Polyploid *Campanula patula* in the Czech Republic

Polyploidní zvonek rozkladitý (*Campanula patula*) v České republice

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Tetraploid *Campanula patula* L. (2n=40) is reported from the Šumava Mts. (the first record from the Czech Republic). A hexaploid (2n=60) was found in the Krušné hory Mts. (the first record of hexaploidy in this taxonomic group). Polyploids differ from the diploids by quantitative morphological characters. A number of localities of presumed polyploids (according to their morphology) are given from both mountains. Polyploids prefer slightly disturbed habitats, mostly along forest tracks. The relation of the tetraploid cytotype to *C. patula* L. subsp. *jahorinae* (K. Maly) Greuter et Burdet and the possible hybrid origin of hexaploids are discussed.

Keywords: *Campanula patula*, polyploidy, cytogeography

Dedicated to Professor Zdeněk Černohorský on his 85th birthday

Introduction

Common, widespread species such as *C. patula*, are usually treated as homogeneous taxa, and little attention is paid to their variation. They are believed to offer no interesting material for biosystematic investigations. Nevertheless, if *C. abietina* Griseb. et Schenk is included, three different ploidy levels (2×, 4× and 8×) have been found to coexist in the group of *C. patula*. Some authors evaluate them as separate intraspecific taxa (Fedorov et Kovanda 1976, Wcisło in Pogan et al. 1980) or even as separate species (Landolt 1975).

Diploids, having the most extensive distribution throughout Europe and expanding to Western Siberia (Hauser 1975, Landolt 1975), are represented by two geographical races: the type subspecies subsp. *patula* (so called northern race) and subsp. *costae* (Willk.) Fedorov (southern race, Hauser 1975, Landolt 1975, Fedorov et Kovanda 1976). The diploid races can be distinguished from each other by a number of morphological characters (for details, see in Hauser 1975, Fedorov et Kovanda 1976).

Landolt (1975) treated the tetraploids as *C. jahorinae* (K. Maly) Landolt or alternatively ("falls die einzelnen Sippen von *C. patula* s.l. als Unterarten eingestuft würden"), als *C. patula* L. subsp. *jahorinae* (K. Maly) Landolt. Under the provisions of the Code (Art. 34.1 and 34.2) both these combinations are invalid. Combination at the subspecific level was later validated by Greuter et Burdet (Greuter 1981). The tetraploid taxon is characterized by quantitative features, e.g., by larger flowers. In addition, the bell-shaped corollas and shorter calyx teeth were found in diploids compared with tetraploids (Hauser 1975, Leute 1978). However, the tetraploids cannot always be distinguished from diploids on the basis of their morphology (e.g. Gadella 1964, Gadella et Kliphuis 1972). The distribution of diploids and tetraploids has so far not been studied in detail, except for extensive cytogeographical data from the Alps and some other regions (Hauser 1975, Leute 1978) (Fig. 1). The occurrence of tetraploids has been studied in detail in Austria, where the distribution of this cytotype seems to be centred (Carinthia, Lower Austria,

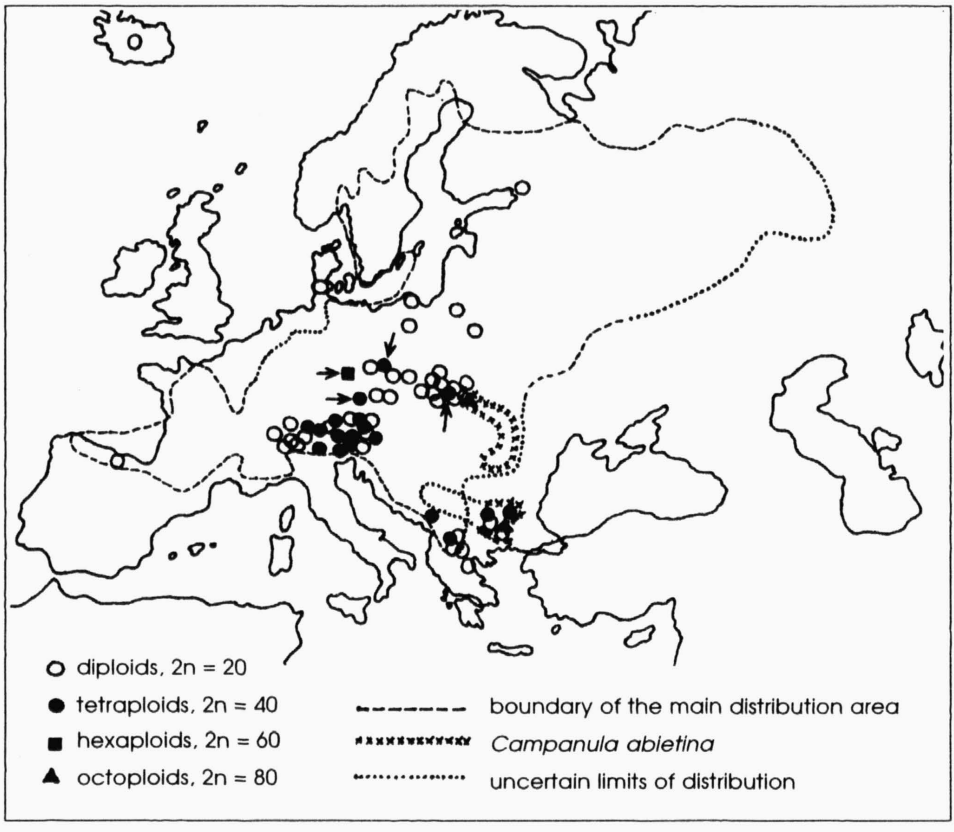

Fig. 1. – Distribution of *Campanula patula* L. and *C. abietina* Griseb. et Schenk according to Meusel, Jäger et al. (1992). The symbols indicate the origin of plants as given in literature data cited in Table 1 (only the references with detailed localities of cytotypes are included). The symbols of cytotypes found by present authors are arrowed.

Eastern Tyrol, expanding along the rivers Inn and Salzach, and to Passau). From there it reaches Germany, Bohemia, northern Slovakia, northern Italy and Slovenia. Its easternmost occurrence is probably represented by isolated localities in Bosnia, Bulgaria and Macedonia. Diploids are reported much more frequently than tetraploids in karyological literature (Table 1, Fig. 1).

The octoploid *C. abietina* Griseb. et Schenk, closely related to *C. patula* group, is distributed in the Eastern and Southern Carpathians (Fedorov et Kovanda 1976, Fig. 1). This is a perennial (a most distinct character distinguishing it from the biennial taxa of the *C. patula* group), characterized by basal stolons with rosettes able to survive winter (Fedorov et Kovanda 1976, Wcisło in Pogan et al. 1980).

Results

Presence of different cytotypes in the Czech Republic

Diploid *Campanula patula* has been reported from the Czech Republic by Kovanda (1983), who studied plants from four localities (Table 1). He also examined material from Slovakia

Table 1. – Chromosome numbers (2n) reported in *Campanula patula* L. s.l. (including of *C. abietina*, designated by asterisk)

2n	Country	Reference
20	Czech Republic	Kovanda 1983
20	Slovakia	Kovanda 1983
20	Slovakia	Hindáková in Májovský et al. 1976
20	Poland	Kovanda 1983
20	Poland	Wcisło in Pogan et al. 1980
20	Poland	Wcisło 1983
20	Spain	Díez et al. 1984
20	Yugoslavia, Greeče	Contandriopoulos 1966
20	Iceland	Löve et Löve 1956
20	Russia, Sweden, Austria, Denmark Yugoslavia	Gadella 1964
20	Macedonia	Gadella et Kliphuis 1972
20, 40	Czech Republic, Slovakia	Kovanda (in prep.)
20, 40	Bulgaria	van Loon et van Setten 1982
20, 40	Austria, Italy	Hauser 1975
20, 40	Carinthia (Austria)	Leute 1978
40	Austria, Yugoslavia	Gadella 1964
40	Macedonia, Crna Gora	Gadella et Kliphuis 1972
40	Bulgaria	Anchev 1976
80*	Poland	Wcisło in Pogan et al. 1980

(two localities) and from Poland (six localities), detecting diploids only (Table 1, Fig. 1). Later, (Kovanda, in prep.) he found tetraploids admixed in populations of diploids in two sites, one in the Czech Republic (the Sudeten Mts.), one in Slovakia (the Levočské pohorie Mts.).

We had an oportunity to examine several plants collected in the Krušné hory Mts. (J. Michálek et J. Hadinec) and in the Šumava Mts. (L. Kirschnerová). These plants possess certain features, attracting attention in the field: they are conspicuously robust, having the corolla approximately of double size compared with *C. patula* s. str. A similar type of *C. patula* was reported from the Krušné hory Mts. by Rohlena as early as in 1925 under the name "*C. patula* var. *stricta* Wallr.," (locality: "Horní louky" meadows below Mt. Klínovec near Jáchymov, Rohlena 1925).

The karyological examination was made on root-tips either of mature plants, collected in the wild and cultivated, or of their spontaneous progeny. The squash temporary slides stained by lacto-propionic orcein were used for chromosome counts. We found the tetraploid level (2n=40) in plants from the Šumava Mts. and hexaploid level (2n=60) in material from the Krušné hory Mts. The localization of collecting sites is as follows:

Campanula patula L., 2n = 40 (Fig. 2a)

Locality: South Bohemia, the Šumava Mts.: Strážný, along forest track on the southeastern slope of Strážný hill, ca 1 km NW of the village, alt. 900 m. Coll. L. Kirschnerová and J. Kirschner 1994.

Campanula patula L., 2n = 60 (Fig. 2b)

Locality: West Bohemia, the Krušné hory Mts.: Rolava, along road to Kraslice, within the catchment area of the Rolava brook, alt. ca 850 m. Coll. J. Michálek VI. 1989.

Fig. 2. – Somatic metaphases of root-tip meristem of polyploid *Campanula patula*: tetraploid, 2n=40 (a), hexaploid, 2n =60 (b). Scale = 10 μ.

Morphology of polyploids

According to their morphology, the polyploid plants collected in the Šumava Mts. (similarly as the plants from Austria reported by Hauser 1975 and Leute 1978), come close to *C. patula* L. var. *jahorinae* K. Maly described in 1907 from Bosnia ("alpine grassland in the Gola Jahorina plateau"): "Pflanze verkahlend. Die entwickelte Blumenkrone 3–4 cm lang, schwach fünfspaltig (tiefer als 1/3), 3.5–4.0 mal so lang als die Kelchzähne, welche etwa doppelt so lang als die Kelchröhre sind. Kelchröhre mit spärlichen Drüssenpunkten" (Maly 1907, p. 184). Populations from the Šumava Mts. are variable not only in quantitative characters but also in the presence or absence of papillae on the calyx. Plants from the Balkans have calyces more densely papillose.

The plants from the Krušné hory Mts., among which hexaploids were found, correspond to the description of *C. patula* var. *jahorinae* by K. Maly (1907) as well, with the following exceptions: (1) they have no papillae on the calyx (likewise *C. patula* s. str. as was found

Table 2. – Quantitative morphological characters of *C. patula* subsp. *patula* and *C. patula* subsp. *jahorinae* (Hauser 1975)

Character	*C. patula* s. str.	*C. patula* subsp. *jahorinae*
Calyx length (cm)	0.8 (0.3–1.1)	1.2 (0.4–1.8)
Corolla length (cm)	2.3 (1.4–2.9)	3.0 (2.0–3.7)
Length of corolla teeth (cm)	1.4 (0.9–2.0)	1.8 (1.1–2.4)
Corolla/Calyx teeth ratio	2.2–5.4	1.7–4.5
Corolla teeth/Calyx teeth ratio	1.2–3.5	1.0–2.7
Pollen size (μ)	24.75–49.50	30.25–52.75
Chromosome number	2n=20	2n=40

on a number of herbarium specimens compared), and (2) the calyx teeth are relatively long (they reach up to half of the corolla or more). The corolla is (2.5–) 3.0–3.5 cm long, the height of plants reaches up to 35–40 (–60) cm. On the other hand, the corolla of the common diploid *C. patula* is approximately 1.5–2.5 cm long and it is divided as far as to its half (see Table 2). In addition, the basal stolons with adventive rosettes have been occassionaly found in wild populations of *C. patula* in the Krušné hory Mts. and this mode of vegetative reproduction was regularly observed in cultivated, two years old plants (J. Hadinec, pers. comm.). However, the stolons are very thin and fragile (as distinct from *C. abietina*), and therefore they may not be always noticeable in herbarium specimens.

It can be concluded that the principal features characterizing diploid and polyploid *C. patula* are only quantitative, making it difficult to distinguish these two taxa safely.

Ecology of polyploids

The polyploids of *C. patula* occur in somewhat shaded habitats especially on the margins of forest paths and (or) tracks, where the vegetation cover and the soil surface are occasionally disturbed by forestry management, or by other human activities (e.g. by mining in the Krušné hory Mts.): lower competition for germinating seeds may be the decisive factor for the success of new seedlings. They also inhabit verges along mountain streams, always in contact with woodlands, never in open landscape; polyploids prefer more humid microclimate (J. Hadinec, pers. comm.). The localities known hitherto are within the height span of (630–) 820–1150 m a.s.l. Plants from corresponding altitudes in the Sudeten Mts. and Carpathians proved diploid, tetraploids having been noted only scattered in two topodemes (Kovanda, in preparation).

Discussion

It is questionable whether the Šumava Mts. tetraploids are referable to subsp. *jahorinae* (K. Maly) Greuter et Burdet. The possibility cannot be excluded that polyploids arise polytopically from various diploid sources in various parts of the species range and assume different morphological characters. To test this hypothesis, a more detailed study of both the Alpine-Illyrian and Šumava tetraploids are required. With regard to the distribution of the tetraploid taxon in Austria, the occurrence of tetraploids at higher elevations of the Šumava Mts. (above 800 m) could be considered as a consequence of so called Alpine migration. According to the present knowledge, localities in the Šumava Mts. would

represent the northernmost part of its distribution area (Fig. 1). However, the scattered distribution of tetraploids among diploids found in the Krkonoše Mts. (Kovanda in prep.), may shift the distribution limit of this taxon even more towards to north.

The tetraploid cytotype is sometimes erroneously included in *C. p.* subsp. *costae* (Willk.) Fedorov (e.g., in Adler et al. 1994). However, tetraploids are morphologically distinct from this subspecies. In addition, *C. patula* subsp. *costae* is a diploid, referred to as a "southern race" by Hauser (1975), and distributed in southwestern Europe. It can be considered as a vicarious race to the diploid *C. patula*, referred to as a "northern race" (for detail see in Landolt 1975, Hauser 1975).

The hexaploid chromosome number in *Campanula patula* is reported for the first time in the present study. It is most probably derived from hybridization between the diploid and tetraploid cytotype, followed by chromosome doubling (allopolyploidy, amphiploidy), which allows to overcome the sterility barrier in hybrids (e.g. Stebbins 1971). In accordance with this assumption, the cultivated hexaploid plants showed an abundant seed set (J. Hadinec, personal communication). The participation of the octoploid *C. abietina* in the origin of the hexaploid cytotype found in the Krušné hory Mts. (i. e., by the hybridization between *C. abietina* and the tetraploid cytotype of *C. patula*) is not probable with respect to geographical isolation of the putative parents (Fig. 1).

However, the occurrence of the tetraploid cytotype among robust, large-flowered plants in the Krušné hory Mts., as well as the occurrence of hexaploids in the Šumava Mts. cannot be excluded, because only few plants of each cytotype have been examined karyologically (they were collected from one locality in the Krušné hory Mts. and from one locality in the Šumava Mts.). Other localities, where similar plants were found, are listed in the Appendix. Polyploidy can be suspected in these plants as well. Stebbins (1938) has shown that polyploidy is most prevalent in herbaceous perennials, and least among woody forms. The answer, most probably, lies in the fact that annuals have little chance of forming polyploids during their single year of existence. In view of this connection it is most surprising to see that in tetraploid *C. patula*, polyploidy is associated with the biennial form which is not principally different from the annual. On the other hand, the hexaploid *C. patula* often develops rudiments of stolons, possibly indicating a transition to the perennial form known in *C. abietina* Griseb. et Schenk.

The differentiation found in such a common and widely distributed species as *Campanula patula* needs further careful investigation, focused namely on distribution of cytotypes and on search for their distinguishing characters. The study of this taxonomic group in the Czech Republic will be continued. We shall be much obliged to field botanists for any informations on robust, large flowered *C. patula*.

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Souhrn

Polyploidní *Campanula patula* L. je poprvé uvedena z České republiky. Tetraploidní cytotyp (2n=40) byl nalezen na Šumavě. Jeho vztah k taxonu *C. patula* L. subsp. *jahorinae* (K. Maly) Greuter et Burdet, jehož centrum rozšíření je podle současných znalostí v Rakousku, není dosud zcela jasný: taxonomické hodnocení

českých tetraploidů zůstává proto zatím otevřené. Podle současných znalostí představuje výskyt tetraploida v ČR nejsevernější výběžek jeho areálu a lze očekávat objevení dalších lokalit.

Hexaploidní *C. patula* (2n=60) byla nalezena v Krušných horách. Mohla vzniknout křížením diploidního a tetraploidního cytotypu a následnou polyploidizací.

Od diploidní *C. patula* se oba polyploidi liší mohutnějším vzrůstem a zejména většími květy (průměrná délka koruny je (2,5–) 3,0–3,5 cm). Tetraploidní cytotyp se chová jako dvouletá rostlina, u hexaploidů bylo pozorováno vegetativní rozmnožování pomocí krátkých, tenkých a křehkých výběžků s adventivními růžicemi s okrouhle vejčitými listy. Vytvářením výběžků může tento cytotyp z Krušných hor poněkud připomínat jiho- a východokarpatský taxon *C. abietina* Griseb. et Schenk, který však je oktoploidní (2n=80) a jehož výběžky jsou mnohem nápadnější. Rostliny z Krušných hor, mezi nimiž se vyskytl hexaploid, mají kalichy bez papil, podobně jako normální rostliny *C. patula*. Jejich kališní ušty jsou relativně dlouhé (dosahují do poloviny délky koruny i více). Rostliny ze Šumavy, mezi nimiž byl nalezen tetraploid, mají kalichy s řídkými papilami, které jsou rovněž uváděny v popisu *C. patula* subsp. *jahorinae* z Bosny.

Ze Šumavy i z Krušných hor je známa řada lokalit (viz Appendix), kde byly podobné velkokvěté morfotypy *C. patula* sbírány a u nichž lze rovněž předpokládat polyploidii. Vyskytují se u nás na prosvětlených, případně polostinných stanovištích ve vyšších polohách (většinou nad 800 m, v Rakousku již od 520 m). Rostou zejména na okrajích cest a silniček, nebo lemují horské toky, vždy však na kontaktu lesa (závislost na humiditě prostředí). Populace vytrvávají na lokalitách řadu let a s největší pravděpodobností se šíří vlivem lidské činnosti. Tyto rostliny preferují člověkem narušená, prosvětlenější lesní stanoviště, zatímco *C. patula* s. str. je spíše lučním druhem.

Diferenciace polymorfní a zároveň hojně rozšířené skupiny *C. patula* L. nezbytně vyžaduje další studium. Uvítáme všechny laskavě poskytnuté informace, zejména o robustních velkokvětých rostlinách vyskytujících se ve vyšších polohách.

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Appendix

[List of localities where *C. patula*, morphologically corresponding to the polyploid cytotype, was found.] Herbarium specimens are deposited in PR (Šumava Mts.) and in the District Museum Sokolov (Krušné hory Mts.). The localities are given in Czech, to make them comprehensible especially to Czech readers.

Seznam lokalit, kde byla nalezena *C. patula* morfologicky odpovídající polyploidnímu cytotypu. Herbářové doklady jsou uloženy v PR (Šumava) a v Okresním muzeu v Sokolově (Krušné hory).

Šumava:

1. Milešice pod Boubínem, u lesní cesty v oboře na hřebeni J vrchu Solovec JJZ obce, 1100 m n. m. (Piechová 1979)
2. Zátoň, podél lesní cesty na jižním svahu vrchu Boubín, 1000 m n. m. (Piechová 1979)
3. Zátoň, okraj lesní silničky ca 1 km S rozcestí „U obrázku", VSV obce, 1000 m n. m., (Piechová 1979)
4. Volary, okraj lesní silničky na jihovýchodním svahu vrchu Boubín, 1150 m n. m. (Kirschnerová et Kirschner 1982)
5. Volary, v sedle mezi vrchy Bobík a Zátoňská hora na křižovatce lesních cest „U obrázku", ca 6 km SSZ od obce, 948 m n. m. (Kirschnerová et al. 9.7. 1992)
6. Volary, okraj lesní silničky na západním svahu Dvorského vrchu od Brixova Dvora k rozcestí "U obrázku", ca 2 km SZ obce, 850–860 m n. m. (Kirschnerová et Rydlo 1994)
7. Strážný, u lesní cesty na jihovýchodním svahu vrchu Strážný, ca 1 km SZ od obce, 900 m n. m., 2n =40 (Kirschnerová et Kirschner 1994)
8. Strážný, na okraji turistické cesty podél jižního okraje lesa v údolí říčky Častá, 1–1,3 km Z obce, ca 840 m n. m. (Kirschnerová et Kirschner 1994)
9. Strážný, u silničky podél říčky Častá, 2–3 km ZSZ obce, plató, 890–900 m n. m. (Kirschnerová et Kirschner 1994)
10. Strážný, na okraji lesní cesty, ca 1,6 km ZSZ-SZ od obce, 1,3 km Z kóty Strážný, 930–950 m n. m. (Kirschnerová et Kirschner 1994)
11. Strážný, u lesní silničky v okolí kóty 1002,5 ca 1,1 km SZ vrchu Strážný, 3,3 km SZ obce (Kirschnerová et Kirschner 1994)
12. Strážný, u lesní silničky mezi říčkami Častá a Řásnice, ca 1,9 km JV vrchu Žďárecká hora, 4,5 km ZSZ obce (Kirschnerová et Kirschner 1994)
13. Strážný, podél lesního průseku po starých vojenských zátarasech, ca 0,4 km JJZ vrchu Žďárecká hora, ca 5,3 km ZSZ obce, 960 m n. m. (Kirschnerová et Kirschner 1994)
14. Strážný, podél lesního průseku po vojenských zátarasech, 1 km JJZ obce (Kirschnerová et Kirschner 1994)
15. Strážný, podél lesní cesty ca 1,3 km JZ obce, 880 m n. m. (Kirschnerová et Kirschner 1994)
16. Strážný, u lesní cesty (oligotrofní stanoviště), Z kóty 915,6 ca 4 km ZJZ obce (Kirschnerová et Kirschner 1994)
17. Soumarský most u Volar, v nivě na levém břehu Vltavy (Kirschnerová et al. 1992)
18. Křišťanov, skupina Knížecího stolce, u lesní silničky (složiště dřeva), ca 200 m SZ kóty 933,6, 2,8 km JJV hájovny Arnoštov (Kirschnerová et Žíla 1994)
19. Modrava, u silničky podél Modravského potoka, 1100–1120 m n. m. (Kirschnerová et al. 1993)

Krušné hory:

20. Jelení-Rolava, okraj a příkop široké lesní cesty (kolem podmáčená smrčina, v porostu *Calamagrostis villosa*) spojující Jelení s Rolavou, ca 400 m V od rozbořené továrny na zpracování cínové rudy, 2 km Z Jelení, 925 m n. m. (J. Michálek 11.7.1988)

21. Jelení-Rolava, okraj lesní silničky 500 m V Velkého cínového dolu, v porostu *Calamagrostis villosa* na kraji prosvětlené smrčiny, 2,5 km VSV Rolavy, 920 m n. m. (J. Michálek et J. Hadinec 9.7.1985)
22. Jelení-Rolava, areál Velkého cínového dolu, rozsáhlá (300 × 400 m) narušená plocha bývalého zařízení na těžbu a zpracování cínové rudy, obklopená podmáčenými smrčinami a vrchovišti, 2,5 km Z Jelení, 925 m n. m., travnatá plocha s ojedinělými smrky – nálet, charakter lesoparku (J. Michálek et P. Kulíšek 14.7.1988)
23. Rolava (osada), podél silnice na Kraslice, v povodí potoka Rolavy, ca 850 m n. m., 2n=60 (J. Michálek 1989)
24. Chaloupky, okraj cesty Chaloupky – Přebuz v údolí Rolavy (stinný úsek ve smrčině, v porostu *Calamagrostis villosa*), ca 700 m ZJZ Chaloupek, tj. od odbočky lesní cesty podél Jeleního potoka, 840 m n. m. (J. Michálek 21.7. 1988)
25. Přebuz-Rudné, okraj a příkop silnice Přebuz – Rudné, ve smrčině u odbočky lesní silničky do Liščího údolí, 920 m n. m. (J. Michálek et J. Hadinec 7.7. 1989)
26. Stříbrná, louka na svahu vpravo silnice Stříbrná – Přebuz, cca 250 m SV křižovatky Stříbrná – Přebuz – Bublava, ca 630 m n. m., výskyt převážně v horní části svažité louky pod silnicí (J. Michálek 31. 5. 1988)
27. Rájec-Rolava, údolí Rájeckého potoka 2 km ZSZ Rolavy, příkop silnice v řídké smrčině, 820 m n. m. (J. Hadinec, J. Lepš, P. Kovář et J. Michálek 21.7. 1988)
28. Stříbrná-Rolava, příkop u silnice v údolí Rájeckého potoka (J. Michálek 23.7. 1987)