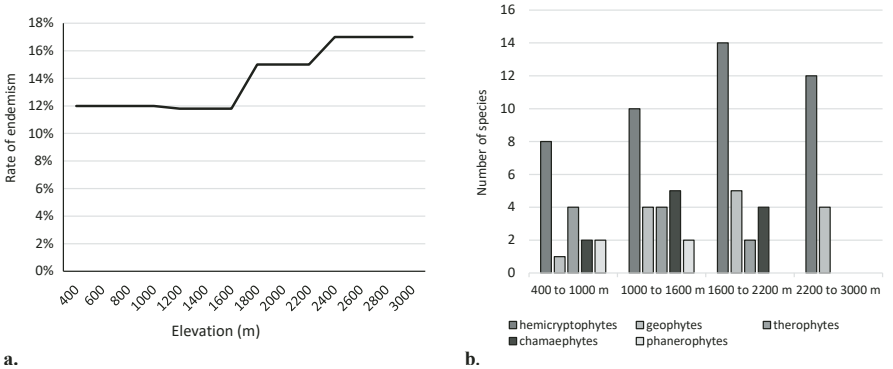
The results showed that the highest number of endemic species is in the mid-elevation zones (1000 to 1600 m and 1600 to 2200 m), as expected considering that most of the area is located in this zone, but according to the number of endemic and non-endemic species in each elevation zone, the highest rate of endemism belongs to the 2200 to 3000 m and then to 1600 to 2200 m zones. The rates of endemism in the 400 to 1000 m and

Tab. 1. A comparison of Sorkhabad Protected Area and Iran in terms of the area size, total species richness, degree of endemism, number of members in the 4 most endemic-rich vascular families and number of endemic species in the phytogeographical regions and in categories of life forms.

	Sorkhabad Protected Area	Iran
Area (km^2)	1,226.18	1,648,195
Endemic genera	2	26
Total species	534	8112
Endemic species	81 (15.2%)	2597 (32%)
No of families	22	65
No. of genera	59	359
Fabaceae	16	687
Asteraceae	14	618
Lamiaceae	9	155
Caryophyllaceae	6	127
Irano-Turanian	67 (83%)	2289 (88%)
Saharo-Sindian	0	133 (5%)
Euro-Siberian	2 (3%)	101 (4%)
Shared	12 (14%)	73 (3%)
hemicryptophytes	50%	60%
chamaephytes	19%	26%
geophytes	15%	6%
therophytes	14%	5%
phanerophytes	2%	3%

1000 to 1600 m zones are low and approximately equal. Therefore, the rate of endemism in the Sorkhabad Protected Area increases with altitude (Fig. 6.a). Among the endemic genera, *Pseudocamelina glaucophylla* N. Busch. is distributed in the 400 to 1000 m zoneand *Clastopus vestitus* (Desv.) Boiss. is distributed in that from 2200 to 3000 m. The distribution of some endemic species was not limited to a specific elevation zone and they were found in several zones, such as *Tanacetum polycephalum* Sch. Bip. which is distributed in all of the four zones. Hemicryptophytes are dominant in all of the elevation zones (400 to 1000 m, 1000 to 1600 m, 1600 to 2200 m, and 2200 to 3000 m) (Fig. 6.b).

Sorkhabad Protected Area is located in the vicinity of several other protected areas. Unfortunately, accurate floristic information from those areas is not available so Table 2 shows a comparison with several protected areas in other parts of Iran. According to



a. **b.**

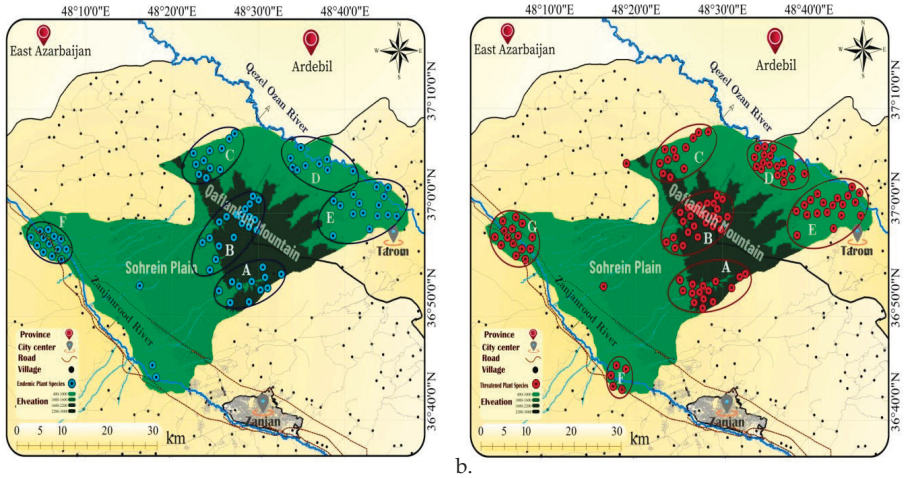
Fig. 6. a. The rate of endemism in different elevation zones. **b.** Life form spectra of the endemic vascular plant species in different elevation zones.

the table, there are more threatened species and endemic threatened species in the Sorkhabad Protected Area than in other areas.

According to the distribution map (Fig. 7), there are more endemic and threatened species in the north, east, northeast, west and southeast parts of the Sorkhabad Protected Area than in the other parts. In the southern and southwestern parts of the area due to the airport and a number of mines and factories, there was no possibility for sampling. The central part, especially in the western half, has a significant reduction in diversity and density of natural vegetation due to agricultural and degraded lands. Areas A to F were introduced as hotspots in terms of endemic and threatened species richness and in total occupied 50,709 ha, or 41.35%, of the Sorkhabad Protected Area. Assuming that each region should have 10–12% of its area under protection to guarantee effective conservation (IUCN 2009, Convention on Biological Diversity 2007), proper planning of conservation management in these hotspots may be effective in guaranteeing the conservation value in this area. Achieving thisobjective requires more detailed studies by conservation experts and based on conservation views and conservati-

Tab. 2. Comparison of the number of endemic and threatened species in Sorkhabad Protected Area and a number of other protected areas in Iran.

	Sorkhabad Protected Area	Lissar Protected Area	Ghorkhod Protected Area	Kalmand Bahadoran Protected Area	Saldaran Protected Area	Palang Galoun Protected Area
Area (ha)	122,618	13,500	43,216	255,000	14,000	34,935
No. of total species	534	542	663	168	267	166
No. of endemic species	81	71	116	31	32	44
No. of threatened species	116	58	-	-	40	29
No. of endemic threatened species	56	24	43	31	14	-



a. b.

Fig. 7. Distribution map of endemic species (a) and threatened species (b) in the Sorkhabad Protected Area.

on analysis. Areas A to F are faced with conservation challenges: A large part of areas A, B, and C are used as promenades for recreational walking while irregular harvesting of edible or medicinal plants is also conducted in these areas. Most of area E is used as arable land. Overgrazing is one of the main challenges in area F. A proper management program is required to protect these areas. The following suggestions can be effective:

1- Informing the people properly, including the installation of signs indicating the boundary of protected areas and educating them about the recognition of endemic and rare species and the importance of vegetation and biodiversity.

2- Restrict construction, management of arable land and control of walking trails.

3- Regulate livestock density and manage planned grazing.

4- Identifying rare species and having proper planning to protect them, including collecting seeds and propagating them.

CONCLUSION

As mentioned, a protected area is a clearly defined geographical space that is established for the conservation of nature, biodiversity and particular species (threatened and endemic species). For this purpose, the protected area and its biodiversity must be accurately assessed and managed accordingly. This study revealed the high richness of vascular plant taxa in the Sorkhabad Protected Area and pointed out that this area faces challenges such as the presence of multiple villages and human communities and the requirements for their presence, the establishment of an airport in the southern part, existence of mines and factories, especially in the southwestern part. Therefore, numerous communication routes, disposal of waste, agricultural lands and uncontrolled plant harvesting have destroyed a very large area of habitats and reduced the diversity and density of natural vegetation, especially in the western half of this protected area. The floristic study of the diversity and distribution of specific species of the Sorkhabad Protected Area shows a significant reduction of vascular plant species in the degraded parts of this protected area. This study also identified the hotspot areas in terms of endemic and threatened species richness. Conducting more detailed conservation studies on these hotspots will help to obtain proper management plans to preserve biodiversity and prevent the extinction of specific species in the Sorkhabad Protected Area.

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REFERENCES

Akhani, H., 1998: Plant biodiversity of Golestan National Park, Iran. Stapfia **53**, Biologiezentrum Linz, Austria. download from www.biologiezentrum.at.

Akhani, H., 2015: Plants and vegetation of North-West Persian Gulf: The coasts and islands of Khore Musa, Mahshahr and adjacent areas. University of Tehran Press, Tehran, 512 pp.

Anderson, S., 1994: Area and endemism. The Quarterly Review of Biology **69**, 451-471.

Assadi, M. (Chief ed.), 1988-2021: Flora of Iran, Vols 1-151. Research Institute of Forests and Rangelands of Iran, Tehran.

Assadi, M., 2006: Distribution patterns of the genus Acantholimon (Plumbaginaceae) in Iran. Iran J Bot. **12**, 114–120.

Bagheri, A., Ghahremaninejad, F., Maassoumi, A.A., Rahiminejad, M.R. & Blattner, F.R., 2017: Nine new species of the species-rich genus *Astragalus* (Leguminosae), Novon **25**, 266-281.

Bagheri, A., Maassoumi, A. A. & Ghahremaninejad, F., 2011: A taxonomic revision of the genus *Astragalus* L. (Fabaceae) in Zanjan province, Iran and describing a new species. Taxonomy and Biosystematics 8, 7-16.

Belanger, J. & Pilling, D., 2019: In FAO commission on genetic resources for food and agriculture assessments. The State of the World's Biodiversity for Food and Agriculture. FAO: Rome, Italy. http://www.fao.org/3/CA3129EN/CA3129EN.pdf.

Benjamin, J. C. & Jeffrey, W.W., 2011: Categorizing locally rare plant taxa for conservation status. Biodiversity and Conservation **20**, 451–463.

Bidarlord, M. & Ghahremaninejad, F., 2016: *Ornithogalum boissieri* (Asparagaceae), a new species from the Talesh Mountains, Iran. Annales Botanici Fennici **53**(1-2), 69-72. http://doi:10.5735/085.053.0213.

Canadas, E.M., Fenu, G., Peñas, J., Lorite, J., Mattana, E. & Bacchetta, G., 2014: Hotspots within hotspots: endemic plant richness, environmental drivers, and implications for conservation. Biological Conservation **170**, 282-291. https://doi.org/10.1016/j.biocon.2013.

Coelho, N., Goncalves, S. & Romano, A., 2020: Endemic plant species conservation: biotechnological approaches. Plants **9**(3), 345. https://doi.org/10.3390/plants9030345.

Davis, P.H. (ed.), 1965-1968: Flora of Turkey and east Aegean islands. Vols. **1–10**. Edinburgh University Press, Edinburgh.

Ezazi, A., Rahchamani, N. & Ghahremaninejad, F., 2014: The flora of Saluk National Park, Northern Khorassan province, Iran. Journal of Biodiversity and Environmental Sciences (JBES) **5**(1), 45-71. http://www.innspub.net.

Ghahreman, A. & Attar, F., 1999: Biodiversity of plant species in Iran. Vol. **1**. University of Tehran Press (UTP), Tehran.

Ghahremaninejad, F. & Nafisi, N., 2011: Floristic study of Munjughlu sanctuary zone in Marakan protected area, East Azarbaijan province, NW Iran. Rostaniha **12**(1), 73-82.

Ghahremaninejad, F., Bidarlord, M. & Attar F., 2012: Floristic study of steppe parts of Lissar protected area (N Iran). Rostaniha **13**(2), 164-188.

Ghahremaninejad, F., Nejad Falatoury, A. & Memariani, F., 2020: Typification and an emended description of *Astragalus moussavii* (Fabaceae, Papilionoideae). Phytotaxa **441**(1), 60-68.

Hasanzadeh, F., Kharazian, N. & Parishani, M.R., 2018: Floristic, life form, and chorological studies of Saldaran Protected Region, Chaharmahal and Bakhtiari Province, Iran. Journal of Genetic Resources **3**(2), 113-129. http://sc.journals.umz.ac.ir.

Hassannejad, S. & Porheidar, S., 2017: A taxonomic revision of genus *Polygonum* L. *sensu lato* (Polygonaceae) for Flora of Iran. Annual Research & Review in Biology **14**(4), 1-5. https://doi:10.9734/ARRB/2017/27339.

IUCN, International Union for Conservation of Nature, 2009: Parks for life: report of the IVth world congress on national parks and protected areas, Gland, Switzerland.

IUCN, International Union for Conservation of Nature, 2022: https://www.iucnredlist.org. IUCN Red List of Threatened Species.

Jalili, A. & Jamzad, Z. 1999: Red data book of Iran. Research Institute of Forests and Rangelands of Iran, Tehran.

Khajoei Nasab, F. & Khosravi, A.R., 2020: Identification of the areas of endemism of the genus *Acantholimon* (Plumbaginaceae) in Iran. Plant Biosystems **154**(5), 726-736. https://doi:10.1080/11263504.2019.1686078.

Mahmoodi, M., Maassoumi, AA. & Hamzehee, B., 2009: Geographic distribution of *Astragalus* (Fabaceae) in Iran. Rostaniha, **10**(1), 112-132.

Mahmoodi, M., Ghahremaninejad, F. & Maassoumi, AA., 2022: Diversiry of vascular plants in Damirli Mountains (Zanjan Province, NW of Iran). Rostaniha **23** (Suppl. 1), 1-131.

Maassoumi, AA., 1998: *Astragalus* in the old world: check-list. Research Institute of Forests and Range-lands, Tehran.

Maassoumi, AA., 2003: Flora of Iran, No. 43: Papilionaceae (*Astragalus* I). Research Institute of Forests and Range lands, Tehran.

Maassoumi, AA., 2014: Flora of Iran, Papilionaceae (*Astragalus* II), no. 77. Research Institute of Forests and Rangelands, Tehran.

Maassoumi, AA., 2018: Flora of Iran: Fabaceae: *Astragalus* III, No. 145. Research Institute of Forests and Rangelands, Tehran.

Maassoumi, AA., 2020a: The comprehensive online resource for the mega genus of *Astragalus*. In: Mega genus *Astragalus* ver.1. http://astragalusofworld.com.

Maassoumi, AA., 2020b: A checklist of *Astragalus* in the world: new grouping, new changes and additional species with augmented data. Research Institute of Forests and Rangelands, Tehran.

Maassoumi, AA. & Ashouri, P., 2022: The hotspots and conservation gaps of the mega genus *Astragalus* (Fabaceae) in the Old-World. Biodiversity and Conservation **31**(8-9), 2119–2139. https://doi:10.1007/s10531-022-02429-2.

Mehrabian, A.R., 2015: Distribution patterns and diversity of *Onosma* in Iran: with emphasis on endemism conservation and distribution pattern in SW Asia. Rostaniha **16**(1), 36–60 (in Persian).

Mehrabian, A.R, Khajoei Nasab, F. & Amini Rad, M., 2021: Distribution patterns and priorities for conservation of Iranian endemic monocots: determining the areas of endemism (AOEs). Journal of Wildlife and Biodiversity **5**(2), 69-87. https://doi:10.22120/JWB.2020.136616.1188.

Memariani, F., Joharchi, M.R. & Akhani, H., 2016: Plant diversity of Ghorkhod Protected Area, NE Iran. Phytotaxa **249**(1), 118-158. http://dx.doi.org/10.11646/phytotaxa.249.1.6.

Mirhosseini, A., Asri Y. & Abolghasemi, M., 2018: A floristic study of the protected area of Kalmand Bahadoran, Yazd Province. Taxonomy and Biosystematics **35**, 84–69.

Mousavi, T.S. & Khosravi A.R., 2010: Patterns of distribution in the family Fabaceae (except *Astragalus*) in Iran. Iran J Bot. **16**, 303–313.

Noroozi, J., Talebi, A., Doostmohammadi, M., Manafzadeh, S., Asgarpour, Z. & Schneeweiss, G.M., 2019: Endemic diversity and distribution of the Iranian vascular flora across phytogeographical regions, biodiversity hotspots and areas of endemism. Scientific Reports **9**, 12991. https://doi.org/10.1038/s41598-019-49417-1.

Podlech, D., 1999: Papilionaceae III, *Astragalus* I. In: Rechinger K.H. (ed.) Flora Iranica no. 174. Akademische Durk-u. Verlagsanstalt, Graz.

Podlech, D., Zarre, S. & Maassoumi, AA., 2001: Flora Iranica, volume 175: Papilionaceae IV, *Astragalus* II [English/Latin]. Flora Iranica Project, 332 pages: 1-197 Text, 1-135 Tables.

Podlech, D., Zarre, S., Maassoumi, AA., Ekici, MK., Sytin, A., 2010: Flora Iranica, volume 178: Papilionaceae VI, *Astragalus* IV (2-volume set) [German/Latin]. Flora Iranica Project, 805 pages: 1-430 Text, 1-375 Tables.

Podlech, D., Maassoumi, AA., Zarre, S., 2012: Flora Iranica volume 179: Papilionaceae VII, *Astragalus* V. In: Rechinger K.H. (ed.) Flora Iranica. Akademische Druck-u Verlagsanstalt, Graz, 312 pages: 1-258 Text, 260-296 Tables.

Podlech, D. & Zarre, S., 2013: A taxonomic revision of the genus *Astragalus* L. (Leguminosae) in the old world (3-volume set). Natural History Museum/Naturhistorisches Museum Wien, Wien.

Rahchamani, N., Ezazi, A. & Ghahremaninejad, F., 2014: The flora of Sarigol National Park, Northern Khorassan Province, Iran. Journal of Biodiversity and Environmental Sciences (JBES) 4(6), 278-307. http://www.innspub.net.

Raunkiaer, C., 1934: The life form of plants and statistical plant geography. Oxford: Clarendon Press.

Rechinger, K.H. (ed.), 1963-2015: Flora Iranica, 1-174: Akademische Druck- u. Verlagsanstalt, Graz, 175: Akademische Verlagsgesellschaft, Salzburg, 176-181: Naturhistorisches Museum, Wien.

Sadeghipour, F, Kharazian, N. & Afsharzadeh, S., 2018: Floristic study of vegetation in Palang Galoun protected region, Isfahan province, Iran. Nova Biologica Reperta 5(3), 274-290.

Sheikh Akbari Mehr, R, Maassoumi, A.A., Saidi, A., 2012: Morphological cladistics analysis of some bifurcate hairy sections of *Astragalus* (Fabaceae) in Iran. Turk J Bot 36, 434-442 © TÜBİTAK. https://doi.org/10.3906/bot-1108-26.

Takhtajan, A., 1986: Floristic regions of the world. University of California Press, California.

Townsend, C.C., Guest, E. & Al-Rawi, A. (eds.), 1966-1974: Flora of Iraq, Vols 1–9. Ministry of Agriculture and Agrarian Reform of the Republic of Iraq, Baghdad.

White, F. & Léonard, J., 1999: Phytogeographical links between Africa and Southwest of Asia. Flora et vegetatio Mundi **9**, 229–246.

Zarrei, M., Wilkin, P. & Chase, M., 2011: *Gagea* Salisb. (Liliaceae) in Iran: an updated species checklist. Phytotaxa **15**, 33–43.

Zohary, M., 1973: Geobotanical foundations of the Middle East, Vols 1–2. Gustav Fischer Verlag, Stuttgart.

Appendix I. Checklist of endemic and threatened species of vascular plants in the Sorkhabad protected area. Life forms: Ph (Phanerophyte), Ch (Chamaephyte), He (Hemicryptophyte), Ge (Geophyte), and Th (Therophyte). Phytogeographical regions: IT (Irano-Turanian), ES (Euro-Siberian), M (Mediterranean), SS (Shaharo-Sindian), Pl (Pluriregional), Cos (Cosmopolitan), SCo (Sub-Cosmopolitan). Endemic: *(Endemic of Iran), **(endemic of Zanjan province), RS (new Record for Sorkhabad protected area), RZ (new Record for Zanjan province). Elevation ranges (meters above sea level). Red list category: LR (Lower Risk), LC (Least Concern), DD (Data Deficient), VU (Vulnerable), NT (Near Threatened) EN (Endangered), ^{G} (Global scope red list). Population status (based on Akhani 2015): 1 = very rare (found only once with one or few individuals in one locality), 2 = rare (found with more than 2 to 10 individuals in a few localities), 3 = fairly common (found in several places, or in one place with a large number of individuals), 4 = common (rather common in many parts or locally very frequent), 5 = very common (found in many parts of the study area, or forming large communities). AOO: estimated Area Of Occupancy and L-rank categories (based on Benjamin 2011): L1 = Critically imperiled (Area < 10 km^2 or fewer than ten 1 km^2 cells), L2 = Imperiled (Area < 50 km^2 or fewer than fifty 1 km^2 cells), L3 = Vulnerable to threat or extinction (Area < 250 km^2 or fewer than two hundred fifty 1 km^2 cells), L4 = Apparently secure (Uncommon but not rare, some cause for long-term concern due to declines or other factors), L5 = Demonstrably widespread, abundant and secure (Common; widespread and abundant).

Families and Species	Life form	Phytogeographical regions	Endemic	Elevation ranges(m)	Red list category & Population status	AOO (km^2) & L-rank
Amaryllidaceae						
Allium dictyoscordum Vved.	Ge	IT	RS	1307	VU - 2	< 10 – L1
Allium scabriscapum Boiss.	Ge	IT		637-1307	DD^{G}- 2	< 10 – L1
Allium shelkovnikovii Grossh.	Ge	IT	*, RS	1875	LR - 2	< 10 – L1
Anacardiaceae						
Pistacia atlantica Desf.	Ph	IT		707-1061	NT^{G}- 3	< 50 – L2
Apiaceae						
Bunium rectangulatum Rech.f.	Ge	IT	*, RS, RZ	2175	2	< 10 – L1
Chaerophyllum macropodum Boiss.	He	IT		1298	DD- 2	< 10 – L1
Echinophora platyloba DC.	He	IT	*	1980	4	L4
Scandix stellata Banks & Sol.	Th	IT	RS	1106-1875	DD- 2	< 10 – L1
Apocynaceae						
Cynanchum acutum L.	He	IT-ES	RS	637	LC^{G}- 1	< 10 – L1
Asparagaceae						
Ornithogalum boissieri Bidarlord & F.Ghahrem.	Ge	IT	*, RS, RZ	2218	1	< 50 – L2
Ornithogalum narbonense L.	Ge	IT	RS	908	DD- 3	< 10 – L1
Asteraceae						
Anthemis triumfettii (L.) DC.	He	IT	*, RS	479-1518	DD- 4	< 50 – L2
Arctium lappa L.	He	PL		1504	LC- 3	< 50 – L2
Centaurea aucheri subsp. *elbursensis* Wagenitz	He	IT	*	2292	LR- 3	< 50 – L2
Centaurea gilanica Bornm.	He	IT	*	1307-2292	LR- 3	< 50 – L2
Cephalorrhynchus microcephalus (DC.) Schchian	Ge	IT	*, RS, RZ	1106	3	< 50 – L2

Appendix. 1. Continued

Families and Species	Life form	Phytogeographical regions	Endemic	Elevation ranges(m)	Red list category & Population status	AOO (km^2) & L-rank
Codonocephalum peacokianum Aitch. & Hemsl.	Ch	IT		1980	DD- 2	< 10 – L1
Cousinia lepida (Bunge) Boiss.	He	IT	*	566	LR- 3	< 50 – L2
Cousinia chrysacantha Jaub. & Spach	He	IT	*	538	LR- 3	< 50 – L2
Cousinia seidlitzii Bunge	He	IT	*	2529	LR- 3	< 50 – L2
Echinops haussknechtii Boiss.	He	IT	*	2138	DD- 4	L4
Gundelia tournefortii L.	He	IT		1274-1293	DD- 3	L4
Helichrysum oligocephalum DC.	He	IT	*	1980	LR- 3	< 250 – L3
Inula aucheriana DC.	Ge	IT-ES	*, RS	2240	2	< 10 – L1
Sclerorhachis platyrachis (Boiss.) Podlech ex Rech. f.	He	IT-ES	*, RS	2090	3	< 10 – L1
Senecio glaucus L.	Th	IT-ES	*	519	3	< 10 – L1
Tanacetum polycephalum Sch.Bip.	He	IT	*	637-2218	DD- 4	L4
Tragopogon porphyrocephalus Rech.f.	He	IT	*	2218	LR- 3	< 10 – L1
Boraginaceae						
Heliotropium dissitiflorum Boiss.	Th	IT-ES	*	535-637	LR- 4	L4
Nonnea persica Boiss.	Th	IT	*	746	4	L4
Onosma bulbotrichum DC.	He	IT	*	1324	4	L4
Brassicaceae						
Barbarea plantaginea DC.	He	IT		2212-2020	LC^G- 3	< 250 – L3
Chorispora persica Boiss.	Th	IT	*	1138	LR- 3	< 10 – L1
Clastopus vestitus (Desv.) Boiss	He	IT	*, RS	2473-2529	LR- 3	< 50 – L2
Matthiola ovatifolia (Boiss.) Boiss.	Ch	IT	*, RS	1992	LR- 3	< 10 – L1
Nasturtium officinale R.Br.	He	IT		1293-2020	LC^G- 3	< 50 – L2
Pseudocamelina glaucophylla N.Busch	He	IT	*, RS	535	LR- 3	< 10 – L1
Capparaceae						
Capparis spinosa L.	Ph	SCo		555	LC^G- 3	< 250 – L3
Caprifoliaceae						
Valeriana leucophaea DC.	Ge	IT	RS	1875	DD- 3	< 50 – L2
Valerianella chlorostephana Boiss. & Balansa	He	IT	RS, RZ	1573	DD- 2	< 10 – L1
Caryophyllaceae						
Acanthophyllum crassifolium Boiss.	Ch	IT	*, RS	2171	LR- 2	< 10 – L1
Buffonia macrocarpa Ser.	He	IT	*	1324	LR- 3	< 10 – L1
Dianthus orientalis subsp. *gorganicus* Rech.f.	He	IT	*	1504	3	< 10 – L1
Silene gynodioica Ghaz.	He	IT	*	1366	LR- 4	< 250 – L3
Silene oligophylla Melzh.	He	IT	*	1518	DD- 3	< 10 – L1
Stellaria scaturiginella Rech.f.	He	IT-ES	*, RS	2232	DD- 3	< 10 – L1
Crassulaceae						
Rosularia sempervivum (M.Bieb.) Berger	He	IT	RS	1293	LR- 2	< 10 – L1
Cupressaceae						
Juniperus excelsa M.Bieb.	Ph	IT-ES		980	LC^G- 4	L4
Cyperaceae						
Carex orbicularis Boott	Ge	IT-ES	RS	2009	LC^G- 3	< 250 – L3
Carex oreophila C.A.Mey.	Ge	IT-ES	RS	2152	DD- 3	< 50 – L2
Carex songorica Kar. & Kir.	Ge	IT-ES	RS	2292	LC^G- 3	< 50 – L2

Appendix. 1. Continued

Families and Species	Life form	Phytogeographical regions	Endemic	Elevation ranges(m)	Red list category & Population status	AOO (km^2) & L-rank
Cyperus rotundus L.	Ge	Cos		504	LC^G- 3	< 250 – L3
Eleocharis caduca (Delile) Schult.	Ge	IT	RS	2212-2292	LC^G- 3	< 250 – L3
Elaeagnaceae						
Elaeagnus angustifolia L.	Ph			1504	LC^G- 4	L4
Ephedraceae						
Ephedra ciliata Fisch. & C.A.Mey.	Ch	IT	RS, RZ	592	LC- 3	< 10 – L1
Ephedra intermedia Schrenk & C.A.Mey.	Ch	IT	RS	980	LC^G- 3	< 10 – L1
Ephedra major Host	Ch	IT-ES		2100	LC^G- 4	L4
Ephedra sarcocarpa Aitch. & Hemsl.	Ch	IT		1106	LC^G- 4	L4
Equisetaceae						
Equisetum telmateia Ehrh.	Ge	IT-ES	RS, RZ	1293	LC^G- 3	< 10 – L1
Fabaceae						
Argyrolobium trigonelloides Jaub. & Spach	He	IT	*	1423	LR- 3	< 50 – L2
Astragalus biserrula Bunge	Th	IT	*, RS, RZ	1307	2	< 10 – L1
Astragalus brachyodontus Boiss	He	IT	*	1315	LR- 3	< 50 – L2
Astragalus gypsaceus Beck	Th	IT	*	1106	3	< 250 – L3
Astragalus hendelanicus Maassoumi	He	IT	*	1417	VU- 3	< 10 – L1
Astragalus lilacinus Boiss.	He	IT	*, RS, RZ	2100	EN- 2	< 10 – L1
Astragalus paralurges Bunge.	Ch	IT	*, RS	2122	LR- 3	< 50 – L2
Astragalus rhodosemius Boiss. & Hausskn.	Ch	IT	*, RS	2085	3	< 250 – L3
Astragalus rubrostriatus Bunge	Ch	IT	*, RS	2159	LR- 3	< 50 – L2
Astragalus sciureus Boiss. & Hohen.	Ch	IT	*	2217	LR- 3	< 10 – L1
Astragalus semilunatus Podlech	Ch	IT	**	2129	LR- 3	< 10 – L1
Astragalus stenolepis Fisch.	Ch	IT	*	1875	3	< 250 – L3
Astragalus tabrizianus Buhse	He	IT	*	1420	VU- 3	< 10 – L1
Astragalus tricholobus DC.	He	IT	*	2175	NT- 3	< 250 – L3
Hedysarum criniferum Boiss.	He	IT	*	2100	LR- 3	< 50 – L2
Lathyrus inconspicus L.	He	IT-ES		1366	LC- 4	< 250 – L3
Medicago orbicularis (L.) Bartal.	Th	IT-ES	RS	1573	LR- 3	< 50 – L2
Onobrychis aucheri Boiss.	Ch	IT	*, RS	1295-1323	DD- 3	< 50 – L2
Trifolium pretense L.	He	IT-ES		2218	LC^G- 3	< 10 – L1
Iridaceae						
Gladiolus atroviolaceus Boiss.	Ge	IT	*, RS	908-1366	LR- 4	L4
Iiris meda Stapf	Ge	IT	*	1316	LR- 2	< 10 – L1
Lamiaceae						
Lagochilus aucheri Boiss.	He	IT	*	1322	LR- 3	< 50 – L2
Mentha longifolia var. *asiatica* (Boriss.) Rech.f.	He	PL		1504	LC^G- 4	< 50 – L2
Nepeta heliotropifolia Lam.	He	IT	*	1980	4	< 250 – L3
Phlomis olivieri Benth.	He	IT-ES	*	2175	4	< 250 – L3
Salvia aristata Aucher ex Benth.	He	IT	*, RS	2100	LR- 3	< 50 – L2
Salvia reuteriana Boiss.	He	IT	*, RS	2175-2493	3	< 250 – L3
Ziziphora clinopodioides Lam.	He	IT-ES	*	2442	VU- 3	< 50 – L2
Ziziphora persica Bunge	Th	IT	*, RS	1875	3	< 50 – L2
Liliaceae						

Appendix. 1. Continued

Families and Species	Life form	Phytogeographical regions	Endemic	Elevation ranges(m)	Red list category & Population status	AOO (km²) & L-rank
Gagea chomutovae (Pascher) Pascher	Ge	IT	RS	2009	LC^G- 1	< 10 – L1
Tulipa montana Lindl.	Ge	IT	*, RS	2028	3	< 50 – L2
Linaceae						
Linum usitatissimum L.	He	IT	*	1621	DD- 3	< 50 – L2
Lythraceae						
Punica granatum L.	Ph	IT-ES		479	LC^G- 3	L4
Malvaceae						
Alcea wilhelminae var. *lineariloba* (I.Riedl) Pakravan	Ch	IT	*, RS	592-918	LR- 3	< 50 – L2
Moraceae						
Ficus carica L.	Ph	IT		592	LC^G- 3	< 250 – L3
Orchidaceae						
Orchis mascula (L.) L.	Ge	IT-ES		2218-2232	LR- 3	< 50 – L2
Papaveraceae						
Corydalis verticillaris subsp. *boissieri* (Prain) Wendelbo	Ge	IT	*, RS	2473	3	< 10 – L1
Fumaria vaillantii Loisel.	Th	IT-ES	*	1138-1992	LR- 4	L4
Glaucium contortuplicatum Boiss.	He	IT-ES	*, RS	535-1106	LR- 4	L4
Papaver tenuifolium Boiss. & Hohen.	He	IT	*, RS	535	3	< 250 – L3
Plantaginaceae						
Veronica anagallis-aquatica subsp. *michuauxii* (Lam.) Elenevsky	Ge	IT	RS	2090	LC^G- 3	< 50 – L2
Platanaceae						
Platanus orientalis L.	Ph	IT		1293	DD^G- 4	< 250 – L3
Plumbaginaceae						
Acantholimon asphodelinum Mobayen	Ch	IT	*, RS, RZ	1314	DD- 3	< 10 – L1
Acantholimon scurpius (Jaub. & Spach) Boiss.	Ch	IT	*	1300	LR- 3	< 50 – L2
Acantholimon wendelboi Rech.f. & Schiman-Czeika	Ch	IT	*	2442	DD- 3	< 50 – L2
Poaceae						
Aegilops tauschii Coss.	Th	IT	RS	724	LC^G- 4	< 250 – L3
Aegilos triuncialis L.	Th	IT	RS	2020	LC^G- 4	< 250 – L3
Avena barbata Pott ex Link	Th	IT	RS	1082	LR- 4	< 250 – L3
Bromus cappadocicus Boiss. & Balansa	He	IT-ES	RS	2292	LR- 3	< 50 – L2
Bromus tomentellus Boiss.	He	IT	*	530	LR- 4	< 250 – L3
Hordeum bulbosum L.	Ge	IT		2212	LC^G- 3	< 50 – L2
Hordeum marinum Huds.	Th	IT	RS	1324	LC^G- 3	< 50 – L2
Phleum montanum K.Koch	He	PL	RS	1875	LC^G- 3	< 50 – L2
Phragmites australis (Cav.) Trin. ex Steud.	He	SCo		2085	LC^G- 4	L4
Polygonaceae						
Atraphaxis aucheri Jaub. & Spach	Ch	IT	*	1320	LR- 3	< 50 – L2
Persicaria lapathifolia (L.) Delarbre	He	IT		2240	LC^G- 3	< 50 – L2
Ptropyrum aucheri Jaub. & Spach	Ch	IT	*	1320	4	L4

Appendix. 1. Continued

Families and Species	Life form	Phytogeographical regions	Endemic	Elevation ranges(m)	Red list category & Population status	AOO (km^2) & L-rank
Polygonum hyrcanicum Rech.f.	He	ES	*, RS	555	LR- 3	< 50 – L2
Pteridaceae						
Adiantum capillus-veneris L.	Ge	SCo	RS	1293	LC^G- 3	< 50 – L2
Ranunculaceae						
Consolida teheranica (Boiss.) Rech.f.	Th	IT	*, RS	504	3	< 10 – L1
Delphinium tuberosum Auch. ex Boiss.	Ge	IT	*, RS	1307	LR- 1	< 10 – L1
Ranunculus elbursensis Boiss.	Ge	ES	*, RS	2217-2473	LR- 3	< 50 – L2
Rhamnaceae						
Paliurus spina-christi Mill.	Ph	IT-ES		479-1106	LR- 4	L4
Rosaceae						
Amygdalus lycioides Spach	Ph	IT	*	479-1082	LR- 4	L4
Cerasus microcarpa (C.A.Mey.) Boiss.	Ph	IT	*	980-1293	4	L4
Crataegus meyeri Pojark.	Ph	IT-ES		980-2240	DD^G- 3	< 250 – L3
Rubiaceae						
Cruciata taurica (Pall. ex Willd.) Ehrend.	He	IT	*	2207	3	< 250 – L3
Galium diploprion Boiss.	Th	IT	*, RS	1573	DD- 3	< 250 – L3
Salicaceae						
Populus euphratica Olivier	Ph	IT	RS	535	LC- 3	< 250 – L3
Populus nigra L.	Ph	PL		1504	DD^G- 5	L5
Salix acmophylla Boiss.	Ph	IT		2493	LC^G- 5	L5
Santalaceae						
Thesium procumbens C.A.Mey.	He	IT	RS, RZ	2473	DD- 2	< 10 – L1
Sapindaceae						
Acer cappadocicum Gled.	Ph	ES	RS	1293	LC^G- 4	L4
Acer monspessulanum L.	Ph	IT		980	LC^G- 3	< 250 – L3
Scrophulariaceae						
Scrophularia rechingeri Grau.	He	IT	**	2080	DD- 3	< 250 – L3
Tamaricaceae						
Tamarix ramosissima Ledeb.	Ph	PL		535-1360	LC^G- 4	L4
Urticaceae						
Urtica dioica var. *dioica* L.	He	SCo		2090	LC^G- 3	< 50 – L2
Xanthorrhoeaceae						
Eremurus kopetdaghensis Karrer	Ge	IT	*, RS	1295	DD- 3	< 10 – L1
Eremurus spectabilis M.Bieb.	Ge	IT		1295	LR- 3	< 50 – L2
Zygophyllaceae						
Zygophyllum fabago L.	He	IT		637	DD- 4	L4