

Liverworts occurring in the snowbeds of the Tatra Mountains (Western Carpathians): list, distribution and threats

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Abstract – This article presents the characteristics of liverworts of snowbeds of the entire Tatra Mountains (Western Carpathians) area based upon studies conducted during 2002-2014. The studies concerned four groups of snowbeds (located on covering and rock slopes) distinguished by geomorphologic criteria. The list of liverworts is composed of 38 species of various degrees of linkage to the studied habitats. The species exclusive to the Tatra Mts snowbeds (*i.e.*, not growing in other habitats) include *Marsupella condensata*, *M. apiculata*, and *Nardia breidleri*. The most frequent and most abundant include *Anthelia juratzkana*, *Fuscocephaloziopsis* (= *Pleurocladula*) *albescens*, and *Pseudolophozia* (= *Lophozia*) *sudetica*. Based upon all available data published from 1814-2014 as well as personal studies (more than 18000 records), the degree of endangerment of snowbed liverworts in the Tatra Mts was determined according to IUCN criteria. New localities are presented for snowbed liverworts thus far considered very rare and previously reported in the Tatra Mts in few localities only (*e.g.*, *Marsupella condensata*, *M. boeckii*, *Nardia breidleri*, and *Moerckia blyttii*), which significantly changes the view of their rarity in the Tatra Mts.

Carpathians / Liverworts / Tatra Mountains / snowbeds / conservation

INTRODUCTION

Snowbeds are inherent parts of alpine mountains. A characteristic feature of the plants of these habitats is the presence of two distinct groups of communities, those dominated by either vascular plants or bryophytes. While the flora and vascular plants of these habitats in the Tatra Mts have been relatively well studied (Krajina, 1933; Balcerkiewicz, 1984; Kliment & Valachovič, 2007), mosses and liverworts have not been a focus of dedicated studies.

The first studies regarding cryptogamic plants in the Tatra Mts come from the second half of the 19th century. The most common snowbed liverworts of the massif (*i.e.*, *Anthelia juratzkana* or *Fuscocephaloziopsis* [= *Pleurocladula*] *albescens*) were recorded as early as 1860-1885 by F. Hazslinszky, A. Rehman, G. Limpricht, J. Krupa, and I. Szyszyłowicz (Górski & Váňa, 2014). The localities of the rarest species of snowbed habitats (*i.e.*, *Nardia breidleri* and *Marsupella apiculata*) have been reported for the first half of 20th century (Schiffner, 1910, 1911; Györfy, 1924; Szepesfalvy, 1926). A recent report has revealed a new Tatra Mts snowbed species, *Gymnomitrium adustum* (Górski & Váňa, 2011). More data about the liverwort flora

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of snowbeds come from phytosociological studies. However, it is worth noting that cryptogamic plant communities in the Tatra Mts have been documented mostly with respect to the most common species creating noticeably distinct units. Snowbed moss plant studies have described only large-area species (*i.e.*, *Polytrichetum sexangularis* or *Pohlietum commutatae*) and only with respect to specific areas of the Tatra Mts (e.g., one alpine valley) (Krajina, 1933; Balcerkiewicz, 1984). Collective studies on the Tatra Mts, summarising the state of knowledge on the snowbed vegetation (Mucina & Maglocký, 1985; Dúbravcová, 2007; Kliment *et al.*, 2010), only slightly present communities dominated by bryophytes. As noticed by Balcerkiewicz (1984), “the Tatra Mts snowbed communities composed of small bryophytes show significant diversity and demand a monographic study” (page 97).

The goal of this paper is to present a synthetic picture of the diversity of snowbed liverwort flora in the background of long-term geobotanical studies conducted in the entire area of the Tatra Mts (both Polish and Slovakian sides). A degree of the endangerment of snowbed species was determined on the basis of all published floristic data as well as personal observations. New localities of the snowbed liverworts considered the rarest and growing only in few localities (*Marsupella condensata*, *M. boeckii*, *Nardia breidlerii*, and *Moerckia blyttii*) were reported, which significantly changes the view of their rarity in the Tatra Mts.

MATERIAL AND METHODS

The list of liverworts growing in the Tatra Mts snowbeds was established based upon studies conducted during 2002–2014 in the entire area of High and Western Tatra Mts (Fig. 1). The documentation included crystalline and metamorphic rocks. Field data were gathered as phytosociological relevés and floristic lists composed of groups of plants that were predominately mosses and liverworts. Formations of vascular plants with low proportions of bryophytes were disregarded.

The following classifications of mossy plant groups in the snowbeds of Tatra Mts were distinguished on the basis of field studies, mostly using geomorphologic criteria:

- (1) small-crumb communities or earthy covering slopes filling hollows or flat sections in the alpine belt – Fig. 1, I (1a, 1b) and II (1c),
- (2) snowbed communities of rock blocks, localised mostly in the hollows of rocks (alpine belt) – Fig. 1, III (2),
- (3) subalpine-alpine earthy snowbeds dominated by liverworts, with significant proportions of vascular plants – Fig. 1, IV (3),
- (4) and mossy epilypytic snowbeds on rock slopes (changing to covering slopes) in places where the snow on the covering slope (alpine belt) sticks to the rocky wall – Fig. 1, II (4).

The original material consisted of 355 phytosociological relevés prepared using the classic Braun-Blanquet method (Dierschke, 1994) and 750 floristic lists. Species cover was determined using the Londo scale (Dierschke, 1994), changed during statistical analysis to the quantitative scale (abundance) of the Braun-Blanquet method, which was modified by Barkman *et al.* (1964; 2m, 2a, 2b). Parameters of synthetic proportions of species and species groups were computed according to the procedure proposed by Pawłowski (1966). To determine the endangerment of species, all available floristic and phytosociological data regarding Tatra Mts



Fig. 1. Mossy plant groups in the snowbeds of Tatra Mountains: 1 – small-crumb communities or earthy covering slopes filling hollows or flat sections in the alpine belt (1a – *Polytrichetum sexangulare*, 1b – *Pohlietum drummondii* *gymnomitriosum brevissimae*, 1c – *Polytrichetum sexangulare fuscocephaloziopsietosum albescentis*), 2 – snowbed communities of rock blocks (*Marsupelletum condensatae*), 3 – subalpine-alpine earthy snowbeds dominated by liverworts, with significant proportions of vascular plants (*Moerckietum blyttii*), 4 – mossy epilyptic snowbeds on rock slopes (*Andreaeetum nivalis anhelietosum juratzkanae*).

I – Slovakia, Western Tatra Mts, upper part of Račková dolina valley (Račkov Zadok), glacial cirque below Mt Jakubíná, 1835 m a.s.l., II – Slovakia, High Tatra Mts, Žabia Bielovodská dolina valley, above S shore of Vyšné Žabie Bielovodské pleso lake, rock walls descending from Mt Veľký Žabi štít, 1800 m a.s.l., III – Slovakia, High Tatra Mts, Piagová dolina valley, 1860 m a.s.l., IV – Slovakia, High Tatra Mts, upper part of Kačacia dolina valley, glacial cirque below Mt Zadný Gerlach, 1925 m a.s.l. (Phot. P. Górski).

liverworts, published during 1814-2014, were taken into consideration, starting from the first report of Wahlenberg (1814). This way, a pool of 18513 records was collected. The degree of threat to the analysed species throughout the Tatra Mts was determined with the use of categories and criteria of the IUCN (IUCN 2012). The nomenclature of the species follows that of Górski & Váňa (2014) for liverworts and Ochrya *et al.* (2003) for mosses. Some of the syntaxa names in the range of associations and subassociations are new and original depictions of the author. Their formal descriptions are presented in another paper regarding bryophyte vegetation of the Tatra Mts snowbeds (Górski, 2015). For each locality of snowbed species, grid square (in bold face) are as defined in the UTM/MGRS cartographic system (1km × 1km).

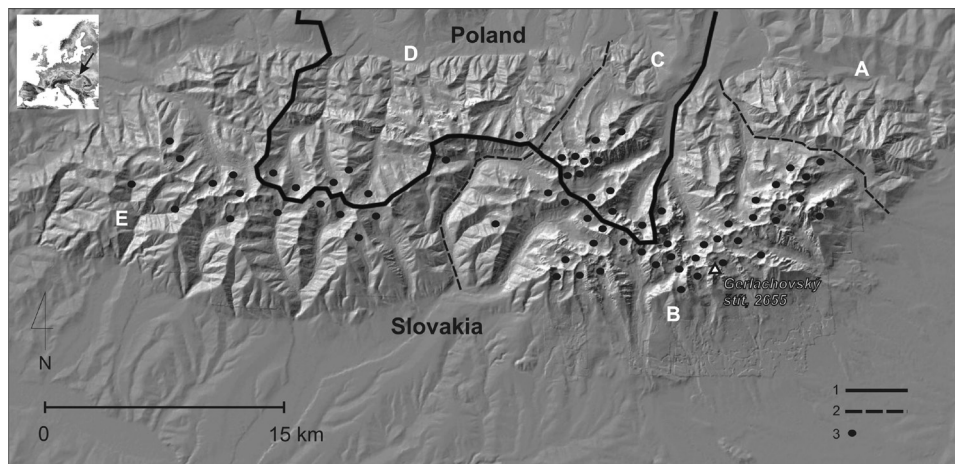


Fig. 2. Location of study area: A – Belianske Tatra Mts (Belanské Tatry), B – High Tatra Mts, Slovak part (Vysoké Tatry), C – High Tatra Mts, Polish part (Tatry Wysokie), D – Western Tatra Mts, Polish part (Tatry Zachodnie), E – Western Tatra Mts, Slovak part (Západné Tatry): 1 – state border, 2 – borders of the various parts of the Tatra Mts, 3 – glacial cirques in which geobotanical documentation was collected (due to the legibility of the map, one dot was made in a high mountain valley, even though studies within its limits included numerous stations: suspended valleys, gullies, basins, and rocky blocks surrounded with lakes).

CHARACTERISTICS OF THE STUDY AREA

The Tatra Mts are the highest mountain ridge in the Carpathians. They are a part of the Central Western Carpathians. The Tatra Mts ridge is 80 km long (56.5 km in a straight line) and the maximum width is 18.5 km (15 km on average). The Tatra Mts are a border ridge separating Poland and Slovakia. The area covers 785 km², including 610 km² (77.7%) in Slovakia and 175 km² (22.3%) in Poland (Radwańska-Paryska & Paryski, 2004). The massif is divided into the Belianske Tatra Mts, the Western Tatra Mts and the High Tatra Mts (Fig. 2).

The Belianske Tatra Mts are located entirely in Slovakia. They cover an area of 67.5 km² and their ridge is *ca* 13 km long. They consist entirely of sedimentary rocks, mostly limestone, marl and dolomite.

The High Tatra Mts cover an area of 335 km². They are the highest mountain range with Mt Gerlachovský štít (Gerlach, 2655 m a.s.l., Slovakia) the highest peak in the Carpathians. On the Polish side, in the borderline ridge, the highest peak of Poland is Mt Rysy (2499 m a.s.l.). The major part of the High Tatra Mts, 253 km², is located in Slovakia (Nyka, 2000). The length of the ridge is 16.5 km (Radwańska-Paryska & Paryski, 2004). The High Tatra Mts are built mostly of a crystalline core of granitoid with little sedimentary rock.

The Western Tatra Mts (*ca* 382.5 km²) occupy almost half of the entire area of the Tatra Mts and most of them, 292 km², are located in Slovakia (Nyka, 2000). The length of the main ridge is *ca* 42 km. Metamorphic (mostly gneissic rock and crystalline slates) and sedimentary rock predominate and the contribution of magma rock (granite) is low.

RESULTS AND DISCUSSION

Characteristics of liverwort flora of Tatra Mts snowbeds

In the investigated localities, 38 liverwort species were recorded (Tables 1 and 4). The most frequent were *Pseudolophozia sudetica*, *Anthelia juratzkana*, and *Fuscocephaloziopsis albescens*. These plants also had the highest cover values in snowbed phytocoenoses (Table 1). In general, *F. albescens* showed the highest quantitative proportion in the Tatra Mts snowbeds. Four groups of species with distinct degrees of habitat preference can be distinguished in the snowbed flora. The first is composed of species exclusive to snowbeds: *Marsupella apiculata*, *M. condensata*, and *Nardia breidlerii*. The second is composed of species that exhibit optimum of growth in snowbeds but are also noted to exist, albeit in lower amounts, in other mountain communities. They can be described as typical for snowbeds. This group includes *Anthelia juratzkana*, *Fuscocephaloziopsis albescens*, *Gymnomitrium adustum*, *G. brevissimum*, *Marsupella boeckii*, *Schistochilopsis opacifolia*, *Moerckia blyttii*, and *Nardia scalaris* (in the alpine belt). The third group is composed of species that are frequently found in snowbeds as well as in other alpine communities, including *Cephalozia bicuspidata*, *Diplophyllum taxifolium*, *Gymnomitrium concinnum*, *Lophozia wenzelii*, *Marsupella emarginata*, *Pseudolophozia sudetica*, and *Trilophozia quinqueidentata*. The final group is composed of liverworts occasionally recorded in snowbeds, whose optimum occurrence exists in other habitats (e.g., *Marsupella sphacelata*, *Gymnocolea inflata*, *Pellia neesiana*, and others [Table 4]).

Several groups of liverworts can be specified depending on the location of snowbeds in the mountainous landscape. Species specific to snowbeds of rock blocks that fill the bottoms of glacial cirques (group 2, see Materials and methods and Fig. 1, III) include *Marsupella condensata*, *Fuscocephaloziopsis albescens*, *Marsupella boeckii*, and *Gymnomitrium concinnum*. The plant formations cover a small area, mostly in hollows (i.e., pits or holes) of rock blocks, in half-shadowy or shadowy conditions. It is worth noting that such bryophyte snowbed formations have been completely unnoticed thus far. This can be confirmed, for example, by sparse literature data on the localities of *Marsupella condensata* that grows only in this group of snowbeds. Until 1979, only five localities of this plant had been reported for the entire Tatra Mts (Szepesfalvy, 1926; Szweykowski, 1956a, b, 1960; Duda & Váňa, 1979). As a result of recent studies carried out in rock-block areas, 78 new localities were found.

Another distinct group is made of communities of lower parts of rock walls, next to covering slopes (Group 4, Fig. 1, II). A rich complex of communities has originated due to the humidity of the habitats (mostly due to dripping water on the rock) and mineral compounds bound by small turfs of bryophytes. Species of this group include typical epiphytes (i.e., *Marsupella boeckii*, *Gymnomitrium adustum*, *G. concinnum*, and *Diplophyllum taxifolium*) as well as liverworts passing from humid habitats (*Marsupella emarginata*, *M. sphacelata*, *Schistochilopsis opacifolia*, and *Solenostoma obovatum*).

The most numerous group of liverworts grows in small-crumb and earthy covering slopes (Group 1, Fig. 1, I, II, Table 3). This group is associated with high variability of habitat conditions and the expansion of these snowbeds in the Tatra Mts. Relatively few species are exclusive to this group; only *Nardia breidlerii* and *Gymnomitrium brevissimum* can be mentioned (Table 1).

Table 1. The proportion of liverworts and selected mosses in snowbeds of the Tatra Mountains

	Group_1		Group_2		Group_4		Group_3		All		
Number of relevés	159		99		69		28		355		
Total number of species in the table	93		58		73		79		140		
Average number of species in the relevé	8		8		8		12		8		
Average moss layer cover [%]	80		81		81		78		80		
Average herb layer cover [%]	6		1		3		41		7		
Liverworts											
<i>Pseudolophozia sudetica</i>	74	694	93	1738	88	1013	79	852	83	1060	
<i>Fuscocephaloziopsis albescens</i>	43	976	64	2071	33	451	46	248	47	1122	
<i>Anthelia juratzkana</i>	53	878	52	689	62	1150	11	136	51	820	
<i>Nardia scalaris</i>	23	565	4	162	30	783	64	1163	22	542	
<i>Cephalozia bicuspidata</i>	8	142	32	356	26	124	54	895	22	259	
<i>Lophozia wenzelli</i>	11	87	31	119	10	23	18	56	17	81	
<i>Solenostoma sphaerocarpum</i>	7	71	3	5	35	468	7	1	11	126	
<i>Marsupella funckii</i>	1	0	4	15	7	30	4	0	3	13	
<i>Gymnomitrium brevissimum</i>	19	430	3	10	1	7			10	198	
<i>Nardia breidlerii</i>	6	302							3	135	
<i>Marsupella apiculata</i>	1	40							1	18	
<i>Marsupella condensata</i>	1	36	55	1623	1	1			16	469	
<i>Marsupella boeckii</i>	4	50	26	209	14	51			12	91	
<i>Gymnomitrium concinnum</i>	3	0	31	154	30	307			16	104	
<i>Trilophozia quinqueidentata</i>			8	68	1	54			3	30	
<i>Cephaloziella divaricata</i>	2	22	2	38					1	20	
<i>Cephaloziella varians</i>			1	38					0	11	
<i>Marsupella emarginata</i>	1	0			36	1331			8	259	
<i>Schistochilopsis opacifolia</i>	9	48	2	0	16	175	7	89	8	63	
<i>Diplophyllum taxifolium</i>	4	10	7	26	17	46	4	0	8	21	
<i>Gymnomitrium adustum</i>	1	0	3	6	9	59			3	14	
<i>Marsupella sphacelata</i>	1	6			7	214	4	2	2	45	
<i>Solenostoma obovatum</i>					7	114					
<i>Moerckia blyttii</i>			1	88	1	91	71	4759	6	418	
<i>Orthocaulis floerkei</i>	7	256			1	1	29	511	6	155	
<i>Pellia neesiana</i>							11	491	1	39	
<i>Gymnocolea inflata</i>	2	28	3	73			4	0	2	33	
<i>Scapania subalpina</i>	1	6	2	5	4	91			2	22	
<i>Scapania helvetica</i>	1	0			1	0	4	0	1	0	
<i>Marsupella sprucei</i>	1	0	1	0					1	0	
<i>Scapania parvifolia</i>	1	0	2	0					1	0	
<i>Bazzania tricenata</i>	1	0							0	0	
<i>Barbilophozia hatcheri</i>			1	0					0	0	
<i>Jungermannia pumila</i>					1	14			0	3	
<i>Scapania umbrosa</i>					1	0			0	0	
<i>Scapania undulata</i>					1	0			0	0	
<i>Harpanthus flotovianus</i>							4	18	0	1	
<i>Calypogeia azurea</i>							4	0	0	0	
Selected mosses											
<i>Polytrichastrum sexangulare</i>	75	1966	43	262	43	187	54	843	59	1056	
<i>Kiaeria starkei</i>	48	782	68	538	55	613	50	356	55	647	
<i>Pohlia drummondii</i>	46	876	53	859	16	96	4	223	39	669	
<i>Pohlia ludwigii</i>	30	1328	6	165	29	653	11	55	21	773	
<i>Bucklandiella sudetica</i>	16	40	9	21	42	378	4	18	18	99	
<i>Andreaea nivalis</i>	10	21	3	0	42	1216	4	2	14	247	
<i>Kiaeria falcata</i>	28	327	8	54	1	0			15	164	
<i>Pohlia nutans</i>	3	25	46	710			7	18	15	211	

Group 1-4: see Material and methods, All – all analyzed relevés made in snowbeds; for each species are given percentage representation in floristic list (in bold) and cover coefficient.

Table 2. Typological units of the bryophyte snowbed vegetation described from the Tatra Mountains

Group of snowbeds	Phytosociological groups	
	class	associations and communities
Group 1	Sh	<i>Pohlietum drummondii</i> gymnomitrietosum brevissimae, <i>P. d. typicum</i>
	Sh	<i>Polytrichetum sexangularis</i> typicum, <i>P.s. fuscocephaloziopsietosum albescentis</i> , <i>P.s. polytrichetosum piliferi</i>
	Sh	<i>Pohlietum ludwigii</i> typicum, <i>P. l. polytrichastretosum sexangularis</i> , <i>P. l. oligotrichetosum hercynici</i>
	Sh	Community with <i>Nardia breidleri</i> (<i>Polytrichion norvegici</i>)
	Sh	Community with <i>Marsupella apiculata</i> (<i>Polytrichion norvegici</i>)
	P-Dh	<i>Nardietum scalaris</i> kiaerietosum starkei
	Sh	<i>Luzuletum spadiceae</i> orthocauletosum floerkei
Group 2	Sh	<i>Marsupelletum condensatae</i>
	Sh	<i>Pohlio nutantis</i> - <i>Fuscocephaloziopsietum albescentis</i>
	Sh	<i>Pohlietum commutatae</i> fuscocephaloziopsietosum albescentis
Group 3	Sh	<i>Moerckietum blyttii</i> typicum, <i>M. b. polytrichastretosum sexangularis</i>
	Sh	<i>Luzuletum spadiceae</i> pelletosum neesianae
Group 4	Ga	<i>Andreaetum nivalis</i> anthelietosum juratzkanae
	Ga	<i>Bucklandiello sudetici</i> - <i>Marsupelletum emarginatae</i>
	Ga	<i>Gymnomitrietum concinnati</i> anthelietosum juratzkanae
	P-Dh	<i>Nardietum scalaris</i> kiaerietosum starkei

Group of snowbeds: see Material and methods.

Ga – *Grimmieta alpestris* Hadač et Vondráček in Ježek et Vondráček 1962, P-Dh – *Pogonato-Dicranelletea heteromallae* v. Hübschmann 1975, Sh – *Salicetea herbaceae* Br.-Bl. in Br.-Bl. et Jenny 1926.

The last group of snowbeds, also found growing on covering slopes, was distinguished due to high proportions of vascular plants (Group 3, Fig. 1, IV). The dominant species of these phytocoenoses are thallus liverworts (i.e., *Moerckia blyttii* and *Pellia neesiana*). *Cephalozia bicuspidata*, *Nardia scalaris*, and *Orthocaulis floerkei* also are highly present compared to other groups of snowbeds.

Among species occurring in the Tatra Mts snowbeds, the largest group (13 of 38; 34%) is the arctic (subarctic)-alpine plants. It is worth noting that when considering all liverworts of that group growing in the Tatra Mts in acidic habitats, the snowbed ones make up 45% of the pool. Their participation in plant cover of mossy snowbeds reached 30% in the investigated plant patches. The highest abundance of arctic (subarctic)-alpine species, accounting for 50% of the cover, can be observed in snowbeds of rock blocks. Another numerous group is the boreal-mountain liverworts (10 of 38; 26%). Their abundance in the phytocoenose cover, however, is markedly lower (18%).

Phytosociological identifiers of groups of mossy Tatra Mts snowbeds

The most phytocoenotically diverse group of snowbeds consists of small-crumb or earthy covering slopes that fill hollow or flat sections in the alpine belt (Group 1). They mostly consist of plant formations dominated by one moss species (i.e., *Pohlia drummondii*, *P. ludwigii*, or *Polytrichastrum sexangulare*).

Table 3. Participation of species groups in the types of mossy Tatra Mts snowbeds

Group of snowbeds		1	2	4	3
Number of relevés		159	99	69	28
Liverworts	a	26	23	25	17
	b	29	40	35	22
	c	37	56	55	56
	d	28	45	45	30
Mosses	a	29	21	25	24
	b	33	37	35	31
	c	59	44	43	17
	d	48	51	46	27
Vascular plants	a	34	13	21	36
	b	38	23	30	47
	c	5	0	2	28
	d	24	4	9	43

Participation measures: a – number of species, b – percentage representation in floristic list, c – percentage proportion of plant cover, d – collective participation of the group.

Group of snowbeds (1-4) see Material and methods.

The range of variability of their habitats with respect to humidity, soil granulation, and exposure is wide. This results in marked diversity of typological units within particular units. Mosses dominate the plant cover of the communities (59% of the cover, 37% liverworts, comp. Table 3). High participation of liverworts was also noted in *Pohlietum drummondii gymnomitrietosum brevissimae*, *Polytrichetum sexangularis fuscocephaloziopsietosum albescens*, and a community with *Nardia breidleri* and *Nardietum scalaris kiaerietosum starkei*. The group of rock-block snowbeds (2) consists of phytocoenoses dominated by liverworts (*i.e.*, *Marsupella condensata* and *Fuscocephaloziopsis albescens*). Liverworts contribute to higher amounts of plant cover and floristic composition than mosses (Table 3). The habitats are less diverse, which results in a poorer complex of plant communities. Compared to the first group of snowbeds, vascular plants are absent (or exist in insignificant proportions) in mossy communities of rock blocks. Snowbeds of lower parts of rock slopes feature greater variability of habitats. The diversity of communities of this group is determined by humidity of the patches, which results from water dripping down the rocks and the level of development of soil layers. The latter factor depends on the presence of ledges (rock shelves), where soil can collect. The soil presence determines the development of phytocoenoses, such as *Andreaeetum nivalis anthelietosum juratzkanae* or *Nardietum scalaris kiaerietosum starkei*. *Bucklandiello sudetici-Marsupelletum emarginatae*, on the other hand, is a typical epilytic community growing on nearly even rock surfaces. Liverworts dominate the cover of phytocoenoses of rock-block snowbeds. The last group of snowbeds (3) is composed of phytocoenoses with high proportions of liverworts (up to 30% of cover, on average) but also high proportions of vascular plants (43%, comp. Table 3). This group includes patches of *Moerckietum blyttii* and *Luzuletum spadiceae pelletosum neesianae*.

Table 4. List of liverworts occurring in snowbeds of the Tatra Mountains and its threats

	<i>H</i>	<i>N</i>	<i>Red lists</i>		<i>Threats</i>
			<i>PL</i> ¹	<i>SL</i> ²	<i>Tatra Mts</i> ³
I. Exclusive snowbed species					
<i>Marsupella apiculata</i>	5	1	R	CR	CR (<i>B2a</i>)
<i>Marsupella condensata</i>	5	78	R	CR	LC
<i>Nardia breidlerii</i>	7	4		EN	EN (<i>B2a</i>)
II. Typical snowbed species					
<i>Anthelia juratzkana</i>	351	258		VU	LC
<i>Fuscocephaloziosis albens</i>	239	199		DD	LC
<i>Gymnomitrium adustum</i>	–	27	I	EN	VU (<i>D2</i>)
<i>Gymnomitrium brevissimum</i>	121	68		EN	LC
<i>Marsupella boeckii</i>	13	104	R	CR	LC
<i>Moerckia blyttii</i>	23	36		EN	NT
<i>Nardia scalaris</i>	403	129			LC
<i>Schistochilopsis opacifolia</i>	59	34		EN	LC
III. Liverworts frequently found in snowbeds as well as in other alpine communities					
<i>Cephalozia bicuspidata</i>	213	235			LC
<i>Diplophyllum taxifolium</i>	291	51			LC
<i>Gymnomitrium concinnum</i>	422	105			LC
<i>Lophozia wenzelii</i>	120	75		NT	LC
<i>Marsupella emarginata</i>	143	84	V		LC
<i>Pseudolophozia sudetica</i>	735	337			LC
<i>Trilophozia quinquedentata</i>	286	38			LC
IV. Liverworts occasionally recorded in snowbeds					
<i>Barbilophozia hatcheri</i>	274	13			LC
<i>Bazzania tricenata</i>	362	14			LC
<i>Calypogeia azurea</i>	167	5			LC
<i>Cephaloziella divaricata</i>	21	12			LC
<i>Cephaloziella varians</i>	2	2		EX	CR (<i>B2a</i>)
<i>Gymnocolea inflata</i>	137	34		VU	LC
<i>Harpanthus flotovianus</i>	37	7		EN	NT
<i>Jungermannia pumila</i>	40	5		VU	LC
<i>Marsupella funckii</i>	130	59			LC
<i>Marsupella sphacelata</i>	132	36		NT	LC
<i>Marsupella sprucei</i>	60	37		NT	LC
<i>Orthocaulis floerkei</i>	233	26			LC
<i>Pellia neesiana</i>	53	16			LC
<i>Scapania helvetica</i>	117	21		VU	LC
<i>Scapania parvifolia</i>	49	12		VU	LC
<i>Scapania subalpina</i>	89	43			LC
<i>Scapania umbrosa</i>	57	17			LC
<i>Scapania undulata</i>	379	22			LC
<i>Solenostoma obovatum</i>	113	18			LC
<i>Solenostoma sphaerocarpum</i>	323	58			LC

Explanation: H – number of historical localities documented during 1814-2014, N – number of new localities documented by P. Górski during 2002-2014, 1 – Red list of liverworts and hornworts in Poland (Klama 2006): 1 – indeterminate, R – rare, V – vulnerable; 2 – Updated checklist of liverworts, hornworts and mosses of Slovakia (Kubinská *et al.*, 2001, IUCN (2001, version 3.1); 3 – threats in the Tatra Mts (orig.), according to IUCN (2012, version 3.1, second edition): CR – critically endangered, EN – endangered, LC – least concern, NT – near threatened, VU – vulnerable; for *B2a* see criteria in IUCN (2012).

Endangerment of liverworts occurring in snowbeds of the Tatra Mts

Among 38 species growing in the investigated habitats, four can be considered threatened and two nearly threatened. The rarest species in snowbeds is *Marsupella apiculata*, found during the study period (2012-2014) in one locality only (Górski & Váňa, 2014). Its endangerment should be graded as CR (critically endangered). This plant previously was reported only from 10 localities in the High Tatra Mts (Szepesfalvy, 1926; Szweykowski, 1957, 1958, 1960; Szweykowski & Koźlicka, 1977; Duda & Váňa, 1980; Balcerkiewicz, 1984). The data from Slovakia (four localities) presented by Krajina (1933) are definitely not valid (Váňa & Duda, 1965; Duda & Váňa, 1980). *Marsupella apiculata* mostly has been misidentified as *Gymnomitrium concinatum* or *G. corallioides*. Revision of herbarium materials from the Slovakian part of the High Tatra Mts has shown that *M. apiculata* grows in four historical localities there found during 1912-1940 (rev. J. Váňa; Duda & Váňa, 1980). Altogether, taking into account valid data from the Polish High Tatra Mts, *M. apiculata* grows in six localities documented with herbarium specimens. Another CR species is *Cephaloziella varians*. There is not enough data to consider this species a snowbed plant. During 2002-2012, it was found and collected twice, including one locality in a snowbed in a rock-block area (Górski & Váňa, 2014). The second locality and historical data from the Tatra Mts (Duda & Váňa, 1974; Klama in Ellis *et al.*, 2011) come from habitats with dripping water.

The level of endangerment of *Nardia breidlerii* can be defined as EN (endangered), although specificity of the occurrence of this plant is closer to the CR criteria. Compared to *M. apiculata*, *N. breidlerii* is found in most historical localities and currently grows in more localities (Górski & Váňa, 2014). It occurs most abundantly in the Kotlina Piatich Spišských Plies valley (High Tatra Mts, Slovakia; Górski & Váňa, l.c.).

It should be emphasised that liverworts previously considered endangered (i.e., *Marsupella condensata*, *M. boeckii*, *Gymnomitrium brevissimum*, *Schistochilopsis opacifolia*, and *Anthelia juratzkana*) currently do not meet criteria of being red-listed. The most noticeable changes (from CR to LC) concern *Marsupella condensata* and *M. boeckii* (Table 4).

List of new localities

***Marsupella boeckii* (Austin) Lindb. ex Kaal.**

POLAND, HIGH TATRA MOUNTAINS: **34UDV2752:** Dolina Gašienicowa valley, glacial cirque below Mt Świnica, blocks of rock SW from Zadni Staw Gašienicowy lake, 49.22307°N, 20.00715°E, alt. 1883 m, *leg.* P. Górski, 20.09.2010 (POZNB 248); **34UDV2851:** Dolina Pięciu Stawów Polskich valley, blocks of rock below Mt Gładki Wierch, alt. 1860 m, *leg.* P. Górski, 27.07.2005 (POZNB 13); **34UDV2852:** Dolina Gašienicowa valley, below and N from Zmarzły Staw lake, rocky wall near route, 49.2248°N, 20.02197°E, alt. 1845 m, *leg.* P. Górski, 31.08.2011 (POZNB 472); Dolina Gašienicowa valley, at the mouth of Zawratowy Żleb gully, alt. 1955 m, *leg.* P. Górski, 1.08.2003 (POZNB 106/2003); Dolina Gašienicowa valley, below Zawrat pass, on stone near route, 49.22152°N, 20.01895°E, alt. 1910 m, *leg.* P. Górski, 8.08.2012 (POZNB 1308); Dolina Gašienicowa valley, blocks of rock above Zmarzły Staw lake, alt. 1855 m, *leg.* P. Górski, 21.08.2005 (POZNB 29/2005); **34UDV2950:** Dolina Pięciu Stawów Polskich valley, below rocky walls descending from Mt Wyżni Liptowski Kostur, alt. 2005 m, *leg.* P. Górski, 25.07.2005 (POZNB 3/2005); **34UDV2952:** Dolinka Kozia valley, blocks of rock at the bottom of the valley, 49.222°N, 20.02657°E, alt. 1960 m, *leg.* P. Górski, 31.08.2011 (POZNB 470); **34UDV3049:** Dolina za Mnichem valley,

blocks of rock below Mt Zadni Mnich, 49.19107°N, 20.04788°E, alt. 1980 m, *leg.* P. Górski, 28.08.2012 (POZNB 1500); Dolina za Mnichem valley, W slope of Mt Mnich, 49.19387°N, 20.05278°E, alt. 1885 m, *leg.* P. Górski, 28.08.2012 (POZNB 1574); Dolina za Mnichem valley, alt. 1790 m, *leg.* P. Górski, 27.09.2007 (POZNB 37/2007); **34UDV3052**: Dolinka Buczynowa valley, blocks of rock at the bottom of the valley, alt. 1795 m, *leg.* P. Górski, 22.09.2005 (POZNB 34/2005); **34UDV3248**: below Mt Kazalnica, rocky wall dripping with water, near route to Mięguszwiecka Przełęcz pod Chłopkiem pass, 49.18645°N, 20.06803°E, alt. 1975 m, *leg.* P. Górski, 2.09.2014 (POZNB 1914).

SLOVAKIA, HIGH TATRA MOUNTAINS: 34UDV2650: Zadna Tichá dolina valley, alt. 1770 m, *leg.* P. Górski, 29.07.2009 (POZNB 25/2009); Zadná Tichá dolina valley, blocks of rock in glacial cirque below Mt Tichý vrch, alt. 1785 m, *leg.* P. Górski, 29.07.2009 (POZNB 54, 65); **34UDV2745**: Važecká dolina valley, blocks of rock N from N shore of Krivánske Zelené pleso lake, 49.16192°N, 20.00682°E, alt. 2020 m, *leg.* P. Górski, 11.08.2010 (POZNB 593); Važecká dolina valley, blocks of rock near SW shore of Krivánske Zelené pleso lake, 49.15792°N, 20.00877°E, alt. 2000 m, *leg.* P. Górski, 11.08.2010 (POZNB 204, 21/2010); Važecká dolina valley, blocks of rock near W shore of Krivánske Zelené pleso lake, 49.15952°N, 20.00887°E, alt. 2005 m, *leg.* P. Górski, 11.08.2010 (POZNB 227); Važecká dolina valley, Jamski Kotol, blocks of rock, 49.15517°N, 20.00867°E, alt. 1930 m, *leg.* P. Górski, 11.08.2010 (POZNB 181); **34UDV2746**: Nefcerka valley, blocks of rock below Nižné Terianske pleso lake, alt. 1940 m, *leg.* P. Górski, 2.08.2012 (POZNB 1298); **34UDV2750**: Kobyliá dolina valley, blocks of rock in SW part of the valley, alt. 1790 m, *leg.* P. Górski, 29.07.2009 (POZNB 64); **34UDV2846**: Nefcerka valley, on stone above E shore of Nižné Terianske pleso lake, 49.1688°N, 20.01477°E, alt. 1947 m, *leg.* P. Górski, 2.08.2011 (POZNB 574); **34UDV2945**: Furkotská dolina valley, below rock wall descending from Mt Štrbské Solisko, 49.15538°N, 20.0302°E, alt. 1945 m, *leg.* P. Górski, 31.07.2012 (POZNB 1329); **34UDV2945**: Mlynická dolina valley, blocks of rock below Mt Malé Solisko, alt. 1945 m, 2015 m, *leg.* P. Górski, 15.08.2008 (POZNB 33/2008, 105); **34UDV2946**: Furkotská dolina valley, blocks of rock near SE shore of Vyšné Wahlenbergovo pleso lake, alt. 2125 m, 2130 m, *leg.* P. Górski, 8.08.2008 (POZNB 86, 13/2008, 14/2008); Mlynická dolina valley, blocks of rock above Okružle pleso lake, below Mt Furkotský štít, alt. 2135 m, *leg.* P. Górski, 10.08.2008 (POZNB 19/2008); Mlynická dolina valley, blocks of rock below Bystrá lávka pass, alt. 2170 m, *leg.* P. Górski, 10.08.2008 (POZNB 50); Mlynická dolina valley, N slope of Bystrá lávka pass, alt. 2245 m, 2285 m, *leg.* P. Górski, 10.08.2008 (POZNB 114, 17/2008); Mlynická dolina valley, near Capie pleso lake, blocks of rock near route, alt. 2070 m, *leg.* P. Górski, 10.08.2008 (POZNB 46); Mlynická dolina valley, below Bystrá lávka pass, rocky cracks with northern exposure, 49.1671°N, 20.02937°E, alt. 2230 m, *leg.* P. Górski, 12.08.2011 (POZNB 663); **34UDV3046**: Mlynická dolina valley, blocks of rock in upper (NE) part of the valley, below rocky walls descending from Mt Veľká Capia veža, alt. 2100 m, *leg.* P. Górski, 11.08.2008 (POZNB 25/2008); **34UDV3048**: Piargová dolinka valley, glacial cirque below Mt Cubrina, 49.18705°N, 20.04422°E, 49.18757°N, 20.0453°E, alt. 1870 m, 1875 m, *leg.* P. Górski, 22.07.2008 (POZNB 7/2008, 12/2008); **34UDV3346**: Drača dolinka valley, blocks of rock above Drače pleso lake, upper part of the valley, 49.16772°N, 20.0865°E, alt. 2125 m, *leg.* P. Górski, 5.08.2010 (POZNB 173, 14/2010); Drača dolinka valley, blocks of rock S from Drače pleso lake, 49.16477°N, 20.09128°E, alt. 2035 m, *leg.* P. Górski, 5.08.2010 (POZNB 213); **34UDV3347**: Žabia Mengusovská dolina valley, Kotlinka pod Vahou basin, alt. 2095 m, *leg.* P. Górski, 13.08.2008 (POZNB 59); **34UDV3349**: Žabia Bielovodská dolina valley, above SE shore of Vyšné Žabie Bielovodské pleso lake, alt. 1710 m, *leg.* P. Górski, 15.08.2009 (POZNB 89); Žabia Bielovodská dolina valley, blocks of rock above S shore of Vyšné Žabie Bielovodské pleso lake, below Mt Veľký Žabi štít, 49.1912°N, 20.09187°E, alt. 1700 m, 1705 m, 1710 m, 1720 m, 1730 m, *leg.* P. Górski, 15.08.2009, 19.09.2009 (POZNB 52, 314, 704, 37/2009, 38/2009, 39/2009, 79/2009); Žabia Bielovodská dolina valley, near SE shore of Vyšné Žabie Bielovodské pleso lake, alt. 1710 m, *leg.* P. Górski, 19.09.2009 (POZNB 140); **34UDV3350**: Žabia Bielovodská dolina valley, blocks of rock near W shore of Nižné Žabie Bielovodské pleso lake, 49.19918°N, 20.09247°E, alt. 1680 m, *leg.* P. Górski, 14.08.2009 (POZNB 88); **34UDV3445**: Zlomisková dolina valley, Kotlina Ľodového plesa basin, rocky wall above S shore of Ľodové pleso lake,

below Lúčne sedlo pass, 49.16193°N, 20.10615°E, alt. 1975 m, *leg.* P. Górski, 5.08.2010 (POZNB 228); **34UDV3446:** Rumanova dolinka valley, blocks of rock near Vyšné Rumanovo pliesko lake, 49.17212°N, 20.10102°E, alt. 2135 m, *leg.* P. Górski, 9.08.2011 (POZNB 573); Rumanova dolinka valley, near E shore of Vyšné Rumanovo pliesko lake, 49.1719°N, 20.1008°E, alt. 2125 m, *leg.* P. Górski, 3.08.2010 (POZNB 9/2010); **34UDV3447:** Ťažká dolina valley, near E shore of Zmarzlé pleso lake, below rocky wall descending from Mt Prédna Pustá veža, alt. 1765 m, *leg.* P. Górski, 20.08.2009 (POZNB 59/2009); Ťažká dolina valley, near SE shore of Ťažké pleso lake, alt. 1680 m, *leg.* P. Górski, 26.08.2009 (POZNB 110); Ťažká dolina valley, upper kettle of the valley, blocks of rock, debris slope between Mt Ganek and Mt Vysoká, 49.1755°N, 20.09785°N, alt. 1980 m, *leg.* P. Górski, 20.08.2009 (POZNB 111); **34UDV3544:** Štôlska dolina valley, blocks of rock in lower part of the valley, slightly above Tatranská magistrála, 49.14893°N, 20.11088°E, alt. 1935 m, *leg.* P. Górski, 10.08.2010 (POZNB 175, 202); **34UDV3545:** SW slope of Mt Končistá, 49.15617°N, 20.11413°E, alt. 2475 m, *leg.* P. Górski, 28.08.2014 (POZNB 1872); **34UDV3546:** Kačacia dolina valley, upper glacial cirque in the valley (Želazny Ogród), blocks of rock below Východná Železná brána pass, alt. 2015 m, *leg.* P. Górski, 16.09.2009 (POZNB 144); **34UDV3547:** Kačacia dolina valley, rocky wall descending from Mt Ganek, alt. 1665 m, *leg.* P. Górski, 22.08.2007 (POZNB 3/2007); **34UDV3645:** below Mt Gerlachovská veža, 49.16317°N, 20.13428°E, alt. 2590 m, *leg.* P. Górski, 7.08.2013 (POZNB 1627, 1628); **34UDV3647:** Litvorová dolina valley, above Litvorové pleso lake, alt. 1895 m, *leg.* P. Górski, 15.09.2009 (POZNB 107); Litvorová dolina valley, glacial cirque below Mt Litvorový štít, alt. 1860 m, *leg.* P. Górski, 17.08.2006 (POZNB 37/2006); Litvorová dolina valley, near S shore of Litvorové pleso lake, 49.17643°N, 20.12872°E, alt. 1860 m, *leg.* P. Górski, 16.09.2009 (POZNB 142); Litvorová dolina valley, rocky outcrops E from Litvorové pleso lake, alt. 1940 m, *leg.* P. Górski, 17.08.2006 (POZNB 34/2006, 35/2006); **34UDV3747:** Svišťová (Bielovodská) dolina valley, Zmarznutý kotol basin, rocky wall below Polský hrebeň pass, 49.17487°N, 20.13838°E, alt. 2060 m, *leg.* P. Górski, 9.08.2012 (POZNB 1159); Svišťová (Bielovodská) dolina valley, blocks of rock in Zmarznutý kotol basin, 49.17915°N, 20.13968°N, alt. 2025 m, *leg.* P. Górski, 26.09.2011 (POZNB 485); **34UDV3748:** Rovienky valley, Zadné Rovienky, glacial cirque below Mt Svišťový štít, 49.18795°N, 20.14728°E, alt. 1775 m, *leg.* P. Górski, 25.09.2011 (POZNB 504); **34UDV3946:** Veľka Studená dolina valley, Dolinka nad Vareškovým Plesom valley, blocks of rock at the bottom of the valley, alt. 1850 m, 1865 m, *leg.* P. Górski, 23.08.2007 (POZNB 9, 10/2007); **34UDV3947:** Veľka Studená dolina valley, blocks of rock W from Zbojnícka chata hut, alt. 1935 m, *leg.* P. Górski, 24.08.2007 (POZNB 8); Veľka Studená dolina valley, rocky wall dripping with water between Dlhé pleso lake and Vareškové pleso lake, alt. 1815 m, *leg.* P. Górski, 23.08.2007 (POZNB 15/2007); **34UDV3949:** Zadná Javorová dolina valley, glacial cirque below Ostrý štít-Javorový štít ridge, alt. 2085 m, *leg.* P. Górski, 16.08.2006 (POZNB 32/2006); **34UDV4048:** Malá Studená dolina valley, Dolina pod Sedielkom valley, below rock walls descending from Priečne Sedlo pass, alt. 2065 m, *leg.* P. Górski, 21.08.2007 (POZNB 2/2007); **34UDV4049:** Zadná Javorová dolina valley, glacial cirque below Mt Ostrý štít, alt. 2125 m 2210 m, *leg.* P. Górski, 16.08.2006 (POZNB 29/2006, 31/2006); **34UDV4051:** Čierna Javorová dolina valley, Čierna záhrada, blocks of rock in the upper part of the valley, near Czarna Siklawa stream, 49.21018°N, 20.17982°E, alt. 1635 m, *leg.* P. Górski, 25.08.2010 (POZNB 165); Čierna Javorová dolina, Čierne mlaki, slabs of rock dripping with water, 49.20945°N, 20.1887°E, alt. 1910 m, *leg.* P. Górski, 26.08.2010 (POZNB 170); **34UDV4148:** Malá Studená dolina valley, sub-glacially eroded step of the Kotlina Piatich Spišských Plies, slabs of rock dripping with water near waterfall, 49.1884°N, 20.20095°E, alt. 1945 m, *leg.* P. Górski, 6.11.2010 (POZNB 264); **34UDV4149:** Kotlina Piatich Spišských Plies valley, blocks of rock E from Prostredné Spišské pleso lake, alt. 2035 m, *leg.* P. Górski, 29.08.2007 (POZNB 25/2007); **34UDV4150:** Čierna Javorová dolina valley, sub-glacially eroded step of the upper kettle (Czarny Bandzioch), on stone near Čierny potok stream, 49.20842°N, 20.19167°E, alt. 1995 m, *leg.* P. Górski, 26.08.2010 (POZNB 29/2010); Čierna Javorová dolina, upper kettle of the valley (Czarny Bandzioch), rock wall with water dripping from above, 49.2067°N, 20.19427°E, alt. 2075 m, *leg.* P. Górski, 26.08.2010 (POZNB 711); **34UDV4151:** Kolová dolina valley, Kotlinka pod Kolovým sedlom, 49.21647°N, 20.20273°E,

alt. 2000 m, *leg.* P. Górski, 1.09.2011 (POZNB 646); **34UDV4152**: Kolová dolina valley, blocks of rock above Kolové pleso lake, 49.21825°N, 20.20028°E, alt. 1820 m, *leg.* P. Górski, 1.09.2011 (POZNB 450); **34UDV4250**: Dolina Kežmarskej Bielej Vody valley, sub-glacially eroded step of the Veľká Zmrzlá dolina valley, alt. 1750 m, *leg.* P. Górski, 21.08.2009 (POZNB 134); Veľká Zmrzlá dolina valley, blocks of rock in lower part of the valley, 49.20448°N, 20.20943°E, alt. 1910 m, *leg.* P. Górski, 27.09.2011 (POZNB 552); **34UDV4251**: Červena dolina valley, blocks of rock near Belasé pleso lake, alt. 1865 m, *leg.* P. Górski, 25.09.2007 (POZNB 31/2007); **34UDV4352**: Dolina Bielych Plies valley, below Mt Koži štít, alt. 1790 m, *leg.* P. Górski, 26.09.2007 (POZNB 1); **34UDV4450**: Huncovská kotlina basin, blocks of rock at the bottom of the valley, alt. 1910 m, *leg.* P. Górski, 17.07.2011 (POZNB 622).

***Marsupella condensata* (Ångstr. ex C. Hartm.) Lindb. ex Kaal.**

POLAND, HIGH TATRA MOUNTAINS: **34UDV2752**: Dolina Gąsienicowa valley, blocks of rock below Mt Świnica, 49.23058°N, 20.01225°E, alt. 1887 m, *leg.* P. Górski, 20.09.2010 (POZNB 246); Dolina Gąsienicowa valley, blocks of rock below Mt Świnica, above Zadni Staw Gąsienicowy lake, alt. 1950 m, *leg.* P. Górski, 20.08.2005 (POZNB 23/2005); **34UDV2753**: Dolina Gąsienicowa valley, glacial cirque below Mt Świnica, blocks of rock near Długi Staw lake, alt. 1845 m, *leg.* P. Górski, 20.08.2005 (POZNB 21/2005); **34UDV2852**: Dolina Gąsienicowa valley, near SW shore of Żmarzły Staw Gąsienicowy lake, 49.22377°N, 20.02213°E, alt. 1778 m, *leg.* P. Górski, 21.09.2010 (POZNB 230); Dolina Gąsienicowa valley, Zadnie Koło, glacial cirque below Mylna Przełęcz pass, 49.22275°N, 20.01258°E, alt. 1975 m, *leg.* P. Górski, 30.08.2011 (POZNB 680); **34UDV2950**: Dolina Pięciu Stawów Polskich valley, below Czarna Ławka pass, alt. 1870 m, *leg.* P. Górski, 27.07.2005 (POZNB 13/2005, 14/2005); **34UDV2952**: Dolinka Kozia valley, blocks of rock, bottom of the kettle, 49.222°N, 20.02657°E, alt. 1960 m, *leg.* P. Górski, 31.08.2011 (POZNB 469); Dolinka Kozia valley, bottom of the kettle, alt. 1920 m, *leg.* P. Górski, 21.08.2005 (POZNB 17, 28/2005); **34UDV2953**: Dolina Pańszczyzycy valley, below rocky walls below main ridge (Orla Perć), below Pańszczycka Przełęcz pass, alt. 1985 m, *leg.* P. Górski, 3.08.2003 (POZNB 114/2003); **34UDV3049**: Dolina za Mnichem valley, snowbeds among blocks of rock, glacial cirque below Mt Cubryna, alt. 2000 m, *leg.* P. Górski, 16.08.2004 (POZNB 16, 150, 20/2004, 21/2004); **34UDV3050**: Dolina Pięciu Stawów Polskich valley, Brzuchaty Piarg, rocky walls below Mt Miedziane, alt. 1905 m, *leg.* P. Górski, 25.07.2005 (POZNB 5/2005); **34UDV3052**: Dolinka Buczynowa valley, bottom of the kettle, blocks of rock, alt. 1795 m, *leg.* P. Górski, 22.09.2005 (POZNB 34/2005); **34UDV3248**: below Mięguszowiecka Przełęcz pod Chłopkiem pass, rock crevices, 49.18407°N, 20.06698°E, alt. 2255 m, *leg.* P. Górski, 2.09.2014 (POZNB 1904).

SLOVAKIA, HIGH TATRA MOUNTAINS: **34UDV2746**: Nefcerka valley, blocks of rock below Mt Krivan, 49.16785°N, 20.00272°E, alt. 1830 m, *leg.* P. Górski, 2.08.2011 (POZNB 643); **34UDV2846**: Furkotská dolina valley, blocks of rock near SE shore of Vyšné Wahlenbergovo pleso lake, alt. 2130 m, *leg.* P. Górski, 8.08.2008 (POZNB 13/2008, 14/2008); Nefcerka valley, blocks of rock E from E shore of Nižné Terianske pleso lake, 49.16727°N, 20.01613°E, alt. 2035 m, *leg.* P. Górski, 2.08.2012 (POZNB 1326); Nefcerka valley, near SW shore of Vyšné Terianské pleso lake, 49.16768°N, 20.02032°E, alt. 2085 m, *leg.* P. Górski, 3.08.2011 (POZNB 605); **34UDV2946**: Mlynická dolina valley, blocks of rock above Okružle pleso lake, glacial cirque below Mt Furkotský štít, alt. 2135 m, *leg.* P. Górski, 10.08.2008 (POZNB 19/2008); **34UDV2947**: Hlinská dolina valley, blocks of rock below Výsné Kôprovské sedlo pass, alt. 1810 m, *leg.* P. Górski, 18.08.2006 (POZNB 40/2006); **34UDV3045**: Mlynická dolina valley, blocks of rock below Mt Malé Solisko, alt. 1950 m, *leg.* P. Górski, 15.08.2008 (POZNB 41); **34UDV3046**: Mlynická dolina valley, blocks of rock above S shore of Vyšné Kozie pleso lake, alt. 2110 m, *leg.* P. Górski, 11.08.2008 (POZNB 22/2008); Mlynická dolina valley, blocks of rock in NE part of the valley, below rocky walls of Mt Veľká Capia veža, alt. 2100 m, *leg.* P. Górski, 11.08.2008 (POZNB 24/2008, 25/2008); **34UDV3048**: Piargová dolinka valley, glacial cirque below Mt Cubrina, 49.18705°N, 20.04422°E, 49.18583°N, 20.04525°E, 49.18757°N, 20.0453°E, alt. 1870 m, 1875 m, 1880 m, *leg.* P. Górski, 22.07.2008 (POZNB 7/2008, 11/2008, 12/2008); Piargová dolinka

valley, glacial cirque below Mt Cubrina, alt. 1865 m, 1870 m, 1875 m, *leg.* P. Górski, 22.08.2006, 28.07.2009 (POZNB 44/2006, 45/2006, 18/2009, 19/2009, 20/2009, 21/2009, 22/2009, 23/2009); **34UDV3148:** Hincova dolina valley, blocks of rock above Veľké Hincovo pleso lake, alt. 1940 m, *leg.* P. Górski, 12.08.2008 (POZNB 30/2008); **34UDV3446:** Rumanova dolinka valley, blocks of rock near Vyšné Rumanovo plesko lake, 49.17212°N, 20.10102°E, alt. 2135 m, *leg.* P. Górski, 9.08.2011 (POZNB 572); Rumanova dolinka valley, blocks of rock, N from Rumanovo pleso lake, 49.17037°N, 20.10015°E, alt. 2160 m, *leg.* P. Górski, 3.08.2010 (POZNB 188); **34UDV3447:** Ťažká dolina valley, upper glacial cirque of the valley, blocks of rock below Mt Kačacia veža, N from Gáleria Ganku, alt. 1805 m, 1820 m, *leg.* P. Górski, 24.08.2009 (POZNB 61/2009, 62/2009); Ťažká dolina valley, upper glacial cirque of the valley, blocks of rock below Mt Ganek, alt. 1925 m, *leg.* P. Górski, 20.08.2009 (POZNB 45); **34UDV3448:** Ťažká dolina valley, upper glacial cirque of the valley, blocks of rock above S shore of Zmarzlé pleso lake, 49.17818°N, 20.09867°E, alt. 1825 m, *leg.* P. Górski, 20.08.2009 (POZNB 67); **34UDV3449:** Ťažká dolina valley, upper part of the lower glacial cirque of the valley, blocks of rock below Mt Pustá stráž, 49.181°N, 20.10603°E, alt. 1780 m, *leg.* P. Górski, 26.08.2009 (POZNB 98); **34UDV3545:** W slope of Mt Končistá, 49.15753°N, 20.11305°E, alt. 2470 m, *leg.* P. Górski, 28.08.2014 (POZNB 1876); **34UDV3546:** Kačacia dolina valley, Źelazny Ogród (upper glacial cirque in the valley), blocks of rock below Východná Źelezná brána pass, alt. 2000 m, *leg.* P. Górski, 16.09.2009 (POZNB 143, 75/2009); Kačacia dolina valley, Źelazny Ogród (upper glacial cirque in the valley), blocks of rock below Východná Źelezná brána pass, 49°10.143'N, 20°07.145'E, alt. 2020 m, *leg.* P. Górski, 16.09.2009 (POZNB 145); **34UDV3647:** Litvorová dolina valley, blocks of rock, below Mt Litvorový štít, alt. 1860 m, *leg.* P. Górski, 17.08.2006 (POZNB 37/2006); **34UDV3745:** Štrbina pod Kotlovým štítom (ridge Malý Gerlach-Gerlachovský štít), 49.16125°N, 20.13598°E, alt. 2560 m, *leg.* P. Górski, 7.08.2013 (POZNB 1625, 1626); **34UDV3746:** Velická dolina valley, Velická kotlina basin, blocks of rock near Vyšné Velické plieska lakes, 49.17233°N, 20.13853°E, 49.1723°N, 20.13588°E, alt. 2100 m, 2125 m, *leg.* P. Górski, 8.08.2012 (POZNB 1145, 1976); **34UDV3747:** Svišťová dolina (Bielovodská) valley, Zmarznutý kotel, blocks of rock, alt. 2020 m, *leg.* P. Górski, 1.08.2006 (POZNB 10, 11); **34UDV3848:** Rovenky valley, Zadné Rovenky, blocks of rock, upper cirque of the valley, below Mt Malý závrat, 49.18718°N, 20.1527°E, alt. 1955 m, *leg.* P. Górski, 25.09.2011 (POZNB 498); **34UDV3947:** Veľka Studená dolina valley, blocks of rock between Dlhé pleso lake and Zbojnická Chata hut, alt. 1900 m, *leg.* P. Górski, 24.08.2007 (POZNB 17/2007); **34UDV4049:** Zadná Javorová dolina valley, blocks of rock, glacial cirque below Mt Ostrý štít, alt. 2125 m, *leg.* P. Górski, 16.08.2006 (POZNB 29/2006, 30/2006); **34UDV4050:** Čierna Javorová dolina valley, Čierne mlaki, blocks of rock below Hrebeň Snehových veží ridge, 49.20793°N, 20.18702°E, 49.2075°N, 20.18718°E, 49.1983°N, 20.1822°E, alt. 1960 m, 1975 m, 2005 m, *leg.* P. Górski, 26.08.2010 (POZNB 164, 25/2010, 26/2010); **34UDV4148:** Malá Studená dolina valley, upper part of the valley, alt. 1935 m, 1945 m, *leg.* P. Górski, 29.08.2007 (POZNB 29/2007, 30/2007); **34UDV4149:** Kotlina Piatich Spišských Plies valley, blocks of rock NW from Veľké Spišské pleso lake, alt. 2070 m, *leg.* P. Górski, 27.08.2007 (POZNB 24/2007); **34UDV4150:** Čierna Javorová dolina valley, Czarny Bandzioch, 49.20782°N, 20.19433°E, alt. 2050 m, *leg.* P. Górski, 26.08.2010 (POZNB 28/2010); **34UDV4152:** Kolová dolina valley, blocks of rock, bottom of the lower kettle, 49.21825°N, 20.20028°E, alt. 1820 m, *leg.* P. Górski, 1.09.2011 (POZNB 449); **34UDV4250:** Veľká Zmrzlá dolina valley, Barania kotlina basin, blocks of rock, 49.20367°N, 20.20733°E, alt. 2005 m, *leg.* P. Górski, 27.09.2011 (POZNB 540); Veľká Zmrzlá dolina valley, sub-glacially eroded step of the valley, 49.20433°N, 20.20925°E, 49.20422°N, 20.20942°E, alt. 1910 m, 1925 m, *leg.* P. Górski, 27.09.2011 (POZNB 546, 549).

Nardia breidlerii (Limpr.) Lindb.

POLAND, HIGH TATRA MOUNTAINS: **34UDV3049:** Dolina za Mnichem valley, bottom of the valley, near Wyżni Staw Staszica lake, snowbed near route, 49.19505°N, 20.05045°E, alt. 1785 m, *leg.* P. Górski, 16.08.2004, 27.09.2007, 28.08.2012 (POZNB 15/2004, 116, 117, 1485; locality published by Szweykowski 1960).

SLOVAKIA, HIGH TATRA MOUNTAINS: **34UDV4148**: Kotlina Piatich Spišských Plies valley, near N shore of Nižne Spišské pleso lake, 49.19052°N, 20.19685°E, alt. 1995 m, 2000 m, *leg.* P. Górski, 29.08.2007 (POZNB 28/2007); **34UDV4149**: Kotlina Piatich Spišských Plies valley, NWW from NW shore of Prostredné Spišské pleso lake, 49.193°N, 20.19802°E, alt. 2000 m, 2005 m, 2025 m, *leg.* P. Górski, 27.08.2007 (POZNB 72, 109, 19/2007, 20/2007, 21/2007); Kotlina Piatich Spišských Plies valley, near NE shore of Vyšne Spišské pleso lake, 49.19468°N, 20.19688°E, alt. 2024 m, *leg.* P. Górski, 22.09.2010 (POZNB 236).

***Moerckia blyttii* (Moerch) Brockm.**

POLAND, HIGH TATRA MOUNTAINS: **34UDV2653**: Dolina Gąsienicowa valley, below Grzędy ridge, backwater near Kotlinowy Stawek lake, SW from Zielony Staw Gąsienicowy lake, 49.23052°N, 19.99492°E, alt. 1690 m, *leg.* P. Górski, 30.06.2010 (POZNB 152); **34UDV2752**: Dolina Gąsienicowa valley, debris slope below rocky walls descending from Mt Świnica, 49.22277°N, 20.01067°E, alt. 1940 m, *leg.* P. Górski, 30.08.2011 (POZNB 471); Dolina Gąsienicowa valley, glacial cirque below Mt Świnica, rocky outcrops SE from Zadni Staw Gąsienicowy lake, alt. 1875 m, *leg.* P. Górski, 20.08.2005 (POZNB 25/2005); Dolina Gąsienicowa valley, glacial cirque below Świnicka Przełęcz pass, 49.22393°N, 20.00715°E, *leg.* P. Górski, 20.09.2010 (POZNB 238); Dolina Gąsienicowa valley, SW from Długi Staw Gąsienicowy lake, on the sub-glacially eroded step of the upper part of the valley, 49.22462°N, 20.00783°E, alt. 1820 m, *leg.* P. Górski, 20.09.2010 (POZNB 247); **34UDV2850**: Dolina Pięciu Stawów Polskich valley, below Kotelnica ridge, above Czarny Staw Polski lake, alt. 1845 m, *leg.* P. Górski, 27.07.2005 (POZNB 15/2005, 16/2005); **34UDV2852**: Dolina Gąsienicowa valley, above Zmarzły Staw Gąsienicowy lake, alt. 1815 m, *leg.* P. Górski, 21.08.2005 (POZNB 30/2005); **34UDV2852**: Dolina Gąsienicowa valley, on the sub-glacially eroded step of the Dolinka Kozia valley, alt. 1810 m, *leg.* P. Górski, 21.08.2005 (POZNB 26/2005); **34UDV2952**: Dolina Gąsienicowa valley, on the sub-glacially eroded step of Dolinka Kozia valley, 49.22192°N, 20.026°N, alt. 1960 m, *leg.* P. Górski, 31.08.2011 (POZNB 460); **34UDV3049**: Dolina za Mnichem valley, rocky outcrops above Stawki Staszica lakes, alt. 1825 m, *leg.* P. Górski, 20.09.2006 (POZNB 33/2005); **34UDV3050**: Dolina Pięciu Stawów Polskich valley, Dolinka za Niedźwiedziem valley, 49.20718°N, 20.05067°E, alt. 1785 m, 1810 m, *leg.* P. Górski, 26.07.2005, 22.08.2012 (POZNB 1154, 7/2005);

POLAND, WESTERN TATRA MOUNTAINS: **34UDV1952**: Dolina Tomanova valley, near route, alt. 1600 m, *leg.* P. Górski, 15.08.1998, *det.* J. Váňa, 2012 (POZNB 988).

SLOVAKIA, HIGH TATRA MOUNTAINS: **34UDV2949**: Temnosmrečinská dolina valley, near NE shore of Vyšné Temnosmrečinské pleso lake, wet *Nardetum*, 49.19°N, 20.03648°E, alt. 1720 m, *leg.* P. Górski, 1.08.2012 (POZNB 1332); Temnosmrečinská dolina valley, rocky outcrops near route, below Nižné Temnosmrečinské pleso lake, 49.19458°N, 20.02685°E, alt. 1670 m, *leg.* P. Górski, 22.07.2008, 30.07.2009 (POZNB 5/2008, 26/2009, 27/2009); Temnosmrečinská dolina valley, rocky outcrops near umarked path, between Nižné Temnosmrečinské pleso and Vyšné Temnosmrečinské pleso lakes, 49.19047°N, 20.03457°E, alt. 1695 m, 1700 m, 1705 m, *leg.* P. Górski, 22.07.2008, 30.07.2009 (POZNB 6/2008, 29/2009, 30/2009, 32/2009); **34UDV3045**: Mlynická dolina valley, small lake (without name) below rocky walls descending from Mt Malé Solisko, 49.1627°N, 20.02237°E, alt. 1840 m, *leg.* P. Górski, 15.08.2008 (POZNB 60; locality published by Krajina 1933); **34UDV3445**: Zlomisková dolina valley, on the sub-glacially eroded step of Kotlina Ľodového plesa basin, near stream, 49.1624°N, 20.1029°E, alt. 1880 m, *leg.* P. Górski, 9.08.2011 (POZNB 647); **34UDV3447**: Ťažká dolina valley, debris slope below rocky walls descending from Mt Kačacia veža, 49.1808°N, 20.10162°E, alt. 1795 m, *leg.* P. Górski, 24.08.2009 (POZNB 35); Ťažká dolina valley, near N shore of Zmarzlé pleso lake, below rocky walls descending from Mt Prédna Pustá veža, alt. 1760 m, *leg.* P. Górski, 20.08.2009 (POZNB 55/2009); **34UDV3448**: Spadová dolinka valley, 49.18673°N, 20.09432°E, alt. 1980 m, *leg.* P. Górski, 25.08.2009 (POZNB 55); Ťažká dolina valley, above SE shore of Ťažké pleso lake, alt. 1670 m, *leg.* P. Górski, 24.08.2009 (POZNB 60/2009); **34UDV3449**: Žabia Bielovodská dolina valley, near E shore of Vyšné Žabie Bielovodské pleso lake, 49.1871°N, 20.09165°E, alt. 1705 m, *leg.* P. Górski, 19.09.2009 (POZNB 138); **34UDV3848**: Rovenky valley, Zadné Rovenky, 49.18747°N, 20.15157°E, alt. 1925 m, *leg.* P. Górski,

25.09.2011 (POZNB 495); **34UDV3947**: Veľká Studená dolina valley, Zbojnícky spád, 49.1785°N, 20.17407°E, alt. 1790 m, leg. P. Górski, 11.08.2011 (POZNB 580); **34UDV4352**: Dolina Bielych Plies valley, alt. 1750 m, 1840 m, leg. P. Górski, 26.09.2007 (POZNB 34/2007, 36/2007).
SLOVAKIA, WESTERN TATRA MOUNTAINS: **34UDV0751**: Spálená dolina valley, rocky outcrops below Roháčske plesa lakes, near Rázcestie k Roháčskym Plesám, alt. 1530 m, leg. P. Górski, 24.07.2006 (POZNB 20/2006).

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