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Dwarf shrub vegetation of rock ledges and clefts in the Pamir Alai Mountains (Middle Asia: Tajikistan)

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Abstract – The paper presents the results of phytosociological researches on rocky slope vegetation in Tajikistan with the aim to establish a comprehensive syntaxonomical classification system. Field studies were conducted in 2010–2014 in Pamir Alai ranges and Pamirian plateau. Nearly 500 relevés documenting rock and scree vegetation were made according to the Braun-Blanquet method. Numerical analyses of selected 58 relevés representing dwarf shrub vegetation on rock ledges made it possible to distinguish: *Ephedro glaucae-Spiraeion baldschuanicae* and *Ephedrion regeliano-fedtschenkoi* alliances, as well as *Spiraeetum baldschuanicae, Rhamnetum coriaceae, Pentaphylloidetum parvifoliae* and *Pentaphylloidetum dryadanthoidis* associations, community of *Ephedra glauca* and community of *Rhamnus minuta.* The classification of vegetation of dwarf shrubs on rock walls occurring in the Pamir Alai Mts is proposed. Because of the species composition, physiognomy and microhabitat conditions, the plant communities were included into *Artemisio santolinifoliae-Berberidetea sibiricae* class Ermakov et al. 2006. The main factors determining the species composition of the classified associations seem to be the elevation above sea level.The newly described syntaxa are largely defined by species restricted to very narrow ranges in Middle Asia.

Keywords: alpine vegetation, *Campanuletalia incanescentis*, chasmophytes, saxicolous communities, syntaxonomy

Introduction

Rocks and screes with their niche diversity create habitats for many specialized plant species (Favarger 1972, Kazakis et al. 2006, Nowak et al. 2011). Rock faces can serve as dry islands, while the crevices, fissures or deep clefts are better supplied with water. Rocky niches can also considerably differ from each other in amount of soil, which is usually not very fertile. The extreme habitat differentiation and uniqueness of petrophytic flora is reflected in the great variety of plant communities developing on rocky walls.

Many phytosociological studies on rupicolous vegetation have been recently conducted in mountainous areas of Europe (e.g., Valachovič et al. 1997, Sanda et al. 2008, Chytrý 2009, Tzonev et al. 2009), especially in the Mediterranean region (e.g., Carmona et al. 1997, Deil 1998, Parolly 1998, Onipchenko 2002, Ermolaeva 2007, Deil et al. 2008, Terzi and D'Amico 2008) as well as arid zones of Asia (e.g. Ermakov et al. 2006, Deil 2014). Despite the considerable areas of mountain ranges and their great diversity in terms of altitudinal amplitude, rock types and climatic conditions, the rock and scree communities in Asia have not yet been studied in detail. The mountain ranges in Tajikistan, especially those with the highest amounts of precipitation (i.e. the Hissar Mts and Alichur Mts), constitute a refuge for a considerable number of stenochoric plant species sensitive to climate change (Kazakis et al. 2006, Baettig et al. 2007, Fay and Patel 2008). The chasmophytic flora of Tajikistan comprises many taxa geographically restricted to this country or to Middle Asia (e.g. *Scutellaria megalodonta*, *S. shugnanica*, *S. zaprjagaevii*, *Achoriphragma darvazicum*, *Dionisia involucrata, Viola majchurensis, Asperula fedtschenkoi*, *Andrachne fedtschenkoi*, *Callipeltis cucullaris*, *Trichodesma incanum*, *Hypericum scabrum*, *Silene brahuica* and many others). Within the project of the phytosociological survey of Tajik vegetation (e.g. Nowak and Nobis 2012, 2013, Nowak et al. 2013a, 2013b) research on chasmophytic vegetation started in 2009. Although a number of papers focused

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Fig. 1. The location of Tajikistan in Middle Asia.

on typical rock vegetation (*Asplenietea trichomanis*) have been presented in recent years, still little is known regarding the scree and talus vegetation or the transitional microhabitats of much eroded rocks or stabile screes (Nowak et al. 2014a, 2014b, 2014c). The problem of classification of dwarf-shrub dominated plots on rocky slopes and rock ledges in Middle Asia needs to be investigated and the relation of these phytocoenoses to both *Asplenietea trichomanis* and *Artemisio santolinifoliae-Berberidetea sibiricae* class finally settled.

The paper is a part of our survey on rock vegetation in Tajikistan with the final intention of building up the syntaxonomical system of all types of rupicolous environments within the country. Particularly it aims at completing the knowledge of the diversity of rock and scree vegetation in Tajikistan as well as presenting the last successional stage of saxicolous communities here – the dwarf shrub communities which should be considered as a pedoclimax vegetation for this kind of habitat.

Material and methods

Study area

Tajikistan covers an area of ca. 143000 km^2 and is located between 36°40'–41°05'E and 67°31'–75°14'N in Middle Asia (Fig. 1). According to recent studies about 4550 vascular plant species occur in Tajikistan with ca. 30% generally accepted as endemics (Nowak et al. 2011). This number is still incomplete, as new investigations regularly add new species to the flora of Tajikistan (e.g. Nobis 2013, Nobis et al. 2014a, 2014b, 2014c). An alpine landscape of high mountains dominates the country. More than 50% of the country's area is located above 3000 m. As typical for the Mediterranean type of climate, the area has generally high solar radiation, as well as a low percentage of cloud cover, high-amplitude annual temperatures, low humidity and precipitation (with the exception of the spring period, when there is a considerable amount of rainfall, Fig. 2). In the south-western regions of Tajikistan, the average June temperatures rise to 30 °C. In the temperate zone and alpine elevations the average temperatures in mid-summer are between 9.7 °C and 13.5 °C. Annual precipitation ranges in Tajikistan from ca. 70 mm (in the mountainous deserts of eastern Pamir and south-western lowlands of the country) to ca. 600 mm (on the southern slopes of the Hissar Range). The limit of perpetual snow is at an altitude of 3500–3600 m in the western Pamir Alai Mts, rising to about 5800 m a.s.l. in the highest elevations of eastern Pamir (Latipova 1968, Narzikulov and Stanjukovich 1968).

The study was situated in different mountain ranges. They include: the Zeravshan Mts, Hissar Mts, Hazratishokh Mts, Darvaz Mts, Rushan Mts, Vanch Mts, Turkestan Mts, Peter I Mts, Yazgulem Mts, Karateginian Mts, Alichur Mts, Shugnan Mts and the Sarikol Mts. All of them belong to the Pamir Alai mountain system (Fig. 3).

Studies on the geology of Tajikistan are still scarce and a bit outdated (e.g. Nedzvedskiy 1968). The middle and

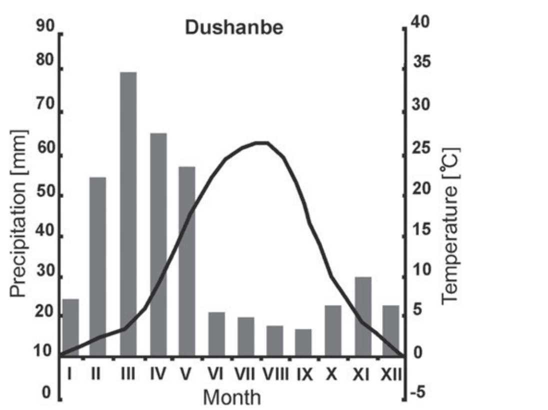

Fig. 2. Climatic characterisation of the study area according to the Dushanbe weather station (850 m a.s.l., N38°34'47''; E68°42'27'', average year temperature 12 °C, yearly precipitation 575 mm.

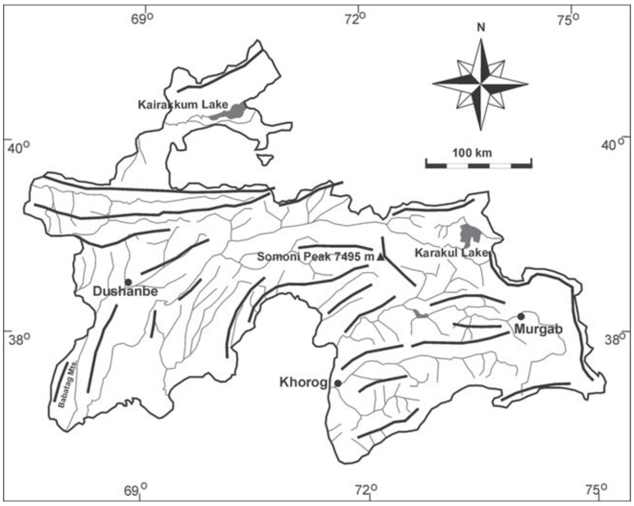

Fig. 3. The area of Tajikistan with main mountain ranges, cities and lakes.

higher parts of the Hissar Mts are largely composed of extrusive rocks, mainly granite, granitoid and syenite (e.g. Varzob valley). Some igneous outcrops also occur in the Darvaz Mts, Kuraminian Mts and in the western Pamir ranges. In the Zeravshan and Turkestan Mts, Cambrian and Silurian sediments predominate. The rocks here are generally limestone (micrite limestone, bituminous limestone, marly limestone and dolomitic coral limestone), marble, dolomite, dolomitic shale, clay shale, phyllitic schist and argillaceous slate. Also, several metamorphic rocks are present within the study area. The most common are migmatic gneiss, conglomerates and metamorphic mudstones. In eastern Pamir, carboniferous sediments dominate, mainly granite, granodiorite and diorite.

The rupicolous vegetation of Tajikistan is for now classified into 32 associations, 2 alliances and one order (Nowak et al. 2014a, 2014b, 2014c). For rock communities of the alpine zone developing on solid rock faces, crevices and ledges the *Campanuletalia incanescentis* Nobis et al. 2013 order and *Asperulo albiflorae-Poion relaxae* Nobis et al. 2013 were proposed (Nobis et al. 2013, Nowak et al. 2014a, 2014b). Plots representing these phytosociological units are characterised by high constancy and abundance of petrophytic taxa with an Irano-Turanian distributional range. The most frequent species contributing to the phytocoenoses are *Campanula incanescens*, *C. lehmanniana, Poa relaxa*, *Artemisia rutenica* and *Sergia regelii*. Due to significant differences in habitat conditions (e.g. inclination, insolation, crevice size, soil amount) and species composition, two main groups of plant communities within *Asperulo albiflorae-Poion relaxae* were distinguished. The first group includes communities inhabiting fine fissures and tiny crevices on rock faces (representing the *Campanulenion lehmannianae* suballiance) and the second group comprises communities developing on larger clefts and small ledges with considerable amounts of soil (representing *Pentanemenion albertoregeliae* suballiance). For the montane and colline zone, the *Caricion koshevnikovii* alliance defining the phytocoenoses dominated by acidophilous species like *Scutellaria hissarica*, *S. schugnanica*, *S. zaprjagaevii*, *S. baldshuanica*, *Tylosperma lignosa* and *Dionysia involucrata* was proposed (Nowak et al. 2014c). The scree and talus vegetation still needs further investigations. The first insights into the vegetation of colluvial cones and sampling of ca. 300 relevés were obtained in 2014 by the team of authors. However the research is still at the beginning stage and the data set will have to be completed and thoroughly analyzed.

Data and analyses

The research was conducted in 2010–2014. We sampled vegetation plots on mountain cliffs, slopes and terrace walls. The studied vegetation patches were located between 890 and 4280 m a.s.l. The vegetation plot size was delimited in such a way as to represent the full floristic composition of the phytocenoses. It varied from 3 to 5 m^2 depending on plant density and the homogeneity of vegetation cover. The sampling procedure covers all altitudinal zones, variety of bedrocks, inclinations and exposures. For each vegetation plot all vascular plants and cryptogams were recorded. Epilithic lichens have not been considered, as non-specific and insignificant in defining the associations. Plant species were recorded according to the Braun-Blanquet method as the most relevant in the analysis of vegetation variability (Braun-Blanquet 1964). The 7-degree cover-abundance scale was transformed into percentage cover in the Juice program: r = 0.1%; + = 1.0%; 1 = 2.5%; 2 = 15.0%; 3 = 37.5%; 4 = 62.5%; 5 = 87.5% (Tichý 2002). The rock type was determined by analyzing the lithology, pore geometry, mineralogical components, texture, permeability, hardness and pH by a professional geologist (see acknowledgments). The phytocoenoses were developed on different types of rock substrate, with a range of pH reaction between 6.2 and 8.8. Hydrogen ion concentrations were measured in aqueous rock solution using the ELMETRON CP-105 pH meter. During field surveys, 488 phytosociological relevés documenting patches representing the *Asperulo-Poion* (Nobis et al. 2013, Nowak et al. 2014a, 2014b), *Caricion koshevnikovii* Nowak et al. 2014 (Nowak et al. 2014c) as well as fern associations on rock clefts and crevices and the association of *Dionysietum involucratae* Nowak et al. 2014 (Nowak et al. 2014d) were taken. Additionally ca. 300 relevés were sampled in scree and talus vegetation to find out the relation of the plots to the main vegetation classes (*Asplenietea rupestria* and *Artemisio santolinifoliae-Berberidetea sibiricae* Ermakov et al. 2006) which should eventually include the samples investigated.

All the relevés were stored in a database using the JUICE program (Tichý 2002). A modified TWINSPAN analysis was conducted (Roleček et al. 2009) to get the initial idea of the data structure and resolution. We applied the pseudospecies cut levels of 0%, 2%, 5% and 10%. The sampled data showed a unimodal response, allowing us to use a detrended correspondence analysis (DCA) with the floristic data set (no down-weighting of rare species) to check the floristic-sociological classification and to show the relationships between the groups. For the ordination, CANOCO for Windows 4.5 was used (Ter Braak and Šmilauer 2002). After grouping the samples, 58 relevés were identified as suitable for the description of dwarf shrub vegetation on rock ledges.

Vegetation classification follows the sorted table approach of Braun-Blanquet (1964). In the analytic tables (Tab. 1, On-line Suppl. Tab. 1), species constancies are given in class I–V (Dierschke 1994). In a case in which a particular species was noted in fewer than 8 relevés, the absolute number of species occurrences was specified in the tables (communities of *Ephedra glauca* and *Rhamnus minuta*). Newly presented syntaxa, described as order, alliance or associations were proposed according to the International Code of Phytosociological Nomenclature (Weber et al. 2000). While distinguishing and ranking the association the works of Nowak et al. (2014a, 2014b, 2014c) were taken into account. The association concept follows Willner (2006).

Plant material collected during field studies is deposited in the Herbarium of the Middle Asia Mountains, housed in OPUN (Opole University, Poland) and KRA (Jagiellonian University, Poland). Species nomenclature follows Czerep-

Tab. 1. Plant communities of the *Ephedrion regeliano-fedtschenkoi* in Pamir Alai Mts in Tajikistan, in 2013. Locations of samples (according to the numbers of relevés): 1, 3, 7 – to the south from Karasu (375754,3; 735421); 2, 4 – to the south-west from Murgab (375541,6; 735202,4); 5, 8 – Chatyr-Tash (380632,1; 735308,3); 6, 9 – Chatyr-Tash (375000,9; 733413,7); 10, 11 – to the Davaz Pass (383747,6; 704301,6).

Relevé number	1	2	3	4	5	6	7	8	9	10	11	Constancy	Number of occurrence
Day/month	24/8	24/8	24/8	24/8	24/8	24/8	24/8	24/8	24/8	20/6	20/6		
pH	8	8.4	7.8	8.4	8.8	8	7.6	7.7	8	8.4	8.4		
Aspect	SE	NW	SE	NW	SE	NE	SE	SE	NE	W	W		
Inclination (degrees)	65	60	65	65	55	55	65	50	65	55	60		
Altitude (m)	3909	4217	3909	4217	3811	4280	3909	3811	4275	3150	3150		
Cover of shrub layer (%)	60	30	35	35	55	35	35	30	20	45	30		
Cover of herb layer (%)	10	15	10	10	5	2	10	3	2	15	25		
Relevé area (m^2)	3	3	3	3	3	3	3	3	3	3	3	rel.	rel.
Number of species	8	8	11	7	5	6	8	8	7	7	10	1−9	10−11
Diagnostic species													
Ass. *Pentaphylloidetum dryadanthoidis*													
Pentaphylloides dryadanthoides b	4	3	3	3	4	3	3	3	2	.	.	V	–
Community of *Rhamnus minuta*													
Rhamnus minuta b	.	.	.	.	.	.	.	.	.	3	2	–	2
All. *Ephedrion regeliano-fedtschenkoi*													
Ephedra fedtschenkoi b	+	1	1	+	.	+	.	.	.	.	.	III	–
O. *Ephedretalia gerardianae* et Cl. *Asplenietea trichomanis*													
Melissitus pamiricus	+	+	1	1	1	.	.	+	+	.	.	IV	–
Poa relaxa	.	.	+	1	+	+	+	+	.	.	+	IV	1
Paraquilegia anemonoides	1	1	+	.	.	.	+	+	+	.	.	IV	–
Artemisia rutifolia	.	1	+	+	.	.	+	+	+	.	.	IV	–
Onosma dichroantha	.	+	.	+	+	+	+	.	+	.	.	IV	–
Potentilla malacotricha	1	1	+	+	.	.	.	+	.	.	.	III	–
Allium tianschanicum	+	.	+	.	.	.	+	.	.	.	.	II	–
Asperula strizhoviae	.	.	.	.	.	.	.	.	.	1	2	–	2
Psychrogeton leucophyllus	.	.	.	.	.	.	.	.	.	+	+	–	2
Sporadic species: *Campanula incanescens* 11; *Eritrichium subjacquemonti* 9.													
Others													
Roegneria czimganica	+	+	+	.	+	.	1	+	+	.	.	IV	–
Draba lanceolata	.	.	.	.	.	.	.	.	.	1	+	–	2
Pseudosedum fedtschenkoanum	.	.	.	.	.	.	.	.	.	+	1	–	2
Rosularia lutea	.	.	.	.	.	.	.	.	.	+	1	–	2
Oxytropis chiliophylla	.	.	+	.	.	+	.	.	.	.	.	II	–
Youngia diversifolia	.	.	+	.	.	.	.	+	.	.	.	II	–
Stipa glareosa	.	.	.	.	.	+	+	.	.	.	.	II	–
Sporadic species: *Androsaceae lehmanniana* 1; *Cerasus verrucosa* b 11; *Ephedra* sp. b 11(1); *Tulipa turkestanica* 10.													

Tab. 2. Principal ecological characteristics of the typified association habitats. Soil amount: M – medium, L – low; Rock type: C – calcareous, N – neutral, A – acidophilous; Insolation (Insol.): H – high, M – moderate, L – low. Exposition: W – western, S – southern, E – eastern, N – northern; Altitude: H – high, M – medium, L – low.

Community	Soil	Rock type	Insol.	Exposition	Altitude
Spiraeetum baldschuanicae	M	A	H/M	W	L
Rhamnetum coriaceae	M	C	H	SE	M
Pentaphylloidetum parvifoliae	L	A	H	N,NW	M/H
Pentaphylloidetum dryadanthoidis	L	A	H	SE	H

anov (1995) with exception of *Ephedra fedtschenkoi* the name of which has been adapted after International Plant Names Index (www.ipni.org).

Results

General floristic features and habitat characteristics

The number of taxa recorded in all relevés totals 133, ranging from 3 to 18 species in particular plots (mean ca. 8). More than 59 taxa exceed 5% constancy. Those with the highest constancy are: *Spiraea baldshuanica* (18 occurrences), *Artemisia rutifolia* (17), *Poa relaxa* (17), *Campanula incanescens* (15), *Rhamnus coriacea*, *Stipa caucasica* (13), *Bromus tectorum*, *Carex koshevnikovii*, *Pentaphylloides parvifolia* (12) and *Callipeltis cucullaris* (11). Most of the contributing species are typical chasmophytes adapted to extreme rocky habitats and almost exclusively restricted to eroded rocks. However, there are also a number of taxa with wide ecological amplitude known from other vegetation types. In some studied plots we found e.g. *Bromus tectorum*, *Poa bulbosa*, *Phleum graecum*, *Conringia planisiliqua* and *Bromus oxyodon* as species frequently sampled earlier in segetal and disturbed habitats of urbanized areas in Tajikistan. The group of plants that inhabits mainly screes was also numerous in the data set. The most frequent were: *Silene brahuica*, *Centaurea squarrosa*, *Veronica rubrifolia*, *Aulacospermum roseum*, *Atraphaxis pyrifolia*. Some of the species, e.g. *Impatiens parvifolia* or *Leptorhabdos parviflora,* are related to the forest communities. Others have come over from the neighboring rock swards (e.g. *Sedum ewersii*, *Rosularia lutea*) or xerothermophilous swards (e.g. *Haplophyllum latifolium*, *Ixiolirion tatarica*). Typically for rock crevice vegetation, moss species also contribute to the sampled plots, however with very low frequency. The most common were *Bryum argenteum*, *B. caespiticum* and *Grimmia pulvinata*.

Detrended correspondence analysis

DCA run for the entire data set clearly segregates relevés representing associations described for the first time: *Spiraeetum baldschuanicae*, *Rhamnetum coriaceae*, *Pentaphylloidetum parvifoliae* and *Pentaphylloidetum dryadanthoidis* (Fig. 4). Also well-distinct are samples representing two new alliances: *Ephedro glaucae-Spiraeion baldschuanicae* (left-bottom part of the diagram) occurring in the western Pamir Alai ranges and *Ephedrion regeliano-fedtschenkoi* (upper-right part of the graph) confined to the uppermost elevations of eastern Pamir. This is due to essential differences in the floristic composition and structure of individual phytocoenoses that accompany considerably different climatic conditions in those two areas. It seems that the vertical gradient of the graph is related to altitude with plots of *Rhamnus minuta* community and *Pentaphylloidetum dryadanthoidis* in the upper part and samples of *Rhamnetum coriaceae* and *Spiraeetum baldshuanicae* in the bottom part. From left to the right the environmental variable which controls the gradient is not so evident. To some extent the floristic differentiation could be related to climate continentality and associated humidity which affect greater share of species originated in Central Asia and Tibetan Plateau. Within the group of western Pamir Alai plots are those described as *Ephedra glauca* community, showing the close relation to the *Spiraeetum baldschuanicae* and *Pentaphylloidetum parvifoliae*.

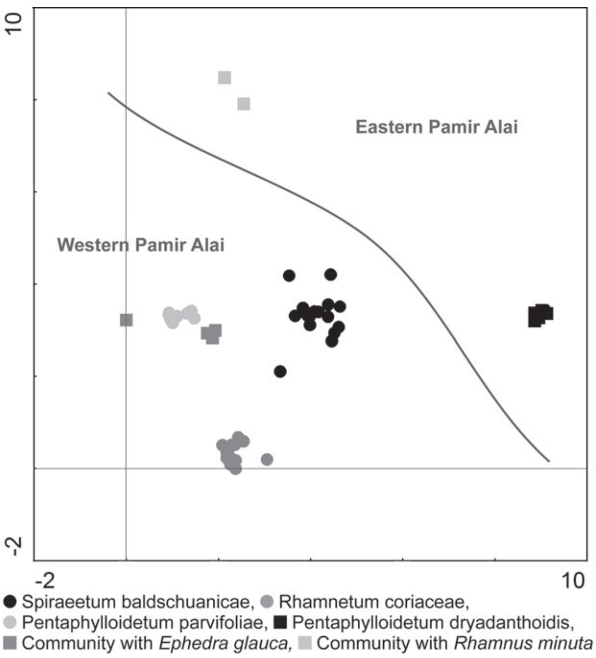

Fig. 4. Detrended correspondence analysis for all samples of rocky dwarf shrub communities in study area (N = 58).

Syntaxa of dwarf shrub vegetation of rock ledges and clefts in the Pamir Alai Mts in Tajikistan

Alliance: *Ephedro glaucae-Spiraeion baldschuanicae* all. nova hoc loco

Holotypus: *Spiraeetum baldshuanicae* hoc loco

Diagnostic species: *Ephedra glauca* (syn. *E. heterosperma*), *E. intermedia, Spiraea baldschuanica.*

Distribution and ecology: The phytocoenoses of the *Ephedro glaucae-Spiraeion baldschuanicae* were recorded in the western Pamir Alai Mts, mainly in the Hissar, Zeravshan and Turkestan ranges and less frequently in the Darvasian and Peter I ranges. The communities plots occur between (1200–)1500–2500(–3000) m a.s.l. The phytocoenoses of *Ephedro glaucae-Spiraeion baldschuanicae* consist on average of moderate number of taxa per plot. Apart from the taxa diagnostic for the alliance, the group of high-abundance species includes: *Artemisia rutifolia*, *Poa relaxa*, *Campanula incanescens*, *Rhamnus coriacea*, *Stipa caucasica*, *Pentaphylloides parvifolia*, *Callipeltis cucullaris*, *Asperula albiflora* and *Clypeola jonthlaspi.* The alliance is intrinsically heterogeneous. There are distinct communities found on slopes and walls with high precipitation and those with lower amount of rainfall. The Hissar and Babatag ranges are inhabited mainly by *Spiraeetum baldschuanicae* while the more arid mountains like Zeravshan serve as habitat for *Rhamnetum coriaceae* and *Pentaphylloidetum parvifoliae*.

1. *Spiraeetum baldschuanicae* ass. nova

Typus relevé: On-line Suppl. Tab. 1, rel. 2, holotypus hoc loco

Diagnostic species: *Spiraea baldshuanica*

The phytocoenoses of *Spiraeetum baldschuanicae* have been found in several stations in the Hissar Mts, mainly on the eastern and southern slopes of the Varzob, Takob, Khondara, Maychura, Sorbo and Sarday-Myena river valleys. *Spiraea baldschuanica* is an endemic species of the western Pamir Alai Mts distributed in the south-western sections of Hissar range at an altitude of 1100–2300 m a.s.l. (Ovchinnikov 1975). The altitudinal distribution of the association is compliant with this amplitude. The samples were taken in the colline zone at the altitudes of 1000 to 1950 m a.s.l. (mean approx. 1500; Fig. 5, On-line Suppl.

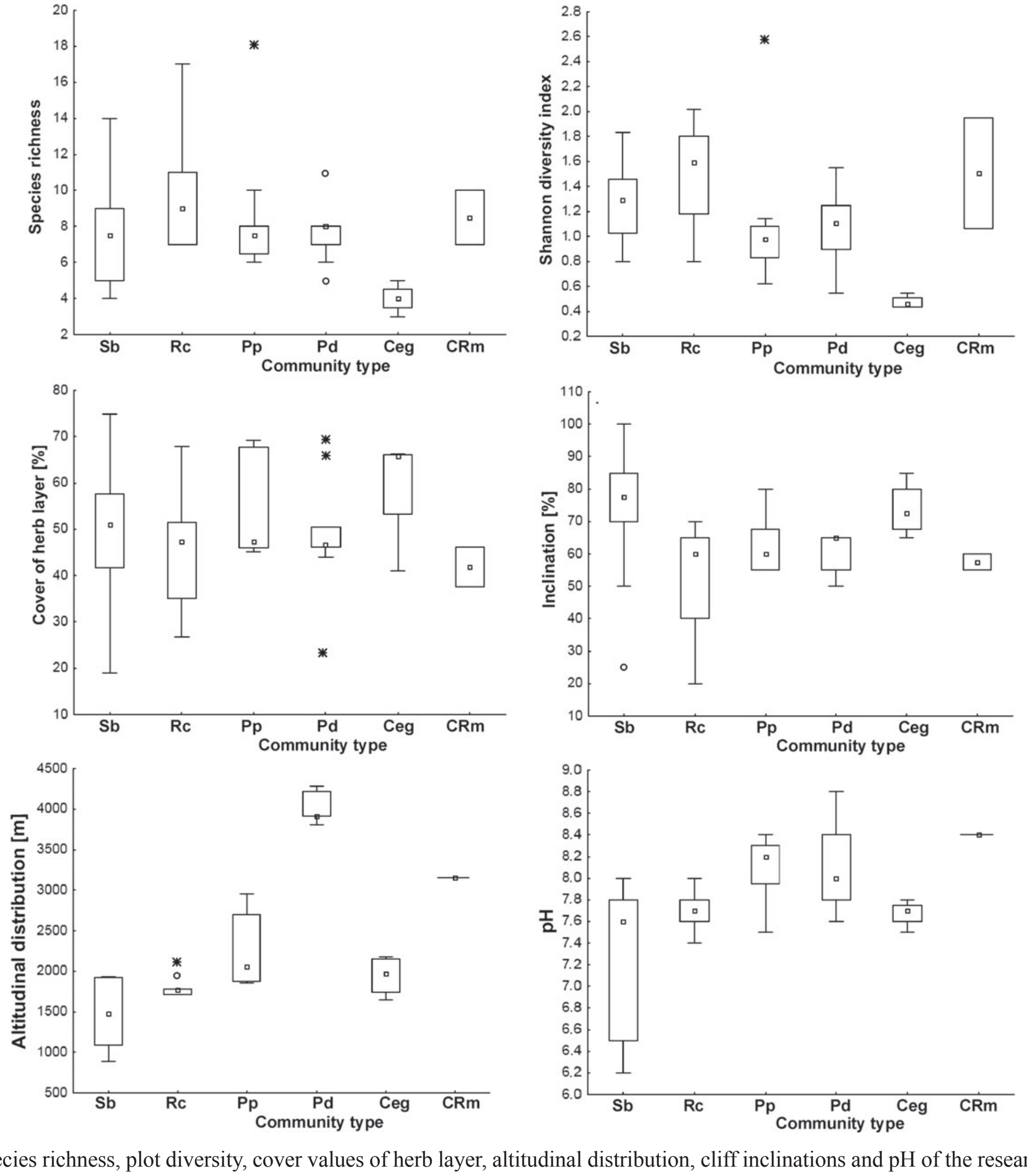

Fig. 5. Species richness, plot diversity, cover values of herb layer, altitudinal distribution, cliff inclinations and pH of the researched communities: *Spiraeetum baldschuanicae* (Sb), *Rhamnetum coriaceae* (Rc), *Pentaphylloidetum parvifoliae* (Pp), *Pentaphylloidetum dryadanthoidis* (Pd) and communities of *Ephedra glauca* (Ceg) and *Rhamnus minuta* (CRm). Whiskers present minimum and maximum observations within fences, block indicates first and third quartile, circles the minimum and maximum value. Outliers are shown as asterisks.

Tab. 1). The association inhabits granite and granodiorite rocks (mean pH 6.6), heavily eroded and generally loose. Its plots were found mainly on western and southern expositions with inclinations of mean value approx. 75°. They are characterised by a moderate abundance of vegetation cover which corresponds to the amount of rain and soil deposit on rock ledges. The total cover of the herb layer generally was between 25 and 100% with a mean value of more than 50% (On-line Suppl. Tab. 1, Fig. 5). The phytocoenosis is characterised by a moderate number of species as rupicolous vegetation is concerned, having in one relevé from 4 to 15 taxa (mean value approx. 8). Mosses contribute quite significantly to the association in comparison to other communities from the alliance. The most abundant were *Bryum caespiticium* and *Schistidium apocarpum.* Among the vascular plants the highest values of constancy and abundance were found in: *Carex koshevnikovii*, *Poa bulbosa*, *P. relaxa*, *Campanula incanescens* and *Bromus tectorum*.

2. *Rhamnetum coriaceae* ass. nova

Typus relevé: On-line Suppl. Tab. 1, rel. 19, holotypus hoc loco

Diagnostic species: *Rhamnus coriacea*

Rhamnus coriacea is an endemic species to Middle Asia, distributed in western Pamir Alai and western Tian-Shan. In Tajikistan it occurs mainly in the Zeravshan, Turkestan and southern part of Darvasian mountain ranges at the altitude of 1300–2600 m a.s.l. (Ovchinnikov 1981). During our research the association defined by *Rhamnus coriacea* was found in a few locations of the Iskander-Daria River Valley in the Zeravshan Mts. The phytocoenoses were found almost exclusively on limestone, rarely on dolomite shales (pH 7.4–8.0). The association prefers slope rocks with south-eastern sunny expositions and inclinations of 20°–70° with a mean of approx. 60°. The phytocoenosis develops on moderate elevations within the lower alpine belt. Mean elevation value for research plots was approximately 1750 m a.s.l. *Rhamnetum coriaceae* is an association with moderate plant cover value per plot. The observed variation of this feature was 27%–67% with a mean of 46% (Fig. 5, On-line Suppl. Tab. 1). The species number per plot reaches one of the highest values between the dwarf shrub communities. From 7 to 17 species were noted in a single relevé. On average 9 species were observed in a sample. Mosses were not observed on eroded slopes within the patches. The most abundant and constant vascular plant species within the phytocoenoses of *Rhamnetum coriaceae* are: *Stipa caucasica*, *Artemisia rutifolia*, *Centaurea squarrosa, Ephedra glauca* and *Silene brahuica*.

3. *Pentaphylloidetum parvifoliae* ass. nova

Typus relevé: On-line Suppl. Tab. 1, rel. 40, holotypus hoc loco

Diagnostic species: *Pentaphylloides parvifolia*

Pentaphylloides parvifolia is a chasmophytic species with wide geographical range, known from Middle Asia, the Altai Mts, Siberia, Mongolia and Western China (Ovchinnikov 1975). In Tajikistan the species occurs along the main Zeravshan ridge at elevations of approximately 1600 to 3000 m a.s.l, reaching here the southern limits of its natural range. During the research, populations of *Pentaphylloides parvifolia* were observed in western and central sections of Zeravshan Range in Pastrud-Daria, Iskander-Daria, Veshan and Zeravshan river valleys. The phytocoenosis was found exclusively on limestone and marble rocks of solid structure with coarse crevices and ledges (pH 7.5–8.4). The phytocoenosis develops on relatively high elevations in the alpine zone with a cool microclimate. The observed altitudinal range of the community was between 1850 to 3000 m a.s.l. (mean approx. 2250 m). The association develops on sloping rock ledges and terraces with the inclination value ranging from 55° to 80° (mean approximately 60°, Fig. 5). *Pentaphylloidetum parvifoliae* was generally found on shady, northern and north-western slopes. The mean value of total herb cover was relatively high and exceeds 45%, ranging from 45 to 70% (Fig. 5). Mosses do not contribute to the association. Apart from the diagnostic species, the most abundant and constant species of vascular plants were: *Callipeltis cucullaris*, *Campanula incanescens*, *Veronica capillipes* and *V. rubrifolia*.

4. Community of *Ephedra glauca*

On-line Suppl. Tab. 1, relevés 44–47.

Ephedra glauca has the optimum of its occurrence in high, alpine elevations and in arid areas, e.g. in Zeravshan and Turkestan ranges. The collected sample contains a few relevés representing dwarf shrub vegetation with domination of *Ephedra glauca.* All of the relevés were taken in the central part of the Zeravshan Mts (1600–2200 m a.s.l.). Despite the fact that it seems to us that this species can not be used as diagnostic for any association, we decide to depict these plots and show them on the diagram. Further survey is needed to check whether it should be regarded only as diagnostic for the alliance or it can also serve as a species defining its own association with central position within the alliance.

Alliance: *Ephedrion regeliano-fedtschenkoi* all. nova hoc loco

Holotypus: *Pentaphylloidetum dryadanthoidis* hoc loco

Diagnostic species: *Ephedra regeliana*, *E. fedtschenkoi*, *E. gerardiana.*

Distribution and ecology: The plots of the *Ephedrion regeliano-fedtschenkoi* were recorded almost exclusively in the highest elevations of eastern Pamir (in the eastern part of Tajikistan). Few samples representing the community with *Rhamnus minuta* were also recorded in the central part of the Darvaz Range. It is possible that the patches representing *Ephedrion regeliano-fedtschenkoi* occur also in arid plateau of eastern Pamir, in western Pamirian ranges (e.g. Vanch, Rushan and Shugnan Mts) as well as in more humid Darvazian Range. The plots were sampled at altitudes of 3150–4275 m a.s.l. The phytocoenoses of *Ephedrion regeliano-fedtschenkoi* had low numbers of taxa per plot, approximately 8 on average (Fig. 5). Apart from the taxa diagnostic for the alliance, the group of species with highest abundance and frequency includes: *Pentaphylloides dryadanthoides*, *Artemisia rutifolia*, *Melissitus pamiricus*, *Poa relaxa*, *Paraquilegia anemonoides* and *Roegneria czimganica.* Defined by the distributional ranges of both *Ephedra* species, the alliance could be delimited to the Pamir, Tian-Shan, Karakorum and western Himalayan ranges. It includes plant communities adapted to the harshest conditions in the arid, nival zone of the central Asian mountains.

5. *Pentaphylloidetum dryadanthoidis* ass. nova

Typus relevé: Tab. 1, rel. 1, holotypus hoc loco

Diagnostic species: *Pentaphylloides dryadanthoides*

Pentaphylloides dryadanthoides distribution is confined to the highest elevations in the Pamirian plateau and in the surrounding mountains, in Tajikistan and western China (Ovchinnikov 1975). The species was found in several sites in central part of eastern Pamir, in Murgab and Alichur river valleys, in Muzkol and Psharskyi ranges. The phytosociological research confirmed that the species builds its own association developing on relatively firm and solid limestone rocks (pH 7.6–8.8). The association prefers elevations in high alpine and nival zones (Fig. 5), within the altitudinal range between 3800 and 4275 m a.s.l. (mean approximately 4000 m). The phytocoenosis develops on rocks with small or medium-sized crevices, on sloping walls, rock faces or on rock tops. The noted inclination values varied significantly between 50° and 65° (Fig. 5). *Pentaphylloides dryadanthoides* prefers generally south-eastern, fully insolated expositions (Fig. 6). In the sample plots, between 6 and 11 taxa were noted (mean approx. 8), so as majority of the rupicolous vegetation, the association should be classified as moderately rich in species. As well as by scarcity of species, the association is characterized by the moderate value of total cover of vascular plants in the plots. It could reach up to 70% with the mean value of approximately 45 % (Fig. 5). No moss species were found within the recorded patches. The group of species with the highest constancy includes: *Artemisia rutifolia*, *Ephedra fedtschenkoi*, *Melissitus pamiricus*, *Onosma dichroantha*, *Paraquilegia anemonoides* and *Roegneria czimganica.*

6. Community of *Rhamnus minuta*

Tab. 1, relevés 10–11.

Rhamnus minuta is a rare species in Tajikistan with its range restricted to a few mountain ranges in the Eastern Tajikistanian and Pamirian geobotanical regions. The species is known also from Kashgaria in western China. Habitat preferences of *Rhamnus minuta*, especially its altitudinal amplitude and bedrock type suggest that the community should be included in *Ephedrion regeliano-fedtschenkoi.* This was clearly confirmed by the results of the numerical ordination (Fig. 4). Plots of the community were found on

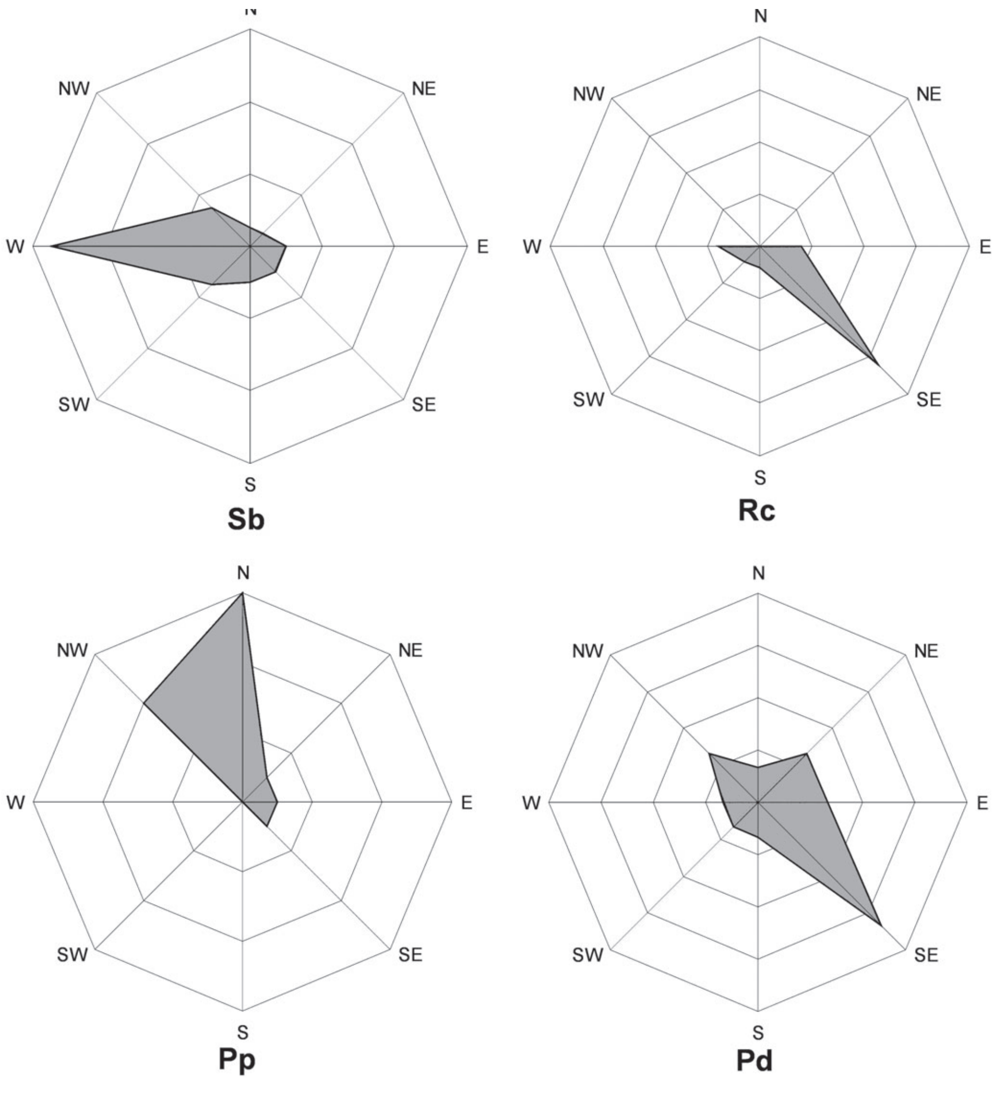

Fig. 6. The exposition preferences of the plant associations researched. *Spiraeetum baldschuanicae* (Sb), *Rhamnetum coriaceae* (Rc), *Pentaphylloidetum parvifoliae* (Pp), *Pentaphylloidetum dryadanthoidis* (Pd).

few limestone outcrops near the Khaburabot Pass at the altitude of approximately 3150 m a.s.l. They develop on solid limestone rocks with western expositions and moderate inclinations (ca. 65°). Within the recorded vegetation plots a considerable contribution of rock swards taxa were noted, among others *Pseudosedum fedtschenkoanum* and *Rosularia lutea*. Unfortunately, the survey in other regions of the *Rhamnus minuta* range did not confirm its presence nowadays. So, at this stage of the research we have decided to present the phytocoenosis as a community.

Synopsis of syntaxa

Based on this study, we propose the following classification of vegetation of dwarf shrubs on rock walls in the Pamir Alai Mts in Tajikistan:

Class: *Artemisio santolinifoliae-Berberidetea sibiricae* Ermakov et al. 2006

Order: *Hyperico scabri-Lactucetalia orientalis* nom. prov. (for explanation see Discussion)

Alliance: *Ephedro glaucae-Spiraeion baldschuanicae* A. Nowak, S. Nowak, M. Nobis et A. Nobis all. nova

1. *Spiraeetum baldschuanicae* A. Nowak, S. Nowak, M. Nobis et A. Nobis ass. nova
2. *Rhamnetum coriaceae* A. Nowak, S. Nowak, M. Nobis et A. Nobis ass. nova
3. *Pentaphylloidetum parvifoliae* A. Nowak, S. Nowak, M. Nobis et A. Nobis ass. nova
4. Community of *Ephedra glauca*

Order: *Ephedretalia gerardianae* nom. prov. (for explanation see Discussion)

Alliance: *Ephedrion regeliano-fedtschenkoi* A. Nowak, S. Nowak, M. Nobis et A. Nobis all. nova

5. *Pentaphylloidetum dryadanthoidis* A. Nowak, S. Nowak, M. Nobis et A. Nobis ass. nova
6. Community of *Rhamnus minuta*

Discussion

Position of the described association in relation to other types of rupicolous vegetation in Tajikistan and Central Asia

Comparing the microhabitat and climatic conditions of Pamir Alai (Middle Asia) to other areas in Eurasia, the most similar must occur in Central Asia. In particular, the eastern Pamir plateau, Turkestan, Zeravshan and the Peter I range seem to be closely related in terms of precipitation, average temperatures and continentality. Only the southern slopes of the Hissar range are remarkably more humid, amounts of precipitation and its distribution throughout a year being Mediterranean rather than continental. Although some authors stressed that the Tajikistan is influenced by a Mediterranean-type bioclimate, it is rather an oro-Mediterranean subtype overlain by extreme and harsh alpine conditions (Rivas-Martinez et al. 2011). Of course there are considerable differences in diurnal temperature oscillations if we compare the valley bottoms and alpine or nival elevations. That is why in our opinion, the climatic conditions of the research area could be compared with the Central Asiatic. Another important issue when analyzing the classification of the studied vegetation is the environmental characteristic of the plots inhabited by dwarf-shrub vegetation. The researched phytocoenoses occupy the transitional habitats between typical *Asplenietea trichomanis* rock faces with crevices and fissures and scree habitats with mobile gravel deposits. This type of microhabitat could be defined as considerably eroded rocks or relatively well stabilized screes. A reflection of this can be seen in the species composition of plant communities with many plants typical for scree vegetation and many coming over from neighboring typical rock habitats. A thorough analysis of the floristic structure of plant communities convinced us to include the rupicolous dwarf shrub vegetation of Pamir Alai into *Artemisio santolinifoliae-Berberidetea sibiricae*. This class was proposed for the taluses and screes of the Western Sayan Mts and the Altai range (Ermakov et al. 2006). As in Central Asia, in Tajikistan too many typical scree species contribute to the researched plots: *Callipeltis cucullaris*, *Stipa caucasica*, *Silene brahuica*, *Clypeola jonthlaspi*, *Veronica rubrifolia*, *Galium spurium*, *Aulacospermum roseum* and others. Also the shrubbery physiognomy, lack of moss layer, very scarce soil content on the sites and the gentle inclination of slopes are fairly similar to those in Altai and Sayan ranges. However, because of the transitional character and the vicinity of rock walls, typical *Asplenietea* species also contribute to the plant communities. Plots representing *Ephedro glaucae-Spiraeion baldschuanicae* are characterized by a considerable share of diagnostic species of the *Campanuletalia incanescentis*, mainly *Campanula incanescens*, *Poa relaxa* and *Carex koshevnikovii*.

Despite the habitat and structural similarities, there are some important differences in species composition of the researched vegetation if compared to phytocoenoses from southern Siberia. Only a few species were found in common with one that had a considerable abundance and frequency – *Artemisia rutifolia*. That is why we propose to include the plant communities of dwarf shrubs in Pamir Alai Mts into a new order within the *Artemisio santolinifoliae-Berberidetea sibiricae*. Provisionally we suggest *Hyperico scabri-Lactucetalia orientalis* with *Hypericum scabrum*, *Lactuca* (*Scariola*) *orientalis*, *Callipeltis cucullaris* as diagnostic taxa. All of them are distributed in Middle Asia, northern Pakistan, northern Afghanistan, Iran and some parts of Near East. As we know from our preliminary studies in Tajikistan, this type of vegetation occurs in semi-arid mountainous areas in colline and alpine belts in western sections of the Pamir Alai ranges. The considerable share of petrophytic species of Irano-Turanian distributional type is typical for this kind of vegetation (Nowak et al. 2014c). Despite some similarities in species composition (i.e. the presence of *Asperula albiflora* and *Poa relaxa*), the physiognomy as well as habitat requirements of the communities from the *Ephedro glaucae-Spiraeion baldschuanicae* are clearly different from those of the associations from the *Caricion koshevnikovii* and *Asperulo-Poion relaxae* alliances. The phytocoenoses of *Ephedro glaucae-Spiraeion baldschuani-*

cae occupy much-eroded walls with coarse ledges and stabilized screes with moderate inclinations (On-line Suppl. Tab. 1). Such conditions are conducive to soil accumulation, increase the fertility of the habitat and allow shrubby vegetation to thrive. Shrubs are the climax vegetation in those biotopes. The shrubby vegetation seems not to be so diverse and species rich as vegetation dominated by herbs. That is why we have decided to include all dwarf shrub associations of rock ledges and clefts in one alliance. It should be stressed, however, that the communities distinguished within the alliance differ in habitat requirements and altitude range. *Spiraeetum baldshuanicae* certainly inhabits more humid, lower and warmer areas than phytocoenoses dominated by *Pentaphylloides parvifolia* and *Rhamnus coriacea*. We had also expected further variation of shrubby rock vegetation in latitudinal gradient, so we explored the south-western part of Tajikistan with the warmest climatic conditions. In that area we were looking for communities with the domination of *Rhamnus baldshuanica* and *Zygophyllum gontscharovii*. Phytocoenoses dominated by the latter species were noted in several locations during our survey in 2013 but only on landslides with inclination of ca. 20–30 degrees, so we could not insert them to dwarf shrub vegetation on screes and rocks.

The situation in the communities in eastern Tajikistan is different. The arid conditions of the highly elevated Pamirian plateau and also of some "rock islands" in Eastern Tajikistanian geobotanical region (Peter I and central section of Darvaz ranges) are rather similar to those prevailing in the arid and semi-arid ranges of Tibet, Karakorum and western Himalayas. As it is shown on the ordination diagram, the difference between those two groups of relevés is considerable. That is why we have decided to classify phytocoenoses from *Ephedrion regeliano-fedtschenkoi* to a distinct order of vegetation. However, the scarcity of phytosociological studies and the areas in China that are difficult of access allow us to propose only a provisional name for that order. This group of plant communities probably includes the *Ephedretum gerardiane* association described for the first time from the western Himalayas (Kojima 1990). Although the *Ephedra* species in the arid areas of Himalaya, Tibet and Karakorum are not restricted to rock habitats but also grow on screes, degraded pastures and stony river beds, their communities can be included in provisional *Ephedretalia gerardianae* order because of climatic and species composition similarities. Our observations done in Pamir Alai indicate that along with increasing continentality and aridisation of climate, petrophytic species, which occur almost exclusively on rock walls, spread also into the neighbouring screes and gravel habitats. The patches of petrophytic vegetation in eastern Tajikistan are really clearly distinct from those occurring in the western areas of the country. Preliminary studies of these communities show significant differences in species composition. As examples of abundant species inhabiting the eastern margins of Tajikistan, *Hippolytia darvasica*, *H. shugnanica*, *Ajania tibetica*, *A. gracilis*, *Inula schmalhauseni*, *Parrya shugnanica*, *Corydalis tenella* and *Waldheimia glabra* can be mentioned. Further studies should specifically identify the species composition of herb and shrub vegetation in dry areas of the highest elevations in central Asian mountains allowing for the preparation of the final classification of rock and scree vegetation. It should be also stressed that our analysis is constrained by the ambiguities in treating the species from *Ephedra* genus, especially in *Ephedra glauca* and *E. intermedia* complexes. Several other taxa like *E. heterosperma*, *E. microsperma*, *E. intermedia*, *E. tibetica*, *E. valida* were described making the field plant determination difficult during the field studies.

Species composition, chorology and habitat of Pamir Alai petrophytic dwarf shrubs

The Pamir Alai rupicolous vegetation is highly diverse in terms of endemism, habitat preferences and physiognomy of phytocoenoses. To date, more than 30 plant associations have been defined (Nobis et al. 2013, Nowak et al. 2014a, 2014b, 2014c). This is due to extreme diversity of ecological niches caused by differences in altitudinal amplitude, bedrock type, exposition, inclination, crevice type, amount of soil and water supply within the biotope. The species also respond to geographical barriers responsible for increasing endemism rate and separateness of the floristic structure. It is commonly known from other mountainous areas that highly elevated mountain ridges fasten the speciation and make the rupicolous flora distinct (Favarger 1972, Médail and Verlaque 1997). The DCA based on floristic composition of sampled plots revealed some considerable differences within the dwarf shrub vegetation in the Pamir Alai Mts (Fig. 4). The main discrimination factor seems to be longitudinal gradient which is related to altitude, precipitation and temperature. In eastern Pamir, the climatic conditions are harsh (arid and cold), so the distinctiveness of the flora is clearly marked in comparison to other regions of Middle Asia. This holds true also in the group of unique species which are almost all confined to those geobotanical subregions (Nowak et al. 2011). These climatic conditions are responsible for the considerable difference between the plots from the western Pamir Alai Mts and the eastern ranges, although the range of Peter I and central and northern sections of the Darvaz Mts could be regarded somehow as transitional area (Fig. 3). The species composition is significantly different in samples from those two areas, with *Allium tianschanicum*, *Asperula strizhoviae*, *Pentaphylloides dryadanthoides*, *Ephedra fedtschenkoi*, *Melissitus pamiricus*, *Oxytropis chiliophylla*, *Potentilla malacotricha*, *Rhamnus minuta*, *Roegneria czimganica*, *Stipa glareosa* and *Youngia diversifolia* occurring exclusively in eastern part of the surveyed area. The evident difference between *Spiraeaetum baldshuanicae* and *Rhamnetum coriaceae* could be explained by the bedrock type. *Spiraea baldshuanica* prefers acidophilous rocks while *Rhamnus* occurs only on limestones (Tab. 2).

The plots sampled in shrubby vegetation in Tajikistan clearly differ from the corresponding rock vegetation communities known from distant ranges in southern Europe or southern Asia (Dimopoulos et al. 1997, Hein et al. 1998, Parolly 1998, Ermolaeva 2007). Only shrubby *Ephedretum gerardianae* described from Nepal can be compared with communities recorded in eastern Pamir (Kojima 1990). However, apart from a few widely distributed taxa like *Convolvulus arvensis*, *Chenopodium botrys* or *Ch. ficifolium,* in the patches of these communities almost no species from our study area were noted. This separateness might be attributed again to the unique habitat conditions in rupicolous environments and the related floristical uniqueness. In result the plant communities are also distinct and the beta diversity of mountainous areas increases (Valachovič et al. 1997, Deil et al. 2008, Deil 2014). The newly described plant associations are largely defined by species restricted to very narrow ranges (e.g. *Spiraea baldshuanica* known only from W Tajikistan, *Anaphallis darvazica* distributed in the southern part of the country, *Atraphaxis seravshanica* known exclusively from Zeravshan Mts, *Dionysia involucrata* occurring in western section of Hissar range or *Onosma atrocyanea* scattered only in western Pamir Alai). This type of stenochory of petrophytic plant species and communities is also observed in many other mountainous areas, especially in those with Mediterranean-type climates, such as the Bokkoya Mts in Northern Morocco (Deil 1994, Deil and Hammoumi 1997), in Gibraltar (Galán de Mera et al. 2000), in Crete and mainland Greece (Dimopoulos et al. 1997), in Bulgaria (Mucina et al. 1990), in the Caucasus and the mountains of Central Asia (Agakhanjanz and Breckle 2002, Ermolaeva 2007), in the Taurus Mts in Turkey (Hein et al. 1998, Parolly 1998) or in Galicia in Spain (Ortiz and Rodriguez-Oubiña 1993).

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On-line Suppl. Tab 1. Associations of the *Ephedro glaucae-Spiraeion baldschuanicae* in Pamir Alai Mts in Tajikistan. Locations of samples (according to the numbers of releves): 1 – Romit (413051,6; 721159,1); 2 – Varzob (385406,4; 684946,9); 3 – Viston (415231,2; 715853,2); 4 – Takob (385018,7; 685505,7); 5, 6, 8 – Varzob (384651,3; 684914,8); 7, 9 – Takob (385038; 685014); 10 – Maychura-post (390139,4; 684705); 11 – Varzob (385620,1; 684811,8); 12 – Efuch (384941,7; 701044,2); 13, 14 – Romit (400958,9; 733215,2); 15, 16 – Khondara (400958,9; 733215,2); 17 – Viston (413051,6; 721159,1); 18 – Takob (385018,3; 685504,6); 19 – Marzich (391126,9; 684420,5); 20 – Khayronbed (390921,2; 682945,1); 21, 27, 29 – between Sarv and Khayronbed (390838,9; 682849,9); 22, 23 – Zeravshan II (391017,8;683044,7); 24, 25, 26, 28 – Sarvoda (391007,1; 683041); 30, 31 – Khayronbed (390645,3; 682455,1); 32, 34 – Chore (391850,5; 682626,9); 33, 35, 36 – 4th Lake (391050,1; 675011,8); 37 – Veshan (392337,2; 681549,5); 38 – Jagnob gorge (391111,6; 685422,2); 39, 43 – Mazari-Sharif (392238,2; 675039,3); 40, 41 – Kante (391455,4; 682927,5); 42 – Poymazor (391850,1; 682622,9); 44 – Takfon (391132,5; 684007,2); 45 – Anzob (391020,5; 684732,7); 46 – Anzob (390956,2; 685119,1); 47 – Zeravshan II (391227,7; 693159).

Relevé 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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	Constancy	Constancy	Constancy	Number of occurrence
day	8	17	9	8	8	8	8	8	8	18	17	18	6	6	6	6	8	14	30	21	17	10	10	17	17	17	17	17	17	17	17	19	19	19	19	19	19	19	19	29	29	11	13	9	9	9	8				
Date: month	6	8	6	6	6	6	6	6	6	6	8	6	6	6	6	6	6	6	6	6	8	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	8	6	6	6	6	6				
year	13	13	13	12	12	12	12	12	12	13	13	13	13	13	13	13	13	12	14	14	13	12	12	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	14	14	12	12	12	12	12	12				
pH	6,6	6,2	7,4	6,2	6,4	6,5	7	6,3	6,5	7,8	6,2	7,5	6,5	6,4	6,8	6,3	6,4	6,2	8	7,7	7,8	7,7	7,7	7,6	7,6	7,6	7,8	7,4	7,8	7,8	–	8	8,2	8,2	7,9	7,9	7,5	8,4	8,2	8,4	8,4	8,1	8,2	7,7	7,8	7,7	7,5				
Aspect	W	W	W	SW	W	W	S	W	S	NE	SW	SW	W	W	W	W	W	NW	S	SE	E	SE	SE	SE	SE	SE	SE	E	SE	W	W	NW	NW	N	N	NW	N	N	NW	E	SE	N	N	S	S	SE	SW				
Inclination (degrees)	85	85	70	60	75	80	75	75	100	80	80	75	85	85	50	70	80	25	70	20	35	35	40	60	60	60	60	45	65	70	70	60	60	55	55	60	55	55	60	75	80	80	60	70	75	65	85				
Altitude (m)	890	1401	1909	1560	1085	1085	1236	1085	1250	1931	1586	1350	1928	1928	1925	1925	890	1590	2092	1778	1770	1743	1743	1714	1714	1714	1775	1713	1775	1961	1961	2913	1874	2913	1874	1874	1856	2215	1878	2482	2482	2959	1897	1825	2110	2181	1650				
Cover of shrub layer (%)	30	60	65	35	20	20	5	45	5	30	45	20	30	40	60	35	30	5	35	30	30	25	30	40	20	15	20	40	30	20	55	55	60	55	45	40	55	55	40	35	30	30	15	70	60	70	3				
Cover of herb layer (%)	15	15	20	15	35	55	30	10	20	25	15	15	20	20	25	25	15	25	15	40	10	15	10	20	25	10	10	15	3	40	10	5	3	3	2	5	3	3	3	10	15	10	40	10	5	5	45				
Cover of moss layer (%)	5	15	–	–	–	–	–	–	–	–	–	–	–	15	15	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–				
Relevé area (m²)	5	3	5	4	3	3	3	3	3	3	3	3	5	5	5	5	5	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	4	rel.	rel.	rel.	rel.
Number of species	8	7	6	8	9	7	4	10	4	8	5	5	5	10	8	11	14	6	8	11	8	7	12	7	9	9	10	17	11	7	7	7	6	8	7	8	10	8	8	7	6	6	18	4	5	4	3	1–18	19–31	32–43	44–47
Diagnostic species																																																			
Ass. *Spiraeetum baldschuanicae*																																																			
Spiraea baldshuanica b	3	4	4	3	2	3	1	3	1	3	3	2	3	3	4	3	3	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	V	–	–	–
Spiraea baldshuanica c	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Ass. *Rhamnetum coriaceae*																																																			
Rhamnus coriacea b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	3	3	3	3	3	3	2	2	2	3	3	2	4	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	V	–	–
Ass. *Pentaphylloidetum parvifoliae*																																																			
Pentaphylloides parvifolia b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	4	3	3	4	4	3	3	3	3	2	.	.	.	.	–	–	V	–
Community of *Ephedra glauca*																																																			
Ephedra glauca b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	4	4	4	1	–	II	–	4
All. *Ephedro glaucae-Spiraeion baldschuanicae* et O. *Hyperico scabri-Lactucetalia orientalis*																																																			
Callipeltis cucullaris	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	+	.	.	1	.	.	.	1	.	+	+	1	.	+	.	.	.	.	1	.	.	.	.	I	II	III	–
Cl. *Artemisio santolinifoliae-Berberidetea sibiricae*																																																			
Stipa caucasica	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	1	1	1	2	1	1	.	+	1	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I	IV	I	–
Silene brahuica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	+	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	+	.	.	.	.	–	II	II	–
Clypeola jonthlaspi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	+	+	+	.	.	.	.	.	.	.	.	.	–	–	III	–
Galium spurium	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	I	I	I	–
Aulacospermum roseum	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	II	–	–
Stipa orientalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Atraphaxis pyrifolia b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	–	I	I	–
Pseudosedum fedtschenkoanum	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	I	–	I	–

Relevé 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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	Constancy	Constancy	Constancy	Number of occurrence
day	8	17	9	8	8	8	8	8	8	18	17	18	6	6	6	6	8	14	30	21	17	10	10	17	17	17	17	17	17	17	17	19	19	19	19	19	19	19	19	29	29	11	13	9	9	9	8				
Date: month	6	8	6	6	6	6	6	6	6	6	8	6	6	6	6	6	6	6	6	6	8	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	8	6	6	6	6	6				
year	13	13	13	12	12	12	12	12	12	13	13	13	13	13	13	13	13	12	14	14	13	12	12	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	14	14	12	12	12	12	12	12				
pH	6,6	6,2	7,4	6,2	6,4	6,5	7	6,3	6,5	7,8	6,2	7,5	6,5	6,4	6,8	6,3	6,4	6,2	8	7,7	7,8	7,7	7,7	7,6	7,6	7,6	7,8	7,4	7,8	7,8	–	8	8,2	8,2	7,9	7,9	7,5	8,4	8,2	8,4	8,4	8,1	8,2	7,7	7,8	7,7	7,5				
Aspect	W	W	W	SW	W	W	S	W	S	NE	SW	SW	W	W	W	W	W	NW	S	SE	E	SE	SE	SE	SE	SE	SE	E	SE	W	W	NW	NW	N	N	NW	N	N	NW	E	SE	N	N	S	S	SE	SW				
Inclination (degrees)	85	85	70	60	75	80	75	75	100	80	80	75	85	85	50	70	80	25	70	20	35	35	40	60	60	60	60	45	65	70	70	60	60	55	55	60	55	55	60	75	80	80	60	70	75	65	85				
Altitude (m)	890	1401	1909	1560	1085	1085	1236	1085	1250	1931	1586	1350	1928	1928	1925	1925	890	1590	2092	1778	1770	1743	1743	1714	1714	1714	1775	1713	1775	1961	1961	2913	1874	2913	1874	1874	1856	2215	1878	2482	2482	2959	1897	1825	2110	2181	1650				
Cover of shrub layer (%)	30	60	65	35	20	20	5	45	5	30	45	20	30	40	60	35	30	5	35	30	30	25	30	40	20	15	20	40	30	20	55	55	60	55	45	40	55	55	40	35	30	30	15	70	60	70	3				
Cover of herb layer (%)	15	15	20	15	35	55	30	10	20	25	15	15	20	20	25	25	15	25	15	40	10	15	10	20	25	10	10	15	3	40	10	5	3	3	2	5	3	3	3	10	15	10	40	10	5	5	45				
Cover of moss layer (%)	5	15	–	–	–	–	–	–	–	–	–	–	–	15	15	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–				
Relevé area (m²)	5	3	5	4	3	3	3	3	3	3	3	3	5	5	5	5	5	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	4	rel.	rel.	rel.	rel.
Number of species	8	7	6	8	9	7	4	10	4	8	5	5	5	10	8	11	14	6	8	11	8	7	12	7	9	9	10	17	11	7	7	7	6	8	7	8	10	8	8	7	6	6	18	4	5	4	3	1–18	19–31	32–43	44–47
Atraphaxis seravshanica b	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	I	–	I	–
Berberis integerrima b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Polygonum paronychioides	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Ziziphora pamiroalaica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	+	.	.	.	.	.	.	.	.	–	–	II	–
Pseudosedum condensatum	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	I	–	–	1
Cerasus verrucosa b	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Rosa maracandica b	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	I	–	–
Piptatherum latifolium	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	–	I	–	1
Origanum tyttanthum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Steptorhamphus crambifolius	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Cephalorhynchus songoricus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	I	–	–
Schrenkia vaginata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	I	–	–

Sporadic species: *Allium oschaninii* 25; *Arabis kokanica* 43; *Bolbosaponaria intricata* 47(3); *Colutea paulsenii* b 20; *Haplophyllum latifolium* 26; *Onosma atrocyanea* 40; *Pachypterygium brevipes* 36; *Piptatherum kokanicum* 43; *Pyrethrum pyrethroides* 40; *Rosularia hissarica* 18(2); *Sanguisorba alpina* 12(1); *Scandix stellata* 20; *Silene longicalycina* 43; *Stroganovia paniculata* 33; *Trichodesma incanum* 20.

Cl. *Asplenietea trichomanis*	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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	1–18	19–31	32–43	44–47
Campanula incanescens	.	1	.	.	.	.	+	+	+	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	1	.	+	.	+	.	.	.	.	.	1	+	+	.	+	+	.	.	II	I	III	2
Carex koshevnikovii	.	1	2	2	2	3	2	1	.	+	.	1	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	III	I	I	–
Artemisia rutifolia	.	.	.	.	.	.	.	.	.	.	.	.	1	2	2	2	.	.	1	2	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	1	.	II	II	I	1
Poa relaxa	.	.	.	.	.	.	.	.	.	2	1	1	1	+	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	+	1	1	.	.	.	II	I	II	1
Asperula albiflora	.	.	.	.	.	.	.	.	.	+	.	.	1	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	1	1	1	1	.	.	.	.	I	I	II	–
Parietaria judaica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	2	+	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	–	II	I	–
Stipa zeravschanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	1	.	.	.	.	.	–	I	II	–
Schistidium apocarpum d	1	2	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Inula glauca	.	.	+	.	.	.	.	.	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Asperula laevis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Scutellaria megalodonta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Grimmia pulvinata d	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Penthathema albertoregelia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	–	I	I	–

Relevé 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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	Constancy	Constancy	Constancy	Number of occurrence
Date: day	8	17	9	8	8	8	8	8	8	18	17	18	6	6	6	6	8	14	30	21	17	10	10	17	17	17	17	17	17	17	17	19	19	19	19	19	19	19	19	29	29	11	13	9	9	9	8				
Date: month	6	8	6	6	6	6	6	6	6	6	8	6	6	6	6	6	6	6	6	6	8	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	8	6	6	6	6	6				
Date: year	13	13	13	12	12	12	12	12	12	13	13	13	13	13	13	13	13	12	14	14	13	12	12	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	14	14	12	12	12	12	12	12				
pH	6,6	6,2	7,4	6,2	6,4	6,5	7	6,3	6,5	7,8	6,2	7,5	6,5	6,4	6,8	6,3	6,4	6,2	8	7,7	7,8	7,7	7,7	7,6	7,6	7,6	7,8	7,4	7,8	7,8	–	8	8,2	8,2	7,9	7,9	7,5	8,4	8,2	8,4	8,4	8,1	8,2	7,7	7,8	7,7	7,5				
Aspect	W	W	W	SW	W	W	S	W	S	NE	SW	SW	W	W	W	W	W	NW	S	SE	E	SE	SE	SE	SE	SE	SE	E	SE	W	W	NW	NW	N	N	NW	N	N	NW	E	SE	N	N	S	S	SE	SW				
Inclination (degrees)	85	85	70	60	75	80	75	75	100	80	80	75	85	85	50	70	80	25	70	20	35	35	40	60	60	60	60	45	65	70	70	60	60	55	55	60	55	55	60	75	80	80	60	70	75	65	85				
Altitude (m)	890	1401	1909	1560	1085	1085	1236	1085	1250	1931	1586	1350	1928	1928	1925	1925	890	1590	2092	1778	1770	1743	1743	1714	1714	1714	1775	1713	1775	1961	1961	2913	1874	2913	1874	1874	1856	2215	1878	2482	2482	2959	1897	1825	2110	2181	1650				
Cover of shrub layer (%)	30	60	65	35	20	20	5	45	5	30	45	20	30	40	60	35	30	5	35	30	30	25	30	40	20	15	20	40	30	20	55	55	60	55	45	40	55	55	40	35	30	30	15	70	60	70	3				
Cover of herb layer (%)	15	15	20	15	35	55	30	10	20	25	15	15	20	20	25	25	15	25	15	40	10	15	10	20	25	10	10	15	3	40	10	5	3	3	2	5	3	3	3	10	15	10	40	10	5	5	45				
Cover of moss layer (%)	5	15	–	–	–	–	–	–	–	–	–	–	–	15	15	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–				
Relevé area (m²)	5	3	5	4	3	3	3	3	3	3	3	3	5	5	5	5	5	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	4	rel.	rel.	rel.	rel.
Number of species	8	7	6	8	9	7	4	10	4	8	5	5	5	10	8	11	14	6	8	11	8	7	12	7	9	9	10	17	11	7	7	7	6	8	7	8	10	8	8	7	6	6	18	4	5	4	3	1–18	19–31	32–43	44–47
Scutellaria hissarica	.	.	.	.	.	1	2	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Asplenium ruta-muraria	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.	.	.	.	.	.	.	.	–	–	I	–

Sporadic species: *Anaphallis darvazica* 11(1); *Asperula czukavinae* 43; *Dionysia involucrata* 9(2); *Galium verticillatum* 17; *Syntrichia ruralis* d 17(1).

Others

Bromus tectorum	1	.	.	+	.	1	.	.	.	.	.	.	.	.	+	+	+	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	+	II	II	I	1
Poa bulbosa	.	+	.	.	2	1	.	+	.	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	II	I	I	–
Centaurea squarrosa	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	1	1	+	.	1	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	III	–	–
Phleum graecum	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	+	.	.	+	.	.	.	.	.	.	.	.	I	–	II	–
Conringia planisiliqua	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	+	.	.	.	.	+	.	+	.	.	.	.	.	.	+	.	–	I	II	1
Veronica capillipes	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	+	+	+	.	.	.	+	.	.	.	.	.	.	.	.	.	–	I	II	–
Veronica rubrifolia	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	+	+	.	.	.	.	.	.	.	.	.	–	–	III	–
Bromus oxyodon	.	.	.	+	.	1	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Vulpia ciliata	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	I	–	I	–
Bryum caespiticium d	.	.	.	.	.	.	.	.	.	.	.	.	.	1	2	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Thymus zeravshanicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	2	.	.	.	.	I	–	I	–
Bryum argenteum d	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	1	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Bromus squarrosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Impatiens parviflora	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	+	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Crepis pulchrum	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Roegneria interrupta	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Sedum ewersii	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Sisymbrium brassiciforme	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Botriochloa ischaemum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	+	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	II	–	–
Alyssum desertorum	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Eremurus stenophyllus	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Clematis orientalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	–	I	–	1
Geranium divaricatum	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–

Relevé 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	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	Constancy	Constancy	Constancy	Number of occurrence
day	8	17	9	8	8	8	8	8	8	18	17	18	6	6	6	6	8	14	30	21	17	10	10	17	17	17	17	17	17	17	17	19	19	19	19	19	19	19	19	29	29	11	13	9	9	9	8				
Date: month	6	8	6	6	6	6	6	6	6	6	8	6	6	6	6	6	6	6	6	6	8	6	6	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	6	6	8	6	6	6	6	6				
year	13	13	13	12	12	12	12	12	12	13	13	13	13	13	13	13	13	12	14	14	13	12	12	13	13	13	13	13	13	13	13	12	12	12	12	12	12	12	12	14	14	12	12	12	12	12	12				
pH	6,6	6,2	7,4	6,2	6,4	6,5	7	6,3	6,5	7,8	6,2	7,5	6,5	6,4	6,8	6,3	6,4	6,2	8	7,7	7,8	7,7	7,7	7,6	7,6	7,6	7,8	7,4	7,8	7,8	–	8	8,2	8,2	7,9	7,9	7,5	8,4	8,2	8,4	8,4	8,1	8,2	7,7	7,8	7,7	7,5				
Aspect	W	W	W	SW	W	W	S	W	S	NE	SW	SW	W	W	W	W	W	NW	S	SE	E	SE	SE	SE	SE	SE	SE	E	SE	W	W	NW	NW	N	N	NW	N	N	NW	E	SE	N	N	S	S	SE	SW				
Inclination (degrees)	85	85	70	60	75	80	75	75	100	80	80	75	85	85	50	70	80	25	70	20	35	35	40	60	60	60	60	45	65	70	70	60	60	55	55	60	55	55	60	75	80	80	60	70	75	65	85				
Altitude (m)	890	1401	1909	1560	1085	1085	1236	1085	1250	1931	1586	1350	1928	1928	1925	1925	890	1590	2092	1778	1770	1743	1743	1714	1714	1714	1775	1713	1775	1961	1961	2913	1874	2913	1874	1874	1856	2215	1878	2482	2482	2959	1897	1825	2110	2181	1650				
Cover of shrub layer (%)	30	60	65	35	20	20	5	45	5	30	45	20	30	40	60	35	30	5	35	30	30	25	30	40	20	15	20	40	30	20	55	55	60	55	45	40	55	55	40	35	30	30	15	70	60	70	3				
Cover of herb layer (%)	15	15	20	15	35	55	30	10	20	25	15	15	20	20	25	25	15	25	15	40	10	15	10	20	25	10	10	15	3	40	10	5	3	3	2	5	3	3	3	10	15	10	40	10	5	5	45				
Cover of moss layer (%)	5	15	–	–	–	–	–	–	–	–	–	–	–	15	15	10	10	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–				
Relevé area (m²)	5	3	5	4	3	3	3	3	3	3	3	3	5	5	5	5	5	3	5	5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	5	5	5	4	rel.	rel.	rel.	rel.
Number of species	8	7	6	8	9	7	4	10	4	8	5	5	5	10	8	11	14	6	8	11	8	7	12	7	9	9	10	17	11	7	7	7	6	8	7	8	10	8	8	7	6	6	18	4	5	4	3	1–18	19–31	32–43	44–47
Allium sp.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	–	–	–
Clematis songarica	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	I	I	–	–
Taeniaterum crinitum	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	I	–	I	–
Koelpinia linearis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	–	I	I	–
Leptorhabdos parviflora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	–	I	–	–
Ziziphora tenuior	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	–	I	I	–
Perovskia virgata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	–	I	I	–
Aulacospermum dichotomum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	+	+	.	.	.	.	.	.	.	.	.	.	.	.	–	–	I	–

Sporadic species: *Avena trichophylla* 5; *Bromus pseudodanthnoniae* 43; *Bunium seravshanicum* 43(1); *Capparis spinosa* 20; *Crepis multicaulis* 28; *Descurainia sophia* 45; *Ferula* sp. 5; *Festuca valesiaca* 28; *Handelia trichophylla* 8; *Ixiolirion tatarica* 15; *Krascheninnikovia ceratoides* 29; *Kudryaschewia jakubi* 29; *Lappula consanguinea* 27; *Minuartia meyeri* 27; *Parietaria serbica* 46; *Scabiosa songarica* 1(1); *Sideritis montana* 28; *Strigosella africana* 29; *Taraxacum* sp. 43; *Thalictrum alpinum* 17(1); *Thlaspi perfoliatum* 43.