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Tentative list of endemic vascular plants of the Zeravshan Mts in Tajikistan: distribution, habitat preferences and conservation status of species

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Abstract: Based on literature data and own fieldwork in the Zeravshan Mts in Tajikistan (Middle Asia), the taxonomic structure, distribution, habitat preferences as well as conservation status of a group of 86 species of vascular plants of endemic character are presented. The tentative list of exclusive endemic plants for the Zeravshan Mts was compiled. They belong to 25 families. The richest is the genus *Astragalus* with 11 species followed by *Cousinia* (8), *Allium* (5) and *Scutellaria* (3). The study has shown that the eastern subregions of the range are richest in endemics, especially, the Mogien-Daria, Seven Lakes, Pastrud-Daria, Ksztut and Yagnob valleys and Kuli-Kalon Plateau. The endemics studied are stenochoric species with very small number of known locations, mainly between one and two. The mean value of the range of the studied endemics is ca. 1140 km^2. The most numerous endemic groups have been recorded at altitudes of around 1,800-2,100 and 2,700-3000 m a. s. l. The habitats harboring the richest group of endemics are rock screes, alpine forests, steppes and semi-savannas, alpine meadows, solid rocks, xerothermophilous shrubs and pastures. Almost half of the endemics have narrow ecological amplitude occurring in only one habitat type. The most important threats to Tajik endemics are intensive grazing and erosion of soils, as well as denudation. Most vulnerable types of vegetation to the human impact are forest and scrub communities. For effective protection of endemics in the Zeravshan Mts, a national park and a net of nature reserves has to be funded.

Key words: altitude, distribution, range, ecology, Funn Mts, Middle Asia

1. Introduction

The Zeravshan Mountains (Golden Mts) are a middle Asian mountain range located within the Pamir-Alai mountain system, in the north-western part of Tajikistan, and eastern part of Uzbekistan. This location, as well as considerable variations in altitude, are favourable to a high floristic diversity. The middle Asian mountains have been recognised to be amongst thirty-four so-called hotspots of biodiversity – the most valuable areas in the world from a species diversity viewpoint (Mittermeier *et al.* 2005). The area is proposed to be a one of eleven most important focal points of future plant diversity studies and conservation (Giam *et al.* 2010). Whole Tajikistan is one of the richest regions of the former Soviet Union as far as plant species diversity is concerned. The 10-volume work dedicated to the flora of the former Soviet Socialist Republic of Tajikistan, prepared by a multi-author team (Ovchinnikov 1957, 1963, 1968, 1975, 1978, 1981; Chukavina 1984; Kochkareva 1986; Kinzikaeva 1988; Rasulova 1991) lists 4,513 vascular plant species as occurring here, however, following Stanjukovich (1982) there are nearly 5,000 species. These plants are assigned to 116 families, of which the taxonomically richest are: Asteraceae (655 species), Fabaceae (520), Poaceae (325), Brassicaceae (248) and Lamiaceae (196). A high species richness has also been noted for some of the 994 genera known, e.g. *Astragalus* (276 species), *Cousinia* (121), *Allium* (100), *Taraxacum* (60) and *Oxytropis* (58). Most of the floristic diversity is present within the Zeravshan Mts, however, there is a lack of complete and up to date analysis of the floristic richness of this area.

Zeravshan vegetation can be generally divided into 20 types (Grigoriev 1944; Stanjukovich 1982; Zakirov

1955): mesophilic deciduous forests (so-called Chernolesya), riverside forests (so-called Belolesya), river-bed forests (so-called Tugay); xerothermophilous shrubs (so-called Shiblyak); alpine coniferous forests (Archevniki); river-bed shrubs; meadows and pastures; segetal vegetation; alpine meadows and swards; steppes and so-called semi-savannas; xerothermophilous swards; xerothermophilous dwarf bushes (so-called Rosaria); desert and semi-desert vegetation; bog-spring vegetation (so-called sazy); tall-herb vegetation; reed vegetation; water vegetation; scree and slide-rock vegetation; rock vegetation (so-called petriphyton) and salt-marsh vegetation.

Endemic plant species, which are most important from a conservation point of view, have not yet been thoroughly studied, neither taxonomically and ecologically, nor as far as chorology and conservation are concerned. Detailed knowledge of distributional patterns of stenochoric species is needed for the effective protection of floral diversity and it also enables a better understanding of the origin of the flora (Agakhanjanz & Breckle 1995; Myers *et al*. 2000; Young *et al*. 2002; Mittermeier *et al*. 2005; Lamoreux *et al*. 2006; Essl *et al*. 2009).

Different species of vascular plants in the Tajik flora, both endemic and non-endemic, experience increasing anthropogenic pressure (Narzikulov 1988; Safarov 2003). Transformation of the natural environment will lead to an impoverishment of this interesting and unique flora, and of biodiversity as a whole, as is the case in other areas of Asia (e.g. Sodhi & Brook 2006; Giam *et al*. 2010). It results from the direct impact, such as the intensification of grazing, harvesting for pharmaceutical purposes and other agricultural activities, the irrigation works, which often reduce the population size and as a consequence leads to species withdrawal (e.g. Gilpin & Soulé 1986). Moreover, global environmental changes such as climate warming and extreme weather conditions significantly reduce the chances of survival of susceptible species, including endangered endemics (Dirnböck *et al*. 2003; Thuiller *et al*. 2005; Malcolm *et al*. 2006; Schwartz *et al*. 2006).

Using literature data and our own floristic and phytosociological researche, we have attempted to address the following questions: (*i*) how are endemic plant species of the Zeravshan Mts distributed in relation to altitude and habitat, (*ii*) what are the range sizes of endemics, (*iii*) what is the degree of risk for endemics in the relation to their habitats and (*iv*) what priorities are needed in the conservation of endemic species in the Zeravshan Mts.

2. Material and methods

2.1. Selection of species and their characteristics

We regarded as endemic species all those plants whose natural distribution range is limited to the terri-

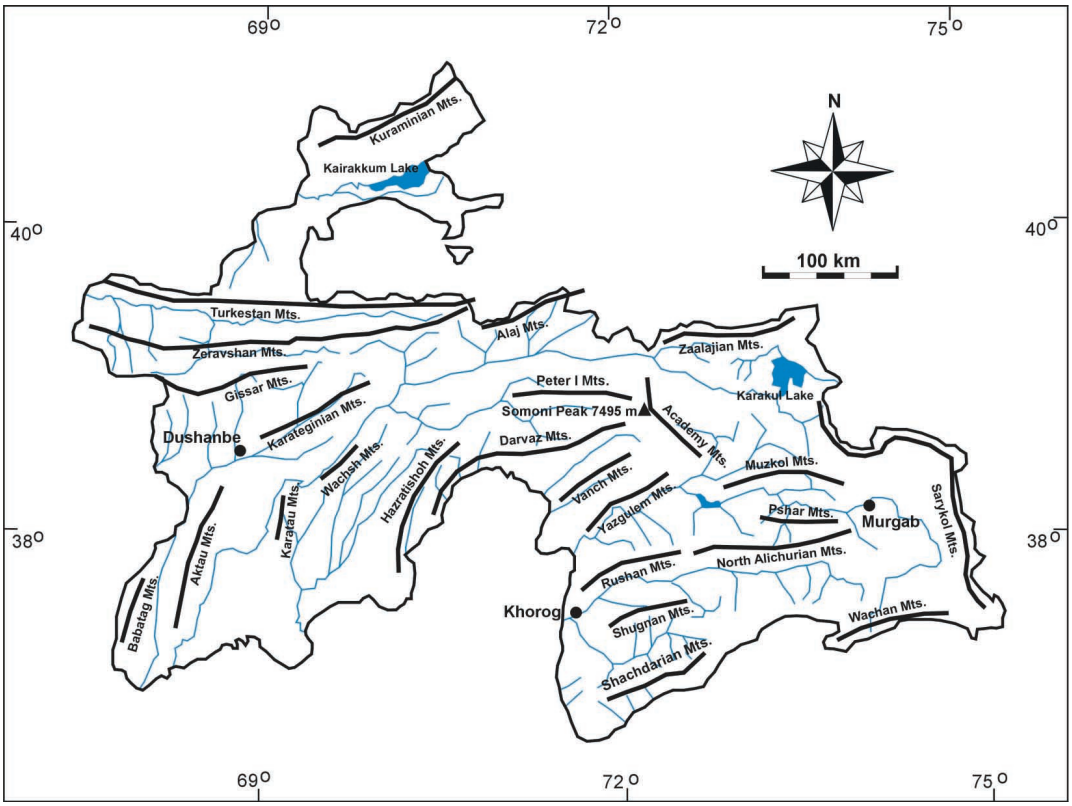

Fig. 1. Map of Tajikistan with main cities, mountain ridges, rivers and lakes (after Narzikulov & Stanjukovich 1968)

tory of the Zeravshan Mts and that occurr exclusively in this area. This approach corresponds to the broadly accepted definition of endemism (e.g. Gaston 1994). These taxa could be species or subspecies and are recognised as endemics *sensu stricto*. We excluded the taxa which in Tajikistan occur only in the Zeravshan Mts, but their geographic ranges cross the national border and some localities are known also from south-west Tian-Shan (e.g. *Astragalus dianthus* Bunge, *Cousinia regelii* C. Winkl., *Cylindrocarpa sewerzowii* (Regel) Regel, *Dryopteris komarovii* Koss., *Polygonum zeravschanicum* Zak., *Primula minkwitziae* W.W. Smith, *Rindera austroechinata* M. Pop., *Scorzonera tau-saghyz* Lipsch. and *Stellaria karatavica* Schischk), northern Afghanistan (*Cicer spinosum* M. Pop. and *Cousinia aurea* C. Winkl.) or western China (*Semenovia pimpinelloides* (Nevski) Manden). Based on literature data (Komarov 1934-1964; Ovchinnikov 1957, 1963, 1968, 1975, 1978, 1981; Chukavina 1984; Kochkareva 1986, Kinzikaeva 1988; Rasulova 1991; Rechinger 1963-2010; Nasir & Ali 1970-1979, 1980-1988; Ali & Nasir 1989-1992; Ali & Qaiser 1993-2007; Zhengyi & Raven 1998; eFloras 2008), it was established that, in total, the studied group comprises 86 taxa (Table 1). For each species we present its life form, taxonomic affiliation, type of habitat occupied and altitudinal amplitude (Tables 1 and 4). In the description of species distribution in the territory of Tajikistan, we have benefited from the geobotanical division proposed by Goncharov (1937). Three main geobotanical subregions have been presented: Zeravshanian A, B and C (Figs. 1 and 3). Taxonomic nomenclature follows the 10-volume Flora of Tajik SSR (Ovchinnikov 1957, 1963, 1968, 1975, 1978, 1981; Chukavina 1984; Kochkareva 1986; Kinzikaeva 1988; Rasulova 1991) and Czerepanov (1995).

Table 1. List of endemic plant species of the Zeravshan Mts with taxonomical status, chorology, frequency, range size, life form and threat level

1	2	3	4	5	6	7	8	9
Acantholimon komarovii Czerniak.	Limoniaceae		x	x	16	8000	4.5	P
Acanthophyllum seravschanicum Golenk.	Caryophyllaceae	x	x	x	12	7500	4.0	P
Alchemilla verae Ovcz.	Rosaceae		x		2	10	7.5	P
Allium crystallinum Vved.	Amarylidaceae	x	x		2	15	5.0	P
*Allium glaciale V*ved.	Amarylidaceae			x	3	50	6.0	P
Allium komarovii Lipsky	Amarylidaceae	x	x		2	20	4.0	P
Allium oreodictyum Vved.	Amarylidaceae	x	x		3	1800	4.0	P
Allium taeniopetalum M. Pop.	Amarylidaceae			x	1	0.1	3.7	P
Asparagus komarovianus Vved.	Liliaceae	x			1	0.1	5.5	P
Asperula pauciflora Tschern.	Rubiaceae	x	x		5	300	2.0	P
Asplenium samarkandense Koss.	Polypodiaceae	x	x		2	15	2.0	P
Astragalus bibracteatus Ovcz. et Rassul.	Fabaceae			x	1	0.1	4.0	T
Astragalus czapdarinus Ovcz. et Rassul.	Fabaceae		x		2	45	7.0	P
Astragalus farctissimus Lipsky	Fabaceae	x			1	0.1	7.0	P
Astragalus kschtutensis Rassul.	Fabaceae	x	x		4	75	6.5	P
Astragalus madruschkendicus Ovcz. et Rassul.	Fabaceae			x	2	45	6.0	P
Astragalus polytimeticus M. Pop.	Fabaceae		x		4	100	5.5	T
Astragalus saratagius Bunge	Fabaceae	x	x	x	30	9500	6.0	P
Astragalus saratagius Bunge subsp. *artschamajani* Rassul.	Fabaceae		x		3	25	6.0	P
Astragalus saratagius Bunge subsp. *sarimensis* Rassul.	Fabaceae		x		1	0.1	4.0	P
Astragalus schutensis Gontsch.	Fabaceae	x			1	0.1	6.0	P
Astragalus subrosularis Gontsch.	Fabaceae	x			4	350	6.7	P
Betula pyrolifolia V. Vassil.	Betulaceae		x		1	0.1	7.0	T
Cardamine seravschanica Botsch.	Brassicaceae		x		2	15	7.0	P
Cirsium rassulovii B. Scharipova	Asteraceae		x	x	2	55	7.3	P
Convolvulus olgae Regel et Schmalh.	Convolvulaceae	x		x	2	20	5.5	T
Corydalis zeravschanica Mikhailova	Fumariaceae		x	x	4	45	7.0	P
Cousinia anomala Franch.	Asteraceae	x	x		23	5350	4.7	P
Cousinia butkovii Tschern.	Asteraceae	x			1	0.1	3.0	B
Cousinia eriotricha Juz.	Asteraceae	x			5	100	4.0	P
Cousinia finitima Juz.	Asteraceae	x	x		3	38	6.0	P
Cousinia maracandica Juz.	Asteraceae	x	x		5	42	5.0	P
Cousinia neglecta Juz.	Asteraceae	x			3	25	5.5	B
Cousinia sarawschanica C. Winkl.	Asteraceae	x	x		15	2650	6.0	P
Cousinia ulotoma Bornm.	Asteraceae		x		1	0.1	5.0	B
Cryptocodon monocephalus (Trautv.) Fed.	Campanulaceae		x		1	0.1	4.0	P
Delphinium nevskii Zak.	Ranunculaceae	x			2	8	4.0	P
Eleagnus songarica Bernh. ex Schlecht.	Eleagnaceae	x	x		6	850	8.0	T
Eremolimon fajzievii (Zak. ex Lincz.) Lincz	Limoniaceae		x		1	0.1	7.0	P
Eremostachys mogianica M. Pop.	Lamiaceae	x	x		3	25	3.7	P
Eremurus pubescens Vved.	Liliaceae	x	x		4	49	5.5	P
Erysimum samarkandicum M. Pop.	Brassicaceae	x	x	x	7	285	6.0	P

1	2	3	4	5	6	7	8	9
Euphorbia rosularis Al. Theod.	Euphorbiaceae		x	x	7	245	4.0	P
Ewersmannia sogdiana Ovcz.	Fabaceae		x		2	45	4.0	P
Ferula fedtschenkoana K.-Pol.	Apiaceae	x	x	x	8	2650	4.0	P
Ferula ovczinnikovii M. Pimen.	Apiaceae	x	x		3	55	5.5	P
Gagea holochiton M. Pop. et Czug.	Liliaceae	x			1	0.1	5.0	P
Gagea minutissima Vved.	Liliaceae		x		1	0.1	6.0	P
Halothamnus seravschanicus Botsch.	Chenopodiaceae			x	1	0.1	5.0	P
Hedysarum korshinskyanum B. Fedtsch.	Fabaceae		x		3	30	4.0	P
Hedysarum mogianicum (B. Fedtsch.) B. Fedtsch.	Fabaceae	x			6	780	7.0	P
Heliotropium seravschanicum M. Pop.	Boraginaceae	x	x	x	9	2800	5.0	A
Jurinea helichrysifolia M. Pop.	Asteraceae		x		3	50	4.0	P
Jurinea trautvetteriana Regel et Schmalh.	Asteraceae		x	x	5	75	6.0	P
Krascheninnikovia ceratoides subsp. *tragacanthoides* (Losinsk.) Ovcz. et Kinz.	Chenopodiaceae	x	x		5	65	5.3	T
Lappula rupicola Zak.	Boraginaceae	x			1	0.1	5.0	P
Lepechinella minuta (Lipsky) M. Pop.	Boraginaceae			x	1	0.1	4.0	P
Lepidium seravschanicum Ovcz. et Junuss.	Brassicaceae	x	x	x	19	4050	5.3	P
Lipskya insignis (Lipsky) Nevski	Apiaceae	x	x		7	1350	6.0	P
Melissitus iskanderi (Vass.) Latsch.	Fabaceae		x		2	15	5.5	P
Nepeta maussarifi Lipsky	Lamiaceae		x		2	35	6.5	P
Nepeta santoana M. Pop.	Lamiaceae			x	2	45	3.5	P
Onopordum seravschanicum Tamamsch.	Asteraceae			x	2	45	7.0	B
Onosma maracandica Zak.	Boraginaceae		x		2	35	4.0	P
Oxytropis lithophila Vass.	Fabaceae		x		3	155	4.0	P
Oxytropis michelsonii B. Fedtsch.	Fabaceae	x	x		18	6500	5.5	P
Primula lactiflora Turkev.	Primulaceae	x	x	x	12	4750	6.7	P
Pseudoclausia olgae (Regel et Schmalh.) Botsch.	Brassicaceae	x			1	0.1	4.0	B
Ranunculus botschantzevii Ovcz.	Ranunculaceae	x			1	0.1	5.0	P
Rheum hissaricum Losinsk.	Polygonaceae	x			2	15	5.0	P
Ribes malvifolium Pojark.	Saxifragaceae		x		1	0.1	2.0	T
Salvia komarovii Pobed.	Lamiaceae	x	x		9	58	5.0	P
Saussurea saxosa Lipsch.	Asteraceae	x		x	6	1850	4.0	P
Scutellaria haestiabunda Juz.	Lamiaceae		x	x	3	2650	5.5	P
Scutellaria picta Juz.	Lamiaceae		x		6	1800	5.0	P
Scutellaria rubromaculata Juz. et Vved.	Lamiaceae	x	x		9	1750	3.0	P
Silene monantha Bondar.	Caryophyllaceae		x		1	0.1	6.0	P
Stipa richteriana Kar. & Kir. subsp. *jagnobica* (Ovcz. et Czuk.) Tzvel.	Poaceae		x	x	3	45	4.5	P
Tanacetopsis handeliiformis Kovalevsk.	Asteraceae	x	x		5	85	5.0	P
Taraxacum comitans Kovalevsk.	Asteraceae			x	2	15	5.5	P
Taraxacum seravschanicum Schischk.	Asteraceae		x		1	0.1	7.0	P
Tragacantha macrantha Boriss.	Fabaceae		x	x	4	155	5.5	T
Tragacantha transoxana (Fisch.) Kuntze	Fabaceae			x	2	125	4.0	T
Tragopogon alaicus S. Nikit.	Asteraceae		x	x	6	1865	4.0	P
Tragopogon serawschanicus S. Nikit.	Asteraceae		x	x	9	2550	5.5	P
Tulipa ingens Hoog	Liliaceae	x	x		3	75	7.0	P

Explanations: 1 – species name; 2 – family; 3-5 – Zeravshanian A, B and C geobotanical subregions; 6 – number of locations; 7 – range size [sq. km]; 8 – threat; 9 – life form, A – annual, B – biennial, P – perennial, S – shrub, T – tree

2.2. Study area

The Zeravshan range in Tajikistan covers ca. 14,000 km^2 and is situated in the north-western part of the country between E 39° 06' – 39° 32' and N 66° 55' – 70° 48' (Figs. 2-3). This is a typical mountainous area, situated between 850 (Zeravshan river valley in the borderland with Uzbekistan) and 5,489 m a.s.l. (peak Chimtarga). The main mountainous subranges within the Zeravshan Mts are Fann, Dukdon, Zinach, Ljangar, Kugibodrawak and several smaller. The range is situated in the temperate climate zone. However, because of altitude and relief, the mountainous character of the climate strongly influences the area. Generally, in Tajikistan there is a high insolation, as well as low cloudiness, high-amplitude annual temperatures, low humidity and precipitation. In the highest alpine zones, the climate is quite severe with average temperatures in July between 9.7 and 13.5°C (Narzikulov & Stanjukovich 1968). Annual precipitation varies here from about 200 to 450 mm. The lower limit of perpetual snow in the Zeravshan Mts is at an altitude of ca. 3,500-3,600 m a.s.l. (Latipova 1968).

The largest rivers here are: Zeravshan, Fan-daria, Mogien-daria, Ksztut, Pastrud-daria, Iskander-daria, Yagnob, Kaftarchona and Daraisusof (Trestman 1968).

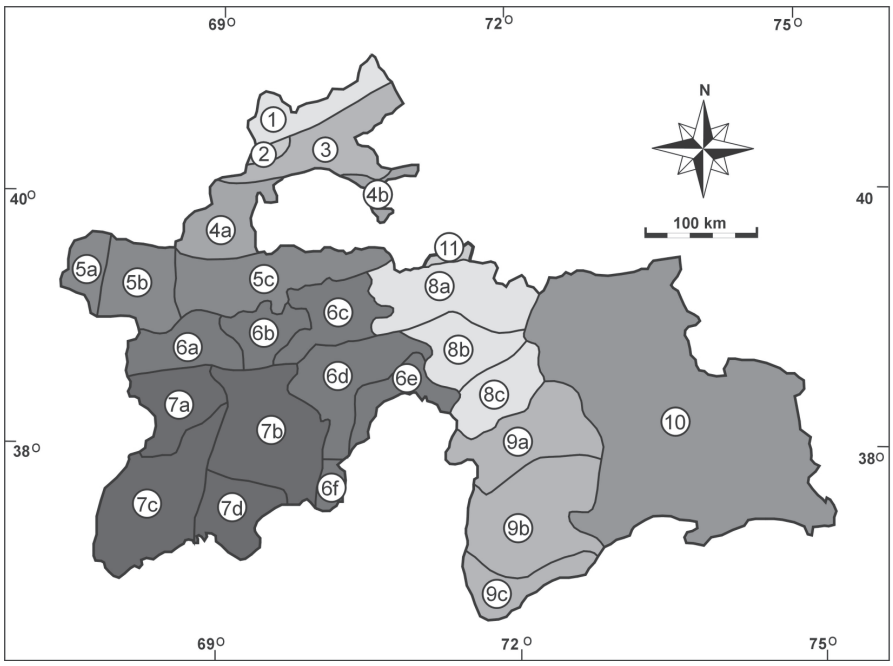

Fig. 2. Geobotanical division of Tajikistan (Goncharov 1937)
Explanations: 1 – Kuraminian, 2 – Mogoltausian, 3 – Prisyrdarian, 4a – Turkestanian A, 4b – Turkestanian B, 5a – Zeravshanian A, 5b – Zeravshanian B, 5c – Zeravshanian C, 6a – Hissar-Darvasian A, 6b – Hissar-Darvasian B, 6c – Hissar-Darvasian C, 6d – Hissar-Darvasian D, 6e – Hissar-Darvasian E, 6f – Hissar-Darvasian F, 7a – South Tajikistanian A, 7b – South Tajikistanian B, 7c – South Tajikistanian C, 7d – South Tajikistanian D, 8a – East Tajikistanian A, 8b – East Tajikistanian B, 8c – East Tajikistanian C, 9a – West Pamirian A, 9b – West Pamirian B, 9c – West Pamirian C, 10 – East Pamirian, 11 – Alajian

2.3. Data and analyses

Data sources regarding the distribution, life form, altitudinal range and habitat preferences, include literature (Ovchinnikov 1957, 1963, 1968, 1975, 1978, 1981; Chukavina 1984; Kochkareva 1986; Kinzikaeva 1988; Rasulova 1991; Zakirov 1955, 1961), our own field-work (2006-2010) and herbarium records.

The range size of a given species (in square km) was extrapolated by calcultating the area between all known localities of this species. In cases when only one population of a species is known, the range was assessed as 0.1 km^2.

Table 2. The level of human impact upon the differentiated vegetation types

Type of anhropogenic pressure	Agriculture and grazing	Harvesting	Erosion	Cuttings	Meliorations	Water contamination and regulation	Σ
Riverside forests (Bielolesya)	2	1	1	3	1	0	8
Alpine forests (Archevniki)	1	1	2	3	0	0	7
Broad-leaved forests (Chernolesya)	2	1	1	3	0	0	7
Meadows and pastures	3	1	2	0	1	0	7
River bed forests (Tugay)	2	1	1	3	0	0	7
Xerothermophilous shrubs (Shiblyak)	2	1	2	2	0	0	7
River bed shrubs	1	1	1	1	1	2	7
Xerothermophilous dwarf shrubs (Rosaria)	2	1	2	2	0	0	7
Alpine meadows and swards	2	1	3	0	0	0	6
Tall herbs	2	2	1	0	1	0	6
Steppes and semi-savannas	2	1	2	0	0	0	5
Xerothermophilous swards	2	1	2	0	0	0	5
Bogs	1	1	1	0	2	0	5
Rushes	1	0	1	0	2	1	5
Deserts and semi-deserts	1	1	2	0	1	0	5
Salt marsh vegetation	1	1	1	0	1	1	5
Scree vegetations	1	1	2	0	0	0	4
Agrocoenoses	1	0	1	0	1	0	3
Water vegetation	0	0	0	0	1	1	2
Rock vegetation	0	1	1	0	0	0	2
Σ	29	18	29	17	12	5	

The degree of endangerment due to a lack of sufficient data for all the populations of analysed species was assessed not according to the method of the IUCN (2001) but indirectly, after evaluating the risk factors for habitats. The determined habitat types were analysed in terms of exposure to the degrading factors threatening the vegetation in Tajikistan (Rathjens 1986; Safarov 2003; Ahmadov *et al*. 2006), i.e., overgrazing or other forms of agricultural intensive activity, poor forestry practices (including deforestation), soil erosion, land reclamation (mainly irrigation), plant collection for pharmaceutical or ornamental purposes, pollution or regulation of watercourses. Each habitat type was assessed using a three-point scale: 1 – low impact, 2 – medium impact, 3 – strong impact. The final value of endangerment for each species was calculated dividing the summed value of the habitat threats by the number of vegetation types in which the species occurs. The final degree of exposure to human impact was expressed by the values between 2 and 8 (Table 2).

3. Results

3.1. Taxonomic groups and life forms

Our inventory of the Zeravshan Mts endemics showed that the total number of species meeting the criteria of endemism reaches 86 taxa, so ca. 13.5% of the officially accepted group of Tajik endemics. These species and subspecies were included in further analyses. Such a high degree of endemism in one range is comparable to the Mediterranean mountainous areas (Favarger 1972; Strid 1993; Médail & Verlaque 1997). It is worth noting that in the flora of the Zeravshan Mts, in addition to endemics at the species or subspecies levels, there are also some endemic genera. To the genera which comply with the definition of endemics *sensu stricto* belong *Cryptocodon* (Campanulaceae) and *Lipskya* (Apiaceae). In the Zeravshan Mts there are no endemic families.

The endemic plants of the Zeravshan Mts belong to 25 families. The richest in endemic taxa are: Fabaceae, Asteraceae, Lamiaceae, Liliaceae, Amarylidaceae, Boraginaceae, Brassicaceae and Apiaceae. In 17 families,

Table 3. Number of Zeravshan endemics in plant families

Family	N End Zer	N End Tjk
Fabaceae	19	297
Asteraceae	18	250
Lamiaceae	7	98
Liliaceae	5	69
Amarylidaceae	5	43
Boraginaceae	4	43
Brassicaceae	4	73
Apiaceae	3	77
Caryophyllaceae	2	66
Ranunculaceae	2	43
Chenopodiaceae	2	27
Limoniaceae	2	27
Poaceae	1	74
Rosaceae	1	46
Rubiaceae	1	24
Polygonaceae	1	17
Betulaceae	1	15
Primulaceae	1	13
Euphorbiaceae	1	12
Campanulaceae	1	11
Fumariaceae	1	10
Convolvulaceae	1	4
Eleagnaceae	1	1
Polypodiaceae	1	1
Saxifragaceae	1	1

Explanations: N End Zer – number of endemic plants in the Zeravshan Mts, N End Tjk – number of endemic plants in Tajikistan

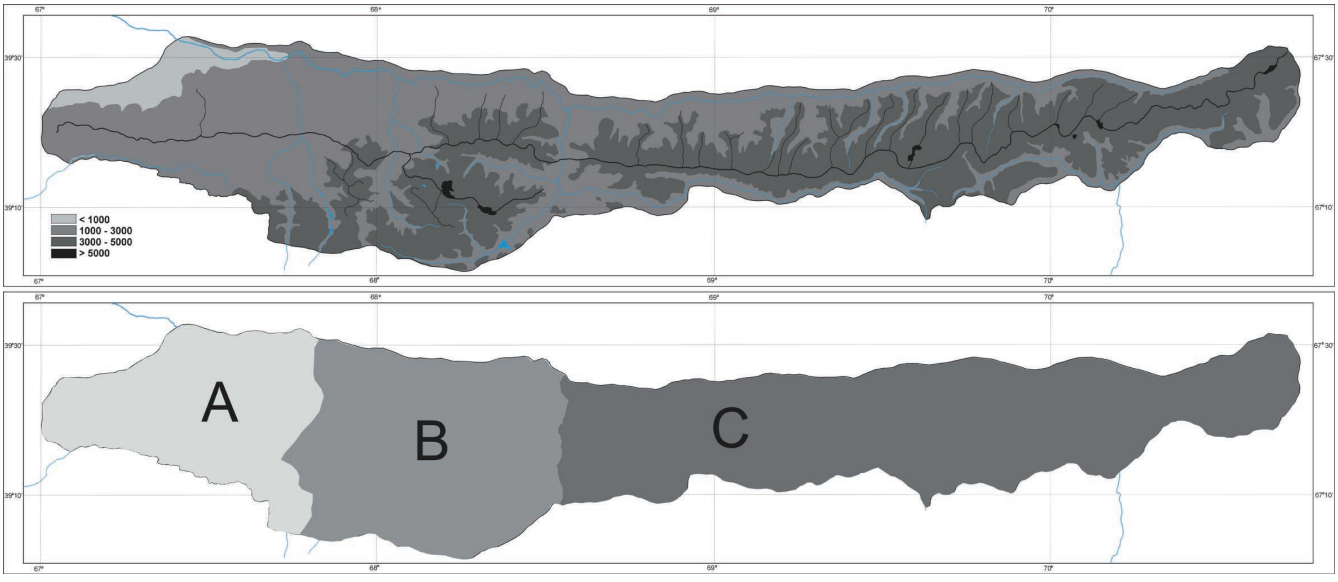

Fig. 3. Hypsometry and geobotanical subdivision of the Zeravshan Mountains (according to Goncharov 1937)

there is only a single endemic species (Table 3). The richest in endemic species is the genus *Astragalus* with 11 species. Numerous endemics were recorded also in the genera *Cousinia* (8), *Allium* (5) and *Scutellaria* (3).

In terms of life forms, definitely the largest group of endemics in the Zeravshan Mts are perennials (71 species). Much less numerous are bushes and shrubs (7 species), biennial plants (5) and trees (2 species), while the lowest number is found amongst annual plants (1 species) (Table 1, Plate I).

3.2. Distribution of endemics

Using the division proposed by Goncharov (1937), the number of endemics found separately in three Zeravshanian subregions was counted (Table 4). Definitely the richest subregion was the central Zeravshanian "B" with 57 endemic plants occurring there (Fig. 3). Quite rich is also the Zeravshanian "A" with 44 endemic taxa. The Zeravshanian "C" subregion harbours 28 endemics. However if we count the number of endemics

Table 4. List of endemic plant species of the Zeravshan Mts with habitat characterization, and altitudinal chorology

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
Acantholimon komarovii	2500	3400	2950	900	x								x						x	x				4
Acanthophyllum seravschanicum	1800	2500	2150	700															x					1
Alchemilla verae	2700	2700	2700	0	x		x																	2
Allium crystallinum	800	1800	1300	1000										x										1
Allium glaciale	3000	3100	3050	100								x												1
Allium komarovii	1200	2200	1700	1000															x					1
Allium oreodictyum	900	1200	1050	300															x					1
Allium taeniopetalum	500	1200	850	700												x			x	x				3
Asparagus komarovianus	1800	2000	1900	200							x								x					2
Asperula pauciflora	1300	1900	1600	600																x				1
Asplenium samarkandense	1700	2600	2150	900																x				1
Astragalus bibracteatus	3050	3050	3050	0															x					1
Astragalus czapdarinus	2500	2500	2500	0		x																		1
Astragalus farctissimus	1800	1900	1850	100	x																			1
Astragalus kschtutensis	2500	3200	2850	700	x							x												2
Astragalus madruschkendicus	2700	2700	2700	0	x								x											2
Astragalus polytimeticus	1500	2800	2150	1300	x														x					2
Astragalus saratagius	2000	3500	2750	1500	x							x						x	x					4
Astragalus saratagius subsp. *artschamajani*	2200	2300	2250	100								x												1
Astragalus saratagius subsp. *sarimensis*	3000	3100	3050	100															x					1
Astragalus schutensis	3000	3500	3250	500	x								x											2
Astragalus subrosularis	2800	3300	3050	500	x			x				x												3
Betula pyrolifolia	2200	2200	2200	0						x														1
Cardamine seravschanica	2700	2700	2700	0	x																			1
Cirsium rassulovii	2300	2500	2400	200			x											x			x			3
Convolvulus olgae	1000	1500	1250	500							x								x					2
Corydalis zeravschanica	2000	2400	2200	400	x			x																2
Cousinia anomala	1700	2600	2150	900									x	x					x					3
Cousinia butkovii	1700	2000	1850	300															x	x				2
Cousinia eriotricha	3000	3200	3100	200															x					1
Cousinia finitima	1300	2300	1800	1000	x								x											2
Cousinia maracandica	900	2500	1700	1600									x	x										2
Cousinia neglecta	1800	2500	2150	700							x								x					2
Cousinia sarawschanica	2000	3500	2750	1500	x			x											x					3
Cousinia ulotoma	1200	1500	1350	300									x											1
Cryptocodon monocephalus	1600	1700	1650	100															x					1
Delphinium nevskii	3300	3800	3550	500															x					1
Eleagnus songarica	1400	1500	1450	100			x																	1
Eremolimon fajzievii	1300	1300	1300	0							x													1
Eremostachys mogianica	1000	1500	1250	500									x						x	x				3
Eremurus pubescens	800	2900	1850	2100	x														x					2
Erysimum samarkandicum	1500	2900	2200	1400	x														x		x			3
Euphorbia rosularis	1900	2800	2350	900															x					1
Ewersmannia sogdiana	1700	1800	1750	100															x					1
Ferula fedtschenkoana	2100	3000	2550	900															x					1
Ferula ovczinnikovii	1800	2500	2150	700	x														x					2
Gagea holochiton	600	600	600	0										x										1
Gagea minutissima	1800	2500	2150	700								x												1
Halothamnus seravschanicus	1200	1500	1350	300										x										1
Hedysarum korshinskyanum	1000	1400	1200	400															x					1
Hedysarum mogianicum	1300	2000	1650	700	x						x													2
Heliotropium seravschanicum	1100	1500	1300	400										x										1
Jurinea helichrysifolia	1300	1600	1450	300															x					1
Jurinea trautvetteriana	1600	1800	1700	200				x					x											2
Kraschenninnikovia ceratoides subsp. *tragacanthoides*	2400	3400	2900	1000								x	x									x		3

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
Lappula rupicola	2800	3000	2900	200								x							x					2
Lepechinella minuta	2900	3100	3000	200															x					1
Lepidium seravschanicum	1600	2200	1900	600	x								x						x					3
Lipskya insignis	800	1300	1050	500										x				x						2
Melissitus iskanderi	2000	2100	2050	100														x	x					2
Nepeta maussarifi	2100	3000	2550	900													x	x						2
Nepeta santoana	2000	2800	2400	800					x										x					2
Onopordum seravschanicum	2700	3000	2850	300	x																			1
Onosma maracandica	2900	3100	3000	200															x					1
Oxytropis lithophila	2400	2700	2550	300															x					1
Oxytropis michelsonii	2300	3300	2800	1000	x							x	x						x					4
Primula lactiflora	2200	3000	2600	800	x			x				x												3
Pseudoclausia olgae	1700	1700	1700	0															x					1
Ranunculus botschantzevii	3300	3500	3400	200											x									1
Rheum hissaricum	1500	3200	2350	1700								x							x					2
Ribes malvifolium	2500	3600	3050	1100																x				1
Salvia komarovii	2000	2100	2050	100									x	x										2
Saussurea saxosa	2300	3000	2650	700															x					1
Scutellaria haestiabunda	2500	3000	2750	500	x														x					2
Scutellaria picta	2100	2800	2450	700	x													x	x	x				4
Scutellaria rubromaculata	2000	2200	2100	200															x	x				2
Silene monantha	2000	2500	2250	500	x								x											2
Stipa richteriana subsp. *jagnobica*	2100	2400	2250	300									x						x					2
Tanacetopsis handeliiformis	900	1500	1200	600										x										1
Taraxacum comitans	1600	2600	2100	1000	x														x					2
Taraxacum seravschanicum	2500	3000	2750	500	x			x																2
Tragacantha macrantha	2000	3000	2500	1000	x														x					2
Tragacantha transoxana	650	1000	825	350															x					1
Tragopogon alaicus	2000	2500	2250	500															x					1
Tragopogon serawschanicus	1300	2800	2050	1500	x														x					2
Tulipa ingens	1600	1800	1700	200							x													1

Explanations: 1 – species name, 2 – altitude min, 3 – altitude max, 4 – altitude mean, 5 – altitude scope, 6 – alpine forests (Archevniki), 7 – broad-leaved forests (Chernolesya), 8 – riverside forests (Biełolesya), 9 – meadows and pastures, 10 – agrocoenoses, 11 – river bed forests (Tugay), 12 – xerothermophilous shrubs (Shiblyak), 13 – alpine meadows and swards, 14 – steppes and semi-savannas, 15 – xerothermophilous swards, 16 – bogs, 17 – rushes, 18 – tall herbs, 19 – river bed shrubs, 20 – scree vegetations, 21 – rock vegetation, 22 – xerothermophilous dwarf shrubs (Rosaria), 23 – deserts and semi-deserts, 24 – salt marsh vegetation, 25 – number of habitats

within the unified area, e.g. 100 km^2, the highest concentration of endemic plants will have the subregion "A" (2.71) and then subregion "B" (1.3) and "C" (0.39).

In terms of the number of exclusive endemics (Fig. 4), Zeravshanian "B" leads with 22 endemics, followed by Zeravshanian "A" with 14 species and Zeravshanian "C" with 10 species noted (Table 5).

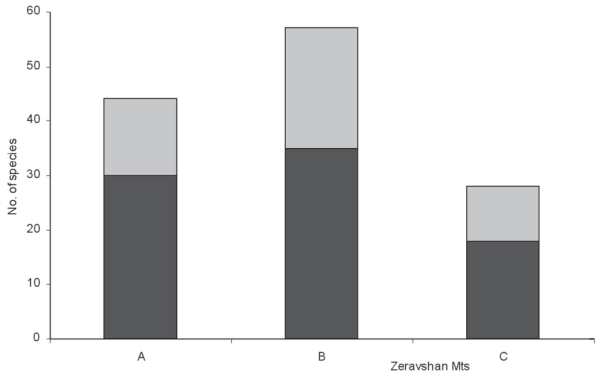

Fig. 4. Number of endemic plants in different subregions of the Zeravshan Mts
Explanations: black – exclusive endemics, gray – endemics known also from other subregions

Table 5. Exclusive endemic species occurring in the three subregions of the Zeravshanian Mts

Subregion "A"	*Asparagus komarovianus*, *Astragalus farctissimus*, *A. schutensis*, *A. subrosularis*, *Cousinia butkovii*, *C. eriotricha*, *C. neglecta*, *Delphinium nevskii*, *Gagea holochiton*, *Hedysarum mogianicum*, *Lappula rupicola*, *Pseudoclausia olgae*, *Ranunculus botschantzevii*, *Rheum hissaricum*
Subregion "B"	*Alchemilla verae*, *Astragalus czapdarinus*, *A. polytimeticus*, *A. saratagius* subsp. *artschamajani*, *A. saratagius* subsp. *sarimensis*, *Betula pyrolifolia*, *Cardamine seravschanica*, *Cousinia ulotoma*, *Cryptocodon monocephalus*, *Eremolimon fajzievii*, *Ewersmannia sogdiana*, *Gagea minutissima*, *Hedysarum korshinskyanum*, *Jurinea helichrysifolia*, *Melissitus iskanderi*, *Nepeta maussarifi*, *Onosma maracandica*, *Oxytropis lithophila*, *Ribes malvifolium*, *Scutellaria picta*, *Silene monantha*, *Taraxacum seravschanicum*
Subregion "C"	*Allium glaciale*, *A. taeniopetalum*, *Astragalus bibracteatus*, *A. madruschkendicus*, *Halothamnus seravschanicus*, *Lepechinella minuta*, *Nepeta santoana*, *Onopordum seravschanicum*, *Taraxacum comitans*, *Tragacantha transoxana*

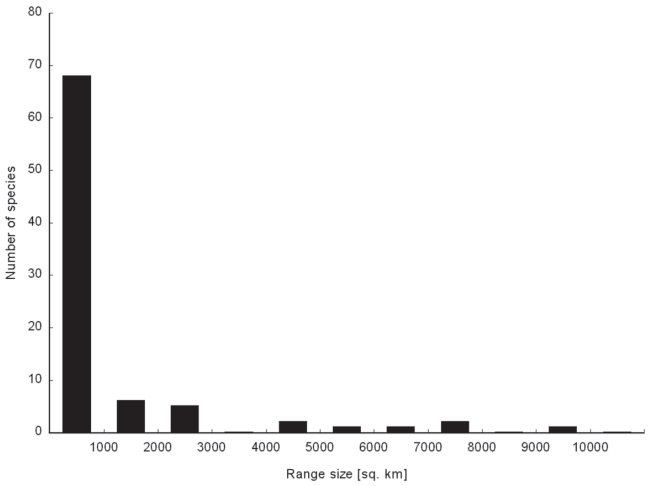

Fig. 5. Range sizes of endemic vascular plant taxa of the Zeravshan Mts

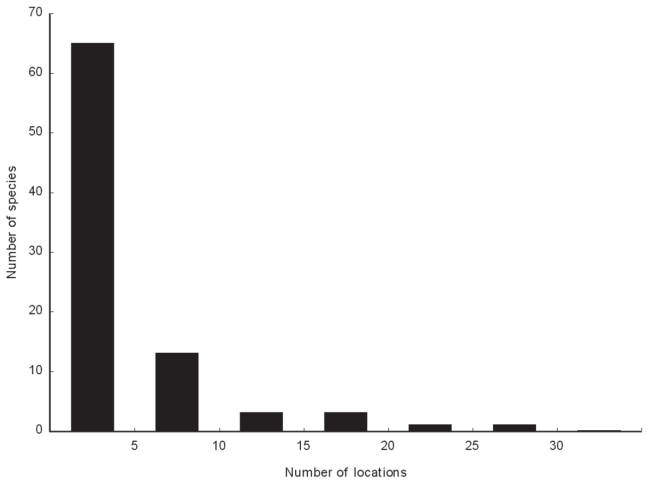

Fig. 6. Number of localities of endemic plants of the Zeravshan Mts

Most endemics of the Zeravshan Mts occur in very restricted number of locations. For several of them are known only single population (e.g. *Allium taeniopetalum, Asparagus komarovianus*, *Astragalus bibracteatus*, *Astragalus farctissimus*, *Betula pyrolifolia*, *Cousinia butkovii*, *Cryptocodon monocephalus*, *Gagea minutissima*, *Lappula rupicola*, *Lepechinella minuta*, *Pseudoclausia olgae*, *Ranunculus botschantzevi*. Only a few appear in more than 5-6 locations and the maximum distribution was noted for *Astragalus saratagius* (30 locations) *Cousinia anomala* (23) and *Lepidium seravshanicum* (19) (Table 2).

The range size of endemic varies from around 0.1 for the species with single locations to ca. 9,500 km^2 with a mean value of ca. 1141 km^2. For the whole group of species studied it is clearly seen that species with small ranges predominate (Table 2, Fig. 5). Also the number of localities of the considered species is very low. Majority of them occur only on 1-2 locations and only a few is known from more than 15 sites (Table 2, Fig. 6).

The largest group of endemics has been recorded at an altitude of about 2,100 m a.s.l. Relatively high is also the number of endemics at the elevation of ca. 1,800-2,100 and 2,700-3,000 m (Fig. 7, Table 6). Both above 3,000 m and below 900 m, the number of endemics remarkably decreases.

The altitudinal amplitude has different values for different taxa. Most often it is around 450-650 m. Despite of its diversity, the endemic species group occurred in a fairly narrow altitudinal range, generally not exceeding 200 m (Fig. 8).

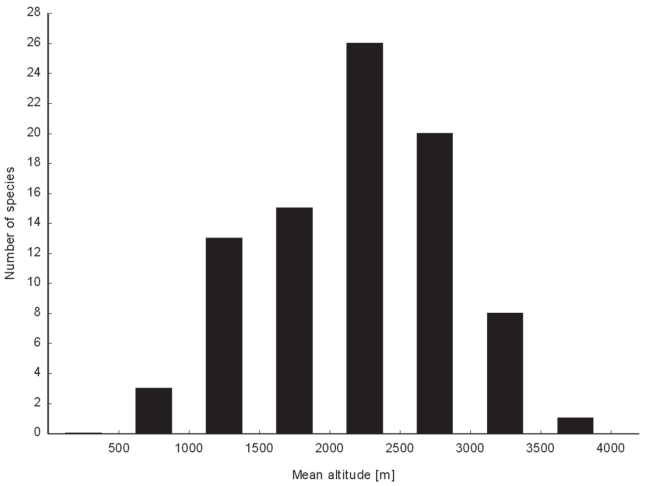

Fig. 7. Altitudinal distribution of endemic vascular plant taxa in the Zeravshan Mts

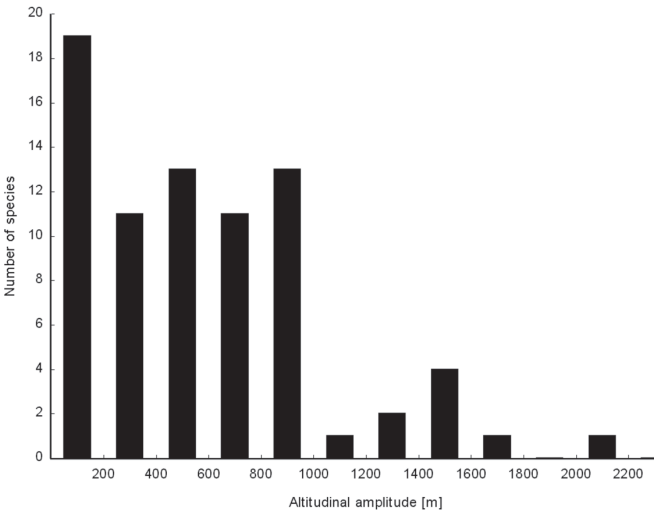

Fig. 8. Altitudinal amplitude of endemic vascular plant taxa of the Zeravshan Mts

3.3. Habitat preferences

Habitat preferences of separate endemic species are clear enough and generally tied to one particular type of biotope or plant community. Therefore these are species with comparatively narrow ecological amplitude. Occasionally, these species are listed in two similar environments in terms of biotic and abiotic habitat conditions. Only in a few cases (species with larger distribution), endemics have been found in several different habitats. This group of taxa comprises: *Acantholimon komarovii*, *Astragalus saratagius*, *Oxytropis michelsonii* and *Scutellaria picta* found in four habitats (Table 4, Plate I).

Table 6. Participation of Zeravshan endemics in different habitat types

Habitat type	Number of endemics	Number of exclusive endemics
Scree vegetations	47	20
Alpine forests (Archevniki)	28	3
Steppes and semi-savannas	15	1
Alpine meadows and swards	11	-
Rock vegetation	9	3
Xerothermophilous swards	9	5
Meadows and pastures	6	3
Xerothermophilous shrubs (Shiblyak)	6	2
Riverbed shrubs	6	-
Riverside forests (Bielolesya)	3	1
Xerothermophilous dwarf shrubs (Rosaria)	2	-
Broad-leaved forests (Chernolesya)	1	1
Bog-spring vegetation	1	1
Riverbed forests (Tugay)	1	1
Tall herbs	1	-
Agrocoenoses	1	-
Deserts and semi-deserts	1	-
Rushes	1	-

Generally, the number of endemics occurring in particular types of habitat is quite differentiated. The most of endemic species have been reported from rock screes. A large number of them also grows in alpine forests, steppes and semi-savannas, alpine meadows, on rocks xerothermophilous shrubs and in pastures (Table 6). Interesting is the habitat distribution of those endemic plants which have been noted only in one type of vegetation. There are 41 such taxa. In this group, predominating habitats are scree and slide rock sites. For numerous endemics occurring exclusively in one vegetation type, the very important biotopes are also xerothermophilous swards, rock habitats and alpine forests, which emphasizes a high separateness and specificity of these types of vegetation.

3.4. Threats and conservation state

Many vascular plant species of Tajikistan are endangered because of the multi-factorial interactions and biotic and abiotic transformations of the environment (vegetation succession, soil erosion, denudation) as well as ongoing anthropogenic pressure. Most significant are: intensive grazing of sheep, goats and cattle, which is conducted both in the meadows, swards, but also in communities of forest and scrub, poor forest management and intensive deforestation for fuel and building material, harvesting of plants for pharmaceutical or ornamental purposes and to a lesser extent, land reclamation (mainly irrigation), pollution and eutrophication of waters (Table 2). In this way, most vulnerable to the human impact are forest and scrub communities. Slightly smaller is the endangerment to grasslands, meadows, tall-herb communities, marshes and reeds. Theoretically least vulnerable is screes and rocky slides vegetation.

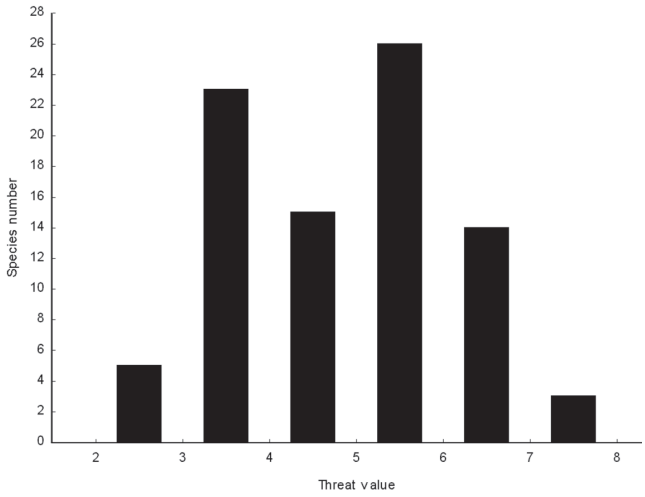

Fig. 9. The endangerment status of endemic vascular plant taxa of the Zeravshan Mts

The impact strength in relation to the entire group of endemics has the normal distribution, with a slight shift towards higher values of exposure to the negative influences of human activities (Fig. 9). The least vulnerable are perennial plants which occur in rock habitats and screes, e.g. *Asperula pauciflora*, *Asplenium samarkandense*, *Ribes malvifolium*, *Cousinia butkovii* or *Scutellaria schugnanica*.

The most endangered plant taxa are predominantly found in riverine phytocoenoses or alpine coniferous forests and include *Eleagnus songorica*, *Alchemilla verae* or *Cirsium rassulovii*. Also species growing in alpine meadows, grasslands, steppes and screes are significantly endangered. These are, among others: *Astragalus czapdarinu*, *Astragalus farctissimus*, *Betula pyrolifolia*, *Cardamine seravschanica*, *Corydalis seravschanica*, *Eremolimon fajzievii*, *Hedysarum mogianicum*, *Onopordum seravschanicum*, *Taraxacum seravschanicum* and *Tulipa ingens*.

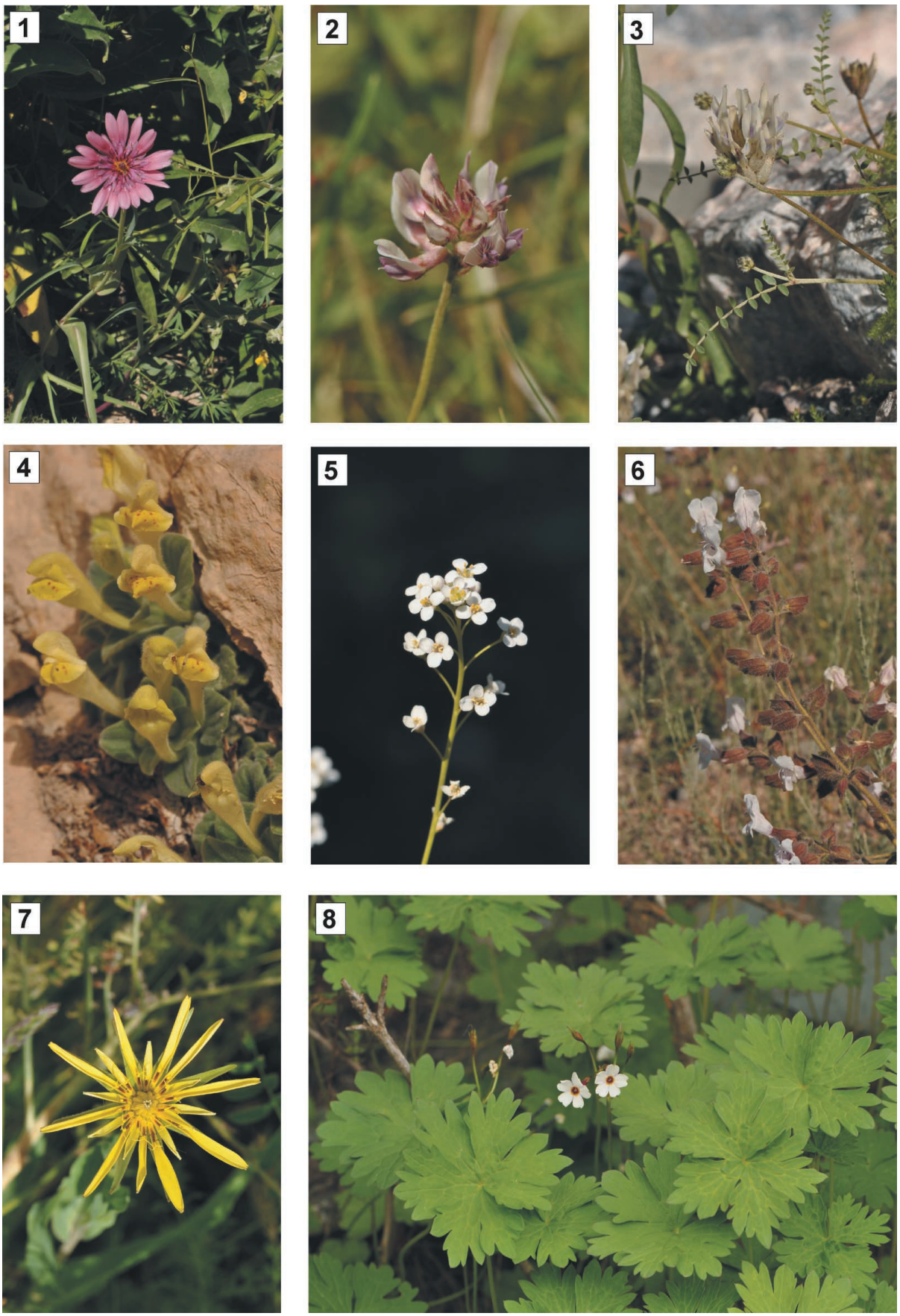

Plate I. Selected endemic species of the Zeravshan Mts

1 – *Tragopogon alaicus* in Seven Lakes Valley (June 2009), 2 – *Oxytropis michelsonii* at Azorchashma Lake (June 2010), 3 – *Astragalus saratagius* in Yagnob Valley near Anzob (July 2009), 4 – *Scutellaria rubromaculata* near Mogien (June 2010), 5 – *Lepidium seravschanicum* near Nofin Lake (June 2010), 6 – *Salva komororii* in xerothermophilous swarols near Shing (June 2009), 7 – *Tragopogon serawschanicus* at the 3rd lake in Seven Lakes Valley (June 2009), 8 – *Primula lactiflora* near Remon (June 2009)

Photographs by Arkadiusz Nowak

4. Discussion

4.1. Number of endemics

The 86 endemics of the Zeravshan Mts constitute about 13.5% of Tajik's vascular endemic plants and ca. 5% of all flora of this mountain range. It is a relatively high percentage, comparable with the literature data for, e.g., mountainous areas in the Mediterranean region (Favarger 1972), which are recognised as one of the most important centres of endemism on earth (Mittermeier *et al*. 2005). These percentages are significantly higher than those of transitional European lowlands (e.g. Pawłowska 1972; Hendrych 1981) and also other areas of Asia with rather lowland character of relief, e.g. Kazakhstan (Pavlov 1956-1966). As a matter of fact, the richness of endemics in the Zeravshan Mts has not been conclusively explored thus far. Mountains are especially rich in endemic species, because these areas are often geographically isolated, have extremely diverse environmental conditions, particularly edaphic and microclimatic (e.g. Favarger & Contandriopoulos 1961; Piękoś-Mirkowa *et al*. 1996). It is highly likely that the intensification of taxonomic researches of the flora of central Asia will result in revisions and descriptions of new species in Tajikistan, including those with small areas of distribution (see e.g. Fritsch *et al*. 2002; Khassanov *et al*. 2007; Nobis *et al*. 2010), as it is known from the better-studied European floras (e.g. Davis *et al*. 1965; Piekoś-Mirkowa *et al*. 1996; Tutin *et al*. 2002). The considerable richness of endemic taxa in Tajikistan is linked, for instance, to the fact that during the Quaternary glaciations, ice sheets did not reach central Asia, and local mountain glaciers did not cover the area of all ecosystems, including the mesophilic forest areas, which have became a refuge for Tertiary floras (Safarov 2003).

4.2. Distribution patterns and hotspots of endemism

The distribution regarding the vertical and horizontal chorology of endemics is certainly a result of very varied land relief and land elevation within the quite long Zeravshan range. The considerable richness of endemics is seen in the medium-height altitudes, especially around Mogian, Iskander-kul, in Pastrud-daria river valley, Yagnob river valley and the zone close to the Hissar Mts (the upper parts of Seven Lakes Valley, Kshtut river valley and Kara-kul river valley). These are hotspots of plant diversity, with elevation generally not exceeding 3,500 m, and the largest area in the zone of 1,800-3,500 m a.s.l. The mountain ridges have here a truly alpine relief, there are numerous mountain lakes, and relatively high precipitation (in comparison to the eastern Tajikistan). The surfaces of glaciers in this region are small compared to the Pamir and the east Tajikistanian region. The relatively low number of endemic plants in Zeravshanian "C" subregion is probably related to the high mean elevation of this area and large land surface under permanent snow cover. Zeravshanian "A" and "B" subregions have much more varied relief and greater height differences. This situation confirms the view that high concentrations of endemics occur on average at medium elevations, within geographically separated and isolated mountain ridges (Agakhanjanz & Breckle 2002). It has also be noticed that the severity of microclimate as well as the extremity of habitats have been identified as the main factors which have an impact on the distinctiveness of flora and speciation of endemics (e.g. Ozenda 1988; Médail & Verlaque 1997; Tribsch & Schönswetter 2003).

Most endemics are encountered at medium elevations of the subalpine zone, in meadow communities, tall-herbs and swards as well as scrub communities. This is comparable to other mountainous regions of the world (Pawłowski 1970; Médail & Verlaque 1997; Borchsenius 1997; Agakhanjanz & Breckle 2002; van der Werff & Consiglio 2004; Essl *et al*. 2009). Habitats with wide altitudinal distribution, e.g. screes, are characterised also by rich endemic representation, however not specific in terms of altitude.

4.3. Habitats

Because of the relatively dry climate and intensive land denudation and erosion, Tajikistan is characterized by vast areas of various types of rock slides and screes. This type of habitat (scree vegetation) is a biotope of the most numerous group of endemics. Partially, that is just a result of extra-zonal character of this habitat and very different habitat conditions in terms of humidity, type of substrate rock, insolation, temperature, inclination, which influence the development of many plant species.

Also alpine steppes and so-called semi-savannas are significantly rich in vascular endemics. High-altitude steppes of Tajikistan are represented by grass communities built by *Festuca* sp., *Poa* sp., *Stipa* sp. and *Artemisia* sp. They develop in a severe climate above 2,000 meters and can be compared, e.g., to subnival zone in the Austrian Alps, also rich in endemics (Essl *et al*. 2009). The alpine forests harbour also relatively high number of endemics. They are rather shrub-like tree stands, open, with very diversified undergrowth depending on inclination, exposition and fertility of the soil substrate. All habitats mentioned are characterised by a high degree of "openness", low productivity and little competition in conjunction with low vegetation cover. This therefore confirms the theory that endemics are taxa with low ecological flexibility (Kruckeberg & Rabinowitz 1985) and competitiveness (Wilson & Keddy 1986), preferring areas of open and patchy commu-

nities, early stages of succession or extreme habitats, where competition is not too high and stress factors few. Reduction in the number of endemics is seen in the nival zone, where in spite of openness and low average vegetation cover, most stringent conditions prevail and the history of vegetation is much shorter (Agakhanjanz & Breckle 1995).

For the exclusive endemics, occurring in only one habitat type, the rock habitats offer suitable conditions. This is because of the adaptations of rock plants to very specific ecological conditions. The high number of endemics of petryphyton is also the result of a relatively large area of such habitat in the rocky mountains of central Asia.

4.4. Threats and conservation

Factors affecting the effectiveness of the protection of flora include the number, surface and management of created conservation areas and protection focused directly on species (Nowak & Nowak 2004). In the territory of the Zeravshan Mts no areas of category I (national parks) or II (landscape parks) have been established. Three sites of category IV (reserves: Zeravshan, Iskander-kul and Sayi-Vota, USAID 2001, Safarov 2003) were created covering the total area of ca. 36500 ha, that is about 0,25% of the area of Zeravshan range. The system is ineffective because of the only one, centralised governmental institution which is not able to monitor and manage all valuable plant populations.

Undoubtedly, insufficient current knowledge of the endemic flora of the Zeravshan Mts doesn't allow to determine precisely the degree of endangerment of each species mainly due to the lack of up to date distributional and population data needed for the evaluation- according to the IUCN method (IUCN 2001). The lack of actual and reliable data is certainly the reason that Zeravshan and also Tajik endemics are ranked so low in the world red data book of plants, which contains only 34 taxa from this country (IUCN 2009). It is possible, however, indirectly, through the analysis of transformation and degree of habitats endangerment, to indicate taxa which face the greatest risks.

The main risk factor for the Zeravshan endemic vascular plants is associated with pastoral economy. Intensive grazing of sheep and goats in the meadows, grasslands, in scrub communities and even in the woods leads to strong transformation of vegetation and to the creation of degenerated habitats, generally poorer in plant species. Grazing often also leads to denudation and soil degradation and consequently to desertification (Breckle & Wucherer 2006), which almost excludes the potential recovery of natural forest vegetation. Example are deciduous woods, mainly with *Juglans regia* and *Platanus orientalis*, which are preserved on very small plots occupying no more than 1% of the territory (Zapriagayeva & Ikonnikov 1968). Forests, mainly mesophilic, are one of the most degraded vegetation types in Tajikistan that occupied 16-18 % of the country territory about 100 years ago and now little more than 1%. Still about 60% of the population of the republic is using wood as fuel (USAID 2001).

5. Conclusions

Summarising the issues in relation to conservation of Tajik endemics, the need for a stronger national administration must be emphasised to deal with biodiversity conservation, which must involve the provision of financial support by international organisations (Giam *et al*. 2010). This was also one of the aims while establishing the global hot-spots network. But also at the national level, the system of nature conservation should be verified, so as to take better account of centres of endemism. It is strongly needed to establishe category I conservation areas in the Zeravshanian "A" and "B" subregions, within the great mountain river valleys of Seven Lakes, Archamidan, Kuli-Kalon and Kara-Kul. Foundation of the Funn Mts (a part of side ridge located between the main Zeravshan range and Hissar Mts range) National Park is fully justified by a great number of conservationally important plant and animal species. Also the supporting network of reserves or refugees should be implemented, covering the most valuable areas. This should help in raising the effectiveness of conservation efforts but also promote the area as a tourist and recreation site.

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