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MOSSES OF KOCIOŁ ŁOMNICZKI GLACIAL CIRQUE (KARKONOSZE MTS) IN RELATION TO ECOLOGICAL AND PHYTOCOENOTICAL DIVERSITY OF HABITATS

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ABSTRACT. As a result of a bryological exploration carried out in 2008 within the Kocioł Łomniczki glacial cirque, a number of 98 taxa (96 species, one subspecies and one variety) was recorded. 80% of them occurred sparsely: 59 species were reported from no more than six stations (10%) and 20 from 7-13 stations (10.1-20%). The 19 species occurred more frequently (but on no more than 50% of the stations) and they are widely distributed within the whole range of altitude and exposition, as well as they occurred in the majority of plant communities. 56 taxa occurred only on one type of substratum while the rest of species showed wider substrate amplitudes. In total estimation the richest in species were: rocks and boulders (42 taxa, 21 exclusive) and coniferous litter and rotten leaves of grasses and ferns (39; 5). A rather high number of species occurring on barks of living trees (dwarf-pine, spruce, mountain-ash and sycamore) was observed – 16 species, but 10 of them were poly-substrate. The analysis of mosses distribution in aspect of phytocoenotical diversity shows they quite well reflect the differentiation of vegetation cover which resulted mostly from the variety of water conditions – 25 species occurred exclusively in patches of hygrophilous communities. Some phytocoenose types showed high bryo-floristical similarity: 60% of common species between dwarf-pine thickets and subalpine grasslands, 43% between spruce forest and dwarf-pine thickets. 19 of the 20 species noted in the patches of the blueberry aggregations appeared to be common with typical form of dwarf-pine thickets and 18 ones common with subalpine grasslands what suggests that this plant formation is not bryologically distinguishable. Species richness and composition of mosses occurring on the particular cirque's walls and the bottom differed visibly. The richest was the southern wall what seems to be a result both of higher ecological and phytosociological differentiation and the most number of research plots.

KEY WORDS: mosses diversity, montane mosses, bryophyte ecology, altitudinal distribution of mosses, bryoflora of Karkonosze

INTRODUCTION

The paper presents results of bryological exploration carried out in 2008 within the Kocioł Łomniczki glacial cirque – the biggest and the deepest glacial cirque situated in the Polish part of the Karkonosze Mts. The aim of the study presented was an analysis of moss species distribution in relation to types of substratum and plant community, as well as to the altitude and walls exposition. Although the object was quite well bryologically described in XIX century and 74 species were reported (see: Wilczyńska 1996) a contemporary bryological data are scanty and relate to only 27 species (Koła 1986, Kwiatkowski 1999 a, b, Fudali et al. 2003).

The following questions arose: How do mosses use vertical, microclimatical, phytocoenotical and substratum varieties within the cirque? Is that diversity reflected in mosses distribution? They concern such detailed topics as: 1) do mosses show vertical preferences within the cirque (it exceeds 300 m altitudinal span)? 2) are there any differences in the species composition or frequency of species occurrence among particular walls of the cirque (Jeník's theory of the anemo-orographic systems (Jeník 1997) assumed microclimatical differences among walls within glacial cirques)? 3) do mosses show any phytocoenotical preferences (patches of various plant communities have been reported from there (Matuszkiewicz and Matuszkiewicz 1974)? What kinds of substratum are colonized?

STUDY AREA

The Kocioł Łomniczki glacial cirque is the biggest and the deepest glacial cirque of the ones situated in the Polish part of the Karkonosze Mts – its bottom lies at the altitude of 1100-1150 m a.s.l. while the upper edges exceed 1430 m a.s.l. (Staffa 1993). From other glacial cirques it differs in lack of moraines, walls formed from naked boulders, presence of stream running along the south-western wall and crossing the bottom, as well as numerous tracts with trickling water originated from the subalpine bogs situated above. Although in the whole altitudinal span the glacial cirque's vegetation is

dominated by the mosaic of dwarf-pine thickets – *Pinetum mughii sudeticum* community (in two forms: dry *P. m. typicum* and wet *P. m. rumicetosum* (Matuszkiewicz and Matuszkiewicz 1974), open blueberry aggregations of *Vaccinium myrtillus*, subalpine grasslands with *Calamagrostis villosa* and *Deschampsia flexuosa* (*Crepido-Calamagrostietum villosae* community) or *Nardus stricta* (*Carici rigidae-Nardetum* community) and aggregations of fern *Athyrium alpestre* (*Athyrietum alpestris* community) numerous patches of other plant communities are also well developed. These are: spruce forest *Piceetum hercynicum* community on lower part of the western wall, deciduous thickets of *Padus petraea* and willows *Pado-Sorbetum* community in the bottom and on lower part of south-western wall, spring phytocoenoses of the *Cardamino-Montion* alliance, herbaceous community *Adenostyletum alliariae* and subalpine swamps developing along tracks of trickling water and stream as well as dry heathlands on boulders and rocky shelfs. Along the bottom and the southern wall a tourist path, made of boulders, is conducted. In some places the path is reinforced with concrete.

MATERIALS AND METHODS

The author's own data have been used only for the analysis; they were gathered during bryological exploration done in the summer and autumn of the 2008. For the bryophytes inventory 63 research plots (each of about 10 m^2) were established in every type of the plant communities developing on each wall and bottom of the glacial cirque in places available for exploration without using of mountaineering equipment. As particular walls differed phytosociologically the number of plots established in there was not equal (Table 1).

In every plot (= station) bryophytes were systematically noted from each type of substratum (rocks or gravel and stones, mineral naked soil, humus layer on soil or rock, coniferous litter or rotten leafs of grasses and ferns, decayed wood, bark of living trees, peat) and some samples of plants were picked up for identification. The altitude was measured using altimeter Suunto. Nomenclature of mosses follows Ochyra et al. (2003), plant communities were recognised according to Matuszkiewicz and Matuszkiewicz (1974).

Table 1. Number of research plots (= stations) representing various types of vegetation established on the particular walls and bottom of the Kocioł Łomniczki glacial cirque

Type of plant community	E	S	W	B	In total
Spruce forest of *Piceetum hercynicum*	3	0	0	0	3
Dwarf-pine thickets:					
– *Pinetum mughii sudeticum typicum*	2	3	5	2	12
– *Pinetum mughii sudeticum rumicetosum*	0	1	1	1	3
High subalpine grasslands *Crepido-Calamagrostietum villosae*	2	7	0	1	10
Short subalpine grasslands *Carici rigidae-Nardetum*	0	2	0	0	2
Blue-berry aggregations of *Vaccinium myrtillus* on boulders	1	4	2	0	7
Athyrietum alpestris along rocky chutes for trickling water	2	1	3	1	7
Spring vegetation of the *Cardamino-Montion alliance*	0	5	1	0	6
Swamps:					
– within *Pinetum mughii sudeticum*	0	1	0	0	1
– within *Crepido-Calamagrostietum villosae*	0	2	0	1	3
Deciduous thickets of *Pado-Sorbetum*	0	0	1	2	3
Rocks or boulders covered only with cryptogams (bryophytes and lichens):					
– dry	0	3	1	0	4
– wet	0	1	0	1	2
In total	10	30	14	9	–

Explanations: B – bottom of the glacial cirque, E – eastern wall, S – southern wall, W – western wall.

RESULTS AND DISCUSSION

General remarks of species diversity and frequency of occurrence

During the studies presented 98 taxa: 96 species and two infraspecies taxa (one subspecies and one variety) were recognised (Table 2). They represent 50 botanical genera. Some of them have been known from only few other places in Karkonosze mountains, ex. *Rhytidiadelphus triquetrus, Pohlia ludwigii, Hypnum calichroum, Heterocladium heteropterum*, *Splachnum sphaericum* and *Dicranodontium uncinatum* while *Dicranoweissia cirrata* have not been reported at all (Wilczyńska 1996, Fudali and Kučera 2003, Fudali 2004, Dunajski and Fudali 2007). Only one species *Ceratodon purpureus* seem to be of anthropogenic origin (occurred exclusively on concrete along tourist path).

Analysis of the stations' number in which mosses were noted shows that most of them occurred sparsely. Only seven species were found as frequent what means they occurred on more than 35% of stations (more than 22) and 12 as quite frequent (14-22 stations; Fig. 1). The number of very rare taxa (reported from no more than 10% of stations what is from 1 to 6) is 59 (60%), including 21 noted only on one plot. The share of rare species (7-13 stations) is 20% (20 species).

Substrata preferences

56 taxa (57%) occurred only on one type of substratum (including 21 species noted sporadically): the most – on rocks (21-9 sporadical), on a naked mineral soil (10-2) and on peat (9-4). The numbers of taxa collected from other substratum types are shown on the Figure 2.

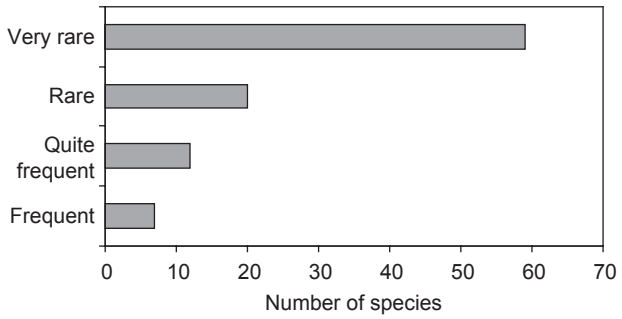

Fig. 1. Number of species in classes of frequency distinguished
Explanations: Very rare – reported from 1-6 stations (no more than 10% of stations), Rare – 7-13 stations (10.1-20%), Quite frequent – 14-22 stations (20.1-35%), Frequent – 23-31 stations (35.1-50%).

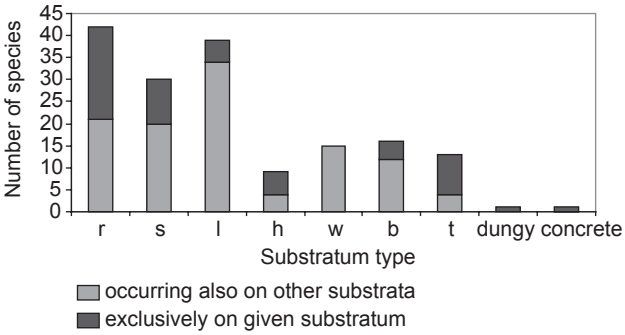

Fig. 2. Participation of species on various substratum types (abbreviations as in Table 2)

The number of bi-substrate species is 20, of three-substrate – 15 and of four-substrate (= poly-substrate) – six. The latter appeared with various frequency (frequent, quite frequent and rare). Its worthy to note that in many cases number of substrata colonized does not depend on a frequency of occurrence (Table 2).

Two substratum types appeared to be the richest in species: rocks and boulders (42 taxa) and coniferous litter and rotten leaves of grasses and ferns (39) and two others the poorest: dungy (1 species) and concrete (1).

A rather high number of species it should be noted occurring on barks of living trees (dwarf-pine, spruce, mountain-ash and sycamore) – 16, but 10 of them were poly-substrate.

Distribution in relation to the diversity of vegetation cover

As it was said above only 21 species occurred exclusively on the rocks and boulders. The rest occupied other substrata which availability depends strongly on the vegetation type. Floristical-ecological notes prove that diversity of plant communities developing within the Kocioł Łomniczki glacial cirque due to different ecological conditions, especially moisture and slope inclination, influence mosses distribution within it – 25 species occurred only in patches of hygrophilous communities. 27 species (including 21 noted sporadically) were noted exclusively in one type of plant communities, in two types – 15, in three types – 17, in four types – 14. The number of species showing wide phytocoenotical amplitude (reported from 7, 8 or 9 types of phytocoenose) was 15 (Fig. 3).

Table 2. Ecological aspects of the mosses distribution within the Kocioł Łomniczki glacial cirque

Name of species	Number of stations	Altitudinal span [m a.s.l.]	Number of stations distributed on the particular cirque's walls	Type of vegetation in which species occurred (number of notes)	Type of substratum on which species occurred (number of notes)
1	2	3	4	5	6
Frequent species					
Dicranum scoparium	31	1110-1430	E-9; S-12; W-5; B-5	P-3; Mt-11; Mh-3; G-4; CN-2; V-6; D-1; Nd-1	b-7; l-31; r-13; w-5
Polytrichastrum alpinum	31	1120-1420	E-8; S-16; W-4; B-3	P-3; Mt-7; Mh-2; G-5; CN-2; V-5; F-3; D-1; Nd-3	l-29; r-14; s-12
Sphagnum girgensohnii	29	1110-1430	E-7; S-11; W-4; B-4	P-2; Mt-5; Mh-3; G-6; F-6; Bm-1; Bg-1; D-1; Nd-1	l-24; r-10; t-3
Sciuro-hypnum reflexum	25	1110-1430	E-6; S-8; W-7; B-4	P-3; Mt-5; Mh-3; G-5; V-2; F-3; D-3; Nd-1	b-6; l-23; r-11, w-6
Rhytidiadelphus subpinnatus	25	1110-1430	E-7; S-11; W-2; B-5	P-2; Mt-8; Mh-2; G-5; CN-2; V-2; F-3; D-1	l-26; w-4
Pleurozium scheberi	25	1110-1420	E-8; S-9; W-4; B-4	P-2; Mt-7; Mh-1; G-6; CN-2; V-7	b-2; l-25; s-3
Plagiothecium curvifolium	24	1100-1430	E-7; S-9; W-5; B-3	P-3; Mt-9; Mh-2; G-2; V-4; F-2; D-2	b-9; l-27; w-7
Quite frequent species					
Pohlia nutans	20	1110-1380	E-5; S-6; W-5; B-4	P-3; Mt-7; Mh-3; G-1; CN- 1; V-2; F-1; D-2	b-3; l-8; s-2; w-3
Dicranodontium denudatum	19	1100-1395	E-5; S-5; W-5; B-4	P-3; Mt-10; Mh-2; G-1; V-1; F-1; D-1	l-8; r-8; w-4

Table 2 – cont.

1	2	3	4	5	6
Codriophorus fascicularis	19	1120-1430	E-1; S-13; W-2; B-3	Mt-3; Mh-1; G-2; F-2; S-2; D-2; Nd-5; Nw-2	r
Hylocomium splendens	19	1090-1400	E-8; S-8; W-1; B-2	P-2; Mt-7; G-6, V-4	l-19; w-3
Buclandiella sudetica	18	1120-1430	E-1; S-10; W-4; B-3	P-1; Mt-7; G-2; F-2; D-1; Nd-3; Nw-2	r
Sanionia uncinata	18	1110-1430	E-4; S-8; W-3; B-3	P-2; Mt-7; Mh-3; G-1; F-2; S-1; D-2	b-8; l-8; r-6; w-4
Sphagnum russowii	17	1150-1415	E-3; S-10; B-4	P-3; Mt-1; G-4; S-1; Bm-4; Bg-4	s-11; r-6
Polytrichum commune	16	1130-1430	E-2; S-10; W-1; B-3	P-1; Mt-1; Mh-4; G-3; F-1; S-3; Bm-1; Bg-2	h
Kiaeria starkei	16	1100-1430	E-2; S-10; W-1; B-3	Mt-8; G-3; CN- 2; Nd-3	l-3; r-13
Philonotis seriata	15	1110-1340	E-2; S-9; B-4	F-1; S-9; G-3; Bg-2	l-3; r-3; s-9
Sciuro-hypnum starkei	15	1110-1360	E-7; S-2; W-3; B-3	P-3; Mt-4; Mh-1; G-2; V-1; F-3; D-1	l-11; r-2; s-2
Orthodicranum montanum	14	1100-1395	E-1; S-7; W-3; B-3	P-2; Mt-8; Mh-3; D-1;	b-6; l-1; w-7
Rare species					
Oligotrichum hercynicum	12	1100-1430	E-2; S-8; W-1; B-1	Mt-2; G-6; V-2; D-1; Nd-1	s
Plagiothecium cavifolium	12	1110-1380	E-3; S-7; B-2	Mt-2; Mh-1; G-2; F-3; S-1, D-1; Nd-2	l-8; r-1; s-3
Plagiomnium medium	11	1100-1430	E-2; S-5; W-3; B-1	Mt-2; Mh-4; G-4; F-1; S-1	l-10; r-1; s-2
Plagiothecium denticulatum	11	1120-1380	E-1; S-7; W-1; B-2	Mt-1; Mh-3; G-2; F-3; S-1; D-1	h-2; l-6; w-2
Hylocomiastrum umbratum	11	1090-1365	E-5; S-4; W-1; B-1	P-3; Mt-4; Mh-1; G-1; V-2	l
Pogonatum urnigerum	11	1100-1430	E-2; S-3; W-3; B-3	Mt-4; Mh-2; G-3; F-1; D-1	l-8; r-1; s-2
Sphagnum squarrosum	11	1120-1340	E-1; S-5; W-2; B-3	Mh-2; F-3; S-3; Bg-2; D-1	s-9; t-2
Rhizomnium magnifolium	11	1120-1380	E-3; S-6; B-2	Mh-3; F-3; S-4; D-1	l-5; r-1; s-3
Dicranella cerviculata	10	1170-1365	E-4; S-5; W-1	P-3; G-5; V-1; Nd-1	s
Dicranum fuscescens	10	1150-1420	E-3; S-5; W-2	Mt-5; Mh-2; G-2; V-1	b-1; l-6; s-2; w-1
Pseudotaxiphyllum elegans	10	1110-1385	E-3; S-4; W-1; B-2	Mt-2; Mh-1; G-1; F-2; S-1; Bg-1; D-1; Nd-1	l-4; r-4; s-1; w-1
Andrea rupestris	9	1130-1395	E-2; S-4; W-2; B-1	Mt-4; G-2; Nd-3	r
Buckiella undulata	9	1090-1395	E-6; S-1; W-1; B-1	P-3; Mt-5; V-1	l-7; s-2
Tetraphis pellucida	9	1110-1395	E-4; S-4; B-1	P-3; Mt-4; Mh-1; V-1	l-1; w-8
Herzogiella striatella	8	1110-1300	E-2; S-1; W-3; B-2	P-1; Mh-3; F-3; D-1	b-1; l-5; r-2
Codriophorus acicularis	8	1120-1340	S-4; W-1; B-3	F-3; S-1; Bg-1; Nw-3	r
Paraleucobrym longifolium	8	1110-1380	S-4; W-3; B-1	P-1; Mt-5; Mh-1; F-1	r-6; w-2
Polytrichum juniperinum	8	1120-1430	E-1; S-6; B-1	Mt-4; G-1; V-1; Nd-2	l-2; r-6
Polytrichum piliferum	8	1120-1395	E-1; S-5; B-2	Mt-2; Mh-1; G-3; V-1; Nd-1	r-6; s-2
Dicranum majus	7	1120-1430	E-4; S-3	P-1; Mt-2; G-2; V-2	l
Very rare species					
Diobelonella palustris	6	1110-1340	S-5; B-1	F-1; S-4; Bg-1	s
Racomitrium lanuginosum	6	1120-1420	E-1; S-3; W-1; B-1	Mt-1; G-3; Nd-2	r
Rhizomnium punctatum	6	1110-1430	S-3; W-1; B-2	Mh-2; G-1; F-2; S-1	r-4; s-2
Plagiothecium succulentum	5	1220-1380	E-2; S-2; W-1	Mh-2; F-3	l
Rhytidiadelphus loreus	5	1090-1430	E-4; S-1	P-1; Mt-3; G-1	h
Straminergon stramineum	5	1110-1280	E-2; S-1; W-1; B-1	P-1; Mh-1; G-1; Bm-1; Bg-1	t
Codriophorus aquaticus	4	1120-1380	S-3; B-1	S-2; Nw-2	r
Cynodontium polycarpum	4	1130-1380	S-2; W-2	Mt-2; G-1; F-1	r
Dicranodontium uncinatum	4	1110-1380	S-1; W-2; B-1	Mt-1; Mh-2; F-1	r
Dicranum flexicaule	4	1220-1365	E-3; S-1	Mt-2; G-1; V-1	l
Ditrichum heteromallum	4	1110-1395	S-3; B-1	P-1; Mt-1; G-1; Nd-1	s
Hymenoloma crispula	4	1170-1395	E-1; S-3	P-1; Mt-2; G-1	r
Plagiothecium laetum	4	1145-1360	E-1; S-1; W-1; B-1	P-1; Mt-2; Mh-1	b-1; l-1; w-2

Table 2 – cont.

1	2	3	4	5	6
Plagiothecium nemorale	4	1280-1365	S-4	Mh-2; S-2	b-1; l-3
Polytrichum strictum	4	1220-1415	E-2; S-2	Bg-4	t
Sciuro-hypnum salebrosum	4	1170-1395	S-2; W-1; B-1	Mt-1; Mh-1; G-2	b-2; l-2
Sphagnum denticulatum	4	1120-1280	E-1; S-2; B-1	Mh-1; S-2; Bg-1	t-2; s-2
Buclandiella heterosticha	3	1340-1390	E-1; S-2	Mt-3	r
Ceratodon purpureus	3	1340-1395	S-3	Nd(antr.)-3	concrete-3
Hygrohypnum ochraceum	3	1120-1430	S-2; B-1	G-1; S-2	l-1; s-2
Mnium hornum	3	1230-1265	E-3	P-2; G-1	h-2; l-2
Mnium spinosum	3	1120-1180	W-1; B-2	P-1; Mh-1; F-1	h-1; l-3
Pohlia nutans var. *schimperi*	3	1365-1395	S-3;	G-2; Nd-1	l-2; s-2
Pohlia wahlenbergii	3	1280-1365	S-3	Mh-2; F-1	s
Polytrichastrum formosum	3	1110-1235	E-1; B-2	P-2; F-1	h-2; l-2
Sphagnum fallax	3	1110-1170	S-1; B-2	S-1; Bm-1; Bg-1	t
Cirriphyllum piliferum	3	1130-1235	S-1; E-1; B-1	P-1; Mh-1; G-1	h
Platyhypnidium riparioides	2	1120-1180	B-2	Nw-2	r
Bryum pallescens	2	1150-1430	S-1; B-1	P-1; Mt-1	r
Bryum pseudotriquetrum	2	1130-1340	S-1; W-1	F-1; S-1	s
Heterocladium heteropterum	2	1130-1300	S-1; W-1	F-1; Nd-1	s
Rhytidiadelphus triquetrus	2	1120-1220	E-2	Mt-1; Mh-1	h
Sphagnum compactum	2	1260-1300	S-2	S-2	s+r
Sphagnum palustre	2	1110-1150	S-1; B-1	Mh-1; Bm-1	s-1; t-1
Sphagnum teres	2	1300-1430	S-2	Mh-1; Bg-1	t
Thuidium tamariscinum	2	1130-1170	W-2	Mt-1; F-1	h
Warnstorfia sarmentosa	2	1280	S-2	S-2	r
Dicranoweisia cirrata	1	1145	W	Mt	b
Brachythecium rivulare	1	1160	B	Nw	r
Brachytheciastrum velutinum	1	1130	W	D	b
Brachythecium albicans	1	1395	S	G	s
Buclandiella affinis	1	1220	E	Mt	r
Buclandiella microcarpa	1	1145	B	D	r
Grimmia donniana	1	1430	S	G	r
Grimmia hartmanii	1	1290	S	F	r
Hypnum callichroum	1	1130	W	F	r
Hypnum cupressiforme	1	1320	W	Mt	b
Hypnum cupressiforme var. *lacunosum*	1	1180	W	V	r
Pohlia ludwigii	1	1340	S	S	s
Plagiothecium platyphyllum	1	1340	S	G	l
Pseudoleskea incurvata	1	1180	W	P	r
Sciuro-hypnum rutabulum	1	1130	B	S	b
Sciuro-hypnum populeum	1	1130	W	Mt	b
Sphagnum cuspidatum	1	1110	B	Bm	t
Sphagnum inundatum	1	1120	B	Bm	t
Sphagnum magellanicum	1	1360	S	Bm	t
Sphagnum riparium	1	1280	S	Bg	t
Splachnum sphaericum	1	1235	E	P	dungy

Explanations: walls: B – bottom, E – eastern, S – southern, W – western; type of vegetation: Bg – plots of swamps within subalpine grasslands, Bm – plots of swamps within thickets of *Pinetum mughii sudeticum*, CN – short subalpine grasslands of *Carici rigidae – Nardetum* community, D – deciduous shrubs of *Pado-Sorbetum*, F – fern community *Athyrietum alpestris*, G – high subalpine grasslands of *Crepido-Calamagrostietum villosae* community, Mh – *Pinetum mughii sudeticum rumicetosum*, Mt – *Pinetum mughii sudeticum typicum*, Nd – dry naked boulders or rocks with cryptogamous communities, Nw – naked boulders or rocks with cryptogamous communities in water, P – spruce forest of *Piceetum hercynicum*, V – blueberry aggregations; substrata type: b – bark of trees and thickets, h – humus decomposed, l – coniferous litter, rotten fragments of grass and fern leafs, r – rocks or boulders (dry or wet with trickling water), s – naked mineral soil, t – peat, w – decaying wood.

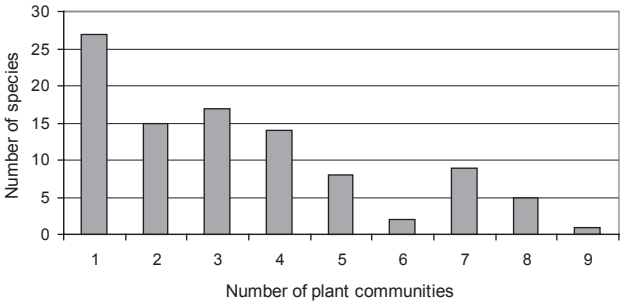

Fig. 3. Participation of species of various width of phytocoenotical amplitude (= number of plant communities in which they occurred)

The most rich in species were dwarf-pine thickets – 64 and high subalpine grasslands – 48 (Table 3). A certain differences in species composition and richness is visible between two forms of *Pinetum mughii sudeticum*: in *P. m. typicum* a number of 51 taxa, with five exclusively occurred in there were noted while in wet form *P. m. rumicetosum* – 42. Floristical similarity (as percentage of common species) between these two forms amounts 45%. High floristical similarity showed dwarf-pine thickets and high subalpine grasslands (60% with *Pinetum mughii typicum* and 38% with *P. m. rumicetosum*) as well as high subalpine grasslands and spruce forest (43%); 13 species occurred in all of these three vegetation types. 19 of the 20 species noted in the patches of the blueberry aggregations appeared to be common with *Pinetum mughii sudeticum typicum* and 18 ones common with *Crepido-Calamagrostietum villosae*. It means that bryologically they are not distinguishable. Similarly all the species recorded in patches of short subalpine grasslands of the *Carici rigidae-Nardetum* community are eurytopic and present in the majority of plant communities developing within the Kocioł Łomniczki glacial cirque.

Some of species occurring in several plant communities showed a certain phytocoenotical specialization having half or more stations only in one of them, ex. *Dicranodontium denudatum*, *Buclandiella sudetica*, *Dicranum fuscescens*, *Rhytidiadelphus loreus* preferred the community of *Pinetum mughii sudeticum typicum*, the most stations of *Oligotrichum hercynicum* and *Dicranella cerviculata* were situated in high subalpine grasslands while *Philonotis seriata* – in spring phytocoenoses.

Altitudinal distribution

In the Karkonosze Mts the altitude of 1250 m a.s.l. is considered as a limit between two vegetational zones: upper forest belt and subalpine belt (Staffa 1993). Analysis of altitudinal distribution of mosses show that 22 species do not exceed the altitude of 1250 m a.s.l. and 16 occurred only above this altitude while 60 taxa (61%) were noted in the whole range of altitude and 34 from near 1100 m a.s.l. to more than 1400 m a.s.l. The latter belong to various classes of frequency: frequent, quite frequent and rare.

Species occurred exclusively in the lowest parts are mainly lowland taxa but there are also some mountain species (*Mnium spinosum, Rhytidiadelphus triquetrus, Pseudoleskea incurvata, Buclandiella microcarpa*). Also among species limited to the higher altitudes there were both lowlands (*Sphagnum magellanicum*, *Hypnum cupressiforme*, *Brachythecium albicans*) and montane taxa (*Pohlia ludwigii*, *Grimmia doniana*, *Pohlia nutans* var. *schimperi*).

Distribution in relation to exposition of the cirque's walls

Species richness and composition of mosses occurring on the particular walls and the bottom differ visibly. The most rich was the southern wall (Table 4) what seems to be a result both of higher phytosociological differentiation and the highest number of research plots.

Table 3. Total number of species recorded in the particular types of plant communities and number of species exclusively noted in them

Type of plant community	Number of species recorded	
	in total	exclusively
Piceetum hercynicum	35	2
Pinetum mughii sudeticum typicum	51	5
Pinetum mughii sudeticum rumicetosum	42	0
Crepido-Calamagrostietum villosae	48	3
Carici rigidae-Nardetum	6	0
Blue-berry aggregations on boulders	20	1
Athyrium alpestre aggregations along rocky chutes for trickling water	36	2
Spring phytocoenoses	25	4
Swamps:		
– within dwarf-pine thickets	9	3
– within grasslands	14	2
Pado-Sorbetum	23	2
Naked boulders or rocks with cryptogamous communities:		
– dry	18	1
– in water	6	2

Table 4. Number of species recorded in particular parts of the Kocioł Łomniczki glacial cirque and species exclusively occurred in there

Eastern wall	Southern wall	Western wall	Bottom
53 / ex. 4	78 / ex. 14	51 / ex. 8	59 / ex. 6

30 species showed wide distribution within the cirque – they were recorded in all the parts and 17 species were noted in three of the parts. Occurrence limited to one wall or bottom showed 32 species, including 21 sporadical (Table 2).

Among species widespread within the cirque some occurred with different frequency on the particular walls. Such species as: *Racomitrium lanuginosum*, *Diobelonella palustris*, *Philonotis seriata*, *Polytrichum juniperinum*, *P. piliferum*, *Sphagnum russowii*, *Oligotrichum hercynicum*, *Codriophorus fascicularis*, *Buclandiella sudetica*, *Orthodicranum montanum*, *Rhizomnium magnifolium* had most of the stations situated on the southern wall while *Buckiella undulata*, *Rhytidiadelphus loreus* and *Sciuro-hypnum starkei* – on the eastern wall. Quoted species are stenotopic and they show narrow ecological or phytocoenotical amplitudes (Dierssen 2001).

CONCLUSIONS

1. Bryophyte layer of the Kocioł Łomniczki glacial cirque is dominated by the 19 mosses species (19% of total moss-flora) widespread within the whole range of altitude and exposition, as well as in the majority of plant communities but some visible differences in species richness and frequency among particular walls of the cirque, patches of various plant communities and substratum types were recognised and documented.

2. Altitudinal span of 300 m which comprises two vegetation zones weekly influences mosses distribution within the Kocioł Łomniczki glacial cirque – 60% of the species occurred in the whole altitudinal range and among the 16 species noted only above the limit of upper mountain forest belt a half are widely distributed also in lowlands.

3. It seems the moss distribution within the cirque quite well reflects the differentiation of vegetation cover which resulted mostly from the variety of water conditions – 25 species occurred exclusively in patches of hygrophilous communities.

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