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Floristic studies, life forms and chorology of plants in Kouh-payeh area, Isfahan Province, Iran

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ABSTRACT

The Kouh-payeh with an area of 3000 km^2 is located at 70 km east of Isfahan on the edge of central Kavir at longitude 52° 26′E and latitude 32° 43′N. In this study, the floristic richness, life form, geographical distribution and conservation status were assessed. All plant species were collected from Kouh-payeh area during 2014-2016. The collected species were identified, then life forms and chorology of each species were estimated. By examining a total of 200 collected plant species, 38 families and 137 genera were found. The dominant life forms were mainly identified as therophytes (45%) and hemicryptophytes (34%). Based on chorotype information, an Irano-Touranian distribution (60%) was generally observed in this area. Other chorotypes such as Irano-Touranian/Saharo-Sindian (6%) and Irano-Touranian/ Euro-Siberian (6%) were present in lower quantities. Among the identified species, 43 endemic species were also recognized. In terms of conservation status, there were Low Risk (77%), Vulnerable (15%) and Data Deficient (8%) needed some conservation policies. This study was performed for the first time in this area.

Keywords: Chorotype, endemic, floristic, Isfahan, Kouh-payeh.

INTRODUCTION

Plant vegetation reflects the biological reactions of geographical regions to the current environmental and historical plant evolution. The assessment of flora including floristic, biological spectrum and geographical distribution are important for recognizing biodiversity (Yousefi 2006a; Zhu *et al.* 2019). Floristic studies are important methods to detect the new plant species and protect natural resources (Feyzi *et al.* 2014). Life forms create a form of equilibrium between plant species and their environment leading to plant adaptation. Notably, life forms from different climates and habitats exhibit different environments influencing the plant species distribution (Vaseghi *et al.* 2008). Chorological studies are important to ascertain species distribution, its variation and identifying endemic species. Genetic resources and diversity studies of each habitat are a necessary prerequisite to the ecological studies, range and watershed management, as well as the gene and medicinal banks (Abbasi *et al.* 2012; Feroz *et al.* 2016). Isfahan Province with an area of 105000 km^2 is located between the Zagros Mountains and the arid Central Plateau. Its natural rangelands and ecosystems are comprised five areas including 1: dry forests (west, south and north), 2: semi-steppe (west and south-west), 3: steppe (center, south-east and north-west), 4: high elevation mountains (south and west) and 5: semi-desert (east, north and north-east). These areas have different climates inducing vegetation diversity (Meteorological Organization in Isfahan 2015). Due to high plant diversity, numerous floristic studies in Isfahan Province have been conducted in different areas including: Vanak-e Semirom (Parishani 2005), Badrud-e Natanz (Abdi & Afsharzadeh 2012), Chadegan (Yousefi *et al.* 2011), Karkas Mountains (Khajedin & Yeganeh 2012), Ghaza-an Kashan (Batouli 2003), Kolah Ghazi (Aryavand 2001) Mouteh, Ghamishlou (Aryavand 2001; Yousefi 2006a), Zarcheshmeh (Kharazian *et al.* 2017)

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and Hanna protected regions (Khajedin & Yeganeh 2010). Their results indicated that the richest families observed in this province include Asteraceae, Poaceae, Fabaceae, Lamiaceae and Brassicaceae (Sadeghipour *et al.* 2018). Accordingly, more vegetation zones were reported from the western areas resulting from appropriate climatic conditions. The presence of endemic plants was also reported from different habitats of this province including Palang Galoun, Badrud-e Natanz, Chadegan and Zarcheshmeh. A total of 104 endemic species were identified in the province (Yousefi *et al.* 2011; Abdi & Afsharzadeh 2012; Kharazian *et al.* 2017; Sadeghipour *et al.* 2018). In the case of endemic species, number and endemism percentage, Iran is the richest country in the Middle East with 22-24% in endemism (Jalili & Jamzad 1999). Moreover, the conservation status reported including extinct, vulnerable and endangered species displays a prospective degree to conservation purposes. Since there is no report about floristic study in Kouh-payeh area, the aims of this study were: 1- to determine the floristic units, life forms, chorology and conservation status, and 2- to identify the endemic plants in the Kouh-payeh area, east of Isfahan Province. All of the study evidences were first reported in Iran.

MATERIALS AND METHODS

Study area

The Kouh-payeh with covering an area of 3000 km^2 is located at 70 km east of Isfahan on the edge of central Kavir at longitude 52° 26′E and latitude 32° 43′N. It is bordered by Ardestan, Borkhar and Meymeh to the north, Jolgeh, Benroud and Harand to the south, Naein and Yazd to the east, and Isfahan to the west. The region encompasses Kouh-payeh, Toudeshk and Sajzi cities with four rural districts, i.e., Toudeshk, Jebel, Zafreh and Sistan. The study area included Toudeshk (encompassing Jeshoughan, garden-e Molla Ahmad, Emamzadeh Ghasem), Jebel (consisting of Abkharak, Alounabad, Aliebrahim, Dakhrabad, Hojatabad), Sajzi, Zafreh (comprising Zafreh, Fesharak) and Kouh-payeh (surrounding Kouh-payeh, mazraeh paein, Hashemabad) (Figs. 1 and 2).

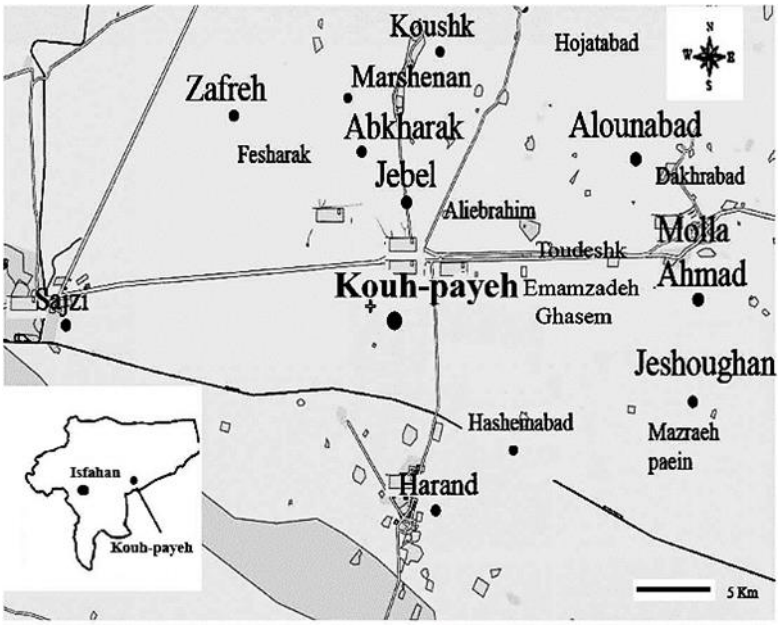

Fig. 1. Geographical location of Kouh-payeh area.

Notably, Toudeshk, Kouh-Payeh and Jebal are characterized by annual and perennial plants such as *Artemisia* and *Astragalus*, while Sajzi and Zafreh regions are considered as semi-desert habitats. Based on the vegetation, plant species are mostly dicotyledons with herbaceous, shrubs or trees and rock cliff plants. Besides, there are some herbaceous monocotyledon species (www.irandesert.com). In this study, the floristic method such as field survey was applied (Mesdaghi 2005). Altitudinal, our study area is laid from 1490 to 2321 m. Based on geological information, the north-eastern part of Kouh-payeh contains sediments quaternary, alluvial fans and clay pan (Ghazanfarpour *et al.* 2007). The soil of some parts is recognized to be very poor containing limestone shell, salt marsh and salt. Sand-covered desert foothills, semi-desert lands and heavy soils were also detected belonging to the fourth geological era (Harati *et al.* 2013). The type of soil is mainly sand, saline and sodic in consistency.

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Gypsum and limestone soils with the majority of chlorine and sodium salts result in an aggregated alkalinity (Zanjirei 2010). In order to identify the climate classification, the Emberger Index (1930) was applied. The Emberger Index: $Q2 = 2000P/M^2 - m^2$ was estimated where P stands for annual precipitation (mm), m = minimum mean temperature in coldest month (°K) and M = maximum mean temperature in hottest month (°K). The climate of the east of the Isfahan region is shaped by low precipitation throughout nine months of the year including drought seasons (Fig. 3). The minimum and maximum mean temperatures were -1.2°C and 29.6°C, respectively. The average annual humidity was found to be less than 50% (36-47%). The dry season in this area occurs from March through November. The mean annual precipitation from east of Isfahan and Kouh-payeh stations was reported 105.09 and 84.25 mm, respectively. Its distribution was irregular and occurred in winter (47.43 mm) and spring (13.83 mm). Finally, based on Emberger's (1930) classification, the climate is desert with a dry climate and harsh winter (Q2 = 4.63).

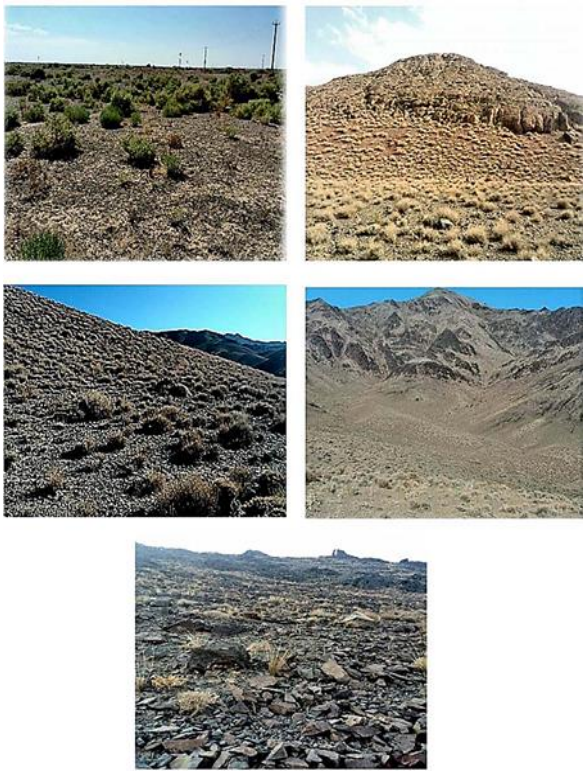

Fig. 2. The landscape of Kouh-payeh area, Isfahan Province.

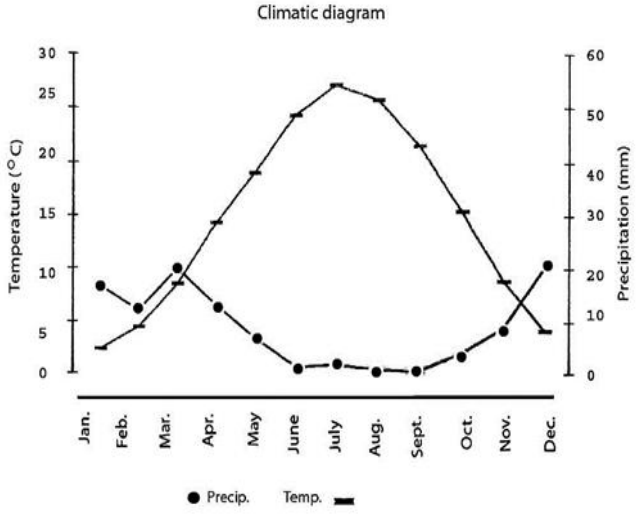

Fig. 3. Climatic diagram from Meteorological station in the east of Isfahan during 1976-2005.

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Vegetation sampling

Collecting plant species and evaluation of the area were accomplished using geographical maps and field visits. The plant species were collected during all of the growing seasons and in several stages mainly from March 2014 through June 2016. Identification of the collected species was carried out using the authentic floras (Rechinger 1963-2015; Ghahreman 1982-2008; Assadi *et al.* 1988-2018; Mobayen 1975-1996; Davis 1965-1988). The elevation of each species was marked by global positioning system (GPS). The herbarium specimens were compared with the herbarium sheets available in Agriculture Research Center of Isfahan (IARC). All of the collected specimens were deposited in the Herbarium of Shahrekord University, Shahrekord, Iran.

The plant life forms were determined using Raunkiaer's method (1934). In addition, the chorotype of studied species was identified using Zohary (1973), Red Data Book, Flora Iranica and Flora of Iran (Rechinger 1963-2015; Assadi *et al.* 1988-2018; Jalili & Jamzad 1999). The conservation status of the studied species was recognized based on the Red Data Book (Jalili & Jamzad 1999).

RESULTS

A total of 200 plant species, 38 families and 137 genera were found in this study (Table 1). Among them, 81% were dicotyledon including 31 families, 118 genera and 180 species, while 16% belonged to monocotyledon including 6 families, 19 genera and 20 species and 3% to gymnosperm including one genus and one species. The highest number of genera was observed in Asteraceae (17%) followed by Poaceae (10%) and Brassicaceae (9%) (Fig. 4).

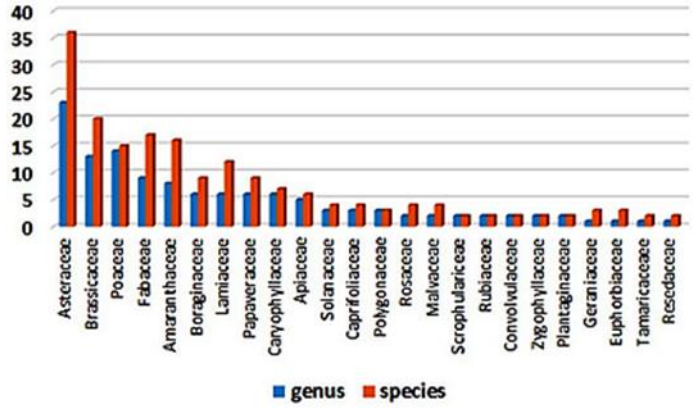

Fig. 4. The genus and species number from each family.

These groups were also the highest species-rich families. A total of 18 species were reported for the first time from Isfahan Province (Table 1). The monotypic taxa were also recognized as 33 families and 97 genera from this area consisting of Asteracea (16%), Poaceae (13%), Brassicaceae (7%) and Fabaceae (7%). Other monotypic genera ranged from 2% to 5%.The highest species-rich genera were *Astragalus* (eight taxa), *Echinops* (four taxa), *Erodium*, *Chenopodium*, *Stachys*, *Nepeta*, *Prunus*, *Salsola*, *Heliotropium*, *Papaver*, *Senecio*, *Tragopogon*, *Centaurea*, *Malcolmia*, *Euphorbia* and *Amaranthus* (each with three taxa).The sub species and varieties number were also identified including 21 subspecies and six varieties (Table 1). The endemic taxa comprised 17 families, 33 genera and 43 species. The highest proportion of endemic species belonged to Asteraceae (18%), Lamiaceae (14%), Fabaceae (11%) and Papaveraceae (9%), while the rest of the families composed 1-3 species (Table 2). *Astragalus* (four taxa), *Nepeta* (three taxa), *Papaver* (three taxa), *Prangos* (two taxa), *Cousinia* (two taxa), *Stachys* (two taxa) and *Prunus* (two taxa) were found in high proportions within endemic species (Table 1). The life forms contained therophytes (45%), hemicryptophytes (34%), chamaephytes (9%), geophytes (6%) and phanerophytes (5%) (Fig. 5). The highest proportion of therophytes belonged to Brassicaceae (15%), Asteracea (13%), Amaranthaceae (11%), Poaceae (10%) and Papaveraceae (8%). In addition, the foremost hemicryptophytes were represented by Asteraceae (29%), Lamiaceae (13%), Fabaceae (11%) and Boraginaceae (9%) (Table 1). Based on a chorological point of view, the geographical units were composed of Irano-Touranian (60%), Irano-Touranian/Mediterranean (7%), Cosmopolite (7%), Irano-Touranian/Euro-Siberian (6%), Irano-Touranian/ Saharo-Sindian (6%), Plu-regional (6%), Irano-Touranian/Mediterranean/Euro-Siberian (4%) and Irano-Touranian/Euro-Siberian/Saharo-Sindian (2%) (Table 3). Furthermore, 65%, 20% and 15% of the identified

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species were found to be mono-regional, bioregional and pluri-regional, respectively (Fig. 6). In the case of conservation status, the observed species were considered as low risk (LR, 77%), vulnerable (VU, 15%) and data deficient (DD, 8%). The highest rates (%) of LR were observed in Asteraceae and Fabaceae, while the highest VU were Lamiaceae and Brassicaceae (Figs. 7A, B). Besides, endemic species with LR (78%), VU (13%) and DD (9%) were also identified (Fig. 7 C). The vegetation forms of some plant species are shown in Fig. 8.

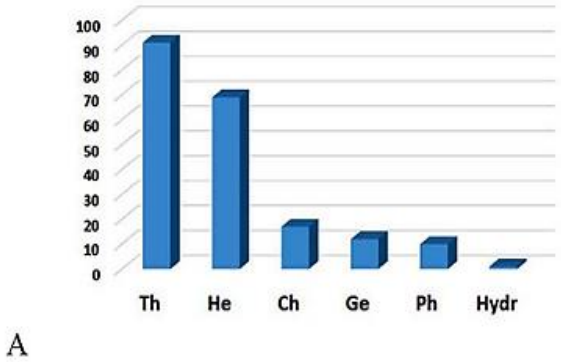

Fig. 5. The frequency of life form. Th: terophyte, He: hemicryptophyte, Ch: chamaephyte, Ph: phanerophyte, Hydr: hydrophyte.

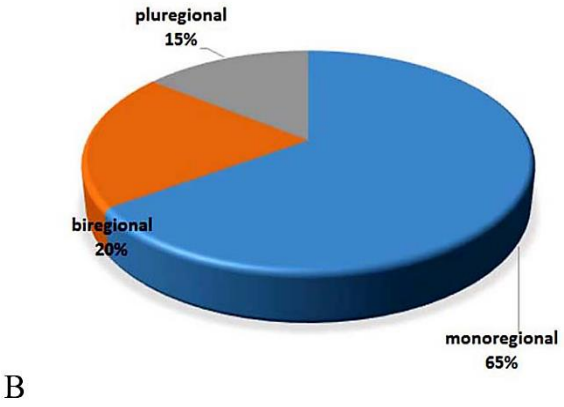

Fig. 6. The rate (%) of mono-regional, bi-regional and pluri-regional of studied species.

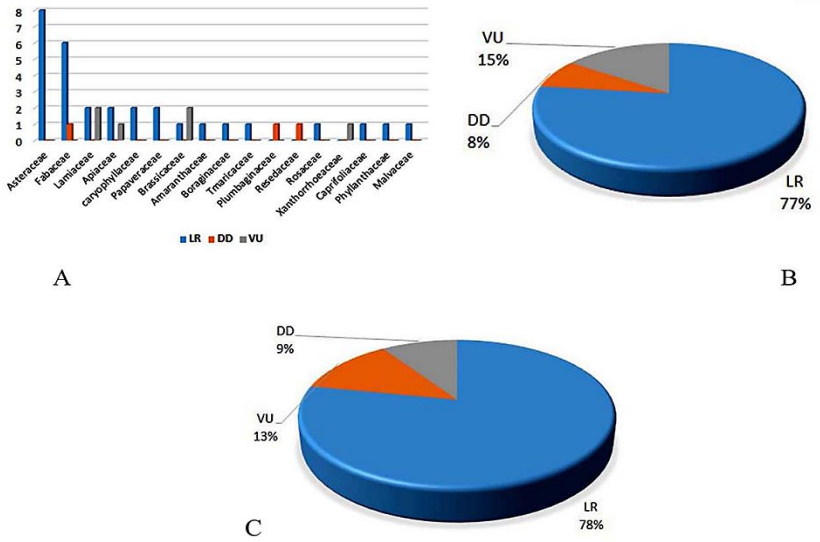

Fig. 7. A, B: The highest amounts of conservation status in each family, C: the conservation status of endemic species. LR: Low Risk, DD: Data Deficient, VU: Vulnerable.

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Table 1. The list of collected species from Kouh-payeh area.

Family/genus/species	Life form	Chorotype	conservation status	Endemic	Altitude (m)	Location	Herbarium No.
Amaranthaceae							
Amaranthus blitoides S. Watson	Th	Pl	LR	en	1769	Kouh-payeh	100
Amaranthus powellii S. Watson	Th	Pl			1769	Kouh-payeh	101
Amaranthus retroflexus L.	Th	Pl			1769	Kouh-payeh	102
Anabasis haussknechtii Bunge ex Boiss.	Ch	IT			1769	Kouh-payeh road	103
Anabasis setifera Moq.	He	IT-SS			1750	Kouh-payeh	104
Atriplex canescens (Pursh) Nutt.	Ch	IT			1769	Kouh-payeh road	105
Bassia eriophora (Schrad.) Asch.	Th	IT			1769	Kouh-payeh	106
Chenopodium album L.	Th	Cosm			1743	Kouh-payeh	107
Chenopodium novopokrovskyanum (Aellen) Uotila	Th	IT-ES			1769	Kouh-payeh	108
Chenopodium vulvaria L.	Th	IT-M-ES			1769	Kouh-payeh	109
Haloxylon ammodendron (C.A.Mey.) Buge ex Fenzl	Ph	IT			1570	Ghehi towards Kouhpayeh	110
Salsola jordanicola Eig.	Th	IT-SS			1769	Kouh-payeh road	111
Salsola schweinfurthii Solms	Ch	IT			1769	Kouhpayeh road	112
Salsola tomentosa (Moq.) Spach.	He	IT			1790	Kouh-payeh road	113
Suaeda aegyptiaca (Hasselq.) Zohary	Th	IT-SS			1526	Sajzi	114
Suaeda arcuata Bunge	Th	IT			1526	Sajzi	115
Amaryllidaceae							
Allium scabriscapum Boiss.	Ge	IT			2064	Zafreh	116
Apiaceae							
Ducrosia anethifolia (DC.) Boiss.	He	IT			1535	Sajzi	117
Echinophora platyloba DC.	He	IT-ES	LR	en	2321	Jebel	118
Eryngium bungei Boiss.	He	IT			2320	Garden-e Molla Ahmad	119
Prangos cheilanthifolia Boiss.	He	IT	LR	en	2058	Jeshoghan	120
Prangos uloptera DC.	He	IT	VU	en			121
Scandix aucheri Boiss.	Th	IT			1730	Kouh-payeh	122
Asparagaceae							
Muscari neglectum Guss. ex Ten.	Ge	IT-M-ES			1769	Kouh-payeh	123
Xanthorrhoeaceae							
Eremurus persicus (Jaub.& Spach) Boiss.	Ge	IT	VU		2321	Jebel	124
Asteraceae							
Achillea santolinoides Lag. subsp. *wilhelmsii*	He	IT			2150	Hojatabad	125
Anthemis odontostephana Boiss.	Th	IT	LR	en	2064	Zefreh	126
Artemisia aucheri Boiss.	Ch	IT			1778	Kouh-payeh road	127
Artemisia sieberi Besser	Ch	IT			1769	Kouh-payeh	128
Carduus pycnocephalus L. subsp. *marmoratus*	Th	IT-M			1526	Sajzi	129
*Centaurea benedicta** (L.) L.	Th	IT			1493	Emamzadeh Ghasem	133
Cyanus depressus (M. Bieb.) Sojak	Th	IT			2321	Jebel	130
Centaurea ispahanica Boiss.	He	IT	LR	en	2300	Jebel	131
Cirsium arvense (L). Scop.	Ge	Cosm			1769	Kouh-payeh	132
Cousinia cylindracea Boiss. var. *patula*	He	IT	LR	en	2320	Garden-e Molla Ahmad	134
Cousinia eriobasis Bunge.	He	IT	LR	en	1526	Sajzi	135
Echinops acantholepis Jaub.& Spach	Th	IT			2064	Zafreh	136
Echinops cephalotes DC.	He	IT	LR	en	1578	Ghehi towards Kouh-payeh	137
*Echinops pungens** Trautv.	He	IT-ES			1760	Kouh-payeh	138
*Echinops tournefortii** Ledeb. ex Ledeb.	He	IT			1768	Kouh-payeh	139
Gundelia tournefortii L.	He	IT-M			2321	Jebel	140
Hertia angustifolia (Dc.) Kuntze	Ch	IT	LR	en	2058	Jeshoghan	141
Jurinea carduiformis (Jaub. & Spach) Boiss	He	IT	LR		2150	Hojatabad	142
Koelpinia tenuissima Pavlov & Lipsch.	Th	IT			2064	Zafreh-Fesharak	143

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Table 1 (continued). The list of …

Family/genus/species	Life form	Chorotype	conservation status	Endemic	Altitude (m)	Location	Herbarium No.
Launaea acanthodes (Boiss). Kuntze	He	IT		en	1700	Kouh-payeh	144
Onopordum acanthium L.	He	IT			2064	Zafreh	145
Onopordum heteracanthum C. A. Mey.	He	IT			1524	Sajzi	146
Picnomon acarna (L.) Cass.	Th	IT-SS			1775	Kouh-payeh	147
Pulicaria undulata (L.) C. A. Mey.	He	IT-SS			2064	Zafreh	148
Rhaponticum repens (L.) Hidalgo	He	IT			2070	Zafreh-Fesharak	149
Scorzonera tortuosissima Boiss.	He	IT			1575	Ghehi towards Kouh-payeh	150
Senecio glaucus L.	Th	Pl			1580	Ghehi towards Kouh-payeh	151
Senecio leucanthemifolius Poir. subsp. *vernalis*	Th	IT-M-ES			1536	Harand towards Kouh-payeh	152
Senecio vulgaris L.	Th	IT-M-ES			2030	Abkharak	153
Sonchus asper (L.) Hill subsp. *glaucescens*	He	IT-M			1768	Kouh-payeh	154
Sonchus oleraceus (L.) L.	Th	Cosm			1769	Kouh-payeh	155
Taraxacum pseudocalocephalum Soest*	He	IT			1737	Mazraeh paein	156
Thevenotia persica DC.	Th	IT			2064	Zafreh	157
Tragopogon caricifolius Boiss.	He	IT-ES	LR	en	1769	Kouh-payeh	158
Tragopogon graminifolius DC.	He	IT			1769	Kouh-payeh	159
*Tragopogon porrifolius** L. subsp. *longirostris*	He	IT			1769	Kouh-payeh	160
Biebersteiniaceae							
Biebersteinia multifida Dc.	Ge	IT-ES-SS			2064	Zafreh	161
Boraginaceae							
Anchusa arvensis (L.) M. Bieb.	He	IT-ES			2030	Abkharak	162
Heliotropium aucheri DC.	He	IT			2160	Alounabad	163
Heliotropium crispum Desf.	Th	IT-SS			1769	Kouh-payeh	164
*Heliotropium dasycarpum** Ledeb. subsp. *transoxanum*	He	IT			1769	Kouh-payeh	165
Lappula microcarpa (Ledeb.) Gurke	He	IT			2064	Zafreh	166
Nonnea caspica (Willd) G.Don subsp. *caspica*	Th	IT		en	1770	Kouh-payeh	167
Nonea pulla (L.) DC. subsp. *rudbarensis*	Th	IT-ES			1769	Kouh-payeh	168
Onosma stenosiphon Boiss.	He	IT	LR	en	2058	Jeshoghan	169
Paracaryum persicum Boiss. subsp. *persicum*	He	IT		en	1493	Emamzadeh Ghasem	170
Brassicaceae							
Alyssum dasycarpum Stephan ex Willd.	Th	IT			1764	Kouh-payeh	171
Alyssum szovitzianum Fisch. & C.A.Mey	Th	IT			1768	Kouh-payeh	172
Capsella bursa_ pastoris (L.) Medik.	Th	Cosm			2040	Mazraeh Ali Ebrahim	173
Descurainia sophia (L.) Webb ex Prantl	Th	Cosm			1737	Mazraeh paein	174
Eruca vesicaria (L.) Cav.	Th	IT			1493	Emamzadeh Ghasem	175
Erysimum crassicaule (Boiss.) Boiss.	Th	IT	LR	en	2032	Abkharak	176
Erysimum cuspidatum (M. Bieb.) DC.	He	M-ES			1769	Kouh-payeh	177
Isatis cappadocica Desv.	He	IT-ES	VU		2064	Zafreh	178
Isatis minima Bunge	Th	IT			2064	Zafreh	179
Lepidium draba L. subsp. *chalepense*	He	IT-M-ES			1761	Kouh-payeh	180
Lepidium vesicarium L.	Th	IT			1493	Emamzadeh Ghasem	181
Malcolmia africana (L.) R.Br. var. *trichocarpa*	Th	IT-SS-M			1769	Kouh-payeh	182
Malcolmia behboudiana Rech. f. & Esfand.	Th	IT			1769	Kouh-payeh	183
Malcolmia scorpoides (Bunge) Boiss.	Th	IT			1769	Kouh-payeh	
Moriera spinosa Boiss.	Ch	IT			2150	Hojatabad	184
Neotorularia torulosa (Desf.) Hedge. & Leonard	Th	IT			2064	Zafreh	185
Olimarabidopsis pumila (Celak.) Al-Shehbaz, O'Kane & R.A.Price	Th	IT-SS			1493	Emamzadeh Ghasem	186
Pseudofortuynia esfandiarii Hedge	He	IT	VU	en	2068	Zafreh	187
Sisymbrium irio L.	Th	Pl		en	2040	Mazraeh Ali Ebrahim	188
Sisymbrium septulatum DC.	Th	IT			2030	Abkharak	189

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Family/genus/species	Life form	Chorotype	conservation status	Endemic	Altitude (m)	Location	Herbarium No.
Ixiolirion tataricum (Pall.) Schult. & Schult. f.	Ge	IT			2160	Alounabad	229
Lamiaceae							
Lamium amplexicaule L.	Th	IT			1758	Kouh-payeh	230
Marrubium anisodon K. Koch	He	IT-M			2058	Jeshoghan	231
Marrubium vulgare L.	He	IT-M			1760	Kouh-payeh	232
Nepeta ispahanica Boiss.	Th	IT		en	2064	Zafreh	233
Nepeta persica Boiss.	He	IT		en	2058	Jeshoghan	234
Nepeta prostrota Benth.	He	IT	VU	en	2064	Zafreh	235
Salvia spinosa L.	He	IT			2321	Jebel	236
Stachys inflata Benth.	He	IT			2064	Zafreh	237
Stachys ixodes Boiss. & Hausskn.	He	IT	LR	en	2300	Jebel	238
Stachys pilifera Benth.	He	IT	LR	en	2321	Jebel	239
Ziziphora clinopodioides Lam. subsp. *rigida*	He	IT	VU	en	2030	Abkharak	240
Ziziphora tenuior L.	Th	IT			2320	Garden-e Molla Ahmad	241
Malvaceae							
Alcea tabrisiana Boiss. & Buhse	Th	IT	LR	en	2090	Jeshoghan	242
Alcea tarica Pakravan & Gahr.	Th	IT			2058	Jeshoghan	243
Malva neglecta Wallr.	Th	IT-M-ES			2150	Hojatabad	244
Malva sylvestris L.	He	IT-M			1769	Kouh-payeh	245
Nitrariaceae							
Peganum harmala L.	He	IT-M-SS			1745	Kouh-payeh	246
Papaveraceae							
Corydalis verticillaris DC.	Ge	IT	LR		2030	Dakhrabad	247
Fumaria vaillantii Loisel.	Th	IT-M-ES	LR	en	2150	Kouh-payeh-Hojat	248
Glaucium oxylobum Bois. & Buhse	He	IT			2144	Alouabaad	249
Hypecoum pendulum L.	Th	IT-M			2160	Alouabaad	250
Papaver dubium L.	Th	IT-M		en	2064	Zafreh	251
*Papaver somniferum** L.	Th	EM		en	1769	Kouh-payeh	252
*Papaver tenuifolium** Boiss. & Hohen.	Th	IT		en	2030	Dakhrabad	253
Roemeria hybrida (L.) DC. subsp. *dodecandra*	Th	IT			1769	Kouh-payeh	254
Roemeria refracta DC.	Th	IT			1580	Ghehi towards Kouh-payeh	255
Phyllanthaceae							
Andrachne buschiana Pojark.	He	IT	LR	en	1526	Sajzi	256
Plantaginaceae							
Plantago lanceolata L.	He	Cosm			2064	Zafreh	257
Veronica polita Fr.	Th	Pl			1769	Kouh-payeh	258
Plumbaginaceae							
Acantholimon aspadanum Bunge	Ch	IT	DD	en	2030	Abkharak	260
Poaceae							
Aeluropus littoralis (Gouan) Parl.	He	IT-M-SS			1770	Kouh-payeh	261
Avena fatua L.*	Th	Cosm			1773	Kouh-payeh	262
Boissiera squarrosa (Sol.) Nevski	Th	IT			1769	Kouh-payeh	263
Bromus tectorum L.	Th	ES			1769	Kouh-payeh	264
Eremopyrum bonaepartis (Spreng.) Nevski	Th	IT			1575	Ghehi towards Kouh-payeh	265
Hordeum murinum L. subsp. *glaucum*	Th	IT-M			1493	Emamzade Ghasem	266
Hordeum vulgar L.	Th	IT			1737	Mazraeh paein	267
*Lolium persicum** Boiss. & Hohen.	Th	Pl			1490	Emamzade Ghasem	268
Melica persica Kunth	Ge	IT			2320	Gardane Molla Ahmad	269
Phalaris minor Retz.	Th	IT-M			1767	Kouh-payeh	270
Phragmites australis (Cav.) Trin. et Steud.*	Hy	Cosm			2323	Gardane Molla Ahmad	271
Poa sinaica Steud.	Ge	IT-SS			2321	Alounabad	272
Schismus arabicus Nees	Ge	IT-ES-SS			2064	Zafreh	273
Stipa Hohenuckeriana Trin. & Rupr.	He	IT		en	1768	Kouh-payeh	274
Triticum aestivum L.	Th	Cosm			1700	Kouh-payeh	275

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Table 1 (continued). The list of …

Family/genus/species	Life form	Chorotype	conservation status	Endemic	Altitude (m)	Location	Herbarium No.
Polygonaceae							
Atraphaxis spinosa L.	Ph	IT			2320	Gardane Molla Ahmad	276
Polygonum arenastrum Boreau	Th	IT-ES			1827	Kouh-payeh	277
Rumex conglomeratus Murray	He	IT-ES			1769	Kouh-payeh	278
Portulacaceae							
Portulaca oleracea L.	Th	Pl			1769	Kouh-payeh	279
Resedaceae							
Reseda buhseana Mull. Arg. var. *buhseana*	Ch	IT	DD	en	2150	Hojatabad	280
Reseda lutea L.	Th	IT-ES-SS			2033	Zafreh	281
Rosaceae							
Prunus dulcis (Mill.) D. A. Webb	Ph	IT			1769	Kouh-payeh	282
Prunus lycioides (Spach) C.K. Schneid. var. *horrida*	Ph	IT	LR	en	2064	Zafreh	283
Prunus scoparia (Spach) C.K.Schneid.	Ph	IT		en	2030	Toudeshk	284
Rosa damascena Herrm.	Ph	IT			1669	Kouh-payeh	285
Rubiaceae							
Callipeltis cucularis (L.) DC.	Th	IT-SS			1800	Kouh-payeh	286
Galium tricornutum Dandy	Th	IT-M			2321	Jebel	287
Scrophulariceae							
Scrophularia striata Boiss.	Ch	IT			2064	Zafreh	288
Verbascum songaricum Schrenk subsp. *songaricum*	He	IT			2321	Jebel	289
Solanaceae							
*Datura innoxia** Mill.	Th	Pl			1769	Kouh-payeh	290
Hyoscyamus pusillus L.	Th	IT-ES-SS			1769	Kouh-payeh	291
Hyoscyamus reticulatus L.	He	IT			2160	Alounabad	292
Lycium deperessum Stocks	Ph	IT			1575	Ghehi towards Kouh-payeh	293
Tamaricaceaee							
Tamarix indica Willd.*	Ph	IT	LR		1575	Ghehi towards Kouh-payeh	294
Tamarix ramosissima Ledeb.	Ph	IT-ES			1529	Hashemabad	295
Zygophyllaceae							
Tribulus terrestris L. var. *terestris*	Th	Cosm			1769	Kouh-payeh	296
*Zygophyllum fabago** L.	He	IT			1526	Sajzi	297

The species have been reported for the first time in Isfahan Province marked with asterisk (*). Ch: chamaephyte, T: therophyte, H: hemicryptophyte, Ph: phanerophyte, G: geophyte, Hy: hydrophyte. IT: Irano-Touranian, ES: Euro-Siberian, IT-M: Irano-Touranian/Mediterranean, IT-ES: Irano-Touranian/Euro-Siberian, IT-SS: Irano-Touranian/Saharo-Sindian, IT-M-SS: Irano-Touranian/Mediterranean/Saharo-Sindian, IT-ES-SS: Irano-Touranian/Euro-Siberian/Saharo-Sindian, IT-M-ES: Irano-Touranian/Mediterranean/Euro-Siberian, EM: Euro/Mediterranean, ES: Euro-Siberian, Cosm: Cosmopolite, Pl: Pluri-regional, DD: Data Deficiency, LR: Low Risk, VU: Vulnerable, En: endemic.

Table 2. The rate (%) of endemic species in each family.

Families	rate (%)
Asteraceae	18
Lamiaceae	14
Fabaceae	11
Papaveraceae	9

Table 3. The rate (%) of chorotype in Kouh-payeh area.

Chorotype	rate (%)
IT	60
Cosm	7
IT-M	7
IT-SS	6
IT-ES	6
Pl	6
IT-M-ES	4
IT-ES-SS	2
IT-M-SS	1
Other	1

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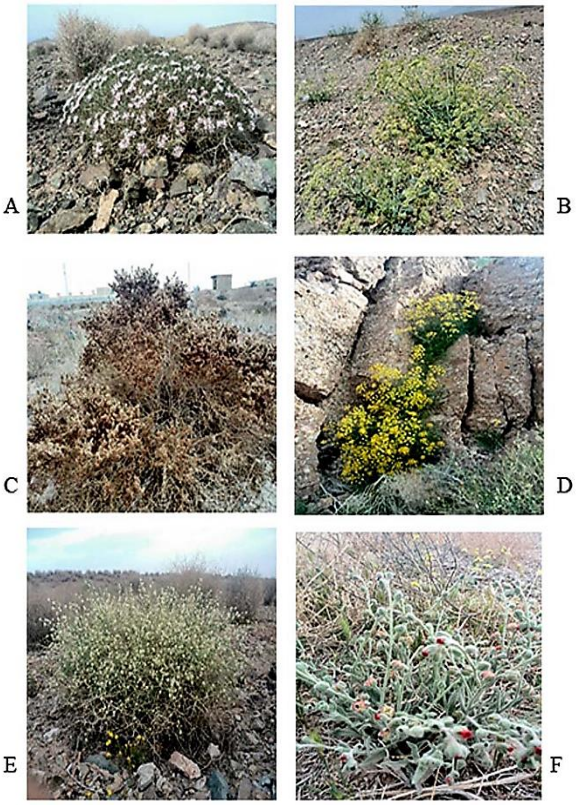

Fig. 8. The vegetative forms of some plant species in Kouh-Payeh area, Isfahan Province. A: *Acanthophyllum squarrosum*, B: *Ducrosia anethifolia*, C: *Salsola jordanicola*, D: *Prangos uloptera*, E: *Moriera spinosa*, F: *Paracaryum persicum*.

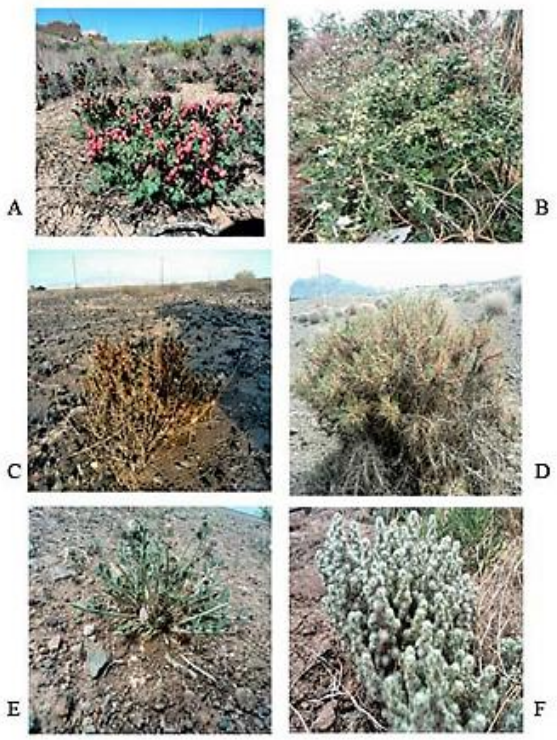

Fig. 8 (continued). A: *Prosopis farcta*, B: *Lycium depresum*, C: *Salsola tomentosa*, D: *Astragalus myriacantha*, E: *Astragalus mucronifolius*, F: *Bassia eriophora*.

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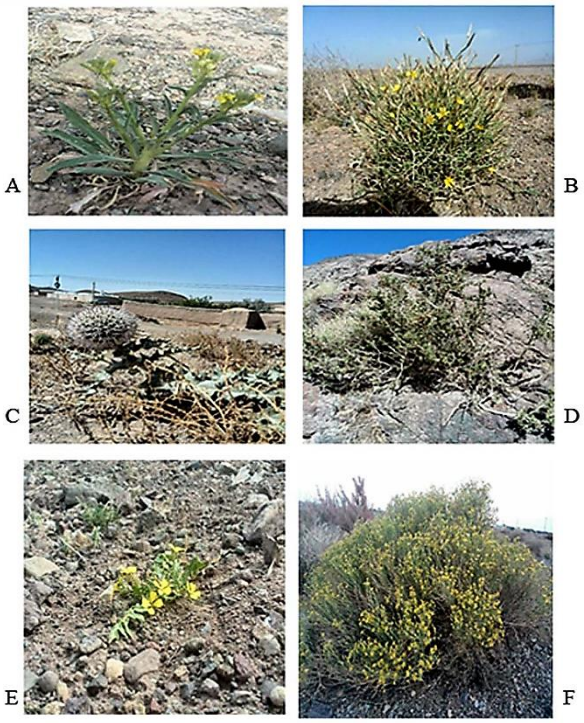

Fig. 8 (continued). A: *Erysimum crassicaule*, B: *Scorzonera tortuosissima*, C: *Echinops pungens*, D: *Atraphaxis spinosa*, E: *Sisymbrium septulatum*, F: *Hertia angustifolia*.

DISCUSSION

Based on the literature, all data are reporting for the first time in the Kouh-payeh area. According to our findings, 200 species belonging to 38 families and 137 genera were collected and identified in this area. The highest species number belonged to Kouh-payeh, while the lowest to Toudeshk, Sajzi, Hashemabad, Dakhrabad, Fesharak and Ali Ebrahim. Regarding the dry climatic conditions, there is a flora adapting the hard environmental conditions. The presence of 43 endemic species is one of the important finding in the Kouh-payeh area. The high existence of endemic species were found in this area, in comparison with the other regions in Isfahan Province (Yousefi *et al.* 2011; Kharazian *et al.* 2017). Our results revealed 36 endemic species localized in the Irano-Touranianareas. The properties of endemic taxa were supported by the results of other authors (Saber Amoli *et al.* 2016). Notably, the number of endemic species in this area are higher than in the desert zones of Iran (Batouli 2003; Saber Amoli *et al.* 2016). The Irano-Touranian areas are considered to be the richest regions in terms of endemism with 1452 endemic species (Zohary 1973; Ghahreman & Attar 1998). *Pseudofortuynia esfandiarii* Hedge (Brassicaceae) is known to be one of the endemic species belonging to drought regions in the Zagros Mountains (Zohary 1973), which was also observed in this study. The lower species number of *Acantholimon* and *Cousinia* highlights the desert conditions. In the present study, both genera exhibited a low species number. Nevertheless, psammophyte were frequently distributed in Irano-Touranian areas. Besides, families such as Boraginaceae, Caryophyllaceae, Poaceae, Tamaricaceae, Amaranthaceae and Zygophyllaceae were mainly observed as halophytes (Zohary *et al.* 1999). Asri (1998) declared that the high presence of Asteraceae, Poaceae and Fabaceae indicates the salinity of soils. Irano-Touranian species were the highest in terms of chorological approach, with 120 species (60%) (Asri 2003; Sadeghipor *et al.* 2018). 70-80% of the floristic units are influenced by the Irano-Touranianarea, followed by other phytogeographic units such as Saharo-Sindian, Mediterranean and Euro-Siberian chorotypes which are less prevalent (Zohary 1973). However, the desert areas of Iran have certainly been influenced by Irano-Touranian chorotype (60%) (Zohary *et al.* 1999). In Kouh-payeh area, the presence of the genus *Salsola*, *Haloxylon*, *Anabasis*, *Zygophyllum*, *Roemeria* and *Ephedra* is considered to be the relict or influential speciesof the Touranian chorotype (Touran Province). Remarkably, *Cyperus*, *Salsola*, *Tamarix*, *Zygophyllum*, *Anabasis*, *Prunus* and *Haloxylon ammodendron* were observed in arid zones of the Kouh-payeh area including the north, north-west, south, west and central areas. Due to the high geographical distribution, *Artemisia* and *Zygophyllum* can also be classified as non-desert plants (Dashtakian & Khosroshahi 2004). Some of the halophytic species of Irano-

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Touranian such as *Suaeda arcuata* (Aralo-Caspian/central Iranian species) determined by Ghazanfar *et al.* (2014) were observed in west of the study area. In different regions of Kouh-payeh, the presence of taxa such as *Euphorbia* sp., *Peganum harmala*, *Glycyrrhiza glabra*, *Eremurus persicus*, *Anabasis* sp., *Suaeda*, *Atriplex*, *Alhagi*, *Haloxylon*, *Prosopis* and *Peganum* illustrates the growth in eroded lands, and desert zones (Badiei 1998). Irano-Touranian Province from the central area has been reported to encompass high floristic richness including *Artemisia sieberi* and other floristic units such as *Launaea acanthodes* (Zohary *et al.* 1999). Other taxa such as *Tamarix ramosissima*, *Phragmites australis* and *Aeluropus littoralis* reported to be distributed in the desert areas of Touran Kavir and the Mouteh regions of Isfahan Province (Rechinger & Wndelbo 1976; Dashtakian & Khosroshahi 2004; Kashki & Amirabadizadeh 2011; Rabiei & Asri 2014), were also observed in the arid zones of the study area including the north, east and central areas. In previous reports from Kavir protected region, *Amygdalus scoparia* were found on mountain slopes (Rechinger & Wendelbo 1976). Regarding the presence of Saharo-Sindian chorotype limited to south of Iran, the presence of this chorotype might be due to the increased dryness and also environmental alterations (Abdi & Afsharzadeh 2012). The existence of *Anabasis setifera*, *Salsola jordanicola*, *Alhagi persarum*, *Astragalus mucronifolius*, *Astragalus anserinifolius*, *Prosopis farcta*, *Callipeltis cucularis*, *Schismus arabicus*, *Olimarabidopsis pumila*, *Malcolmia Africana* and *Scrophularia striata* in the Irano-Touranian/Saharo-Sindian chorotype confirms environmental alterations in the study area. The presence of Saharo-Sindian species in the area revealed the influence of this chorotype (Asri 2003). The life forms from the Raunkiaer's method have been classified based on vegetative bud positions during critical seasons (Raunkiaer 1934). The majority of life forms in this area were assessed as therophytes with 91 species (45%) influencing by the desert areas and cold climate of central Iran (Archibold 1995; Eshghi Malayeri *et al.* 2013). The high presence of therophytes in each region exhibits the high grazing, precipitation rates, short growing seasons, intensity of human intervention and damage due to species combination (Arya *et al.* 2011; Ghahremaninejad *et al.* 2012; Gurgin Karaji *et al.* 2013; Rafay *et al.* 2013). Hemicryptophytes with 69 species (34%) were found in high proportions in the study area, since they are characterized of long dryness, high temperatures in summer with high evaporation rates and unsuitable environmental conditions (Mahdavi *et al.* 2012). For the most part, desert regions of Iran display a high range of therophytes and hemicryptophytes (Vakili Shahrebabaki 2015). In the present study, low rates (%) of chamaephytes and phanerophytes suggest that these plants are not adapted to the climate and edaphic conditions (Heidari *et al.* 2013). A low rate of the phanerophyte life forms (5%) may be due to the water erosion (Eshghi Malayeri *et al.* 2013; Kharazian *et al.* 2017), since these forms are less stable in dry environments. It seems that this area may not have appropriate conditions for the trees or shrubs (Zohary 1973). Chamaephytes and phanerophytes will be damaged to a higher extent in unfavorable biological conditions than other life forms (Saber Amoli *et al.* 2016). From the point view of conservation status, the plant species have been affected by the vegetation damages caused by overgrazing, changes in pastures and limited distribution (Abdi 2008; Saeidi Mehrvarz and Ashouri Nodehi 2015; Milani *et al*. 2017). With respect to the endemic species, 25 species were in LR, while four species in VU, also needed to be considered in different ways. Saving seeds, cultivated or domesticated plants, avoiding plant harvest, decreased grazing, conservation policies and avoiding erosional events are the main goals in order to protect species richness and this natural resource. Protection assignments in natural resources should be considered for germplasm preservation.

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مطالعات فلوریستیک، اشکال زیستی، و کورولوژی ناحیه کوهپایه در استان اصفهان، ایران

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چکیده

ناحیه کوهپایه با مساحت ۳۰۰۰ کیلومتر مربع، در ۷۰ کیلومتری شرق اصفهان، حاشیه کویر مرکزی و در موقعیت جغرافیایی ۵۲ درجه و ۲۶ دقیقه طول شرقی و ۳۲ درجه و ۴۳ دقیقه عرض شمالی واقع شده است. در این تحقیق، غنای فلوریستیک، شکل زیستی، پراکنش جغرافیایی و وضعیت حفاظتی گونه‌ها ارزیابی شد. تمام گونه‌های گیاهی در طی سالهای ۱۳۹۳ الی ۱۳۹۵ از ناحیه کوهپایه جمع‌آوری شدند. شناسایی نمونه‌های جمع‌آوری شده، تعیین شکل زیستی و کورولوژی هر یک از گونه‌ها نیز انجام شد. در این مطالعه، ۲۰۰ نمونه گیاهی جمع‌آوری شد. ۳۸ تیره و ۱۳۷ جنس شناسایی شد. اغلب اشکال زیستی تروفیت (۴۵ ٪) و همی کریپتوفیت (۳۴٪) مشخص شدند. بر پایه اطلاعات کوروتیپ، در این ناحیه عمدتاً ناحیه رویشی ایرانی-تورانی (۶۰ ٪) مشاهده شد. دیگر کوروتیپ‌ها مانند ایرانی-تورانی\صحرا-سندی (۶ ٪) و ایرانی-تورانی\اروپا-سیبری (۶٪) در مقادیر کمتری حضور داشتند. در بین گونه‌های شناسایی شده، ۴۳ گونه انحصاری نیز مشخص شد. از نظر وضعیت حفاظتی، موقعیت در خطر کم (۷۷٪)، آسیب‌پذیر (۱۵٪) و کمبود داده (۸ ٪) حضور داشتند که نیاز به برخی سیاست‌های حفاظتی دارد. این مطالعه برای اولین بار در این ناحیه انجام شده است.

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