

**Alpine flora of Hezar mountain (SE Iran)****بررسی فلور آلبی کوه هزار، جنوب شرق ایران\***

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**Abstract**

Iran is a mountainous country. Hezar Mt., is an isolated mountain with the highest peak of 4465 m (above sea level) located in southeast of Iran. This paper aims to provide a general overview of alpine phytodiversity of Hezar Mt. Alpine regions are above timber-line which is dependent on the climate, slopes and human activities. The timberline at Hezar Mt., is varying from 3200 m (North slope) to 3,350 m (South slope). In this study, 208 species belonging to 122 genera and 39 families are known from the subalpine and alpine zone of Hezar. Hemicryptophytes dominate in the alpine belt (67%) and chamaephytes constitute 15% of the alpine flora, most of them are thorny cushions. Species number declines remarkably with increasing altitude whereas proportion of endemism is increasing. The altitudinal maximum record for the flowering plants is 4450 m. The phytogeographical analysis shows that about 46% (97 species) of the alpine flora of Hezar are Iranian endemic and subendemic and the origin of alpine flora of Hezar is Irano-Turanian. Some useful alpine species and some threatening factors to environment are also mentioned.

**Keywords:** Alpine flora, endemism, Hezar Mt., phytogeography, vegetation

**خلاصه**

ایران یک کشور کوهستانی است. کوه هزار با ۴۴۶۵ متر ارتفاع (بالتر از سطح دریا) در جنوب شرق ایران واقع شده است. هدف از این مقاله آرایه یک دیدگاه کلی از تنوع گیاهی آلبی کوه هزار می‌باشد. ناحیه آلبی (کوهستانی) که بالای خط درختی (خط فرضی که بالای آن هیچ درختی رشد نمی‌کند) واقع شده به عواملی چون آب و هوا، شیب و اثرات انسانی بستگی دارد. خط درختی در کوه هزار از ۳۲۰۰ متر (در شیب شمالی) تا ۳۳۵۰ متر (در شیب جنوبی) متغیر است. در این مطالعه، ۲۰۸ گونه گیاهی متعلق به ۱۲۲ جنس و ۳۹ تیره از ناحیه آلبی و نیمه‌آلبی کوه هزار شناسایی گردید. شصت و هفت درصد گیاهان ناحیه آلبی همی‌کریپتوفیت و ۱۵٪ کامفیت بودند و بیشتر آن‌ها را گونه‌های پشته‌ای خاردار تشکیل می‌دهد. تعداد گونه‌ها با افزایش ارتفاع کاهش می‌یابد اما درصد بومزادی با بالا رفتن ارتفاع افزایش نشان می‌دهد. حداکثر ارتفاع ممکن برای رویش گیاهان گلدار ۴۴۵۰ متر گزارش شد. الگوی پراکنش جغرافیایی فلور ناحیه آلبی کوه هزار نشان داد حدود ۴۶٪ (۹۷ گونه) اندمیک و نیمه‌اندمیک ایران می‌باشند و منشأ فلور آلبی کوه هزار ایران-تورانی است. برخی گونه‌های مفید آلبی و نیز برخی عواملی که محیط را تهدید می‌کنند، ذکر می‌شوند.

**واژه‌های کلیدی:** بومزادی، پوشش گیاهی، جغرافیای گیاهی، فلور، کوه هزار

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## Introduction

Iran is a country with high mountains. A number of well adopted groups of plants occupy alpine zone of Iran mountains. Flora and vegetation of Iran alpine zone have been poorly studied. The alpine zone is the area between the upper limit of trees (timberline) and the lower limit of permanent snow. In Iran timberline is around 3000 m above sea level and varies in the range of 2200–3600 m. This variation is caused mainly by climate, grazing and human activities.

The area under study with 900 km<sup>2</sup> is located in the southeast of Iran (Fig. 1). This area is situated at latitude 29°27'00"- 29°33'00" N and longitude 57°15'00"- 57°24'00" E (Fig. 2). Hezar is an isolated mountain with the highest peak of 4465m altitude. It is the fourth highest summit in Iran. The nearest main mountains to Hezar are Lalezar with the highest peak of 4351 m in the West and Jupar with the highest peak of 4135 m in the North. The alpine zone in Hezar lies between ca. 3200–4450 m.

The first floristic data on the Hezar Mt. area dates backs to Bornmüller (1892–1893) (Bornmüller 1911, 1937, 1938, 1940, 1942). The next investigation of flora and vegetation of this region goes back to Rechinger who have collected many plants from the area (Rechinger 1963–2010). In the past two decades, a number of Iranian botanists have also investigated this area and published their own studies, such as Mirtadzadini (2004), Ajani *et al.* (2010), and Noroozi *et al.* (2010).

The aim of this project was to determine the subalpine and alpine flora of Hezar with special reference to phytogeography, vegetation and endemism. Ecological conditions seem to play an important role in the diversification and adaptation of plant groups and their life forms.

## Materials and Methods

In order to study the alpine flora of Hezar, firstly, data such as meteorological records, topographic maps and geological characteristics were gathered. The different slopes of Hezar were also investigated and the specimens were collected during 2008–2010 between

March and October in each year. The specimens were prepared according to established herbarium techniques. The plant samples were identified according to Flora Iranica (Rechinger 1963–2010), Flora of Iran (Assadi *et al.* 1988–2009), Flora of Iraq (Townsend *et al.* 1966–1985) and Flora of Turkey (Davis 1965–1980). All original specimens are kept in the Avicenna Herbarium of Islamic Azad University, Science and Research branch, Tehran (IAUH).

The whole Flora Iranica (Vols 1–178) was reviewed and all previous records of Hezar were extracted. The flora of alpine and subalpine are listed in Appendix 1. Phytogeographical patterns and endemism proportion were determined according to Flora Iranica (Rechinger 1963–2010) and Red Data Book of Iran (Jalili & Jamzad 1999). The life forms are assigned according the Raunkiaer method (Raunkiaer 1934).

### - Geology

The geological combination of the area is very complicated and it is not possible to present it in a condensed form here. The reader is referred to Dimitrijevic (1973). The Early alpine orogenic events lasted from 200 Ma to around 65 Ma. Late Cretaceous movements caused the extensive volcanism during Eocene. Upper Eocene volcanic show a well developed recurrence of phases each beginning with andesite-basalt, basalt, and small amounts of alkaline rocks (trachyandesite, albite-trachyte), and ending with acidic types (mostly rhyolites and rhyogacites and their pyroclastics) containing limestone beds. Andesite-basalts are the most widespread.

### - Climate

The climatic information was obtained from the nearest meteorological station. Rayen station located ca 15 km NE of study area at 2235 m altitude. Climate of this area is arid and cold. The lowest and highest extreme temperatures are –14° C and 40° C. In most parts of Hezar, the precipitation increases by altitude. The main period of precipitation is during the late autumn, winter and early spring. The data of Rayen station at the NW of Hezar, show

that the winter rainfall comprises 56%, spring 22%, autumn 32% and the summer only 1% of the annual precipitation. Average number of frost days counts 73 with a maximum during January. Ecological climate diagram shows that the period of aridity of this area starts from late April and continues to end of November. The period of humidity is between November and early April (Fig. 3).

## Results and Discussion

### - Flora

The number of known plant species in Iran is nearly 7,300 species (Akhani 2006). A first evaluation of the alpine species shows that 682 species belonging to 193 genera and 39 families are known from the alpine zone of Iran (Noroozi *et al.* 2008). About 400 taxa were collected from Hezar mountain. Of these, 208 species from 39 families and 122 genera were recorded from the alpine zone (Appendix 1). Previously 94 taxa have been reported by Bornmüller (1892–93) and Rechinger (1963–2010) in the Flora Iranica. Of these, nine taxa exclusively collected by Bornmüller (1892–93) and Rechinger (1963–2010) that is marked with two asterisks in Appendix 1.

Here we report 119 taxa as new records for Hezar alpine flora. *Asteraceae* (17 genera, 31 species) is the most common angiosperm family in the Hezar alpine flora, followed by *Fabaceae* (5 genera, 26 species), *Caryophyllaceae* (6 genera, 18 species), *Lamiaceae* (9 genera, 17 species), *Scrophulariaceae* (5 genera, 14 species), *Brassicaceae* (12 genera, 12 species), *Apiaceae* (8 genera, 9 species), respectively. The genera with the greatest number of taxa are *Astragalus* with 21, *Nepeta* 8, *Veronica* 8 and *Silene* with 6 species. So far, nearly 800 species of *Astragalus* have been reported from Iran with an endemic rate of nearly 65% (Maassoumi 2005). Comparison of Hezar alpine flora with Himalayan flora indicates that about 30% of species (58 taxa) in Hezar have in common with Himalaya (<http://mercury.bio.uaf.edu>).

### - Noteworthy reports

*Tanacetum fisherae* Aitch. & Hemsl. was previously reported from northeastern and central Afghanistan and Pakistan (Rechinger 1987). During this study, it was

identified from West and East slopes of Hezar mountain (3400–3800 m). *Tanacetum fisherae* is closely related to *T. pamiricum* (O. Hoffm.) Bornm. (IAUH-537) (Fig. 4).

*Nepeta* L. is the largest genus of *Lamiaceae* in Iran with 75 species (Jamzad *et al.* 2003), 21 species are known from alpine area (Noroozi *et al.* 2008). It is an Irano-Turanian element and Iran is one of the centers of diversity for the genus.

*Nepeta natanzensis* Jamzad was described firstly from Karkas mountain (3300 m) in Esfahan province (Jamzad 2006). It belongs to the natural group of species placed in sect. *Capituliferae*. The characteristic features of the species in this group are the capitates inflorescence, the curved corolla tube and the calyx with an oblique throat. In this paper *Nepeta natanzensis* is reported from west slope of Hezar (4000–4400 m) in Kerman province after its first record from type locality (IAUH-673) (Fig. 5b).

*Silene daenensis* Melzh. (sect. *Auriculatae*) was reported for the first time only from the SW of Iran, Daena Mt. (Rechinger 1988). In this study it is reported from SE of Iran, Hezar Mt. (4000–4450 m) for the second time for the alpine flora (IAUH-595).

### - Phytogeography

About 24% of species of Iranian vascular plants are endemic (Akhani 2006). Almost 22.5% of Iran endemic species are restricted to alpine life zone. Approximately 58% of alpine species are endemic and subendemic for Iran (Noroozi *et al.* 2008). The results in this paper showed 46% of Hezar alpine species are Iranian endemic and subendemic.

Phytogeographical studies show that the origin of Hezar alpine flora is Irano-Turanian. This result is according to previous investigations (Zohary 1973, Noroozi *et al.* 2008). The alpine zone in Hezar is between 3200–4450 m. Vascular plants seem to reach their maximum altitudes in the Himalayas, where *Stellaria clecumbens* occurs at 6135 m. (Swan 1961). The altitudinal maximum record for the flowering plants in Hezar is ca. 4450 m and includes the species such as *Ranunculus eriorrhizus* (4455 m), *Potentilla nuda* (4440 m), *Nepeta natanzensis* (4400 m), *Astragalus tenuiscapus* (4420 m) and *Gagea allexii* (4455 m).

The chorology of alpine species of Hezar could be classified into following subgroups:

- Euro-Siberian/Irano-Turanian species

The first group includes those species which are widely distributed from the European Alps to Iran which may also occur further east to Central Asia, Himalaya, Siberia and East Asian Mountains. Examples of widespread Euro-Siberian/Irano-Turanian species are: *Orchis coriophora*, *Artemisia tournefortiana*, *Nonnea caspica*, *Cerastium dichotomum*, *Silene viscosa* subsp. *viscosa*, *Chenopodium foliosum* subsp. *foliosum*, *Krascheninnicovia ceratoides*, *Juniperus excelsa*, *Centurium pulchellum*, *Marrubium anisodon*, *Draba aucheri* and *Ceratocephalus falcata*.

- Widespread Irano-Turanian species

Some are widespread species from Central Anatolia and/or Caucasus to Afghanistan, and sometimes Central Asian mountains and Himalaya such as *Psychrogeton amorphoglossus*, *Veronica biloba*, *Asperula glomerata* subsp. *filiformis*, *Piptatherum publiflora*, *Piptatherum molinioides*, *Ribes orientale*, *Biebersteinia multifida*, *Epilobium minutiflorum*, *Astragalus siliquosus*, *Carex songorica*, *Allium cathadicarpum*, *Silene coniflora*, *Silene conoidea*, *Dianthus orientalis*, *Cerastium inflatum*, *Lepyrodiclis holosteoides* and *Onobrychis cornuta*.

- Irano-Afghanistan or Irano-Afghanistan and Himalayan and Central Asian species

The third group represents species which are common species between mountains in East and SE Iran and Afghanistan and sometimes Himalaya and Central Asia. They are: *Ferula hezar-lalehzarica*, *Bromus gracillimus*, *Oxytropis hirsutiuscula*, *Trachydium depressum*, *Gagea exilis*, *Graellsia saxifragifolia*, *Cousinia lasiolepis*, *Primula capitellata*, *Tanacetum pamiricum*, *Tanacetum fisherae*, *Salvia rhytidea*, *Artemisia persica*, *Rhamnus prostrata*, *Levisticum officinale*, *Lepyrodiclis stellarioides*, *Polygonum rottboellioides*, *Cirsium bracteosum*, *Cirsium arvense* and *Arnebia euchroma*.

The third group shows that there is high similarity between flora of Hezar and Afghanistan and sometimes Himalaya and Central Asia. On the other hand, there is no continuous mountain chain between Hezar and these

mountains, so some of these species show interesting disjunctions such as *Cousinia lasiolepis*, *Primula capitellata*, *Tanacetum pamiricum*, *Tanacetum fisherae*, *Salvia rhytidea*, *Artemisia persica*, *Psychrogeton alexeenkovi* and *Rhamnus prostrata*. It seems during postglacial the elevation of the alpine belt rose and these species became disjuncted (Noroozi et al. 2008). An interesting example of a similar link was shown by the distribution range of the isolated species *Levisticum officinale* W.D. Koch. (Rechinger 1987). This species with a main range in E Afghanistan shows disjunct occurrence only on Hezar mountain.

*Gagea alexii* Ali & Levichev was described from northern Pakistan (Chitral, including boundary area with Afghanistan) and eastern Tajikistan. This species was recently collected for the first time from the subnival zone of the Hezar mountain, southern Iran (Kerman province) (Ajani et al. 2010). The presence of these species in the alpine zone of the Hezar Mt. shows floristic affinities of Hezar Mt., with the Hindu Kush and Central Asia especially in high altitudes.

- **Endemic species**

Hezar mountain is characterized by a very rich flora with high number of endemic and subendemic species. This is because of the geographical isolation of this mountain system. Approximately 46% (95 species) of Hezar alpine flora are Iranian endemic and subendemic. Proportion of endemics in the alpine zone of Alborz is ca. 32%, Zagros 46%, Hindu Kush 20%, 12% in the Pyrenees and 10% in the Alps. The result supports the hypothesis that the proportion of endemism increases with increasing altitude (Vetaas & Grytnes 2002, Paulli et al. 2003) whereas in Hindu Kush mountains endemism decreases with increasing elevation (Breckle 1974). The number of species decreases from 85 species in 3200 m to 6 species above 4400 m (Fig. 6). In Hezar mountain, genera with high endemic and subendemic proportion are *Acantholimon* (5 species, 100%), *Nepeta* (8 species, 100%) and *Astragalus* (14 species, 70%) respectively (Appendix1).

## - Vegetation

Timberline in Iran mountains is not dense at all places (Noroozi *et al.* 2008). In Iran timberline is around 3200–3600 m compared to eastern neighboring mountain systems: Hindu Kush 3500 m, Pamir mountains 4000 m and Europe mountains such as: Pyrenees 2300 m and Alps 3000 m (Gomez *et al.* 2003).

In general, altitude of timberline decreases from south (3350 m) to north (3200 m) in Hezar (Fig. 7). The lower limit of the alpine zone in Hezar is 3200 m. The *salix alba* tree line ranges from 3000 m to 3200 m. Several shrubby species, such as *Amygdalus*, *Berberis*, *Rosa*, *Cotoneaster* and *Lonicera* forming the lower limit of alpine belt. In upper limit, treeline ends to scattered *Juniperus excelsa* and *Ribes orientale*. Species richness and vegetation cover are decreasing by increasing altitude in Hezar.

### - Vegetation zone in Hezar mountain:

The subalpine-lower alpine zone (3000–3600 m): This zone is covered by different tall umbelliferous genera like *Dorema*, *Ferulago* and *Ferula* (Fig. 8b). *Artemisia aucheri* is a dominant species with high cover-abundance in this zone. Other dominant species of these vegetation types in Hezar are: *Cirsium bracteosum*, *Hertia intermedia*, *Astragalus* and *Euphorbia* spp.

The lower alpine-upper alpine zone (3600–4000 m): The general appearance of this zone is organized by large thorn cushion plants. The prominent species of these vegetation types are: *Astragalus hazarensis*, *Astragalus schistocalyx*, *Acantholimon haesarensense*, *Onobrychis cornuta* and *Semenovia suffruticosa* communities (Fig. 8a). Other dominant species of this zone are *Levisticum officinale*, *Scrophularia subaphylla*, *Artemisia persica*, *Nepeta assurgens*, *Nepeta daenensis*, *Linaria lineolata*, *Ziziphora clinopodioides* and *Salvia rhytidea*. These areas are free of snow for a longer period compared with higher altitude vegetations. Slopes are often steep and are often dominated by screes.

The rocky habitats of lower alpine-upper alpine areas are covered by species such as *Corydalis rupestris*, *Graellsia saxifragifolia*, *Psychrogeton* spp., *Arnebia euchroma*, *Rosularia modesta* and *Parietaria judaica*. Life

forms of these species are restricted to chamaephytes and hemicryptophytes. Plant cover and richness are low.

The upper alpine-subnival zone (4000–4450 m): This region is covered by snow up to the early summer. *Thymus carmanicus* communities with high cover-abundance are dominant in upper alpine-subnival zone. Species like *Allium lalezaricum*, *Gagea* spp., *Veronica kurdica* subsp. *filiacaulis* and *Astragalus abditus* are scattered among *Thymus* communities as companion species. *Ranunculus eriorrhizus* is the dominant species in the subnival zone in Hezar. Other important species are: *Asperula glomerata*, *Astragalus tenuiscapus*, *Potentilla nuda*, *Draba aucheri*, *Tanacetum pamiricum*, *Veronica kurdica* subsp. *filiacaulis* and *Nepeta natanzensis*. These species are restricted to chamaephytes and hemicryptophytes dominated vegetation types.

Screes are the major habitats of the upper alpine-subnival zone in Hezar and the other high mountains. *Cicer tragacanthoides*, *Asperula glomerata*, *Astragalus tenuiscapus*, *Silene daenensis*, *Gagea alexii* and *Nepeta natanzensis* are important species of Hezar scree habitats. The species richness of these habitats is very low.

Wetland habitats extend from lower treeline (2800 m) to almost 4000m in south slope in Hezar. The dominant species of these habitats is *Mentha longifolia* with high cover-abundance. Other dominant species are: *Artemisia tournefortiana*, *Primula capitellata*, *Carex songorica*, *Glaux maritima*, *Orchis coriophora*, *Taraxacum* spp and *Veronica anagalis-aquatica*.

Hezar vegetation types are similar to the formation of Alborz and Zagros mountains (Noroozi *et al.* 2008), and Middle Asia (Ahmadov *et al.* 2006).

### - Life form

Wind is an ever-present environmental factor in alpine zone. Although wind speed is greatly reduced near the ground, the low stature and sparse cover of the vegetation enable the wind to be more effective compared with taller and more stratified vegetation. Many alpine plants have wiry, tough branches with densely packed leaves at the tips to reduce wind battering. Their leaves are also generally small and tough, which makes them less

easily frozen or dried out and less likely to be damaged by wind, hail and snow. Hairs on the leaves prevent air movement over the leaf surface and thereby protect the leaves from the cold (Billings *et al.* 1959).

Hemicryptophytes and Chamaephytes are dominant in the alpine and subalpine zone of Hezar mountain.

The life forms of alpine species of Hezar could be classified into following subgroups:

**Hemicryptophytes:** Hemicryptophytes dominate in the alpine area (67%). It is represented by species such as *Arnebia euchroma*, *Paracaryum rugulosum*, *Thymus carmanicus*, *Nepeta natanzensis*, *Silene daenensis*, *Veronica kurdica*, *Astragalus tenuiscapus*, *Ferulago angulata*, *Levisticum officinale*, *Piptatherum molinioides*, *Melica persica* and *Carex distans*.

**Chamaephytes:** Chamaephytes involve 15% of the alpine and subalpine flora; most of them are thorny cushions. Cover of these forms is high in most of the habitats. They may be thorny like *Onobrychis cornuta*, *Acantholimon haesarense* and *Acantholimon modestum* or not spiny like *Astragalus ajubensis*, *Cicer tragacanthoides*, *Cirsium bracteosum*, *Euphorbia hebecarpa*, *Scutellaria multicaulis*, *Artemisia tournefortiana*, *Hertia intermedia*, *Semenovia suffruticosa* and *Verbascum haesarense*.

**Phanerophytes:** Phanerophytes have low frequency and consist of species like *Juniperus excelsa*, *Salix alba*, *Rhamnus prostrata*, *Ribes orientale*, *Cotoneaster nummularia*, *Cotoneaster persica*, *Lonicera nummulariifolia*, *Rosa beggeriana*, *Berberis integerrima* and *Amygdalus eburnea*.

**Geophytes:** Geophytes mainly belong to *Liliaceae*, *Alliaceae* and *Geraniaceae*. It composes 5% of Hezar alpine and subalpine flora. Species like *Allium lalesaricum*, *Allium cathadicarpum*, *Gagea exillis*, *Gagea stipitata*, *Tulipa biflora*, *Colchicum schimperi*, *Biebersteinia multifida*, *Potentilla nuda*, *Geranium tuberosum* and *Ranunculus eriorrhizus*.

**Therophytes:** Annual species compose about 10% of the Hezar alpine and subalpine flora. Therophytes decrease with increasing altitude and become quite rare in high altitude (Körner 1999). Species like *Nepeta bornmulleri*, *Nepeta ispahanica*, *Bromus gracillimus*, *Veronica biloba*, *Veronica*

*rubrifolia*, *Callipeltis cucullaris*, *Galium aparine*, *Cerastium dichotomum*, *Cerastium inflatum* and *Cerastium holosteoides* are reported from the region.

- Useful alpine species

Alpine habitats are favorable habitats for collection of medicinal plants. A number of 87 medicinal species were reported by informants in the region. These species belong to 76 genera and 35 families. The useful alpine species of Hezar could be classified into following subgroups:

- Plants of medicinal uses: *Arnebia euchroma* (Royle) Jonst. (*Boraginaceae*) (Local name: Havachue) is a perennial plant of the alpine region distributed in Persia, Pamir, the Tien Shan, the Himalaya and western Tibet between an altitudinal range of 3700–4200 m above sea level (Manjkhola 2005). Local people of Hezar Mt., use the roots of it as poultice for fracture, contusion and sedative. Shikonin and its derivatives extracted from the roots of *A. euchroma* have been known since ancient times and used as dyes for silk and food products. Shikonin, possesses antibacterial, antifungal, anti-inflammatory and wound healing properties. The species is also used in various diseases of the tongue and throat as well as fevers and cardiac disorders. Furthermore, *A. euchroma* exhibits potent anti-HIV activity (Kashiwada *et al.* 1995).

*Levisticum officinale* W.D. Koch. (*Apiaceae*) (Local name: Karafs) is a perennial plant of the alpine region distributed in the SE Iran (Hezar Mt.) and E Afghanistan. The roots, leaves and fruits are used in the treatment of stomachache, kidney stones, diabetes by local people.

*Dorema ammoniacum* (*Apiaceae*) (Local name: Eshterk) is often used internally in the treatment of chronic bronchitis (especially in the elderly), asthma and externally, it is used as a plaster for swellings of the joints.

- Plants used in veterinary: Roots of *Berberis integerrima* (Local name: Zarch) are used as intestinal vermifuge and digestive tonic for sheep and goats. Oil from the seeds of *Eruca sativa* L. used as antifungal and anti-infection for dermal problems in domestic animals. Roots of *Bryonia aspera* Steven ex Ledeb (Local name: Angoorak) are used for digestive problems for horse.

- Plants of non-medicinal uses: Some species have other uses such as wild vegetable *Dracocephalum polychaetum* as a flavor and *Levisticum officinale* as a traditional vegetable. Leaves and stems raw or cooked used as a savory flavouring in salad and soup. The leaves can be used fresh or dried and are available from late winter until late autumn.

- Nature threats

Cold-adapted alpine species are stressed by some factors such as climate warming, human activities and grazing.

Climate change poses a direct threat to alpine plants. After the Polar Regions, alpine environments are amongst those most affected by global climate change (Kullman 2004). Cold-adapted alpine species are stressed by climate warming, and more importantly, must compete with species from lower elevations extending their ranges upward. On mountains around the world, increasing temperatures force alpine plants to migrate upwards until they reach the highest elevations. Mountain ranges, where large numbers of endemic plants are distributed, are very likely to suffer critical species losses (Theurillat & Guisan 2001).

In recent years long-term drought has damaged the vegetation of Hezar northern area. In addition, overgrazing impact is increasingly threatening the fragile subalpine and alpine ecosystem in this mountain.

Over-exploitation of medicinal plants such as *Levisticum officinale*, *Thymus carmanicus*, *Arnebia euchroma*, *Dracocephalum polychaetum* and *Dorema ammoniacum* by local people, herbalist and traders, threatens rare alpine species. Many of these plants are potentially endangered and vulnerable taxa. Because alpine plants grow very slowly, they cannot quickly re-grow the lost leaves or flowers. Ultimately, alpine environments need strong management to survive, therefore, local people should be informed about threats of their environment.

Lately, a Manganese extraction factory has been established in 30 Km of NW of Hezar Mt., which pollutes the air and cause soil toxicity. It is a direct threat to fauna and flora of the region. Exposure to excessive Mn can cause toxic effects on biodiversity.

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## Appendix 1. Floristic list of Hezar Mt., alpine and subalpine flora

Species	Altitude (m)	Endemicity	Herbarium No. (IAUH)
<b>Alliaceae</b>			
<i>Allium cathadicarpum</i> Wendelbo	3000–3200, SubA.		494
<i>A. lalesaricum</i> Freyn. & Bornm.	3700–4000, A.	En (Iran)	493
<b>Apiaceae</b>			
<i>Bupleurum exaltatum</i> M. Bieb.	3200–3400, A.		496
<i>Conium maculatum</i> L.	3000, SubA.		
<i>Dorema ammoniacum</i> D. Don.*	3400, A.	En (Iran)	
<i>D. aucheri</i> Boiss.	3000–3600, A.	En (Iran)	497
<i>Ferula hezar-lalehzarica</i> Ajani*	3000–3800, A.		500
<i>Ferulago angulata</i> (Schlecht.) Boiss.	3000–3500, A.	En (Iran)	501
<i>Levisticum officinale</i> W.D. Koch.	3400–3700, A.		93801 (TARI)
<i>Semenovia suffruticosa</i> (Freyn. & Bornm.) Manden.*	3400–3800, A.	En (Iran)	502
<i>Trachydium depressum</i> (Boiss.) ssp. <i>depressum</i>	3400–4400, SubN.		502
<b>Asteraceae</b>			
<i>Aegopordon berardioides</i> Boiss.*	3400–3600, A.	SubEn	506
<i>Artemisia aucheri</i> Boiss.	3400–4000, A.	SubEn	507
<i>A. persica</i> Boiss.	3600–4400, SubN.		508
<i>A. tournefortiana</i> Reichenb.	3400, A.		509
<i>Centaurea isphahanica</i> Boiss.	3000–3300, SubA.	En (Iran)	511
<i>Chamageron asterellus</i> (Bornm.) Botsch.	3400, A.	En (Iran)	
<i>Cirsium arvense</i> (L.) Scop.*	3200, SubA.		513
<i>C. bracteosum</i> DC.*	3300–3500, A.	SubEn	514
<i>C. pyramidale</i> Bornm.*	3200–3500, A.	En (Iran)	
<i>Cousinia fragilis</i> C. Winkl. & Bornm.	3700–4400, SubN.	En (Iran)	
<i>C. hazarensis</i> Mirtadzadini & Attar*	3000–3400, SubA.	En (Hezar)	
<i>C. lasiolepis</i> Boiss.*	3300–3600, A.		516
<i>C. longifolia</i> C. Winkl. & Bornm.	3000, SubA.	En (Iran)	515
<i>C. onopordioides</i> Ledeb.*	3100, SubA.		517
<i>Echinops lalesarensis</i> Bornm.*	2800–3200, SubA.	En (Iran)	520
<i>Erigeron acer</i> L. ssp. <i>lalezaricus</i> Rech. f.	3000–3600, A.	En (Iran)	521
<i>Hertia intermedia</i> (Boiss.) O. Kuntze.	2700–3400, A.	SubEn	523
<i>Jurinea bungei</i> Boiss.*	3200, SubA.	En (Iran)	524
<i>Psychrogeton allexeenkovi</i> Krasch.	4000–4400, SubN.	SubEn	528
<i>P. amorphoglossus</i> (Boiss.) Novopokr.*	3400–4200, SubN.		529
<i>Psychrogeton chionophilus</i> (Boiss.) Krach.	3600, A.	En (Iran)	
<i>Scorzonera mucida</i> Rech. f., Aell. & Esfand.*	2800–3200, SubA.	En (Iran)	532
<i>S. pussila</i> Pall.*	2800–3200, SubA.		533
<i>S. ramosissima</i> DC.*	3000–3400, SubA.		535
<i>Senecio subnivalis</i> Y. Ajani, J. Noroozi & B. Nord.	4434, SubN.	En (Iran)	
<i>Sonchus maritimus</i> L.*	3000–3200, SubA.		536
<i>Tanacetum fisherae</i> Aitch. & Hemsl.*	3400–3800, A.		537
<i>T. pamiricum</i> (O. Hoffm.) Bornm.**	4400, SubN.		
<i>T. parthenium</i> (L.) Sch. Bip.*	3000–3200, SubA.		538
<i>Taraxacum syriacum</i> Boiss.	3000–3400, A.		539
<i>Varthemia persica</i> DC.*	3000–3400, A.	SubEn	542
<b>Berberidaceae</b>			
<i>Berberis integerrima</i> Bunge.	2800–3200, SubA.		543
<b>Boraginaceae</b>			
<i>Arnebia euchroma</i> (Royle) L.M. Johnst.*	3800–4000, A.		544
<i>Heliotropium aucheri</i> DC. ssp. <i>aucheri</i>	3000, SubA.	SubEn	547
<i>Nonnea caspica</i> (Willd.) G. Don.*	3200–3800, A.	SubEn	550
<i>N. persica</i> Boiss.*	3600–3900, A.	SubEn	551
<i>N. suchtelenioides</i> H. Riedl**	3000, SubA.	En (Iran)	
<i>Onosma stenosphon</i> Boiss.	3200–3600, A.	En (Iran)	552
<i>Paracaryum rugulosum</i> (DC.) Boiss.*	3400–4300, SubN.		553

## Appendix 1 (contd.)

**Brassicaceae**

<i>Alyssum linifolium</i> Steph. ex Willd.*	3000, SubA.		555
<i>Capsella bursa-pastoris</i> L.*	3000–3200, SubA.		558
<i>Cardaria draba</i> (L.) Desv.	2700–3200, SubA.		559
<i>Choriospora tenella</i> (Pall.) DC.*	3200–3300, SubA.		560
<i>Clypeola dichotoma</i> Boiss.*	3000–3200, SubA.		561
<i>Conringia persica</i> Boiss.*	2800–3300, SubA.		562
<i>Draba aucheri</i> Boiss.**	4000–4400, SubN.		
<i>Eruca sativa</i> Lam.*	2900–3200, SubA.		567
<i>Erysimum crassicaule</i> (Boiss.) Boiss.*	2800–3200, SubA.	En (Iran)	568
<i>Graellsia saxifragifolia</i> (DC.) Boiss.	3000–3800, A.	SubEn	571
<i>Malcolmia africana</i> (L.) R. Br.*	2800–3200, SubA.		572
<i>Robeschia schimperii</i> (Boiss.) O.E. Schulz*	3000–3400, A.		574

**Campanulaceae**

<i>Campanula kermanica</i> (Rech. f., Allen & Esfand.) Rech. f.*	3000, SubA.	En (Iran)	579
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**Caprifoliaceae**

<i>Lonicera nummularifolia</i> Jaub. & Spach.*	3200–3400, SubA.		580
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**Caryophyllaceae**

<i>Acanthophyllum bracteatum</i> Boiss.*	2800–3000, SubA.	SubEn	583
<i>A. heratense</i> Schiman-Czeika**	2900, SubA.	SubEn	
<i>A. sordidum</i> Bunge ex Boiss.*	2800–3400, A.	SubEn	582
<i>A. spinosum</i> (Desf.) C.A. Mey.*	2800–3200, SubA.	SubEn	
<i>Arenaria minutissima</i> Rech. f. & Esfand.*	3400, A.	En (Iran)	584
<i>Cerastium dichotomum</i> L.	3000–3200, SubA.		585
<i>C. holosteoides</i> Fries*	3200, SubA.		586
<i>C. inflatum</i> Link ex Desf.*	3200, SubA.		587
<i>C. umbellatum</i> Huds.*	3200, SubA.		588
<i>Dianthus macronthoides</i> Hausskn. ex Bornm.*	3200, SubA.	En (Iran)	589
<i>D. orientalis</i> Adams.*	3600–3800, A.		590
<i>Lepyrodiclis holosteoides</i> (C.A. Mey.) Fenzl ex Fisch. & C.A. Mey.	3200, SubA.		591
<i>L. stellarioides</i> Schrenk. ex Fisch. & C.A. Mey.	3000, SubA.		592
<i>Silene coniflora</i> Nees ex Otth.*	3200, SubA.		593
<i>S. conoidea</i> L.	3000, SubA.		
<i>S. daenensis</i> Melzh.*	4000–4200, SubN.	En (Iran)	595
<i>S. noctiflora</i> L.*	3000–3500, A.	SubEn	596
<i>S. nurensis</i> Boiss. & Hausskn.	3500–4000, A.	En (Iran)	
<i>S. viscosa</i> (L.) Press.	3000, SubA.		598

**Chenopodiaceae**

<i>Chenopodium foliosum</i> (Moench) Aschers*	3000, SubA.		600
<i>Krascheninnikovia ceratoides</i> Guldenst.*	3600, A.		602

**Crassulaceae**

<i>Rosularia modesta</i> (Bornm.) Janson*	3000–3400, SubA.	En (Iran)	610
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**Cucurbitaceae**

<i>Bryonia aspera</i> Stev. ex Ledeb.	3400, A.		611
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**Cupressaceae**

<i>Juniperus excelsa</i> M. Bieb.	3300–3600, A.		
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**Cyperaceae**

<i>Carex distans</i> L.*	3000, SubA.		612
<i>C. songorica</i> Kar. & Kir.**	3000, SubA.		
<i>Blysmus compressus</i> (L.) Panzer. ex Link*	3400, A.		613

**Ephedraceae**

<i>Ephedra intermedia</i> Schrank. et C.A. Mey.*	3200–3500, A.		615
<i>E. major</i> Host.*	3000–3500, A.		616

## Appendix 1 (contd.)

<b>Euphorbiaceae</b>			
<i>Euphorbia buhsei</i> Boiss.*	2800–3300, SubA.	SubEn	617
<i>E. hebecarpa</i> Boiss.	3000–3600, A.	SubEn	
<i>E. microsciadia</i> Boiss.	3000–3600, A.	SubEn	
<b>Fabaceae</b>			
<i>Astragalus abditus</i> Podlech*	3800–4200, SubN.		622
<i>A. ajubensis</i> Bunge	3200, SubA.	En (Iran)	623
<i>A. anserinifolius</i> Boiss	2800–3000, SubA.	En (Iran)	624
<i>A. boivulatus</i> Bunge	2800–3000, SubA.	En (Iran)	625
<i>A. camptoceras</i> Bunge	2800–3000, SubA.		
<i>A. cephalantus</i> DC.	3000–3400, A.	En (Iran)	626
<i>A. glaucacanthos</i> Fischer	2800–3000, SubA.	En (Iran)	629
<i>A. glucofoliolatus</i> Dieterle*	2800–3000, SubA.	SubEn	
<i>A. hezarenis</i> Zarre	3600–4000, A.	En (Hezar)	630
<i>A. horridus</i> Boiss.	2800–3000, SubA.	En (Iran)	
<i>A. huthianus</i> Freyn. & Bornm.*	2800–3000, SubA.	En (Iran)	631
<i>A. jesdianus</i> Boiss. & Buhse	2800–3000, SubA.	En (Iran)	632
<i>A. minutissimus</i> Freyn. & Bornm.**	3000, SubA.		
<i>A. oxyglottis</i> M. Bieb.	2800–3000, SubA.		633
<i>A. podolobus</i> Boiss. & Hohen.*	2800–3000, SubA.		634
<i>A. schistocalyx</i> Bunge	3500–4450, SubN.	En (Iran)	635
<i>A. siliquosus</i> Emend. Podlech.	2800–3000, SubA.		636
<i>A. spachianus</i> Boiss. & Buhse	2800–3000, SubA.	En (Iran)	637
<i>A. tenuiscapus</i> Freyn. & Bornm.*	4000–4450, SubN.	En (Iran)	639
<i>A. vicarius</i> Lipsky	2800–3000, SubA.		640
<i>Cicer kermanense</i> Bornm.	3600, A.	En (Iran)	
<i>C. tragacanthoides</i> Jaub. & Spach.*	3400–4000, A.	En (Iran)	641
<i>Colutea persica</i> Boiss.	3000–3200, SubA.	En (Iran)	642
<i>Onobrychis cornuta</i> (L.) Desv. ssp. <i>cornuta</i>	3400–3800, A.		647
<i>Oxytropis hirsutiusscula</i> Freyn.**	3000, SubA.		
<i>O. heratensis</i> Bunge**	3000, SubA.	SubEn	
<b>Fumariaceae</b>			
<i>Corydalis rupestris</i> Ky.*	3000–3400, A.	SubEn	651
<i>Fumaria asepsala</i> Boiss.	3000–3400, A.		652
<b>Gentianaceae</b>			
<i>Centurium pulchellum</i> (Swartz.) Druce**	2800–3000, SubA.		
<b>Geraniaceae</b>			
<i>Biebersteinia multifida</i> DC.*	3000–3400, A.		653
<i>Geranium tuberosum</i> L.*	3000, SubA.		655
<b>Grossulariaceae</b>			
<i>Ribes orientale</i> Desf.	3400–4000, A.		656
<b>Juncaceae</b>			
<i>Juncus inflexus</i> L.	3000–3400, SubA.		658
<b>Lamiaceae</b>			
<i>Dracocephalum polychaetum</i> Bornm.	3200–3600, A.	En (Iran)	659
<i>Lamium amplexicaule</i> L.*	3200, SubA.		661
<i>Marrubium anisodon</i> C. Koch	3600, A.		662
<i>Mentha longifolia</i> (L.) Hudson	3000–4000, A.	En (Iran)	
<i>Nepeta assurgens</i> Hausskn. & Bornm.*	3200–4000, A.	En (Iran)	664
<i>N. bornmulleri</i> Hausskn. ex Bornm.	3400, A.	En (Hezar)	666
<i>N. daenensis</i> Boiss.*	4000, A.	SubEn	667
<i>N. glomerulosa</i> Boiss. ssp. <i>carmanica</i> (Bornm.) Rech. f.	3000–3800, A.	En (Iran)	669
<i>N. glomerulosa</i> Boiss. ssp. <i>glomerulosa</i>	3000–3800, A.	En (Iran)	
<i>N. mahanensis</i> Jamzad & Simmonds*	3000, SubA.	En (Iran)	671

## Appendix 1 (contd.)

<i>N. natanzensis</i> Jamzad*	4000–4400, SubN.	En (Iran)	673
<i>N. persica</i> Boiss.*	3400, A.	SubEn	674
<i>N. saccharata</i> Bunge*	3000–3200, SubA.	SubEn	675
<i>Salvia nemerosa</i> L.*	3200, SubA.		677
<i>S. rhytidea</i> Benth.	3400–3800, A.	SubEn	678
<i>Scutellaria multicaulis</i> Boiss.*	3400–3800, A.	SubEn	679
<i>Thymus carmanicus</i> Jalas	3600–4200, A.	SubEn	680
<i>Ziziphora clinopodioides</i> Lam.	3600, A.	SubEn	681
<b>Liliaceae</b>			
<i>Colchichum schimperi</i> Janka.*	3400, A.		683
<i>Eremurus persicus</i> (Jaub. & Spach) Boiss.	3000–3500, SubA.		684
<i>Gagea exillis</i> Vved.*	3000, SubA.		685
<i>G. alexii</i> Ali & Levichev*	4450, SubN.		
<i>G. stipitata</i> Merckl. ex Bunge*	4000, A.		687
<i>Tulipa biflora</i> Pall.*	3000–4440, SubN.		689
<b>Onagraceae</b>			
<i>Epilobium minutiflorum</i> Hausskn.	3000, SubA.		693
<b>Orchidaceae</b>			
<i>Orchis coriophora</i> L.*	3200, SubA.		695
<b>Papaveraceae</b>			
<i>Papaver fugax</i> Poir*	3800, A.		700
<b>Plantaginaceae</b>			
<i>Plantago gentianoides</i> Sibth. & Sm.	3400, A.		702
<b>Plumbaginaceae</b>			
<i>Acantholimon chlorostegium</i> Rech. f. & Schiman-Czeika*	3000–3400, A.	En (Iran)	704
<i>A. haesarense</i> Bornm. ex Rech. f. & Schiman-Czeika	3800–4200, A.	En (Hezar)	705
<i>A. modestum</i> Bornm. ex Rech. f. & Schiman-Czeika*	3800–4200, A.	En (Iran)	706
<i>A. scorpius</i> (Jaub. & Spach) Boiss.*	3200–3500, A.	En (Iran)	707
<i>A. serotinum</i> Rech. f. & Schiman.-Czeika*	3200–3400, A.	En (Iran)	708
<b>Poaceae</b>			
<i>Bromus gracillimus</i> Bunge.*	3000–3400, SubA.		712
<i>Calamagrostis pseudophragmites</i> (Hall. F.) Koel.*	3200–3600, A.		715
<i>Melica persica</i> Kunth.*	3000–3600, A.		719
<i>Piptatherum molinioides</i> Boiss.*	3200–3800, A.		720
<i>P. publiflora</i> Hack.	3000–3400, A.		721
<i>Psathyrostachys fragilis</i> (Boiss.) Nevski.*	3000–3400, SubA.		724
<i>Stipa parviflora</i> Desf.*	3000–3400, SubA.		725
<b>Polygonaceae</b>			
<i>Polygonum dumosum</i> Boiss.*	3400–3800, A.		727
<i>P. rottboellioides</i> Jaub. & Spach.*	3500–4000, A.		728
<b>Primulaceae</b>			
<i>Glaux maritima</i> L.*	3000–3200, SubA.		732
<i>Primula capitellata</i> Boiss.	3200–3400, A.	SubEn	733
<b>Ranunculaceae</b>			
<i>Adonis aestivalis</i> L.	2800–3200, SubA.		734
<i>Ceratocephalus falcata</i> (L.) Pers.*	3200–3400, SubA.		735
<i>Clematis ispanhanica</i> Boiss.*	3000, SubA.		736
<i>Ranunculus eriorrhizus</i> Boiss. & Buhse*	3700–4450, SubN.	En (Iran)	739
<b>Rhamnaceae</b>			
<i>Rhamnus prostrata</i> Jacquem. ex Parker.*	3400–3600, A.		741
<b>Rosaceae</b>			
<i>Amygdalus eburnea</i> Spach.*	3000–3400, SubA.	En (Iran)	742

## Appendix 1 (contd.)

<i>A. elaeagnifolia</i> Spach.	3000–3400, SubA.	En (Iran)	743
<i>Cotoneaster nummularia</i> Fisch. & C.A. Mey.*	3000–3400, SubA.		744
<i>C. persica</i> Pojark.*	3000–3400, SubA.	En (Iran)	745
<i>Potentilla nuda</i> Boiss.	3000–4400, SubN.	En (Iran)	746
<i>Rosa beggeriana</i> Schrenk.	3000–3400, SubA.		747
<b>Rubiaceae</b>			
<i>Asperula glomerata</i> (M. Bieb.) Griseb.*	4000–4200, SubN.		749
<i>Callipeltis cucularis</i> (L.) Rothm.*	3000, SubA.		750
<i>Galium aparine</i> L.*	3200, SubA.		751
<i>Rubia albicaulis</i> Boiss.*	3400–3700, A.	SubEn	752
<b>Salicaceae</b>			
<i>Salix alba</i> L.*	3000–3400, SubA.		753
<b>Scrophulariaceae</b>			
<i>Antirrhinum orontium</i> L.*	3000–3200, SubA.		754
<i>Linaria lineolata</i> Boiss.*	3400–4000, A.		755
<i>Scrophularia leucoclada</i> Bunge.*	3000–3400, SubA.		757
<i>S. subaphylla</i> Boiss.	3500–4450, SubN.	SubEn	758
<i>Verbascum carmanicum</i> (Bornm.) Hub.-Mor.	3400, A.	En (Iran)	759
<i>V. haesarense</i> Freyn. & Bornm.	3600, A.	En (Iran)	
<i>Veronica anagalis-aquatic</i> ssp. <i>Michauxii</i> (Lam.) A. Jelen	3000–3200, SubA.		761
<i>V. biloba</i> Schreb.*	3000–3400, SubA.		762
<i>V. campylopoda</i> Boiss.*	3400, A.		763
<i>V. daranica</i> Saeidi & Ghahreman*	3600, A.	En (Iran)	
<i>V. kurdica</i> Benth. ssp. <i>filicaulis</i> (Freyn.) M.A. Fischer.	4000–4450, SubN.		764
<i>V. macropoda</i> Boiss.*	3000–400, SubA.	SubEn	765
<i>V. persica</i> Poir.*	3000, SubA.		766
<i>V. rubrifolia</i> Boiss. ssp. <i>respectatissima</i> M.A. Fischer*	3000–3400, SubA.	SubEn	767
<b>Solanaceae</b>			
<i>Hyoscyamus pusillus</i> L.*	3000–3200, SubA.		768
<i>H. senecionis</i> Willd. E. Grondsel	3000–3800, A.		770
<b>Urticaceae</b>			
<i>Urtica dioica</i> L. ssp. <i>dioica</i> *	3400–3600, A.		774
<i>Parietaria judaica</i> L.*	3000–3200, SubA.		775

**Symbols and abbreviations:**

Non-asterisk species: taxa have been reported by Bornmüller (1892–1893) and Rechinger (1963–2010) previously. One asterisk species (\*): New records for Hezar Mt., Two asterisk species (\*\*): Plants exclusively collected by Bornmüller and Rechinger from Hezar Mt.

Altitude: A. (Alpine), SubA. (Subalpine), SubN. (Subnival)

Endemicity: En (Iran), En (Hezar), SubEn (Subendemics)

(Subendemic species refer to those species which their distributions extend in the surrounding mountains of Iranian borders).



Fig. 1. Study area.

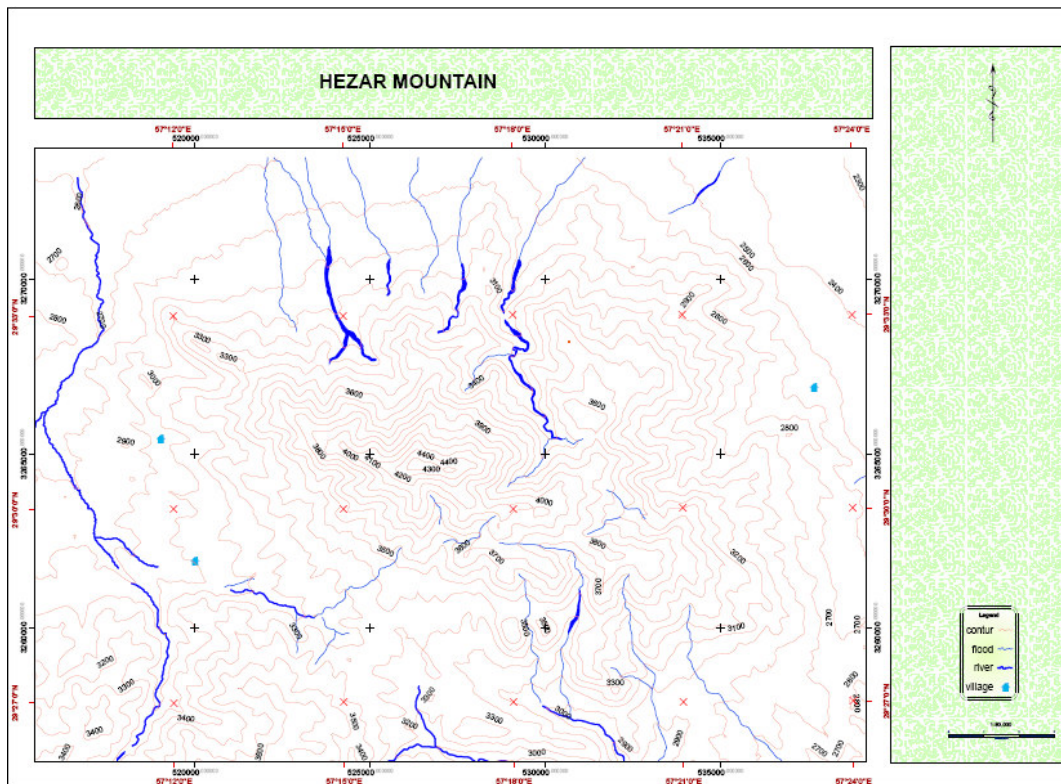


Fig. 2. Topographic map of Hezar Mt. (1:80,000).

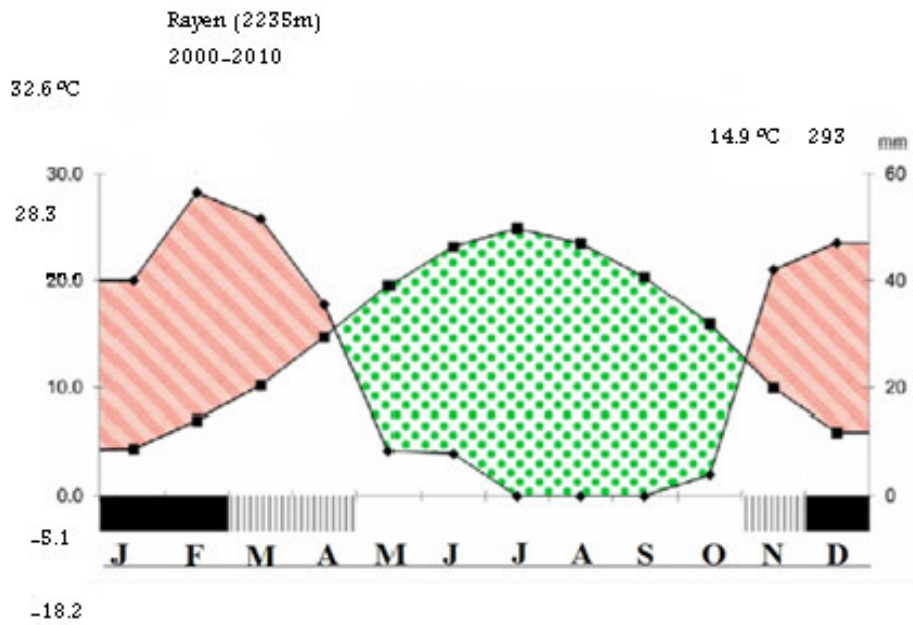


Fig. 3. Ecological climate diagram of Rayen meteorological station, indicating monthly average of temperature and precipitation and relative humidity (hatched) and relative arid (stippled) seasons.



Fig. 4. *Tanacetum fisherae* (x 1).

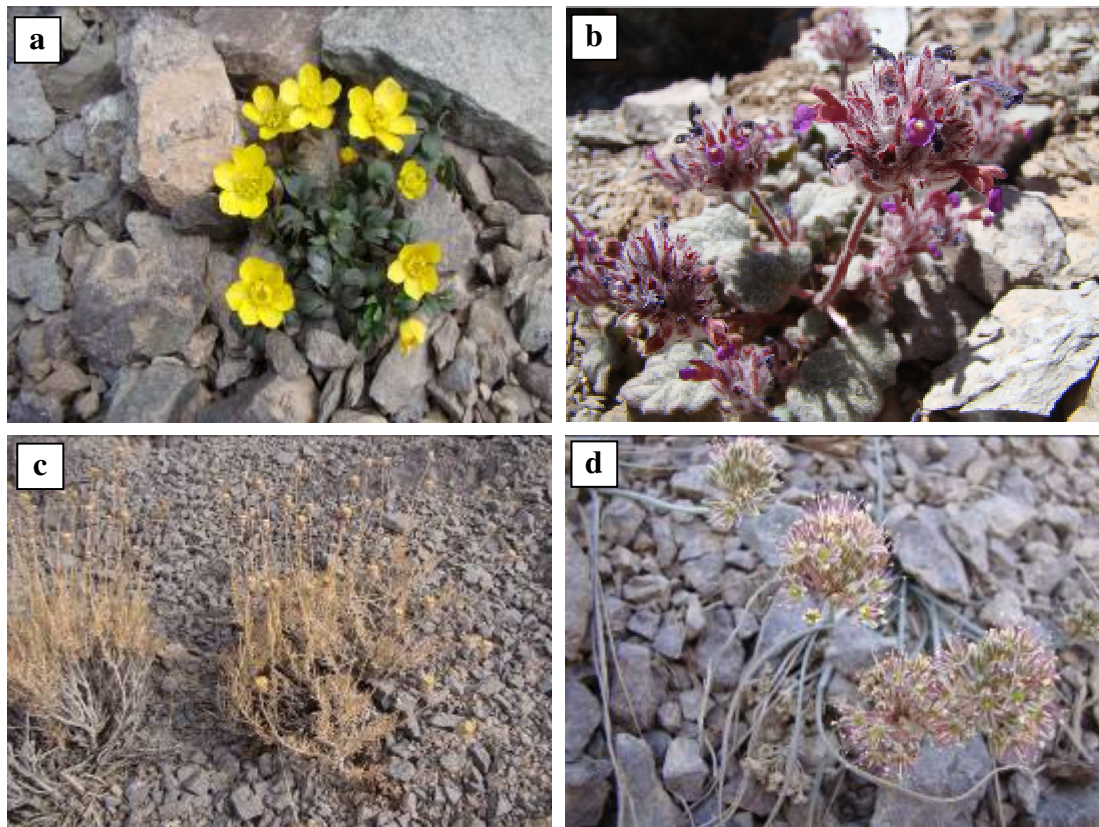


Fig. 5. Some typical alpine and subnival species of Hezar Mt.: a. *Ranunculus eriorrhizus* (4440 m), b. *Nepeta natanzensis* (4450 m), c. *Tanacetum fisherae* (3800 m), d. *Allium lalezaricum* (4200 m) (Photo: P.R).

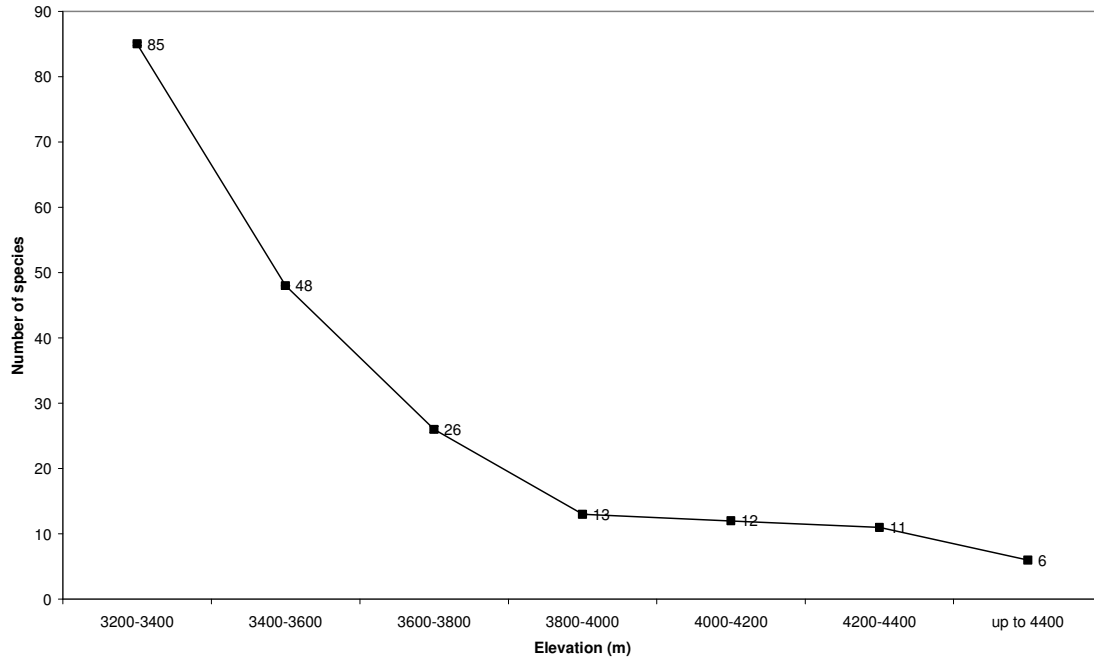


Fig. 6. The decreasing number of vascular plant species along the elevation gradient for Hezar Mt.





Fig. 7. Timberline in North slope of Hezar Mt. (3200 m).



Fig. 8. Representative images of vegetation types in Hezar Mt.: a. *Semenovia suffruticosa* communities in south slope (3800 m), b. Giant umbellifer (*Ferula hezar-lalehzarica* community) and traganthic *Astragalus* vegetation in west slope (3800 m) (Photo: P.R).