

VARIABILITY AND DISTRIBUTION OF *DITRICHUM FLEXICAULE* SENSU LATO IN THE CZECH AND SLOVAK REPUBLICS

VARIABILITA A ROZŠÍŘENÍ MECHU *DITRICHUM FLEXICAULE* SENSU LATO
V ČESKÉ A SLOVENSKÉ REPUBLICE

IVAN NOVOTNÝ

Abstract

Novotný, I., 1997: Variability and distribution of *Ditrichum flexicaule* sensu lato in the Czech and Slovak Republics. *Acta Mus. Moraviae, Sci. nat.*, 81(1996):157-192 (with Czech summary).

The variability, fructification and distribution of the moss *Ditrichum flexicaule* s. l. in the Czech and Slovak Republics is evaluated. Methods of multivariate analysis were used in the evaluation of variability.

Key words: Mosses, multivariate analysis, *Ditrichum gracile* (Mitt.) Kunze, fructification.

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Introduction

Ditrichum flexicaule s. l. is a variable taxon distributed over almost all the world. Frisvoll (1985) reports this complex from the following territories (according to Index Muscorum Wijk & al. 1962): Europe, North America 1, Central America 2, Asia 1, Asia 2, Asia 4, Australia 2.

In the Czech and Slovak Republics, two groups can be distinguished within this collective species. Besides *D. flexicaule* (Schleich. ex Schwaegr.) Hampe there is another conspicuous taxon. At present, according to Allen et al. (1994), this taxon should be named *D. gracile* (Mitt.) Kunze, described from Ecuador (= *D. crispatissimum* (C. Müll.) Par.). The taxonomy of the whole group has been treated by Frisvoll (1985).

Crum & Anderson (1981) report that *D. flexicaule* shows exceptional variability, and they furthermore write that at the extremes of development, several habitat responses have been recognized. Small plants with small leaves and only slightly excurrent costae have been called the var. *densum* (BSG) Braithw., and a form with even smaller leaves is called the var. *densum* fo. *brevifolium* (Kindb. ex Macoun) Grout. The var. *densum* frequently produces stout erect "flagelliform" branches; to this form the name fo. *estellae* Habeeb can be applied. Robust plants with long, loosely flexuose, and more or less twisted leaves with long excurrent costae have been called *D. giganteum* Williams and *D. flexicaule* fo. *sterile* (De Not.) Smirn.

According to Tuomikoski & al. (1973), *Ditrichum giganteum* appears to be distinct from *D. flexicaule*, 'judged from the growing immixed'. From our experience in the

Canadian Rockies and many other places, we have drawn just the opposite conclusion and have related all differences in size, appearance, and microscopic detail to conditions of growth (especially shade and moisture)." Duell (1992) also prefers evaluation of *D. crispatisimum* (= *D. gracile*) at the variety level only.

Frisvoll (1985), having evaluated taxonomically the whole collective taxon *D. flexicaule* s. l., conceives *D. crispatisimum* (C. Müll.) Par. (= *D. gracile*) on the species level. More recently, after Frisvoll's evaluation, the species was studied by Casas & al. (1990, 1992) in the Iberian Peninsula and the adjacent islands, and by Smith (1993) in Great Britain and Ireland. Smith (1993) writes of this taxon: "Although most specimens are easily identifiable, *D. flexicaule* and *D. crispatisimum* are poorly defined on a par with species such as *Racomitrium heterostichum* and *R. affine* or *Ulota bruchii* and *U. crispa*."

The taxonomy of this group is difficult, in the first place because the ecological amplitudes of the two taxa overlap. *D. gracile* is apparently a relatively young taxon and is separated from *D. flexicaule* s. s. by a barrier which probably shows different intensity in different parts of its range, in depending on the ecological condition in each region.

This paper is part of a treatment of the genus *Ditrichum* Hampe in the region under study. Its purpose is also to evaluate and illustrate the variability of the taxa under study, using multivariate analyses. On the basis of a study of available herbarium material, the distribution in the region under study is also evaluated. Both species are comprehended as a poorly-defined species, as there exist some transitive forms between them, even if most specimens are easily identifiable.

Material

The results presented here are based on a study of herbarium specimens from the collections of BRA, BRNM, BRNU, CB (one specimen), LIT, OLM, OP, PL, PRC and those from private herbariums of B. Buryová (herb. BUR), RNDr. Z. Hradilek (herb. HRA), Z. Pilous (herb. ZP), and Prof. Dr. J. Váňa, DrSc. (herb. VAN). It was impossible to borrow material from the herbarium SLO for the necessary studies.

In herbarium specimens the term mixed "population" is given in quotation marks, as it only pertains to dead plants which have only been studied morphometrically. In the case of material included in multivariate analyses, the numbers of the respective samples are printed in boldface type in the list of localities. The multivariate analyses also included a number of specimens coming from territories other than the study region. These are listed in Table 2.

Methods

In order to understand the boundary between the two taxa within *D. flexicaule* s. l., it was necessary to carry out a morphometrical analysis. The use of multivariate methods in the evaluation of such series has been summarized, e. g., by Podani (1994). For the morphometrical analysis, I selected at random 95 specimens, coming mostly from the Slovak and Czech Republics. Ten such specimens came from other territories (see Table 2). Within this series, I also evaluated duplicate specimens deposited in various herbariums. In all, I have measured 29 duplicate specimens belonging to 13 "populations" from 13 localities.

The morphometrical analyses involved 7 characters which have also been used by other authors to separate the two taxa, and which are practically possible to evaluate in each specimen. They are the following: absolute number of hyaline cells at the edge of leaf base (hyacel); curvature of cell wall at leaf base near costa (curvat), using a 1-3

scale (straight, intermediate, curved); absolute length of leaf (leafle) in mm; awlness of leaf (awlness), using a 1–3 scale (not awl-shaped, intermediate, awl shaped); length ratio of cells on costa: cells on leaf edge in its awl-shaped part (shorte), using a 1–3 scale (longer on costa, intermediate, shorter on costa than on edge); denticulation of leaf tip (tootne), using a 1–4 scale (1 = not toothed, 4 = most toothed); absolute breadth of tip at a distance of 35 μm . The values of each of these characters were determined three times and averaged for the multivariate analyses. The metric characters include hyacel, leafle, and tipbre. Ordinal scale was used to estimate the curvat, awlness, shorte and tootne. Such a series, common in taxonomic studies, in which characters are estimated using various scale types, can be termed mixed data.

Two methods of multivariate analysis have been used to evaluate the data obtained:

1. First the principal component analysis (PCA) was used (Fig. 3) (ter Braak 1987). The method is based on correlation matrices. The individual samples were ordinated by means of this method. However, the use of this method is not quite correct, as it presumes that most characters show normal distribution. This, however, can only be presumed in the series under study for three of the seven characters measured (leafle, tipbre, hyacel). Using the PCA, however, the series was divided into two groups corresponding to my evaluation, those samples that were subjectively evaluated as transitive lying more or less between the two groups. The PCA has also made it possible to estimate the significance of the characters mentioned above (hyacel, curvat, leafle, awlness, shorte, tootne, tipbre).

2. Second, the principal co-ordinate analysis (PCoA) was carried out (Figs. 4, 5), performed by the PRINCOOR programme from the SYN-TAX 5.0 parcel (Podani 1994) using the Gower coefficient. This method is earmarked for mixed data and thus can be considered to be quite appropriate for the case of the series under study. By means of this programme, I have obtained the co-ordinates of the particular samples on three axes. Fig. 4 shows the plots of these points on the base level. For both taxa, this figure shows only the visible samples, the intermediate types (rings) and the boundary separating them.

3. A dendrogram has also been constructed (Fig. 6) with the use of the Gower coefficient and the average linkage clustering method. The dendrogram clearly shows the position of all samples under study. Various letters have been used to indicate duplicate specimens from the same "population". Dashes denote transitive samples.

In 20 specimens included in multivariate analyses, also the axillary hairs were evaluated (Fig. 7). I measured their length (μm) and determined the number of cells that formed them. On the basis of results obtained from the PCoA, the specimens were classified under either taxon. The t-test was used to compare the mean lengths of axillary hairs in the two series. The specimens belonging to the intermediate series were not evaluated.

Since the fructification of the taxa under study may differ in different regions, it is important to estimate the fructification of the two taxa. Data on the percentages of fertile specimens of *D. flexicaule* are based on all herbarium specimens except those deposited in BRA, OP and LIT. In the region under study, *D. flexicaule* is more frequently fertile, and thus the approximate value of percentage of specimens which developed sporogons is sufficiently significant. In the study region, *D. gracile* is only exceptionally fertile, and I have evaluated all known fertile specimens from that region.

The localities in the Czech Republic are listed according to the phytogeographic division of Skalický (1988), those in Slovakia according to Futák (1980). Within individual districts the localities are arranged chronologically. In case a taxon was

repeatedly collected in a locality, this locality is included according to the earliest finding. The localities are indicated in cartograms by separate symbols only if they are more than 3 km apart. The central European mapping grid is included for better orientation (cf. Slavík 1986).

Tab. 1. Comparison of *D. flexicaule* and *D. gracile*, with emphasis on gametophytic characteristics (modified according to Frisvoll 1985).

Character	<i>Ditrichum flexicaule</i>	<i>Ditrichum gracile</i>
Robustness and size (Table 1, 2: C, B)	usually the smaller of the two, usually not robust, (0.5) 1–5(–6)cm	usually the larger of the two, usually robust, (3)4–7.5 cm
Colour	usually dull green or brownish green	usually glistening yellowish-green or golden
Tomentum (Table 1, 2:A)	stems often densely matted with red-brown tomentum, but slightly tomentose tufts occur	usually less tomentose and the cushions looser, but rather densely tomentose tufts occur
Leaves, orientation when dry (Table 1, 2:A, B)	subulae rarely spirally twisted together, rarely falcate, not secund	subulae often spirally twisted together, often falcate, sometimes secund
Leaves, length (Table 1, 2:C)	relatively short, \pm 3 mm	relatively long, 4–7 mm
Leaves, (Table 1, 2:C)	from base rather suddenly narrowed into a comparatively short subula	lamina more gradually tapering towards a comparatively long subula
Leaves, dentation of subula (Table 1, 2:D)	none or a few small teeth at the extreme apex, rarely more denticulate	frequently spinulose-denticulate at the apex and minutely denticulate for quite a distance down the margin, sometimes almost entirely
Costa, appearance and delimitation (Table 1, 2:E)	dorsally convex and well-defined towards the lamina	less dorsally convex and ill-defined
Costa, dorsal cells (Table 1, 2:G)	usually longer than the adjacent laminal cells	usually shorter than the adjacent laminal cells
Cells of the leaf base, structure (Table 1, 2:F)	isodiametric	or shortly rectangular with straight to slightly curved walls
Cells of the marginal border of the leaf base (Table 1, 2:F)	relatively short and thick-walled, usually distinctly marked towards the inner laminal cells in (0) 1–2(3) rows	narrow, elongate and frequently pseudohyaline, usually less marked towards the inner cells in (1)2–4 rows

Key distinction of the two taxa can be made as follows:

- a) Plants more robust, leaves 4–7 mm long, subulate, spirally twisted when dry, denticulate at the apex, dorsal costal cells on the upper part of the leaf usually shorter than the adjacent laminal cells. Cells of the leaf base usually elongate with curved walls. Cells of the marginal border of the leaf base narrow, elongate and frequently pseudohyaline.

Ditrichum gracile

- aa) Plants smaller, leaves \pm 3 mm long, subulate, no denticulation at the apex, dorsal costal cells in the upper part of the leaf usually longer than the adjacent laminal cells. Cells of the leaf base isodiametric, or shortly rectangular with straight to slightly curved walls. Cells of the marginal border of the leaf base relatively short and thick-walled.

Ditrichum flexicaule

Results

Fig. 1 shows a typically developed *D. gracile* plant and details. The same parts of a typically developed *D. flexicaule* plant are shown in Fig. 2. The differences between these two taxa are shown in Table 1.

Fig. 3 shows the results of the PCA. The transitive forms, indicated by crosses (problematical samples by slanting dashes) lie between *D. flexicaule* (*D. f.*) and *D. gracile*

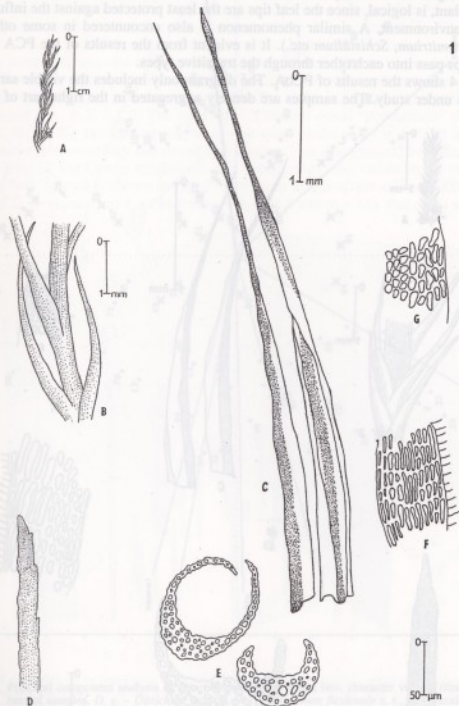


Figure 1. *Ditrichum gracile* (Mitt.) Kunze - A. Plant. B. Detail of the plant part. C. Leaves. D. Subula. E. Cross sections of the leaves. F. Cells of the leaf base. G. Dorsal costal and laminal cells of the leaf.

(*D. g.*). The vectors indicate characters on the basis of which the multivariate analysis has been implemented (hyacel, curvat, leafle, awlnes, shorte, tootne, tipbre). The distribution of the samples along axis 1 is explained by hyacel, curvat, leafle, awlnes and shorte. The fairly uniform distribution of the characters and the proximity of the vectors indicating them (awlnes – a supplementary vector) suggest their mutual correlation. The distribution of the samples along axis 1 is the least clearly explained by tootne and tipbre. The greater variability of characters found at the leaf tips, as compared with other parts of plant, is logical, since the leaf tips are the least protected against the influence of external environment. A similar phenomenon is also encountered in some other taxa (e. g. *Racomitrium*, *Schistidium* etc.). It is evident from the results of the PCA that the two groups pass into each other through the transitive types.

Fig. 4 shows the results of PCoA. The diagram only includes the visible samples of the series under study. The samples are densely aggregated in the right part of the

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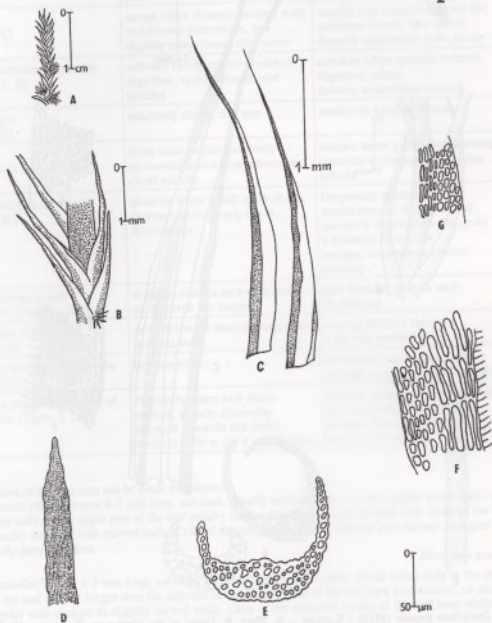


Figure 2. *Ditrichum flexicaule* (Schleich. ex Schwaegr.) Hampe – Explanations as in Figure 1.

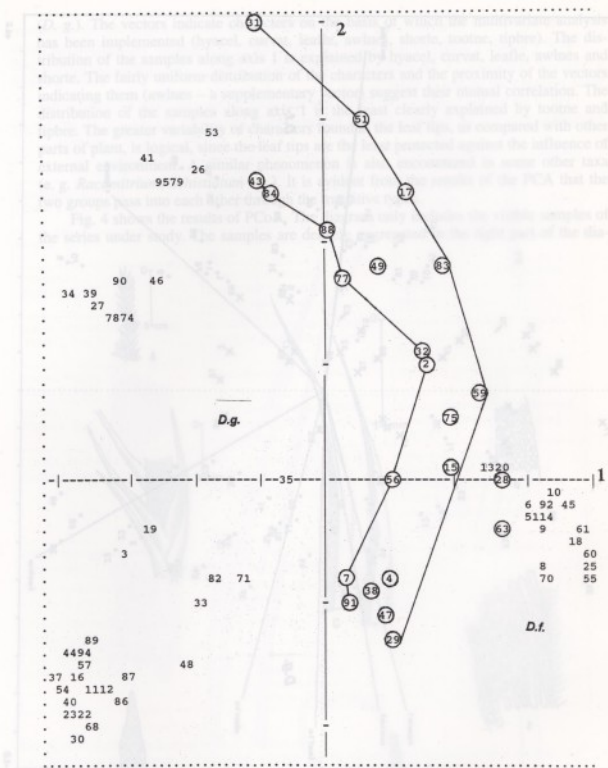


Figure 4. Principal co-ordinate analysis performed by the PRINCOOR programme of the *Ditrichum flexicaule* sensu lato. (The plots on the base level.) Number of samples, left side - *Ditrichum gracile* (*D. g.*), right side - *Ditrichum flexicaule* s. s. (*D. f.*), circles - transitive samples, 28, 63 - problematic samples.

gram (*D. f.*), indicating greater homogeneity of the *D. flexicaule* group as compared with *D. gracile*, the plots of which are more scattered in the left part of the diagram (*D. g.*). The transitive types are indicated by rings and surrounded by a solid line. The horseshoe shape of the belt they form is the result of the so-called arch (or horseshoe) effect, which is usually considered an undesirable property of metric ordination methods (Podani 1994). Furthermore, it is evident from the diagram that the two groups merge through transitive types which are less abundant than the typical taxa. The series is primarily divided along the first axis, which expresses the highest variability after the reduction of the original multidimensional space (Podani 1994). It is evident from Fig. 5 that the variability in the size of the third axis is greatest in the transitive samples.

In many respects, the results are much more clearly shown in the dendrogram in Fig. 6. From the dendrogram the exact position of all samples is evident. The position of duplicate "populations" indicates two facts: 1) The series under study comprises a mixed "population" (A, B, F, K). 2) The variability of the individual "populations" is considerable (C, H, J). The two groups into which the series under study is divided in case that the considerable variability and mixed "populations" are disregarded, are defined only at a high level of the Gower coefficient. The morphology and variability of the axillary hairs of both species is shown in Fig. 7. The mean length of the axillary hairs in specimens of *D. flexicaule* was $\bar{x} = 184.0$ mm, s. d. = 22.9 mm ($n = 12$), that of *D. gracile* was

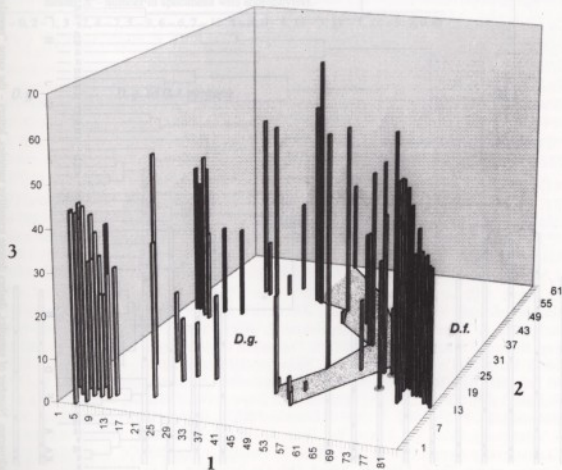


Figure 5. Principal co-ordinate analysis performed by PRINCOOR programme. Tridimensional diagram. Explanations as in Figure 4, dotted area = transitive samples.

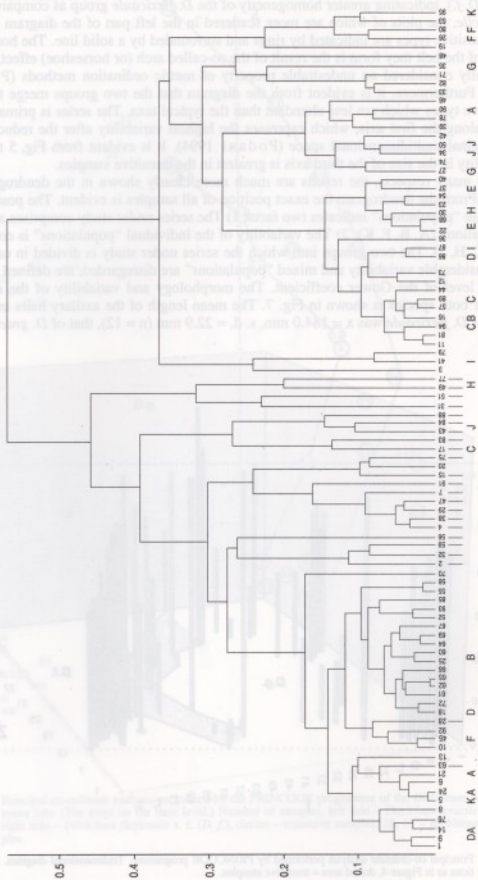


Figure 6. Dendrogram. Number of samples, dashes denote transitive samples, letters – the same “populations”.

\bar{x} = 269.3 mm, s. d. = 94.8 mm (n = 4). These mean values are statistically non-significantly different at p = 0.05. The evaluation of axillary hairs is impracticable in all specimens.

Table 2. Specimens coming from localities outside the study region, included in multivariate analyses.

40	<i>D. g.</i> Voralberg, Gönferswald at Feldküh, 1890, Scheible, herb. ZP.
46	<i>D. g.</i> Festungberg at Ruffstein, 23. 8. 1860, J. Juratzka, herb. ZP.
47	<i>D. f.</i> Unterhberg, Bartsch, herb. ZP.
52	<i>D. f.</i> USSR, 64°40'N - 43°20'E, prov. Archangelsk, distr. Pinega, Golubino, Tarakanij ravine, S facing slope with gibs outcrops, on gibs, 100 m, 10. 8. 1988, M. Ignatov, herb. ZP.
53	<i>D. g.</i> ad <i>D. f.</i> vergens, Canada, Alberta, on dry boulder near stream Maligne Canyon, Jasper National Park, 3,600-3,800 ft., 23. 6. 1955, H. Crum, herb. ZP.
54	<i>D. g.</i> British Columbia, Chilewack valley, limestone outcrop near intersection of Sleas Creek with Chilewack River, open silt on cliff shelves, 16. 11. 1978, W. B. Schofield et J. van Veltzen, herb. ZP.
55	<i>D. f.</i> USSR, Caucasus, Georgia, on dry rocks on hillside above the Turtle lake, Tbilisi, 17. 6. 1985, C. C. Townsend, herb. ZP.
56	<i>D. g.</i> ad <i>D. f.</i> vergens, Rossia Subcarpatica, Berlebás, inundated stones in Tisa, 7. 1937, Z. Pilous, herb. ZP.
57	<i>D. g.</i> Rossia Subcarpatica, Kosovská Polana, 16. 8. 1937, Z. Pilous, herb. ZP.
73	<i>D. g.</i> Lunz, only steril., 1894, Handke, PRC.

Table 3. Fructification of *D. flexicaule* (Schwaegr.) Hampe in the course of the year (X - number of month, Σ - number of specimens with sporophytes).

1 - 0, 2 - 1, 3 - 2, 4 - 7, 5 - 9, 6 - 6, 7 - 13, 8 - 4, 9 - 4, 10 - 3, 11 - 1, 12 - 0. Σ = 49

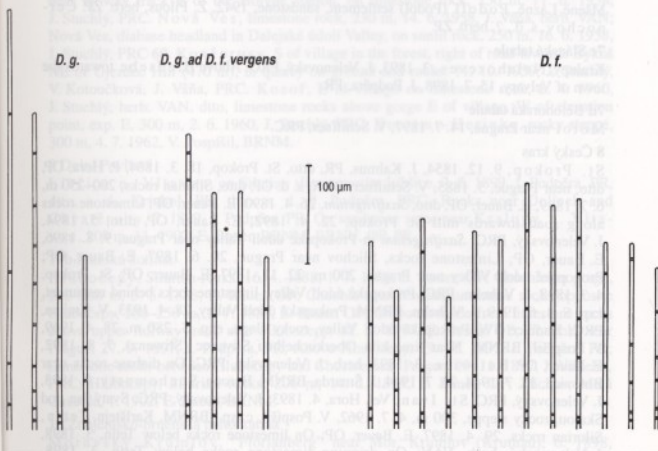


Figure 7. Axillary hairs. *Ditrichum gracile* (*D. g.*), *Ditrichum flexicaule* s. s. (*D. f.*), *D. gracile* (*D. g.*) ad *D. flexicaule* (*D. f.*) vergens.

Taxonomical estimation of the group under study

In the case of typically developed plants, the two taxa can be separated by using a number of characters given in the table and key below. As follows from the preceding section, the series of the characters mentioned is variable and thus the table and key are not reliable in the case of transitive plants.

Distribution in the Czech and Slovak Republics

Ditrichum flexicaule (Schleich. ex Schwaegr.) Hampe

Czech Republic

4a Lounské středohoří

Vel. Kuzov, 1. 3. 1936, J. Šimr, LIT, dtto, E side of Kuzov Hill near Třebenice (Trgiblitz), basalt soils, 1. 5. 1939, K. Preis, PRC.

4b Labské středohoří

Pokratice, 1 km N of village, "Pokratická bílá stráž" nature reserve, sunlit xerothermic grass plot, 260 m, 11. 7. 1984, I. Novotný, BRNM.

5a Dolní Poohří

On humid slope below Radobýl near Litoměřice, 5. 1902, J. Podpěra, PR.

7a Libochovická tabule

Mšené Lázně, Podolí (Podol) settlement, sandstone, 1942, Z. Pilous, herb. ZP. Černochovo, s. d., ? herb. ZP.

7c Slánská tabule

Kralupy, Nelahozeves, 3. 1893, J. Velenovský, PRC. Above Hleďsebe towards the town of Velvary, 15. 7. 1898, J. Podpěra, PR.

7d Bělohorská tabule

Motol near Prague, 14. 7. 1897, V. Schiffner, PRC.

8 Český kras

St. Prokop, 9. 12. 1854, J. Kalmus, PR, dtto, St. Prokop, 18. 3. 1884, P. Hora, OP, dtto, near Prague, 5. 1885, V. Schiffner, BRA, s. d. OP, dtto, Silurian rocks, 200–250 m, 6. 7. 1889, E. Bauer, OP, dtto, *Saxifragetum*, 26. 4. 1890, E. Bauer, OP; Limestone rocks along road towards mill St. Prokop, 22. 4. 1892, E. Bauer, OP, dtto, 5. 1894, J. Velenovský, PRC; *Saxifragetum* in Prokopské údolí Valley near Prague, 9. 8. 1896, E. Bauer, OP; Limestone rocks, Slichov near Prague, 20. 6. 1897, E. Bauer, OP; Prokopské údolí Valley near Prague, 200 m, 22. 11. 1897, E. Bauer, OP; St. Prokop, 4. 3. 1898, J. Vilhelm, PRC; Prokopské údolí Valley, limestone rocks behind restaurant, exp. S, 1. 6. 1919, J. Vilhelm, BRNM; Prokopské údolí Valley, 28. 4. 1933, V. Krajina, PRC; Jinonice SW, Prokopské údolí Valley, rocky slope, exp. S, 280 m, 28. 4. 1969, V. Pospíšil, BRNM. Near lime-kiln Oberkuchelbau Slivenec (Slivenz), 7. 8. 1892, E. Bauer, OP. Butovice, 3. 1893, herb. J. Velenovský, PRC; On diabase rocks near Butovice, 13. 7. 1944, 23. 7. 1944, J. Šmarda, BRNM. Beroun, Suhomasty, 8. 1893, J. Velenovský, PRC. St. Ivan, Vel. Hora, 4. 1893, J. Velenovský, PRC; Svatý Jan pod Skalou, rocky steppe, 300 m, 4. 7. 1962, V. Pospíšil, c. sp., BRNM. Karlštejn, Tetín, Silurian rocks, 29. 4. 1897, E. Bauer, OP; On limestone rocks below Tetín, 3. 1898, J. Velenovský, herb. VAN; On dripping limestone rocks below Tetín, 3. 1898, J. Velenovský, c. sp., PRC; On Silurian rocks near Tetín, 200 m, 11. 1898, E. Bauer, BRNM, BRNU, OP, PR, PRC, herb. VAN, dtto, 29. 5. 1900, 10. 10. 1900, E. Bauer, OP;

Tetín, failed quarry below limestone rocks, exp. N, 240 m, 10. 5. 1959, J. Stuchlý, PRC; Tetín, limestone rock, 240 m, 28. 5. 1959, J. Stuchlý, herb. VAN. On limestone rocks near Srbsko, 14. 2. 1899, J. Podpěra, c. sp., PR, dtto, 4. 1900, J. Podpěra, c. sp., BRNM; Srbsko, at waterfall, sunlit limestone rocks, 8. 3. 1945, Z. Pilous, herb. ZP; Císařská rokle Gorge, 8. 3. 1945, Z. Pilous, herb. ZP, dtto, on limestone rock, 11. 4. 1959, J. Stuchlý, P. Troják, PRC 70, dtto, on limestone rocks in middle part, 250 m, 19. 4. 1959, J. Stuchlý, herb. VAN, dtto, lower part on dry rocks, 230 m, 3. 9. 1959, J. Stuchlý, PRC, dtto, on tops of limestone rocks above gorge continuing from end of Císařské rokle Gorge, 300 m, 8. 11. 1959, J. Stuchlý, PRC 67, dtto, on ground and rocks, 350 m, 16. 4. 1960, J. Stuchlý, PRC; Sunlit slopes near Koda, 9. 3. 1945, Z. Pilous, herb. ZP; On limestone rocks in Koda Valley, 270 m, 4. 1949, Z. Pilous, BRA, BRNM, BRNU, OP, PR, dtto 220 m, J. Váňa, herb. VAN; Srbsko, rocks near road towards Hostýn, 13. 3. 1945, Z. Pilous, herb. ZP; Valley of the Kačák Brook on left bank upstream of the mouth into Berounka, on dry limestone rock, 220 m, 3. 9. 1950, J. Stuchlý, PRC; Loděnický potok Valley, on limestone rocks, 220 m, 17. 3. 1960, J. Váňa, herb. VAN; Srbsko, Pláně, slopes grown with *Quercus pubescens*, 350 m, 31. 5. 1979, V. Pospíšil, BRNM. On limestone rocks near Radotín, 15. 10. 1899, J. Podpěra PR; Radotínské údolí Valley, 8. 5. 1902, A. Bayer, BRNM; Radotín, 8. 5. 1920, ?, PR; In open mixed forests on limestone rocks in Radotínské údolí Valley near the town of Radotín, 300 m, 4. 1933, M. Deyl, PR; In Radotínské údolí Valley near the town of Radotín, diabase soil, 200 m, 5. 1933, M. Deyl, herb. ZP. Dalejské údolí Valley, near railway track E of the Holyně station, on limestone rock, 250 m, 11. 6. 1958, J. Stuchlý, PRC. Nová Ves, limestone rock, 230 m, 14. 6. 1958, J. Váňa, herb. VAN; Nová Ves, diabase headland in Dalejské údolí Valley, on sunlit rock, 250 m, 16. 6. 1958, J. Stuchlý, PRC 69. Koněprusy, S of village in the forest, right of road towards Bykoš NE of Újezdec Hill (470 m), in quarry on ground and rocks, 11. 10. 1959, J. Stuchlý, V. Kotoučková, J. Váňa, PRC. Kosof, E of village on limestone rock, 2. 4. 1960, J. Stuchlý, herb. VAN, dtto, limestone rocks above gorge E of village, W of elevation point, exp. E, 300 m, 2. 6. 1960, J. Stuchlý, PRC. Hostím – Herinky, rocky steppe, 300 m, 4. 7. 1962, V. Pospíšil, BRNM.

9 Dolní Povltaví

Liběice n. Vltavou, on Silurian slate opposite Libšice, 7. 5. 1899, J. Podpěra, PR, dtto, s. d., Krtchol, PR, dtto, s. d., J. Podpěra, PRC. Rocks near Dolínek and Chvatěruby, 7. 1899, J. Podpěra, PR. On sandstone scree near Kralupy n. Vltavou, 200 m, 11. 1902, E. Bauer, BRNM, BRNU, OP, PR.

10b Pražská kotlina

Hlubočepy, Silurian rocks, 16. 4. 1888, 1. 7. 1888, E. Bauer, OP; Chuchle, in gorge, 200–300 m, 5. 5. 1888, E. Bauer, OP; Chuchle near Prague, limestone rocks opposite Hlubočepy, 200–250 m, 1. 7. 1888, E. Bauer, OP; On booth made from limestone rocks above upper railway track near Hlubočepy, 12. 5. 1897, E. Bauer, OP; Chuchle near Prague, 27. 9. 1897, J. Podpěra, PR; Above Hlubočepy, 19. 11. 1897, J. Podpěra, PR; Limestone rocks between Hlubočepy and Chuchle near Prague, 19. 11. 1897, J. Vilhelm, PRC; Hlubočepy, Silurian rocks, 200 m, 14. 2. 1899, E. Bauer, OP; Zlíchov, Malá Chuchle, 1. 1902, E. Bauer, BRNM.

16 Znojemsko-brněnská pahorkatina

Moravský Krumlov, "Florianberg" near Mor. Krumlov (Krumau), 6. 1898, G. Niessel, BRNU, dtto, on Permian rocks near Mor. Krumlov, 300 m, 4. 1908, J. Podpěra, BRNM, PR, dtto, *Carpineto-Quercetum* 0.2 km NW by N of church Sv. Florian on right bank of the river Rokytná, 290 m, 4. 7. 1985, I. Novotný, BRNM.

Rokytná, Tábor Hill, 338 m, 29. 3. 1946, J. Dvořák, BRA, BRNM, dtto, valley of the river Rokytná, N of conglomerate slopes of elevation point Tábor, 320 m, 7. 6. 1990, L. Pujmanová, LIT, dtto, Rokytná, elevation point Tábor, conglomerate rocks, 300 m, 16. 5. 1995, I. Novotný, BRNM. On serpentine rocks near Mohelno, 6. 5. 1906, R. Picbauer, BRNM, BRNU, dtto, 11. 6. 1944, J. Šmarda, BRNM; In the valley of the river Oslava near Mohelno, 250 m, 4. 1908, J. Podpěra, BRNM, PR; On serpentine rocks of Mohelno serpentine steppe, under slope near Jihlava River, 15. 4. 1944, 30. 3. 1954, V. Vlach, BRNM; Mohelno, ravine below Antoník, facing Čertův ohon, 350 m, 17. 4. 1962, V. Pospíšil, BRNM. Květnice near Tišnov, limestone rocks, 350 m, 3. 4. 1907, J. Podpěra, BRNM, PR, dtto, 4. 5. 1907, J. Podpěra, BRA, BRNM, BRNU, OP, PR, PRC; dtto, limestone rocks, 350 m, 4. 1930, J. Šmarda, BRNM, dtto, 31. 5. 1947, V. Pospíšil, BRNM, OLM, dtto, 6. 1947, J. Duda, BRNM; S slope of Květnice, on limestone rocks, 360 m, 26. 4. 1977, R. Doležal, BRNM, dtto, forest-steppe, square 6664, 380 m, 23. 5. 1993, I. Novotný, BRNM. Drásovský kopec Hill near Tišnov, 400 m, 5. 1907, J. Podpěra, BRNM, PR, dtto, 300 m, 6. 7. 1935, 4. 1936, J. Šmarda, BRNM, dtto, 2. 4. 1953, V. Vlach, BRNM. On limestone rocks of Čebínka Hill near Tišnov, 400 m, 5. 1907, J. Podpěra, BRNM, dtto, 5. 1913, J. Podpěra, BRNM, dtto, limestone rocks, 350 m, 4. 1934, J. Šmarda, BRNM, dtto, 20. 9. 1942, V. Vlach, BRNM; Čebínka (431 m), limestone rocks, exp. S, 350 m, 22. 4. 1967, L. Pokluda, BRNM. Ivančice, on conglomerate permian rocks towards Řeznovice, s. d., J. Podpěra, PR; Budkovice, 29. 9. 1912, J. Podpěra, PR.

17b Pavlovské kopce

On Pavlov Hills (Polauer Bergen), limestone rocks, 11. 6. 1864, J. Kalmus, BRNU, PR, dtto, Kotelná hora Hill, limestone rocks, 24. 10. 1920, J. Podpěra, PR, dtto, Děvín, 534 m, 3. 4. 1956, V. Pospíšil, BRNM, dtto, Děvín, S slope, shaded rocks near defile, 16. 5. 1963, V. Pospíšil, BRNM; Pavlov, Pavlovské vrchy Hills nature reserve, square 7265, 440 m, 22. 5. 1994, I. Novotný, BRNM; Věstonice, (Bei Wisternitz an [and illegible]), 22. 10. 1865, J. Kalmus, BRNU; Mikulov, Růžový vrch Hill near Mikulov (Rosenstein prope Nikolasburg), limestone rocks, 3. 1904, J. Podpěra, BRNM, BRNU, OP, PR, PRC; Mikulov, Klentnice, Růžový hrad Ruin, limestone rocks, 430 m, 27. 5. 1963, V. Pospíšil, BRNM; Mikulov, on limestone rocks above Perná, limy soil, Jurassic, 300 m, 3. 1904, J. Podpěra, BRNM; Mikulov, Perná, Kotlová, elevation point 438 m, 29. 6. 1964, V. Pospíšil, BRNM. Mikulov, Svatý Kopeček Hill (Heiliger Berg prope Nikolasburg) on limestone rock, 4. 1904, J. Podpěra, BRNM, dtto, 3. 1907, J. Podpěra, PR, dtto 5. 5. 1955, V. Vlach, BRNM, dtto, limestone rocks, 360 m, 12. 4. 1956, dtto, 26. 3. 1957, dtto, limestone rocks, 350 m, 15. 5. 1962, V. Pospíšil, BRNM, dtto, 400 m, 23. 8. 1984, J. Duda, BRNM, herb. ZP. Mikulov, Šibeničník S of village, 15. 6. 1948, V. Pospíšil, BRNM. Mikulov, Turold, 1.3 km N of church, limestone rocks, 380 m, 16. 5. 1962, V. Pospíšil, BRNM.

19 Bílé Karpaty stepní

Vojšice, near Háj in Kněždub, 18. 8. 1912, M. Béňa, BRA.

20a Bučovická pahorkatina

Vyškov, Větrníky, denuded place in steppe, 13. 6. 1929, J. Podpěra, PR.

20a Hustopečská pahorkatina

Stránská skála Rock near Brno, 300 m, 4. 1909, J. Podpěra, BRNM, dtto, 269 m, 9. 1928, R. Doležal, BRNU, dtto, on limestone rock, 24. 3. 1946, V. Pospíšil, BRNM, dtto, limy soil with *Tortella inclinata*, 300 m, 26. 12. 1947, J. Müller, BRNU, dtto, square 6866, 310 m, 26. 5. 1993, I. Novotný, BRNM. Hodonín (Kobyli), Čejč, Velký vrch Hill, elevation point 264 m, 3 km W of village, 7. 6. 1963, V. Pospíšil, BRNM.

22 Halštrovská vrchovina

In masses on wall of limestone rocks near Rotava (Rothau), 6. 6. 1893, E. Bauer, OP, PR, PRC.

32 Křivoklátsko

Skryje near Beroun, Čertovy skály Rocks, left bank of Berounka River, 22. 7. 1944, J. Šmarda, BRNM.

34 Plánický hřeben

Klatovy, Plánice, failed limestone quarry on elevation point 581 m, 1.5 km S of village, 24. 3. 1972, M. Vondráček, PL.

35d Březnické Podbrdsko

Mirovice, limestone rocks, 1935, Z. Pilous, herb. ZP.

37a Horní Pootaví

Dolejší Krušec (Unt. Körsalz) near Hartmanice (Hartmanitz), on walls, 8. 1917, A. Oborny, PRC 58.

37b Sušicko-horažďovické vápence

Horažďovice, Hejná, Pučanka, limestone rocks, 30. 10. 1942, J. Vaněček, PR, dtto, on shaded limestone rocks below top of Pučanka Hill, 600 m, 7. 7. 1960, M. Vondráček, c. sp., BRA, PL, dtto, nature reserve, limestone rock, 600 m, 16. 6. 1966, V. Pospíšil, BRNM. Rábí, 20. 8. 1957, Z. Pilous, herb. ZP, dtto, on limestone rock in castle moat, 520 m, 27. 5. 1980, M. Vondráček, PL. Klatovy, Velké Hydčice, rock above railway track NE of the village, 10. 6. 1966, V. Pospíšil, BRNM, dtto, little limestone rocks on base of wooded slope near railway track N of the village, 16. 5. 1981, M. Vondráček, PL. Horažďovicko, Budětice, Líšná Hill, little limestone rocks on N slope, 540 m, 19. 4. 1982, M. Vondráček, c. sp., PL, dtto, Líšná Hill, limestone pit excavated on NW foot of hill, 500 m, 19. 4. 1982, M. Vondráček, PL.

37c Nezdické vápence

Strašín, on rocks near of cave, 560 m, 9. 5. 1984, M. Vondráček, PL.

37i Českokrumlovské předšumaví

Č. Krumlov, above Dobrkovice (Turkovice), 8. 1899, J. Podpěra, PR, dtto, towards "Weichseln" near Krumlov, 8. 1899, J. Podpěra, PR, dtto, "Městský vrch" above N limit of town, limestone rock, 600 m, 17. 6. 1976, V. Pospíšil, c. sp., BRNM.

52 Ralsko-bezděžská tabule

Ralsko (Roll) in castle ruins, 6. 8. 1897, V. Schifner, PRC 76, dtto, 5. 1899, J. Podpěra, PR, dtto, (Kumerské pohoří mountain range near Kuřivody, Kümmergebirge), limy sandstone, *Minuartia setacea* - *Thymus angustifolius* ass., 1937, K. Preis, PR.

56b Jilemnické Podkrkonoší

Lánov (Langenau), on the limestone rocks in "Sattler", Vrchlabí (Hohenelbe) district, 16. 5. 1888, v. Cypers, 16. 5. 1888, PR, dtto, on limestone rocks, 560 m, 5. 1948, Z. Pilous, c. sp., BRA, BRNM, OP, PL. On limestone rocks on "Weisenstein" near Černý důl (Swartzenthal), 690 m, 14. 9. 1892, V. Cypers, OP, dtto, on limestone soil, 7. 1956, Z. Pilous, BRA, BRNM, LIT, herb. ZP.

67 Českomoravská vrchovina

Olešnice, near Lhotka on limestone rocks, 6. 6. 1938, J. Šmarda, BRNM.

68 Moravské podhůří Vysočiny

Tišnov, Výří skály Rocks near Sokolí near Vev. Bílýška, 25. 5. 1941, J. Šmarda, BRNM. Uherčice village, rock terraces on the left bank of Dyje River, 100 m from

the border, 2. 7. 1993, L. Tichý, BRNM. Podyjí National Park, Čížov, "Hardeggská stráž" Slope above Čížov – Hardegg road, limestone rock, 350 m, 8. 9. 1993, Z. Hradílek, herb. HRA, ditto, at customs-house near Dyje River in forest-steppe, square 7161, 350 m, I. Novotný, 15. 5. 1994, BRNM. Podyjí National Park, Lukov, 2.1 km SW by W of the village, limestone rocks above "Uhlířská cesta" above Dyje River, 325 m, 25. 8. 1995, Z. Hradílek, herb. HRA.

70 Moravský kras

"Josephthal" Canyon, 4. 1868, K. Roemer, c. sp., BRNU; Adamov, Josefské údolí Canyon, 9. 8. 1942, J. Podpěra, PR, ditto, s. d., A. Zlatník, Macocha (Mazocha) Abyss, s. d., K. Roemer, BRNU, ditto, Bottom of Macocha Abyss, 20. 11. 1960, F. Grüll, BRNM, ditto, 1. 1962, L. Vaněčková, BRNM. Blansko, lime, 1888, J. Velenovský, PRC. On shaded rocks in Punkva Valley, 26. 6. 1898, J. Podpěra, PR; On limestone rocks in Punkva Valley between Sloup and Blansko, 27. 8. 1902, F. Bartsch, BRNU; Pustý žleb Canyon near Blansko, limestone rocks, 350 m, 30. 3. 1907, J. Podpěra, BRNM, PR; On limestone rocks in Pustý žleb Canyon near the town of Blansko, 320 m, 4. 1910, J. Podpěra, BRNM, BRNU, OP; Above Skalní mlýn Mill near Blansko, 5. 1911, J. Podpěra, c. sp., PR; In Punkva Valley, s. d., J. Podpěra, PR, ditto, s. d., J. Vilhelm, PRC; Punkva Valley, Macocha, little rocks, 9. 1964, F. Grüll, BRNM. Býččí skála Rock near Adamov, limestone soil, 300 m, 31. 3. 1907, J. Podpěra, c. sp., BRNM, steril. BRNU, PR, steril. PRC 60, ditto (Bijc skála), 31. 9. 1907, J. Podpěra, PRC. Suché údolí Valley near Blansko, limestone soil, 400 m, 2. 5. 1909, J. Podpěra, c. sp., BRNM, PR; On limestone rocks in Suchý žleb Canyon near the town of Blansko, 320 m, 4. 1914, J. Podpěra, c. sp., BRNM, BRNU, OP; Suché údolí Valley near Blansko, 4. 1914, J. Podpěra, c. sp., BRNM, ditto, 360 m, 10. 1928, R. Doležal, BRNM, ditto, 26. 9. 1943, J. Šmarda, c. sp., BRNM, ditto, in forest, at base of rocks, 8. 8. 1950, V. Vlach, BRNM, ditto, on rocks of a wall along road from Suchý žleb Canyon towards upper bridge at Macocha Abyss, 8. 9. 1971, F. Grüll, BRNM, ditto, valley about 0.7 km NW of village Vilémovice, on limestone rocks of NE slope, 435 m, 7. 5. 1975, R. Doležal, BRA 440 m, BRNM, OP. On limestone rocks near Sloup, 500 m, 3. 6. 1909, J. Podpěra, c. sp., BRNM, PR, ditto, 22. 3. 1962, L. Vaněčková, BRNM. Brno, Šumbera, on lime, 5. 1913, J. Podpěra, PR, PRC. On limestone rock on Lysá hora Hill near Ochoz, (S slope), 24. 8. 1927, R. Doležal, BRNU; On limestone cliffs facing Lysá hora on Říčky near Obce, 8. 11. 1927, R. Doležal, BRNU; On limestone rocks above Pekárna Cave near Ochoz, 440 m, 6. 4. 1928, R. Doležal, BRNU; On shaded and humid rocks facing Lysá hora (cadastre of Mokrý), 410 m, 11. 1937, R. Doležal, c. sp., BRNM, ditto, 20. 11. 1968, steril., ditto, 23. 6. 1969, c. sp., R. Doležal, BRNM; On top limestone rocks on N slope facing Lysá hora, 425 m, 1. 2. 1974, R. Doležal, BRA, OP; Little terraces rich in humus of limestone rocks on SW by S slope near Lysá hora, 330 m, 17. 11. 1974, R. Doležal, BRNM; Limestone rocks above Jelínek's Mill in the Říčka Valley near Ochoz, 19. 5. 1975, R. Doležal, BRNM; Ochoz, Lysá hora Hill, on SW slope on limestone rocks, 360 m, 9. 8. 1979, V. Pospíšil, BRNM, BRNU. On "granosyenite" rocks in Arnoštovo údolí Valley near Blansko, 310 m, 11. 4. 1928, R. Doležal, BRNU. Limestone rocks near Babice, 8. 1928, R. Doležal, BRNM, BRNU. Limestone rocks in Říčka Valley near Líšeň, 9. 1928, R. Doležal, BRNU. Blansko, Rasovna near Holštejn, 410 m, 10. 1928, R. Doležal, BRNM, ditto, limestone rocks, 460 m, 20. 6. 1937, J. Šmarda, BRNM, ditto, 8. 4. 1952, V. Pospíšil, BRNM, OLM; Holštejn, sink 0.5 km S of village, 480 m, 14. 7. 1980, V. Pospíšil, BRNM. Blansko, on limestone rocks near Jedovnice Sink, 6. 5. 1936, J. Šmarda, BRNM. Brno, mixed forest on Hády Hill, 4. 1946, J. Müller, BRNU. Scree below Rytířská, 17. 4. 1962, J. Šmarda,

c. sp., BRNM. Blansko, Staré Zámky, 500 m, 23. 5. 1962, V. Pospíšil, BRNM. On exposed limestone rocks SE of Rudice, exp. SW, 470 m, 26. 4. 1974, R. Doležal, BRA, BRNM, OP. Ostrov u Macochy, 0.7 km SW, shaded little rocks in forest, 460 m, 15. 9. 1984, R. Pantůček, BRNM.

70a Bouzovská pahorkatina

Zkamenělé zámky near Bouzov (Búsov), limestone rocks, 450 m, 5. 1905, J. Podpěra, PR; Javofičko near Litovel, Zkamenělý zámek 0.5 km W of elevation point Špramek (535 m), limestone rock on N top, 450 m, 9. 5. 1971, L. Pokluda, BRNM.

71b Dražanská plošina

Vojtěchov u Litovle, Stráň (560 m), limestone rocks 1.5 km N of elevation point, 460 m, 22. 5. 1971, L. Pokluda, BRNM.

75 Jesenické předhůří

Moravský Beroun, Hajmrov settlement, shaded phyllite rocks N of village, 550 m, 28. 8. 1974, L. Pokluda, BRNM.

76a Moravská brána vlastní

Kotouč near Štramberk, 9. 1904, J. Podpěra, PR, dtto, 4. 11. 1928, 10. 5. 1929, 4. 10. 1929 – rocks at Šipka, 11. 1929, 5. 1930, J. Otruba, OLM, dtto, "Kesselberg, Heilige Berg", s. d., J. Otruba, BRNM, dtto, place "Bezručova vyhlídka", 460 m, 13. 8. 1950, J. Jedlička, BRNM, dtto, on rock near T. G. Masaryk memorial, 450 m, 22. 8. 1950, J. Jedlička, BRNM, dtto, on limestone rocks below "Glorietum", 10. 10. 1951, J. Duda, OP, herb. VAN, dtto, on limestone rocks (west), 500 m, 16. 10. 1951, J. Duda, OLM, OP, dtto, near cave Šipka, on limestone rocks, 480 m, 16. 10. 1951, J. Duda, OP, dtto, on limestone rock near cave Šipka, 480 m, 18. 10. 1951, J. Duda, OLM, OP, herb. VAN, dtto, near Šipka, 11. 7. 1952, V. Pospíšil, BRNM. Štramberk, on SW slopes Zámecká hora Hill above the town, 540 m, 16. 8. 1950, J. Jedlička, BRNM, dtto, 18. 10. 1951, J. Duda, OP, herb. VAN. Štramberk, on limestone rock "Dolní skalky", 450 m, 17. 8. 1950, J. Jedlička, BRNM, dtto, Skalky, 1. 6. 1952, V. Pospíšil, BRNM.

78 Bílé Karpaty lesní

Bojkovice, sandstone rocks above Bzová, 30. 5. 1931, J. Podpěra, BRNM.

80a Vsetínská kotlina

Vsetín, Bařiny, slope on N limit of Kýchová S of railway station, 450 m, 30. 9. 1966, V. Pospíšil, BRNM.

81 Hostýnské vrchy

Torrent below Hostýn, pasture near bath (quarry) SE by S of the town, on NW foot of Hostýn Hill, 450 m, 24. 7. 1963, V. Pospíšil, BRNM.

84a Beskydské podhůří

On limestone rocks near Staříč near Místek, 7. 1941, J. Šmarda, BRNM, dtto, failed limestone quarry N of the village, 370 m, 1. 11. 1967, V. Pospíšil, BRNM, dtto, Kamenná Reserve, on teschenite substrate, 350 m, 15. 4. 1994, J. Duda, BRNM.

93a Krkonoše lesní

Paseky n. Jizerou, limestone rock, 4. 1952, Z. Pilous, herb. ZP8.

93b Krkonoše subalpínské

Near Staré hutě in Obří důl, 6. 1920, R. Traxler, PRC; Obří důl, limestone rocks on Rudník, 10. 5. 1947, Z. Pilous, herb. ZP. On limestone rocks near Kovárna N of Pec, 8. 1945, J. Šmarda, c. sp., BRNM. Kotelné jámy, 6. 1946, Z. Pilous, herb. ZP, dtto, Kotel, 9. 1951, Z. Pilous, herb. ZP.

93c Rýchory

On limestone soil "Schaffergaben" near Horní Maršov (Maršov), 6. 1906, R. Traxler, PR. Limestone rocks above Suchý důl, 10. 1946, Z. Pilous, herb. ZP.

97 Hrubý Jeseník

Vřesová studánka, on the rocks (Brünnelheide), 8. 1848, ?, OP, dtto (Brünnelheide), s. d., J. Spatzier, OP, dtto, 1,333 m, 7. 1947, J. Šmarda, BRNM, dtto, on rocks above chalet (locality of *Carex rupestris*), 1,300 m, 1. 10. 1961, L. Pokluda, BRNM. Kotlina in Jeseníky mts., 1,200 m, 7. 1904, J. Podpěra, PR, BRNM; Velká kotlina, 1974, J. Kůrková, c. sp., BRNM. On gneiss rocks of Petrovy kameny Mt. (Peterstein), 1,440 m, 8. 1905, J. Podpěra, PR. Horní Lipová, On limestone rocks below "Sand Ulrich" Hill, s. d., Hora, OP; Lipová, 600 m, 19. 8. 1948, J. Müller; On limestone rocks of Smrk (Fichtenstein) (794 m) N of Dolní Lipovec, 750 m, 29. 6. 1955, J. Šmarda, BRNM; Mramorový vrch Hill (708 m) near Horní Lipová, shaded limestone rock below old quarry, exp. NE by N, 600 m, 8. 8. 1967, L. Pokluda, BRNM. Small limestone rocks near the village of Ostružná, exp. E., 740 m, 19. 5. 1975, R. Doležal, BRA, BRNM, dtto, 0.5 km from church, 19. 5. 1975, V. Pospíšil, BRNM.

99a Radhošské Beskydy

Staré Hamry, in the forest Baraní, on rock of Skalka Hill, 684 m, 8. 1949, J. Duda, BRNM, OLM, dtto, 22. 5. 1956, J. Duda, OLM, OP.

Slovak Republic

3 Slovenský kras

Near the town of Turňa n. B. on plain Dlhý breh, on rocks, exp. N, 12. 7. 1935, Brym, PRC; Rocks near Háj, s. d., M. Deyl, PR; Turnianský hrad Castle, 8. 4. 1982, Z. Pilous, BRNM, OP, herb. ZP. Rožňava, Silická planina Plain, SW of Joles, 400 m, 5. 1947, J. Šmarda, BRNM. Turňa, Zadielská dolina Canyon, 12. 4. 1957, V. Pospíšil, BRNM. Silická planina plateau, on the hill Kamenný kopec (Lászlótető) near the village of Kečovo, 450–500 m, Brzotinské skály Rocks, lower part, 8. 4. 1982, Z. Pilous, BRNM, OP, herb. ZP. Sokolí hrad Castle near Silica, 8. 4. 1982, Z. Pilous, BRNM, OP, herb. ZP, dtto, 9. 4. 1982, Z. Pilous, herb. ZP. Hrušovská forest-steppe, 8. 4. 1982, Z. Pilous, BRNM, OP, herb. ZP.

9 Biele Karpaty (south part)

Zemianské Podhradie, on Chúmov Ridge from Ivanovská dolina Valley, 7. 1869, J. L. Holuby, BRA; Limestone hill near Zemianské Podhradie (Nemes Podhragy), 8. 6. 1870, J. L. Holuby, BRA; Dry limestone hill near Bošáca, 6. 1870, J. L. Holuby, BRA; Zemianské Podhradie (Nemes Podhragy), on limestone rocks of the "Rešetárovec" Hill, 24. 10. 1886, J. L. Holuby, BRA. Nové Mesto, Černochoh, 8. 1885, V. Schiffrer, BRA.

10 Malé Karpaty

Vápenná (Raxturm), 23. 5. 1926, J. Podpěra, c. sp., PR. Limestone slope below ruin near Plavecké Podhradie, 450 m, 15. 8. 1938, J. Šmarda, BRNM; Pohanská hora Hill near Plavecké Podhradie, limestone rocks, 450 m, 15. 8. 1938, J. Šmarda, BRNM; Near cave below Plavecký hrad Ruin, 5. 4. 1958, Z. Pilous, herb. ZP; Plavecké Podhradie, limestone rocky steppe N of village, 300 m, 27. 9. 1967, V. Pospíšil, BRNM; Plavecký hrad Ruin, cave, 8. 1968, Z. Pilous, herb. ZP. Holý vrch Hill near Smolenice, 4. 5. 1951, J. Šmarda, BRNM; Trstín, Holý vrch, W slope, 370 m, 23. 6. 1954, M. Růžicka, BRA. Ostrý kameň Rock, 4. 4. 1958, Z. Pilous, herb. ZP. About 1.5 km NE of the village Hradišťa pod Vrátnom, on limestone rocks on right side of the road, 260 m, 20. 5. 1976, R. Doležal, BRA, BRNM, OP.

12 Tribeč

Nitra, Kalvárie, Jurassic limestone above Nitra, 200 m, 25. 5. 1928, R. Doležal, BRNU. Nitra, Gýmeš castle ruin, on rocks, 450 m, 26. 5. 1928, R. Doležal, BRNU. Nitra, in crevices of rocks on top of Zobor, 570 m, 24. 5. 1928, R. Doležal, BRNU, dtto, 560 m, 26. 5. 1928, BRNU; Steppe plateau above Svorádova jeskyně Cave below Zobor near Nitra, 12. 4. 1936, V. Vlach, BRNM, dtto, 23. 5. 1952, BRNM; On limestone rocks south of the Zobor Mt. near Nitra, 400–500 m, 3. 6. 1958, A. Boros, OP. Limestone rocks on N slope of Žibrica above Žirany, 9. 6. 1938, V. Vlach, BRNM. Pleška near Dražovce in the Zobor group of Tribečské vrchy mts. near Nitra, 18. 6. 1952, V. Vlach, BRNM.

13 Strážovské a Súľovské vrchy

Súľov, on rocks, 5. 1871, J. L. Holuby, BRA; Near Súľov, limestone rocks, 3. 6. 1922, J. Podpěra, c. sp.; Near Petrikova skála limestone rock, 5. 6. 1922, J. Podpěra, c. sp., PR; Manín, 1935, Z. Pilous, herb. ZP, PRC; Súľov, In valley of the river E of village, 5. 4. 1947, J. Jedlička, BRNM; On sandy limestone rock in the valley near Manínská soutěska Defile, near Záskanie village, 400 m, 6. 4. 1947, J. Jedlička, J. Müller, partly c. sp., BRNM, BRNU, OP; On limestone rock in Manínská soutěska Defile, 6. 4. 1947, J. Jedlička, c. sp., BRNM; Manínská soutěska Defile, limestone rock towards NW, 400 m, 17. 10. 1967, V. Pospíšil, BRNM; Small Manínská soutěska Defile, rocks, 30. 8. 1971, Z. Pilous, BRA, OP; Súľov, defile around spring, 30. 8. 1971, Z. Pilous, BRA, OP, dtto, rocks around waterfall, 30. 8. 1971, Z. Pilous, BRA; Súľovská soutěska Defile, lateral gorge, 30. 8. 1971, Z. Pilous, BRA; Súľov above church, sunlit limestone rocks, 3. 9. 1971, Z. Pilous, BRA; Súľov, shady side of limestone rocks above church, 3. 9. 1971, Z. Pilous, OP, BRA; Manínská soutěska Defile, mouth of gorge, 3. 9. 1971, Z. Pilous, BRA, OP. Trenčanské Teplice, "Baba", limestone soil, 6. 6. 1922, J. Podpěra, PR. Trenčín baths and environs, on ground at Klepáč Mt., 5. 1929, M. Beňa, BRA, dtto, on rocks, 8. 5. 1934, M. Beňa, BRA. On limestone slope above locality of *Rhus cotinus* near Timoradza, 6. 1936, V. Vlach, BRNM; Bánovce n. B., Smradľavý vrch Hill near Timoradza, limestone rocks, 11. 8. 1938, J. Šmarda, BRNM, PR. Bánovce n. B., limestone rocks near Slatinka, 11. 8. 1938, J. Šmarda, BRNM; Slatinka n. B., on ground, 300 m, 1. 5. 1949, M. Ballogh, herb. ZP, dtto, near spring, 350 m, 4. 5. 1949, M. Ballogh, herb. ZP, dtto, s. d., M. Ballogh, BRA. Bánovce n. B., Latkovský les Forest, on ground, s. d., M. Ballogh, BRA, dtto, Uhrovec, on rock, s. d., M. Ballogh, BRA. Povážská Teplá, valley 2 km SW of village, on limestone stones and rocks, 350 m, 21. 10. 1969, V. Pospíšil, BRNM. Dolný Hričov, 0.5 km SE of village, pasture, 350 m, 13. 8. 1970, V. Pospíšil, BRNM. Strážov, top, small limestone rocks, 14. 9. 1976, J. Kúrková, BRNM; Zliechov village, Strážov Mt., 1200 m, 21. 6. 1989, J. Váňa, herb. VAN. Trenčanské Mitice, steppe slope near quarry 3 km SW by W of church in Kostolné Mitice, 360 m, 25. 7. 1977, V. Pospíšil, BRNM. Hričovské Podhradie, 350 m, 10. 5. 1986, J. Duda, OLM, dtto, Komíny, 450 m, 2. 5. 1987, J. Duda, herb. ZP; Lietavská Lúčka village, limestone W slopes, 400 m, 28. 9. 1986, J. Duda, herb. ZP; Lietavská Svinná, Strážná Hill, 680 m, 19. 4. 1987, J. Duda, herb. ZP; Lietava village, rocks near road, 430 m, 15. 8. 1991, Jiří Duda, herb. ZP; Dubnica n. V., Košecké Podhradie village, ruin, 350–400 m, 11. 8. 1991, J. Duda, herb. ZP 51. Porúbka village, valley of river below Borgy Hill, 380 m, 25. 3. 1989, J. Duda, BRNM, herb. ZP 13, dtto, hill toward E, 480–500 m, 2. 2. 1991, Jiří Duda. Jasenové, valley of river, 500 m, 26. 3. 1989, Jiří Duda, BRNM.

14b Vtáčnik

Veľké Pole, Molerov Štál 4 km W of church, limestone grassy hill (pasture), 580 m, 10. 6. 1975, V. Pospíšil, BRNM.

14e Štiavnické vrchy

Sklenné Teplice, 1.5 km S of village, on limestone rocks in forest, 400 m, 7. 6. 1984, I. Novotný, BRNM. Vyhne, 2 km E of village, limestone rock on limit of forest, in pasture, 500 m, 7. 6. 1984, I. Novotný, BRNM.

14f Javorie

Pliešovce near the town of Zvolen, 1 km E of village on limestone stones, 450 m, 9. 6. 1984, I. Novotný, BRNM.

16 Muráňská planina

Near path to Muráň castle ruin, 950 m, 5. 1929, R. Doležal, c. sp., BRNM. Dolní Martinová, between Tisovec and Muráň, 420 m, 5. 1929, R. Doležal, BRNM. Cigánka, above Muráň village, 940 m, 5. 1929, R. Doležal, c. sp., BRNM. Not far from gamekeeper's lodge on Veľká lúka Meadow, 1000 m, 5. 1929, R. Doležal, BRNM. NW slope of Cigánka along hiker's path toward Muráň, limestone rock, 500–800 m, 24. 9. 1963, V. Pospíšil, BRNM. Červená skala Rock, small limestone rocks on left bank of Hron River, 750 m, 16. 8. 1976, J. Dvořák, BRA, BRNM. Veľká Stožka nature reserve, limestone rocks, 1100–1200 m, 19. 9. 1995, B. Buryová, herb. BUR.

17 Slovenský raj

Kláštorská, 12. 7. 1938, Z. Pilous, c. sp., herb. ZP; On limestone rocks between Kláštorská and foot of Suchá Belá Mt., 13. 7. 1959, J. Šmarda, c. sp., BRNM. Kysel, limestone walls, 600 m, 26. 7. 1938, J. Šmarda, BRNM, dtto, 26. 8. 1838, BRNM. Pusté Pole in Dobšinská dolina Valley, limestone rocks, 700 m, 18. 12. 1957, J. Tomášek, BRNM; Above Hnilec (Gölnitz) River near Pusté Pole, 900 m, 11. 6. 1958, A. Boros, OP; Pusté Pole, on limestone rocks at Vernár railway station, 910 m, 1. 8. 1967, L. Pokluda, c. sp., BRNM. Vernár, small limestone rocks above village, 850 m, 15. 7. 1968, L. Pokluda, c. sp., BRNM. Železná vrata, S shaded side, 14. 10. 1969, V. Pospíšil, BRNM. Čingov, exp. S 30°, limestone rocks, *Brachypodio-pinetum*, 550 m, 13. 8. 1971, J. Michalko, BRA, dtto, 600 m, BRA; Hrabušice, Hornád River gorge, 6. 1978, Z. Pilous, BRA, BRNM, OP, herb. ZP; Hrabušice, 1 km NW of Kláštorská group of cottages, 9. 6. 1979, J. Kůrková, BRNM. Stratená near Dobšinská ľadová Cave, Z. Pilous, BRNM.

18 Stredné Pohornádie

Košice, on serpentine rocks at Jaklovec, near Margecany, 26. 5. 1928, R. Doležal, BRNU, dtto, (Jekelsdorf b. Göllnitz), 8. 1930, H. Laus, PR, dtto, (Kalkberg b. Jekelsdorf), 8. 1930, H. Laus, OP. Margecany, Vápenica, limestone rocks, 669 m, 28. 7. 1937, J. Šmarda, BRNM. Margecany, Sívec (784 m), limestone rocks, 27. 7. 1937, J. Šmarda, c. sp., BRNM. Branisko, Rajtopiky (1,043 m), limestone rocks, 1. 8. 1938, J. Šmarda, BRNM. Margecany, Folkmarská skala Rock, limestone rocks, 918 m, 6. 8. 1938, J. Šmarda, BRNM. Košice, Malá Vieska, 8. 7. 1958, J. Šmarda, BRNM. Prešov, Rudník, limestone rocks on ridge, S below top, 1,000 m, 3. 8. 1959, V. Pospíšil, BRNM. Prešov, Lipovce, "Kamenná baba" valley, 600 m, 4. 8. 1959, V. Pospíšil, BRNM, dtto, SW of "Húrky", 5. 8. 1959, V. Pospíšil, c. sp., BRNM, dtto, "Húrka", 6. 8. 1959, V. Pospíšil, BRNM; Lipovce, "Kamenná baba" valley, 9. 1973, Z. Pilous, OP, herb. ZP 21, 24; 4. 1989, Z. Pilous, herb. ZP 14.

20 Vihorlatské vrchy

Podhorod', 15. 3. 1937, J. Buček, BRNM; Popričný Mts., Podhorod', NW by N village outskirts, pasture near ruin, limestone rocks, 18. 6. 1970, V. Pospíšil, BRNM.

21a Lúčanská Fatra

On Klak Mt., 1,200 m, 6. 1931, J. Suza, PR; Klak, 7. 9. 1940, J. M. Novacký, BRA; Klak, 1,362 m, 9. 1937, Z. Pilous, BRA, OP, herb. ZP 4. Strečno, 1934, Z. Pilous, herb. ZP 9,18. Žilina, on rock, s. d., M. Balogh, BRA. Turčianská kotlina Valley, Valča, exp. S 40°, dolomite, *Brachypodio-pinetum*, 520 m, 13. 7. 1971, J. Michalko, BRA. Stráňavy, defile in the valley of Hýrov, 500 m, 27. 6. 1978, J. Duda, herb. ZP. Žiar, Jasenovo, limestone rocks above left bank of brook 0.5 km SW of village, exp. S, 630 m, 3. 7. 1980, V. Pospíšil, BRNM. Višňové village, top of Valentinov diel Mt., 800 m, 17. 8. 1984, Jiří Duda, BRNM, dtto, rock at foot of Valentinov diel Mt., in Višňovská dolina Valley, 600 m, 6. 8. 1989, J. Duda, BRNM, herb. ZP. Turie village, top of Kozol Mt., 1,140 m, 20. 10. 1984, J. Duda, BRNM, OLM, herb. ZP, dtto, Turská skála Rocks at Turianský potok Brook, 400 m, 26. 9. 1987, J. Duda, herb. ZP, dtto, valley of Turianský potok Brook, 500 m, 8. 5. 1988, J. Duda, herb. ZP 20, dtto, top of Čipičie Mt., 932 m, 13. 8. 1988, Jiří Duda, OLM. Kamenná village Poruba, valley of Porubský potok Brook, 550 m, 21. 10. 1989, J. Duda, BRNM. Martinské hole mts., mountain between Minčol Mt. and Jastrabná Mt., 1,100 m, 17. 8. 1992, Jiří Duda, BRNM.

21b Kriváňská Fatra

Below Suchý vrch Hill, 8. 1928, R. Doležal, BRNU; Suchý, 1,400 m, 1934, Z. Pilous, herb. ZP, dtto, mountain peak among dwarf pines, 7. 1979, Z. Pilous, BRA, OP, herb. ZP. Suchý, Biele skaly Rocks, 9. 1979, Z. Pilous, OP, herb. ZP 45. On limestone rocks near ruin of Starý hrad Castle, 460 m, 6. 1933, Z. Pilous, BRA, BRNU, OP, PR. Ozhora Valley, 1934, Z. Pilous, herb. ZP. Stráže, 1934, Z. Pilous, c. sp., herb. ZP. Párnica, granite, 1935, Z. Pilous, herb. ZP. Rozsutec, limestone rocks, 1,500 m, 8. 1936, J. Šmarda, BRNM; On limestone rock of peak Malý Rozsutec, 1,226 m, 6. 7. 1951, J. Duda, OP; Bílé skály Rocks near Velký Rozsutec Mt., 1,150 m, 6. 7. 1951, J. Duda, OP; On limestone rock in valley of Biela River SE slope of Rozsutec Mt., 1,100 m, 17. 6. 1965, I. Pišút, BRA; Rozsutec, Nové diery Rocks, limestone rocks, 8. 1972, Z. Pilous, c. sp., OP, herb. ZP, dtto, rocks on peak, 8. 1972, Z. Pilous, BRA, OP, herb. ZP, dtto, Skalné mesto, limestone rocks, 8. 1972, Z. Pilous, BRA, OP, herb. ZP, dtto, Pofudňové skaly Rocks, limestone rocks, 8. 1972, Z. Pilous, BRA, OP, herb. ZP, dtto, Štefanová, pastures above Slahorka, 8. 1972, Z. Pilous, BRA, OP; Chlieb, limestone rocks, 1,500 m, 8. 1937, J. Šmarda, BRNM. Jánošíkove diery Rocks, on rock, 700 m, 9. 7. 1971, A. Fekiačová, BRA. Tiesňavy, 7. 1978, Z. Pilous, herb. ZP 2. Veľká Bránica, 9. 1978, Z. Pilous, BRA, OP, herb. ZP, dtto, 7. 1978, herb. ZP. Strateneec, 8. 1979, Z. Pilous, herb. ZP. Vrátná Reserve, 9. 1980, Z. Pilous, BRA, OP, herb. ZP; Vrátné, s. d., A. Zlatník, BRNM. Fatranský Kriváň Reserve, 9. 1980, Z. Pilous, BRA, BRNM, OP, herb. ZP 5. Sokolec Reserve, 6. 1984, Z. Pilous, BRA, OP, herb. ZP 25. Nezbudská Lúčka village, limestone rocks, 400 m, 27. 9. 1986, J. Duda, herb. ZP.

21c Veľká Fatra

Javorina, limestone rock, 1,330 m, 8. 1936, J. Šmarda, BRNM. Čierny kameň, 8. 1952, Z. Pilous, herb. ZP. Suchý vrch (1554 m), limestone rock, 9. 7. 1953, J. Šmarda, BRNM. Gaderská dolina Valley, 1963, Z. Pilous, herb. ZP, dtto, on dry shaded limestone rocks above road, exp. N, 800 m, 9. 7. 1969, V. Peciar, BRA 93, BRNM; Blatnica, Gadier, Padva Reserve, 5. 1967, Z. Pilous, BRA, OP, herb. ZP 6; Blatnica, rocks above village, 5. 1975, Z. Pilous, herb. ZP; Blatnica, Tlstá, 1,400 m, 7. 1976, Z. Pilous, BRA, OP, herb. ZP, dtto, Blatnická dolina Valley, Jasienok, 8. 1976, Z. Pilous, BRA, OP. Foot of Žarnovka beyond Korytnica towards Donovaly, *Festucetum sulcatae*, exp. S-SE, 740 m, 1. 7. 1963, J. Michalko, BRA. Suchý vrch Mt.,

spruce forests, 1,500 m, 10. 6. 1987, A. Kubinská, BRA; Suchý vrch Mt., 15 m below peak from S, 1,535 m, 2. 10. 1987, A. Kubinská, BRA. CHPV Bukovina, travertine terrace, 640 m, 11. 8. 1988, A. Kubinská, BRA. Babiagora, s. d., Pantoczek, BRA.

21d Chočské vrchy

Prosiek, 7. 1937, J. Jedlička, BRNM; On limestone rocks in Prosecká dolina Valley, 700 m, 14. 8. 1969, R. Doležal, BRNM, dtto, 2 km NW by N of village, Prosečanský žleb Gully, 750 m, 13. 6. 1971, V. Pospíšil, BRNM; Prosiecka dolina Valley, rocky limestone slopes above brook, 800 m, 15. 10. 1972, J. Horníčková, BRNM. Choč, limestone rocks, 7. 1952, Z. Pilous, herb. ZP. Ružomberok, travertine "v Lúčkách", 7. 1958, Z. Pilous, herb. ZP; Lúčky, 7 km NW by W "Pod Holicou", grassy hill on watershed, pasture, 830 m, 6. 8. 1969, V. Pospíšil, BRNM. Ružomberok, Valaská Dubová NW, Brestová, places with limestone stones, 740 m, 6. 8. 1969, V. Pospíšil, BRNM.

22 Nizké Tatry

On dolomite rock in spruce forest on slope of Hradovica near Malužiná, 17. 7. 1935, V. Vlach, c. sp., BRNM; Malužiná, in valley of Svidný potok Brook, 1. 10. 1960, J. Šmarda, BRNM; in valley below Veľký Bok Mt., 1,600 m, 17. 8. 1967, J. Váňa, herb. VAN; Small limestone rocks below peak of Veľký Bok, 1,650 m, 17. 9. 1974, J. Dvořák, BRA, BRNM; Malužiná, Veľký Bok (1,727 m), crevices of small limestone rocks on S ridge, 1,600 m, 26. 5. 1975 c. sp., 7. 7. 1978, 26. 7. 1978 c. sp., L. Pokluda, BRNM; Kráľova Lehota, Svarínka Valley, Veľký Bok (1,727 m) on limestone stones in humid gully on NW slope below E ridge, 1,480 m, 9. 9. 1981, L. Pokluda, BRNM. Liptovský Hrádok, on limestone rock of Borová hora Mt., 880 m, 2. 11. 1952, J. Duda, OP, dtto, on limestone rock near Porúbka village, 800 m, 2. 5. 1953, J. Duda, OP; Liptovská Porúbka, Selnice (1,243 m), half-shaded little limestone rocks on N foot, exp. W, 730 m, 19. 9. 1980, L. Pokluda, BRNM, dtto, half-shaded little limestone rock in brook valley towards Brtkovice, exp. NE, 780 m, 26. 5. 1982, L. Pokluda, BRNM. Poprad, Baba near Lučivná, 600 m, 19. 7. 1953, J. Šmarda, BRNM. Liptovská Lužná, Salatín, 21. 7. 1957, Z. Pilous, herb. ZP, dtto (1,630 m), limestone (dolomite) little rocks on W slope, exp. SW, 1,500 m, 17. 5. 1981, L. Pokluda, BRNM. Below Siná, 7. 1958, Z. Pilous, c. sp., herb. ZP; Siná, 8. 1959, Z. Pilous, herb. ZP, dtto (1,560 m), half-shaded rock on S ridge, exp. SW, 1,400 m, 14. 9. 1979, J. Pokluda, BRNM, dtto, E ridge, shaded base of small limestone rocks, exp. N, 1,500 m, 12. 10. 1979, L. Pokluda, BRNM, dtto, Na jame (1,438 m), half-shaded limestone rock on NW ridge, exp. SW, 1,050–1,170 m, 2. 6. 1980, 23. 6. 1984 SW ridge, 1,460 m, L. Pokluda, BRNM, dtto, unshaded limestone rock on NW ridge, exp. N, 1,400 m, 2. 6. 1980, L. Pokluda, BRNM. Krakova hole Mt., 7. 1958, Z. Pilous, herb. ZP; On N slope of Krakova hoľa Mt., dolomite substrate, 1,700 m, 15. 6. 1968, Jeslík, BRA, dtto (1,751 m), top dolomite small rocks, exp. NE, 1,740 m, 23. 6. 1974, 13. 10. 1979, 8. 8. 1980, 27. 5. 1972, 19. 9. 1985, L. Pokluda, BRNM. Predajná, on limestone small rocks above Jasenský potok Brook N of village, exp. SE, 480 m, 19. 7. 1966, L. Pokluda, BRNM. Lupča, SW by W, dolomite hill above road, 400 m, 21. 5. 1968, V. Pospíšil, BRNM; Partyzánska Lupča, Lupčanská dolina Valley, small rocks along road, 760 m, 30. 9. 1989, L. Pujmanová, LIT. On NW slope of Kozie Chrbty below Ďumbier Mt., limestone substrate, 1,600 m, 29. 9. 1969, Jeslík, BRA 92. Liptovský Ján, Stanišovská dolina Valley, shaded limestone rock, 850 m, 28. 6. 1973, L. Pokluda, BRNM, dtto, Pred Bystrou, Javorie Valley, half-shaded limestone rock, 1,150 m, 22. 6. 1974, L. Pokluda, c. sp., BRNM; Pred Bystrou, limestone rock 1.5 km W of gamekeeper's lodge, 1,050 m, 11. 5. 1978, L. Pokluda, BRNM. Liptovský Ján, Kráľička (1758 m) small limestone rocks on ridge, 1,700 m, 24. 6. 1974, L. Pokluda, BRNM; Liptovský Ján, Štiavnica Valley,

Králička (1,758 m), NE base of small limestone rocks, 1,600 m, 27. 5. 1983, L. Pokluda, BRNM. Hučiaky Valley, below Salatín, small sandstone rocks, 1,300 m, 12. 7. 1974, A. Fekjačová, BRA; Ružomberok, Ludrovská dolina Valley, Hučiaky Canyon, limestone rock, 750 m, 21. 5. 1977, L. Pokluda, BRNM. Demänovská dolina Valley, about 0.2 km N of Svoboda Cave, limestone rock on right bank of brook, 900 m, 10. 8. 1975, R. Doležal, BRNM, ditto, shaded limestone rock, exp. N, in transverse valley E of the stone-built Odboj Chalet, 900 m, 13. 9. 1979, L. Pokluda, BRNM, ditto, valley above spring below Studená diera, shaded base of limestone rocks, exp. W, 800 m, 16. 9. 1979, L. Pokluda, BRNM, ditto, limestone rock exp. N, in Machnatá Valley, 950 m, 31. 5. 1980, L. Pokluda, BRNM, ditto, on small humid limestone rock on left bank of Demänovka, exp. E, 730 m, 6. 9. 1981, L. Pokluda, c. sp., BRNM; Demänovská dolina Valley, Machnatá small Valley, limestone rock, exp. W, 860 m, 1. 10. 1983, L. Pokluda, BRNM. Iľanovská dolina Valley, on sunlit limestone rocks at mouth of valley, exp. E, 720 m, 7. 9. 1981, L. Pokluda, BRNM; Iľanovo, solitary half-shaded limestone rock at end of NE ridge of Demänovská hora Mt. (1,304 m), exp. NW, 800 m, 25. 5. 1982, L. Pokluda, c. sp., BRNM. Čierny Váh, Ništoková gamekeeper's lodge, shaded limestone rock, 850 m, 8. 7. 1978, L. Pokluda, BRNM. Liptovská Teplička, valley of Ždiar Brook, small limestone rock above gamekeeper's lodge, 1,000 m, 3. 8. 1978, L. Pokluda, BRNM, ditto, limestone (dolomite?) rock in valley SW on E slope, exp. NE, 1,150 m, 10. 8. 1978, 19. 8. 1978, L. Pokluda, BRNM. Ružomberok, Biela puť (640 m), small limestone rocks above road, exp. W, 550 m, 15. 5. 1981, L. Pokluda, BRNM. Vyšný Šliač near Ružomberok, small travertine rocks near Čertovica sulphuric spring E of village, 600 m, 29. 5. 1982, L. Pokluda, c. sp., BRNM. Slovenská Lupča near B. Bystrica, on sunlit limestone slope N of village, exp. SE, 470 m, 8. 7. 1982, L. Pokluda, BRNM. Dubová-Zámotie near B. Bystrica, limestone rock above Pioneer camp, exp. SE, 600 m, 10. 7. 1982, L. Pokluda, BRNM. Ráztoka near B. Bystrica, small limestone rocks on slope above village, exp. SE, 500 m, 10. 7. 1982, 10. 7. 1988, L. Pokluda, BRNM. Lazisko near Lipt. Mikuláš, Mošnica Valley-Jaloviarka (1,429 m), shaded limestone rocks on N ridge, exp. N, 1,250 m, 22. 9. 1985, L. Pokluda, BRNM. Limestone rocks on forest border above confluence of Bílý and Černý Váh near Kráľova Lehota (Kozie chrbty), 670 m, 20. 10. 1987, M. Holubáč, PL. Závažná Poruba, 1.3 km S of village, on limestone rock, 740 m, 16. 10. 1993, I. Novotný, BRNM.

23a Západné Tatry

On granite of Salatínský vrch Mt. in Liptovské hole, 1. 7. 1927, R. Doležal, BRNU; Liptovské hole, Dlhá jama = basin between Predný Salatín Mt. and elevation point 1,712 m, 1,500 m, 12. 8. 1950, M. Součková, BRNM. Liptovské hole, Osobitá, 4. 1932, ditto, limestone rocks, 1,500 m, 8. 1935, both J. Šmarda, BRNM; Zuberec village, Osobitá Mt., 1,480–1,687 m, 7. 8. 1986, Jiří Duda, herb. ZP. Liptovské hole, Sivý vrch, 8. 1947, Z. Pilous, herb. ZP, ditto (1,805 m), dry limestone boulders on grassy slope near path, exp. NW, 1,500 m, 28. 9. 1976, V. Peciar, BRA 83, BRNM. Úplazky below Záruby, limestone rock, 7. 1956, Z. Pilous, herb. ZP. Zadná Tichá, 1,800 m, 14. 8. 1959, J. Šmarda, BRNM. Zuberec, Volarčiaská dolina Valley, 1,050 m, 6. 8. 1978, Jiří Duda, herb. ZP. Červené vrchy, on shaded limestone rock near Diera Cave in Javorový žleb Gully, 1,460 m, 18. 8. 1995, I. Novotný, BRNM. Mts. Červené vrchy, N of Rozpadlý grúň Mt., in rock crevice, 1,530 m, 18. 8. 1985, B. Buryová, herb. BUR.

23b Vysoké Tatry

In Mlyncá valley, Nadskok, 26. 7. 1921, 1,900–2,000 m, J. Podpěra, PR; Near Lake Pleso nad Skokom, 1,811 m, 8. 1947, J. Šmarda, BRNM, OP. Near Železná

brána, limestone soil, 1,600 m, 21. 7. 1922, 29. 7. 1922, J. Podpěra, c. sp., BRNM, PR. Below col sedlo Soliska in *Oxygria digina* – *Papaver burseri* ass., granite soil, 2,140–2,270 m, s. d., V. Krajina, PRC 62. Malý Satan, in *Silene acaulis* ass., granite soil, 2,380 m, 31. 7. 1932, V. Krajina, PRC 65; In col sedlo of Satan in *Silenote acaulis*, granite soil, 2,330 m, 2. 8. 1932, V. Krajina, PRC 61; Satan, in *Andreaeto nivalis*, granite soil, 2,155–2,170 m, 2. 8. 1932, V. Krajina, PRC 66; Zadná Bašta, *Agrostietum alpinae*, granite soil, 2,340 m, 12. 8. 1932, V. Krajina, PRC 64. Velická dolina Valley, 1,700 m, 9. 8. 1953, 14. 8. 1954, J. Šmarda, BRNM; Above Velické pleso Lake, 1,700 m, 16. 8. 1959, J. Šmarda, BRNM. Mylonite above Zelené pleso Lake, 10. 7. 1957, Z. Pilous, herb. ZP. Polský hřebec Ridge, s. d., Z. Pilous, herb. ZP. Mylonite below Svišťovka, 7. 7. 1957 c. sp., 15. 7. 1957, Z. Pilous, herb. ZP 7; Velká Svišťovka, 1,800 m, 7. 8. 1958, J. Šmarda, BRNM. Ostreva, 21. 8. 1958, 1,750 m, J. Šmarda, BRNM.

23c Belianské Tatry

On peak of Zadní Jatky Mt., 2,000 m, 1. 8. 1922, J. Podpěra, PR, dtto, 15. 9. 1947, V. Pospíšil BRNM, OLM, dtto, 1,950 m, 23. 8. 1951, J. Šmarda, BRNM; Hlúpy, Jatky, 1,930 m, *Firmeto* – *Salicetum reticulatae*, 8. 8. 1933, K. Domin, J. Suza, PRC; Jatky (2,024 m), limestone rocks, humus, 18. 7. 1937, J. Šmarda, BRNM, PRC. Rocks beyond Tatranská kotlina Valley, 1. 8. 1925, V. Krajina, PRC; Tatranská kotlina Valley, on limestone rock towards hunters' lodge, 7. 8. 1933, K. Domin, J. Suza, PRC. Rocks below Muráň, limestone rock, 8. 1925, V. Krajina, PRC; Cave on Muráň, 7. 9. 1989, Z. Pilous, BRA, herb. ZP. Limestone rocks between Havran and Nový, 24. 8. 1925, V. Krajina, PRC; Havran (2,154 m) small limestone rocks on peak, 20. 7. 1937, J. Šmarda, BRNM, PR, PRC, dtto, 23. 7. 1955, BRNM; dtto, on limestone rock, 7. 1953, Z. Pilous, BRA, BRNM, LIT, herb. ZP. Hlúpy (2,062 m), sandstone "rendy" on S slope, 1,900 m, 18. 7. 1937, J. Šmarda, BRNM, PR; In basin below Hlúpy, 8. 1947, Z. Pilous, herb. ZP 1; Hlúpy (2,062 m), limestone rocks on peak, exp. N, 2,055 m, 23. 6. 1969, L. Pokluda, BRNM, dtto, base of rocks on NW ridge, 1,950 m, 13. 6. 1969, L. Pokluda, BRNM; Above tree line below Hlúpy, 8. 1987, Z. Pilous, herb. ZP. Predné Koperšády, 21. 6. 1938, Z. Pilous, herb. ZP. Bujačí, 1,800 m, 21. 6. 1938, Z. Pilous, herb. ZP, dtto, 1,950 m, 8. 1947, J. Šmarda, BRNM, OP, dtto, 7. 1951, Z. Pilous, herb. ZP; On limestone soil on S ridge of Bujačí vrch Mt., 1,800 m, 8. 1956, M. Vondráček, herb. ZP; Below peak of Bujačí, 1,945 m, 21. 5. 1958, V. Ježek, BRNM; Holubyho dolina Valley on rock in Skalní brána, 1,623 m, 9. 9. 1954, E. Hadač, BRNM; Rakúský chrbát Ridge, 1,800 m, 18. 7. 1955, J. Šmarda, BRNM, dtto, ridge, 1,800 m, 22. 7. 1955, J. Šmarda, BRNM, OP, PL, dtto, 1,830 m, 8. 8. 1956, V. Ježek, BRNM; On ground on Rakúský chrbát Ridge, 1,800 m, s. d., M. Vondráček, herb. ZP; On small rock below Rakúský chrbát Ridge – Velbloud, 7. 8. 1956, V. Ježek, BRNM; Holubyho dolina Valley, limestone rock on W end of Murárik wall, 1,600 m, 8. 1956, M. Vondráček, BRNM, PL; Holubyho dolina Valley, col between Jelení and Rysí Rocks, 1,580 m, 8. 1956, M. Vondráček, PL. Ždiarská Vidla, 2,000 m, 6. 1929, R. Doležal, BRNM, dtto, 2,148 m, 8. 1947, J. Šmarda, BRNM, herb. ZP 38, dtto, 8. 1947, Z. Pilous, herb. ZP 10; Peak of Ždiarská Vidla, 8. 1961, Z. Pilous, herb. ZP; Peak of Ždiarská dolina Valley, 15. 8. 1947, V. Pospíšil, BRNM; On limestone rocks near Ždiar village, 1,120 m, 8. 1947, Z. Pilous, BRA 85; Skalní vrata, 1,600 m, 12. 7. 1949, J. Šmarda, BRNM; Tatranská kotlina Valley – Skalní vrata, limestone rock, 900 m, 7. 8. 1973, L. Pokluda, BRNM. Faixova louka Meadow, 1,450 m, 13. 7. 1949, J. Šmarda, BRNM. Košiary, 7. 1951, Z. Pilous, herb. ZP. Bialčanská dolina Valley, on granite rocks, 1,750 m, 12. 8. 1953, J. Šmarda, BRNM; Dolina Siedmich prameňov Valley on lime-

stone rocks, near path from Protěž Chalet to Tatranská kotlina Valley, 1,300 m, 23. 7. 1958, M. Vondráček, herb. ZP. Hlásná skála Rock, 7. 1955, Z. Pilous, herb. ZP. Peak of Velká Jelení skála Rock, 1,500 m, 20. 7. 1955, 7. 7. 1957, J. Šmarda, BRNM. Tristarský důl Valley, 1,200 m, 23. 7. 1955, J. Šmarda, BRNM. Below Jelenia skala Rock, 3. 8. 1955, V. Ježek, BRNM. On upper small rock near Protěž Chalet, 12. 8. 1957, V. Ježek, BRNM. Ždiar, Monkova dolina Valley, on small limestone rock, exp. E, 920 m, 23. 6. 1969, L. Pokluda, BRNM, dtto, small rocks in forest, 1,150 m, 5. 9. 1974, J. Dvořák, BRNM, dtto, limestone at dry place, 1,240 m, 14. 8. 1995, B. Buryová, herb. BUR. On limestone rocks on slope of "Kotek" reserve above Tatranská kotlina Valley, 880 m, 24. 9. 1993, M. Holubář, PL.

24 Pieniny

Haligovské limestone Rocks, 800 m, 22. 7. 1937, J. Šmarda, c. sp., BRNM, PRC 72. On limestone rocks in defile of Dunajec River, 450 m, 23. 7. 1937, J. Šmarda, BRNM; Limestone rocks above Dunajec River, 450 m, 6. 9. 1974, BRNM, OLM; Road between villages Červený Kláštor and Lipovec, 550 m, 26. 6. 1985, J. Váňa, herb. VAN. Veľký Lipník, limestone rock on pasture 1 km NE by N of church, 670 m, 13. 9. 1981, V. Pospíšil, c. sp., BRNM, dtto, pasture on top of hill 1.2 km NE by N of church, 700 m, 13. 9. 1981, V. Pospíšil, L. Pospíšilová, BRNM, OLM.

26a Liptovská kotlina

Liptovský Hrádok, on limestone rock of Borová hora Mt., 880 m, 2. 11. 1952, J. Duda, OLM.

26b Spišské kotliny

Spišské Podhradie, on limestone rocks of Spišský hrad Castle, 6. 1930, R. Doležal, BRNM, dtto, knoll near Spišská kapitula "Na Pažici", limestone rocks, 460 m, 30. 7. 1938, J. Šmarda, BRNM; Spišský hrad Castle, limestone rock, 630 m, 20. 9. 1977, J. Sofron, PL. At Primovce village, 14. 7. 1936, ?, PRC; Poprad, Horka, melaphyre rocks near Primovce, 4. 1973, Z. Pilous, BRA, OP, herb. ZP; Spišská N. Ves, Primovce, s. d., Lánik, BRNM. Spišské Vlasy, Poračský járok, limestone rocks, 620 m, 25. 7. 1937, J. Šmarda, BRNM. Spišské Podhradie, Drevenik, limestone rocks, 612 m, 29. 7. 1938, J. Šmarda, c. sp., BRNM. Sivá Brada, 7. 1950 c. sp, 7. 1959 steril., Z. Pilous, herb. ZP, dtto, Spišské Podhradie NW, limestone rock with sulphuric spring, 500 m, 30. 8. 1966, V. Pospíšil, BRNM. Svit, limestone hill N of the town near road to Poprad, 21. 6. 1965, V. Pospíšil, BRNM.

27a Biele Karpaty (north part)

Vlára, in Vršatec Mt., 29. 6. 1922, J. Podpěra, c. sp., BRNM, BRNU; Limestone rocks on Vršatec, 28. 7. 1925, V. Vlach, BRNM; Vršatec, 22. 6. 1962, J. Šmarda, BRNM, dtto, Vršatecké Podhradie NE by N, 850 m, 5. 8. 1969, V. Pospíšil, c. sp., BRNM, dtto, limestone rock, 26. 4. 1972, J. Sofron, PL. Púchov nad Váhom, Hrabovka, limestone Skala Rock NE above village, wall, 350 m, 24. 4. 1963, V. Pospíšil, BRNM. Čachtice, on limestone rocks near ruin NW of village, 400 m, 9. 6. 1966, V. Pospíšil, BRNM. Lednica, sunlit slope near ruin, 510 m, 9. 9. 1981, V. Pospíšil, BRNM.

27b Javorníky

Městečko, Mostecká skala Rock NE of village, limestone rock, exp. N, 400 m, 24. 4. 1963, 5. 5. 1971, V. Pospíšil, BRNM. Nimnica, grassy slope SE of village above right bank of Váh River, 280 m, 16. 6. 1965, V. Pospíšil, BRNM. Hatné NW, limestone hill (rock) Hrádek, 330 m, 18. 10. 1967, V. Pospíšil, BRNM. Dolní Mariková, "Horka" NW of church, limestone rock, 18. 10. 1967, V. Pospíšil, BRNM. Divínka NW, Velký vrch, rocks and stony slope on N and NE foot, 400 m, 9. 10. 1968, V. Pospíšil, BRNM.

Povážské Podhradie, Udiča, 2 km SE, elevation point Klapé (645 m) small limestone rocks and boulders on S slope, 550 m, 22. 10. 1969, V. Pospíšil, BRNM.

28 Západné Beskydy

Orava, Trstěná, limestone cliff above town, 8. 1947, Z. Pilous, herb. ZP.

29 Spišské vrchy

Flora of Levoča (Leutschoviensis), in "Rehberg" Mt., 25. 7. 1885, V. Greschik, BRA. Vyšné Ružbachy, Suchý kráter Rock, travertine near N limit of spa, 650 m, 12. 10. 1976, 6. 11. 1976, V. Pospíšil, BRNM, dtto, small travertine rocks in woodlandpark of spa, 640 m, 3. 11. 1976, L. Pospíšilová, BRNM, dtto, small travertine rock on NE slope of source "Kráter" near Kriváň building in spa, 2. 11. 1976, L. Pospíšilová, BRNM, dtto, pasture between woods on hiker's path marked blue and yellow, 700 m, 3. 11. 1976, V. Pospíšil, BRNM, dtto, stony slope above N limit of village, pasture, 650 m, 20. 10. 1977, V. Pospíšil, BRNM, dtto, top of travertine rocks above quarry, 610 m, 16. 10. 1979, V. Pospíšil, BRNM. Jarabina, 2 km NE, limestone rocks on pasture, exp. N, 740 m, 30. 9. 1978, V. Pospíšil, L. Pospíšilová, OLM, dtto, 1.8 km NW by N of church, "Jarabinská prieloma", limestone rock, 650 m, 1. 5. 1980, V. Pospíšil, BRNM, OLM, dtto, on limestone rocks above right (W) bank of brook facing quarry, 680 m, 1. 5. 1980, V. Pospíšil, L. Pospíšilová, BRNM, OLM. Stará Ľubovňa, valley below ruin, limestone rocks, exp. N, 600 m, 29. 10. 1982, V. Pospíšil, c. sp., BRNM, OLM. Stráňany, elevation point Vysoké skalky, top rock, exp. N, 1,050 m, 17. 10. 1984, V. Pospíšil, L. Pospíšilová, BRNM, OLM, dtto, small limestone rocks in forest 1.2 km NE of village, 800 m, 17. 19. 1984, V. Pospíšil, L. Pospíšilová, BRNM, OLM. Údol, small limestone rocks 1 km S of village, 550 m, 20. 10. 1984, V. Pospíšil, L. Pospíšilová, c. sp., BRNM, OLM.

30b Čergov

Kyjov, limestone Zadné skalie Rocks 1 km SW by S of village, 730 m, 3. 11. 1982, V. Pospíšil, L. Pospíšilová, BRNM, OLM.

Unidentified localities

Mosses of Tatra mts., on bare soil on "Dürrenberg" Mt. near Kežmarok, 5. 1884, V. Greschik, BRA. Borek, Ústa, 10. 5. 1897, S. Truchli, BRA. Azoic banks near Bukovec, 5. 1897, J. Velenovský, PRC. On rocks facing Bělá railway station, 6. 1899, J. Podpěra, PR. (perhaps Bělá p. Bezdězem). "Höllenthal", 15. 5. 1904, F. Nábělek, BRA. Slovenia, Podtisoška, limestone rocks, 995–1,040 m, 11. 8. 1925, V. Krajina, PRC. Slovenia, *Caricetum firmae*, below Ponzači, limestone rock, 1,860 m, 30. 8. 1945, V. Krajina, PRC.

Ditrichum gracile (Mitt.) Kunze

Czech Republic

8 Český kras

St. Ivan, 1894, J. Velenovský, PRC, dtto, On humid Silurian limestone, St. Ivan near Beroun (Bernau), 250 m, 7. 5. 1899, E. Bauer, BRNM, BRNU, OP, PR c. sp., herb. VAN ad *D. f. vergens*, dtto, On limestone rocks near Srbsko near Beroun, 4. 1900, J. Podpěra, BRNM, BRNU ad *D. f. vergens*, dtto, On humid Silurian limestone, St. Ivan near Beroun (Bernau), 250 m, 15. 5. 1900, E. Bauer, herb. ZP 31 ad *D. f. vergens*, dtto, On limestone rocks near Srbsko near Prague, 5. 1900, J. Podpěra, BRNU, dtto, St. Ivan near Beroun, 7. 1913, J. Podpěra, PR, dtto, Rocks near St. Ivan, 2. 5. 1915, S. Trapl, herb. ZP 28 ad *D. f. vergens*, dtto, Svatý Jan pod Skalou, "Propadlá voda" gorge on dry limestone rock, 250 m, 7. 6. 1959, J. Stuchlý, PRC 71 *D. g.*, herb. VAN ad *D. f. vergens*.

33i Českokrumlovské předšumaví

Černá v Pošumaví, 0.5 km E of Jestřábí estate – overgrown limestone quarry, leg. D. Blažková, 23. 8. 1961, CB.

93a Krkonoše lesní

Near Špindlerův mlýn (Spindelmühle), 9. 1896, J. Velenovský, PRC; Rocks near Špindlerův mlýn, 1,100 m, 12. 7. 1930, M. Béňa, BRA 91 ad *D. f. vergens*, dtto, left bank of Labe River near road to Dívčí lávky close to village, on rocks, 720 m, 10. 9. 1959, J. Stuchlý, PRC 68, dtto, limestone inclusion in rock along road from Špindlerův mlýn to Dívčí lávky, 760 m, 11. 9. 1959, J. Váňa, herb. VAN.

93b Krkonoše subalpínské

On mica schist rocks on slope of Kotel (Kesselkoppe) facing "Kessel" (1,390 m), 17. 9. 1890, v. Cypers, PR. In Čertova zahrádka, 9. 1896, J. Velenovský, PRC 74, dtto, 6. 1947, Z. Pilous, herb. ZP 48.

93c Rýchory

Horní Maršov, on limestone rock, 7. 1954, Z. Pilous, BRA, LIT, herb. ZP; Maršov IV., limestone rock, 9. 1954, Z. Pilous, herb. ZP.

97 Hrubý Jeseník

Kotlina, on slate rocks, 1,200 m, 7. 1904, J. Podpěra, BRNM.

Slovak Republic

3 Slovenský kras

Torňa n. Bodvou (Torna), Zadielská dolina Valley, 8. 1930, H. Laus, OLM.

15 Slovenské Rudohorie

Olcnava, valley, 9. 1973, Z. Pilous, herb. ZP, 22, 37.

17 Slovenský raj

On bridge below Kláštorisko near Dobšiná, 14. 7. 1928, ?, PR. Spišská N. Ves, on limestone rocks above Letanovský mlyn, 6. 1930, R. Doležal, BRNM. On limestone rocks of Čertova Sihot Mt. towards Kláštorisko near Spišské Tamásovce, 800 m, 12. 7. 1958, A. Boros, OP, herb. ZP 44. Hrabušice, valley of Biela voda above Sokol gamekeeper's lodge, on rocks in forest, 650 m, 16. 6. 1969, V. Pospíšil, BRNM, dtto, Velký Sokol, 6. 1978, Z. Pilous, BRA 89, BRNM, OP, herb. ZP 39, dtto, Piecky, 6. 1978, Z. Pilous, BRA, BRNM, OP, herb. ZP 33. Stratená, 1.5 km NE by E of village, rocks above brook near road from Glác, 800 m, 16. 6. 1970, V. Pospíšil, BRNM, dtto, Stratená souteska Valley, 6. 1978, Z. Pilous, BRA, BRNM, OP, herb. ZP 36, dtto, Stratená near Dobšinská ľadová Cave, 6. 1978, Z. Pilous, BRNM, OP, herb. ZP 3, 42.

18 Stredné Pohornádie

Branisko, Lipovce, 8. 1967, Z. Pilous, herb. ZP, dtto, Kamenná baba Valley, 9. 1973, Z. Pilous, BRA 90 + *D. flexicaule*.

21a Lúčanská Fatra

Strečno, on limestone rocks, 1934, Z. Pilous, PL.

21b Kriváňská Fatra

On limestone rocks near Nezbud village, Lúčka, 300 m, 8. 1934, Z. Pilous, BRNM, BRNU, PR, PRC, herb. ZP 49 ad *D. f. vergens*, 30 *D. g. Terchová, Vrátná Valley*, 1935, Z. Pilous, herb. ZP. Glacial basin of Chleb (1,644 m) 7. 1936, J. Šmarda, PR. Starý hrad Castle, 1939, Z. Pilous, herb. ZP, 11. Rozsutec, Vyhnaná Valley, limestone rocks, 8. 1972, Z. Pilous, BRA *D. g.*, OP ad *D. f. vergens*, herb. ZP 34, 50 *D. g.*, 43 ad *D. f. vergens*. Suchý, Biele skaly Rocks, 9. 1979, Z. Pilous, BRA 80, herb. ZP

Sokolec Reserve, 6. 1984, Z. Pilous, herb. ZP 16. Fatranský kriváň Reserve, 9. 1980, Z. Pilous, BRA 95.

21c Velká Fatra

Blatnica, Gader, Vrátna Valley, 5. 1975, Z. Pilous, BRA, OP, herb. ZP 27, 35, dtto, Blatnická dolina Valley, Jasienok, 8. 1976, Z. Pilous, herb. ZP 15 ad *D. f. vergens*.

21d Chočské vrchy

Mouth of Kvačianská dolina Valley about 0.9 km N of Kvačany village, on small limestone rock above Kvačianka Brook, 625 m, 9. 8. 1975, R. Doležal, BRA 82, dtto, humid small limestone rock above road in slope (exp. W) about 1.2 km N of Kvačany village, 640 m, 9. 8. 1975, R. Doležal, BRA 87, herb. ZP 41, OP, dtto, Kvačianská dolina Valley, 500 m, 23. 5. 1984, J. Váňa, herb. VAN.

22 Nízké Tatry

Svatojánská dolina Valley, 22. 7. 1928, ?, PR, dtto, on travertine rock in Svatojánská dolina Valley about an hour's walk from Lipt. Sv. Ján, 560 m, 1. 5. 1951, V. Vlach, BRNM, dtto, Jánská dolina Valley, small limestone rocks above river, facing a well 1.6 km N of gamekeeper's lodge, 800 m, 12. 5. 1978, L. Pokluda, BRNM, dtto, in Jánská dolina Valley, on humid limestone rocks, 760 m, I. Novotný, 15. 10. 1993, BRNM ad *D. f. vergens*. In forests between limestone (and dolomite) rocks near Malužiná, 6. 8. 1936, V. Vlach, BRNM ad *D. f. vergens*, dtto, Liptovský hrádok, on limestone soil in N slope of Velký Bok Mt., 1,400 m, 15. 8. 1968, B. Wagner, LIT. Lipt. Mikuláš, on humid limestone rocks in lateral valley left of Vyveranie in direction from Demänová dolina Valley towards Krakova hoľa, 800 m, 13. 8. 1969, R. Doležal, BRNM ad *D. f. vergens*, dtto, Krakova hoľa (1,751 m), Prednie, small limestone rock towards col below Kúpeľ, 1,550 m, 10. 9. 1973, L. Pokluda, BRNM ad *D. f. vergens*, dtto, crevices of limestone rocks on NE slope, 1,700 m, 9. 6. 1978, L. Pokluda, BRNM ad *D. f. vergens*, dtto, Pustie (1,501 m), shaded limestone rocks on ridge, exp. NW, 1,500 m, 13. 10. 1979, L. Pokluda, BRNM, dtto, 11. 10. 1979, L. Pokluda, BRNM ad *D. f. vergens*. Demänová dolina Valley, about 0.4 km N of Sloboda Cave, on humid limestone rocks on right bank of brook, 900 m, 10. 8. 1975, R. Doležal, BRA 86, BRNM, dtto, about 0.3 km N of Sloboda Cave, on limestone boulder on right bank of brook, 900 m, 10. 8. 1975, R. Doležal, BRA 84 ad *D. f. vergens*, dtto, small valley facing a well, crevices of limestone rock, exp. NW, 900 m, 15. 9. 1979, L. Pokluda, BRNM ad *D. f. vergens*. Lipt. Mikuláš, Siná (1,560 m), E ridge, shaded small limestone rocks, exp. N, 1,500 m, 12. 10. 1979, L. Pokluda, BRNM. Michalovo near Kráľ. Lehota, Hradištie (1,325 m), on small limestone rock at entrance to valley, exp. SE, 800 m, 24. 5. 1982, L. Pokluda, BRNM. Lipt. Mikuláš, Kvačianská dolina Valley, on half-shaded limestone rock above brook, exp. NE, 850 m, 24. 6. 1984, L. Pokluda, BRNM ad *D. f. vergens*. On Kralička Rock 1 km E of chata Hrdinov Chalet, 1,350 m, 31. 8. 1978, N. Gutzerová, PL. Partizánská Lupča, Lupčianská dolina Valley, Bralné Nature Reserve (in prep.), small limestone rocks on both sides of valley at N foot of Očenášková Mt., 800–850 m, 1. 10. 1989, L. Pujmanová, LIT. On limestone rocks in Bielo Valley near Lipt. Ján, 800 m, 17. 5. 1993, M. Holubáč, c. sp., PL.

23a Západné Tatry

Liptovské hole, Smutná dolina Valley, calciferous mica schist, 8. 1947, Z. Pilous, herb. ZP 12. Liptovské hole, Smrečianská dolina Valley, rocks below chalet, 30. 8. 1970, Z. Pilous, herb. ZP 23. Roháče, place Mačie diery ca 4.5 km E of Zuberec village, 1,070 m, 24. 5. 1984, J. Váňa, Z. Soldán, L. Pujmanová, PRC 59 ad *D. f. vergens*. Roháče, Juráňova dolina Valley, on limestone rock above Tiesňavy, 1,040 m, 29. 9. 1990, Z. Soldán, PRC 63 ad *D. f. vergens*.

23b Vysoké Tatry

Humid mossy rocks with *Heliosperma* below Široké pole, limestone, 1,509 m, 6. 8. 1925, V. Krajina, OPRC 77 ad *D. f. vergens*. Limestone rock at 2nd spring on hiker's path in Bielowodská dolina Valley (with *Bryum pseudotriquetrum*) 1,080 m, 17. 5. 1993, M. Holubáf, PL.

23c Belianské Tatry

On NE slopes of High Tatra mts., 7. 1893, V. Greschik, BRA, 79, PRC. Ždiarská Vidla, *Dryado-Salicetum* below peak, limestone rock, 2,080 m, 6. 8. 1925, V. Krajina, PRC 78; Basin between Hlúpý and Ždiarská Vidla, 9. 1947, Z. Pilous, herb. ZP 29 ad *D. f. vergens*. On peak of Muráf Mt., 7. 1929, J. Suza, PR. Tatranská Kotlina, 8. 1930, H. Laus, PR. Gaflovka *Dryastetum* on limestone rocks, 1,600 m, 4. 8. 1933, K. Domin, J. Suza, PRC 75 ad *D. f.* In valley of Rigfanský potok Brook below gully, 1,000 m, 10. 7. 1935, V. Horák, herb. ZP. Belianská dolina Valley, on border of *Piceetum*, 550 m, 20. 8. 1935, G. Brižický, PR. Pod Bednárským Valley, 8. 1947, Z. Pilous, herb. ZP. On limestone rocks near Ždiar village, 1,120 m, 8. 1947, Z. Pilous, BRNU, PR, herb. ZP 32 ad *D. f. vergens* BRA 86. Hlúpý Mt., on limestone rock, 7. 1953, Z. Pilous, BRA 89, 94, LIT, herb. ZP 17 ad *D. f. vergens*. Skalní vrata, 8. 1954, E. Hadač, BRNM ad *D. f. vergens*. Holubyho dolina Valley, slope between Bujací and Murárik wall, 1,700 m, 8. 1956, M. Vondráček, PL, ditto, Jelení skála Rock, 1,600 m, 8. 1956, M. Vondráček, PL, ditto, rocky slope between Bujací and Murárik wall, 8. 1956, M. Vondráček, BRNM ad *D. f. vergens*. On limestone rock in Monkova dolina Valley, 1,240 m, 23. 9. 1993, M. Holubáf, PL.

24 Pieniny

Borštyková skala Rock, limestone rock, exp. N, 475 m, 19. 8. 1870, Steinitz, BRA 81. Defile of Dunajec River, 7. 1950, Z. Pilous, herb. ZP 19, ditto, Bank of Dunajec River below Tri hromady, 10. 10. 1957, E. Hadač, PL, ditto, Defile of Dunajec River, right bank, 28. 12. 1970, J. Sofron, PL, ditto, near Červený Kláštor village, 450 m, 24. 6. 1985, J. Váňa, herb. VAN, ditto, between village Červený Kláštor and Lesnica, on limestone rocks, 20. 8. 1995, B. Buryová, herb. BUR, ditto, 420–450 m, 20. 8. 1995, I. Novotný, BRNM + ad *D. f. vergens*. Lesnica, grassy slope above left bank of Lesnický potok Brook 0.2 km upstream from mouth into Dunajec River, 450 m, 13. 9. 1981, V. Pospíšil, BRNM ad *D. f. vergens*, ditto, limestone rocks above right bank of Dunajec River, W of mouth of Lesnický potok Brook, 440 m, 20. 9. 1981, V. Pospíšil, BRNM.

26b Spišské kotliny

Levoča (Leutschau), on rocks in forest, 3. 1930, BRA 88 ad *D. f. vergens*.

28 Západné Beskydy

Orava-Tvrdošín, 3 km N of village, 2 km S of outlet of Orava from dam, marsh, path below it, 600 m, 6. 8. 1969, V. Pospíšil, BRNM ad *D. f. vergens*.

29 Spišské vrchy

Lubovnianská vrchovina, Jarabina, 2 km NE, limestone rocks on pasture, exp. N, 740 m, 30. 9. 1978, V. Pospíšil, L. Pospíšilová, BRNM ad *D. f. vergens*.

Unidentified localities

Šíp, Orava, J. Klika, PR ad *D. f. vergens*. Poprad, 7. 1937, J. Jedlička, BRNM.

The distribution of *D. flexicaule* and *D. gracile* in the Czech and Slovak Republics is shown in Figs. 8 and 9. Most of the localities of *D. flexicaule* are concentrated in the Slovakian part of the Western Carpathians. There *D. flexicaule* is not found in regions formed by acid volcanic rocks. In mountain ranges also containing limestone or other

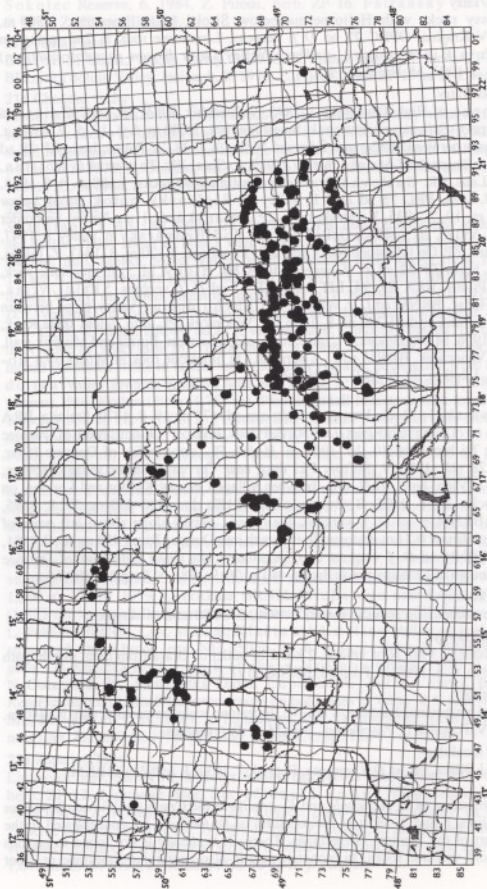


Figure 8. Distribution of *Ditrichum flexicaule* (Schwaegr.) Hampe.

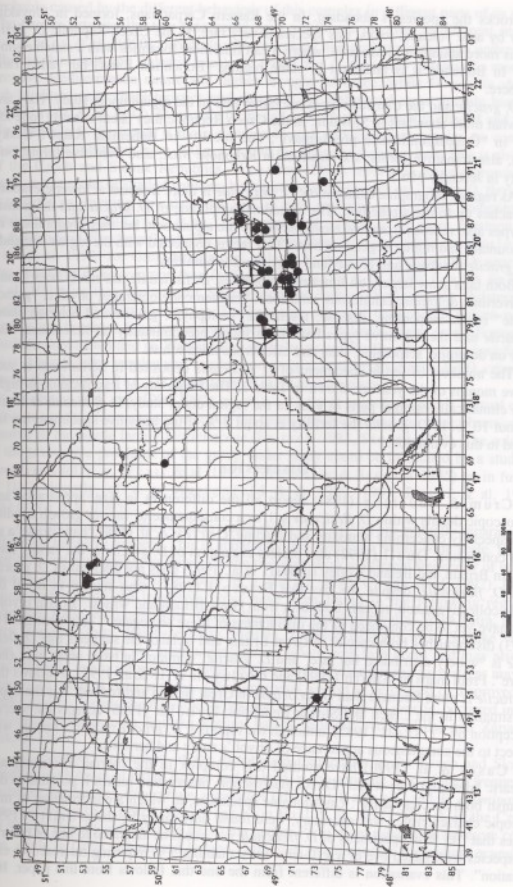


Figure 9. Distribution of *Ditrichum gracile* (Mitt.) Kuntze - full dots, transitive samples - triangles.

basic rocks the species is abundant. In the Eastern Carpathians, formed in Slovakia mostly by acid volcanic rocks, this species is very rare. In the Czech Republic *D. flexicaule* is more abundant in Moravia, where it can find more localities with a suitable substrate. In Bohemia it is abundant in some regions (Bohemian Karst) but rather rare elsewhere.

D. gracile and the transitive types are rather rare in the region under study. They are somewhat more abundant in Slovakia. In the Czech Republic they occur scantily (one locality in "Českokrumlovské předšumaví"; one locality in Bohemian Karst ("Český kras"), also transitive forms; six localities in Krkonoše Mts., also transitive forms; one locality in Jeseníky Mts.)

As regards orographic distribution, *D. flexicaule* is more frequent at lower elevation, but reaches up to the alpine belt. The altitudinal amplitude of *D. gracile* and the transitive types also reaches from low elevations up to the alpine belt, but they predominate in the mountain and higher vegetation belts. This fact is connected with the higher demands of *D. gracile* for shade and greater and more durable humidity.

Both taxa grow largely on limestone substrates. *D. flexicaule* has rarely been found on travertine, dolomite, calciferous sandstone, Permian conglomerates, phyllite, "granosyenite" rocks, serpentine, diabase, teschenite, melaphyre, granite and Silurian slate; *D. gracile* and the transitive types have been found predominantly on limestones, also rarely on dolomite, serpentine, slate and calciferous mica schist.

The numbers of fertile specimens of *D. flexicaule* deposited in herbariums in successive months of the year are shown in Table 3. The frequency of fructification is highest in climatically optimal parts of year. In the region under study, *D. flexicaule* is fertile at about 10 %. In *D. gracile* the fertility is about 3 %, if the transitive specimens are included in this evaluation.

Discussion

Crum & Anderson (1981) report all the differences in size, appearance and microscopic details within *D. flexicaule* s. l. as a consequence of various growth conditions, especially concerning humidity and shading. Corley & al. (1981) have drawn a similar conclusion. Duell (1992) also prefers evaluation of *D. gracile* at the variety level only. In Britain and Ireland Corley (in Hill & al. 1992) does not distinguish *D. gracile* from *D. flexicaule*, despite the fact that Frisvoll (1985), who studied in detail the whole collective taxon, reports both taxa from Great Britain and writes: "British bryologists have yet to be convinced of the distinctness of these segregates". However, Smith (1993) distinguishes both species in Great Britain and Ireland. He suggests that *D. flexicaule* is "widely distributed but rare" and *D. gracile* "common in basic areas, rare elsewhere". From maps by Smith (1993) and Corley (in Hill & al. 1992), it follows that *D. gracile* is more frequent than *D. flexicaule* in Great Britain and Ireland. It is the opposite situation in the Czech and Slovak Republics. Nyholm (1986) accepts the species conception by Frisvoll (1985), although she reports it *D. gracile* only in a remark with respect to the simultaneous appearance of Frivoll's study and her own.

Casas & al. (1990) have studied this complex in the Iberian Peninsula and Balearic Isles, and they write: "Direct macroscopic observation makes it possible to distinguish both species easily". Questionable specimens, in which a confirmation of microscopic characteristics was necessary, were found only rarely by them. Smith (1993) writes that "95 % of specimens of *D. flexicaule* s. l. could be allocated to one or other of the species with naked eye or a $\times 10$ lens, the remaining 5 % requiring microscopic examination". This evaluation is different from the one that follows from this paper. It is

probably caused by the different behaviour of this complex in different parts of its range. The barrier between the two taxa could have a different intensity in different regions.

Casas & al. (1990) also dealt with chorology and ecology in the area under study (Iberian Peninsula and Balearic Isles) and found that *D. flexicaule* possessed a more expressive Mediterranean nature and higher drought tolerance, while *D. gracile* showed sub-Mediterranean characteristics and demands for higher and more durable humidity (also Casas & al. 1992). *D. gracile* forms tall and extensive stands in shaded and moist places, while *D. flexicaule* is more common in rock crevices. Both species are confined to calcareous substrates from 300 m a. s. l. to the alpine (subalpine) belt. This is also true of the Czech and Slovak Republics. Nyholm (1986) reports *D. gracile* growing on basic, moist rocks in shaded habitats, beside streams, in ravines etc., while *D. flexicaule* is reported as growing on calcareous soil, in rock crevices, in rich fens, sometimes in sand dunes. Tuomikoski & al. (1973) report *D. gracile* to be more common than *D. flexicaule* in Newfoundland. The same follows from Smith (1993) and Corley (in Hill & al. 1992) for Great Britain and Ireland. In the Iberian Peninsula *D. gracile* is also somewhat more common than *D. flexicaule* (Casas & al. 1990). Frahm (in Frey & al. 1994) writes: "Selten mit Sporogonen. In dichten dunkelgrünen Polstern auf Kalkboden durch ganz Europa, in Trockenrasen oder auf trockeneren Felsen relativ niedrig, an feuchten Standorten in großen lockeren Polstern. Sehr große Formen in feuchten Schluchten und an Wasserfällen sind als var. *sterilis* De Not. (var. *longifolium* Zett.) beschrieben worden und werden von einigen Autoren als eigene Art *D. crispissimum* (C. Müll.) Par. (*D. giganteum* Williams) angesehen."

Ochyra & Kuta 1990(1992) report $n = 13$ for *D. gracile*, which is a usual chromosome number for various species of the genus *Ditrichum*, and the basic chromosome number of the whole family *Ditrichaceae* (Fritsch 1982, Steere 1972). The solution of the taxonomic problems of the group under study could be facilitated by a study of isoenzymes (cf. e. g. Wyatt & al. 1992, 1993, Shaw & Srodon 1995) or, in future, of DNA directly (cf. e. g. Marienfeld & al. 1989, 1991, Reski & al. 1994, Gazdová & al. 1995).

In different regions the two taxa under study (*D. f.*, *D. g.*) are mutually separated by differently intensive barriers. This is apparently true even on a world-wide scale. Due to their different ecological requirements, the two taxa show a different frequency of occurrence in different parts of their range (e. g. Smith 1993, Casas & al. 1992). In the region under study the transitive types have been found in the following regions: Bohemian Karst, Krkonoše Mts. (Czech Republic); Kriváňská Fatra, Velká Fatra, Nízké Tatry, Západné Tatry, Belanské Tatry, Pieniny, Západné Beskydy Mts., Spišské vrchy Hills (Slovakia). These are mostly territories in which both taxa occur and may also be fertile (largely mountain regions). Thus, occasional hybridisation and its vestiges may be assumed to occur in these regions. This hypothesis has yet to be proved or disproved by further studies. Merely the transitive types, and not the typical *D. gracile*, occurred in the phytogeographical units Spišské kotliny basins (Spišské vrchy Hills) and Západné Beskydy Mts.

As concerns comparison of the distribution frequencies in the Czech and Slovak Republics with those of Great Britain and Ireland, is the opposite ratio of their frequency similar to the species *Pleuroidium subulatum* (Hedw.) Rabenh. and *P. acuminatum* Lindb. (Novotný 1992 (1993), Finch (in Hill & al. 1992). That is, in the Czech and Slovak Republics *Ditrichum flexicaule* and/or *Pleuroidium subulatum* are more common, while in Great Britain and Ireland *Ditrichum gracile* and/or *Pleuroidium acuminatum*.

I found *D. gracile* in herbarium collections labelled *D. flexicaule*, without indication of a corresponding variety, or as *D. flexicaule* var. *longifolium* Zett. Several times *D. flexicaule* var. *densum* (B. S. G.) Braithw. has been reported in the literature from Slovakia (e. g. Šmarda (1948), Pilous 1988 (1991)), but *D. gracile* has been only mentioned from the territory under study by Duell (1984); his Czechoslovak data originated from Z. Pilous. Pilous & Duda (1960) reports on *D. flexicaule*: "Besides long-leaved forms a form occurs in our country with short, straight leaves, its mats are dense, low."

Conclusion

One may state on the basis of the results of the present study that transitive types exist between the two taxa. *D. flexicaule* is a more homogeneous taxon than *D. gracile*. The intensity of the barrier between the two taxa, and thus also the abundance of the transitive types, may differ in different parts of the range, depending on the conditions in a given region. On the basis of the present study it is not recommended to carry out any taxonomical changes. However, the results (cf. the principal co-ordinate analysis [Figs. 4–6]) also suggest that the two taxa could be evaluated on the subspecific level. It is necessary, however, to consider the vast range of the taxa under study, and to carry out detailed investigations in other representatively selected regions in order to assess the variability in dependence on its geographical distribution. Furthermore, it is necessary to analyse the morphology of sporophytes in a sufficiently numerous and representative series.

The use of multivariate analytical methods cannot be considered to provide more objective results, only significant help in the study of these taxa. It may be useful to evaluate questionable populations separately on the basis of more numerous material. Additional information on this group can be obtained from further studies based on quite independent analyses, e. g., of isoenzymes or DNA directly.

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SOUHRN

Ditrichum flexicaule s. l. se vyznačuje výjimečnou variabilitou. V České a Slovenské republice se vyskytují dva nápadné taxony. Je to *Ditrichum flexicaule* (Schwaegr.) Hampe a *D. gracile* (Mitt.) Kunze [= *D. crispatisimum* (C. Müll.) Par.]. Byla provedena morfometrická analýza, při níž bylo na 95 náhodně zvolených vzorcích hodnoceno 7 znaků. Jednalo se o následující znaky: počet hyaliničních buněk na okraji báze listu (hyacel), křivost stěn buněk na bázi listu blíž žebru (curvat), délka listu (leafle), šídlovitost listu (awlness), poměr délky buněk na žebru a na okraji listu v jeho šídlovité části (shorte), zubatost špičky (tootne), sířka špičky ve vzdálenosti 35 µm od vrcholu (tipbre). Obě taxony a hodnocené znaky jsou znázorněny na obr. 1 a 2. Jejich rozlišovací znaky jsou uvedeny v tab. 1. Znaky byly hodnoceny na ordinální nebo metrické škále. Pro vyhodnocení tohoto souboru byly použity dvě metody multivariační analýzy. Nejdříve byla použita analýza hlavních komponent (PCA). Použití této metody není v případě daného souboru zcela korektní, protože tato metoda předpokládá, že většina znaků je hodnocena na metrické škále. Pro tento soubor, který obsahuje data

hodnocená na různých typech škál (smíšená data), je zcela korektní vyhodnocení pomocí analýzy hlavních koordinát (PCoA). Byl použit program PRINCOOR z balíku SYNTAX 5.0.

Výsledky multivariačních analýz jsou znázorněny na obrázcích 3–6. Výsledky obou metod ukazují, že taxon *D. flexicaule* s. l. je možno rozdělit na dvě skupiny odpovídající taxonům *D. flexicaule* s. s. a *D. gracile*. Tyto skupiny přecházejí prostřednictvím přechodných typů, které jsou méně početné a vykazují větší variabilitu ve srovnání s oběma taxony (obr. 5). Tyto přechodné vzorky vytvářejí skupinu, která má díky tzv. arch (horseshoe) efektu podkovovitý tvar. Výsledky PCA ukazují též důležitost jednotlivých hodnocených znaků. Jako nejméně spolehlivý znak se ukázala zubatost (tootne) a šířka (tipbre) špičky. Je možno vyslovit hypotézu, že oba taxony jsou odděleny v různých oblastech různě intenzivní bariérou v závislosti na ekologických podmínkách. To lze předpokládat též v rámci celého areálu, který v případě *D. flexicaule* s. l. představuje téměř celý svět.

Na obrázku 7 jsou znázorněny axilární chlupy, které pro rozlišení obou taxonů nejsou vhodné. Na obrázcích 8 a 9 je pomocí bodových map znázorněno rozšíření obou taxonů v České a Slovenské republice. Druh *D. flexicaule* je velmi hojný ve slovenské části západních Karpat, především v oblastech s hojnějším výskytem vápenců nebo jiných bazických hornin. V České republice je hojnější na Moravě, kde nachází více stanovišť s vhodným substrátem. V Čechách je hojný pouze v některých oblastech (Český kras), ale jinak je zde poměrně vzácný. Taxon *D. gracile* je celkově dosti vzácný. Poněkud hojnější je na Slovensku. V České republice se vyskytuje jen ve čtyřech oblastech (Českokrumlovské předsumaví – 1 lokalita; Český kras – 1 lokalita, též přechodné typy; Krkonoše – 6 lokalit, též přechodné typy; Hrubý Jeseník – 1 lokalita).

Oba taxony nacházíme především na vápencích, ale též na dalších bazických horninách. Z hlediska výškového rozšíření je výskyt *D. flexicaule* soustředěn především v nižších polohách, ale nalezneme ho též až v alpinských oblastech. *D. gracile* má výškovou amplitudu rovněž od nízkých až do vysokých nadmořských výšek, ale převažuje v horském a vyšších vegetačních stupních. *D. flexicaule* je plodné zhruba z 10 % (tab. 3) *D. gracile* je plodné zcela výjimečně v 3 % případů.

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