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 Krušně 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 (2x, 4x and 8x) have been found to coexist in the group of *C. patula*. Some authors evaluate them as separate intraspecific taxa (Fedorov et Kovanda 1976, Wcislo 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,
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

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

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

(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 opportunity 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 Drüsenspunkten” (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)

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

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 occasionally 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 Krusné 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 Krusné 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 Krusné 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*.

**Acknowledgments**

We would like to express our thanks to Mr. J. Hadinec for providing plants for karyological study, and for
valuable information on *C. patula* in the Krusné hory Mts. We are also obliged to Dr. J. Michálek (District
Museum Sokolov) and to Dr. J. Chrtěk, CSc. (National Museum Průhonice) for loan of herbarium specimens.

**Souhrn**

Polyploidní *Campanula patula* L. je poprvé uvedena z České republiky. Tetraploidní cytotyp (2n=40) byl
nalezena na Šumavě. Jeho vzťah 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
References


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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 JIZ obce, 1100 m n. m. (Pichová 1979)
2. Zátoň, podél lesní cesty na jižním svahu vrchu Boubín, 1000 m n. m. (Pichová 1979)
3. Zátoň, okraj lesní silničky ca 1 km S rozcestí „U obrázku“, VSV obce, 1000 m n. m., (Pichová 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 křížovatce 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. Stražný, u lesní cesty na jihovýchodním svahu vrchu Stražný, ca 1 km SZ od obce, 900 m n. m., 2n = 40 (Kirschnerová et Kirschner 1994)
8. Stražný, 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. Stražný, u silničky podél říčky Častá, 2–3 km ZSZ obce, platò, 890–900 m n. m. (Kirschnerová et Kirschner 1994)
10. Stražný, na okraji lesní cesty, ca 1,6 km ZSZ-SZ od obce, 1,3 km Z kóty Stražný, 930–950 m n. m. (Kirschnerová et Kirschner 1994)
11. Stražný, u lesní silničky v okolí kóty 1002,5 ca 1,1 km SZ vrchu Stražný, 3,3 km SZ obce (Kirschnerová et Kirschner 1994)
12. Stražný, u lesní silničky mezi říčkami Častá a Řásnice, ca 1,9 km JV vrchu Žďárská hora, 4,5 km ZSZ obce (Kirschnerová et Kirschner 1994)
13. Stražný, podél lesního průseku po starých vojenských zátarasách, ca 0,4 km JJZ vrchu Žďárská hora, ca 5,3 km ZSZ obce, 960 m n. m. (Kirschnerová et Kirschner 1994)
14. Stražný, podél lesního průseku po vojenských zátarasách, 1 km JJZ obce (Kirschnerová et Kirschner 1994)
15. Stražný, podél lesní cesty ca 1,3 km JJZ obce, 880 m n. m. (Kirschnerová et Kirschner 1994)
16. Stražný, u lesní cesty (oligotrofní stanoviště), Z kóty 915,6 ca 4 km JJZ obce (Kirschnerová et Kirschner 1994)
17. Soumarský most u Volar, v nivě na levém břehu Vltavy (Kirschnerová et al. 1992)
18. Křišťánov, skupina Knížecího stolce, u lesní silničky (složitě dřeva), ca 200 m SZ kóty 933,6, 2,8 km JJV hájovny Arnoštov (Kirschnerová et Žila 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 tovarny 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 smrký – 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 (stinny úsek ve smrčině, v porostu **Calamagrostis villosa**), ca 700 m ZJZ Chaloupky, 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, ca 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)