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Ecology and phytosociology of *Cotoneaster* shrublands in Central Alborz of Iran

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Abstract: The genus *Cotoneaster* is considered an important taxon in the woodlands of the Mediterranean and Irano-Turanian regions. Some species of this genus were reported from the Irano-Turanian alpine woodlands. Irano-Turanian mountainous wood and shrublands have a great importance in terms of water and soil conservation, biodiversity and plant richness. There is a lack of quantitative and qualitative statistics available for many of these ecosystems. This research focused on the ecology and phytosociology of *Cotoneaster* shrublands in central Alborz (Iran), with emphasis on *C. kotschyi*, an endemic drought-tolerant species. Data was collected based on the Braun-Blanquet method. TWINSPAN was used to analyse the vegetation data. Species-environment analysis was performed by CCA (Canonical Correspondence Analysis) and one-way ANOVA.

Relevés were classified into three distinct groups regarding their floristic composition. By organizing the phytosociological table, a new subassociation was defined and named as *Rhamno pallasii-Juniperetum excelsae cotoneastretosum kotschyi* subass. nova. This syntaxon is distributed in the range of 2,200–2,430 m a.s.l. between two other groups, i.e. *Cotoneastro nummulariis-Juniperetum excelsae* and *Rhamno pallasii-Juniperetum excelsae. Cotoneaster kotschyi* ecologically is near to *Rhamnus pallasii* which is characteristic for Juniper communities on shallow soils and stony lands. Among the environmental variables, slope, soil texture, pH, lime and saturation percent are the most important distinguishing factors of this subassociation. So, the new syntaxon is found in the habitat with an average slope of 60%, sandy-loam soils and pH and lime percent less than other studied communities. The subassociation *cotoneastretosum kotschyi* has a higher amount of sand content compared to the other vegetation groups.

Cotoneaster nummularius is an indicator of vegetation communities with relatively evolved soils. However, *C. kotschyi* grows in poor and shallow soils. *C. kotschyi* is a differential species which indicates the variability between the two main Alpine associations of the Irano-Turanian region. It is an appropriate species for plantation in the semi-arid mountainous areas. The ecological demands and the floristic composition of these plantations are determined in this article.

Keywords: *Cotoneaster kotschyi*, *Juniperus excelsa*, species-environment relationships, Mediterranean, Irano-Turanian shrublands

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Introduction

Mountainous forests play an important role in terms of water and soil conservation, biodiversity, rehabilitation of vegetation and wildlife protection. These functions are more substantial in arid and semi-arid areas. The Irano-Turanian region, is one of the great phytogeography zones of arid lands in the world, and mostly consists of steppes and deserts. However, it partially covers some mountainous forests and woodlands which further make it an unique ecosystem. In this region, phanerophytes mainly consist of shrubs. Almost all of them are tolerant to harsh conditions such as drought and cold. Furthermore, shrubs are an important component of mountain ecosystems in terms of productivity and diversity (Elzein et al., 2011). The dominant species in forest communities in the mountainous regions of Irano-Turanian zone are *Juniperus excelsa* M.Bieb., *Pistacia* spp. and *Amygdalus* spp. (Sagheb-talebi et al., 2014). Species such as *Cotoneaster* spp., *Berberis* spp., *Lonicera* spp., *Rhamnus pallasii* Fisch. & C.A.Mey, *Cerasus microcarpa* Boiss., *Rosa* spp. and occasionally *Paliurus spina-christi* Mill. occur with Juniper trees (Zohary, 1973; Klein, 2001; Kartoolinejad & Moshki, 2014; Ravanbakhsh et al., 2016). It is believed that these forest stands and scattered Juniper trees were originally steppe forests that were likely a dominant vegetation type in all southern slopes of the Alborz Mountains (Zohary, 1973). These forest and woodland communities belong to the class *Junipero-Pistacietea* Zohary 1973.

Various species of the genus *Cotoneaster* constitute a dominant species of the Irano-Turanian shrublands. *Cotoneaster kotschyi* (C.K.Schneid.) G.Klotz is an endemic shrub species (Ried, 1969; Khatamsaz, 1992) that often occurs sporadically in the southern slopes of the Alborz Mountains and Kerman (Khatamsaz, 1992), but rarely appears in certain landscapes with high sociability and forms shrub communities (Ravanbakhsh et al., 2010). This taxon has not yet been assessed for the IUCN Red List (2016), but its habitat is mainly endangered by human activities. *C. kotschyi* is very tolerant to drought that makes it a suitable species for reforestation and carbon sequestration projects in arid and semi-arid mountainous regions. Ravanbakhsh et al. (2010) found *C. kotschyi* in South Alborz at 1,950 to 2,650 m a.s.l. along with *Juniperus excelsa*, *Amygdalus lycioides* Spach and *Cerasus microcarpa*. Mohammadi et al. (2015) studied the traditional use of this species and showed that *Cotoneaster* fruit can be used to treat asthma. Various species of *Cotoneaster* have the diagnostic role in phytosociology of Mediterranean and sub-Mediterranean regions. *Cotoneaster nummularius* Fisch. & C.A.Mey. along with *Juniperus oxycedrus* L. and *Berberis crataegina* DC. are indicator species of shrub story in *Querco vulcanicae-Juniperetum excelsae* Kargioglu 2005 in Turkish Yandag forests (Kargioglu & Tatli, 2005). This community can be generally observed on the limestone bedrock covered by brown forest soil with slopes of 5–20% and altitude of 1,300 to 1,600 m a.s.l.. *Rhamnus pallasii* and *Cotoneaster nummularius* grow well in the eroded areas of the Fırat valley in Turkey and are suitable for preventing erosion (Kaya, 1999). The species of the genus *Cotoneaster* along with *Prunus*, *Rosa* and *Quercus* are the pioneer species in succession steps in *Cedrus libani* A.Rich. forests (Beals, 1965). Some species of *Cotoneaster* were considered as protected shrubs of the Polish Sudety Mountains (Boratyński et al., 1999). *Cotoneaster nummularius* and *Lonicera nummulariifolia* Jaub. & Spach are characteristic species of *Cotoneastro nummulariis-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015 which occurs in the 2,250–2,750 m a.s.l. on loam, clay loam and sandy loam soils in the South Alborz (Ravanbakhsh et al., 2016). *Cotoneaster racemiflora* K.Koch. and *Rosa laccrans* Boiss. & Buhse occur in Juniper forest communities of the Himalayas in different geographical directions from 2,100 to 2,800 m a.s.l. (Ahmed, 2006).

Natural resources management and sustainable development are based on initial recognition and analysis of vegetation, which provides a basis to prevent the extinction of species or plant communities. The identification and analysis of plant communities, especially forest communities, can provide an example for the rehabilitation and development of vegetation communities, particularly in arid and semi-arid regions. Therefore, the objective of this study was the analysis of vegetation and species-environment relationships in *Cotoneaster* shrublands of Alborz mountains, with emphasis on the ecological behaviour of *C. kotschyi*.

Material and methods

Study area

This study was carried out in the Central Alborz Mountains. Two species of *Cotoneaster*, *C. nummularius* and *C. kotschyi*, along with some other species that constitute shrublands of the Central Alborz. *C. nummularius* has a wide distribution in shrublands, but *C. kotschyi* often grows sporadically. The Rooteh Forest Reserve of Central Alborz is one of these areas, where the species are observed in shrubland formation with a high degree of sociability. Therefore, this habitat was selected for this phytosociological study (Fig. 1). This habitat with an area of 7.5 hectares was located next to the Rooteh village. The mean annual precipitation of this region is 687 mm, mostly in the form of snow. The dry season of this area

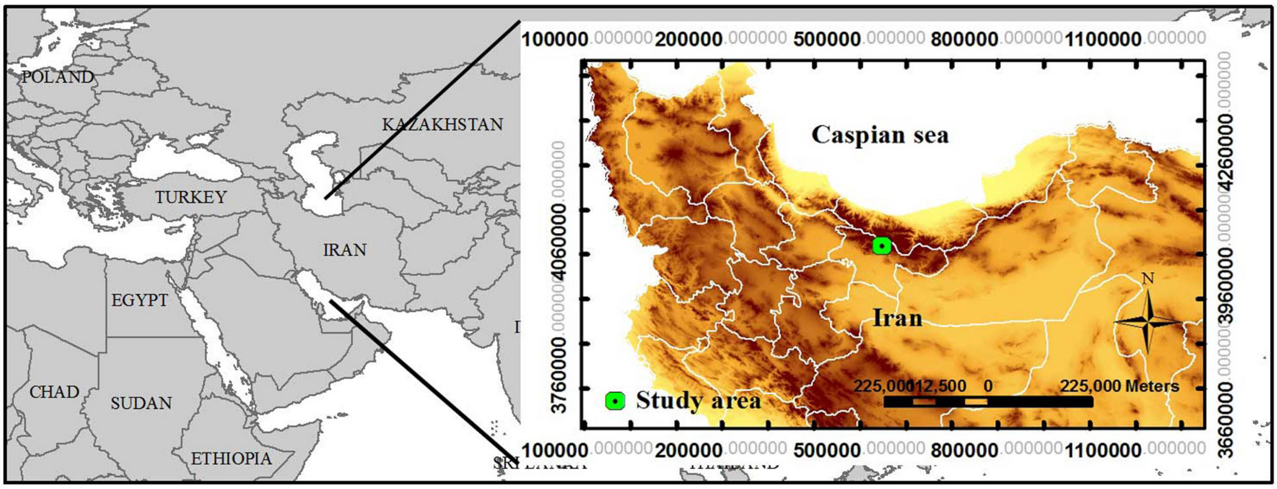

Fig. 1. Location of *Cotoneaster kotschyi* stand

lasts about 4–5 months. The geological formations of sedimentary rocks consist of siltstone, shale, dolomite and conglomerate. Soils are typically antisols and inceptisols.

Data collection and analysis

Field data were collected based on the Braun-Blanquet method (Braun-Blanquet, 1951; Biondi, 2011). For each phytosociological relevé a set of environmental data including topography and soil properties were also recorded. The soil samples were taken from the 10–30 cm depth. In addition to the relevés belonging to *C. kotschyi* community, some relevés of related communities were considered in order to prepare the phytosociological table. A total of 27 relevés were taken. The recognition of plant species was performed using *Flora of Iran* (Assadi, 1988–2016) and *Flora Iranica* (Rechinger, 1963–2005).

The analysis of the vegetation data was performed by TWINSPAN (Hill, 1979). After sorting vegetation with TWINSPAN, the diagnostic species were determined. Diagnostic (characteristic and differential) species are species with the distinct concentrations of occurrence or abundance in a particular vegetation unit (Chytrý & Tichý, 2003). The diagnostic species can be used as characteristic species to diagnose plant associations, or for determining the subassociation as differential species. The diagnostic value of species was based on the fidelity concept, which was considered as dependence of one special species within a particular community (Poore, 1955). To calculate fidelity the Chytrý et al. (2002) method was applied using JUICE ver. 7.0 software (Tichý, 2002). Using Fisher's exact test, the significance of fidelity values were investigated at the 1% P-value (Tichý, 2002). The diagnostic species were controlled and confirmed based on their chorology, viability, ecological properties and bibliography. Afterwards, characteristic, differential and companion species were determined. The nomenclature of new syntaxon was applied according to the International Code of Phytosociological Nomenclature, 3rd edition (Weber et al., 2000).

The ordination method was used to assess the species-environment relationships (Kent & Coker, 1994). Since the species data in this study generally showed a non-linear species response curve, CCA (Canonical Correspondence Analysis) was applied to investigate the vegetation-environment relationships (Lepš & Šmilauer, 1999) using PC-ORD 4 software (McCune & Mefford, 1999) and Canoco 4.5 (ter Braak & Smilauer, 2002). For the application of ordination method, the different measurement units of environmental variables were standardized (ter Braak, 1986). The significance of the CCA axes and species-environment correlations were assessed using the Monte-Carlo test.

In multivariate analysis, the environmental variables should not be a linear combination of variables. This problem can occur for example in the case of soil texture parameters (sand, silt and clay), which entails the removal of one of variables in each case (Palmer, 1993). Therefore, here the variable silt was removed from CCA ordination. The variable aspect was investigated based on the four main directions (90, 180, 270 and 360) and was applied in the analysis after being categorized into four classes of artificial variables. This results in an easier interpretation of data (Palmer, 1993). Due to the large number of species and relevés, their presentation in a single diagram was impossible. Therefore, highly-correlated species were used for presentation in the diagram. Furthermore, the ANOVA followed by Duncan analysis was used to compare the effects of environmental parameters (i.e. soil and topographic variables) in different vegetation groups using IBM SPSS Statistics ver. 22.

Results

Species classification

The relevés were classified into three distinct groups regarding the floristic composition using TWINSPAN method. The first and second groups showed similar floristic compositions and placed with each other in a larger group. In the following, the groups will be explained based on the results presented by Juice software.

1. Group 1
   - Constant species: *Juniperus excelsa*, *Rhamnus pallasii*
   - Diagnostic species: *Rhamnus pallasii*, *Ephedra major* Host
2. Group 2
   - Constant species: *Rhamnus pallasii*, *Cotoneaster kotschyi*, *Cerasus microcarpa*, *Amygdalus lycioides*
   - Diagnostic species: *Cotoneaster kotschyi*, *Valerianella tuberculata* Boiss., *Gundelia tournefortii* L., *Amygdalus lycioides*, *Pistacia atlantica* Desf.
3. Group 3
   - Constant species: *Juniperus excelsa*, *Cotoneaster nummularius*, *Lonicera nummulariifolia*, *Berberis integerrima* Bunge., *Hypericum scabrum* L., *Dactylis glomerata* L.
   - Diagnostic species: *Cotoneaster nummularius*, *Lonicera nummulariifolia*, *Astragalus aegobromus* Boiss. & Hohen., *Cousinia calocephala* Jaub. & Spach.

Phytosociology

Following the classification of vegetation groups, the relevés and species were arranged in phytosociological table (Table 1). The analysis of the characteristic species of each group and comparing them with published syntaxa (Table 2) showed that the first and third groups can be classified as *Rhamno pallasii-Juniperetum excelsae* and *Cotoneastro nummulariis-Juniperetum excelsae* (Tables 1 & 2), whereas the second group is a new syntaxon. Therefore the bibliography for floristic composition of the new syntaxon (with emphasis on *Rhamnus pallasii*, *Cotoneaster kotschyi*, *Valerianella tuberculata* and *Pistacia atlantica*) is provided and organized in the synoptic table (Table 2). The species *Pistacia atlantica* is recognized as a diagnostic species for the new syntaxon. This species was already listed as characteristic species of other associations (Zohary, 1973; Quézel et al., 1980; Togonidze, 2011) (Table 2). In addition, *P. atlantica* appears in the altitude of 1,300–1,800 m a.s.l. (Marvie Mohadjer, 2005), whereas its presence in our study area was not in the typical altitude of it. Therefore, the presence of *P. atlantica* along with the characteristic species of *Rhamno pallasii-Juniperetum excelsae*, as well as an endemic species *C. kotschyi* represented their differential role to establish a new subassociation. This floristic composition is unique and has never been described yet (Table 2). Based on the synoptic table, the presence of *Rhamnus pallasii*, *Cerasus microcarpa*, *Berberis integerrima* and *Conringia planisiliqua* Fisch. & C.A.May. in the floristic composition, as the characteristic species of order *Juniperetalia excelsae* Ravanbakhsh & Hamzeh'ee 2015, and *Juniperus excelsa* and *Amygdalus lycioides*, as the characteristic species of class *Junipero-Pistacietea* Zohary 1973, indicates that this new syntaxon belongs to these order and class. *Juniperus excelsa*, *Rhamnus pallasii* and *Pistacia atlantica* were reported as characteristic species of some other associations in the Mediterranean and Caucasus (Table 2), but most of them belong to *Quercetea pubescentis* Doingt & Kraft 1955 (Tel et al., 2010) and their floristic composition is considerably different from the Alborz associations.

Therefore, the classification of the new syntaxon and the related syntaxa are as follow:

- **Class**: *Junipero-Pistacietea* Zohary 1973
- **Order**: *Juniperetalia excelsae* Ravanbakhsh & Hamzeh'ee 2015
- **Association**: *Rhamno pallasii-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015
- **Subassociation**:
  - *Rhamno pallasii-Juniperetum excelsae cotoneastretosum kotschyi* subass. nova hoc loco
  - Holotypus: Table 1, rel. 25
  - Differential species: *Cotoneaster kotschyi*, *Valerianella tuberculata*, *Pistacia atlantica*
  - Higher syntaxa characteristic species: *Juniperus excelsa*, *Amygdalus lycioides*, *Rhamnus pallasii*, *Cerasus microcarpa*, *Berberis integerrima*, *Conringia planisiliqua*, *Ephedra major*

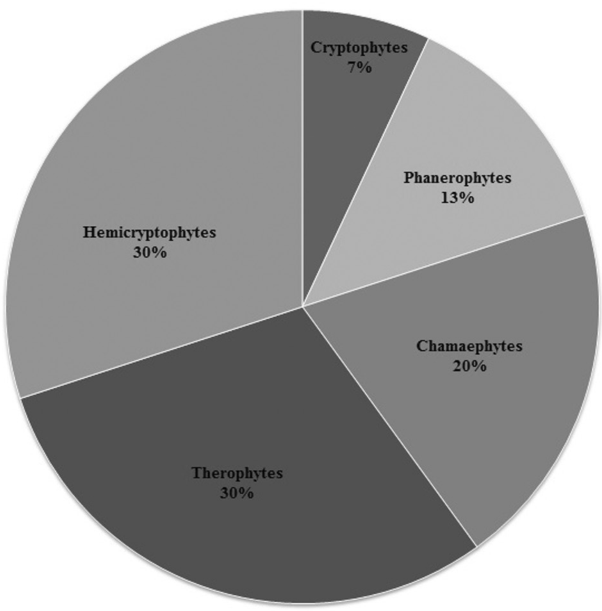

Fig. 2. Life form groups in *Cotoneaster kotschyi* habitat

Table 1. Floristic composition in the studied communities (Col. 1–16: *Rhamno pallasii-Juniperetum excelsae*; Col. 1–6: *Rp-Je cotoneastretosum kotschyi*; Col. 17–26: *Cotoneastro nummulariis-Juniperetum excelsae*)

Succesive number		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	Constancy
Relevé number		22	23	24	21	25	26	9	10	3	4	1	2	7	8	5	6	19	18	13	14	11	12	17	15	20	16	
Area of Relevé (m^2)		150	150	150	100	100	100	225	225	225	100	25	225	150	225	225	225	225	150	225	225	225	225	225	225	100	225	
Altitude (m)		2317	2376	2355	2350	2300	2300	2113	2150	2135	2174	2370	2360	2235	2080	2270	2273	2386	2416	2460	2498	2260	2445	2670	2594	2719	2441	
Exposition		200	210	110	180	190	200	90	180	180	180	90	180	180	180	180	180	90	180	270	180	180	180	180	180	180	270	
Slope [%]		55	55	60	60	70	70	35	35	30	35	10	50	35	65	45	45	55	45	25	55	40	30	45	55	50	35	
Tree layer [%]		5	0	5	5	5	10	60	40	60	40	5	60	40	70	40	40	40	70	60	70	40	40	40	20	40	40	
Shrub layer [%]		70	50	50	50	70	60	20	20	10	10	30	10	10	40	5	10	60	20	70	20	70	70	60	60	50	20	
Herb layer [%]		20	30	10	50	30	10	15	5	5	15	15	5	15	5	25	15	35	15	60	5	5	30	15	15	15	35	
I. ChAss. *Rhamno pallasii-Juniperetum excelsae*																												
Rhamnus pallasii	b	2	1	3	3	2	2	2	3	3	3	3	2	2	3	2	3	.	.	.	.	.	.	.	.	.	.	IV
II. DSubass. *cotoneastretosum kotschyi*																												
Cotoneaster kotschyi	b	3	3	2	3	4	3	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Valerianella tuberculata		+	+	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Pistacia atlantica	a	+	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
III. ChAss. *Cotoneastro nummulariis-Juniperetum excelsae*																												
Cotoneaster nummularius	b	.	+	.	.	+	+	.	.	.	.	.	.	.	.	.	.	3	3	4	3	2	4	4	4	3	3	IV
Lonicera nummulariifolia	a	.	1	.	.	1	1	+	+	.	.	+	.	.	.	.	+	1	1	2	2	2	1	2	1	1	2	IV
Dactylis glomerata		.	.	.	.	+	.	.	.	.	.	.	1	.	.	.	.	1	1	1	2	+	2	2	2	2	1	III
Asperula arvensis		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	+	+	+	+	.	.	.	1	II
Astragalus aegobromus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	1	r	+	1	.	.	.	II
Chalcanthus renifolius		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	1	1	1	I
Astragalus citrinus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	+	.	.	.	.	I
IV. ChO. *Juniperetalia excelsae* & ChCl. *Junipero-Pistacietea*																												
Juniperus excelsa	a	.	+	.	1	.	2	4	4	4	3	+	3	4	4	4	4	3	4	4	4	3	4	3	3	4	3	V
Berberis integerrima	b	.	+	.	.	.	.	.	+	.	+	+	+	1	2	1	.	1	+	2	+	3	1	2	1	1	1	IV
Cerasus microcarpa	b	1	1	1	1	2	1	.	.	.	.	.	.	.	+	.	+	.	1	3	+	3	2	1	1	+	.	IV
Rubia florida		.	.	.	.	.	.	1	.	.	1	.	.	1	1	1	+	.	1	+	1	1	+	1	1	.	1	III
Conringia planisiliqua		+	+	.	.	.	.	1	.	+	1	.	1	+	+	.	.	+	.	.	1	.	.	.	.	.	1	III
Cousinia calocephala		.	.	.	.	.	.	r	.	.	.	.	+	.	.	.	.	+	.	+	+	+	r	+	+	.	.	II
Amygdalus lycioides	b	1	2	1	3	+	1	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	II
Berberis crataegina	b	.	.	.	.	.	.	1	.	.	.	.	.	.	1	.	.	.	.	2	.	.	2	.	.	.	.	I
Ephedra major	b	.	.	.	.	.	.	2	2	2	2	.	.	1	2	.	2	.	.	.	.	.	.	.	.	.	.	II
Rosa canina	b	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	+	.	.	I
Silene aucheriana		.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	1	.	I
Silene marschallii		.	.	.	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	+	.	.	.	+	I
Celtis caucasica	a	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
V. Others																												
Psathyrostachys fragilis		+	.	1	+	+	1	1	1	1	+	.	.	+	1	1	1	1	1	.	.	1	.	+	+	.	+	IV
Verbascum speciosum		+	+	+	+	+	1	r	+	+	.	+	.	+	+	+	.	+	1	.	+	+	+	.	+	.	.	IV
Euphorbia cheiradenia		+	.	+	.	+	.	1	1	1	+	+	.	1	1	.	.	1	+	+	+	1	1	1	+	1	.	IV
Alyssum minus		1	+	+	1	+	1	1	+	1	1	1	1	1	1	1	1	.	1	1	1	1	1	1	.	.	1	V
Acinos graveolens		1	1	+	1	1	1	.	1	.	.	+	1	.	1	1	1	.	1	1	+	+	+	.	.	.	.	IV
Senecio vernalis		1	1	1	1	1	1	1	R	1	1	1	.	1	.	+	.	1	1	+	1	.	1	1	+	.	.	IV
Bromus tectorum		1	1	1	1	1	1	.	1	1	1	1	.	1	+	1	1	1	1	1	1	+	1	1	.	.	.	V
Astragalus verus		1	1	1	1	.	1	.	.	.	+	+	2	.	.	+	+	+	.	1	+	1	+	.	.	.	+	IV
Hypericum scabrum		+	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	+	1	1	1	+	2	2	2	1	2	III
Geranium persicum		1	+	1	1	1	1	.	.	.	+	1	1	.	.	+	.	.	.	+	1	.	+	+	.	+	.	III

Succesive number	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
Relevé number	22	23	24	21	25	26	9	10	3	4	1	2	7	8	5	6	19	18	13	14	11	12	17	15	20	16	
Lamium amplexicaule	1	+	1	1	1	1	.	1	.	1	.	1	.	1	1	1	.	.	.	.	.	+	.	.	.	.	III
Arabis nova	1	1	.	1	1	1	.	.	1	1	.	1	.	1	1	1	.	.	.	.	.	+	.	1	.	+	III
Galium aparine	1	1	+	1	1	1	.	.	1	1	.	.	1	.	1	1	.	1	1	1	1	1	1	1	.	.	IV
Lappula sinaica	+	.	+	+	+	1	.	.	+	+	.	+	+	.	1	1	+	.	.	.	.	+	.	.	.	+	III
Papaver dubium	+	.	+	+	+	1	1	.	.	+	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	II
Artemisia aucheri	.	.	.	.	.	.	1	1	+	+	.	+	1	.	.	+	1	1	+	.	+	+	.	1	1	1	III
Eremurus spectabilis	.	.	.	.	.	.	.	.	+	.	1	1	+	.	+	+	+	1	1	+	1	1	1	+	.	1	III
Crucianella glauca	.	1	.	.	.	1	1	.	.	.	.	.	1	1	1	1	1	1	.	1	1	.	1	.	1	1	III
Alyssopsis mollis	.	+	.	1	+	.	.	1	.	1	.	.	1	.	1	1	1	.	1	1	.	1	.	.	.	.	III
Scariola orientalis	+	.	+	1	1	.	.	.	.	.	.	1	1	.	+	.	1	.	+	1	+	1	1	.	.	.	III
Minuartia meyeri	.	+	.	.	1	1	.	+	+	+	1	.	1	.	.	+	1	.	1	.	+	.	.	.	.	.	III
Veronica biloba	+	+	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	1	1	1	.	1	1	1	.	+	III
Eremopoa persica	.	.	.	1	1	1	1	1	+	1	1	1	1	1	1	1	1	.	1	.	.	.	.	.	.	+	III
Astragalus compactus	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	.	.	+	+	1	.	II
Callipeltis cucullaris	+	+	.	1	1	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	+	+	.	.	.	.	II
Ziziphora tenuior	1	1	+	1	1	+	+	.	+	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	II
Tulipa montana	+	.	+	1	1	1	.	.	.	+	.	1	r	.	+	.	.	.	.	.	.	.	.	.	.	.	II
Acantholimon festucaceum	.	.	.	.	.	.	2	1	+	+	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	+	II
Onobrychis cornuta	.	.	.	.	.	.	1	.	.	.	+	.	.	+	.	.	.	1	1	1	.	.	1	2	.	+	II
Stipa arabica	.	.	.	.	.	.	.	+	.	+	+	+	+	.	.	+	.	.	.	.	.	.	.	.	1	.	II
Elymus hispidus	1	.	.	.	+	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	1	.	1	.	.	.	II
Melica persica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	+	r	+	+	.	.	II
Alliaria petiolata	.	+	.	1	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	II
Holosteum glutinosum	.	.	.	.	.	.	.	.	.	.	.	.	1	+	1	+	.	.	.	.	+	+	.	.	.	.	II
Clypeola jonthlaspi	+	.	+	+	+	.	.	.	.	.	.	.	+	.	1	.	.	.	.	.	.	.	.	.	.	.	II
Viola modesta	.	.	.	.	.	.	.	.	.	1	+	.	1	.	+	+	1	.	.	1	+	1	.	.	1	.	II
Descurainia sophia	.	.	.	.	.	.	1	.	+	.	+	.	+	.	+	r	.	.	.	.	.	.	.	.	.	1	II
Ceratocephala testiculata	.	.	.	.	.	.	1	1	+	+	+	.	1	.	.	.	.	.	.	.	.	.	.	.	1	.	II
Veronica capillipes	.	.	.	.	.	.	1	.	+	1	.	.	+	1	1	1	.	.	.	.	.	.	.	.	.	.	II
Crepis sancta	.	+	.	.	.	+	.	.	.	.	+	.	.	.	r	.	.	.	.	.	+	.	+	.	.	.	II
Scandix stellata	.	+	.	+	+	1	.	.	.	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	II
Scandix aucheri	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	1	.	.	1	.	.	.	.	I
Centaurea virgata	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	+	1	1	.	.	II
Teucrium polium	.	+	1	.	.	+	1	1	1	.	.	.	1	1	2	.	.	.	.	.	.	.	.	.	.	.	II
Eryngium billardieri	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	+	+	.	+	+	.	+	1	.	II
Alyssum inflatum	.	.	.	.	.	.	+	+	.	.	1	1	.	1	.	.	.	.	.	1	.	.	.	.	1	.	II
Stachys lavandulifolia	.	1	1	.	.	1	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Valerianella szowitsiana	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I
Acanthophyllum glandulosum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	+	.	+	+	.	.	.	+	I
Bromus tomentellus	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	1	I
Fumaria asepala	.	+	.	+	.	1	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	I
Stachys inflata	.	.	.	.	.	.	1	1	.	.	.	.	.	1	+	.	.	.	.	.	+	.	.	.	.	.	I
Colchicum speciosum	+	.	+	.	.	.	.	.	.	.	.	.	.	.	r	.	.	.	.	.	.	.	.	.	.	.	I
Allium iranicum	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	1	.	.	.	I
Marrubium vulgare	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	I
Salvia limbata	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	1	+	.	+	.	1	.	.	.	I
Muscari caucasicum	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	+	+	+	r	.	.	1	.	II

Sporadic species: I. *Acanthophyllum microcephalum* 14(2), *Agropyron cristatum* 12(+), *Allium derderianum* 16(+), *Arenaria polycnemifolia* 7(1) & 8(+), *Arenaria serpyllifolia* 11(1), *Boissiera squarrosa* 14(+), *Buglossoides arvensis* 10(+) & 11(+), *Eremopyrum bonaepartis* 8(+) & 9(+), *Eremopyrum confusum* 14(r), *Gagea reticulata* 11(r), *Helichrysum oligocephalum* 4(+) & 11(+), *Hypericum helianthemoides* 14(+), *Iris pseudocaucasica* 15(r), *Lepyrodiclis stellarioides* 13(+), *Linaria lineolata* 14(r)., *Nepeta pungens* 16(+), *Polygonum molliaeforme* 7(1), *Rochelia persica* 11(+) &12(+), *Stelleropsis iranica* 7(1) & 8(1), *Thymus fedtschenkoi* 15(1), *Trigonella* sp. 11(+), *Valantia* sp. 10(+), 11(+) & 16(+), *Valerianella plagiostephana* 9(+) & 13(+), *Verbena officinalis* 5(+) & 10(+), *Veronica rubrifolia* 15(+) & 16(+), *Vicia vernalosa* 14(+), *Ziziphora clinopodioides* 11(+) & 3(1). **II.** *Asyneuma amplexicaule* 1(+), *Gundelia tournefortii* 2(1) & 3(1), *Isatis cappadocica* 2(+) & 3(1), *Linaria simplex* 4(+), *Malcolmia africana* 4(+), *Parietaria judaica* 1(+) &4(1), *Phlomis olivieri* 6(+), *Sanguisorba minor* 5(+), *Sisymbrium irio* 4(+), *Tanacetum parthenium* 4(r), *Tragopogon* sp. 1(+). **III.** *Acantholimon erinaceum* 26(r), *Aethionema arabicum* 19(+), *Aethionema cordatum* 23(1) & 26(1), *Cardaria draba* 22(1), 24(1) & 25(1), *Chaerophyllum macropodum* 19(r), *Cirsium congestum* 22(+) & 23(r), *Cirsium strigosum* 17(+), 23(+) & 25(1), *Convolvulus arvensis* 23(+), *Galium mite* 23(r), *Herniaria incana* 26(+), *Lappula barbata* 23(1), *Mesostomma kotschyanum* 23(+), *Minuartia lineata* 22(+), *Oryzopsis holciformis* 22(r), *Rosa beggeriana* 21(1) & 22(+), *Rosa persica* 21(+), *Saponaria viscosa* 24(r), *Silene swertiifolia* 23(+), *Sisymbrium gaubae* 22(1), *Taeniatherum crinitum* 17(+), 19(+) & 20(1), *Thesium kotschyanum* 25(1), **V.** *Alkanna bracteosa* 5(+) & 23(+), *Bromus danthoniae* 7(1), 14(+), 15(+), 16(+) & 21(1), *Bupleurum exaltatum* 6(+), 13(+) & 23(+), *Cerastium dichotomum* 4(+), 10(+), 11(+) & 12(+), *Cerastium inflatum* 4(+), 15(r) &17(1), *Drabopsis verna* 9(+), 11(+), 14(+) & 21(1), *Ferula ovina* 1(+), 23(+) & 25(1)., *Linaria striatella* 10(+) & 25(+), *Nonea pulla* 6(+) & 17(+), *Poa bulbosa* 11(1), 12(1), 15(+) & 16(+), *Thlaspi perfoliatum* 2(+), 5(+) & 17(1).

Ecological conditions of the new syntaxon: This sub-association could be observed in mountainous habitat with shallow soils and rocky protrusions located on south, southwest and southeast aspects. It is distributed in 2,000–2,400 m a.s.l. Soil pH values vary between 7 and 7.6, lime 2.5–8.5%, organic matter 1–3%, and in sandy loam soil textures.

In total, 98 species were identified in *C. kotschyi* habitat, which belong to 87 genera and 33 families. The families with the most species were: Apiaceae, Asteraceae, Lamiaceae, Rosaceae and Poaceae with 14, 11, 11, 7 and 6 species, respectively. The most abundant life forms were related to cryptophytes and therophytes (Fig. 2).

Analysis of vegetation in relation to environmental variables

The results of CCA analysis followed by the Monte Carlo test show that the first three components could be used for interpreting the results (Table 3). These components explain a total of 57.2% of variance in the species-environment relationships. The first component shows highly positive correlations with altitude, soil organic carbon and nitrogen (Table 4). Therefore, the first axis represents a gradient of these three variables. The second component shows a highly positive correlation with slope and sand, while it is negatively correlated with soil lime and pH (Table 4). In other words, moving on the positive direction of second axis, the slope increases as the soil becomes sandier. The first and second components have the highest eigenvalues, used for presenting the results in the diagram (Fig. 3).

The position of relevés (plots) in each diagram shows effective indicator species and environmental factors. The arrows represent the environmental variables gradient. The effective variables have a longer arrow. The relevés of *cotoneastretosum kotschyi* placed in the top left corner of the diagram (Figure 3), which on the one hand represents a higher slope and sandier soil and on the other hand shows lower soil pH and lime percentage of habitat. The position of relevés of *cotoneastretosum kotschyi* along the height vector indicates that this subassociation is placed between two other communities (i.e. *Cotoneastro nummulariis-Juniperetum excelsae* and *Rhamno pallasii-Juniperetum excelsae*).

The soil organic matter and nitrogen content are distinctive factors between *C. nummulariis-J. excelsae* and *Rh. pallasii-J. excelsae*. *Rh. pallasii-J. excelsae* and its subassociation *cotoneastretosum kotschyi* occur in the soils with lower organic matter and nitrogen compared to *C. nummulariis-J. excelsae*. The main difference of subassociation habitat with its above-rank syntaxon (i.e. *Rh. pallasii-J. excelsae*) is in soil texture, pH, lime and slope, so that the *cotoneastretosum kotschyi* could be observed in the soils with a lower pH, lower lime content, lighter soil texture (sandier) and steeper slopes.

The species location on the CCA biplots represents the characteristic and differential species of vegetation groups (Fig. 3). *Cotoneaster kotschyi*, *Valerianella tuberculata* and *Pistacia atlantica* are the differential species of *cotoneastretosum kotschyi* placed in the upper left corner of the diagram. These species show a preference for sandy soils and steep slopes. It was also observed that this species composition grows in the soils with lower pH values and lower lime contents compared to other vegetation groups studied here.

Cotoneaster nummularius, *Lonicera nummulariifolia*, *Astragalus aegobromus* and *Cousinia calocephala* were characteristic species of *Cotoneastro nummulariis-Juniperetum excelsae* which were located along the first axis in the positive direction matched with the location of the most relevés of the community. Species located in this area of the diagram had a preference for higher organic matter and nitrogen soil content which also tend to appear at higher altitudes in comparison to other species. In the negative direction of first axis, *Rhamnus pallasii* appears, suggesting that this species occurs at lower altitudes and in the soils with lower

Table 2. Abbreviated synoptic table of 11 syntaxa in Iran, Mediterranean and Caucasus. Only species with higher constancy are shown[1]

Column No.	1	2	3	4	5	6	7	8	9	10	11
Class	*Junipero-Pistacietea* Zohary 1973					*Ephed-retea*	Not defined		*Quercetea pubescentis* Kraft 1955 (Tel et al., 2010)		
Order	*Juniperetalia excelsae* Ravanbakhsh & Hamzeh'ee 2015				Not defined	*Ephedretalia nazaria* Nazarian et al. 2004	Not defined	Not defined	*Quercetalia pubescenti- petraeae* (Blasi et al. 2004)	*Quercetalia pubescentis* Kraft 1955	*Quercetalia pubescentis* Kraft 1955
Association & Subassociation	*Cotoneastro nummularis-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015	*Rhamno pallasii-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015			*Amygdalo -Pistacietum* Zohary 1973	*Rhamno pallasii-Ephedretum majoris* Nazarian et al. 2004	*Juniperetum spinoso-fruticosum* Togonidze 2011	*Pistacieto-Juniperetum* Togonidze 2011	*Pistacio mutica–Juniperetum excelsae* Grebenshchikov et al. 1990 (Demina & Ogureeva 2014)	*Pistacio atlantica-Rhamnetum graecus* Quézel et al. 1980.	*Balloto-Rhamnetum pallasii* Tatlı & Altan 1987 ((Öztürk et al. 2015)
		ajugetosum chamaecisti Ravanbakhsh & Hamzeh'ee 2015	*gypsophiletosum aretioidis* Ravanbakhsh &Hamzeh'ee 2015	*cotoneastretosum kotschyi* subass. nov.							
Location	Iran	Iran	Iran	Iran	M.E.[2]	Iran	Georgia	Georgia	Russia	Turkey	Turkey
Ch. Ass. 1[3]											
Cotoneaster nummularius	V										
Lonicera nummulariifolia	V										
Dactylis glomerata	V										
Astragalus aegobromus	IV										
Asperula arvensis	III										
Chalcanthus renifolius	II										
Silene aucheriana	II										
Silene marschalii	II										
Astragalus citrinus	I										
D. SubAss. 2											
Ajuga chamaecistus		IV									
Bupleurum exaltatum	I	IV									
Noaea mucronata		IV									
Astragalus podolobus		III									
Johrenia platycarpa		III									
Silene spergulifolia		III									
D. SubAss. 3											
Tanacetum polycephalum			IV								
Gypsophila aretioides			III								
Pimpinella tragium			III								
Helichrysum oligocephalum			II								
D. SubAss. 4											
Cotoneaster kotschyi				V							
Valerianella tuberculata				V							
Pistacia atlantica				III	+			II	+	+	
Ch. Ass. 2–4											
Rhamnus pallasii		V	IV	V		V	II	I			V
Ephedra major		III	IV			V					
Ch. Order & Class 1–5											
Cerasus microcarpa	IV	II	II	V				I			

Column No.	1	2	3	4	5	6	7	8	9	10	11
Class	*Junipero-Pistacietea* Zohary 1973					*Ephed-retea*	Not defined		*Quercetea pubescentis* Kraft 1955 (Tel et al., 2010)		
Order	*Juniperetalia excelsae* Ravanbakhsh & Hamzeh'ee 2015				Not defined	*Ephedretalia nazaria* Nazarian et al. 2004	Not defined	Not defined	*Quercetalia pubescenti- petraeae* (Blasi et al. 2004)	*Quercetalia pubescentis* Kraft 1955	*Quercetalia pubescentis* Kraft 1955
Association & Subassociation	*Cotoneastro nummularis-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015	*Rhamno pallasii-Juniperetum excelsae* Ravanbakhsh & Hamzeh'ee 2015			*Amygdalo -Pistacietum* Zohary 1973	*Rhamno pallasii-Ephedretum majoris* Nazarian et al. 2004	*Juniperetum spinoso-fruticosum* Togonidze 2011	*Pistacieto-Juniperetum* Togonidze 2011	*Pistacio mutica–Juniperetum excelsae* Grebenshchikov et al. 1990 (Demina & Ogureeva 2014)	*Pistacio atlantica-Rhamnetum graecus* Quézel et al. 1980.	*Balloto-Rhamnetum pallasii* Tatlı & Altan 1987 ((Öztürk et al. 2015)
		ajugetosum chamaecisti Ravanbakhsh & Hamzeh'ee 2015	*gypsophiletosum aretioidis* Ravanbakhsh &Hamzeh'ee 2015	*cotoneastretosum kotschyi* subass. nov.							
Location	Iran	Iran	Iran	Iran	M.E.[2]	Iran	Georgia	Georgia	Russia	Turkey	Turkey
Rubia florida	V	III	I	I							
Berberis integerrima	V	IV	II	I							
Conringia planisiliqua	II	II	III	II							
Juniperus excelsa	V	V	V	III			II		+		
Amygdalus lycioides	I	III	IV	V	+						
Ch. Ass. 7–9											
Juniperus foetidissima							III	V	+		
Juniperus oxycedrus							II		+		
Paliurus spina-christi							III	I	+		
Berberis iberica							I	I			
Lonicera iberica							I	I			
Spiraea hypericifolia							II				
Ephedra procera							I				
Jasminum fruticans								I	+		
Cotoneaster integerrimus								I			
Teucrium polium		III	IV	III				I	I		
Asparagus verticillatus									+		
Ch. Ass. 10											
Rhamnus graecus										+	
Ch. Ass. 11											
Ballota nigra subsp. *nigra*											V
Polygonum convolvulus											V
Spiraea crenata											IV
Acinos arvensis											III
Sobolewskia clavata											II
Ch. Order & Class 9–11											
Continus coggyria								I	I		V
Teucrium chamaedrys											V
Quercus pubescens									I	+	

[1] Ch: characteristic species; D: differential species; [2] Middle East; [3] It refers to the column numbers.
+ was applied when the constancy was not specified in the original article.

Table 3. Eigenvalues and species-environment correlation coefficients for the first three components with the results of Monte Carlo test

	Component 1	Component 2	Component 3
Eigenvalue	0.36**	0.31**	0.23**
Cumulative percentage variance explained:			
of species data	12.2	22.3	30
of species-environment relation	23.2	42.6	57.2
Pearson correlation	0.95**	0.95*	0.95
Kendall (Rank) correlation	0.80**	0.83*	0.69

**Significant at P<0.01 level; * Significant at P<0.05 level.

Table 4. The correlation of environmental variables with first three components of CCA

Variables	Correlations[1]		
	Component 1	Component 2	Component 3
Altitude	0.863	0.361	0.186
Aspect	0.264	0.168	–0.422
Slope	–0.210	0.544	–0.618
pH	0.208	–0.607	0.262
Lime	–0.118	–0.833	–0.108
Total N	0.640	–0.103	0.123
Organic C	0.664	–0.153	0.005
SP[2]	0.644	–0.377	0.162
Sand	–0.251	0.498	–0.484
Clay	0.055	–0.432	0.261

[1] Intraset correlations of ter Braak (1986); [2] Water saturation [%]

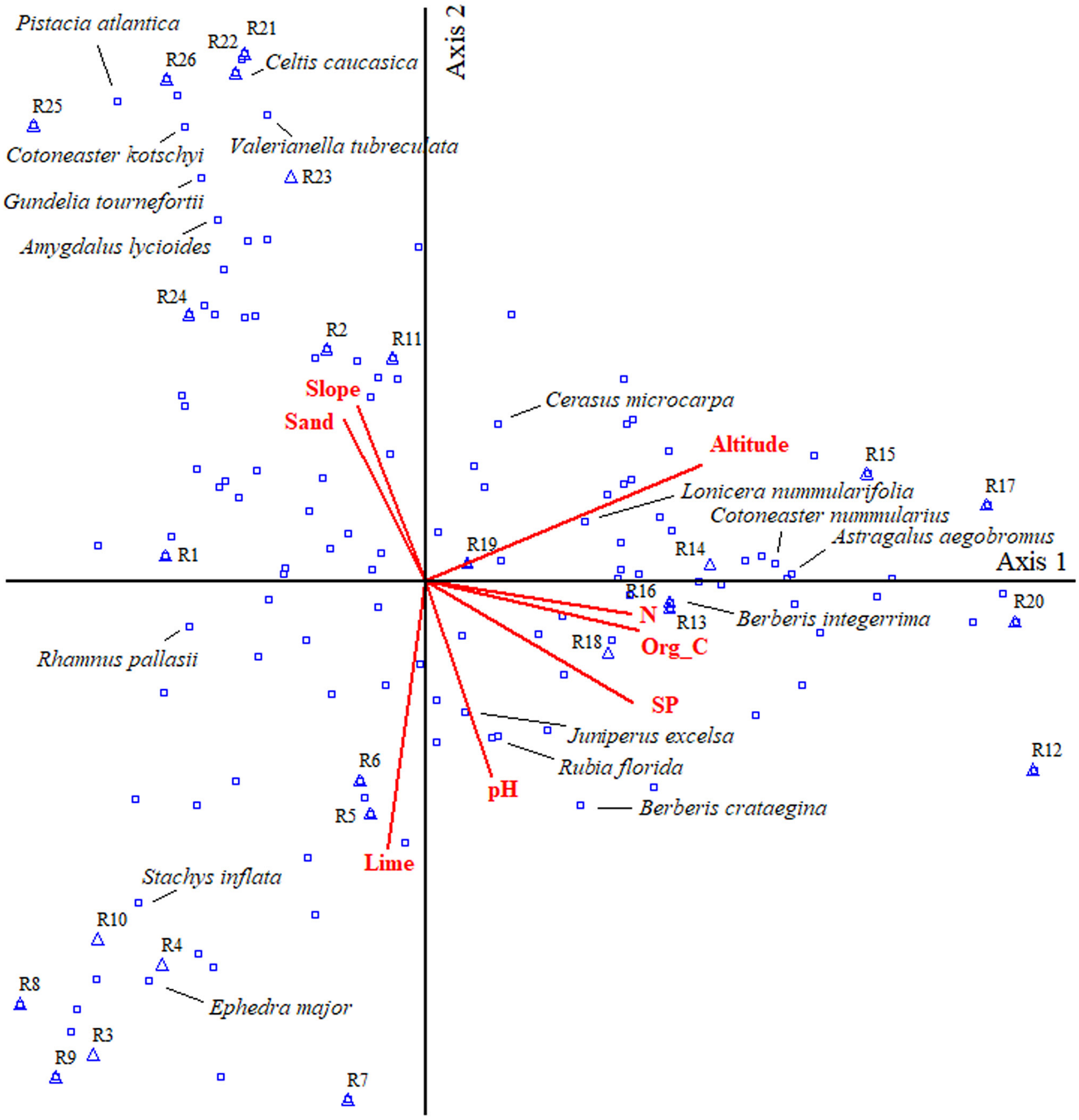

Fig. 3. The distribution of species and plots in the CCA ordination diagram (axis 1 and axis 2)
The arrows for environmental variables indicate the direction of maximum change of that variable; Δ – relevés with their names (R1, R2, etc.); □ species (just diagnostic and highly-correlated species are presented).

Table 5. The average of environmental variables for different groups using Duncan mean comparison[1]

Variable	*Rh. pallasii-J. excelsae*	SD [2]	*C. nummulariis-J. excelsae*	SD	*Cotoneastretosum kotschyi*	SD
Altitude (m)	2216 [a]	(101)	2488 [b]	(137)	2333 [c]	(32)
Slope %	38.5 [a]	(14.3)	43.5 [a]	(10.8)	61.7 [b]	(6.8)
Aspect	162 [a]	(40)	189 [a]	(51)	181 [a]	(36)
pH	7.86 [a]	(0.28)	7.78 [a]	(0.13)	7.42 [b]	(0.19)
Lime %	21.3 [a]	(8.9)	12.3 [b]	(7.0)	4.2 [c]	(2.3)
Organic matter %	2.59 [a]	(1.16)	5.02 [b]	(2.66)	1.87 [a]	(0.72)
N %	0.12 [a]	(0.05)	0.20 [b]	(0.10)	0.10 [a]	(0.06)
SP %	42.3 [a]	(4.5)	48.2 [a]	(8.7)	33.6 [b]	(8.8)
Sand %	39.29 [a]	(13.51)	40.20 [a]	(13.73)	60.99 [b]	(12.48)
Silt %	33.01 [a]	(9.11)	33.50 [a]	(9.37)	22.11 [b]	(7.91)
Clay %	27.69 [a]	(7.19)	25.30 [ab]	(10.27)	17.91 [b]	(8.12)

[1]Similar letters indicate no significant difference amongst groups; [2] Standard Deviation.

nitrogen and organic matter content. Similarly, the relevés of *Rh. Pallasii-J. excelsae* are located along the negative direction of first axis. *Ephedra major*, *Stachys inflata* and *Teucrium polium* L. showing a tendency to grow in more lime-rich habitats with low organic matter.

Analysis of variance and comparison of environmental variables in the vegetation groups

The ANOVA results showed that altitude, slope, pH, lime, organic matter, soil nitrogen, water saturation level, sand and silt content are significantly different amongst vegetation groups (Table 5). In terms of altitude, *cotoneastretosum kotschyi* is located between *C. nummulariis-J. excelsae* and *Rh. pallasii-J. excelsae* (Table 5). The subassociation *cotoneastretosum kotschyi* is distributed on average at 60% slopes which is significantly higher than those for *C. nummulariis-J. excelsae* or *Rh. pallasii-J. excelsae*. The soil pH and lime, organic carbon and nitrogen, water saturation percent are lower in *cotoneastretosum kotschyi* compared to two other groups. In terms of soil texture, *cotoneastretosum kotschyi* also contains higher amounts of sand, and lower amounts of silt and clay compared to the two other groups, with a significant difference observed between sand and silt (Table 5). Furthermore, the organic matter and water saturation level in *C. nummulariis-J. excelsae* is significantly higher than in *Rh. pallasii-J. excelsae*, and the first community is located at higher altitude compared to the second community.

Discussion

Vegetation

The genus *Cotoneaster* is considered an important taxon in woodlands of Irano-Turanian, Caucasian and Mediterranean regions (i.e. *Cotoneaster nummularius* in *Querco vulcanicae-Juniperetum excelsae* in Turkey (Kargioglu & Tatli, 2005; Ozkan et al., 2010) and in *Cotoneastro nummulariis-Juniperetum excelsae* in Iran (Ravanbakhsh et al., 2016); *C. integerrimus* Medik. as a characteristic species of *Pino-Juniperetea* Rivas-Martinez 1964 in the Central and Eastern Mediterranean region (Brullo et al., 2001) and in *Pistacieto-Juniperetum* of Georgia (Togonidze, 2011) and *C. racemiflora* in Juniper forests of the Himalayas (Ahmed, 2006). Based on the results of this study, the *Cotoneaster* shrublands of the Alborz are placed in *Cotoneastro nummulariis-Juniperetum excelsae* and *Rhamno pallasii-Juniperetum excelsae cotoneastretosum kotschyi* subass. nov. Introduction of the new subassociation increased the number of subassociations of *Rhamno pallasii-Juniperetum excelsae* to three (Table 2). The subassociations already introduced, *gypsophiletosum aretioidis* and *ajugetosum chamaecisti*, were restricted to the rocky habitat and the mountains to dry plains, respectively (Ravanbakhsh et al., 2016), while *cotoneastretosum kotschyi* is located in the sandy-loam soil and mountainous areas far from the dry plains. According to the literature, different species of *Cotoneaster* appear with *Rhamnus* species in different syntaxa together and sometimes with *Juniperus* (Kaya, 1999; Abido & Kurbaisa, 2003; Togonidze, 2011) which reflects the phytosociological relationship amongst these genera. In our study area, these genera were presented together as well, and *C. kotschyi*, *Rh. pallasii* and *J. excelsa* along with other species which constitute a unique vegetation unit with special floristic composition.

Environmental variables

Among the environmental factors, slope, soil texture, pH, lime and saturation level were the most important distinguishing factors of *cotoneastretosum kotschyi*. Moreover, this community appears in the altitudes of 2,200–2,430 m a.s.l., i.e. in an intermediate height range between the *C. nummulariis-J. excelsae* and *Rh. pallasii-J. excelsae*. The species composition of *cotoneastretosum kotschyi* also showed the characteristic species of both mentioned communities such *Rhamnus pallasii* and *Cotoneaster nummularius*.

Soil organic matter and nitrogen were the distinctive factors between the two communities of *C. nummulariis-J. excelsae* and *Rh. pallasii-J. excelsae*. Generally *Rh. pallasii-J. excelsae* can be more frequently observed in shallow, unqualified soil compared to the other community. In Juniper woodlands in East Georgia the *Rhamnus pallasii* can also be seen as an understory shrub in rocky shallow soils (Togonidze, 2011). In North Central Alborz (in Elika ecoton) *Rhamno pallasii-Ephedretum majoris* was observed on calcareous soils and at warmer south geographical aspects (Nazarian et al., 2004). Furthermore, *Rhamnus rhodopeus* was reported as the differential species of alliance in habitats of *Querco trojanae-Juniperetum excelsae* in shallow soil with limestone bedrock, on the southern slopes in Macedonia (Matevski et al., 2010), which is similar to *Rhamno pallasii-Juniperetum excelsae* habitat in Alborz mountains of Iran. On the other hand, *Cotoneaster nummularius* is the characteristic species of Juniper communities on brown forest soils with limestone bedrock, and 5–20% slope (Kargioglu & Tatli, 2005) indicating preference or a deeper soil and more favourable conditions compared to *Rh. pallasii-J. excelsae* habitat.

The main differences of the *cotoneastretosum kotschyi* habitat with its superior association (i.e. *Rh. pallasii-J. excelsae*) are in soil texture, pH, lime and slope, so that *cotoneastretosum kotschyi* was distributed in more acidic soils, with lower lime, lighter textures (i.e. sandy-loam) and steeper slopes.

The *Cotoneaster* genus have inherent ecological diversity. For instance, *Cotoneaster integerrimus* Medik. grows on rocky habitats with low or medium soil depth in Georgia (Togonidze, 2011) and on lithosols and entisols, which are typically poor in humus and organic matter in the Central and East Mediterranean regions (Brullo et al., 2001), while *Cotoneaster nummularius* was observed in low-slope habitats with brown forest soils in Turkey (Kargioglu & Tatli, 2005). *Cotoneaster racemiflora* was reported in Juniper communities in the Himalayas at altitude of 2,100–2,800 m a.s.l. (Ahmed, 2006). Therefore, different *Cotoneaster* species can occur in varying environmental conditions, ranging from moist habitats with fertile soils to those with shallow and poor soils. These conditions can also be seen in Alborz, where *Cotoneaster nummularius* is the indicator of communities with relatively evolved soils. However, *Cotoneaster kotschyi* appears in habitats featuring poor and shallow soils. In terms of the ecological nature, the latter species is in fact similar to *Rhamnus pallasii*, the characteristic species of *Juniperus* communities on shallow soils and stony lands. This was confirmed by both phytosociological and environmental variables analysis. Therefore, locating the syntaxon with the diagnostic species of *Cotoneaster kotschyi* within *Rhamno pallasii-Juniperetum excelsae* is ecologically confirmed.

The floristic composition of *Juniperus excelsa* group in the Shohada protected area in western Azerbaijan with species such as *Amygdalus pabotii* Browicz, *Rhamnus pallasii* and *Pistacia atlantica* (Hassanzadeh & Mohammdi, 2010) is similar to those that were studied in the Alborz region. This habitat can be observed in altitude of 1,650–2,200 m a.s.l., slopes > 60%, pH of 8 and sandy clay in texture, which are ecologically similar to our study area.

Co-occurring plant species of a targeted species can be used to define suitable habitats, taking into account biotic interactions (Baumberger et al., 2012). Regarding the results of this study, Rooteh Forest Reserve has a unique plant composition (in particular in terms of tree and shrub species), thus it must be protected as genetic reserve and seed bank for the further studies as well as for rehabilitation of the *C. kotschyi* habitat.

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