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Exploring the Monocotyledonous Geophytes Flora: Isfahan Province, Iran

Azadeh Akhavan Roofigar *
Research Division of Natural Resources, Isfahan Agricultural and Natural Resources Research and Education Center, AREEO, Isfahan, Iran
a.akhavan@areeo.ac.ir

Abstract
Determining the geophyte flora is of principal significance, not only for the conservation of plant diversity but also for its economic impact. Many geophytes hold economic value, serving as food sources, medicinal plants, and ornamental species. This paper presents the first comprehensive study of monocot geophytes in Isfahan province, Iran, focusing on their composition and species diversity. The study exposed a total of 187 taxa (including species and subspecies), covering 61 genera and 15 families among monocotyledonous geophytes in Isfahan province. Remarkable families comprise Poaceae (44 taxa; 23.52%), Amaryllidaceae (35 taxa; 18.72%), Liliaceae (27 taxa; 14.43%), Iridaceae and Asparagaceae (17 taxa; 9.09%). Moreover, the research identified that 66 species (35.29% of all taxa) belong to the Irano-Turanian region (monoregional), ten species (5.35%) are pluriregional, 14 species (7.48%) exhibit cosmopolitan distribution, while 97 taxa (51.87%) are shared across the Irano-Turanian region and other floristic regions. The study also determined 25 taxa as endemic to Iran, creating 13.36% of all monocotyledonous geophytes in Isfahan province. The conclusions highlight the critical need for the application of effective conservation strategies to conservation these valuable geophyte species.
Keywords: *Allium*, Bulbous plant; Conservation; Endemic; Iran; Taxonomy.

Introduction

Geophytes represent a distinct life form, characterized by an underground storage organ, such as a rhizome, tuber, corm, or bulb (Hamrick 1996; Parsons 2000; Proches et al. 2006; Kamenetsky 2013). They play a vital role in protecting the plant during harsh conditions, as documented by Dafni et al. (1981); Parsons (2000); Kamenetsky (2013). These life forms are commonly found in monocots, including Iridaceae, Orchidaceae, and Amaryllidaceae, and are also present in certain dicot taxa (Meerow 2013). Many geophyte monocot species in genera such as *Allium* L., Iris L., *Narcissus* L., and *Tulipa* L. are widely cultivated as ornamentals (Kamenetsky 2013). These plants serve both aesthetic and economic purposes, being used as cut flowers, preserved plants, and garden plants. Moreover, they have a long history of use for both food and medicine. For example, within the genus *Allium*, several species have economic value, counting onions (*A. cepa* L.), garlic (*A. sativum* L.), leeks (*A. ampeloprasum* L.), and Persian shallots (*A. stipitatum* Regel), which are used as vegetables, flavor crops, and traditionally as medicinal and ornamental plants (Fritsch & Friesen 2002). Classifying geophyte species is crucial not only for preserving plant diversity and conservation status but also for the economy (Çakır 2017). Furthermore, conserving endemic geophytes is crucial for maintaining biodiversity. The number of known vascular plant species in Iran is 8,112, of which monocots comprise 1,164 species, including 175 endemics (Noroozi et al. 2019). Iran hosts more than 200 bulbous plant species from various families within its monocot flora, making it one of the most significant centers of plant diversity, particularly for geophyte species (Farahmand & Nazari 2015).

Isfahan province, located in the center of the Iranian plateau and along the eastern slopes of the Zagros mountain range, stands as one of Iran's main centers for the diversity and distribution of plant species. This province falls within the Irano-Turanian phyto-geographic region, encompassing five distinct zones: forests, high mountains, semi-steppes, steppes, and semi-desert regions (Akhavan Roofigar & Bagheri 2021; Noroozi et al. 2020). The province's topography exerts a significant influence on the climate across its various zones, shaping the environmental conditions unique to each area. The peaks within Isfahan province are critical centers of endemism in Iran. The region's diverse flora comprises of numerous species, with a majority having high ornamental

*Corresponding author
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appeal. Most areas of the province, particularly its mountainous regions, are recognized as rich habitats for geophyte species. Numerous floristic studies have been conducted in Isfahan province (Abbasi et al. 2012; Akhavan Roofigar & Bagheri 2021; Asri 2008; Batooli 2018; Khajeddin & Yeganeh 2010; Kharazian et al. 2017; Parishani 2005; Yousofi et al. 2011), shedding light on its botanical prosperity and ecological significance. To date, there have been no comprehensive studies on geophytes in Isfahan province or the entire country published as an article or as a separate study. However, neighboring countries, especially Turkey, have undertaken several studies on geophyte species, resulting in the documentation of 978 geophyte species in the flora of Turkey (Güner 2012; Korkmaz et al. 2014; Mammadov & Sahranç 2003; Çelik et al. 2004; Eker et al. 2008; Özuslu & İskender 2009; Şekeroğlu et al. 2013). Numerous studies have also been conducted in different parts of the world (Tojibaev et al. 2018; Dechir et al. 2019; Cuéllar-Martínez & Sosa 2016; Rundel 1996), further highlighting the global interest in geophyte research. The first comprehensive study of monocot geophytes in Isfahan province is aimed to be conducted in this paper, serving as a case study for the flora of Iran.

Materials and Methods

Study area

Isfahan province covers a vast area of over 107,000 km² and exhibits a wide altitudinal range, from 700 meters below sea level in the east and northeast around Khour va Biabanak to 4,409 meters in the west of the province at Mt. Dena (Semirom). Due to its extensive size, diverse topography, and varying climate, Isfahan is divided into multiple regions, including mountains, plains, and deserts, leading to the growth of various vegetation types throughout the province. According to statistics from weather stations in different regions of Isfahan province, annual precipitation varies, ranging from approximately 45 mm in the central deserts of the eastern regions to 1,000 mm in the west and southwest of the province. These diverse environmental conditions produce suitable habitats for a wide range of geophyte species. Based on valid floristic studies conducted in the province (as mentioned above) and the author's ongoing research projects, various areas, including Golestankooh, Khansar, Golpayegan, Fereydunshahr, and Semirom, serve as biodiversity hotspots in Isfahan province.

Data collection

To collect a complete list of monocot geophytes in Isfahan province, species reported for the region were identified using herbarium specimens from the SFAHAN and HUI herbaria. Furthermore, relevant valid references, the latest articles, and monographs on *Allium*, *Gagea* Salisb, *Leopoldia* Parl., *Poa* L. and *Stipa* L. (Freitag 1985; Zarrei et al. 2007; Zarrei et al. 2011; Jafari & Maassoumi 2011; Fritsch & Abbasi 2013; Kavousi 2015; Bidarlord & Ghahremaninejad 2022;) were consulted. The references, which included monocot families/genera from Flora Iranica (Rechinger 1963-2015) and Flora of Iran (Assadi et al. 1989-2023), were reviewed, and all previous records related to Isfahan province were extracted. Additionally, sampling was conducted in various natural habitats of the area during the growing seasons between 2013 and 2019, and species identification was carried out using the reliable sources mentioned above. Virtual herbaria were also utilized to compare the identified species with images of type specimens and species collected from neighboring countries. All species names in this study follow the International Plant Names Index (IPNI 2023) and Plants of the World Online (POWO 2023). The taxonomic classification of taxa within different plant families was determined using the APG IV classification (Chase et al. 2016; Ghahremaninejad & Nejad Falatoury 2016). To determine the origin of the plants and their endemic status, references related to various species were checked in neighboring countries (Komarov 1934-1957; Davis 1965-1988; Townsend et al. 1966-1985; Tutin & Heywood 1964-1980). Moreover, the stem metamorphosis (Bulb, Tuber, Corm, and Rhizome) of the geophyte samples was recognized based on the original descriptions of the taxa in the relevant literature. Distributions, endemism, and other traits of species were checked by Plants of the World Online (POWO 2023), Flora Iranica (Rechinger 1963-2015) and Flora of Iran (Assadi et al. 1989-2023). Finally, the list of monocot geophytes of Isfahan province was documented. In this work, more than 1500 herbarium specimens belonging to different monocot families were carefully reviewed.

Results

The results of the present study reveal the presence of 15 plant families and 61 genera, comprising a total of 187 geophytic taxa within Isfahan province (Fig 1, Table 1). Poaceae stands out as the largest family in Isfahan, with 44 species, accounting for 23.52% of the total. This is followed by Amaryllidaceae with 35 species (18.72%), Liliaceae with 27 species (14.43%), and Iridaceae and Asparagaceae, with 17 species (9.09%). Cyperaceae is another notable family with 15 species (8.02%). (Fig 2). These six families together include 82.88% of all recorded species, amounting to 155 taxa. The remaining families each comprise one to seven taxa, totaling 32 species (17.12%). According to the number of species, *Allium* with 32 taxa (17.11%) was the biggest genus. *Gagea* was the second with ten taxa (5.35%), *Iris* with nine taxa (4.82%) wsa the third, *Bellevalia* Lapeyr. was the forth with eight taxa (4.28%), *Colchicum* L., *Tulipa* L. and *Poa* L. were the fifth with seven taxa (3.74%) and *Gladiolus* L. was sixth with six taxa (3.20%) (Fig 3). Among the taxa determined in the study area, 66 species (35.29%) belonged to the Irano-Turanian region (monoregional), ten species (5.35%) were pluriregional, 14 species (7.48%) were cosmopolitan, and 97 taxa (51.87%) were shared elements between the Irano-Turanian region and other floristic regions (Euro-Siberian, Mediterranean, or Saharo-Sindian) (Table 1). Totally 25 out of 66 IT elements (13.36 % of total species) were endemic to Iran. The names of endemic taxa include *Allium assadii* Seisums, *A. austroiranicum* R. M. Fritsch, *Allium bungei* Boiss., *Allium chloroneurum* Boiss., *A. chlorotepalum*, *A. esfahanicum* R. M. Fritsch, *A. graveolens* (R. M. Fritsch) R. M. Fritsch, *A. koelzii* (Wendelbo) Perss. & Wendelbo, *A. longivaginatum* Wendelbo, *A. minutiflorum*, *A. monophyllum* Vved. ex Czerniak., *A. ubipetrense* R. M. Fritsch, *Arum giganteum Ghahr.*, *Bellevalia cyanopoda* Wendelbo, *B. shiraziana* Parsa, *B. tristis* Bornm., *Colchicum varians* (Freyn & Bornm.) Dyer, *Fritillaria zagrica* Stapf, *Gladiolus persicus* Boiss., *Iris hymenospatha* subsp. *hymenospatha*, *I. meda* Stapf, *Leopoldia ghouschtchiensis* Jafari & Maassoumi, *Ornithogalum sintenisii* Freyn; *Stipa haussknechtii* Boiss. and *Ungernia flava* Boiss. & Hausskn. (Table 1). The distribution of stem metamorphosis of the geophyte species collected from the Isfahan province was as follows: Bulbous 45.45%, Rhizomatous 39.04%, Corm 8.02% and

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Tuber 7.49% (Fig 4).

Fig. 1. Some geophyte species of Isfahan province: (A): *Allium iranicum*; (B): *Fritillaria persica*; (C): *Fritillaria imperialis*; (D): *Allium xiphopetalum*; (E): *Ixiolirion tataricum*; (F): *Allium austroiranicum*; (G): *Iris iberica*.

Table 1. Taxonomic composition of the monocotyledonous geophytes flora of the Isfahan province. IT: Irano-Turanian region, ES: Euro-Siberian region, M: Mediterranean region, Plur: pluriregional elements, Cosm: cosmopolitan. B: Bulb, R: Rhizom, C: Corm, T: Tuber.

Taxon	Endemic	Type of Geophyte	Chorotype
Amaryllidaceae			
Allium affine Ledeb.	×	B	IT, ES, M
Allium ampeloprasum L.	×	B	IT, ES, M
Allium ascalonicum L.	×	B	IT, M, SS
Allium assadii Seisums	✓	B	IT
Allium atroviolaceum Boiss.	×	B	IT, ES
Allium austroiranicum R. M. Fritsch	✓	B	IT
Allium borszczwoii Regel	×	B	IT
Allium bungei Boiss.	✓	B	IT
Allium caspium (Pall.) M.Bieb.	×	B	IT
Allium chloroneurum Boiss.	✓	B	IT
Allium chlorotepalum R. M. Fritsch & M. Jaeger	✓	B	IT
Allium dictyoprasum C.A.Mey. ex Kunth	×	B	IT, ES, SS
Allium eriophyllum Boiss.	×	B	IT, ES
Allium esfahanicum R. M. Fritsch	✓	B	IT, SS
Allium graveolens (R. M. Fritsch) R. M. Fritsch	✓	B	IT
Allium iranicum (Wendelbo) Wendelbo	×	B	IT, ES
Allium koelzii (Wendelbo) Perss. & Wendelbo	✓	B	IT
Allium leucosphaerum Aitch. & Baker	×	B	IT
Allium longivaginatum Wendelbo	✓	B	IT
Allium macrochaetum Boiss. & Hausskn.	×	B	IT, ES
Allium materculae Bordz	×	B	IT, ES
Allium minutiflorum Regel	✓	B	IT

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Taxon	Endemic	Type of Geophyte	Chorotype
Amaryllidaceae			
Allium monophyllum Vved. ex Czerniak.	✓	B	IT
Allium rubellum M. Bieb.	×	B	IT
Allium sabulosum Steven ex Bunge	×	B	IT
Allium scabriscapum Boiss.	×	B	IT, ES
Allium stamineum Boiss.	×	B	IT, M, ES
Allium stipitatum Regel	×	B	IT, SS
Allium ubipetrense R. M. Fritsch	✓	B	IT
Allium umbilicatum Boiss.	×	B	IT, ES
Allium vineale L.	×	B	IT, ES, M
Allium xiphopetalum Aitch. & Baker	×	B	IT
Sternbergia colchiciflora Waldst. & Kit.	×	B	IT, ES, M
Ungernia flava Boiss. & Hausskn.	✓	B	IT
Ungernia trisphaera Bunge	×	B	IT
Araceae			
Arum conophalloides Kotschy ex Schott	×	T	IT
Arum giganteum Ghahr.	✓	T	IT
Arum kotschyi Boiss. & Hohen.	×	T	IT, M
Arum virescens Stapf	×	T	IT
Biarum carduchorum (Schott) Engl.	×	T	IT
Asparagaceae			
Asparagus breslerianus Schult. & Schult.f.	×	R	IT, ES
Asparagus griffithii Baker	×	R	IT
Asparagus persicus Baker	×	R	IT, ES
Asparagus verticillatus L.	×	R	IT, ES, M
Bellevalia cyanopoda Wendelbo	✓	B	IT
Bellevalia glauca (Lindl.) Kunth	×	B	IT
Bellevalia longipes Post	×	B	IT, ES, M
Bellevalia longistyla (Miscz.) Grossh.	×	B	IT
Bellevalia paradoxa (Fisch. & C.A.Mey.) Boiss.	×	B	IT, ES
Bellevalia saviczii Woronow	×	B	IT
Bellevalia shiraziana Parsa	✓	B	IT
Bellevalia tristis Bornm.	✓	B	IT
Drimia maritima (L.) Stearn	×	B	IT, M
Leopoldia longipes (Boiss.) Losinsk.	×	B	IT, ES
Leopoldia ghouschtchiensis Jafari & Maassoumi	✓	B	IT
Leopoldia tenuiflora (Tausch) Heldr.	×	B	IT, ES, M
Muscari neglectum Guss. ex Ten.	×	B	IT, ES, M
Asphodelaceae			
Asphodelus tenuifolius Cav.	×	T	IT, SS
Eremurus inderiensis (M. Bieb.) Regel	×	T	IT, ES
Eremurus luteus Baker	×	T	IT
Eremurus persicus (Jaub. & Spach) Boiss.	×	T	IT, SS
Eremurus spectabilis M. Bieb.	×	T	IT, ES
Butomaceae			
Butomus umbellatus L.	×	R	Pl
Colchicaceae			
Colchicum kotschyi Boiss.	×	C	IT, ES
Colchicum persicum Baker	×	C	IT
Colchicum robustum (Bunge) Stef.	×	C	IT, ES
Colchicum schimperi Janka ex Stef.	×	C	IT, SS
Colchicum soboliferum (C.A.Mey.) Stef.	×	C	IT, ES
Colchicum szovitsii Fisch. & C.A.Mey.	×	C	IT, ES
Colchicum varians (Freyn & Bornm.) Dyer	✓	C	IT
Cyperaceae			
Bolboschoenus affinis (Roth) Drob	×	R	Cosm
Bolboschoenus maritimus (L.) Palla	×	R	Cosm
Carex divisa Huds.	×	R	Cosm
Carex nutans Host	×	R	Cosm
Carex orbicularis subsp. *kotschyana* (Boiss. & Hohen.) Kukkonen	×	R	IT, ES
Carex physodes M.Bieb.	×	R	IT, M, ES
Carex stenophylla Wahlenb.	×	R	IT, M, ES
Cyperus conglomeratus Rottb.	×	R	IT, SS

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Taxon	Endemic	Type of Geophyte	Chorotype
Amaryllidaceae			
Cyperus eremicus Kukkonen	×	R	IT, SS
Cyperus longus L.	×	R	Pl
Eleocharis palustris (L.) Roem. & Schult.	×	R	Pl
Eleocharis quinqueflora (Hartmann) O.Schwarz	×	R	Cosm
Schoenoplectus lacustris (L.) Palla	×	R	Pl
Scirpoides holoschoenus (L.) Sojak	×	R	Pl
Trichophorum pumilum (Vahl) Schinz & Thell.	×	R	Cosm
Iridaceae			
Crocus cancellatus Herb.	×	C	IT
Crocus haussknechtii (Boiss. & Reut. ex Maw) Boiss.	×	C	IT
Gladiolus atroviolaceus Boiss.	×	C	IT, M
Gladiolus halophilus Boiss. & Heldr.	×	C	IT
Gladiolus italicus Mill.	×	C	Pl
Gladiolus kotschyanus Boiss.	×	C	IT
Gladiolus persicus Boiss.	✓	C	IT
Gladiolus segetum Ker Gawl.	×	C	IT, ES, M
Iris acutiloba C.A.Mey.	×	R	IT
Iris barnumiae Foster & Baker	×	R	IT
Iris hymenospatha subsp. *hymenospatha*	✓	R	IT, SS
Iris hymenospatha subsp. *leptoneura* Mathew & Wendelbo	×	R	IT
Iris iberica subsp. *lycotis* (Woronow) Takht.	×	R	IT
Iris meda Stapf	✓	R	IT
Iris reticulata M.Bieb.	×	B	IT, ES
Iris songarica Schrenk	×	R	IT
Iris spuria subsp. *musulmanica* (Famin) Takht.	×	R	IT, ES
Ixioliriaceae			
Ixiolirion tataricum (Pall.) Schult. & Schult.f.	×	B	IT, ES, M
Juncaceae			
Juncus gerardii Loisel.	×	R	Cosm
Juncus inflexus L.	×	R	Cosm
Juncus rigidus Desf.	×	R	IT, M, SS
Juncaginaceae			
Triglochin maritima L.	×	R	Cosm
Liliaceae			
Fritillaria gibbosa Boiss.	×	B	IT, ES
Fritillaria imperialis L.	×	B	IT
Fritillaria persica L.	×	B	IT
Fritillaria reuteri Boiss.	×	B	IT
Fritillaria zagrica Stapf	✓	B	IT
Gagea alexeenkoana Miscz	×	B	IT, ES
Gagea confusa A. Terrac.	×	B	IT, ES
Gagea dschungarica Regel	×	B	IT, ES
Gagea fistulosa (Ramond ex DC.) Ker Gawl.	×	B	IT, ES, M
Gagea fragifera (Vil.) E. Bayer & Lopez..	×	B	IT, ES
Gagea gageoides (Zucc.) Vved.	×	B	IT, ES
Gagea kunawurensis (Royle) Greuter	×	B	IT, ES
Gagea minima (L.) Ker Gawl.	×	B	IT, ES, M
Gagea reticulata (Pall.) Schult. & Schult.f.	×	B	IT, M, SS
Gagea villosa (M.Bieb.) Sweet	×	B	IT, M
Ornithogalum arcuatum Stev	×	B	IT
Ornithogalum cuspidatum Bertol.	×	B	IT
Ornithogalum narbonense L.	×	B	IT, ES, M
Ornithogalum orthophyllum Ten.	×	B	IT, ES, M
Ornithogalum sintenisii Freyn	✓	B	IT, ES
Tulipa biebersteiniana Schult. & Schult.f.	×	B	IT, ES
Tulipa biflora Pall.	×	B	IT, ES, SS
Tulipa humilis Herb.	×	B	IT
Tulipa montana Lindl.	×	B	IT, ES
Tulipa schmidtii Fomin	×	B	IT
Tulipa suaveolens Roth	×	B	IT
Tulipa systola Stapf	×	B	IT
Orchidaceae			
Dactylorhiza umbrosa (Kar. & Kir.) Nevski	×	T	IT, ES
Epipactis persica (Soo) Nannfeldt	×	R	IT, ES

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Taxon	Endemic	Type of Geophyte	Chorotype
Amaryllidaceae			
Gymnadenia conopsea (L.) R.Br.	×	T	Pl
Orchis collina Banks & Sol. ex Russell	×	T	IT, ES, M
Orchis palustris Jacq.	×	T	IT, ES, M
Poaceae			
Aeluropus lagopoides (L.) Thwaites	×	R	Pl
Aeluropus littoralis (Gouan) Parl.	×	R	IT, ES, M
Aeluropus macrostachyus Hack.	×	R	IT, SS
Agropyron intermedium (Host) P. Beauv.	×	R	IT, SS, M
Agropyron trichophorum (Link) K. Richt.	×	R	IT, ES, M
Agrostis gigantea Roth	×	R	IT, ES, SS
Alopecurus arundinaceus Poir.	×	R	IT, ES, SS
Arrhenatherum kotschyi Boiss.	×	B	IT
Bromus inermis Leyss.	×	R	Cosm
Calamagrostis pseudophragmites (Haller f.) Koeler	×	R	IT, ES, M
Ctabrosa aquatic (L.) P. Beauv.	×	R	IT, ES, M
Catabrosella humilis subsp. *humilis*	×	R	IT, ES
Colpodium humile (M. B.) Griseb.	×	B	IT, ES
Cynodon dactylon (L.) Pers.	×	R	Cosm
Elymus repens (L.) Gould	×	R	IT, ES, M
Eragrostis collina Trin.	×	R	IT, ES
Hordeum bulbosum L.	×	B	IT, M, SS
Melica jacquemontii subsp. *canescens* (Regel) Bor	×	R	IT
Melica jacquemontii subsp. *jacquemontii*	×	R	IT
Melica persica Kunth subsp *persica*	×	R	IT
Melica persica Kunth subsp *inaequiglumis*	×	R	IT
Pennisetum orientale Rich.	×	R	IT, SS
Phragmites australis (Cav.) Trin. ex Steud.	×	R	Cosm
Poa bactriana Roshev subsp. *glabriflora*	×	B	IT
Poa bulbosa L. subsp. bulbosa	×	B	IT, ES, M
Poa bulbosa L. subsp. *vivipara*	×	B	Pl
Poa pratensis L subsp. *angustifolia.*	×	R	Pl
Poa sinaica Steud.	×	B	IT, M
Poa trivialis L subsp. *sylvicola*	×	R	IT, ES, M
Poa trivialis L subsp. *trivialis.*	×	R	IT, ES, M
Polypogon viridis (Gouan) Breistr.	×	R	IT, ES
Psathyrostachys fragilis (Boiss.) Nevski	×	R	IT
Puccinellia bulbosa (Grossh.) Grossh.	×	B	IT
Sorghum halepense (L.) Pers.	×	R	Cosm
Stipa arabica Trin. & Rupr	×	R	IT, ES, M
Stipa haussknechtii Boiss.	✓	R	IT
Stipa hohenackeriana Trin. & Rupr	×	R	IT, ES
Stipa iranica Freitag	×	R	IT, ES
Stipa parviflora Desf. *(Achnatherum parviflorum)*	×	R	IT, ES
Stipagrostis barbata Scholz	×	R	IT
Stipagrostis karelinii (Trin. & Rupr) Tzvelev	×	R	IT
Stipagrostis pennata (Trin.) De Winter	×	R	IT, ES
Stipagrostis plumose var. *plumosa*	×	R	IT, ES
Stipagrostis raddiana	×	R	IT, ES
Typhaceae			
Sparganium erectum L.	×	R	IT, ES, M
Typha grossheimii Pobed.	×	R	IT, ES
Typha latifolia L.	×	R	Cosm
Typha minima Funck	×	R	IT, ES, M

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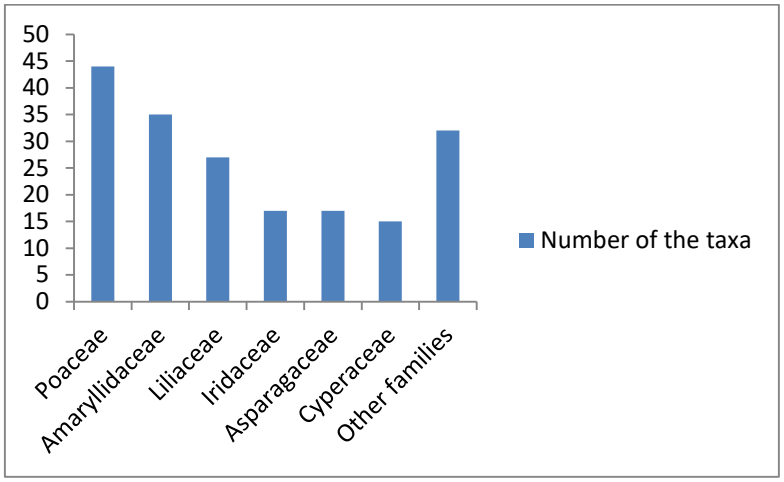

Fig. 2. Largest families by number of geophyte species in Isfahan province

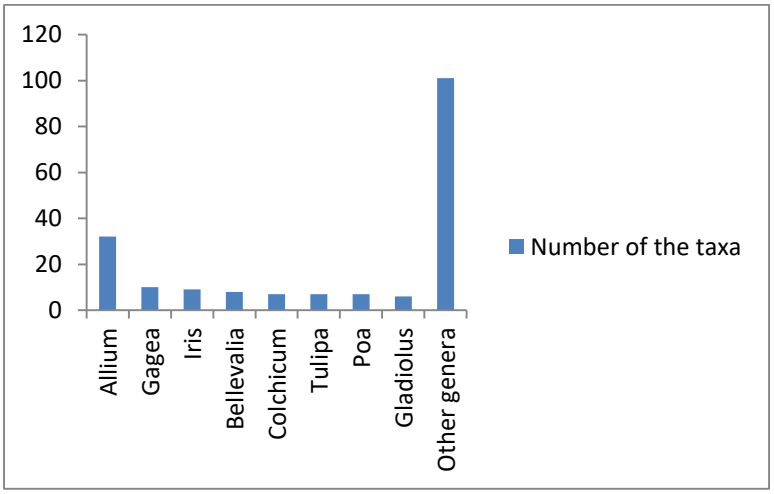

Fig. 3. Largest genera by number of species in Isfahan province

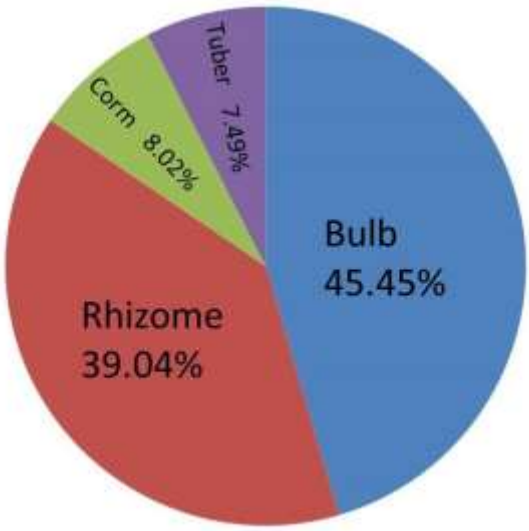

Fig. 4. Different types of underground stem metamorphosis (type of geophytes) in Isfahan province.

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Discussion

The flora of Iran is rich in the number of endemic species. Most of the species are restricted to higher mountains that provide optimal conditions and specific habitat requirements for them. Thirty-two percent of Iranian vascular plant species are endemic and limited to this area (Noroozi et al. 2019). Some geophytes are restricted to a small area and considered as an endemic or sub-endemic species. In contrast, the other ones such as taxa belonging to Cyperaceae and Poaceae families are widespread and distributed in all wetlands from the lowlands to subalpine areas.

Geophytes include many economically valuable species used as vegetables, spices, medicines or ornamental plants. Isfahan province represents an area with high species richness with numerous endemic species, particularly in the mountainous regions and the alpine zones. This study marks the first investigation in Isfahan province that revises geophyte species, providing valuable information for documenting the diversity and conservation of monocot geophytes. The present study highlights Isfahan province as a significant region in the field of geophyte plants, documenting a total of 187 species. Poaceae emerges as the most prominent family, including 44 species (23.52% of the total). The study exposes a diverse range of genera and families, including Amaryllidaceae, Liliaceae, Iridaceae, Asparagaceae, and Cyperaceae. Comparing this with two studies conducted in the provinces of Iğdır and Erzincan in Turkey indicates that Iğdır identified 52 geophyte plant species, with dominant families such as Asparagaceae, Amaryllidaceae, Liliaceae, Iridaceae, Asteraceae, and Orchidaceae. In Erzincan, 50 geophyte plant species covering 22 genera and 13 families were identified. These comparative insights contribute to a better understanding of the distribution and diversity of geophyte taxa in Isfahan province. The genera with the highest number of species were *Allium* (32 taxa), *Gagea* (10 taxa) and *Iris* (9 taxa) as shown in Table 1. In the current study, *Allium* emerged as the most prominent genus in terms of the number of species, aligning with the findings of many other studies conducted in different regions to identify geophyte plants (Korkmaz & Ilhan 2015). *Allium* is indeed one of the most abundant genera of monocots in Iran, comprising 137 species, and characterized by high levels of endemism, with 83 taxa reported (Fritsch & Abbasi 2013; Noroozi et al. 2019). Some of the *Allium* species are classified as narrow and locally endemic species. In recent years, several new *Allium* species have been introduced to the flora of Iran and or Isfahan, including *A. chlorotepalum* R.M. Fritsch & M. Jaeger, *A. minutiflorum* Regel and *A. kuhrangense* Akhavan, Saeidi & R.M. Fritsch (Razyfard et al. 2011; Memariani et al. 2012; Fritsch & Abbasi 2013; Fritsch & Amini Rad 2013; Akhavan et al. 2014; Bagheri et al. 2020).

Numerous field studies conducted in various regions of Isfahan province have highlighted the diverse factors that play a crucial role in the preservation and sustainability of geophytes (Parishani 2005; Kharazian et al. 2017; Akhavan Roofigar & Bagheri 2021). Many of these geophytes particularly *Allium* species are valued for their food and folk medicinal properties (Abbasi et al. 2007). Unfortunately, several medicinal species such as *A. stipitatum* are facing the risk of extinction in certain areas of Isfahan. In general, the harvesting of bulbs or leaves for medicinal purposes, as well as the cutting of flowers, poses significant threats to these species. Significant portions of land have recently been allocated for agricultural purposes, leading to the destruction and fragmentation of natural habitats. This, in turn, poses a great threat to plant species, mainly geophytes, in different parts of Isfahan. Moreover, road construction projects, serving various purposes, have had a profound impact on habitats, particularly in the alpine ecosystems of Isfahan. These road developments have resulted in the destruction of substantial areas, providing easy access to high altitudes for both humans and livestock, which can impact the delicate ecosystems. Also, climate change is an additional threat to geophyte species in the province. Since many of these plants thrive in alpine areas, shifts in temperature and reduced rainfall have become two critical factors influencing species migration and altering their distribution. As a result, many species have been observed in new habitats, with some no longer found in their previously documented locations. Establishing protected areas is recognized as a critical strategy for the conservation of plant species. In Isfahan province, particularly in the western regions, such as Khansar County (Golestankooh), efforts have been made to create protected areas. These protected regions serve as vital conservation measures, aiming to protection, among others, the remaining populations of *Fritillaria imperialis* in the western parts of Isfahan.

Conclusions

In recent years, unfortunately, some geophytes in Iran have faced the pending threat of extinction due to human activities that directly impact both species and their habitats. Causes such as the expansion of crop cultivation, excessive overgrazing, illegal harvesting of flowers and bulbs by local communities, road construction, mining activities, and lengthy drought are among the conspicuous contributors to this dangerous situation. Consequently, the conservation of plant richness in this area becomes imperative for the protection of biodiversity. To address these issues, creating protected areas, applying effective measures to control overgrazing, establishing botanical gardens for endangered species, and ex-situ conservation of seeds and bulbs of endemic and endangered plant species as practical strategies for protection.

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