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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 Hyrcanain 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 Hindukush 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) (Khalili1973).

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 screes (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 36º 26′ 16.1″, E 051º 03′ 23.2″ and N 36º 24′ 05.9″, E 050º 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).

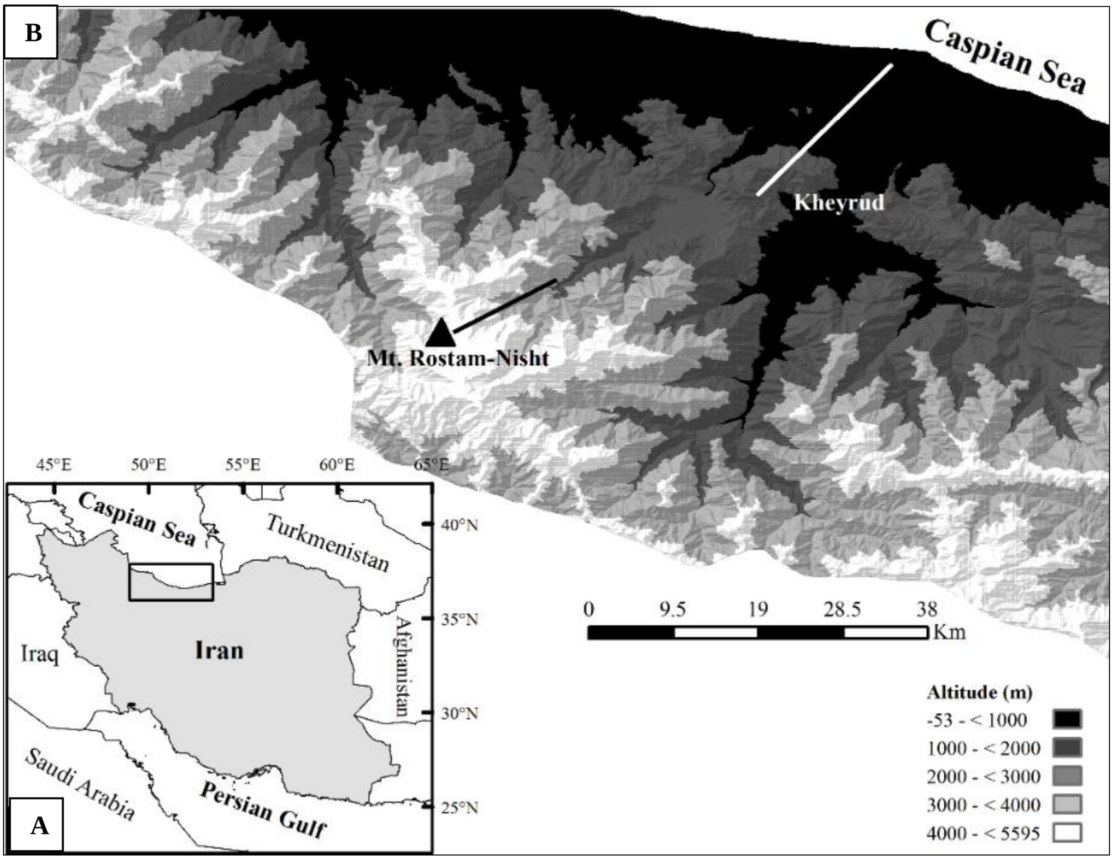

Figure 1. The study area. A. The location of Iran and the Alborz Mountain in the south of Caspian Sea. B. The western part of the northern slope of the central Alborz; Black line shows the studied altitudinal transect along Rostam-Nisht peak, and the white line shows the altitudinal transect along Kheyrud forest

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 10m 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 Hyrcanian 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″12´–51°39″56´ E 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, 9.69%) 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).

Table 1. Checklist of identified plant species at Mt. Rostam-Nisht with life form categories and the altitudinal distribution range per species

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		
Cupressaceae		
Juniperus communis L.	Ph	2500-2600
Monocots		
Alliaceae		
Allium ampeloprasum L. subsp. *iranicum* Wendelbo.	Ge	2000-3500
Allium capitellatum Boiss.	Ge	3600-3800
Allium derderianum Regel.	Ge	2200-3800
Allium umblicatum Boiss.	Ge	2100-2900
Araceae		
Arum maculatum L.	Ge	2100-2200
Cyperaceae		
Carex divulsa Stokes.	Hem	2200
Carex songorica Kar. & Kir.	Hem	2000-2300
Iridaceae		
Iris imbricata Lindl.	Ge	2500
Iris reticulata M. Bieb.	Ge	2200
Ixioliriaceae		
Ixiolirion tatarica Pall.	Ge	2200-2600
Liliaceae		
Fritillaria kotschyana Herb. subsp. *kotschyana*	Ge	2600-2900
Gagea gageoides (Zucc.) Vved.	Ge	2400-3900
Muscari neglectum Guss. ex Ten.	Ge	2100-2600
Ornithogalum bungei Boiss.	Ge	2000-2600
Ornithogalum orthophyllum Ten.	Ge	2400-3800
Puschkinia scillioides Adams.	Ge	2900-3100
Poaceae		
Agropyron leptorum (Nevski) Grossh.	Hem	2800
Agropyron longe aristata	Hem	3500-4200
Agropyron pectiniforme Roem. & Schult.	Hem	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 tometollus Boiss.	Hem	2600-3600
Bromus variegatus M. Bieb.	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 perenne L.	Hem	2300
Lolium rigidum Gaudin.	Hem	2400-3000
Melica jacquemontii Decne. f. subsp. *hohenackeri* (Boiss.) W.Hempel	Hem	3000-3700
Melica persica Kunth.	Hem	2400-3000
Milium vernale M. Bieb.	Thr	2300
Oryzopsis gracilis (Mez) Pilg.	Hem	3100-3800
Phleum iranicum Bornm. & Gauba	Hem	2100-3000
Phleum paniculatum Huds.	Thr	2000-2600
Poa araratica Trautv.	Hem	2400-3400
Poa bulbosa L.	Hem	2000-4100
Poa cf. *annua* L.	Thr	4300
Poa longifolia Trin.	Hem	2000-2700
Poa nemoralis L.	Hem	2700
Poa sp.1	Hem	2100-4000
Poa sp.2	Hem	4400
Trisetum flavescens (L.) P.Beauv.	Hem	2200-3700
Eudicots		
Aceraceae		
Acer campestre L.	Ph	2000-2200
Apiaceae		
Anthriscus nemorosus (M.Bieb.) Spreng.	Hem	2400-3700
Bunium cylindricum (Boiss. Hohen.) Drude in Engler & Prantl.	Hem	2500-3700
Bupleurum exeltatum M.B.	Hem	2600
Cervaria cervariifolia (C.A. Mey) M. Pimen.	Hem	2100-2900
Ferula szowitsiana D.C. var. *kandavanensis*	Ch	2100-3100
Heracleum pastinacifolium C. Koch.	Ch	2400-2900
Laser trilobum (L.) Borkh.	Hem	2900-3500
Pimpinella tragium Vill. subsp. *lithophila*	Hem	2000-3800
Prangos ulopterae DC.	Ch	2500-2900
Torilis radiata Moench.	Thr	2100
Trachydium depressum (Boiss.) Boiss. subsp. *depressum*	Hem	3700-4300
Asteraceae		
Achillea aucheri Boiss. subsp. a*ucheri*	Hem	3600-3700
Achillea millefolium L. subsp. *elbursensis*	Hem	2100-3400
Anthemis triumfettii (L.) DC. subsp. *khorassanica*	Hem	2000
Artemisia absinthium L.	Ch	2000-3000
Artemisia chamaemelifolia Vill.	Ch	2100-3400
Artemisia melanolepis Boiss.	Hem	3700-4300
Centaurea zuvandica (Sosn.) Sosn.	Ch	2400-2500
Cirsium lappaceum M. Bieb. subsp. *ferox* Boiss.	Ch	2100-3600
Cirsium vulgare (Savi.) Ten.	Ch	2000-2300
Cousinia pinarocephala Boiss.	Hem	2400-3800
Cousinia pterocaulos (C.A.Mey) Rech.f.	Hem	2000-4200
Crepis multicaulis Ledeb. subsp. *multicaulis*	Hem	3900-4000
Crepis sancta (L.) Babc. subsp. *wemausensis*	Hem	2000-2400
Crepis willemetioides Boiss.	Hem	2000-2900
Erigeron caucasicus Stev. subsp. *venustus* (Botsch.) Grierson.	Hem	3900-4200
Helichrysum graveolens Sweet.	Hem	2900-3600
Helichrysum plicatum DC.	Hem	2500-3300
Helichrysum psychrophilum Boiss.	Hem	3400-4100
Hieracium procerigenum Litw. & Zahn.	Hem	2300-2600
Lactuca wilmhelsiana Fisch. & C.A.Mey.) in DC.	Ch	2000-2700
Leontodon hispidus L. var. *mazanderanicus* Rech.f.	Hem	2500-3700
Psygrogeton amorphoglassus (Boiss.) Novopokr.	Hem	3900
Scorzonera cinerea Boiss.	Hem	2400-2500
Scorzonera radicosa Boiss.	Hem	4000
Senecio vulcanicus Boiss.	Hem	3800-4200
Tanacetum coccineum (Willd.) Grierson. subsp. *coccineum*	Hem	2500-2600
Tanacetum parthenium (L.) Sch. Bip.	Hem	2300-3000
Tanacetum polycephalum Sch.Bip. subsp. *duderanum*	Ch	2000-3700
Taraxacum sp.1	Hem	2100-3700
Taraxacum sp.2	Hem	2000-2900
Taraxacum sp.3	Hem	3400-4000

Taraxacum sp.4	Hem	2800-4000
Tragopogon gongylorrhizus Rech.f.	Hem	2200-3700
Tragopogon kotschyi Boiss.	Hem	3400-3600
Berberidaceae		
Berberis integerrima L.	Ph	2200
Bongardia chrysogonum (L.) Griseb.	Hem	2400
Boraginaceae		
Alkana frigida Boiss.	Hem	3000-3300
Cynoglossum creticum Miller.	Ch	2000-2300
Echium amoenum Fisch. & C.A. Mey.	Hem	2200
Lappula microcarpa Gürke.	Hem	2000-3500
Myosotis lithospermifolia Hornem.	Hem	2000-3500
Myosotis olympica Boiss.	Hem	4300-4400
Nonnea persica Boiss.	Hem	2000-3700
Onosma dichroanthum Boiss.	Hem	2000-2800
Rochelia disperma (L.F.) Koch.	Thr	2000-2300
Rochelia peduncularis Boiss.	Thr	2700
Solenanthus stamineus J.F.Macbr.	Ch	2700-3500
Brassicaceae		
Aethionema grandiflorum Boiss. & Hohen.	Hem	2500-2600
Alliaria petiolata (M. B.) Cavara & Grande	Hem	2200
Alyssopsis mollis (Jacq.) O. E. Schulz	Hem	2000
Alyssum desertorum Stapf. var. *desertorum*	Thr	2000-2900
Alyssum minus (L.) Rothm. var. *micranthum* (C.A. Mey.) Dudley.	Thr	2700
Alyssum repens Baumg. var. *trichostachyum* (Rupr.) Hayek.	Hem	2100-2900
Anchonium elichrysifolium Boiss.	Hem	2500-4000
Arabis caucasica Willd. subsp. *caucasica*	Thr	2700-4400
Arabis sp.	Thr	2700
Cardaria draba (L.) Desv.	Hem	2000-2300
Descurainia sophia (L.) Webb. in Berth.	Thr	2100-2600
Didymophysa aucheri Boiss.	Hem	4200-4500
Draba nemorosa L.	Thr	2200-4200
Erysimum caespitosum DC.	Hem	2000-2200
Erysimum cuspidatum D.C	Hem	2700-4100
Isatis gaubae Bornm.	Hem	2300-3700
Sisymbrium irio L.	Thr	2200-2400
Thlaspi hastulatum (Stev.) ex DC.	Thr	2000-3400
Campanulaceae		
Asyneuma amplexicaule Hand.-Mazz. subsb. *amplexicaule*	Hem	2600-3500
Asyneuma pulchellum Bornm.	Hem	2400-2600
Campanula glomerata L.	Hem	3600
Campanula stevenii M.Bieb.	Hem	2600-3700
Caprifoliaceae		
Lonicera floribunda Boiss. & Buhse.	Ch	2500
Caryophyllaceae		
*Acantholimon hohenackeri*Ledeb.	Ch	2900-3200
Arenaria alsinoides Willd.	Thr	2000-3500
Arenaria gypsophiloides L.	Hem	2600-3300
Arenaria insignis Litw.	Hem	3700-4300
Cerastium dichotomum L.	Thr	2200-2700
Cerastium purpurascens Adams. var. *elbursense* (Boiss.) Moschl.	Hem	3900-4500
Dianthus orientalis subsp. *stenocalyx*	Hem	2000
Herniaria glabra L. var. *glaberrima* Fenzl. in Ledeb.	Hem	2100-2600
Herniaria hirsuta L.	Thr	3000-4000
Herniaria incani Lam.	Hem	2000-3300
Minuartia lineata (Boiss.) Bornm.	Hem	2500-3800
Minuartia recurva Schinz. & Thellung.	Hem	3400-4300
Minuartia sclerantha (Fisch. & C.A. Mey.) Thellung.	Thr	2000-2200
Petrohagia alpina (Habl.) Ball & Heywood.	Hem	2100
Silene aucheriana Boiss.	Hem	2500-3600
Silene bupleuroides L.	Hem	2900-3500
Silene latifolia Poir.	Hem	2100-3500
Silene marschallii C.A. Mey. subsp. *sahendica* (Boiss. & Buhse) Malzh.	Hem	2800-3400
Stellaria alsinoides Boiss. & Buhse.	Thr	2400-2700

Stellaria media (L.) Vill.	Thr	2000-2600
Chenopodiaceae		
Chenopodium foliosum Aschers.	Thr	3300
Cistaceae		
Helianthemum nummularium Mill.	Hem	2100-2600
Convolvulaceae		
Convolvulus arvensis L.	Hem	2000-2700
Crassulaceae		
Rosularia sempervivum (M.Bieb.) A.Berger.	Hem	2100
Sedum lenkoranicum Grossh.	Hem	2100
Sedum pallidum M.B.	Thr	2000-3300
Sedum spurium M.Bieb.	Hem	2100-3000
Sempervivum iranicum Bornm. & Gauba.	Hem	2600-2900
Euphorbiaceae		
Euphorbia szovitsii Fisch. & Mey.	Thr	2700
Fabaceae		
Astragalus (Sect. Adiaspastus) *aureus* (Willd.)	Ch	2000-3000
Astragalus (Sect. Adiaspastus) macrosemius Boiss. & Hohen.	Ch	3400-4300
Astragalus (Sect. Caprini) *aegobromus* Boiss. & Hohen. in Boiss.	Hem	2100-3700
Astragalus (Sect. Caprini) *chrysanthus* Boiss. & Hohen.	Hem	2900-3300
Astragalus (Sect. Hololeuce) *alyssoides* Lam.	Hem	3200-4100
Astragalus (Sect. Hymenostegis) *naftabensis* Širj. & Rech.f.	Ch	2900-3300
Astragalus (Sect. Hyppoglottidei) *atricapilus* Bornm.	Hem	3700-4100
Astragalus (Sect. Hyppoglottidei) *nurensis* Boiss. & Buhse.	Hem	2600
Astragalus (Sect. Incani) *askius* Bunge.	Hem	2500-3200
Astragalus (sect. Malacothrix) *beckii* Bornm.	Hem	2400-3600
Astragalus (Sect. Ornithopodium) *ornithopodioides* Lam.	Hem	3100
Astragalus (Sect. Theiochrus) *siliqusus*	Hem	2600
Astragalus microcephalus Willd. subsp. *microcephalus*	Ch	2200-2400
Coronilla orientalis Mill.	Hem	2000-2600
Medicago lupulina L.	Thr	2000-2700
Medicago minima (L.) Bartalini.	Thr	2000
Medicago rigidula (L.) All. Approx. var. *submitis* (Boiss.) Heyn.	Thr	2100
Medicago sativa L.	Hem	2200-2600
Onobrychis cornuta (L.) Desv.	Ch	2600-3600
Oxytropis kotschyana Boiss. & Hohen.	Hem	2800-3600
Oxytropis persica Boiss.	Hem	4000-4100
Trifolium arvense L. var. *arvense*	Thr	2000-2300
Trifolium canescens Willd.	Hem	2000-2100
Trifolium nigrescens Viv. subsp. *petrescens* (Clem.) Holmboe.	Thr	2000-2900
Trifolium repens L.	Hem	2200
Fumariaceae		
*Corydalis angustifolia*DC.	Hem	3300-3500
Corydalis marschalliana (Pall.) Pers.	Hem	2200-2300
Corydalis verticillaris subsp. *verticillaris*	Hem	3700
Fumaria vaillantii Loiseh. in Desv.	Thr	-
Gentianaceae		
Gentiana septemfida Pall.	Hem	2800
Geraniaceae		
Erodium cicutarium (L.) Lher. ex Aiton.	Hem	2000-2200
Geranium lucidum L.	Thr	2000-3000
*Geranium tuberosum*L.	Hem	2200-2900
Hypericaceae		
Hypericum armenum Jaub.	Hem	3000
Hypericum elongatum subsp. *elongatum*	Hem	2000-2600
Hypericum scabrum L.	Hem	2600-2700
Lamiaceae		
Ajuga comata Stapf.	Hem	2500-2600
Betonica nivea Stev. subsp. *mazandarana* (Bornm.) Rech.f.	Ch	2900-3700

Dracocephalum aucheri Boiss.	Hem	4300-4500
Dracocephalum kotschyi Boiss.	Hem	3000
Dracocephalum thymiflorum L.	Thr	2400-2700
Lallemantia iberica (Stev.) Fisch. & C.A. Mey.	Thr	2700
*Lamium album*L. subsp. *album*	Hem	2800-3100
Lamium amplexicaule L.	Thr	2000-2200
Leonorus cardiaca L. subsp. *cardiaca*	Ch	3700
Marrubium astracanicum Jacq.	Ch	2100-3300
Nepeta racemosa Lam.	Ch	2000-3700
Phlomis anisodonta Boiss.	Ch	2000-3200
Phlomis olivieri Benth.	Ch	2300-2600
Salvia atropatana Bunge.	Hem	2000-3200
Salvia sclarea L.	Hem	2500
Scutellaria glechomoides Boiss.	Hem	4200
Scutellaria pinnatifida A. Hamilt. subsp. *pinnatifida*	Hem	2000-3200
Stachys balansae Boiss. & Kotschy ex Boiss.	Ch	2200
Stachys byzantina K.Koch.	Ch	2000-2900
Stachys lavandulifolia Vahl.	Hem	2500-3500
Teucrium chamaedrys L. subsp. *syspirense* (C.Koch.) Rech.f.	Hem	2200-2300
Teucrium polium L.	Hem	2000-2800
Thymus fedtschenkoi Ronniger.	Hem	2600-4100
Thymus kotschyanus Boiss. & Hohen.	Hem	2200-3900
Ziziphora clinopoides Lam. subsp. *elbursensis* (Rech.f) Rech.f.	Hem	3000-4100
Linaceae		
Linum nervosum Waldst. & Kit. var. *bungei* (Boiss.) Sharifnia	Hem	2500-3100
Malvaceae		
Alcea sp.	Ch	2000
Malva neglecta Wallr.	Hem	2100-2700
Orobanchaceae		
Orobanche sp.	Hem	2600
Papaveraceae		
Papaver armeniacum (L.) DC.	Hem	2300-2900
Papaver fugax Poir.	Hem	2200-3700
Plantaginaceae		
Linaria elymaitica (Boiss.) Kuprian.	Hem	2100-3400
Plantago atrata Hoppe.	Hem	2000-4100
Plantago lanceolata L.	Hem	2200
Polygonaceae		
Oxyria digyna (L.) Hill	Hem	4200
Polygonum rottboellioides Jaub. & Spach.	Hem	2400-3000
Polygonum serpyllaceum Jaub. & Spach.	Hem	2400-4200
Rumex chalepensis Miller.	Ch	2000-2700
Rumex elbursensis Boiss.	Ch	2900-3600
Rumex scutatus L.	Hem	2100-2800
Primulaceae		
Androsace maxima L.	Hem	2000-3900
Androsace villosa L.	Hem	2600-4300
Primula macrocalyx Bunge.	Hem	2000-2600
Ranunculaceae		
Ceratocephala testiculata (Crantz) Roth.	Thr	2000-2300
Delphinium aquilegifolium (Boiss.) Bornm.	Ch	2100
Delphinium lanigerum Boiss.	Ch	2100-3000
Ficaria kochii (Ledeb.) Iransharh. & Rech.	Hem	2800-3500
Paraquilegia caespitosa J.R.Drumm. & Hutch.	Hem	4200
Ranunculus crymophilus Boiss. & Hohen.	Hem	3900-4300
Ranunculus repens L.	Hem	2900-3600
Thalictrum foetidum L.	Hem	2400-2900
Rosaceae		
Cerasus microcarpa (C. A. Mey.) Boiss.	Ph	2100-3000
Crataegus microphylla K.Koch.	Ph	2000-2200
Crataegus sp.	Ph	2000-2100
Geum urbanum L.	Hem	2100
Potentilla adscharica Sommier. & Levier. ex Keller.	Hem	2900
Potentilla argentea L.	Hem	3000
Potentilla bungei Boiss.	Hem	2000-3100
Potentilla hirta L.	Hem	2100
Potentilla hololeuca Boiss.	Hem	4300
Potentilla iranica (Rech.) Schiman-Czeika	Hem	2100-3200
Potentilla polyschista Boiss. & Hohen.	Hem	4300-4400
Potentilla reptans L.	Hem	2600-2900
Potentilla sp.	Hem	3200
Prunus divaricata Ledeb.	Ph	2000-2500
Rosa iberica Stev. in Bieb.	Ch	2000-2900
Sanguisorba minor Scop. subsp. *muricata* (Spach.) Briq.	Hem	2000-2800
Rubiaceae		
Asperua glomerata subsp. *bracteata*	Hem	3800
Asperula setosa Jaub. & Spach.	Hem	2400-3200
Crucianella suaveolens C.A. Mey.	Hem	2000-3200
Cruciata taurica (Pall. ex Willd.) Ehrend.	Hem	2100-2200
Galium aparine L.	Thr	2200-2700
Galium aucheri Boiss.	Hem	4000-4400
Galium ghilanicum Stapf.	Thr	2000-2400
Galium hyrcanicum C.A.Mey.	Hem	2100-3900
Galium spurim L.	Thr	2000-3000
Galium verum L. subsp. *glabrescens* Ehrend.	Hem	2000-2900
Saxifragaceae		
Saxifraga exarata Vill. subsp. *moschata*	Hem	2800-2900
Saxifraga iranica Bornm.	Hem	3200
Scrophulariaceae		
Pedicularis caucasica M.Bieb.	Hem	3400-4000
Pedicularis condensata M. Bieb.	Hem	2600-3400
Pedicularis pycnantha Boiss.	Hem	3500-3700
Scrophularia amplexicaulis Benth.	Hem	2900-3700
Scrophularia elbursensis Bornm.	Hem	2100-2600
Scrophularia variegata M. Bieb. subsp. *variegata*	Hem	2100-3700
Verbascum speciosum Schrad.	Ch	2000-3000
Veronica aucheri Boiss.	Thr	3900-4500
Veronica biloba Schreb.	Thr	2100-3800
Veronica hederifolia L.	Thr	2000-2300
Veronica kurdica Benth. subsp. *kurdica*	Hem	2500-4100
Veronica paederotae Boiss.	Hem	4200-4300
Veronica persica Poir.	Thr	2100-2600
Veronica rechingeri M.A.Fisch.	Hem	2000-3600
Veronica verna L.	Thr	2000-2700
Urticaceae		
Urtica dioica L.	Ch	2200-2300
Valerianaceae		
Valeriana sisymbriifolia Vahl.	Hem	2500-3700
Violaceae		
Viola alba Besser.	Hem	2100-3100
Viola occulta Lehm.	Thr	2200-3200

Note: Ph: Phanerophyte, Ch: Chamaephyte, Ge: Geophyte: Hem: Hemicryptophyte, Thr: Therophytes

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

Plant groups	Eudicots	Monocots	Gymnosperms	Pteridophytes
Mt. Rostam-Nisht				
Families	75	14.58	2.08	8.33
Genera	82.74	13.69	0.6	2.98
Species	81.94	15.72	0.33	2.01
Kheyrud forest				
Families	72.15	13.92	1.27	12.66
Genera	73.53	18.63	0.49	7.35
Species	73.22	17.97	0.34	8.14

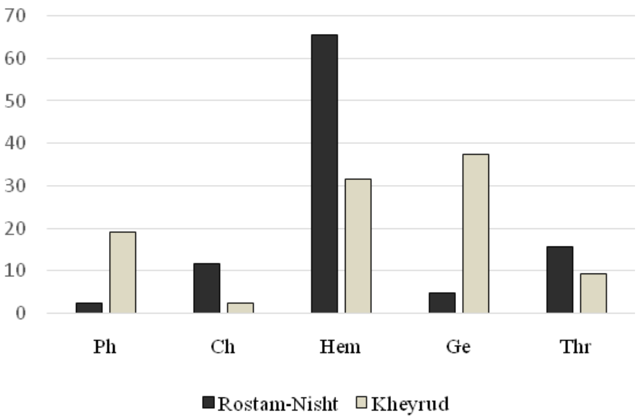

Figure 2. The comparison of life form spectrum in Mt. Rostam-Nisht and Kheyrud forest

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 hemicryptophytes (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 hemicryptophytes (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 hemicryptophytes. 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 hemicryptophytes (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 Hyrcanian 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 (Camarero 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 Hyrcanian 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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