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# BRYOPHYTES OF THE GLACIAL CIRQUES IN THE GIANT MOUNTAINS AND HRUBÝ JESENÍK MTS. (THE CZECH REPUBLIC)

## Mechorosty krkonošských a jesenických karů (Česká republika)

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Preliminary results of the comparative inventory survey of the glacial cirques in the High Sudetes show that the localities have extraordinarily rich bryophyte flora, totalling recently between ca 210 and 320 species, with the historical evidence of further 10 to 20 % non-retrieved taxa. The only relatively species-poor site are the Sněžné strže ravines that despite sharing some geomorphological similarities with the cirques including the avalanche action do not have the comparable extent of suitable (micro)habitats where the competitive ability of vascular plants is hampered enough. The proportion of threatened taxa and their microlocalities seems to follow the species numbers, further enhancing the differences among localities.

Předběžné výsledky srovnávacího inventarizačního průzkumu ledovcových karů Vysokých Sudet potvrzují mimořádně bohatou bryoflóru, čítající v současné době mezi ca 210 a 320 druhy, s dalšími 10 až 20 % historicky udávaných nepotvrzených údajů. Jedinou druhově chudší lokalitou jsou Sněžné strže, které přes určité geomorfologické podobnosti s kary včetně výskytu lavin nemají dostatečný rozsah vhodných (mikro) stanovišť s omezenou kompetiční silou cévnatých rostlin. Podíl ohrožených druhů a jejich mikrolokalit vcelku přesně kopíruje celkové počty druhů, a dále zvýrazňuje rozdíly mezi lokalitami.

**Keywords:** bryoflora, Giant Mts., Hrubý Jeseník Mts., glacial cirques, threatened
**Klíčová slova:** bryoflóra, Krkonoše, Hrubý Jeseník, ledovcové kary, ohrožené

## INTRODUCTION

The glacial cirques in the Czech part of the High Sudetes are well-known centres of floristic diversity for a variety of reasons. The major ones obviously include high substrate diversity and dynamics, which

prevents dominants from forming species-poor alpine meadows, heaths or dwarf pine growths. The substrate diversity need not necessarily mean the various types of rocks (some of the cirques have been formed in pure granite) but rather the number of niches formed by the micro-relief shapes. The high dynamics is supported by the steep sloping of cirque faces, richness of water sources and the common avalanche action that helps the slopes remain unforested at below-tree limit altitudes. In 2001–2003, we have surveyed the bryoflora of three cirques in the Giant Mts. and three cirques or similar but less geomorphologically developed concave-shaped slopes in the Hrubý Jeseník Mts. Though historically relatively well-known, this was the first systematic survey of all localities, aimed at the complete inventory, supplemented by recording of at least basic demographic and empirically-ecological data for selected ca 40 rare and threatened species. In total, nearly 200 man days have been spent in the field by the authors, which on one hand makes this survey perhaps the largest and most comprehensive historical bryofloristic project but on the other hand, still has not enabled to cover more than some 1–5 % of the cirque area.

## DESCRIPTION OF THE LOCALITIES

In the Giant Mts., the studied localities were the double cirque at Kotel Mt., the cirque face of the Labský důl valley (encompassing several more or less developed cirques and rocky faces) and Úpská jáma cirque. In the Hrubý Jeseník Mts., we studied the cirque of 'Velká kotlina' at Vysoká hole Mt., the 'Malá kotlina' at Velký Máj Mt. and 'Sněžné strže' ravines at Červená hora Mt. The sites differ of course in many aspects, such as the size, geomorphological shaping, type of rock, aspect etc. but all share the placement in one geographic region (the farthest line connecting the two westernmost and easternmost cirques is about 145 km, and the southernmost locality lies about 80 km more to the south than the northernmost one) at a very similar altitude, with the bottoms of the cirques in the upper montane belt and the faces in the subalpine belt. The Sněžné strže ravines are somewhat odd among the other localities, as it is not a cirque but rather shallow ravines with eastern aspect, sharing however the avalanche action with the rest of localities, which prevents the dense forestation of the slopes. The main features are summarized in the following table:

**Tab. 1.** Main features of studied localities and extent surveyed area.
Hlavní charakteristiky studovaných lokalit a rozsah studované plochy.

| Locality | Coordinates | area (ha) | altitudinal span | major aspects of the cirque faces | major geol. substrates | man days spent | surveyed area (%) |
|---|---|---|---|---|---|---|---|
| Cirques of Kotel Mt. | See next row | 60 | 1120–1400 | SE to SW | mica schist, granite, erlan, limestone | 41 | 3,4 |
| dtto including the slopes of Kotel Mt. above the cirque face | 50°45'N, 15°32'E | 90 | 1120–1435 | – | dtto | 45 | 2,5 |
| Cirques of Labský důl | 50°46'N, 15°33'E | 105 | 1030–1340 | NNE to SE | granite | 27,5 | 1,3 |
| Úpská jáma cirque | 50°44'N, 15°43'E | 80 | 1050–1500 | NE to SSW | granite, gneiss | 34,5 | 2,1 |
| Sněžka Mt. | 50°44'N, 15°45'E | 35 | (1420)–1600 | – | mica schit | 5,5 | 0,8 |
| Sněžné strže | See next row | 9 | (1050)–1300 | ENE to ESE | phyllite (acid), gneiss | 10 | 5 |
| dtto including the slopes of Červená hora Mt. above the ? ravines | 50°09'N, 17°08'E | 12 | (1050)–1330 | – | dtto plus base-richphyllite | 13 | 5,4 |
| Malá kotlina cirque | 50°02'N, 17°13'E | 19 | (1100)–(1370)–1450 | ESE to S | phyllites, acid anabase-rich | 20,5 | 5,4 |
| Velká kotlina cirque | 50°03'N, 17°14'E | 41 | 1120–(1310)–1370 | E to S | mixture of base-richand acid schists, mostly phyllites | 45 | 5,5 |

The localities in the Giant Mts. generally reach higher up into the subalpine belt (the limit of the alpine belt is around 1500 m), the uppermost parts (>1300–1350 m) of the localities in the Hrubý Jeseník Mts. are, on the other hand, densely covered with bilberry heaths or dwarf pine growths as a result of milder conditions caused by gentle sloping; these parts have not been surveyed by us at all. The aspects of all our localities are similar, covering on average around 90° with the axis heading toward southeast. The geological substrates are nearly invariably acidic only in the Labský důl, at Sněžka Mt. and in the Sněžné strže ravines, the other localities have a mixture of acidic and slightly base-rich rocks; only in the Velká kotlina cirque the acidic substrates are in apparent minority but even here the schists are only moderately basic.

## METHODS

The floristic methods were essentially the same as those of Kučera & Buryová 1999 with some improvements. The major localities have been split into study sites according to prominent geomorphologic features (most often broader surroundings of smaller streams and ravines). The size of the study sites was thus quite variable, depending mostly on the degree of geomorphologic homogenity; the longer dimension of a site has not exceeded ca 500 m but the width of the studied swath oscillated between ca. 30 and 200 m. The study sites are shown in Figs. 1.–2.

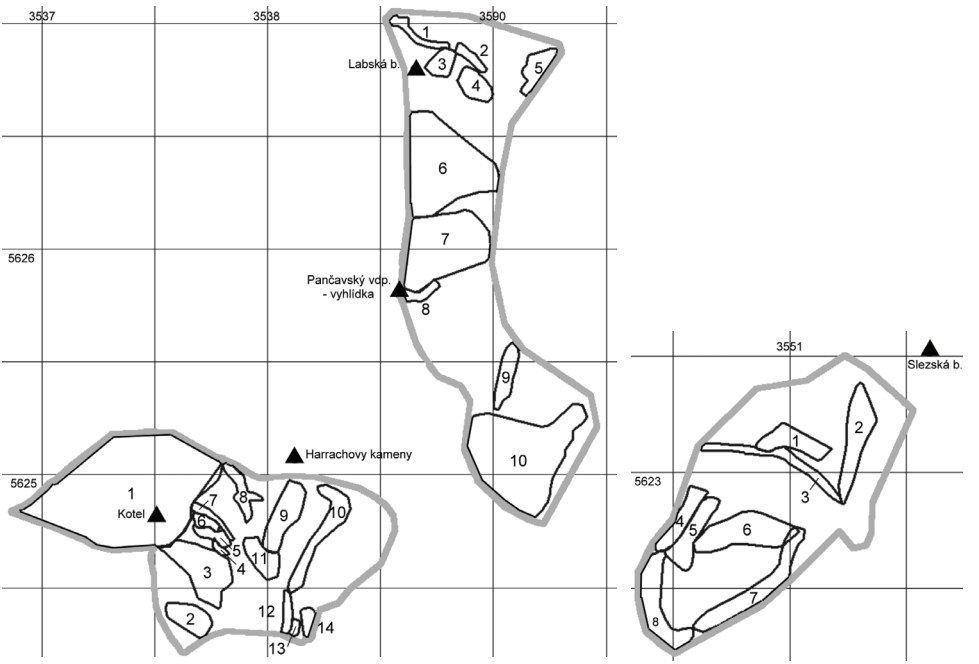



**Fig. 1.** Study sites of the Giant Mts. The coordinates shown are the grid of S-1942 in M33 zone (mesh=500 m).

**Obr. 1.** Studované 'mezolokality' Krkonoš. Souřadnice (po 500 m) jsou zobrazeny v systému S-1942, pásu M33.

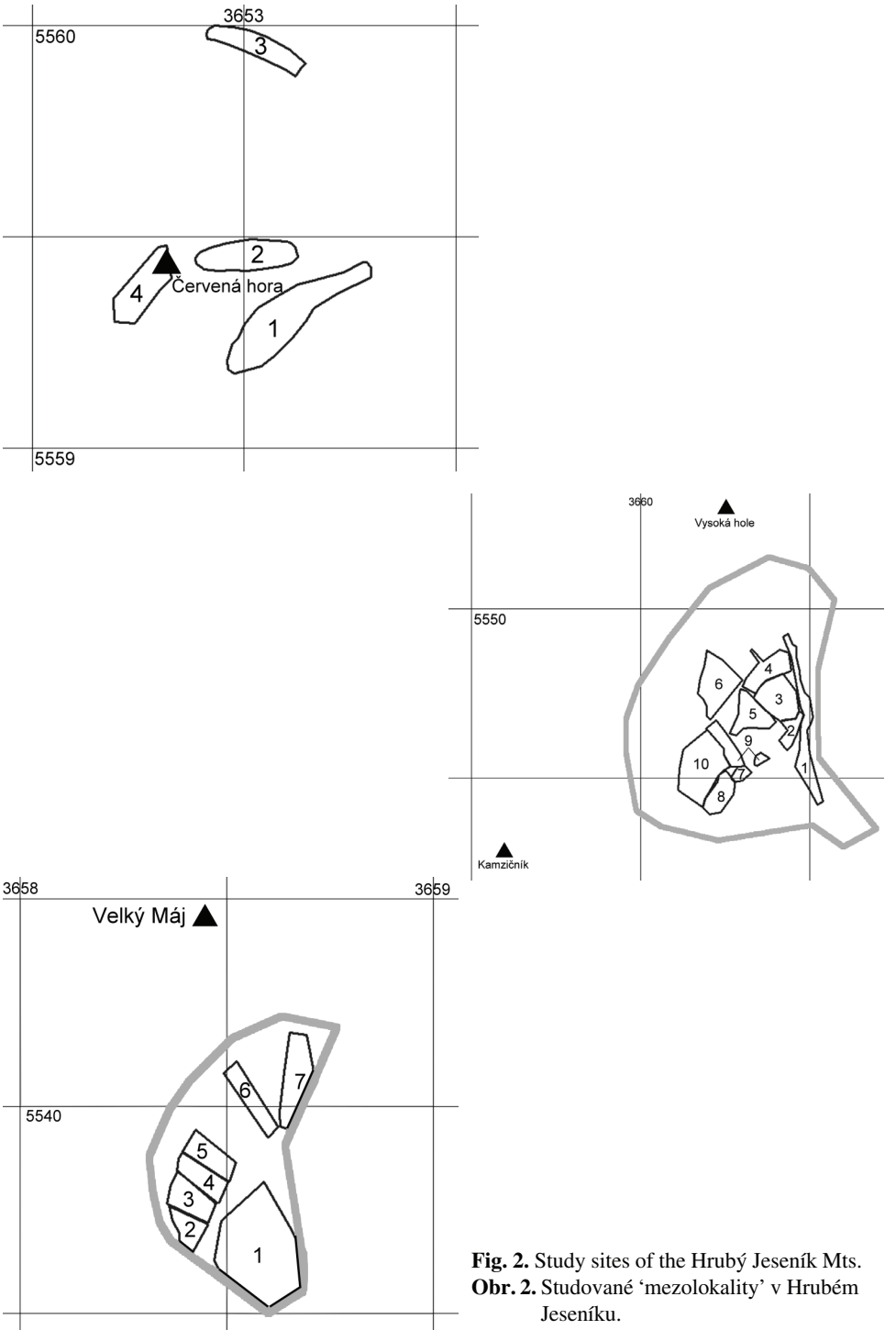


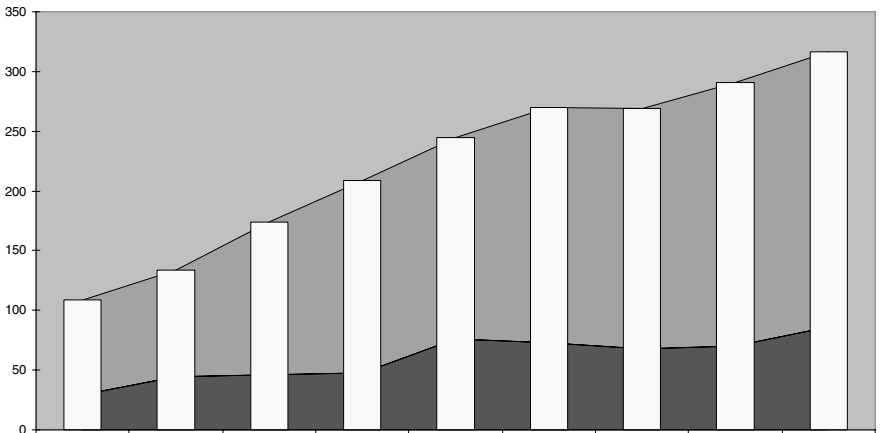

**Fig. 2.** Study sites of the Hrubý Jeseník Mts.
**Obr. 2.** Studované ‘mezolokality’ v Hrubém Jeseníku.

Each site has been surveyed by the whole group when possible (usually the group consisted of three or four), mostly during the whole day, each bryologist noting the bryophytes in his own recording card (with exception of the 2001 data when only one card per site was written). Intentionally collected were only bryophytes, which could not be identified in the field with certainty or which herbarium record was felt to be useful, observing that no population was endangered by the amount of collected material. All important finds have been localized using the handheld GPS devices (Garmin Etrex, Geko and GPS12 series), the co-ordinates and altitudes have been corrected using the projection on raster maps in the scale 1:10 000, which enabled the accuracy of ca 5–20 m. For each recorded species, empirical ecological data have been noted, as well as the presence of sporophytes, perianths and gemmae for each species was noted and the relative frequency at the site estimated. Nomenclature in the text, as well as the Red List categories (IUCN ver. 3.1), correspond to KUČERA & VÁŇA 2003.

## RESULTS

### 1. Species richness

The results for the main localities are summarized in the following graph (Fig. 1.). For purposes of comparison, the locality 'Sněžka Mt.' was added to show a different type of locality in similar conditions. The numbers include also several generally recognized infraspecific taxa but their number never exceeded some 2 %. The lists for the localities in Hrubý Jeseník Mts. are not yet closed but represent at least 95 % of the recorded species.




| | Mt Sněžka | Sněžné strže ravines | Mt Červená hora with the Sněžné | Malá kotlina cirque | Úpská jáma cirque | Cirques of Labský důl | Cirques of Mt Kotel | Mt Kotel with its cirques | Velká kotlina cirque |
|---|---|---|---|---|---|---|---|---|---|
| Mosses | 80 | 90 | 128 | 161 | 169 | 197 | 201 | 221 | 231 |
| Liverworts | 29 | 44 | 46 | 48 | 76 | 73 | 68 | 70 | 86 |
| Total | 109 | 134 | 174 | 209 | 245 | 270 | 269 | 291 | 317 |

**Fig. 3.** Species numbers for the whole studied localities.
**Obr. 3.** Počty druhů na celých studovaných lokalitách.

The differences in the species richness are rather great but it is very difficult to compare these numbers, as they are not merely a reflection of the site richness, but to a large extent also of the survey density and area. The floristic richness is of course not evenly distributed. If we get closer into the

localities, inspecting the numbers at the individual study sites, we can perhaps obtain a more precise reflection of the site richness, although even here the number of man days on the survey and the site area differed markedly. The following graphs show the results for the sites; for the localization, see the maps on Figs. 1.–2.

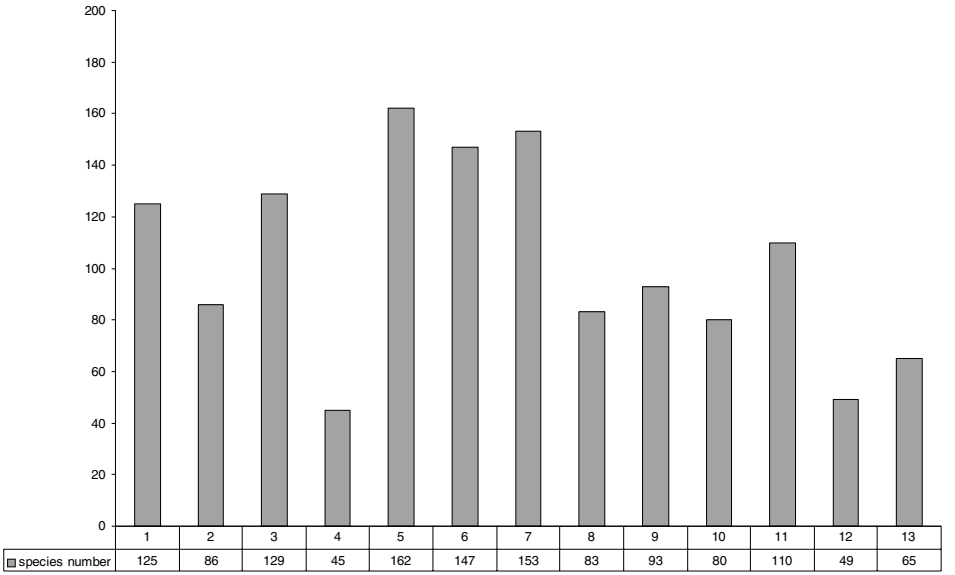



**Fig. 4.** Species numbers of particular study sites within Kotel Mt.
**Obr. 4**. Počet druhů na 'mezolokalitách' v rámci lokality Kotel.

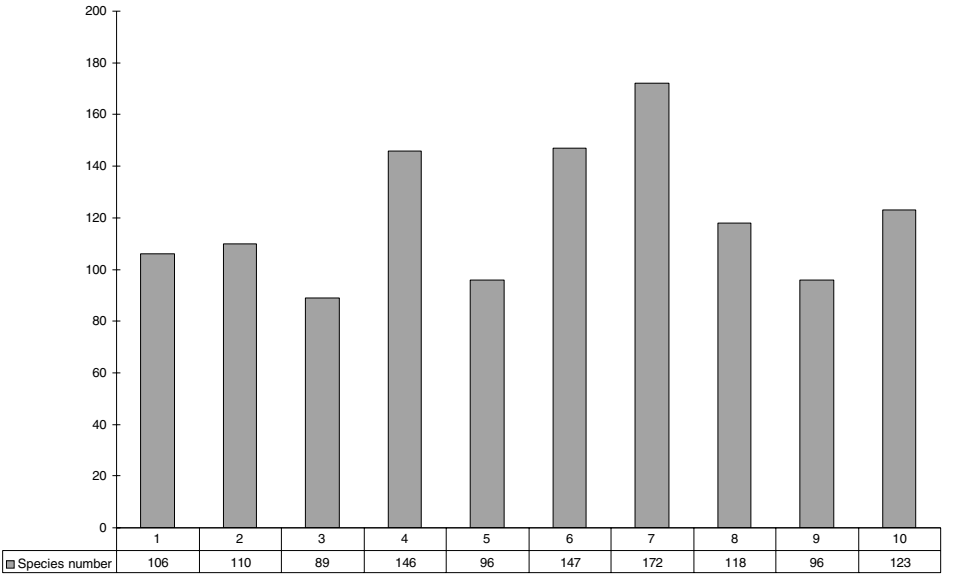



**Fig. 5.** Species numbers of particular study sites within the cirques of Labský důl.
**Obr. 5.** Počet druhů na 'mezolokalitách' v rámci lokality Labský důl.

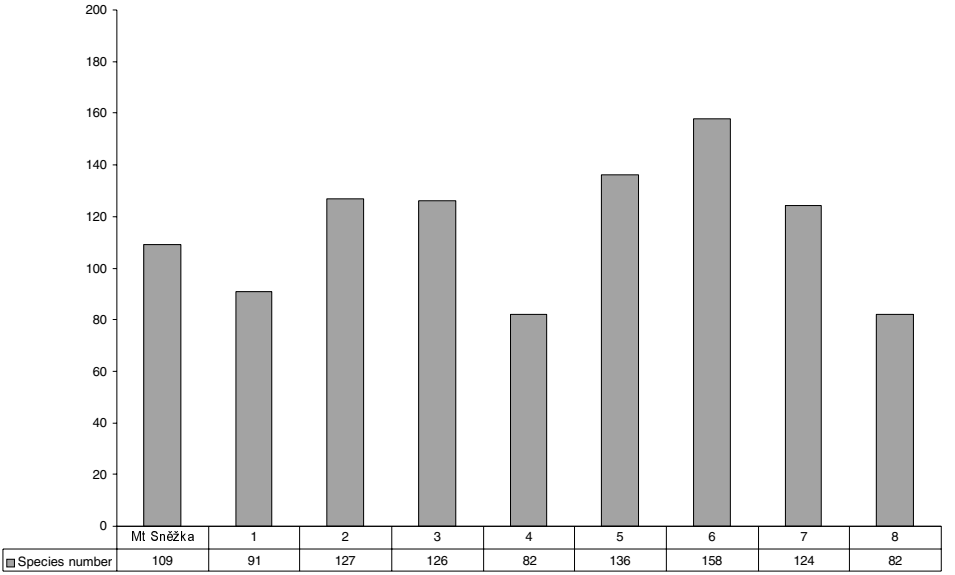



**Fig. 6.** Species numbers of particular study sites within the Úpská jáma cirque and Sněžka Mt.
**Obr. 6.** Počet druhů na 'mezolokalitách' v rámci lokality Úpská jáma a Sněžka.

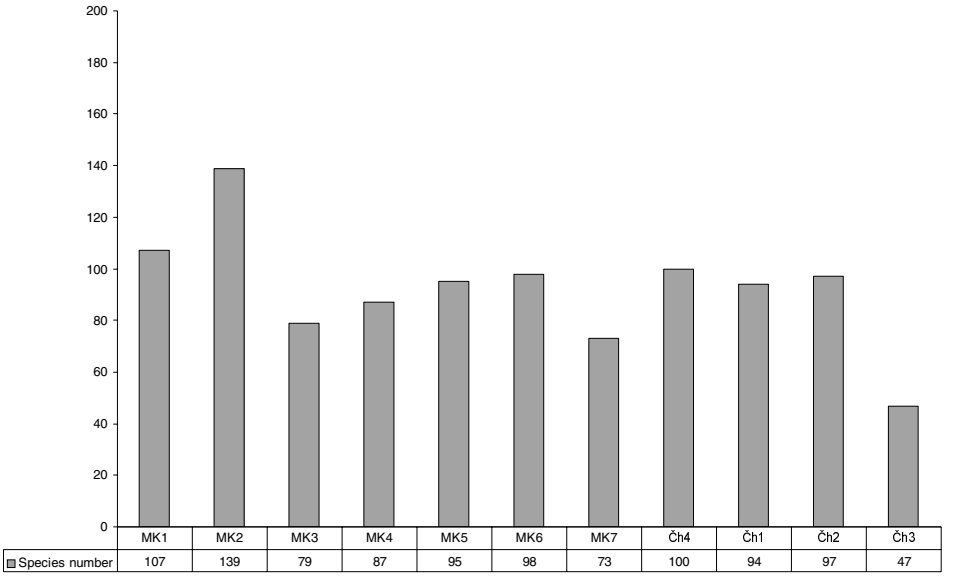
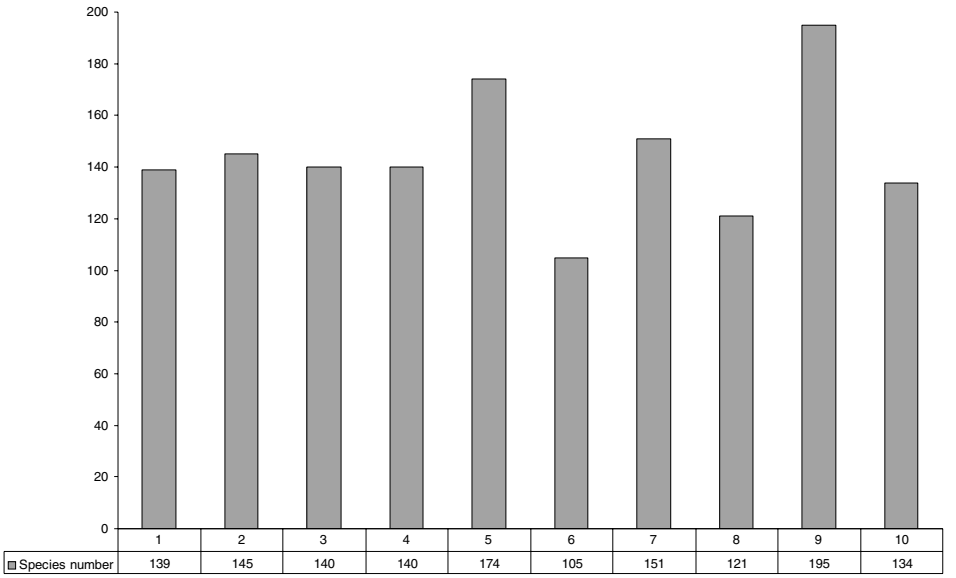


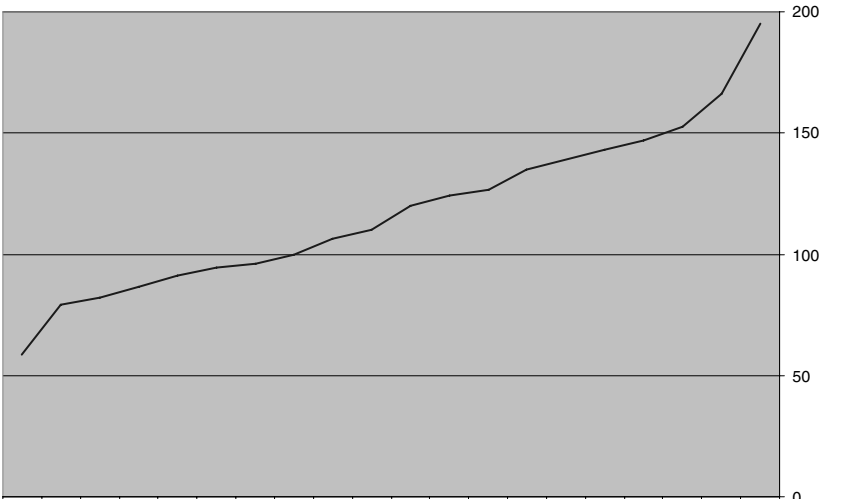

**Fig. 7.** Species numbers of particular study sites within the cirque and Sněžné strže ravines.
**Obr. 7.** Počet druhů na 'mezolokalitách' v rámci lokalit Malá kotlina a Sněžné strže.




| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| Species number | 139 | 145 | 140 | 140 | 174 | 105 | 151 | 121 | 195 | 134 |

**Fig. 8.** Species numbers of particular study sites within the Velká kotlina cirque.
**Obr. 8.** Počet druhů na 'mezolokalitách' v rámci lokality Velká kotlina.

The average site of some 100–200 metres length on average hosts about 110 bryophyte species (75 % of sites are support within 91 and 139 species, see Fig. 9.), although there are extreme localities with less than 50 or more than 160 species at the similar area. The extremes have however been enlarged by the number of man days spent or the area, given to a large extent by the attractiveness of the site.

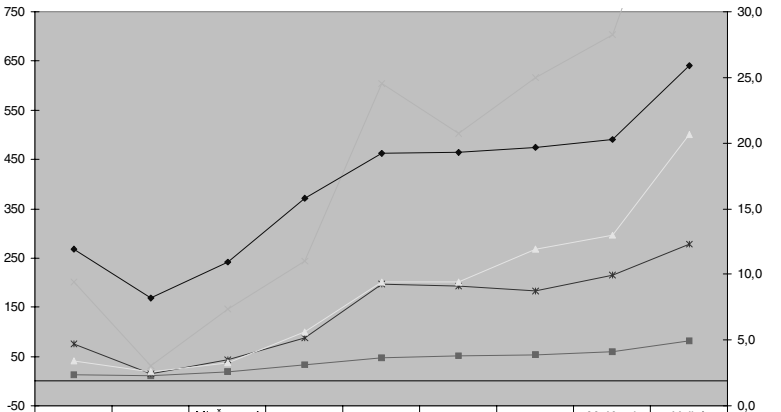



| percentils | 0,05 | 0,10 | 0,15 | 0,20 | 0,25 | 0,30 | 0,35 | 0,40 | 0,45 | 0,50 | 0,55 | 0,60 | 0,65 | 0,70 | 0,75 | 0,80 | 0,85 | 0,90 | 0,95 | 1,00 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| species number | 58,6 | 79,2 | 82 | 86,4 | 91 | 94,6 | 96,2 | 99,6 | 106 | 110 | 120 | 124 | 127 | 135 | 139 | 143 | 147 | 153 | 166 | 195 |

**Fig. 9.** Percentiles for numbers of taxa found within the study sites.
**Obr. 9.** Percentilový graf pro počty druhů na 'mezolokalitách'.

## 2. Endangered and other interesting elements of the flora

Before describing the threatened taxa, it is necessary to emphasize that the degree of threat posed to many of the taxa has to a large degree been estimated from the data acquired during this survey. Prior to the survey, only the preliminary Red Lists of the liverworts and hornworts (VÁŇA 1993) and mosses (VÁŇA 1995) existed. The collected data helped to re-estimate the degree of threat in taxa, having their main distribution centre at the studied localities – these results are included in KUČERA & VÁŇA 2003. The numbers of threatened taxa in the categories according to IUCN (2001) are listed and shown in the following graph.




| | Mt Sněžka | Sněžné strže ravines | Mt Červená hora with the Sněžné | Malá kotlina cirque | Úpská jáma cirque | Cirques of Labský důl | Cirques of Mt Kotel | Mt Kotel with its cirques | Velká kotlina cirque |
|---|---|---|---|---|---|---|---|---|---|
| sum threatened | 13 | 11 | 19 | 33 | 47 | 52 | 53 | 59 | 82 |
| weighted sum threatened | 76,5 | 14 | 43,5 | 87 | 198 | 194 | 182,5 | 216 | 277,5 |
| sum loc. threatened | 41 | 19 | 37 | 100 | 202 | 202 | 267 | 297 | 500 |
| weighted sum loc. threatened | 200,5 | 30,5 | 145,5 | 243,5 | 603,5 | 503 | 616,5 | 703 | 1139 |
| % threatened | 11,9 | 8,2 | 10,9 | 15,8 | 19,2 | 19,3 | 19,7 | 20,3 | 25,9 |

**Fig. 10.** Numbers of threatened taxa and their localities. Weighted sum has been calculated to assign larger impact to more threatened taxa, according roughly to the IUCN 3.1 quantitative criteria B, C and D applied during the Red List evaluation (IUCN 2001). The weight of one VU taxon has been equalled to 1, the LR and DD taxa equal to 0.5, EN=4 and CR=20.

**Obr. 10.** Počty ohrožených druhů a jejich lokalit. Pro zohlednění rozdílného významu jednotlivých kategorií ohrožení bylo uplatněno vážení kategorií , odpovídající přibližně kvantitativním kritériím B, C a D podle IUCN 3.1 (IUCN 2001). Váha jednoho taxonu kategorie VU byla nastavena na 1, potom LR a DD taxony váží 0.5, EN=4 a CR=20.

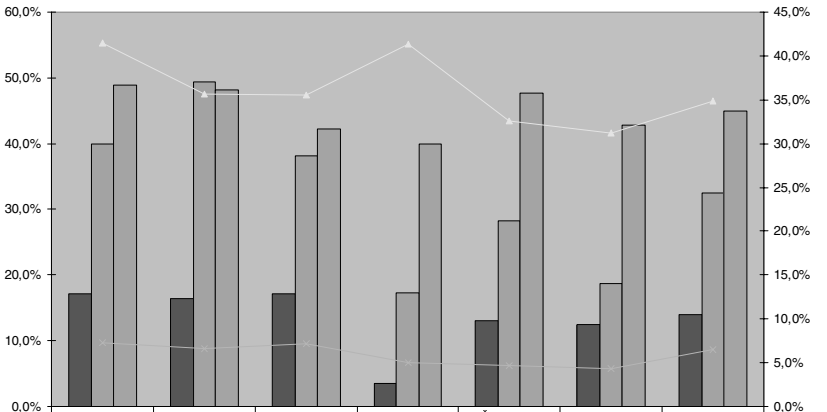
The numbers of threatened taxa quite precisely copy the overall number of taxa but further enhance the differences between poorer and richer localities. Even the percentages of non-weighted sums of threatened taxa at the localities increase with the species number. The only notable exception is Sněžka Mt., with a relatively low species number but higher percentage of threatened taxa, especially in the highest risk categories (the sum of weighted threatened elements nearly reaches the twice-as-species-rich cirque of Malá kotlina). The same pattern is visible in the numbers of indovidual microsites for threatened taxa and their weighted sum.

Among the new records particularly outstand the species recorded for the first time in the country – *Lescuraea patens*, *Isopterygiopsis muelleriana*, *Syntrichia norvegica*, *Pohlia nutans* subsp. *schimperi* (for more detailed account on these taxa, see KUČERA & al. 2003 and BLOCKEEL & al. 2003). It is

interesting that in the case of the first two newly recorded species those taxa have been for long generally known and accepted; this confirms how little the localities in fact have been historically surveyed, despite the numerous earlier accounts. Another interesting group of species that could be confirmed at the localities are those which have earlier (VÁŇA 1993, 1995) been regarded extinct (*Haplomitrium hookeri*, *Meesia uliginosa*, *Pseudoleskeella tectorum*) or have not been seen for more than 50, in some cases even more than 100 years (*Lophozia quadriloba*, *Anomobryum julaceum*, *Encalypta rhaptocarpa*, *Hypnum callichroum*, *Isopterygiopsis pulchella*, *Kiaeria falcata*, *Lescuraea mutabilis*, *L. radicosa*, *Mnium thomsonii*, *Tortula eucalyptrata* (=*Desmatodon latifolius*), *Warnstorfia pseudostraminea*; outside the cirques *Dicranum spadiceum* at Tabulové skály rocks and *Tortula mucronifolia* at Petrovy kameny rocks, both in the summit part of the Hrubý Jeseník Mts.).

## 3. Fertility and gemmae production

It is generally assumed that fertility is to certain degree associated with the health state of the populations. The connection is by no means straightforward, as it is perhaps most influenced by the humidity at the site but a slow process of dwindling sporophyte production over the time period of the say last two hundred years is obvious. Our data may thus be interesting for comparison in the future. The problem of comparison may however arise from the association with humidity, as there are great differences in the yearly means of precipitation; notably the year 2002 was extraordinarily wet in the growing season and 2003 was extremely dry (only very few data have however been recorded during 2003). In hepatics, where the sporophyte production is confined to a short time period, we noted the presence of perianths as well, which might signal the later or earlier production of sporophytes. Unfortunately, not all hepatics and no mosses form the perianths or other easily in the field detectable character of gamatangia-forming. The production of gemmae, on the other hand, is mostly species-specific; they are probably not formed as a response to the environmental conditions but maybe the comparisons in future prove different. The preliminary results are shown in Fig. 11.




| | Mt Kotel with its cirques | Cirques of Labský důl | Úpská jáma cirque | Mt Sněžka | Mt Červená hora with the Sněžné strže ravines | Malá kotlina cirque | Velká kotlina cirque |
|---|---|---|---|---|---|---|---|
| sporophytes livs. | 17,1% | 16,4% | 17,1% | 3,4% | 13,0% | 12,5% | 14,0% |
| sporophytes or per. livs. | 40,0% | 49,3% | 38,2% | 17,2% | 28,3% | 18,8% | 32,6% |
| sporophytes mosses | 48,9% | 48,2% | 42,3% | 40,0% | 47,7% | 42,9% | 45,0% |
| gemmae livs. | 41,4% | 35,6% | 35,5% | 41,4% | 32,6% | 31,3% | 34,9% |
| gemmae mosses | 7,2% | 6,6% | 7,1% | 5,0% | 4,7% | 4,3% | 6,5% |

**Fig. 11.** Percentages of sporophyte-, perianth- and gemmae- forming liverworts and mosses.
**Obr. 11.** Podíl játrovek a mechů tvořících sporofyty, perianty a gemy.

The sporophyte production was recorded in 40–50 % of mosses and 13–17 % of liverworts (except for Sněžka Mt. where only one sporophyte-producing liverwort was recorded) but if we count the value of 'sporophyte or perianth' production in liverworts, the proportion of 'fruiting' liverworts rises to similar values (20–50 %) as in mosses. The values for sporophyte production in mosses are quite similar throughout all localities whereas in hepatics the localities of the Hrubý Jeseník Mts. and at Sněžka Mt. supported much less sporophyte and perianth production. The production of gemmae is again quite similar throughout the localities, and significantly higher in the liverworts.

## DISCUSSION

### Species composition

Fig. 12. shows the floristic similarity using the cluster analysis (presence-absence data of taxa were included). The results show the relative floristic proximity of the cirques within the Giant Mts.; all localities of the Hrubý Jeseník Mts. appear more distant. Interestingly, the similarity of the two nearby cirques of Velká and Malá kotlina is smaller than that of all localities in the Giant Mts. versus those of the Hrubý Jeseník Mts.; this is also reflected when the analysis is made with a different set of data that does not include the species of Kotel Mt. outside its cirques – then the Velká kotlina of Hrubý Jeseník Mts. and Kotelní jámy of the Giant Mts. fall within one cluster.

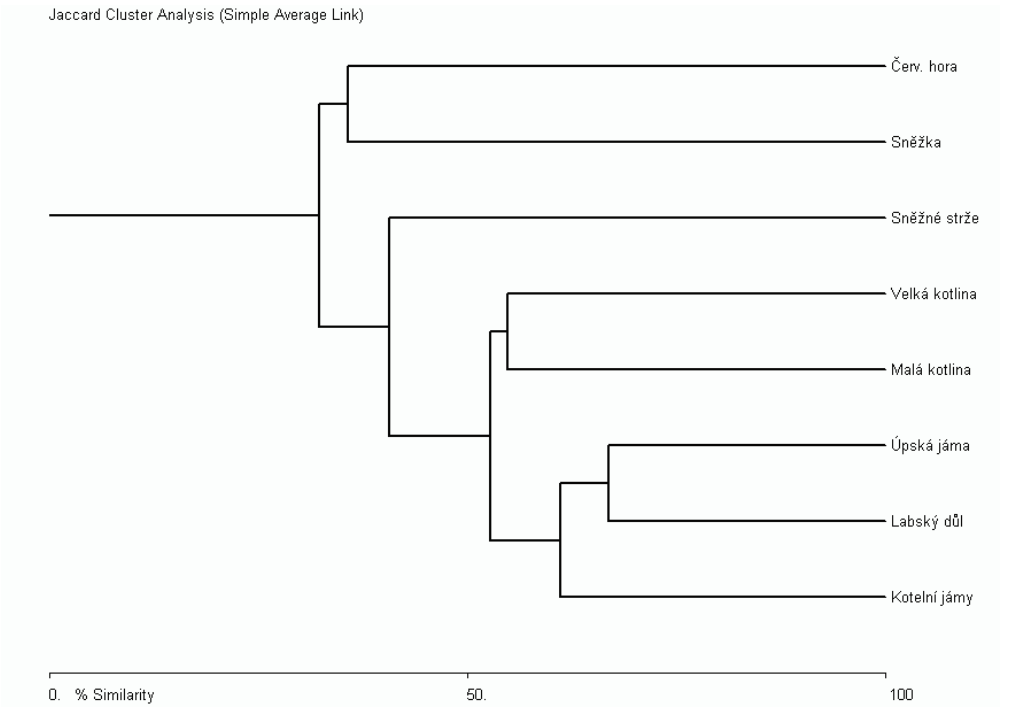


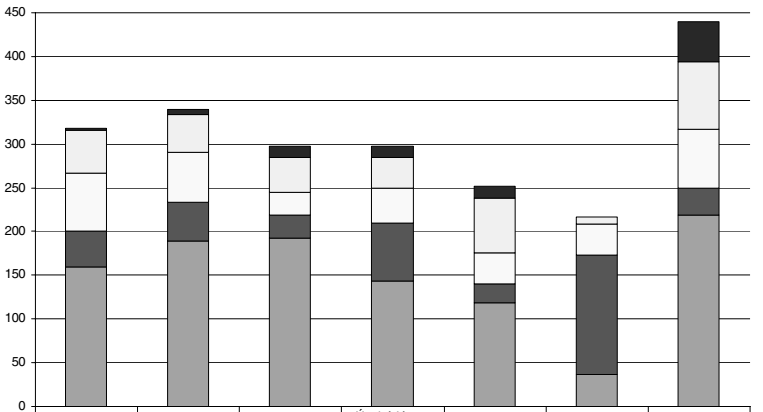

**Fig. 12.** Floristic similarity of studied localities as figured by the cluster analysis (average linkage, Jaccard's distance measure).
**Obr. 12.** Floristická příbuznost lokalit, zobrazená pomocí shlukovací analýzy (average linkage, Jaccardovy vzdálenosti).

## SPECIES RICHNESS

All sites, perhaps with the exception of Sněžné strže ravines, proved to be extraordinarily, and also comparably rich in bryophytes. The numbers of taxa by far exceed the usual number for even much larger areas. The richest site proved to be Velká kotlina in the Hrubý Jeseník Mts. (the final number will probably be still somewhat higher), closely followed by the sites at Kotel Mt., Labský důl and Úpská jáma, all in the Giant Mts. The other sites were gradually poorer, probably due to much smaller extent causing the small diversity of microsites and substrates. The presence of base-rich substrates is generally mentioned as a reason for high species diversity at both Velká kotlina of Hrubý Jeseník Mts. and Kotel Mt. of Giant Mts. Our data seem not to contradict this hypothesis (though it must be more precisely formulated to encompass the key reason of presence of *both* base-rich and acid substrata at both sites). However, we have proved that even the monotypic substrate can support a fully comparable species richness if the other key factors causing the high diversity are accomplished, i.e. the diversity of microhabitats and sufficent area of space where the competitive ability of vascular plants is diminished. The best example of this is the Labský důl valley, which, if surveyed in the same detail as the Velká kotlina, might prove to be the richest locality at all. On the other hand, the presence of base-rich substrata does not necessarily mean the high species diversity, as evidenced by the case of the Malá kotlina, where this advantage is diminished by the low geomorphological variability, smaller area and altitudinal span.

## HISTORICAL CHANGES

One of the most interesting results of floristic results is the comparison with earlier state. Unfortunately, this task is virtually unachievable without having similarly profound results from the history. Despite the large number of bryologists that have visited the localities and often even published their collections (the most important summaries having perhaps been those of Milde 1869, Limpricht 1876 and Šmarda 1952 but our literature search included more than 300 entries), none of the localities has been subject to systematic




| | Labský důl | Kotel | Úpská jáma | Úpská jáma, survey 98-00 included | Červená hora | Malá kotlina | Velká kotlina |
|---|---|---|---|---|---|---|---|
| Not retrieved, doubtful reports | 2 | 6 | 12 | 12 | 14 | 0 | 46 |
| Not retrieved | 49 | 43 | 40 | 35 | 63 | 8 | 77 |
| Found new | 67 | 57 | 26 | 40 | 35 | 35 | 68 |
| Found new but historical occ. likely | 40 | 45 | 27 | 67 | 22 | 136 | 30 |
| Confirmed occurrence | 160 | 189 | 192 | 143 | 118 | 37 | 219 |

**Fig. 13.** Numbers of confirmed and not retrieved taxa at the localities.
**Obr. 13.** Počty potvrzených a nenalezených taxonů.

survey (the only exception being perhaps the Úpská jáma cirque and Sněžka Mt. where KUČERA & BURYOVÁ (2001) made a similar, though much more limited survey in 1998–2000; no real changes can however be expected to occur within such a short time period). The summary of the present-time and historical data about the bryoflora of individual localities is illustrated in the following graph (Fig. 13.).

The graphs show that the percentage of confirmed historical species oscillates around 50 % of the total in the typical case. Two exceptions exist – one of the recently more deeply surveyed Úpská jáma cirque, where the confirmed occurrences account for two thirds and, on the other hand, the Malá kotlina in the Hrubý Jeseník Mts., historically completely neglected, with only 45 literature records. The new records account – again in typical case – for some 22 to 35 % of the flora, of which a significant part (between 30 and 80 %) however belongs to the common species that have earlier not been recorded in non-systematic surveys. Only 8 % of taxa have been found new in the recently surveyed Úpská jáma cirque (to show this difference, we present two bars for this locality – one with the previous survey included and another without it).

The number of not retrieved species varies between 14 and 31 % (beside the Malá kotlina cirque) but the higher percentages are perhaps still inflated by numerous doubtful records; subtracting them the not retrieved taxa account for between 13 and 26 %, of which sometimes larger proportion is composed by taxa occurring in the lower parts of the localities that have not been subject to present study. We would thus be able to push the percentages down to some 10 % of the flora in most cases, perhaps with the notable exception of the slopes of Červená hora Mt. where the anthropic pressure has been stronger in the past than on the rest of the localities. The non-retrieved taxa from all localities account for 226 taxa; an important part of them (ca. 30 %) belongs to either arctic-alpine or other high-montane elements (see Fig. 14.) that apparently retreat.

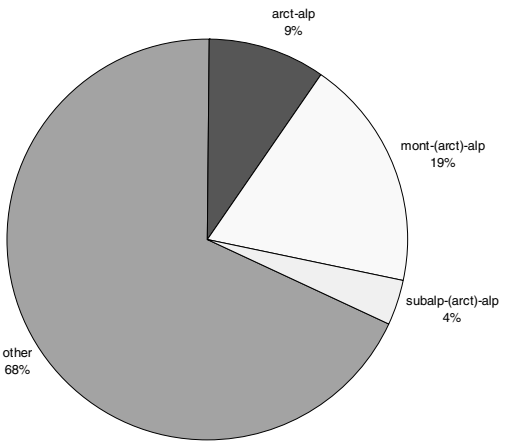



**Fig. 14.**
Proportion of alpine elements within the non-retrieved taxa. The 'other' elements mostly belong to montane and broad distributions.
**Obr. 14.**
Podíl vysokohorských prvků mezi nenalezenými taxony. Položka 'ostatní' zahrnuje převážně montánní a široké typy rozšíření.

The ecological groups of those mosses are rather broad, the majority belonging to epilithic and terrestric mosses. The generally retreating ones (epiphytes, epixylic species) constitute only about 12 %, which is caused mainly by the generally low proportion of these ecologic groups in the flora of the cirques.

## CONCLUSIONS

Glacial cirques of the Giant Mts. and Hrubý Jeseník Mts proved to be extremely rich localities in bryophyte species, hosting at each locality between 210 and 320 taxa except for the Sněžné strže ravines which however cannot be described as a glacial cirque. The total of all taxa recorded both historically and recently rises up to some 400 taxa in the Velká kotlina cirque and between 300–350 species for the other

historically better explored cirques (Úpská jáma, Kotel, Labský důl). This survey revealed a large number of new records – the addition to the known flora of the sites was between ca. 30 and 50 % (380 % in case of historically neglected Malá kotlina cirque). Unfortunately it confirmed also some losses; the non-retrieved taxa accounted for something between 15 and 25 % of the historically known flora, although some of the historical records have definitely been made outside the delimited study area or have been reported in error. Even so we have lost perhaps some 10 % of the historical richness caused perhaps by three major reasons: (1) gradual warming and consequential successional changes, mostly expansion of grasses or heaths, (2) catastrophic events like avalanche action that perhaps destroyed some of the spatially limited populations and (3) anthropic changes, at the study sites perhaps a direct destruction of populations rather than destruction of habitat, caused both by casual but too numerous visitors (Červená hora Mt., Petrovy kameny rocks) and the bryologists themselves picking out the most 'interesting' species and thus decimating the limited populations of threatened taxa.

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## SOUHRN

Výsledky inventarizačního bryofloristického průzkumu tří krkonošských ledovcových karů (Kotelních jam, karů Labského dolu a Úpské jámy) a tří karů nebo podobně utvářených lokalit v Hrubém Jeseníku umožnily poprvé srovnat jejich floristické složení, druhovou bohatost, výskyt ohrožených elementů a další charakteristiky. Inventarizace pomohla nově objevit mezi 30 a 50 % taxonů na lokalitách, mezi nimi i čtyři zcela nové pro naše území; kolem dvaceti druhů bylo nezvěstných více než 50 let. Postavení druhově nejbohatší lokality potvrdila jesenická Velká kotlina (ca 320 recentně prokázaných a historických přibližně 400 druhů), avšak rozdíl oproti krkonošským karům je menší, než vyplývá z historických údajů. Patrně nejbohatší krkonošskou lokalitou je Labský důl, kde bylo přes nižší počet dnů průzkumu potvrzeno stejné množství druhů jako v Kotelních jamách. Ústup druhů není vzhledem k charakteru historických dat možné zcela přesně kvantifikovat, ale jednoznačně byl v řádu ca 10 % prokázán a postihuje do značné míry druhy s vysokohorským charakterem rozšíření.

## REFERENCES

Blockeel T. L., Bednarek-Ochyra H., Czernyadjeva I. V., Draper I., Fudali E., Kučera J., Long D. G., Ros R. M., Ochyra R., Schumacker R., Smith V. R., Sollman P., Sotiaux A., Thingsgaard K. & Zmrhalová M. 2003: New national and regional bryophyte records, 8. Journal of Bryology, 25: 217–221.

IUCN 2001: IUCN Red List Categories and Criteria. Version 3.1. IUCN Species Survival Commission, Gland, Switzerland & Cambridge, UK. (ii + 30 pp.).

Kučera J. & Váňa J. 2003: Check- and Red list of the bryophytes of the Czech Republic (2003). Preslia, 75: 193–222.

Kučera J. & Buryová B. 2000: Bryofloristic survey of the summit region of the Eastern Krkonoše Mts. (Czech Republic). Opera Corcontica, 36: 105–132.

KUČERA J., HRADÍLEK Z., BURYOVÁ B. & HÁJEK P. 2003: Two additions to the moss flora of the Czech Republic – *Hypnum sauteri* Schimp. and *Lescuraea patens* Lindb. Preslia, 75: 255–262.
LIMPRICHT K. G. 1876: Laubmoose. In: COHN F. (ed.), Kryptogamen-Flora von Schlesien, J. U. Kern's Verlag, Breslau.
MILDE J. 1869: Bryologia Silesiaca. Arthur Felix, Leipzig.
ŠMARDA J. 1952: Mechorosty Hrubého Jeseníku. Přírodovědecký sborník Ostravského kraje, 13: 447–488.
VÁŇA J. 1993: Předběžný seznam ohrožených mechorostů České republiky I. Játrovky (Hepatophyta) a hlevíky (Anthocerotophyta). Preslia, 65: 193–199.
VÁŇA J. 1995: Předběžný seznam ohrožených mechorostů České republiky II. Mechy (Bryophyta). Preslia, 67: 173–180.