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Changes in flora, life forms and geographical distribution of herbaceous plant species along an altitudinal gradient in oak forests, Iran

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ABSTRACT

Intended to examine the effects of altitude on flora, life forms and geographical distribution of herbaceous species, this study was conducted in Kabirkouh forests of Darreshahr, located in Ilam Province, Iran, by selecting an area (circa 300 ha) in this forest. The study area was divided into three elevational classes and 63 systematic random plots were sampled (21 in each of the elevational classes). In order to record the herbaceous cover, the surface area of the plots was determined using the minimal area method. Then the herbaceous species and their percent coverage were recorded based on the Van der Marel criterion. A total of 109 herbaceous species belonging to 92 genera and 24 families were identified in the study area. The most frequent species were in the Asteraceae (23 species) and Poaceae (16 species) families. The results showed that in all three elevational classes, therophytes were the dominant life form of the area. The frequency of the therophytes in the first altitude class was higher than in the other classes. The second predominant life form was hemicryptophytes, whose frequency in the third class was higher than the other classes. Other life forms observed in the region were cryptophytes and chamaephytes, respectively which made up the least proportion of the area's plant population. In addition, the results indicated that within all of the elevational classes, a high percentage of the existing plants of the study area belonged to the Irano-Turanian floristic region. Generally, the altitude had a significant effect on the distribution of the flora of the study area.

Keywords: Elevation, Herbaceous vegetation, Plant life form, Zagros forests.
Article type: Research Article

INTRODUCTION

Generally, identifying and introducing the flora of a particular region is especially important to assess many important variables that are critical to proper management of forest: forest condition, wildlife habitat quality, forage conditions, country's vegetation, and invasive and endangered species (Safikhani 2001; Kashipazha et al. 2004; Hedwall & Brunet 2016). The plant life occurring in a particular region or time is called flora. The flora is a result of biological communities' responses to environmental conditions. The study and examination of flora are critical to understand the biodiversity and to manage natural resources (Deljouei *et al.* 2018). There is a balanced interaction between plants and the surrounding environment through which the plants adapt to the environmental conditions. The result of such adaptation is the establishment of specific life forms that are well adapted to the environment. The life forms of species in any plant community are various and this difference among the species is the structural basis of plant communities (Leuschner & Ellenberg 2017). Besides being dependent on genetic characteristics, the life forms of plants also depend on environmental factors. Therefore, plants have different life forms in varied communities and climate regions (Prasad 1995; Elmas & Kutbay 2019). Altitude is one of the ecological factors that play a significant role in determining the life form of plants in each

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DOI:
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Publisher: University of Guilan, Iran

region (Rawal *et al.* 2018). The Raunkiaer system is the complete categorizing system of plants using life form classes. In this method, the life forms of plant species based on the position of the growth buds were divided into five groups including Phanerophytes, Chamaephytes, Hemicryptophytes, Cryptophytes and Therophytes following an unsuccessful growth season (Raunkiaer 1934). In terms of geographical distribution, a plant would survive only if it can withstand the geographical conditions of a new region. There are different factors contributing to the distribution of species and the formation of plant communities. Hence, it is apparently necessary to study the geographical distribution of species to identify these factors (Chen & Feng 2002). The mountain vegetation of Iran has been studied by several researchers (e.g., Deljouei *et al.*, 2017, 2018; Rahmanian *et al.*, 2019). In western Iran, researchers (Rostami 2012; Darvishnia *et al.* 2012; Gorgin Karaji *et al.* 2013; Jalilian *et al.* 2014; Abbasi *et al.* 2015) have conducted studies on the flora of these areas. To our knowledge, few studies have been conducted to examine the effects of altitude on flora and the life form of plant species in Zagros forests. In addition, it is critical to be aware of the vegetation condition of the area, considering the vulnerability of Zagros forests and the presence of livestock in these ecosystems. According to the presence of livestock in these ecosystems, awareness of the vegetation situation is necessary in order to increase awareness of their health and, if necessary, to restore the vegetation in these areas. Hence, this study aims to examine the effects of altitude on the flora, life forms and geographical distribution of herbaceous species in the Kabirkouh forestland of Ilam Province.

MATERIALS AND METHODS

Study area

The study area is located in Kabirkouh of Darreshahr town in the southern part of Ilam Province. The area is located in (33˚ 03' 44" to 33˚ 09' 18" N) and (47˚ 18' 41" to 47˚ 23' 30" E). The study area was 300 ha and the altitude range was between 700 and 1600 m a.s.l (Fig. 1). The average slope in the whole plots is about 25 %, and the dominated geographical aspect is the south direction. The average annual rainfall, mean annual temperature, average minimum and maximum annual temperatures were 400 mm, 21.2 °C, 13.4°C and 29.1 °C, respectively (Darreshahr's Synoptic station; IRIMO, 2018). The dominant tree of the area is *Quercus brantii*. Also, *Acer monspessulanum*, *Pistacia atlantica*, *Pistacia mutica*, *Ziziphus spina-christi*, *Ficus* sp., *Lonicera* sp., *Amygdalus* sp., *Pyrus* sp., *Crataegus* sp., and *Celtis australis* are present in the area. The most abundant soil type in the study area is Lithosols. The texture of the soils varies from clay to clay-loam and have a pH between 7.5 and 8.1.

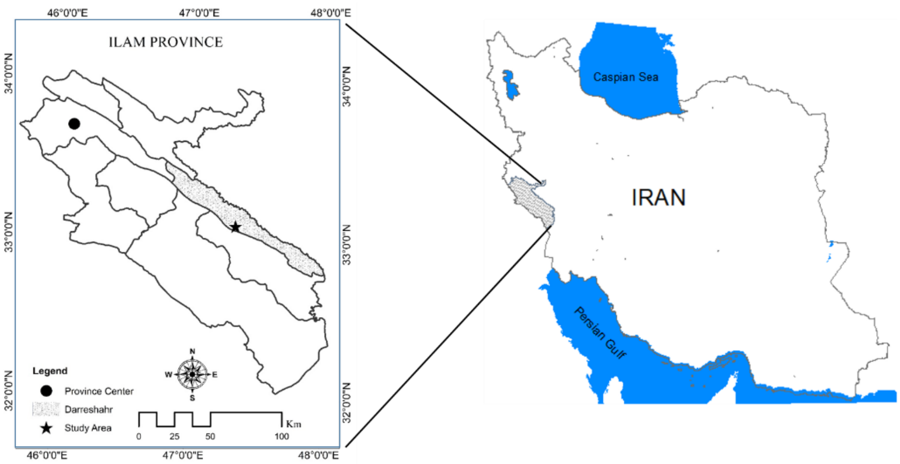

Fig. 1. The geographic location of study area.

Sampling and data collection

Following a field survey, the study area was divided into three elevational classes (700-1000, 1000-1300 and 1300-1600 meters a.s.l.; Fig. 2). A total of 63 sample plots (21 plots in each elevational class) were selected and sampled in a systematic random method. In order to record herbaceous cover, the area of the plots was determined using the minimal area method. The herbaceous species and their percentage cover were recorded. Whittaker sampling method and species level curve were used to determine the minimal level (Whittaker 1977). Thus, the plot size was determined to be 16 m^2 (4 × 4 m). Therefore, herbaceous species and their percent cover were

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recorded based on the Van der Marel frequency-domination index (Westhoff & van der Maarel 1978; Table 1). Species identification was carried out using Flora Iranica (Rechinger 1963-2010), Iran (Assadi 1988-2016), Iraq (Townsend & Guest 1966-1988) and Flora Turkey (Davis 1965-1988). The species life forms were determined based on the Raunkiaer classification (Raunkiaer 1934). In addition, geographical distributions of the species were then recognized by Zohary (1973), Takhtajan (1986) and White & Leonard (1991), according to their distribution regions and based on the vegetation regions of Iran.

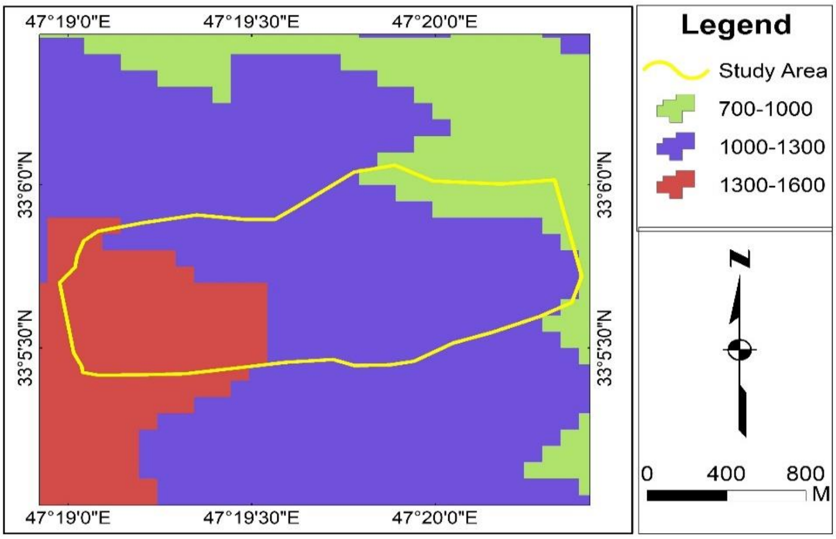

Fig. 2. The study area's map of elevational classes.

RESULTS AND DISCUSSION

Floristic characteristics

The list of herbaceous species of the study area, their life forms, and their geographical distribution are presented in Table 1.

Table 1. The list of herbaceous species of the study area, their life forms, and their geographical distribution.

Scientific name	Life form	Geographical distribution
Amaranthaceae		
Amaranthus retroflexus L.	Th	Pl
Apiaceae		
Ammi majus L.	Th	IT
Anisosciadium orientale DC.	Th	IT
Bifora testiculata (L.) Spreng.	Th	IT-ES
Bupleurum croceum Fenzl	He	IT
Bupleurum lancifolium Hornem.	Th	IT-SS
Ducrosia flabellifolia Boiss.	He	IT
Eryngium thyrsoideum Boiss.	He	IT
Pimpinella deverroides Boiss.	He	IT
Scandix iberica M.B.	Th	IT
Scandix pecten- veneris L.	Th	IT
Asteraceae		
Achillea wilhelmsii C. Koch.	He	IT-ES-SS
Anthemis haussknechtii Boiss. & Reut.	Th	IT
Atractylis cancellata L.	Th	M
Carduus arabicus Jacq. ex Murray.	Th	M-ES
Carlina kurdica Meusel & Kastner.	Th	IT
Cnicus benedictus L.	Th	IT
Codonocephalum stenocalathium Rech.f.	Th	IT
Conyza canadensis (L.) Cronq.	Th	Cosm
*Crupina crupinastrum (*Moris) Vis.	Th	IT-M-ES
Echinops pachyphyllus Rech.f.	He	IT
Gnaphalium luteo-album L.	Th	Cosm

Caspian Journal of Environmental Sciences, Vol. 19 No. 4 pp. 619-627
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Scientific name	Life form	Geographical distribution
Gundelia tournefortii L.	He	IT
Hedypnois rhagadioloides (L.) F.W. Schmidt.	Th	IT-M
Lactuca serriola L.	Th	IT-M-ES
Lapsana communis L.	He	IT-ES
Onopordon acanthium L.	He	IT
Onopordon heteracanthum C.A. Mey.	He	IT-ES
Picnomon acarna (L.) Cass.	He	IT
Scorzonera calyculata Boiss.	Cr	IT
Scorzonera phaeopappa (Boiss.) Boiss.	Cr	IT
Senecio vernalis Waldst. & Kit.	Th	IT-ES
*Steptorrhamphus tuberosus (*Jacq.) Grassh.	He	IT-M
Urospermum picroides (L.) Desf.	Th	IT-M
Boraginaceae		
Anchusa italica Retz.	He	IT-M-ES
Anchusa strigosa Labill.	He	IT-M
Asperugo procumbens L.	Th	IT-M-ES
Lithospermum arvense L.	Th	IT
Onosma nervesum H. Riedl.	He	IT
Solenanthus circinnatus Ledeb.	He	IT
Cannabaceae		
Cannabis sativa L.	Th	IT
Caryophyllaceae		
Dianthus strictus Banks & Soland.	Ch	IT
Pteranthus dichotomus Forssk.	Th	IT-ES-SS
Silene conoidea L.	Th	IT-M
Vaccaria grandiflora (Fisch. & DC.) Jaub. & Spach	Th	IT-M-ES
Chenopodiaceae		
Atriplex patulum L.	Th	IT
Cistaceae		
Helianthemum salicifolium (L.) Miller.	Th	IT-M-ES
Cruciferae		
Aethionema grandiflorum Boiss. & Hohen.	Th	IT
Alyssum campestre L.	Th	IT
Biscutella didyma L.	Th	IT-M
Brassica napus L.	Th	IT-SS
Descurainia sophia (L.) Webb & Berth.	Th	IT-M-ES
Erucaria hispanica (L.) Druce.	Th	M
Hirschfeldia incana (L.) Lag.	Th	Pl
Neslia apiculata Fisch., C. Mey. & Avee-Lall.	Th	IT
Sinapis arvensis L.	Th	IT
Thlaspi perfoliatum L.	Th	IT-M
Cucurbitaceae		
Cucumis melo L.	Th	IT
Cyperaceae		
Cyperus fuscus L.	Th	IT-M-ES
Euphorbiaceae		
Euphorbia macrostegia Boiss.	He	IT
Coronilla scorpioides (L.) W.D.J. Koch.	Th	IT
Hymenocarpus circinnatus (L.) Savi.	Th	M
Lathyrus cicero L.	Th	IT-M
Trifolium purpureum Loisel. var purpureum.	Th	IT-M-ES
Trifolium repens L.	He	IT
Trifolium tomentosum L.	Th	IT
Vicia variabilis Freyn & Sint.	He	IT-ES
Fumariaceae		
Fumaria asepala Boiss.	Th	IT-ES
Geraniaceae		
Erodium gruinum (L.) L' Her, ex Aiton.	Th	IT
Geranium lucidum L.	Cr	IT
Geranium tuberosum L.	Cr	IT
Iridaceae		
Gladious segetum Ker-Gawl.	Cr	IT
Labiatae		

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Publisher: University of Guilan, Iran

Scientific name	Life form	Geographical distribution
Lamium amplexicaule L.	Th	ES
Marrubium cuneatum Russel.	He	IT
Phlomis bruguieri Desf.	He	IT
Salvia compressa Vent.	He	IT
Salvia indica L.	He	IT
Liliaceae		
Chlorophytum comosum	Th	IT
Fritillaria imperialis L.	Cr	IT-M
Fritillaria straussii Bornm.	Cr	IT
Muscari neglectum Guss.	Cr	IT-M
Malvaceae		
Hibiscus trionum L.	Th	IT
Malva neglecta Wallr.	He	IT-M-ES
Poaceae		
Aegilops umbellulata Zhuk.	Th	IT
Avena sativa	Th	IT
Bromus danthoniae Trin.	Th	IT
Bromus fasciculatus Presl var. alexandrines Tell.	Th	IT-M
Bromus scoparius L.	Th	IT-M-ES
Bromus sericeus Drobov.	Th	IT
Bromus sterlis L.	Th	IT-M-ES
Bromus tomentellus Boiss.	He	IT
Catabrosa aquatic (L.) P. Beauv.	He	M
Echinaria capitata (L.) Desf.	Th	IT-M
Heteranthelium piliferum (Banks & Soland.) Hochst.	Th	IT
Hordeum leporinum Link.	Th	IT-M
Lolium rigidum Gaudin.	Th	IT-M
Lophochloa phleoides (Vill.) Reichenb.	Th	IT
Poa bulbosa L.	Cr	IT-M-ES
Saccharum ravennae (L.) Murray.	He	IT-M-SS
Podophyllaceae		
Bongardia chrysogonum (L.) Spach.	Cr	IT
Leontica leontopetalum L.	Cr	IT
Ranunculaceae		
Delphinium cyphoplectrum Boiss.	He	IT-M-ES
Ficaria kochii (Ledeb.) Iranshahr & Rech.f.	Cr	IT
Ranunculus oxyspermus Willd.	Cr	IT-ES
Ranunculus arvensis L.	Th	IT-M-ES
Ranunculus asiaticus L.	Cr	IT-M-ES
Thalictrum sultanabadense Stapf	He	IT
Scrophulariaceae		
Verbascum alceoides Boiss. & Hausskn.	He	IT-ES
Valerianaceae		
Valerianella vesicaria (L.) Moench.	Th	IT-M

A total number of 109 herbaceous species belonging to 92 genera and 24 families were identified in the study area. The highest frequency belonged to Asteraceae and Poaceae families (Fig. 3), while other families including Brassicaceae, Boraginaceae, Fabaceae, and Apiaceae had less proportion of vegetation cover. Iridaceae, Cucurbitaceae, Cyperaceae, and Amaranthaceae were observed only in the first elevational class. Similarly, Podophyllaceae, Chenopodiaceae, Cannabaceae, Valerianaceae, and Euphorbiaceae were identified only in the second class and Fumariaceae only in the third class which accounts for a small percentage of the vegetation cover (Fig. 3).

The life form of plant species

The plant life forms associated with the highest and lowest elevation classes were found to be therophytes and chamaephytes, respectively (Fig. 4). The frequency of different life forms changed with elevation (Fig. 4).

The geographical distribution (chorotype) of plant species

The highest chorotype of plant species in all elevational classes was observed in the Irano-Touranian element, while the second-highest chorotype in Irano-Touranian, Mediterranean and Europe-Siberian element (Fig. 5).

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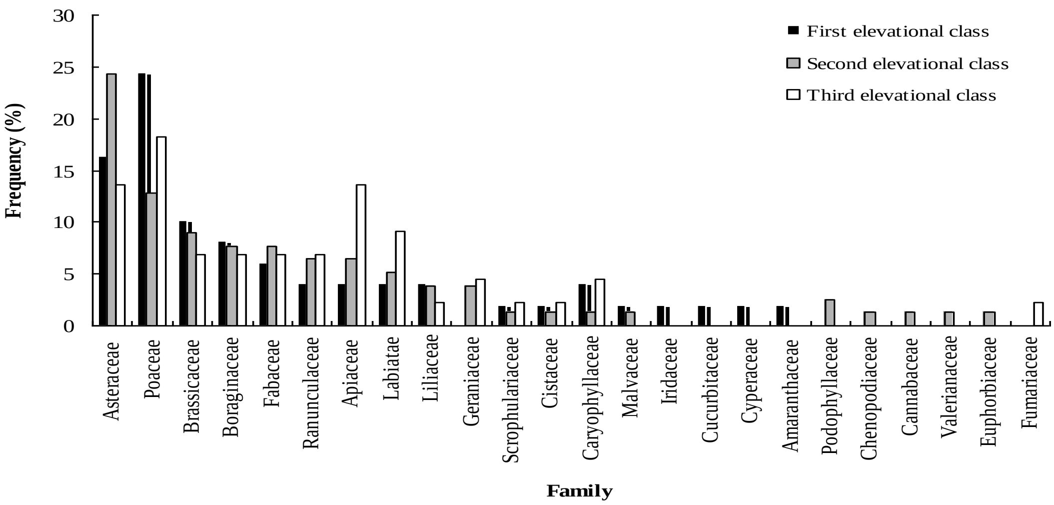


Fig. 3. Chart of families' percentage in different elevational classes.

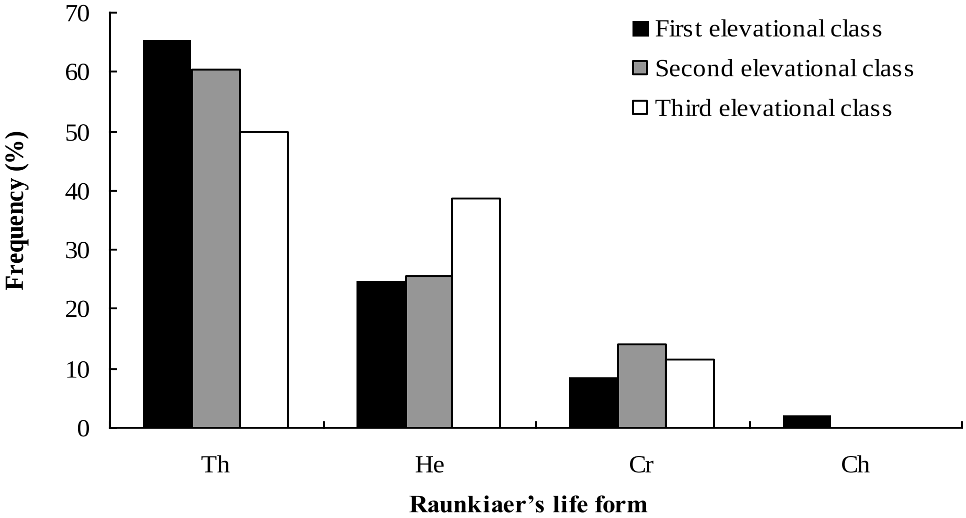
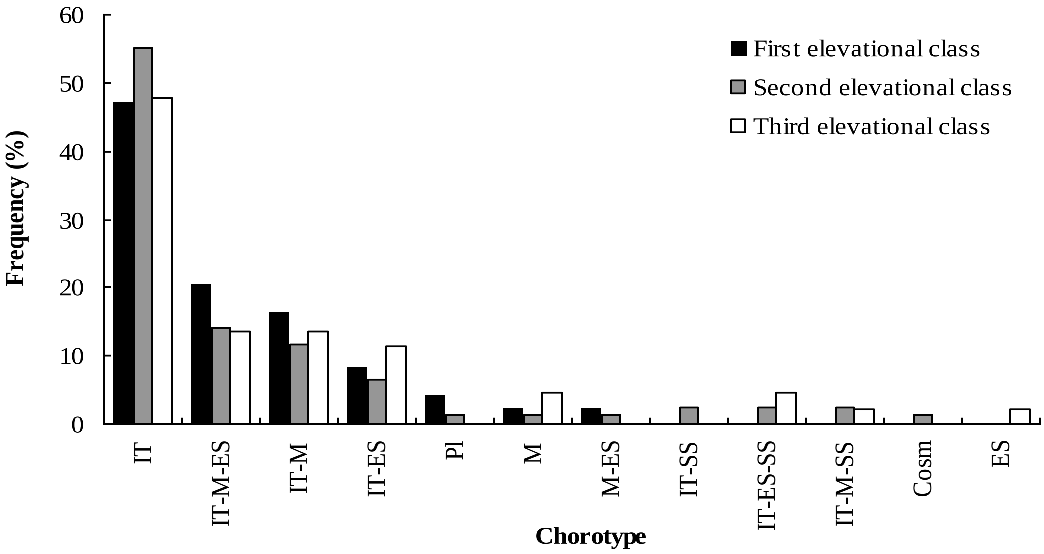


Fig. 4. Frequency of plant species Raunkiaer's life-form percent in different elevation.



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DISCUSSION

In the study area, 109 species of herbaceous plants belonging to 92 genera and 24 families were identified. Host and Pregitzer (1991) reported 90 herbaceous species in the 76 oak stands of USA. In the present study, the most frequently observed species were from Asteraceae (23 species) and Poaceae (16 species) families. Similar to our result, Kharkwal *et al.* (2009) reported that in the oak forest of Himalaya, Asteraceae was the most frequent family. In addition, Pulido *et al.* (2006) found that Asteraceae is a largest family in the oak forest of Columbia. The fact that Asteraceae and Poaceae families exhibit the most species in the herb stratum of the oak forest, is in agreement with observations from Mexican oak forests (Rzedowski, 1978; Encina-Domínguez et al. 2011).

The high abundance of species from the Asteraceae family might be due to livestock grazing and the degradation of flora in the area. In this regard, Kashipazha *et al.* (2004) in a floristic study of Shad garden reported that the abundance of Asteraceae is due to the degradation of vegetation in several parts of the region. Davis (1972) suggested that the reason for the observed high abundance of species from the Asteraceae, seems to be the strong resistance of this family to unfavorable environmental conditions. Davis (1972) also reported that the seeds of this family germinate faster than those of the others. Rostami (2012), introduced Asteraceae and Poaceae as two plant families with high richness, suggesting that it is due to the overgrazing in the area. Consistent with our results, some authors reported these families as exhibiting the highest numbers of species studied in this region of Iran including Darvishnia *et al.* (2012) in Manesht and Ghelarang, Ilam Province; and Jalilian *et al.*, (2014) in Baharab of the Zagros Mountains.

The frequency of Asteraceae was lower in the third elevational class, which might be a result of less degradation and grazing on higher elevations of the area. By comparing the three elevation range, it is found that Iridaceae, Cucurbitaceae, Cyperaceae, and Amaranthaceae appeared only in the first class, while Podophyllaceae, Chenopodiaceae, Cannabaceae, Valerianaceae, and Euphorbiaceae only in the second, and Fumariaceae only in the third class. These families account for a small percentage of plant vegetation in the area.

The results of examining the life forms of plant elements indicated that Therophytes are the dominant life form in the study area. In areas with low annual rainfall, average high temperatures and prolonged drought periods, the vast majority of the species in the plant communities would adopt the drought-resistant life form of Therophytes (da Costa *et al.* 2007). Given that Zagros forests are semi-arid forests of the country, the above consequence would not be unexpected.

The presence of Therophytes, which are generally commonly associated with dry areas (Asri 1999), indicates that site degradation occurred in the area (Jauffret & Lavorel, 2003; Ghahreman *et al.* 2006; Deljouei *et al.* 2018). Once examining the impacts of livestock grazing on the herbaceous species and their life forms, Prasad (1995) suggested that in the areas under the influence of grazing by livestock, the frequency of Therophytes is higher than in protected areas. In addition, by comparing the three elevational classes in the study area, we found that the frequency of Therophytes in the first class (32 species, 65.31%) is higher than in the other classes, indicating a further degradation in the lower elevations, because lower elevations are more exposed to livestock grazing. Temperature reduction by increasing altitude is another reason for the decline of Therophytes at high altitudes of the study area. Literature reviews indicated that therophytes are abundant in the first stages of succession, whereas phanerophytes are rare (Houssard *et al.* 1980). As most therophyte species are light-demanding, the increased penetration of light to the forest understorey is a key factor favoring such life forms (Godefroid & Koedam 2004; Deljouei *et al.* 2018). The second predominant life form in the study area is Hemicryptophytes – a life form that is abundant in the alpine climate. Due to temperature reduction at high altitudes, the abundance of Hemicryptophytes in the third elevational class was higher than in the other classes, indicating the compatibility of Hemicryptophytes with the ecological conditions of alpine areas (Ghahremani Nejad & Agheli 2009). The other life forms in the region were Cryptophytes and Chamaephytes respectively, which included the remaining percentage of the plants in the area. The low percentage of these life forms reveals their low adaptability to the climate and soil conditions of the area.

The results of observing the geographical distribution of plant species displayed that in all three elevational classes, a high percentage of the existing plants of the area belong to the Irano-Touranian region. The main cause of dominance of the Irano-Touranian elements in the study area could be the specific site conditions of the area (in terms of air temperature and air humidity). In addition, the presence of genera such as Anthemis, Cannabis, Echinops, Phlomis, Onosma, Salvia, and Silene, whose species are among the Irano-Touranian vegetation elements, exhibits the dominance of the Irano-Touranian elements within the study area.

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CONCLUSION

Based on the results of this study, in Zagros mountainous areas where the temperature drops down, Cryophytes have increased in number. On the other hand, in lower lands of the area which are more accessible and are exposed to degradation, Therophytes are abundant. Furthermore, in agreement with the previous studies, it could be concluded that generally, altitude causes alterations in the vegetation type of an area of oak forests. However, identification of flora and life forms of Zagros forests, their relationship with topographic factors to learn more about these sites, and conservation of the vegetation established in these sites are among the topics that require more examination. Increasingly, these topics become more important, and there is a need for similar studies in this context under different sites and conditions.

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