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Investigation of flora, life form and geographical distribution of plant species in north-west of Ludab region, Kohgiluyeh and Boyer-Ahmad province, Iran

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ABSTRACT

Ludab region, known for its unique landscape comprising a vast fertile plain surrounded by high mountains and covered by loose oak forests, is a part of Boyer-Ahmad County in southern Zagros mountain range (West Iran) with an area of 87,715 km^2 located 110 km north-west of the capital city, Yasuj. The aim of this research is to assess floristic elements, life forms, chorology, and endemic, medicinal, pasture, and poisonous species in Ludab region. For this purpose, several field trips were done and specimens of three regions of Ludab including Dar-e Bid, Chin, and Gelal were collected during different seasons. A total of 235 species representing 184 genera and 52 families were recognized in the region among which 55 species were endemic to the country. Regarding the life form, the majority of species were hemicryptophytes (45%; 106 species), followed by therophytes (33%; 77 species), phanerophytes (9%; 22 species), geophytes (9%; 22 species), and chamaephytes (4%; 8 species). Most of the species showed the Irano-Turanian (61%) chorotype, while Irano-Turanian/Eurosiberian (16%) chorotype was the next frequent one. From an economical point of view, we recognized 157 medicinal, 67 pasture, and 73 poisonous plant species. A conservation status survey indicated most plant species to be at a low risk (74%), and only few species to be endangered (2%), and vulnerable (2%). Overall, north-west of Ludab region presents a valuable genetic resource due to high number of endemic, medicinal, pasture, and poisonous species.

Keywords: Conservation; Chorology; Endemism; Floristic; Life form; Zagros Mountains

Introduction

Flora of a certain area is the product of the plants adapted to the environmental condition, plant evolution in past, and geographical history. The presence of plant habitats is mainly connected to the geographical factors such as altitude and gradient, erosion, climate, and soil (1). Floristic richness of Iran is exceptional among the South West Asian countries. The presence of wet forests in the north, different shrubs such as *Prunus* L.,

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Pistacia and *Juniperus* in mountainous areas of Alborz, Zagros, and Kopet Dagh mountains, and *Quercus* forests in the west, besides mountainous steppe communities in the highlands, desert steppes, Mangrove forests in the south and different types of wetlands vegetation are examples of the habitat diversity in Iran (2).

To understand the floristic composition of a certain area, it is necessary to study the history, paleoecology, geographical position, as well as qualitative and quantitative features of the habitats (3). Moreover, differences in life form in the flora determines the shape of plant communities. Life form is a constant feature gained from morphological adaptation to the environment (4).

In terms of vegetation and communities, Iran is a rich country. The main reasons for this diversity are the topological and climatic variations that led to high endemism (5, 6). Zagros Mountain range is known as an important reservoir in west and south-west of Iran including different habitats and climates (4). Kohgiluyeh and Boyer-Ahmad province with an area of 16,264 km^2 is located in south of Zagros Mountains, extended within longitudes 49° 52' to 51° 52' E and latitudes 29°49′ to 31°28′ N. This province is located between central plateau and south coast plains, which result in subtropical climates in southern parts and cold climates in north. Moreover, the high altitudinal range, presence of numerous high mountains, variation in annual precipitation among different parts, and extreme fluctuations in temperature make the province as connective of several floristic units. Although cold regions exhibit dense plant vegetation, non-dense and sparse vegetation exist in subtropical part. The cold regions have the potential to support forests and grasslands (7).

Various floristic studies are available on Kohgiluyeh and Boyer-Ahmad province and Zagros areas including Saverz, Khaeiz, Sorkh Mountains, Soulak and Yasuj regions, Palang Galoun, Saldaran and Meymand protected regions (4, 8-12). A total of 900 species, 350 genera and 90 families have been reported in this province until now (13). Moreover, 123 Iranian endemic species were identified in this province (4, 11-12). Besides, some important subtropical tree/shrubs such as *Ziziphus spina-christi* (L.) Desf. and *Ziziphus nummularia* (Burm.f) Wight & Arn, and some typical mountainous and species rich genera such as *Astragalus* L., and *Acantholimon* C.A.Mey. were reported as typical taxa in this province (9).

It is known that life forms are the result of ecological adaptation and lead to special characteristics of plant communities (12, 14). The main types of life form are: phanerophytes, chamaephyte, hemicryptophyte, geophyte, and therophyte (10, 15).

From a chorological point of view, the type of vegetation is associated with certain geographical distribution patterns (17). Irano-Turanian floristic region forms the most conspicuous phytochorion in Iran, while other chorotypes, viz. Euro-Siberian, Saharo-Sindian, and Mediterranean show less coverage over the country (17, 18, 19). The Zagros Mountain range in west of Iran is assigned to Mesopotamian and Irano-Turanian phytochoria. Several species are known as applied plants in Zagros Mountains. As an example, a total of 101 medicinal and 52 pasture plant species were found in Saverz Mountains and forests around that (11, 20). There are also reports on conservation status of plant species distributed in Zagros area listing them as endangered, low-risk, data-deficient, and vulnerable (4, 12, 21).

Ludab region in Kohgiluyeh and Boyer-Ahmad province is known for its diverse landscape and ethnobotanical tradition among native population. However, there is no detailed investigation on the flora of this region which would be essential to future conservation management program. The aims of the present research were to: 1- identify the floristic elements, life forms, and geographical distribution of plant species in Ludab region, 2- determine the endemic, medicinal, pasture, and poisonous species as applied plants in this region, and 3- investigate the conservation status of the species.

Materials and methods

Study area

Ludab region belongs to the central part of Boyer-Ahmad County with an area of 87,715 km^2 and is located 110 km north-west of Yasuj city at longitude of 50° 42' E and latitude of 30°57′N. Three areas from Ludab were investigated in this research, i.e. Dar-e Bid (50° 54' E, 31° 0' N), Chin (50° 52' E, 31° 1' N), and Gelal (50° 49' E, 31° 3' N) (Fig. 1). Other regions near to Ludab are Hamz-e Ali and Margun in the north-east,

Dena protected region in the east and north-east, Heydar-abad Sofla, Sarfaryab, and Gordakan in the south, Dehno and Chahartakhte Liaghat villages and Zarin Mountain in the north-west, Nil Mountain and Dehdasht in the south-west, Siah and Shorm Mountains in the north, and Dishmouk in the west. The climatic conditions of this region have already been investigated using the De Martonne aridity index according to the formula: $I=P/T+10$, where P indicates the annual precipitation and T is the annual mean temperature (22).

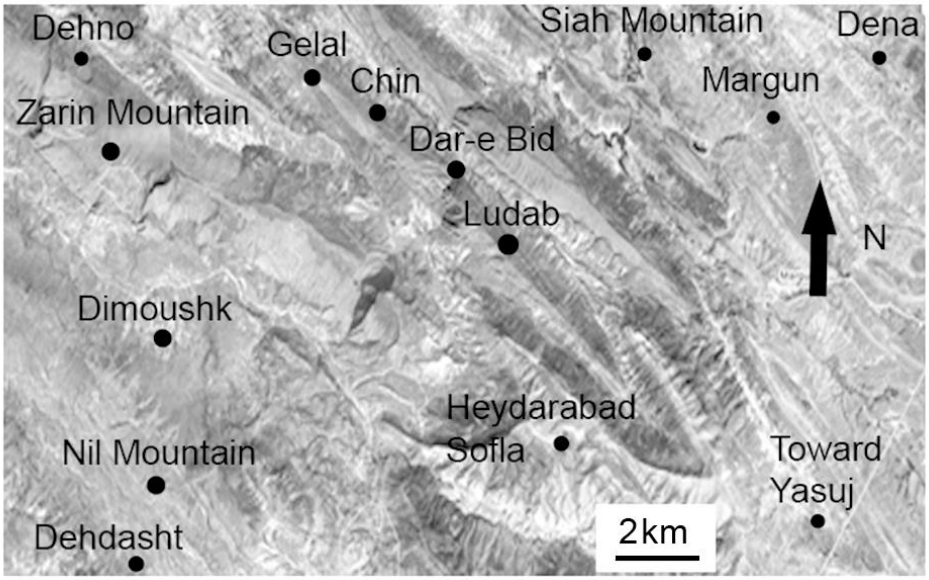

Figure 1. Geographical location of Ludab region in Kohgiluyeh and Boyer-Ahmad province.

Some geological features of the study area are as follows. Asmari formation produced a high anticline in the Boyer-Ahmad and Dena Counties. Some of the most important anticlines in this province were Pazanan, Mokhtar, Dehno, and Khaviz. Bauxite deposit from Dehdasht belongs to the belt of Iran-Himalaya bauxite-Karstout. Dehdasht is located at outcrop anticline of Kouh-e Siah, Kouh-e Nil, and Mandan. Mandan anticline is one of the most known bauxite regions from Zagros folding. There are various geological formations such as Gachsaran, Mishan, Aghajari and Quaternary in this region (23).

Previous analyses showed that the soil of Ludab region has medium-permeability with medium and low drainage. The soil is composed of sand, silt, loam, and clay-silt with significant amounts of phosphorous. Moreover, surface and deep rock as well as gravels were observed in this area (24).

Research methods

The studied area was investigated by geographical maps. Then the samples were collected from Dar-e Bid, Chin and Gelal regions during March 2016 to November 2017. The plant samples were identified using the regular references including 'Flora Iranica' (25), 'Flora of Iran' (26, 27), 'The vegetation of Iran' (28), 'Flora of Turkey' (29), and other related publications (30). A regular floristic methodology for field surveying was used (31). The altitude was documented for all samples using a Garmin GPS (USA). The identified species were also checked for exact citation and authority using International Plant Name Index (32), the plant list (33), and Ghahremaninejad et al. (2017) (34). The identified specimens are deposited in the Herbarium of Shahr-e Kord University.

Raunkiaer's method (16) was applied to determine life forms of each collected sample. The chorology was determined using Zohary (17), Jalili and Jamzad (6), and Flora of Iran (27). The conservation status was extracted from the Red Data Book of Iran (6). Moreover, the potential medicinal, pasture, and poisonous implication of the species were identified

using the corresponding literature (35-36). The statistical charts and tables were prepared in Microsoft Excel.

Results

Dehdasht city is the nearest climatological station to Ludab region. Based on reports provided by this station during 2006-2017, mean annual temperature was 23.2°C, with a maximum of 33.6°C and a minimum of 9.9°C in June and January, respectively. The mean annual precipitation was 403.5 mm (Fig. 2) (http://irimo.ir). Based on De Marton's aridity Index, the climate of the study area is semi-arid (I=12.1).

The results of floristic studies showed a total of 235 species, 184 genera, and 52 families in Ludab including Gelal, Dar-e Bid, and Chin regions. Most of the species

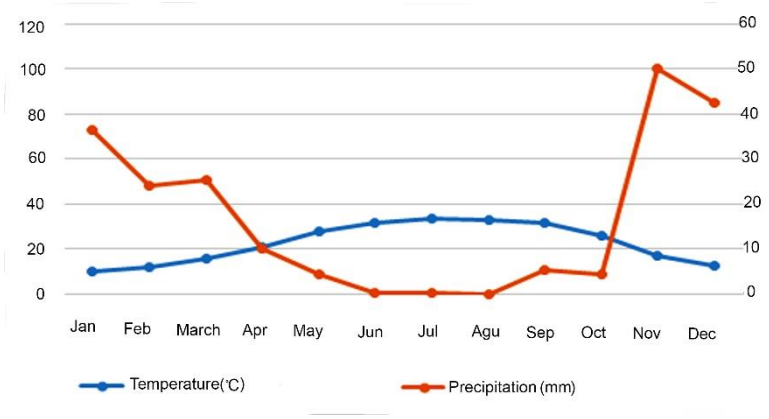

Figure 2. Climatological curve of Dehdasht city during years 2006-2017.

were collected from Gelal and Chin regions. Moreover, 12 families, 30 genera, and 39 species were monocotyledonous (23%), 39 families, 154 genera, and 196 species were dicotyledonous (75%), and one species (*Orobanche nana*) was a holoparasite (2%) (Appendix 1; Fig. 3). The maximum number of species belonged to Asteraceae (32 spp.), Brassicaceae (23 spp.), Lamiaceae (22 spp.), Fabaceae (21 spp.), and Apiaceae (20 spp.) (Fig. 3, Appendix 1). The genera *Stachys* L. (5 spp.), *Bromus* Scop. (4 spp.), *Salvia* L. (4 spp.), *Medicago* L. (4 spp.), *Astragalus* L. (4 spp.), *Allium* L. (4 spp.), *Convolvulus* L. (3 spp.), *Euphorbia* L. (3 spp.), *Silene* (3 spp.), and *Prunus* L. (3 spp.) were the most species rich genera (Fig. 3). A total of 148 monotypic genera were also recognized in this region. As shown in Figure 3, the highest number of monotypic genera belonged to Asteraceae (20 genera), Brassicaceae (17 genera), Apiaceae (16 genera), Poaceae (13 genera), Fabaceae (11 genera), and Lamiaceae (11 genera), respectively.

The life forms surveyed were: hemicryptophytes (45%; 106 spp.), therophytes (33%; 77 spp.), phanerophytes (9%; 22 spp.), geophytes (9%; 22 spp.), and chamaephytes (4%; 8 spp.), respectively (Fig. 4, Appendix 1). The most frequent hemicryptophytes belonged to the families: Lamiaceae (20%, 21 spp.), Asteraceae (16%, 17 spp.), Apiaceae (14%, 15 spp.), Brassicaceae (11%, 12 spp.), and Fabaceae (9%, 10 spp.). The highest number of therophyte species was represented by the families: Asteraceae (19%, 15 spp.), Poaceae (17%, 13 spp.), Brassicaceae (14%, 11 spp.), Fabaceae (8%, 6 spp.), Caryophyllaceae (6%, 5 spp.), Boraginaceae (6%, 5 spp.), and Apiaceae (6%, 5 spp.), respectively.

In terms of geographic distribution patterns (Fig. 4), there were various chorotypes among the surveyed species. The species representing the Irano-Turanian phytochorion with 61% were the most frequent type. The Irano-Turanian/Eurosiberian (16%), Irano-Turanian/Mediterranean (5%), Irano-Turanian/ Eurosiberian/ Mediterranean (4%), Irano-Turanian/Saharo-Sindian (3%), Irano-Turanian/ Eurosiberian/Mediterranean/ Saharo-Sindian (2%), Irano-Turanian/Eurosiberian/ Saharo-Sindian (1%), cosmopolite (8%), and Pluriregional (1%) elements stand at next ranks, respectively. The maximum proportion of Irano-Turanian chorotype was represented by Asteraceae

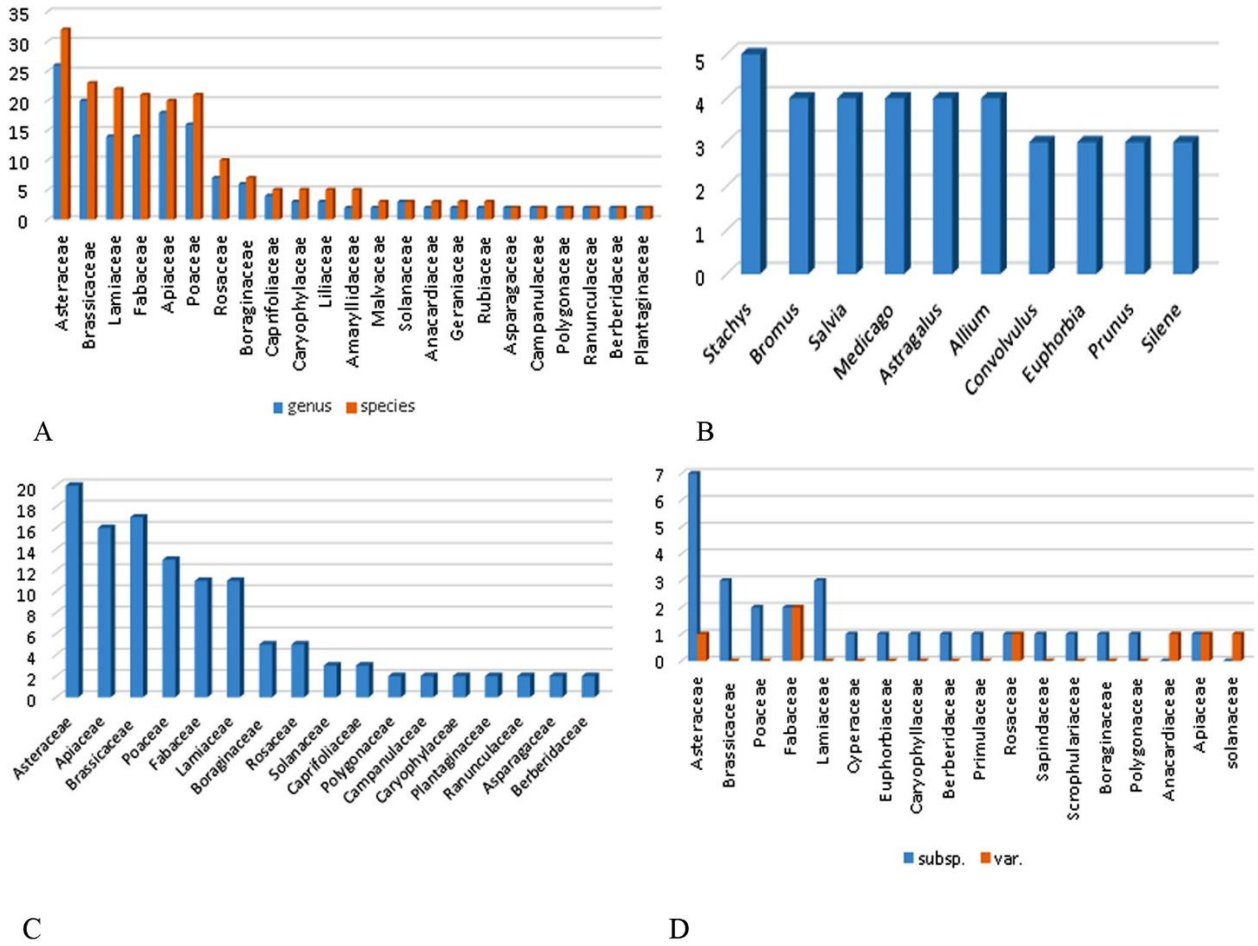

Figure 3. A. Number of genera and species in each family. B. Number of species in each genus. C. Number of the monotypic genera in each family. D. Number of subspecies and varieties in each family.

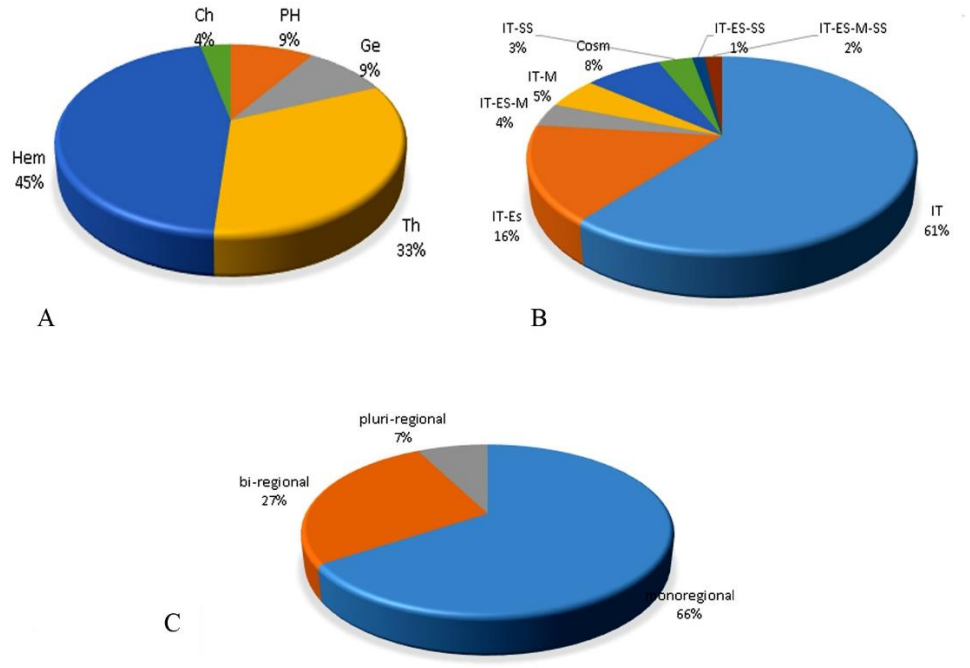

Figure 4. The proportion of: A) life form, B) geographical distribution, and C) mono-regional, bi-regional, and pluri-regional distribution.

(12%, 17 spp.), Apiaceae (12%, 17 spp.), Lamiaceae (11%, 16 spp.), Brassicaceae (8%, 11 spp.), and Fabaceae (7%, 10 spp.), respectively. The mono-regional (66%, 141 spp.), bi-regional (27%, 58 spp.), and pluri-regional (7%, 16 spp.) elements were also identified (Fig. 4).

In terms of applied plant species (Fig. 5), we recognized 157 medicinal species mostly belonging to Asteraceae (14%, 22 spp.), Lamiaceae (13%, 21 spp.), Apiaceae (11%, 17 spp.), Fabaceae (9%, 14 spp.), and Brassicaceae (8%, 12 spp.), respectively. As shown in Figure 5, a total of 67 pasture species were identified including members of Fabaceae (21%, 14 spp.), Poaceae (19%, 13 spp.), Apiaceae (16%, 11 spp.), Brassicaceae (9%, 6 spp.), and Asteraceae (6%, 4 spp.). There were 73 poisonous species in this region belonging mostly to Fabaceae (12%, 9 spp.), Asteraceae (12%, 9 spp.), Brassicaceae (10%, 7 spp.), and Lamiaceae (5%, 4 spp.).

A total of 55 Iranian endemic species were identified, most of which were members of Asteraceae (15%, 8 spp.), Lamiaceae (13%, 7 spp.), Fabaceae (13%, 7 spp.), Apiaceae (9%, 5 spp.), Rosaceae (7%, 4 spp.), Boraginaceae (7%, 4 spp.), and Brassicaceae (5%, 3 spp.), respectively. Among the endemic species we recognized 33 medicinal ones which mostly belonged to Lamiaceae (22%, 7 spp.), Asteraceae (18%, 6 spp.), Rosaceae (12%, 4 spp.), and Apiaceae (12%, 4 spp.) (Fig. 6).

The conservation statues of the studied species were: at low risk (LR, 74%, 40 spp.), data deficient (22%, 12 spp.), endangered (2%, 1 spp.), and vulnerable (2%, 1 spp.) (Fig. 7). The highest LR category belonged o the species of Fabaceae, Lamiaceae, Asteraceae, Brassicaceae and Apiaceae, respectively, while EN category was only observed in Alliaceae (Fig. 7).

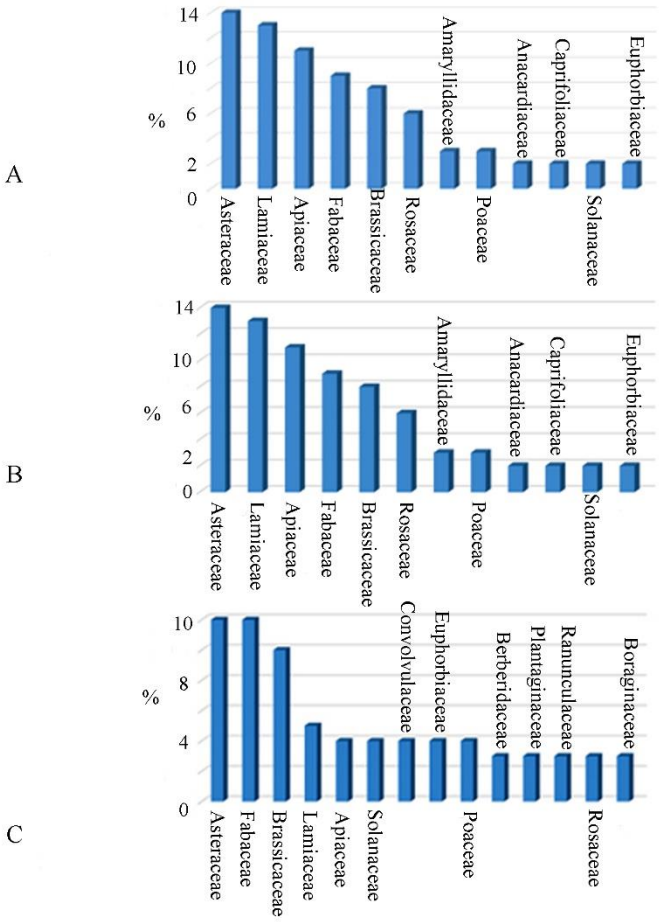

Figure 5. Proportion of economic plant species in large families. A. Medicinal, B. Pasture, and C. Poisonous.

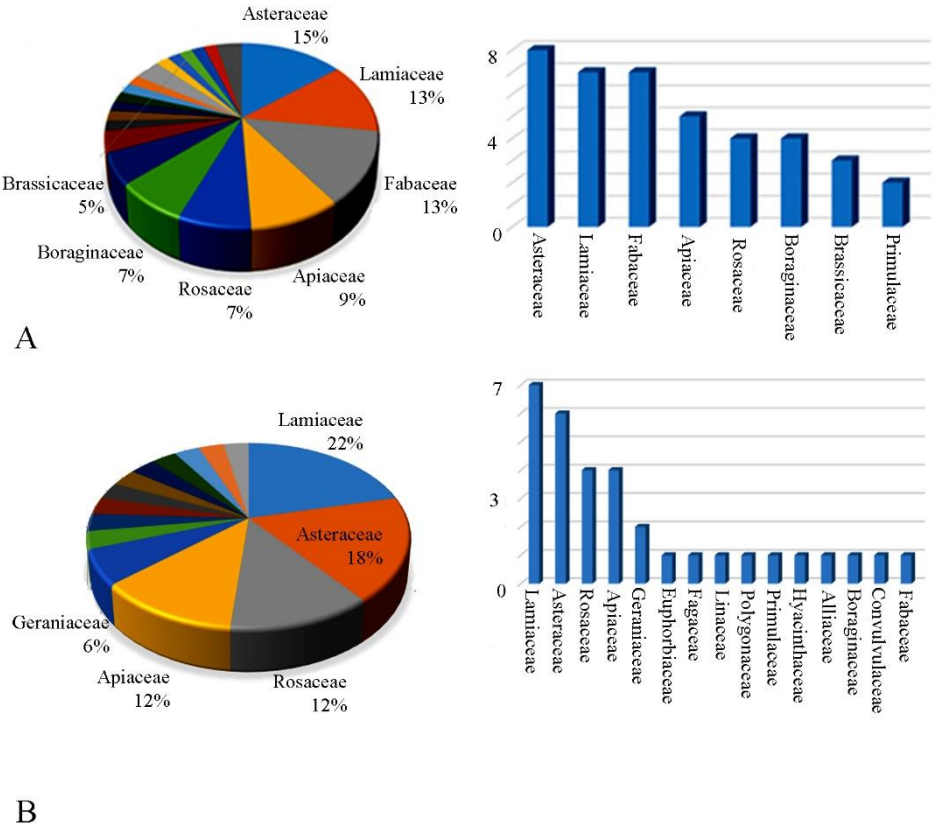

Figure 6. Percentage of: A. endemic species, and B. endemic-medicinal species.

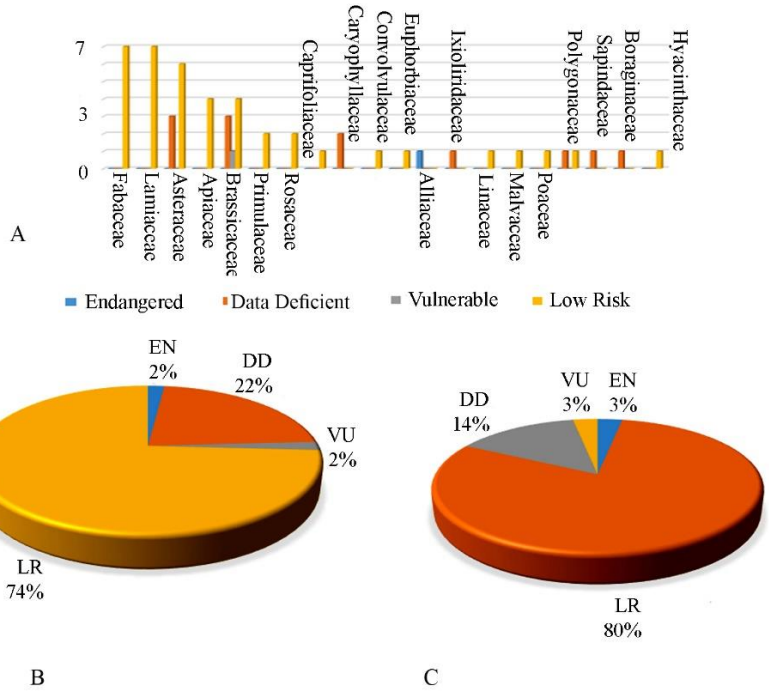

Figure 7. A, B. Conservation status in some important plant families in the area in species number and percent, and C. The percentage of conservation status among the endemic species.

Discussion

In this study we recognized 235 species, 28 subspecies, and 7 varieties assigning to 184 genera, and 52 families from three areas in Ludab region which cover an area of 87,715 km^2. Previous floristic researches from selected regions in Kohgiluyeh and Boyer-Ahmad province reported 295 species in Saverz Mountains (11), 929 species in Yasuj region (9), and 279 species in Meymand protected region (10). Our study reveals that Ludab region is also species rich, although the area of this region is less than other regions covered in previous analyses (9-11). Most probably the wide altitudinal range, precipitation fluctuation along topological gradients, and ecological variations influenced the diversity and richness of species in Zagros Mountains (4, 12). Asteraceae, Brassicaceae, Lamiaceae, Fabaceae, and Apiaceae were the largest families in terms of species number in the studied region, respectively, which is in accordance with previous results (9-10, 12). High presence of Asteraceae with many ruderal representatives in the region is probably correlated with destruction of the area, evolutionary factors, high species number of the family worldwide, adaptability of its members to cold mountains, effective seed dispersal, and resistance against grazing (4, 9-10). The high number of species belonging to both Lamiaceae and Fabaceae can be attributed to favorable edaphic conditions for members of these families (19, 37). The genera *Stachys*, *Astragalus*, *Medicago*, *Salvia* and *Bromus* as the most species rich genera in the area were also reported to be important components of Zagros Mountains (4, 11-12).

The presence of several monotypic genera in our area indicates the importance of its flora to house taxa with unique morphological traits that could be of evoulutionary importance (Fig. 3). These results are in accordance with previous reports from Zagros region (12, 19).

The high frequency of hemicryptophytes among the life forms recognized, is most probably due to the cold mountainous climate (38) in most parts of the area which is again in accordance with previous reports from Zagros Mountains (4, 9-10). The high presence of therophytes is also indicative of inappropriate conditions in this region including short favorable growing time, low precipitation, and highland conditions (39). Other life forms such as geophytes and chamaephytes were present with lowest frequency, probably due to extreme soil erosion in this region by natural or antropogenic factors (41-42). The low quantity of phanerophyte life form (9%) in the studied area can probably be explained by geographical position, high mean altitude, and high temporal and spatial fluctuations in temperature (43).

The chorotype assessment results show our area as a typical Irano-Turanian vegetation of high-altitudes (9-10, 36) since more than half of the species (141 spp.) are Irano-Turanian elements. The genera *Achillea* L., *Allium* L., *Anthemis* L., *Astragalus*, *Cousinia* Cass., *Centaurea* L., *Phlomis* L., *Silene* L., and *Stachys* are some indicators of this vegetation unit (45-46). The presence of bi-regional (58 spp.), and pluri-regional (16 spp.) in Ludab region is in accordance with previous floristic reports in Zagros Mountains (4).

The presence of some typical species including *Pistacia khinjuk* Stocks, *P. atlantica* Desf. and *Prunus scoparia* (Spach) C.K.Schneid. are known to characterize the Irano-Armenia subprovince of the Irano-Turanian region. In addition, *Quercus brantii* Lindl. as the dominant species of Zagros forests as well as *Acer monspessulanum* L. and *Daphne mucronata* Royle are indicative elements of Kurdistan-Zagros subprovince (46-47). The frequent presence of *Alhagi maurorum* Medik. and *Euphorbia* spp. in our samples shows the intensity of disturbance in the studied area. Some representatives of cold climates among studied species are: *Aethionema grandiflorum* Boiss. & Hohen., *Allium jesdianum* Boiss. & Buhse, *Arnebia hispidissima* (Lehm.) A.DC., *Brossardia papyracea* Boiss., *Bunium elegans* (Fenzl) Freyn, *Colchicum persicum* Baker, *Echinophora cinerea* (Boiss.) Hedge & Lamond, *Eryngium billardierei* Delile, *Grammosciadium scarbidum* Boiss., *Inula britanica* L., *Mathiola ovatifolia* Boiss., *Neslia paniculata* (L.) Desv., *Onopordum leptolepis* DC., and *Solenanthus circinatus* Ledeb. (10-11).

Existence of 55 Iranian endemic species illustrates the special value of this region for protection management strategies. In addition, a total of 297 potentially applied plant species were identified in this region which is in agreement with previous investigations on Zagros Mountains and indicate the potentials as well as risks in conservation strategies of this region. The

presence of medicinal, pasture, and poisonous plants in plant families Lamiaceae, Fabaceae, Brassicaceae, Apiaceae, Asteraceae, Euphorbiaceae, and Poaceae was also reported in previous studies on Zagros Mountains (12).

Conclusion

Ludab region has valuable genetic resources with a high percentage of endemic, endemic-medicinal, medicinal, pasture, and poisonous plants. Although some of plant families are in good conditions from a conservation point of view, they need more attention in terms of natural resources management. Destruction of habitats as a result of drought, erosion, competition, overgrazing, urban development, usage of human and animals, as well as inappropriate climate conditions are the major risk factors threatening the vegetion of this area. Accordingly, we suggest performing some measures such as preservation of seed of the endemic and threatened species and establishing a seed bank for such plants. Leaving some area in this region for protection or performing a conservation plan, as well as management of natural resources to prevent grazing and erosion would be other options for saving the natural vegetation in this area.

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Editorial Note

Volume 7, issue 2 of Progress in Biological Sciences was initialy scheduled to be published in December 31, 2017. However, some administrative changes leaded to a major delay in processing of the manuscripts. This issue is actually published in May 1, 2020. Editor-in-chief apologizes deeply for any inconvenience caused especially to the authors.