Comparative study of floristic diversity along altitude in the northern slope of the central Alborz Mountains, Iran

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Abstract. Moradi H, Attar F. 2019. Comparative study of floristic diversity along altitude in the northern slope of the central Alborz Mountains, Iran. Biodiversitas 20: 305-312. The Alborz is one of two main mountain chains in the north of Iran. The flora and vegetation of the sub-alpine and alpine zone of the central Alborz are less known comparing to the vegetation of lower altitudes with Hyrcanian forests. In this study, floristic composition and life-form spectra were investigated along an altitudinal transect ranging from 2000 m to the alpine and sub-nival peak of Mt. Rostam-Nisht at 4500 m. We compared the floristic diversity of the studied transect with the data obtained from an earlier studied transect in Kheyrud forest. A total of 299 taxa were found in the survey which showed high species diversity in the area. In addition, our results showed remarkable difference in life form categories between lower altitudes (Hyrcanian forests) and sub-alpine and alpine zones.

Keywords: Alpine flora, biodiversity, Caspian forest, conservation, elevation

INTRODUCTION

Biodiversity includes the variety of species, genes they contain, the communities and ecosystems of which they are a part (McNeely et al. 1990). In a particular region, it indicates the richness in floristic composition, i.e., the diversity of species which in any given plant community is often termed as species richness (Van der Maarel 2005). The rapid loss in species and habitats, and changing the pattern of vegetation due to various biotic and abiotic factors have imposed the assessment of diversity. So, the need for floristic knowledge as a base for biodiversity conservation is required. This knowledge can help to monitor the species loss, distribution of species and the effect of anthropogenic pressures on species habitat destruction (Pant and Samant 2012). Such studies can finally locate hot spots and areas with high biodiversity for conservation (Phillips et al. 2003).

Floristic studies are undertaken by many researchers following various aspects of species diversity. E.g. studying the diversity of plant life forms in different vegetation types or communities (Siadati et al. 2010; Naqinezhad et al. 2015) afford direct structural components of vegetation stands and explaining vegetation structure (Box 1981). In this regard, assessment of biodiversity along altitudes can reduce plant community complexity. This is because of steep environmental gradients at relatively short distances (Körner 2007) which simply disclose the latitudinal changes of diversity (Mc Cain 2007). Some aspects of mountains such as spatial scale, power of theoretical tests and variability of taxonomic signal make them ideally suited for examining biodiversity (Körner 2000; Mc Cain 2009; Qiong et al. 2012) and attract many researchers to compare them floristically.

The Alborz, the best-known mountain range in Iran has been poorly investigated, particularly ecologically and botanically in alpine areas (Noroozi et al. 2008). In Iran, the studies related to vegetation structure as well as the flora mainly focused on forests (e.g. Jafari and Akhani 2008; Siadati et al. 2010; Jafari et al. 2013; Naqinezhad et al. 2015; Gholizadeh et al. 2017), while few studies were conducted in the regions above 2000 m (e.g. Akhani et al. 2013; Mahdavi et al. 2013; Noroozi et al. 2011; Moradi et al. 2017).

The current investigation is a part of a project to study the vegetation and ecological properties of sub-alpine and alpine areas along an altitudinal transect in high mountains of the central Alborz. The main objective of this study was to provide a floristic list of the vascular plants in the area. This can lead to complement the information about the locality of the species, specifically those with restricted altitudinal distribution. Besides, it provides more knowledge on biodiversity conservation. Moreover, we compared the floristic composition of our studied transect with a transect located in Kheyrud forest (50-2200 m) where is belonged to the Hyrcanian forests. The Hyrcanian forest is a unique natural closed-canopy deciduous forest with a gradient of floristic changes (Moradi et al. 2016) in northern slope of the Alborz from Caspian Sea level to the altitudes at <2800 m. The findings should provide insights to (i) the potential of biodiversity within the central Alborz Mountains, and (ii) a comparison between the flora and life forms of our studied area and Kheyrud forest.
MATERIALS AND METHODS

Study area

The Alborz extends at the southern shore of the Caspian Sea from the Ararat mountainous range, in the border of Armenia in the west to Hindu Kush range in Afghanistan to the east. It acts as a natural barrier between the Caspian Sea and the Central Plateau of Iran. The Alborz is topographically divided into eastern, central and western Alborz with maximal altitudes between 3000-3500 m and the valleys with a minimum of around 2000 m. It includes several peaks in the central Alborz with more than 4000 m, e.g., Mt. Damavand (5671 m) and Mt. Alamkuh (4840 m) (Khalili 1973).

The Alborz has two distinct climatic regimes for northern and southern slopes. The climatic information delineates a dry to semi-dry climate with a semi Mediterranean rainfall regime mainly in winter on the southern slope. Conversely, in the northern slope, there is a humid and sub-humid climate with maximum precipitation in autumn and winter and a relative minimum rainfall in spring with no real dry season. The climate is cold and sub-humid in lower altitudes (2100 m) and cold and dry in the sub-alpine and alpine zones (2400-4000 m) (Khalili 1973).

The northern and southern slopes divide the Alborz floristically. The southern slope is covered by dry Irano-Turanian steppic plant assemblages, while the Hyrcanian forest encompasses the northern slope in lower altitudes (<2800m) and is characterized by temperate broad-leaved deciduous trees (Zohary 1973; Frey and Probst 1986). Toward higher altitudes, in sub-alpine areas, the grasslands and steppic vegetation replace the Hyrcanian forest, which is mainly divided into tall herbaceous vegetation (Noroozi 2014), grassland with scattered trees and grasslands with thorn cushion (Frey and Probst 1986). Thorny cushions are mostly found at sub-alpine altitudes with lowest temperature and long snow cover duration (Klein 1987) followed by chasmophytic and mobile screen species at alpine and nival areas in rocky habitats and screees (Klein 1982; Noroozi et al. 2008; Noroozi 2014).

Our studied transect is located on the northern slope of the central Alborz in the Mazandaran province between N 36° 26′ 16.1″, E 051° 03′ 23.2″ and N 36° 24′ 05.9″, E 050° 57′ 43.7″. It consists of starts from 2000 m a.s.l. just above the timberline until 4500 m to the peak of Mt. Rostam-Nisht (Figure 1).
Vegetation sampling
Field sampling was performed during the growing season (summer and spring) of 2013 to 2015 in a total of 76 vegetation plots. Three 10 x 10 m vegetation plots were allocated in each 100 m elevational interval along an altitudinal transect ranging from 2000 m up to 4500 m, in sub-alpine, alpine and nival areas. We took only one vegetation plot at 4500 m because of little space at the peak. The data related to the location, elevation, slope degree and exposition of the plots were noted. The voucher specimens were deposited in the central Herbarium of Teheran University (TUH) and were identified based on Flora Iranica (Rechinger 1963-2010), Flora of Iran (Assadi et al. 1988-2015) and Flora of Iraq (Townsend et al. 1966-1985). We followed Raunkiaer's classification (Raunkiaer 1934) to separate the life forms of the species found in our survey.

In order to compare the floristic composition of the Hycranian forest and steppic grasslands of the central Alborz, we considered the sub-alpine, alpine and nival areas of Mt. Rostam-Nisht and the data from an earlier studied transect in Kheyrud forest (Siadati et al. 2010). This transect is located 7 km east of Nowshahr in Mazandaran province, between 51°33˝05΄N and 36°33˝08˝−36°45˝05΄N, ranging from 50 to 2100 m a.s.l. (Figure 1).

The methods for collecting vegetation data in Kheyrud transect was similar to the transect in Mt. Rostam-Nisht including the altitudinal intervals between the plots (100 m), the number of the plots per interval (3 plots), nomenclature and the extracted species attributes. However, the size of the plots differed between two transects (10 x 10 m in Mt. Rostam-Nisht and 20 x 20 m in Kheyrud forest) because of the difference in their vegetation types (closed forests vs. grasslands).

RESULTS AND DISCUSSION
Floristic diversity and the comparison of their vegetation types
The locality of the Alborz between Hindu Kush-Himalaya Mountains in the east, and Anatolia and Caucasus Mountains in the west makes it so important and strategic in terms of historical, evolutionary, phytogeographical and biogeographical aspects (Noroozi et al. 2008; Naqinezhad et al. 2017). The Caucasus and Central Anatolian Mountains have been identified as the areas with a strong biogeographic connection with the Alborz (Noroozi 2008). The occurrence of a high number of vascular plant species in these mountainous ecosystems demonstrates their high floristic diversity and biodiversity importance. A total of 299 plant taxa of vascular plants were recorded along our altitudinal transect in Mt. Rostam-Nisht (Table 1), as a representative of the sub-alpine, alpine and nival areas of the central Alborz. While, based on studies on Caucasus and literature survey, 226 species, 96 genera and 35 families were recorded in the sub-nival belt of the Caucasus within a range of 2800 (2900) – 4000 m (Shetekari et al. 2012). In the western and central Taurus, 180 vascular plant species were exclusive to the highest life zone which 150 species were found in altitudes higher than 3000 m (Parolly 2015). The study on the Naran Valley located in the western Himalayan province of the Irano-Turanian region demonstrated 198 species and 68 families (Khan et al. 2012).

Although the Alborz mountain is rich in plant species, this is not applied to all altitudinal ranges, e.g., the highest number of species (58 species) was occurred in lower altitudinal ranges at 2200 m, while, a few numbers of species (4 species) were found at 4400 m.

The recorded species was belonged to 48 families and 168 genera, among them were four families of pteridophytes, one family of gymnosperms and 43 families of angiosperms. Eudicots with 36 families, 139 genera and 245 species were the richest group, while monocots had 7 families, 23 genera and 47 species in the studied flora (Table 2). The families Asteraceae (34 taxa, 11.37%), Poaceae (31 taxa, 10.37), Lamiaceae (25 taxa, 8.36%), Fabaceae (25 taxa, 8.36%) and Caryophyllaceae (20 taxa, 6.99%) showed the highest species richness. The families Brassicaceae (18 taxa, 6.02%), Rosaceae (16 taxa, 5.35%), Scrophulariaceae (15 taxa, 5.02%), Boraginaceae (11 taxa, 3.68%), Apiaceae (11, 3.68%) and Rubiaceae (10 taxa, 3.34%) were the next species-rich families.

The families Asteraceae (17, 10.12%), Lamiaceae (15, 8.93%), Brassicaceae (14, 8.33%), Poaceae (13, 7.74%), Apiaceae (11, 6.55%) and Caryophyllaceae (10, 5.95%) were the most genera rich. The genera with the highest species richness were Astragalus (13 taxa, 7.74%), Potentilla (9 taxa, 5.36%), Veronica (8 taxa, 4.76%), Bromus (7 taxa, 4.17%), Poa (7 taxa, 4.17%) and Galium (6 taxa, 3.57%). The genera such as Astragalus, Nepeta, Cousinia, Potentilla, Silene and Oxytropis were found to be the richest genera in the area which was reported by other researchers (e.g., Noroozi et al. 2008; Rechinger 1963-2010). These genera have been found in Mt. Rostam-Nisht, particularly in high altitudes. Accordingly, these genera contained a high number of endemic species, e.g., 7 out of 13 taxa of Astragalus are the endemic taxa which occurred mainly at altitudes higher than 3500 m in the studied area.

The variation in different groups of taxa is another reflection of high floristic diversity along lowland-mountain transects in the central Alborz. Here, a clear example is the higher occurrence of pteridophytes in Kheyrud forest (in altitudes 50-2200 m) than sub-alpine and alpine areas (2000-4500 m). The high soil humidity in wet seasons and dense canopy tree covers in forests makes the pteridophytes show a remarkable diversity (Siadati et al. 2010) in the forest, though they are few in the sub-alpine and alpine areas. This can simply mirror the variation of plant groups along altitude which may also reveal the climatic variation in the Alborz (Moradi et al. 2017).
| Name of taxa            | Life form | Altitudinal range |
|------------------------|-----------|-------------------|
| **Pteridophytes**      |           |                   |
| Aspleniaceae           |           |                   |
| Asplenium ceterach L.  | Hem       | 2200-2800         |
| Asplenium septentrionale (L.) Hoffm. | Hem | 2100 |
| **Dryopteridaceae**    |           |                   |
| Dryopteris dilatata (Hoffm.) A. Gray. | Hem | 2800-3100 |
| **Equisetaceae**       |           |                   |
| Equisetum ramosissimum Desf. | Hem | 2100-2200 |
| Polypodiaceae          |           |                   |
| Polypodium interjectum Shivas. | Hem | 2100 |
| **Pteridaceae**        |           |                   |
| Adiantum capillus-veneris L. | Hem | 2800 |
| **Gymnosperms**        |           |                   |
| Juniperus communis L.  | Ph        | 2500-2600         |
| **Monocots**           |           |                   |
| Alliaceae              |           |                   |
| Allium ampeloprasum L. subsp. iranicum | Ge | 2000-3500 |
| Allium capillatum Boiss. | Ge       | 3600-3800         |
| Allium dederi Noël. & Regel. | Ge | 2200-3800 |
| Allium umbilicatum Boiss. | Ge       | 2100-2900         |
| **Asteraceae**         |           |                   |
| Arum maculatum L.      | Ge        | 2100-2200         |
| **Cyperaceae**         |           |                   |
| Carex divisa Stokes.   | Hem       | 2200              |
| Carex songoricar Kar. & Kir. | Hem | 2000-2300 |
| **Iridaceae**          |           |                   |
| Iris imbricata Lindl.  | Ge        | 2500              |
| Iris reticulata M. Bib. | Ge        | 2200              |
| **Isidioideae**        |           |                   |
| Isoliron tatarica Pall. | Ge       | 2200-2600         |
| **Liliaceae**          |           |                   |
| Fritillaria kotschyan a Herb. subsp. kotschyan a | Ge | 2600-2900 |
| Gagea gageoides (Zucc.) Vved. | Ge | 2400-3900 |
| Muscari neglectum Guss. ex Ten. | Ge | 2100-2600 |
| Ornithogalum hangu Boiss. | Ge       | 2000-2600         |
| Ornithogalum orthophyllum Ten. | Ge | 2400-3800 |
| Puschkinia scilloides Adams. | Ge | 2800-3100 |
| **Poaceae**            |           |                   |
| Agropyron leporatum (Neves) Grossh. | Ge | 2800 |
| Agropyron longe aristata | Hem       | 3500-4200         |
| Agropyron pectiniforme Roem. & Schult. | Ge | 2800-3300 |
| Alopecurus textilis Boiss. | Hem | 2600-4400 |
| Bromus biebersteinii Roem. & Schult. | Hem | 3100-4100 |
| Bromus briziformis Fisch. & C.A. Mey. | Thr | 2000-2700 |
| Bromus erectus Huds. | Hem       | 2600              |
| Bromus tectorum L.      | Thr       | 2000-2600         |
| Bromus tomentosus Trin. | Hem       | 2000-3500         |
| Bromus tomentosus Boiss. | Hem | 2600-3600         |
| Bromus variegatus M. Bib. | Hem | 3100-4100         |
| Dactylis glomerata L.  | Hem       | 2000-3500         |
| Festuca ovina L.        | Hem       | 2900-4300         |
| Hordeum glaucum Steud.  | Thr       | 2300              |
| Lolium multiflorum Lam. | Thr       | 2700-3300         |
| Lolium perene L.        | Hem       | 2300              |
| Lolium rigidum Gaudin.  | Hem       | 2400-3000         |
| Melica jacquemontii Decne. f. subsp. hohenackeri (Boiss.) W.Hempel | Hem | 3000-3700 |
| Melica persica Kunt.    | Hem       | 2400-3000         |
| Milium vernale M. Bib.  | Thr       | 2300              |
| Oryzopsis gracilis (Mez) Pilg. | Hem | 3100-3800 |
| **Eudicots**            |           |                   |
| Acer campestre L.       | Ph        | 2000-2200         |
| **Aipaceae**            |           |                   |
| Anthriscus nemorosus (M.Bieb.) Spreng. | Hem | 2400-3700 |
| Bupleurum cylindricum (Boiss. Hohen.) | Hem | 2500-3700 |
| Drude in Engler & Prantl. |           |                   |
| Bupleurum exaltatum M.B. | Hem | 2600 |
| Cervaria cervifolia (C.A. Mey) M. Pimen. Hem | Hem | 2100-2900 |
| Ferula szovitsiana D.C. var. Ch | Hem | 2100-3100 |
| kandhanensis |           |                   |
| Heracleum pastinaci folium C. Koch. | Ch | 2400-2900 |
| Laser trilobum (L.) Borkh. | Hem | 2900-3500 |
| Pimpinella tragiun Vill. subsp. lithophila | Hem | 2000-3800 |
| Prangos ulopterae DC. | Hem | 2500-2900 |
| Torilis radiata Moench. | Thr | 2100 |
| Trachydis suggesperos (Boiss.) Boiss. subsp. depressus | Hem | 3700-4300 |
| **Asteraceae**          |           |                   |
| Achillea aucheri Boiss. subsp. aucheri | Hem | 3600-3700 |
| Achillea millefolium L. subsp. elbursensis | Hem | 2100-3400 |
| Anthemis trianfettii (L.) DC. subsp. | Hem | 2000 |
| khorassanica |           |                   |
| Artemisia abansithium L. | Ch | 2000-3000 |
| Artemisia chamaemelitfa Vill. | Ch | 2100-3400 |
| Artemisia melanolip Boiss. | Hem | 3700-4300 |
| Centaurea zuversindo (Sosn.) Sosn. | Ch | 2400-2500 |
| Cirsium lappaceum M. Bib. subsp. ferox | Ch | 2100-3600 |
| Boiss. |           |                   |
| Cirsium vulgare (Savi.) Ten. | Ch | 2000-2300 |
| Cossinia pincarnosho Boiss. | Hem | 2400-3800 |
| Cossinia ptericaus (C.A.Mey) Rech.f. | Hem | 2000-4200 |
| Crepis multicaulis Ledeb. subsp. | Hem | 3900-4000 |
| multicaulis |           |                   |
| Crepis sancta (L.) Babc. subsp. | Hem | 2000-2400 |
| wensensens |           |                   |
| Crepis welmeioides Boiss. | Hem | 2000-2900 |
| Erigeron caucasicus Stev. subsp. venustus | Hem | 3900-4200 |
| (Botsch.) Grierson. |           |                   |
| Helichrysum graveolens Sweet. | Hem | 2900-3600 |
| Helichrysum picatum DC. | Hem | 2500-3300 |
| Helichrysum psychophylion Boiss. | Hem | 3400-4100 |
| Hieracium procerigregen Litt. & Zahn. | Hem | 2300-2600 |
| Lactuca wilmhelsiana Fisch. & C.A.Mey. | Ch | 2000-2707 |
| in DC. |           |                   |
| Leontodon hispidus L. var. | Hem | 2500-3700 |
| mazanderanicus Rech.f. |           |                   |
| Pyrogeton amorphoglossus (Boiss.) Novopokr. | Hem | 3900 |
| Scorzonera cinerea Boiss. | Hem | 2400-2500 |
| Scorzonera radicoso Boiss. | Hem | 4000 |
| Senecio vulcanicus Boiss. | Hem | 3800-4200 |
| Tanacetum cocineum (Willd.) Grierson. | Hem | 2500-2600 |
| subsp. cocineum |           |                   |
| Tanacetum parthenin (L.) Sch. Bip. | Hem | 2300-3000 |
| Tanacetum polycyphalum Sch.Bip. subsp. Ch | Ch | 2000-3700 |
| Tatarianum sp.1 | Hem | 2100-3700 |
| Tatarianum sp.2 | Hem | 2000-2900 |
| Tatarianum sp.3 | Hem | 3400-4000 |

Table 1. Checklist of identified plant species at Mt. Rostam-Nish with life form categories and the altitudinal distribution range per species.
| Genus                      | Species Code/Description                      | Locality | Notes                  |
|----------------------------|-----------------------------------------------|----------|------------------------|
| *Berberidaceae*            |                                               |          |                        |
| Berberis integerina L.     |                                               | Ph 220   |                        |
| Bongardia chrysogonum (L.) Griseb. |                       | Hm 2400  |                        |
| *Boraginaceae*             |                                               |          |                        |
| Alkana frigida Boiss.      |                                               | Hm 2000  |                        |
| Corydalis crenatum Miller. |                                               | Ch 2000  |                        |
| Echium amoenum Fisch. & C.A. Mey. |                     | Hm 2200  |                        |
| Lappula microcarpatürk.    |                                               | Hm 2000  |                        |
| Myosotis lithospermifolia Hornem. |                               | Hm 2000  |                        |
| Myosotis olympica Boiss.   |                                               | Hm 2000  |                        |
| Nonnea persica Boiss.      |                                               | Hm 2000  |                        |
| Oinosma dichroanthum Boiss. |                                               | Hm 2000  |                        |
| Roschelia disperma (L.F.) Koch. |                              | Hm 2000  |                        |
| Roschelia peduncularis Boiss. |                             | Hm 2000  |                        |
| Solenanthus stamineus J.F. Macbr. |                         | Hm 2000  |                        |
| *Brassicaceae*             |                                               |          |                        |
| Aethionema grandiflorum Boiss. & Hoven. |                   | Hm 2000  |                        |
| Allaria petiolata (M.B.) Cavara & Grande |                      | Hm 2200  |                        |
| Alyssopsis mollis (Jacq.) O.E. Schulz |                              | Hm 2000  |                        |
| Alyssum desertorum Stapf. var. desertorum |                      | Hm 2200  |                        |
| Alyssum minus (L.) Rothm. var. micranthus (C.A. Mey.) Dudley | | Hm 2100 |                        |
| Alyssum repens Baumg. var. trichostachyum (Rupr.) Hayek. | | Hm 2100 |                        |
| Anchonion elychrifolium Boiss. |                            | Hm 2500  |                        |
| Arabis caucasica Willd. subsp. caucasica |                    | Hm 2700  |                        |
| Arabis sp.                 |                                               | Hm 2700  |                        |
| Cerastium draba (L.) Desv. |                                               | Hm 2400  |                        |
| Descurainia sophia (L.) Webb. in Berth. |                 | Hm 2400  |                        |
| Didymothypha auehi Boiss.  |                                               | Hm 2200  |                        |
| Draba nemorosa L.          |                                               | Hm 2200  |                        |
| Erysimum caespitatum DC.   |                                               | Hm 2200  |                        |
| Erysimum cispadatum D.C.   |                                               | Hm 2200  |                        |
| Isatis gauhei Bornm.       |                                               | Hm 2200  |                        |
| Silvertchium L.            |                                               | Hm 2200  |                        |
| Thlaspi hastulatum (Stev.) ex DC. |                     | Hm 2200  |                        |
| *Campanulaceae*            |                                               |          |                        |
| Asyneuma amplexicaule Hand.-Mazz. subsp. amplexicaule | | Hm 2600  |                        |
| Asyneuma pulchellum Bornm. |                                               | Hm 2600  |                        |
| Campanula glomerata L.     |                                               | Hm 2600  |                        |
| Campanula stenifert M. Bihe. |                                         | Hm 2600  |                        |
| *Capsifoliaceae*           |                                               |          |                        |
| Loniceria floribunda Boiss. & Buhse. |                 | Ch 2500  |                        |
| *Caryophyllaceae*          |                                               |          |                        |
| Acantholinon hovenackeri Lede. |                               | Ch 2900  |                        |
| Arenaria alsinoides Willd. |                                               | Hm 2400  |                        |
| Arenaria gypsophilies L.   |                                               | Hm 2600  |                        |
| Arenaria insignis Litw.    |                                               | Hm 3700  |                        |
| Cerastium dichtanum L.     |                                               | Hm 2200  |                        |
| Cerastium purpurascens Adams var. elburserae (Boiss.) Moschle. | | Hm 3900 |                        |
| Dianthus orientalis subsp. stenocalyx |                       | Hm 2000  |                        |
| Herniaria glabra L. var. glaberrima |                       | Hm 2100  |                        |
| Fenzl. in Lede.            |                                               | Hm 2100  |                        |
| Herniaria hisuta L.        |                                               | Hm 3000  |                        |
| Herniaria incaidam L.      |                                               | Hm 2000  |                        |
| Minuartia lineata (Boiss.) Bornm. |                     | Hm 2500  |                        |
| Minuartia recurva Schinz. & Thellung. |                   | Hm 3400  |                        |
| Minuartia scutelata (Fisch. & C.A. Mey.) Thellung. | | Hm 2000  |                        |
| Petrohagia alpina (Hahl.) Ball & Heywood. |                   | Hm 2100  |                        |
| Silene auehteriana Boiss.  |                                               | Hm 2500  |                        |
| Silene bupleureoids L.     |                                               | Hm 2900  |                        |
| Silene latifolia Poir.     |                                               | Hm 2100  |                        |
| Silene marshallii C.A. Mey. subsp. sahendica (Boiss. & Buhse) Malshi. | | Hm 2800 |                        |
| Stellaria alsinoides Boiss. & Buhse. |                 | Hm 2400  |                        |
| *Chenopodiaceae*           |                                               |          |                        |
| Chenopodium foliosum Aschers. |                                 | Hm 2300  |                        |
| *Cistaceae*                |                                               |          |                        |
| Helianthemum nummularium Mill. |                                   | Hm 2100  |                        |
| *Convolvulaceae*           |                                               |          |                        |
| Convolvulus arvensis L.    |                                               | Hm 2200  |                        |
| *Crassulaceae*             |                                               |          |                        |
| Rosularia sempervivum (M.Bieb.) A.Berger. |                       | Hm 2100  |                        |
| Sedum lenkoranicum Grossh. |                                               | Hm 2100  |                        |
| Sedum palloidum M.B.       |                                               | Hm 2200  |                        |
| Sedum crupinum M.Bieb.     |                                               | Hm 2100  |                        |
| *Euphorbiaceae*            |                                               |          |                        |
| Euphorbia zviotisis Fisch. & Mey. |                         | Hm 2700  |                        |
| *Fabaceae*                 |                                               |          |                        |
| Astragalus (Sect. Adiastpustus) aureus (Willd.) | | Hm 2000  |                        |
| Astragalus (Sect. Adiastpustus) |                                 | Hm 3400  |                        |
| Boiss. & Hohen. in Boiss.  |                                               | Hm 2900  |                        |
| Astragalus (Sect. Caprini) chrysanths |                       | Hm 2900  |                        |
| Astragalus (Sect. Holooleue) alysoiides Lam. Hm 3200-410 | | Hm 2900  |                        |
| Astragalus (Sect. Hnymenostegi) |                                     | Hm 3200  |                        |
| *Fumariaceae*              |                                               |          |                        |
| Astragalus (Sect. Hypognolotidei) |                               | Hm 3700  |                        |
| *Geraniaceae*              |                                               |          |                        |
| Cardaria draba (L.) Webb. in Berth. |                         | Hm 2100  |                        |
| *Hypericaceae*             |                                               |          |                        |
| Hypericum armenum Jaub.    |                                               | Hm 2300  |                        |
| Hypericum elongatum subsp. elongatum |                       | Hm 2900  |                        |
| Hypericum scabrum L.       |                                               | Hm 2900  |                        |
| *Lamiaceae*                |                                               |          |                        |
| Ajuga comata Stapf.        |                                               | Hm 2500  |                        |
| *Orobanchacea*             |                                               |          |                        |
| *Plantaginaceae*           |                                               |          |                        |
| *Polemoniaceae*            |                                               |          |                        |
| *Polygalaceae*             |                                               |          |                        |
| *Ranunculaceae*            |                                               |          |                        |
| *Resedaceae*               |                                               |          |                        |
| *Scrophulariaceae*         |                                               |          |                        |
| *Senecionaceae*            |                                               |          |                        |
| *Saxifragaceae*            |                                               |          |                        |
| *Saxifragoideae*           |                                               |          |                        |
| *Stellariaceae*            |                                               |          |                        |
| *Stylidiaceae*             |                                               |          |                        |
| *Tropaeolaceae*            |                                               |          |                        |
Rosaceae
Lamium album subsp. album
Lamium amplexicaule
Leontopodium cardicae L. subsp. cardicae
Marrubium astracanicum Jaq.
Nepeta racemosa Lam.
Phlomis anisodonotu Boiss.
Phlomis olivieri Benth.
Salvia atropatana Bunge.
Salvia scabra L.
Scutellaria glechomoides Boiss.
Scutellaria pinnatifida A. Hamilt. subsp. pinpinifolia
Stachys balansae Boiss. & Kotschy ex Boiss.
Stachys byzantina C.Koch.
Stachys lavandulifolia Vahl.
Teucrium chamaedrys L. subsp. syriense (C.Koch.) Rech.f.
Teucrium polium L.
Thymus fedtschenkoi Roniger.
Thymus kotschyanus Boiss. & Hohen.
Ziziphora clinopoides Lam. subsp. elbusensis (Rech.f.) Rech.f.

Linaceae
Linum nervosum Waldst. & Kit. var. bungei (Boiss.) Sharifinia
Malva neglecta Wallr.

Orobanchaceae
Orobanchus sp.

Papaveraceae
Papaver armeniacum (L.) DC.
Papaver fugax Poir.

Plantaginaceae
Linaria elymaeflora (Boiss.) Kuprian.
Plantago atrata Hoppe.
Plantago lanceolata L.

Polygonaceae
Oxyria digyna (L.) Hill
Polygonum rotboellioides Jaub. & Spach.
Polygonum serpyllaceum Jaub. & Spach.
Rumex chamaemorus Miller.
Rumex elbusensis Boiss.
Rumex scutatus Boiss.

Primulaceae
Androsace maxima L.
Androsace villosa L.
Primula macrocalyx Bunge.

Ranunculaceae
Ceratophyllum testiculatum (Crantz) Roth.
Delphinium aquilegifolium (Boiss.) Bornm.
Delphinium lanigerum Boiss.
Ficaria kochii (Leder.) Irmshart. & Rech.
Parasenecion caespitosa J.R.Drumm. & Hutch.
Ranunculus crymophilus Boiss. & Hohen.
Ranunculus repens L.
Thalictrum foetidum L.

Rosaceae
Cerasus microcarpa (C. A. Mey.) Boiss.
Crataegus microphylla K.Koeh.
Crataegus sp.
Geum urbanum L.

and Potentilla adscatica Somnier. & Levier.
ex Keller.

Potentilla argentea L.
Potentilla bungei Boiss.
Potentilla hirta L.
Potentilla hololeuca Boiss.
Potentilla iranica (Rech.) Schiman-Czeika Hem.
Potentilla polychistha Boiss. & Hohen.
Potentilla reptans L.
Potentilla sp.
Prunus divaricata Ledeb.
Rosa iricita Stev. in Bib.
Sanguisorba minor Scop. subsp. muricata

(Bsch.) Briq.

Rubiacese
Asperula glomerata subsp. bracteata
Asperula setosa Jaub. & Spach.
Crucianella suaveolens C.A. Mey.
Crucifera taurica (Pall. ex Willd.) Ehrend.
Galium aparine L.
Galium aucheri Boiss.

Galium glauconicum C.A.Mey.

Galium spp.

Galium verum L. subsp. glabrescens

Schrophulariaceae
Scrophularia elbursensis

(Spur.) Briq.

Scrophularia amplexicaulis Benth.
Scrophularia elbursensis Bornm.
Scrophularia variegata M. Bieb. subsp. variegata

Verbascum speciosum Schrad.
Veronica aucheri Boiss.
Veronica bilara Schreb.
Veronica hederifolia L.
Veronica kurdica Benth. subsp. kurdica
Veronica paederota Boiss.
Veronica persica Poir.
Veronica rechingeri M.A.Fisch.
Veronica verna L.

Urticaceae
Urtica dioica L.

Valerianaceae
Valeriana saxatilis Bieb.

Violaceae
Viola alba Besser.

Viola golluca Lemm.

Note: Ph: Phanerophyte, Ch: Chamaephyte, Ge: Geophyte: Hem: Hemicryptophyte, Th: Therophyte

Table 2. Comparing the percentage of taxa within different plant groups along two altitudinal transects in Mt. Rostam-Nish and Kheyurud forest

| Plant groups | Eudicots | Monocots | Gymnosperms | Pteridophytes |
|--------------|----------|----------|-------------|---------------|
| Mt. Rostam-Nish | Families | Genera | Species | Species |
| Families | 75 | 82.74 | 81.94 | 73.22 |
| Genera | 14.58 | 13.69 | 15.72 | 17.97 |
| Species | 2.08 | 0.6 | 0.33 | 0.34 |
| Kheyurud forest | Families | Genera | Species | Species |
| Families | 72.15 | 73.53 | 72.00 |
| Genera | 13.92 | 18.63 | 20.00 |
| Species | 1.27 | 0.49 | 0.25 |

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The similarities and differences of floristic comparison of the vegetation in Mt. Rostam-Nisht and Kheyrud forest were notable. Our findings represented close number of taxa, i.e. 299 taxa in the mountain and 295 taxa in the forest, but the number of different plant groups was different. As mentioned, pteridophytes were high in the forest comparing to the sub-alpine and alpine areas. Besides, the number of families and genera were less in the Mt. Rostam-Nisht while the species-rich genera were less in the forest (Table 2). The genera with high number of species occurred in Mt. Rostam-Nisht, e.g. the genus Astragalus with 13 taxa (7.74%) represented the richest genus in our studied area, while the genus Carex with 8 taxa (2.71%) was found as the richest genus in Kheyrud forest. Furthermore, there were 37 genera (12.54%) with two taxa and 149 genera (50.51%) with only one taxon in Kheyrud forest, while there were 37 genera (12.37%) with two taxa and 100 genera (33.44%) with only one taxon in the Mt. Rostam-Nisht.

The comparison of diversity in Mt. Rostam-Nisht and Kheyrud forest is manifest not only in the floristic composition, but also in terms of life forms of the plants. Life form reflects the adaptive responses of plants to environment and climate (Archibold 1995) and provides differences of various vegetation types (Neilson 1993; Archibold 1995). The dominant life forms were hemicyryptophytes (196 taxa, 65.55%) followed by therophytes (47 taxa, 15.72 %) and chamaephytes (35 taxa, 11.71 %). Geophytes (14 taxa,4.68 %) and phanerophytes (7 taxa, 2.34 %) contained low proportion of life forms in the studied transect (Figure 2).

The comparison of life form spectrum between mountain and forest displayed an obvious difference in the proportion of phanerophytes. They were more in the forest than in Mt. Rostam-Nisht (19.2% vs. 2.34%), while the occurrence of chamaephytes (11.71% vs. 1.4%) and hemicyryptophytes (65.55% vs. 30.6%) was higher in our studied area than in Kheyrud forest. Interestingly, the geophytes contained only 4.68% of the flora in sub-alpine and alpine areas, whereas they confined higher proportion (37.5%) in the forest. Finally, therophytes were more common in Mt. Rostam-Nisht (15.72%) than in the forest (9.3%) (Figure 2). In this regard, phanerophytes in Kheyrud forest are a common group which decreases with altitude and are scattered at forest/steppe ecotones, and finally disappeared at altitudes higher than 2400 m. Although, climatic stresses such as winter snow cover is supposed to filter out trees in high altitudes (Körner 1999) (see Moradi et al. 2017 for more details), but Noroozi and Körner (2018) believed that the absence of trees up to 2850 m is best explained by millennia of detrimental land use practices. Chamaephytes, a well-known life form in the mountains, with a long altitudinal range from 2800-4300 m in Mt. Rostam-Nisht, seems to cope effectively with grazing in lower altitudes and climatic harshness of high altitudes (Moradi et al. 2017).

The major variation of life form proportions across two transects is also related to geophytes and hemicyryptophytes. Generally, geophytes comprise little number of species in alpine zones (Noroozi et al. 2011) as in our studied area. The sub-alpine and alpine zones are commonly characterized by hemicyryptophytes (Noroozi et al. 2008) which are associated with colder climates and longer periods of coldness (Raunkiaer 1934). The activities such as human effects, grazing and disturbance can make suitable habitats for therophytes in both Mt. Rostam-Nisht and Kheyrud forest. Therophytes have been found as indicators for highly stressful habitat in the forests (Siadati et al. 2010; Naqinezhad et al. 2015). Similarly, Mt. Rostam-Nisht, particularly in lower altitudes is threatened by land use changes, strong grazing pressure and trampling which resulted to the growth of some annual species such as Alyssum minus, Descurainia sophia, Sisymbrium irio and Thlaspi hastulatum.

**Threat and conservation**

The changing of vegetation types and habitats from Hycanian forest to the timberline and the particular vegetation of the forest/steppe, makes the Alborz an important landscape for conservation of species and biodiversity. The importance is more when treeline ecotones between forest and steppe are discussed. Climatic warming might cause an upslope ascent of treeline ecotones and the consequent contraction and fragmentation of alpine areas (Camargo et al. 2006). So, treeline ecotones can be considered as early indicators of future changes and the stability of forest stands under the increasing stresses of climate change (Walker et al. 2003). Although, the ecotones and alpine areas of the Alborz are naturally more protected comparing to the forests, but they supply a large amount of food capacity for cattle, so is highly under the pressure of sheep grazing mainly in last decades. Human and agricultural activities, livestock grazing, severe harvesting of endangered species for economic and ornamental purposes as well as the collection of medical plants are the main threats in the Hycanian forest (Naqinezhad et al. 2017). On the other hand, overgrazing of the vegetation in the delicate sub-alpine and alpine areas caused destruction in vegetation, habitat and biodiversity loss and intensive reduction in space for endemic and narrow distributed species (Noroozi et al. 2008). The Alborz Mountains should receive considerable ecological
attention for both conservation and theoretical reasons. More preserving and conservation of species and habitat is needed to protect its diverse and distinctive flora and vegetation.

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