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FLORA, LIFE FORMS, CHOROTYPES AND IUCN INDEX OF PLANT SPECIES IN SOSAN PROTECTED AREA, IRAN

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Abstract

Iran has a unique geobotanical position among the Middle Eastern countries. Sosan is located in the easternmost point of Khuzestan province. This region is one of the wealthiest plant habitats, and this study aimed to determine the dependence of plants from the phytogeographic perspective on different vegetation zones. For this study, field data were obtained using 1500 sample plots in a systematic random grid. Plant life forms were determined using the Raunkiaer method, and the geographical distribution of species was determined based on the vegetation zones classified by Zohary and Takhtjan. The results of this study showed that 169 plant species belonging to 127 genera and 50 families were identified. The Fabaceae, Poaceae, and Asteraceae families were the most important in this study. The study of life forms showed that therophytes (37.29%), hemicryptophytes (32.54%), phanerophytes (17.75%), cryptophytes (7.1%), and chamaephytes (5.32%), most important life forms of the plant. Also, the geographical distribution study showed that Irano-Turanian (58.6%), Irano-Turanian, Mediterranean (11.2%), Irano-Turanian, Sahara-Sindian (7.7%), and Irano-Turanian, Euro-Siberian (7.1%) were identified as the most important chorotypes in this region. The IUCN index study showed that the most critical group in this region is the data-deficient species. In this study, the species without information (88.57%), the species at risk (7.7%), the species of least concern (2.95%), the species vulnerable (1.18%), and the species in danger (0.59%) of the species identified in this protected area.

Key words: Lifeforms; Geographical distribution; IUCN index; Middle east; Sosan; Khuzestan

Introduction

Iran holds a unique geobotanical position among Middle Eastern countries, serving as a bridge between major phytogeographical regions, namely the Irano-Turanian, Euro-Siberian, and Saharan-Sindian zones (Zohary, 1963). Its diverse geographical features and climatic conditions support a rich diversity of plant species, giving Iran a distinctive position in global plant geography. It is recognized as one of the ten primary centers of speciation worldwide, with approximately 8,000 plant species reported, of which 1,810 are endemic, representing a unique national resource (Ghahreman & Attar, 2003). Despite this richness, many areas remain understudied and require further attention regarding vegetation cover (Kazemian *et al*., 2004).

Documenting the flora of a region not only reflects its natural potential but also provides critical information for research, particularly in applied sciences (Dolatkhahi *et al*., 2011). Floristic identification and the study of geographical distribution form the foundation of ecological research, enabling assessment of environmental capacity, evaluation of current conditions, prediction of future trends, and implementation of effective management strategies (Taghipour *et al*., 2011). The flora of a region reflects the interplay between the biological community and environmental conditions, plant evolution, and the region's historical geographical context (Razavi *et al*., 2009). Plant systematics, one of the oldest and most essential branches of botany, organizes and records plant diversity, with the correct name each plant serving as a key to understanding its biology (Mozaffarian, 2005). Moreover, studying regional flora is crucial for evaluating ecological capacity, the effectiveness of management, and the potential conservation of endangered and vulnerable species (Najafi Tire Shabankareh *et al*., 2013).

The relationship between plant species and their environment establishes adaptive balances, resulting in specific forms in harmony with local conditions. Raunkiaer's biological spectrum classifies plants based on the location and protection of buds during adverse seasons, with variations in vegetative forms reflecting climatic differences (Vaseghi *et al*., 2008). According to Raunkiaer (1934), plants are categorized into five life forms: Phanerophytes, Chamaephytes, Cryptophytes, Hemicryptophytes, and Therophytes. Studying plant geographical distribution is vital for determining species ranges, detecting changes due to environmental factors, and identifying endemic species, as each species exhibits specific ecological tolerances and adaptations (Nemati Paykani *et al*., 2021). Previous floristic studies in Khuzestan Province have highlighted regional variation. Dinarvand *et al*., (2018) reported low species richness in dust-affected plains due to uniform fine-grained sediments and lack of slopes. Taghipour *et al*., (2011) documented 72 families, 255 genera, and 382 plant species in the Alaa and Yellow River regions. Pourrezaei *et al*., (2010) identified 202 species from 46 families in the Tangbon Behbahan watershed, with 34.7% Irano-Turanian, 61.6% Sudanic, and 7.8% shared elements.

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Attar Roshan *et al*., (2014) studied the forests of Imamzadeh Abdullah Baghmalek, identifying 154 species across 106 genera and 38 families. Fabaceae (20 species), Poaceae (20 species), Asteraceae (19 species), and Lamiaceae (12 species) collectively represented 46.1% of all species, while Hemicryptophytes were the dominant lifeform.

Sosan District, located 35 km northwest of Izeh County in eastern Khuzestan and bordering Chaharmahal and Bakhtiari Province, is among the richest plant habitats in the region. This study aimed to assess the floristic composition and geographical dependence of plants, examining life forms, and determining the conservation status of species. Such knowledge is essential for scientific land management, developing conservation strategies, and sustainable exploitation of natural resources.

Material and Methods

The study was conducted in an oak forest within the Sosan Protected Area, located in southwestern Iran, Khuzestan Province, between 385927-394690 E longitude and 3556144-3566262 N latitude (Fig. 1). The study site covers an area of approximately 8,458 hectares ,with elevations ranging from 435 to 2,475 m above sea level. The average annual precipitation is 596 mm with a mean annual temperature of 19.1°C. Based on the De Martone aridity index (19.81), the region is classified as semi-arid, whereas the Amberger coefficient (60.86) indicates sub-humid. Field sampling and data collection field surveys were conducted using 1,500 systematically randomized sample plots, each measuring 20 m × 20 m. Within each plot, all tree and shrub species were recorded, and their abundance and canopy cover were estimated by measuring crown diameters (Mataji *et al*., 2013). Herbaceous species were documented using Whitaker's nested plot method, with a minimum area of 100 m² was established for each sample (Muller & Ellenberg, 1974). Plot locations and species counts were plotted along the X and Y axes, and the intercept point where the cumulative curve became horizontal was used to determine the minimum area for herbaceous species. Although the calculated minimum plot area was 81 m², a standardized 100 m² area was adopted to ensure a greater accuracy.

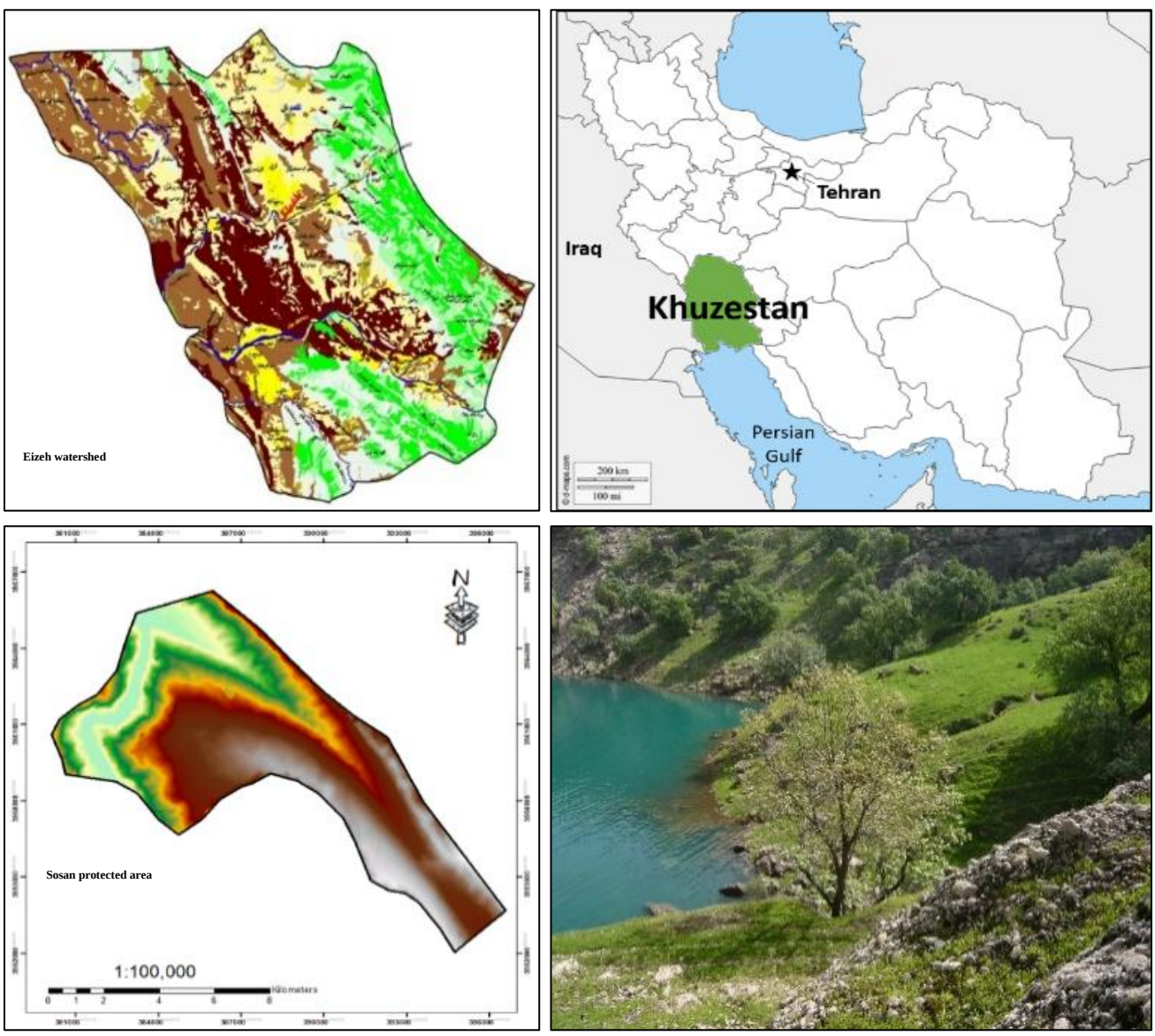

Fig. 1. Map of studied area.

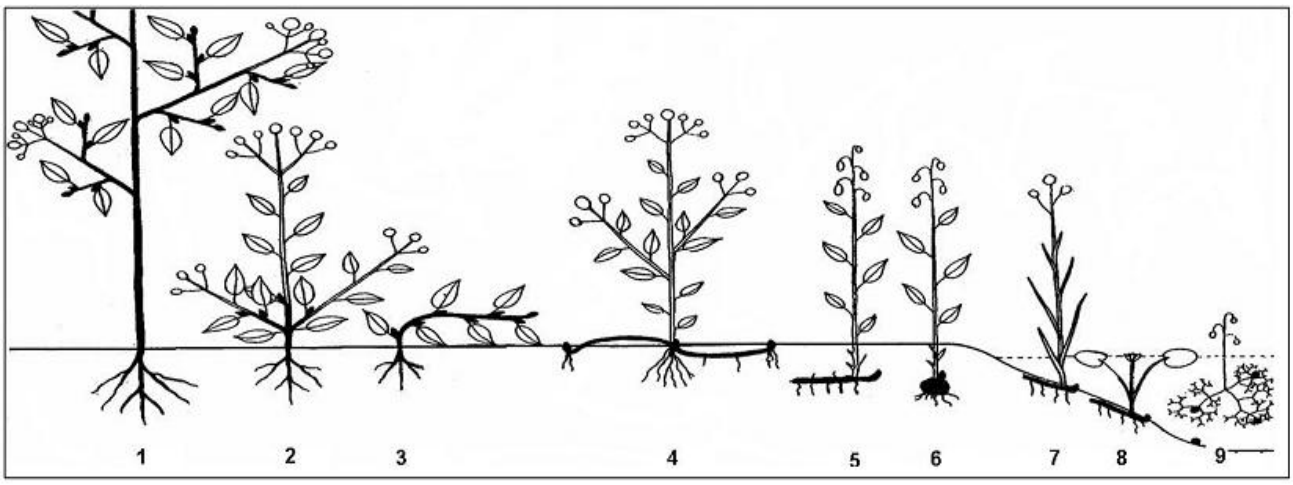

Fig. 2. Plant life forms based on the Raunkiaer classification. 1: Phanerophyte; 2 and 3: Chamaephyte; 4: hemicryptophyte; 5,6,7,8 and 9: cryptophyte (5 and 6: Geophytes; 7: Helophytes; 8 and 9: Hydrophyte) and Therophytes.

All the collected species were identified using authoritative references including Flora Iranica (Rechinger, 1998), Flora of Iraq (Townsend & Guest, 1985), Flora of Turkey (Davis, 1965-1985), Flora of Iran (Assadi *et al*., 1988; Ghahreman, 1975-1999), Flora of Khuzestan (Mozaffarian, 1999) and Flora of Ilam (Mozaffarian, 2005). The voucher specimens were deposited in the herbarium of Islamic Azad University, Ahvaz, Plant lifeforms were determined according to Raunkiaer's method (Raunkiaer, 1934), based on the position of the regenerative buds during unfavourable seasons. Winter herbaceous die-back, followed by spring regrowth from underground buds, allowing categorization into five main group: phanerophytes, chamaephytes, hemicryptophytes, cryptophytes, and therophytes (Fig. 2).

Geographical distribution and chorological analysis of species was assessed based on previously established floras and vegetation zones defined by Zohary (1963, 1973) and Takhtajan (1986). Chorological types were assigned to each species to determine the prevalence of phytogeographic elements in the study area.

To assess conservation status, the identified species in this study were evaluated based on field sampling data and cross-referenced with the International Union for Conservation of Nature Red List (Anon., 2012). The assessment was conducted at a global scale following the most recent IUCN classification criteria. The categories considered included Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), and Data Deficient (DD). Species for which sufficient information was not available in the IUCN database were assigned to the Data Deficient (DD) category.

In addition to conservation assessment, plant utilization was recorded and analyzed. Species were classified based on their uses, including forage, medicinal, industrial, edible, and urban green space applications, in order to comprehensively evaluate the ecological and economic significance of the regional flora.

Results

In this study, 169 plant species from the area were identified in 2021, representing 127 genera and 50 families. Among these, 69 species were annuals and 100 were perennials. A comprehensive list of families and species in the study area, including life forms, life cycles, duration, palatability, chorology, uses, and IUCN status, is presented in Table 1.

The most important families were Fabaceae (29 species), Poaceae (23 species), and Asteraceae (22 species), collectively accounting for 43.8% of all species. The families Rosaceae and Lamiaceae (8 species), Apiaceae (7 species), and Caryophyllaceae (6 species) followed in importance. Convolvulaceae included 4 species, while Asclepiadaceae, Campanulaceae, Liliaceae, Rhamnaceae, and Thymelaeaceae each contained three species. The families Anacardiaceae, Boraginaceae, Brassicaceae, Dipsaceae, Malvaceae, Plantaginaceae, Rubiaceae, Ranunculaceae, Polygonaceae, and Scrophulariaceae comprised two species each. Finally, Aceraceae, Adiantaceae, Amaranthaceae, Amaryllidaceae, Apocynaceae, Araceae, Moraceae, Caprifoliaceae, Cupressaceae, Euphorbiaceae, Fagaceae, Gentianaceae, Geraniaceae, Juncaceae, Capparidaceae, Morinaceae, Papaveraceae, Plumbaginaceae, Primulaceae, Rutaceae, Solanaceae, Tamaricaceae, Ulmaceae, Valerianaceae, Verbenaceae, Vitaceae, and Zygophyllaceae were each represented by a single species (Fig. 3).

A study of plant life forms using Raunkiaer's method (Raunkiaer, 1934) indicated that the most dominant group was Therophytes. In this study, Therophytes accounted for 37.29% of the total species, Hemicryptophytes were 32.54% followed by Phanerophytes 17.75%, Cryptophytes 7.1%, and Chamaephytes 5.32%. The spectrum of life forms is presented in Fig. 4.

The study of geographical distribution indicated that the most important chorotype in the area is Irano-Turanian. In this study, Irano-Turanian (IT) accounted for 58.6% of the total flora followed by Irano-Turanian-Mediterranean (IT, M) 11.2%, Irano-Turanian-Sahara-Sindian (IT, SS) 7.7%, and Irano-Turanian-European-Siberian (IT, ES) 7.1%. Collectively, these chorotypes represent 84.6% of all species in the area. The geographical distribution spectrum is presented in Fig. 5.

The IUCN index assessment indicated that the most critical group in this area was data-deficient species. In this study, data-deficient species constituted 88.57% of the identified species, critically endangered species 7.7%, species of least concern 2.95%, vulnerable species 1.18%, and endangered species 0.59% within this protected area (Fig. 6).

Table 1. List of family, species, life form, chorotypes, usability, and IUCN index of Sosan protected area.

Species	Family	Life form	Chorology	Usability	IUCN Index				
					EN	VU	CR	DD	LC
Acer monspessulanum L.	Aceraceae	Ph	IT, ES	S, F, I		*			
Amaranthus viridis L.	Amaranthaceae	Th	Cosm	S				*	
Adiantum capillus-veneris L.	Adiantaceae	Cr	Cosm	S, M				*	
Ixiolirion tataricum Herb.	Amaryllidaceae	Cr	IT, M, SS	S				*	
Pistacia atlantica Desf.	Anacardiaceae	Ph	IT, M, SS	S, I, M, F, Fo		*			
Pistacia khinjuk Stocks.	Anacardiaceae	Ph	IT	S, I, M, F, Fo				*	
Dorema aucheri Boiss.	Apiaceae	He	IT	F, S, M, I				*	
Eryngium glomeratum Lam.	Apiaceae	He	IT	S, F				*	
Ferula stenocarpa Boiss. & Hausskn. ex Boiss.	Apiaceae	He	IT	F, S, M, I				*	
Ferulago macrocarpa Boiss.	Apiaceae	He	IT	F, S, M, I				*	
Ferulago macrocarpa Boiss.	Apiaceae	He	IT	F, S, M, I				*	
Haussknechtia elymaitica Boiss.	Apiaceae	He	IT	S, I, M, F, Fo				*	
Malabaila secacul (Mill.) Boiss.	Apiaceae	He	IT	S, F, M				*	
Prangos uloptera DC.	Apiaceae	He	IT	S, F, M				*	
Nerium indicum Mill.	Apocynaceae	Ph	IT	S, G				*	
Arum elongatum Steven.	Araceae	He	IT	S, F				*	
Marsedenia erecta (L.) R. Br.	Asclepiadaceae	Ph	IT, M	S				*	
Periploca aphylla Decne.	Asclepiadaceae	Ph	IT, ES	S, F				*	
Pergularia tomentosa L.	Asclepiadaceae	Ph	IT, ES	S, M				*	
Achillea tenuifolia Lam.	Asteraceae	He	IT	S, F, M				*	
Achillea wilhelmsii K. Koch.	Asteraceae	He	IT, SS	S, F, M				*	
Anthemis persica Boiss.	Asteraceae	Th	IT	S, F, M			*		
Carduus pycnocephalus L.	Asteraceae	Th	IT, M	S, F				*	
Centaurea bruguierana Hand.	Asteraceae	Th	IT, SS	S, F				*	
Centaurea iberica Trev. ex Spreng.	Asteraceae	Th	IT, M	S, F				*	
Centaurea hyalolepis Boiss.	Asteraceae	He	IT	S, F				*	
Cirsium congestum Fisch & C.A. Mey. ex DC.	Asteraceae	He	IT	S, F				*	
Echinops dichorus Boiss. & Hausskn.	Asteraceae	He	IT	S, F, M				*	
Jurinea proteoides Boiss. & Hausskn. ex Boiss.	Asteraceae	He	IT	S				*	
Lactuca serriola L.	Asteraceae	He	IT, ES, M	S, F				*	
Notobasis syriaca Cass.	Asteraceae	Th	IT	S, F				*	
Onopordon leptolopis DC.	Asteraceae	He	IT	S, F				*	
Pentanema divaricatum Cass.	Asteraceae	Th	IT	S				*	
Picnomon acarna (L.) Cass.	Asteraceae	He	IT, M	S				*	
Picris strigosa M. Bieb.	Asteraceae	Ph	IT	S				*	
Reichardia orientalis Hochr.	Asteraceae	He	IT	S				*	
Silybum marianum (L.) Gaertn.	Asteraceae	He	Cosm	S, F				*	
Sonchus oleraceus L.	Asteraceae	Th	Cosm	S, F, M				*	
Tanacetum polycephalum Sch. Bip.	Asteraceae	He	IT	S, F, M				*	
Urospermum picroides (L.) F. W. Schmidt.	Asteraceae	Th	IT-M	S				*	
Onosma bulbotricha DC.	Boraginaceae	He	IT	S				*	
Rindera lanata Bunge.	Boraginaceae	He	IT	S				*	
Eruca sativa Mill.	Brassicaceae	Th	IT, ES, M	S, M				*	
Sisymbrium officinale (L.) Scop.	Brassicaceae	Th	IT	S, F, M				*	
Campanula cecilii Rech. f. & Schiman-Czeika.	Campanulaceae	Th	IT	S, F				*	
Campanula perpusilla A. DC.	Campanulaceae	He	IT	S, F				*	
Campanula reuteriana Boiss. & Balansa.	Campanulaceae	Th	IT	S, F				*	
Lonicera nummularifolia Jaub. & Spach.	Caprifoliaceae	Ph	IT	S, F					*
Acanthophyllum microcephalum Boiss.	Caryophyllaceae	Ch	IT	S, F, I				*	
Arenaria serpyllifolia L.	Caryophyllaceae	Th	IT	S, F				*	
Dianthus siphonocalyx Blakelock.	Caryophyllaceae	He	IT	S, F				*	
Herniaria cinerea DC.	Caryophyllaceae	Th	IT, M	S, F				*	
Silene lagenocalyx Fenzl ex Boiss.	Caryophyllaceae	Th	IT	S, F				*	
Vaccaria phyramidata Medicus.	Caryophyllaceae	Th	IT, ES	S				*	
Cleome iberica DC.	Cleomaceae	Th	IT, M	S				*	
Convolvulus chondrilloides Boiss.	Convolvulaceae	Th	IT	S, F				*	
Convolvulus oxyphyllus Boiss.	Convolvulaceae	He	IT	S, F				*	

Table 1. (Cont'd.).

Species	Family	Life form	Chorology	Usability	IUCN Index				
					EN	VU	CR	DD	LC
Convolvulus reticulatus Choisy	Convolvulaceae	He	IT	S, F				*	
Convolvulus stachydifolius Choisy.	Convolvulaceae	He	IT	S, F, P				*	
Juniperus polycarpus L.	Cupressaceae	Ph	IT	S, I, G, M					*
Cephalaria dichaetophora Boiss.	Dipsaceae	Th	IT	S				*	
Scabiosa calocephala Boiss.	Dipsaceae	Th	IT	S				*	
Euphorbia peplus L.	Euphorbiaceae	Th	ES, IT, M	S				*	
Astragalus adshendens Boiss. & Hausskn. ex Boiss.	Fabaceae	Ph	IT	F, S, M, I				*	
Astragalus arbushulinuss Bornm. & Gauba.	Fabaceae	He	IT	S, F, M			*		
Astragalus hamosus L.	Fabaceae	Th	IT	S, F				*	
Astragalus fasciculifolius Boiss.	Fabaceae	Ph	IT	S, F			*		
Astragalus murinus Boiss.	Fabaceae	He	IT	S, F				*	
Astragalus strictifolius Boiss.	Fabaceae	He	IT	S, F				*	
Astragalus susianus Tietz. & Zarre.	Fabaceae	Th	IT	S, F			*		
Astragalus talemansurensis Sirj. & Rech.	Fabaceae	Ch	IT	S, F			*		
Hymenocarpus circinnatus (L.) Savi.	Fabaceae	Th	IT, SS	S, F				*	
Lotus corniculatus L.	Fabaceae	He	IT, ES, M	S, F				*	
Medicago laciniata (L.) Miller.	Fabaceae	Th	IT, M, SS	S, F				*	
Medicago polymorpha L.	Fabaceae	Th	IT, ES	S, F				*	
Medicago rigidula (L.) All.	Fabaceae	Th	IT, M	S, F			*		
Medicago radiata L.	Fabaceae	Th	IT, M	S, F				*	
Medicago scutellata Mill.	Fabaceae	Th	IT	S, F				*	
Onobrychis crista- galli Lam.	Fabaceae	Th	IT	S, F				*	
Onobrychis iransharii Rech f.	Fabaceae	He	IT	S, F				*	
Onobrychis ptolemaica DC.	Fabaceae	He	IT	S, F				*	
Scorpiurus muricatus L.	Fabaceae	Th	IT, SS	S, F				*	
Taverniera nummularia DC.	Fabaceae	Ch	IT, SS	S, F			*		
Trigonella anguina Delile.	Fabaceae	Th	IT	S, F				*	
Trifolium campestre Schreb.	Fabaceae	Th	IT, ES, M	S, F				*	
Trifolium grandiflorum Schreb.	Fabaceae	Th	IT, ES, M	S, F				*	
Trifolium lappaceum L.	Fabaceae	Th	IT, ES, M	S, F				*	
Trifolium purpureum Loisel.	Fabaceae	Th	IT, ES, M	S, F				*	
Trigonella stellata Forssk.	Fabaceae	Th	IT	S, F				*	
Trifolium tomentosum L.	Fabaceae	Th	IT	S, F				*	
Quercus persica Jaub & Spach.	Fagaceae	Ph	IT, ES	I, F, S, Fo, G, M				*	
Vicia ervilia Willd.	Fabaceae	Th	IT	S, F				*	
Vicia monantha Retz.	Fabaceae	Th	IT	S, F				*	
Gentiana olivieri Griseb.	Gentianaceae	He	IT, SS	S, F				*	
Erodium cicutarium (L.) L'Her. Ex. Aiton.	Geraniaceae	Th	IT, M, SS	S, F				*	
Juncus bufonius L.	Juncaceae	Cr	IT, ES	S, F				*	
Mentha longifolia (L.) Hudson	Lamiacae	He	IT	S, F, Fo, M			*		
Muscari tenuiflorum Tausch.	Liliaceae	Cr	IT, M	S				*	
Nepeta persica Boiss.	Lamiacae	He	IT	S, F, M				*	
Phlomis anisodonta Boiss.	Lamiaceae	He	IT	S, F				*	
Phlomis persica Boiss.	Lamiaceae	He	IT	S, F			*		
Phlomis olivieri Benth.	Lamiacae	He	IT	S, F				*	
Salvia compressa Vent.	Lamiacae	He	IT	S, F, M				*	
Teucrium polium L.	Lamiaceae	He	Cosm	S, F, M				*	
Tulipa clusiana DC.	Liliaceae	Cr	IT	S				*	
Urginea maritima Baker.	Liliaceae	Cr	IT, SS	S, M				*	
Alcea aucheri Alef.	Malvaceae	He	IT	S, F, M				*	
Malva parviflora L.	Malvaceae	Th	IT, M	S, F, Fo, M				*	
Ficus carica L.	Moraceae	Ph	IT, M	S, F, Fo, M				*	
Morina persica L.	Morinaceae	He	IT	S, F				*	
Papaver dubium L.	Papaveraceae	Th	IT	S, M				*	
Plantago ovata Forssk.	Plantaginaceae	He	IT	S, F, M				*	
Plantago psyllium L.	Plantaginaceae	Th	IT, ES	S, F, M				*	
Acantholimon scorpius (Jaub. & Spach) Boiss.	Plumbaginaceae	Ch	IT, M	S, F, M				*	

Table 1. (Cont'd.).

Species	Family	Life form	Chorology	Usability	IUCN Index				
					EN	VU	CR	DD	LC
Aegilops triuncialis L.	Poaceae	Th	IT	S, F				*	
Aegilops umbellulata Zhuk.	Poaceae	Th	IT	S, F				*	
Agropyron trichophorum K. Richt.	Poaceae	Ch	IT, M	S, F				*	
Arrhenatherum kotschyi Boiss.	Poaceae	Cr	IT	S, F					*
Avena ludoviciana Durieu.	Poaceae	Th	IT, M	S, F				*	
Bromus danthoniae Trin. ex C. A. Mey.	Poaceae	Th	IT	S, F				*	
Bromus tectorum L.	Poaceae	Th	Cosm	S, F				*	
Bromus scoparius L.	Poaceae	Th	IT	S, F				*	
Bromus tomentelus Boiss.	Poaceae	He	IT	S, F			*		
Cynodon dactylon (L.) Pers.	Poaceae	Cr	Cosm	S, F				*	
Catapodium rigidum (L.) C. E. Hubb.	Poaceae	Th	IT	S, F				*	
Cymbopogon olivieri (Boiss.) Bor.	Poaceae	He	IT	S, F				*	
Heteranthelium piliferum Hochst ex Jaub. & Spach.	Poaceae	Th	IT	S, F				*	
Hordeum bulbosum L.	Poaceae	Cr	IT	S, F				*	
Hyparrhenia hirta (L.) Stapf.	Poaceae	He	IT, M	S, F				*	
Lolium rigidum Gaudin.	Poaceae	Th	IT, M	S, F				*	
Lophochloa phleoides (Vill) Rchb.	Poaceae	Th	IT	S, F				*	
Melica persica Kunth.	Poaceae	Cr	IT, ES, M, SS	S, F				*	
Poa annua L.	Poaceae	Cr	IT, ES, M	S, F				*	
Poa bulbosa L.	Poaceae	Cr	IT, SS	S, F					*
Sorghum halepense (L.) Pers.	Poaceae	Cr	Cosm	S, F				*	
Stipa capensis Thunb.	Poaceae	Th	IT	S, F				*	
Vulpia myuros (L.) C. C. Gmel	Poaceae	Th	Cosm	S, F				*	
Rumex ephedroides Bornm.	Polygonaceae	Ph	IT	S, F			*		
Rheum ribes L.	Polygonaceae	Cr	IT	S, I, M, F, Fo				*	
Anagallis arvensis L.	Primulaceae	Th	Cosm	S, F, M				*	
Ceratocephalus falcatus (L.) Pers.	Ranunculaceae	Th	IT, ES	S				*	
Delphinium cyphoplectrum Boiss.	Ranunculaceae	He	IT	S, F				*	
Rhamnus cornifolia Boiss. & Hohen.	Rhamnaceae	Ph	IT	F, S, M, I				*	
Rhamnus persica Boiss. & Hohen.	Rhamnaceae	Ph	IT	F, S, M, I				*	
Ziziphus nummularia (Burm f.) Wight & Arn.	Rhamnaceae	Ph	IT	S, F, Fo, M				*	
Amygdalus scoparia Spach.	Rosaceae	Ph	IT	S, F, Fo, M				*	
Amygdalus horrid Spach.	Rosaceae	Ph	IT	S, F, M			*		
Cerasus microcarpa Boiss.	Rosaceae	Ph	IT	S, I, M, F, Fo	*				
Cerasus mahaleb Mill.	Rosaceae	Ph	IT	F, S, M, I					*
Cotonester nummularioides Pojark.	Rosaceae	Ph	IT	S, F, M				*	
Crataegus azarolus L.	Rosaceae	He	IT, ES, M	S, I, M, F, Fo				*	
Pyrus syriaca Boiss.	Rosaceae	Ph	IT	S, I, Fo, M				*	
Sanguisorba minor Scop.	Rosaceae	Ch	IT, ES	S, F				*	
Callipeltis cucularia (L.) DC.	Rubiaceae	Th	IT, SS	S				*	
Galium sataceum Lam.	Rubiaceae	Th	IT, M	S				*	
Haplophyllum tuberculatum Gürke.	Rutaceae	He	IT, SS	S				*	
Scrophularia striata Boiss.	Scrophulariaceae	He	IT	S, F				*	
Verbascum sinuatum L.	Scrophulariaceae	He	IT	S				*	
Lycium shawii Roem. & Schult.	Solanaceae	Ph	IT, SS	S, F				*	
Tamarix leptopetala Bunge.	Tamaricaceae	Ph	IT, M	S			*		
Daphne mucronata Royle.	Thymelaeaceae	Ph	IT, ES	S, F, I				*	
Daphne stapfii Bornmüller et Keissler.	Thymelaeaceae	Ph	IT	S, F				*	
Thymelaea mesopotamica (C. Jeffrey) B. Peterson.	Thymelaeaceae	Th	IT, SS	S, F				*	
Celtis caucasica Willd.	Ulmaceae	Ph	IT, ES	S, F				*	
Valerianella vesicaria Moench.	Valerianaceae	Th	IT	S				*	
*Vitex pseudo-negundo (*Husskn.) HandMzt.	Verbenaceae	Ph	IT	S, F, M				*	
Ampelopsis vitifolia (Boiss.) Planch.	Vitaceae	Ph	IT, SS	S, F, Fo, M				*	
Peganum harmala L.	Zygophyllaceae	He	IT, M, SS	S, M				*	

Ph: Phanerophyte, He: Hemicryptophyte, Th: Therophyte, Ge: Geophyte, Ch: Chamaephyte, IT: Irano-Turanian, M: Mediterranean, SS: Sahara-Sindian, ES: Euro-Siberian, Cosm: Cosmopolite, Fo: Food, I: Industrial, M: Medicinal, G: Green Space, S: Soil Protection and F: Fodder, EN: Endangered, Vu: Vulnerable, LC: Least Concern, DD: Data Deficient, CR: Critically Endangered

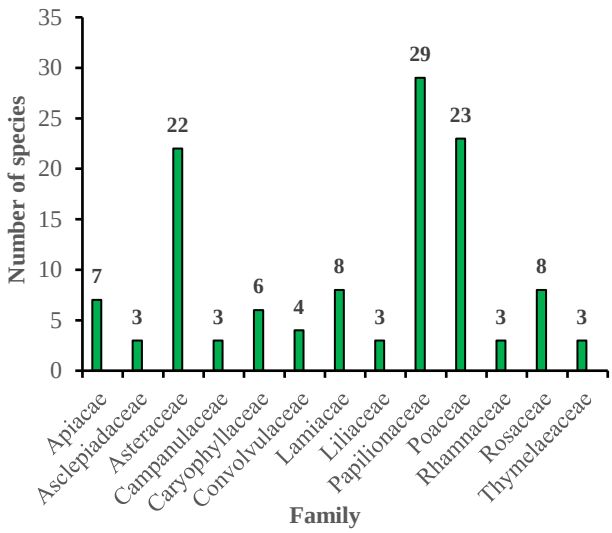

Fig. 3. Family number of plants in Sosan protected area.

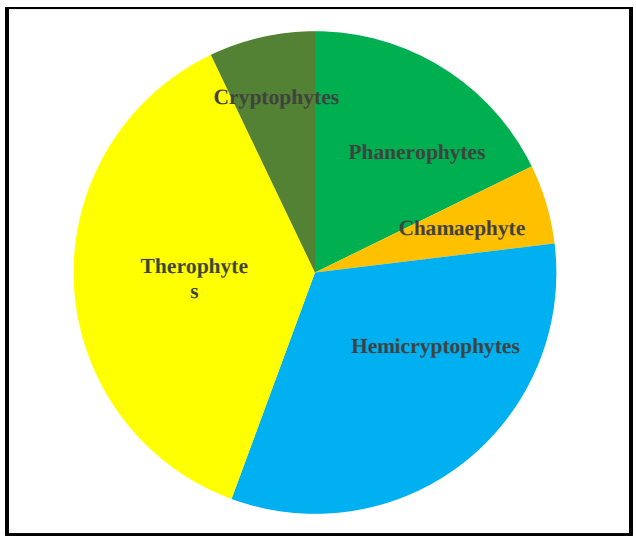

Fig. 4. Life forms spectrum of plants in Sosan protected area.

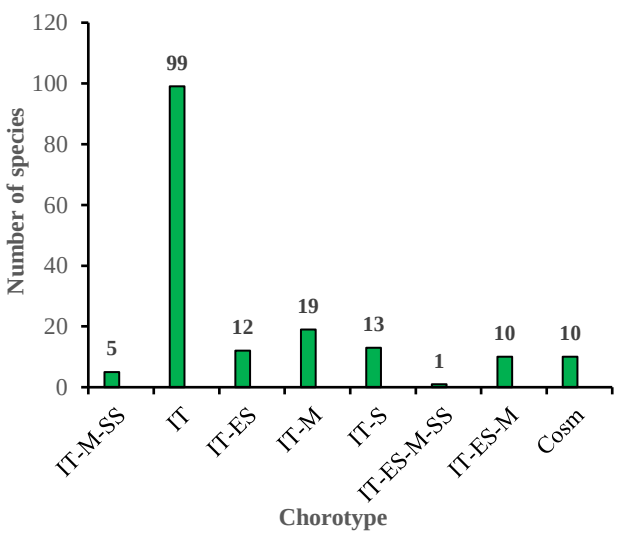

Fig. 5. Chorological types of spectrums in flora in Sosan protected area.

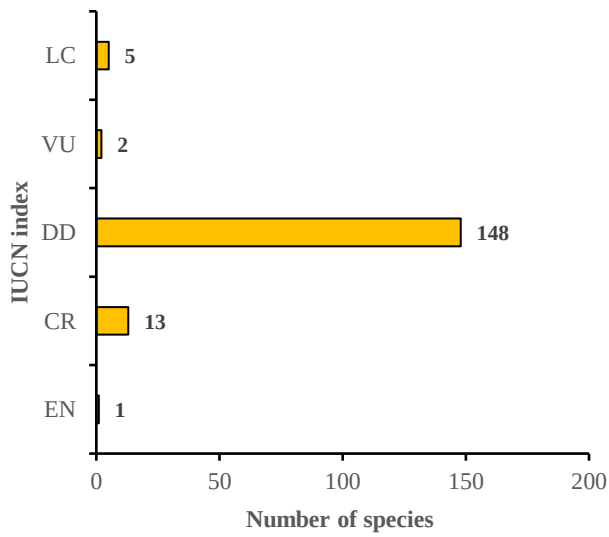

Fig. 6. Classification of plant species based on IUCN index in Sosan protected area.

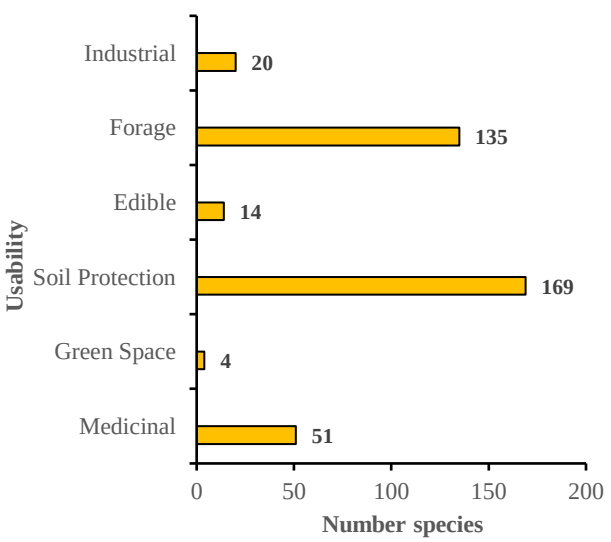

Fig. 7. Classification of plant species based on use in Sosan protected area.

In this study, the use of plant species was investigated, and it was found that 100% of the plant species of the study area effectively protected the habitat soil. Of the studied species, 79.88% were forage plants, 30.17% followed by medicinal plants, 11.83% are industrial plants, 8.28% edible plants, whereas 2.36% plants were being used in urban green spaces (Figs. 7 and 8).

Discussion

According to the results, Asteraceae (22 species), Poaceae (23 species), and Fabaceae (29 species) are the most prominent families in terms of species richness in the study area. This pattern, where the majority of regional species richness is concentrated within a limited number of families, has been reported in many regions of Iran (Ghahreman *et al*., 2006; Salehi *et al*., 2023; Atashgahi *et al*., 2018). The relative abundance of Asteraceae species is attributed to their high diversity across the country, and the evolutionary development of this family has enhanced

its distributional capacity (Attar Roshan and Heydari, 2014). In addition, special morphological, anatomical, and physiological traits such as high adaptability to adverse ecological conditions, particularly in the mountainous and arid Irano-Turanian region, production of tiny seeds, presence of spines and thorns, and synthesis of secondary metabolites have contributed to their success. In some genera, these characteristics have promoted species diversification (Jafari Kokhdan *et al*., 2015; Vahabi *et al*., 2017). Furthermore, as many species of this family are not grazed, one of the primary causes of vegetation destruction (overgrazing) does not significantly affect their persistence (Noori *et al*., 2018). The dominance and relative abundance of Asteraceae species are consistent with previous studies (Nadaf, 2021; Fattahi *et al*., 2021; Bagheri *et al*., 2020).

The richness of Poaceae species in the region is also of particular importance due to their forage value and role in soil conservation. Because the terminal bud of many Poaceae species is located close to the soil surface, they suffer less damage from destructive factors such as grazing. This resistance is largely related to the presence of intercalary meristems in many Poaceae species, which are located at the base of leaves and stems near the soil surface. These meristems enable rapid regrowth after grazing or mechanical damage, thereby enhancing the persistence and competitive ability of grasses under disturbance conditions (Briske, 1996; Skinner & Nelson, 1995). This characteristic (Sharifi Neiar, 1996), along with their production of numerous small seeds, may help explain the wide distribution and diversity of this family (Attar Roshan *et al*., 2022).

The presence of four *Astragalus* species with different lifeforms in the study area indicates cold, high-altitude, and semi-arid conditions, in agreement with the findings of other studies (Bagheri *et al*., 2020; Atashgahi *et al*., 2018; Mohammadi *et al*., 2021). This genus is one of the characteristic elements of the Irano-Turanian vegetation zone (Manafzadeh *et al*., 2016). The study's results suggest that the area is rich in plant diversity. Among all lifeforms, Hemicryptophytes are dominant (32.54%), followed by Therophytes (37.29%). Plant life forms reflect adaptation to environmental, particularly climatic, conditions (Dehshiri *et al*., 2017). According to Mobayen (1995), the high frequency of Therophytes is related to the Mediterranean climate, while the abundance of Hemicryptophytes is associated with cold and temperate climates. Overall, the dominance of Hemicryptophytes and Therophytes indicates the influence of both Mediterranean and cold-temperate climates on the flora of the area.

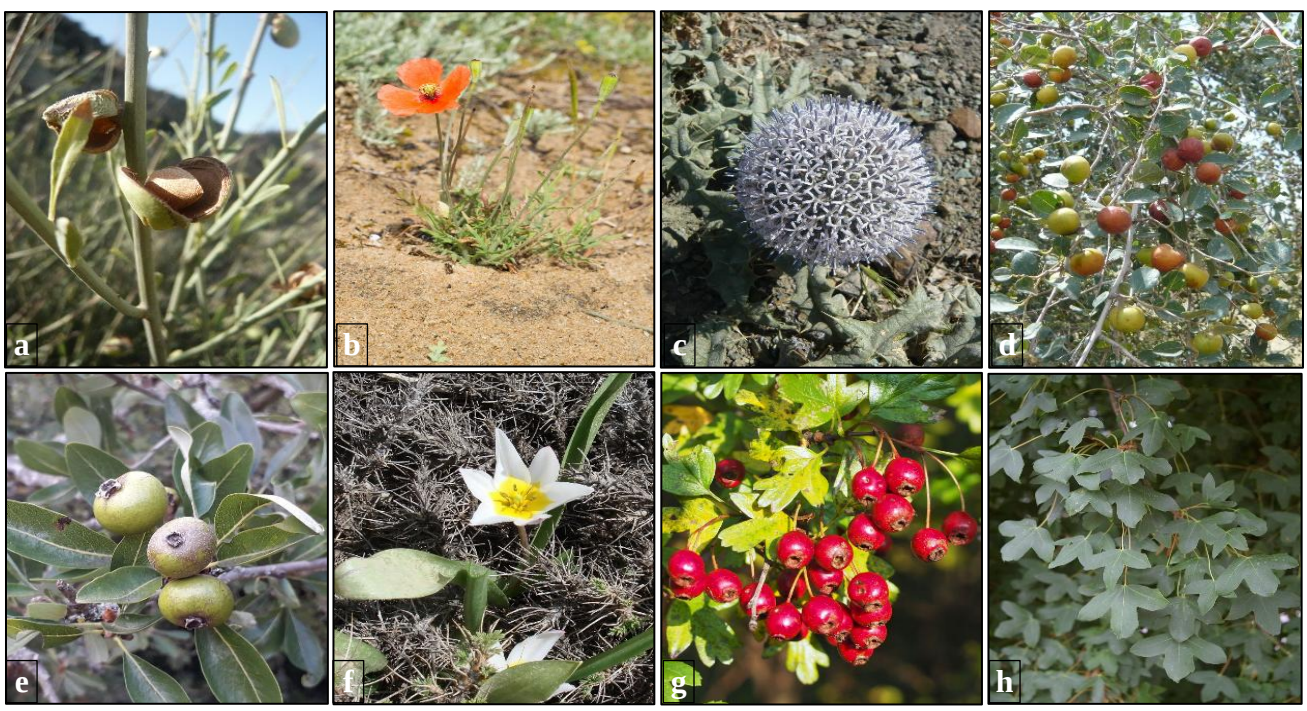

Fig. 8. **a:** *Amygdalus scoparia*, **b:** *Papaver dubium*, **c:** *Echinops dichorus*, **d:** *Ziziphus nummularia*, **e:** *Pyrus syriaca*, **f:** *Tulipa clusiana*, **g:** *Crataegus azarolus*, **h:** *Acer monspessulanum*.

Therophytes are characterized by a short life cycle and the ability to rapidly complete their growth and reproduction during favourable seasons. This strategy allows them to avoid summer drought by surviving in the form of seeds, making them well adapted to environments with pronounced seasonal dryness (Grime, 2001; Baskin & Baskin, 2000). Hemicryptophytes are the predominant lifeform, and their abundance is linked to adaptation to cold, semi-arid, and mountainous climatic conditions. According to Archambult (1996), their presence indicates mountainous terrain, with soil moisture preserved by snowmelt during the growing season. Their abundance also reflects their ability to regenerate from buds at the soil surface during the cold season (Abbasi *et al*., 2015). Nadaf (2021) further attributed their abundance to fertile soils. Several studies have reported Hemicryptophytes as the most important lifeform in the region (Shirvani Shahenayati, 2020; Ahvazi *et al*., 2015; Karimi *et al*., 2016). The geographical distribution of plant species reflects the influence of different vegetation zones

(Mobayen, 1985). Because 58.6% of the species in this area are Irano-Turanian elements, the region can be classified as part of the Irano-Turanian zone, which is characterized by low rainfall and long dry seasons (Zohary, 1973; Takhtajan, 1986; Leonard, 1988; Leonard, 1993; Heydari *et al*., 2021). The Irano-Turanian region is the source of many taxa, particularly xerophytes of neighboring regions (Manafzadeh *et al*., 2013). This highlights its importance for biodiversity conservation as a center of species dispersal. Given the large proportion of Irano-Turanian elements and shared taxa with other regions, the study area must be regarded as an important reservoir of genetic resources (Atashgahi *et al*., 2018). The study area's considerable percentage of Irano-Turanian elements and shared species with other regions underscores its special significance for species richness, with applications in pharmaceuticals, soil conservation, industry, and as edible plants (Jafari Kokhdan *et al*., 2019). In addition, 13 threatened species were recorded according to Anon., (2012) criteria, reflecting extensive degradation of natural habitats. In Iran, 83% of vulnerable and 71% of endangered species are perennial herbaceous plants, consistent with the present study, where most of the threatened species fall into this category (Jalili and Jamzad, 1999).

Finally, it should be emphasized that the presence of potentially threatened species, the proximity of highlands to tourist areas, destructive human activities such as road construction and power transmission lines, and uncontrolled access of mountaineers and tourists all necessitate stronger management and protection measures. Such efforts are essential to ensure regeneration, reproduction, and long-term survival of plant species, particularly valuable endemic species that represent the genetic capital of this area.

Conclusion

The study area is remarkably rich in plant diversity. Documenting the floristic composition of habitats is essential for advancing ecological research, management, and the conservation of both plants and animals. However, the resources available for conserving species and ecosystems are limited compared to the pressing needs. Therefore, directing conservation and management efforts requires clearly defined priorities, with floristic studies serving as a fundamental tool in biodiversity research, as considered in this study. In this research, the identification of 169 plant species in the area together with their chorology, plant families, and lifeforms provides critical information for future ecological investigations, as well as for the conservation and management of this wildlife refuge in Iran.

Conflict of Interest: The authors declare that there are no conflicts of interest regarding the publication of this paper.

Authors Contribution: S.AR: Conceptualized and designed the study, carried out field surveys and plant sampling, performed data curation and statistical analyses, interpreted the results, and prepared the original draft of the manuscript. **M.R.T:** Contributed to methodology development, floristic and chorological analyses, data validation, and critical revision of the manuscript. **S.K.F**: Contributed to supervision of some stages of the research, interpretation of the findings, and final review and editing of the manuscript.

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