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Pulsatilla styriaca (Ranunculaceae) is a new species for the Bulgarian flora, and conspecific with *P. subslavica*

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Abstract: *Pulsatilla styriaca (P. halleri subsp. styriaca)*, up to now considered endemic to Styria within Austria, is reported as new for the Bulgarian flora. Earlier, it had been identified as *P. halleri* s. str. *(P. halleri subsp. halleri)* because it is clearly different from *P. rhodopaea (P. halleri subsp. rhodopaea)* distributed in Bulgaria. The only three populations situated in western Sredna Gora (W Balkan mts.) are small and have been monitored during the period 1998–2013. Population sizes are decreasing and the species thus endangered in Bulgaria. By morphological (phytographical) evidence, using features of traditional *Pulsatilla* taxonomy, the differences between the Bulgarian and Styrian populations of *P. styriaca*, in respect to the variation amplitude, proved to be negligible. This taxon, however, turned out to be conspecific with *P. subslavica* distributed endemically in Slovakia. This is demonstrated by a comparative survey of Slovak specimens attributed to this species and specimens of *P. styriaca* from Styria. Consequently, *P. styriaca* is no longer endemic to Styria and Austria but exhibits a highly disjunct distribution range covering western central Slovakia, eastern Austria (Styria) and western Bulgaria. Bulgarian, Slovakian and Austrian habitats of this species are compared und the conservation status is discussed.

Key words: *Pulsatilla styriaca*; *Pulsatilla halleri subsp. styriaca*; *Pulsatilla halleri* agg.; *Pulsatilla subslavica*; *Pulsatilla slavica*; *Pulsatilla rhodopaea*; *Pulsatilla grandis*; new species of Bulgaria; disjunct distribution range; endemism; Bulgaria; Slovakia; Styria

Zusammenfassung: ***Pulsatilla styriaca (Ranunculaceae)* ist eine neue Art der bulgarischen Flora und konspezifisch mit *P. subslavica***
Pulsatilla styriaca (P. halleri subsp. styriaca) wurde als drei kleine, benachbarte Populationen in der westlichen Sredna Gora (Balkangebirge) gefunden. Die Sippe war ursprünglich als *P. halleri (P. halleri subsp. halleri)* identifiziert worden, da sie sich deutlich von der in Bulgarien längst bekannten *P. rhodopaea (P. halleri subsp. rhodopaea)* unterscheidet. Sie stimmt jedoch mit den steirischen Exemplaren der *P. styriaca* – in Anbetracht der Variationsbreite – völlig überein. Die Populationsgrößen nehmen von 1996 bis 2013 ab, sodass sie in Bulgarien gefährdet ist. Phytographische Vergleiche anhand der in der *Pulsatilla*-Taxonomie üblichen Merkmale zeigten, dass *P. styriaca* mit der bisher als slowakischen Endemiten betrachteten *P. subslavica* konspezifisch ist. Somit ist *P. styriaca* nicht länger ein steirischer und österreichischer Endemit, sondern weist ein deutlich disjunktes Areal auf, das von der mittleren Slowakei über das östliche Österreich (Steiermark) bis ins westliche Bulgarien reicht. Die Habitate der *P. styriaca* (s. lat.) in Bulgarien, der Slowakei und in Österreich werden verglichen und der Naturschutzstatus erörtert.

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Introduction, Materials and Methods

Objective

During floristic investigations in the western Sredna Gora by the first author, when studying the locality of *Anthemis argyrophylla* – a critically endangered and protected species, local endemic and tertiary relict –, a population of a *Pulsatilla* was found which was preliminarily identified as *Pulsatilla halleri* (s. str.) *(Anemone halleri)* (Tashev 2008). Later, two more small populations were found, a survey on the literature and the herbarium collections in Bulgaria and in Austria was performed and several Floras were consulted: Jordanov & Kožuharov (1970), Damboldt & Zimmermann (1974: 221), Tutin & Akeroyd (1993), Maurer (1996), Fischer & al. (2008). By this, evidence accumulated that these Bulgarian populations belong to *P. styriaca*, a species so far considered endemic to Austria.

The habitat of the Bulgarian locality was identified according to Kavrakova & al. (2005) and the Interpretation Manual for the habitats in the European Union, Eur 15.2. (2002). The code followed NATURA 2000 (HD-Code), European Nature Information System (EUNIS database v. 2) and "Classification of the Palaearctic habitats" (PAL. CLASS), version 1996.

The second author, curator of the phanerogams in the state herbarium of Styria, compared those Bulgarian specimens with plants not only of *P. styriaca* from Styria but also with specimens of *P. subslavica* from Slovakia, because the new Bulgarian populations seem to look as closely to *P. styriaca* as to *P. subslavica*. So, the questions arose, (1) whether both these species might be conspecific, separated just by a geographic disjunction, and (2) whether and to what extent the three entities differ in those features traditionally used in the taxonomy of *Pulsatilla*.

Materials

Pulsatilla "*styriaca*" fide A. Tashev from Bulgaria: 4 specimens (2 flowering, 2 fruiting; herbarium A. Tashev, Sofia), used for diagnostic comparison with herbarium material in the Bulgarian herbaria SOM, SO and SOA as well as in the Viennese hebaria W, WU, WHB and WFBVA. – *Pulsatilla styriaca* from Styria: 66 specimens (42 flowering, 15 fruiting, 9 vegetative; GJO), used for diagnostic comparison. – *Pulsatilla subslavica* from Slovakia: 62 specimens (18 flowering, 35 fruiting, 11 vegetative; SAV), used for diagnostic comparison. – *Pulsatilla slavica* from Slovakia: ca. 30 specimens checked (SAV). – *Pulsatilla halleri* s. str.: ca. 10 specimens checked (GJO, GZU). – *Pulsatilla rhodopaea* from Bulgaria: 3 specimens checked (herbarium A. Tashev, Sofia).

Methods

For comparison of the Bulgarian populations with *Pulsatilla styriaca* and with *P. subslavica* 27 features, most of them used by Krause (1958) are analyzed on the basis of 132 specimens and the data arranged in Table 1. That student of Walter Zimmermann's *Pulsatilla* research group (Zimmermann 1935–1939, 1958, Aichele & Schwegler 1957)

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emphasized strong variation in all the taxa of *P. halleri* group and recommended the use of mean values. Following her, our second author calculated arithmetic means as well.

Taxonomy of *Pulsatilla halleri* group

In their monograph of the genus *Pulsatilla*, Aichele & Schwegler (1957) include *P. styriaca* together with *P. halleri*, *P. velezensis*, *P. taurica*, *P. slavica*, *P. grandis*, and *P. vulgaris* in their *subsect. Vulgares* within *sect. Pulsatilla*. This narrow species concept is followed by, e.g., Futák (1982) and Gutermann & Niklfeld (1973). Krause (1958) in her comprehensive and detailed study sinks *P. halleri*, *P. styriaca*, *P. slavica*, and *P. taurica* to subspecific rank summarizing them within *P. halleri* s. lat. and adding *subsp. macedonica* and *subsp. rhodopaea*. This wider species concept is followed by, e.g., Jordanov & Kožuharov (1970), Greuter & al. (1989), and Tutin & Akeroyd (1993).

The present paper, however, follows, for the time being, the narrow species concept: At species rank, these taxa all together (excluding *P. vulgaris* and *P. grandis*), according also to several more modern authors (e.g., Gutermann & Niklfeld 1973) form *P. halleri* agg.

***Pulsatilla halleri* group** (= *P. halleri* s. lat., *P. halleri* agg., "Spec. coll. [= 'Sammelart'] *Halleri*" sensu Aichele & Schwegler 1957 without presenting any diagnosis) is, however, difficult to delimit from *P. vulgaris* group (*P. vulgaris* agg., "Spec. coll. *Vulgaris*"), that is why both are united by Damboldt & Zimmermann (1974: 216) as

Table 1: Excerpt of Table 9 in Aichele & Schwegler (1957: 168), listing differential characters (translated from German by authors R.H. and M.A.F.). — **Tab. 1:** Auszug aus Tab. 9 in Aichele & Schwegler (1957: 168). Liste der Unterscheidungsmerkmal zwischen den beiden Arten.

	P. styriaca	*P. slavica* sensu Aichele & Schwegler (1957)
Diameter of flower	7 cm	8 cm
Length of involucrum	3 cm	3.5 cm
Number of involucrum lobes	16	18
Scape (below involucrum) length at anthesis	7 cm	8 cm
Width of leaf lobes	1 cm	1.2 cm
Number of leaf lobes	about 50	fewer than 50
Further traits	basal leaf segments usually slightly petiolulate; catadromous segment of 2nd order slightly separated	leaves often with 1 pair of segments only; leaf segments relatively strongly connate
Distribution	endemic to Styria	endemic to Slovakia: region near Trenčin and High Tatra

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"*P. vulgaris*-Artengruppe". Krause (1958) does not provide any description of her *P. halleri* (s. lat.). Tutin & Akeroyd's (1993: 266) description mentions: "Stems 3–12 cm (up to 45 cm in fruit). Basal leaves persistently and often densely lanate, 1-pinnate with 3–5 segments, the terminal long stalked, segments pinnatifid; lobes oblong-lanceolate; cauline leaves united below, sericeous. Flowers 5.5–8.5 cm in diameter, campanulate, erect or suberect, dark violet; perianth segments usually straight, acute, 2–3 times as long as the stamens." – Jordanov & Kožuharov (1970) characterize "*P. halleri*" (comprising *subsp. halleri* and *subsp. rhodopaea*) in the species key by basal leaves 1-pinnate or rarely 2-pinnate with 3–5 basal segments. – Damboldt & Zimmermann (1974: 217, 220) characterize their "*P. halleri*" (comprising *subsp. halleri* and *subsp. styriaca*) by leaf segments (2–)6–11(–22) mm wide; basal leaves not fully developed when flowering, strongly hairy and shining silky when young, later on villous, segment tops with a conspicuous hair tuft; leaves comparatively weakly pinnate; tepals usually 6 and 3–5 cm long, outer ones usually longer, mainly purple-violet; top of styles violet; fruitlets 5–5.5 mm long, the style (in fruit) 35–40 mm long and strongly hairy; chromosomes: $2n = 32$. For most of these features no comparable counterparts are provided in *P. grandis* and *P. vulgaris*.

This species group inhabits dry stony places in bushes, exclusively on limestone. Its distribution includes central (Alps, western Carpathians) and southeastern Europe (Balkan Peninsula, Crimea). In Bulgaria the species group reaches the easternmost peripheral part of its distribution area (Krause 1958: 3, Jordanov & Kožuharov 1970: 108, Tutin & Akeroyd 1993: 266). The species group, therefore, belongs to the Alpine-Carpathian-Balkan floristic element ("Alp-Carp-Bal"). The present distribution of *Pulsatilla rhodopaea (= P. halleri subsp. rhodopaea)* in Bulgaria – the only taxon within *Pulsatilla halleri* group reported before – includes Middle Rhodopes and eastern Stara planina (Jordanov & Kožuharov 1970, Panov 1975, Kožuharov 1992, Dimitrov 2002, Delipavlov & Cheshmedjiev 2003, Assyov & Petrova 2006). According to (Assyov & Petrova 2006) its vertical distribution covers the range 300–1400 m a. s. l., and according to Delipavlov & Cheshmedjiev (2003) *P. rhodopaea* occurs within the range 500–1500 m a. s. l.

Pulsatilla styriaca (Pritz.) Simonk. in Magyar Bot. Lapok 5 (5–7): 178 (1906) (see Figs. 1–4).
≡ (basionym:) *Anemone halleri var. styriaca* Pritz. in Linnaea 15: 575 (1841)
≡ *Anemone styriaca* (Pritz.) Hayek in Oesterr. Bot. Z. 52: 477, 479 (1902)
≡ *Pulsatilla halleri subsp. styriaca* (Pritz.) Zämelis in Acta Horti Bot. Univ. Latv. 1 (2): 104 (1926)

Pulsatilla slavica G. Reuss, Května Slov.: 5 (1853), non sensu Aichele & Schwegler (1957) (see Figs. 5–7).
≡ *P. halleri subsp. slavica* (G. Reuss) Zāmels in Acta Hort Bot. Univ. Latv. 1 (2): 104 (1926)

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≡ *Anemone wahlenbergii* Szontagh in Verh. k. k. Zool.-Bot. Ges. Wien 13: 1082 (1863), nom. illeg.
≡ *Pulsatilla wahlenbergii* (Szontagh) Baenitz (1895), nom. illeg.
≡ *P. halleri subsp. slavica var. wahlenbergii* Aichele & Schwegler in Feddes Repert. Spec. Nov. Regni Veg. 60: 1–230 (1957)
≡ *P. slavica var. wahlenbergii* (Szontagh) Dostál in Folia Mus. Rerum Nat. Bohemiae Occid., Bot. 21: 6 (1984), nom. illeg.

Pulsatilla subslavica Futák ex K. Goliášová in Biológia, A (Bratislava) 36: 867–868 (1981) (see Figs. 8–11).
= *P. slavica* auct., non G. Reuss
= *P. slavica subsp. slavica var. slavica* sensu Aichele & Schwegler (1957) and Krause (1958), typo excl.
= *P. slavica subsp. subslavica* (Futák) Dostál in Folia Mus. Rerum Nat. Bohemiae Occid., Bot. 21: 6 (1984)

Fig. 1: Herbarium specimens of fruiting *Pulsatilla styriaca* from Styria (Austria), Peggauer Wand N of Graz, leg. E. Korb, 20 June 1908, and leg. K. Fritsch, 3 June 1902 (W). — **Abb. 1:** Herbarbelege von fruchtenden *Pulsatilla styriaca* aus der Steiermark (Österreich), Peggauer Wand N von Graz, leg. E. Korb, 20. Juni 1908 und leg. K. Fritsch, 3. Juni 1902 (W).

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Fig. 2: Herbarium specimens of flowering and vegetative *Pulsatilla styriaca* from Styria (Austria), near Peggau, leg. Eu. v. Pittoni (GJO). — **Abb. 2:** Herbarbelege einer blühenden und einer vegetativen *Pulsatilla styriaca* aus der Steiermark (Österreich), bei Peggau, leg. Eu. v. Pittoni (GJO).

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Fig. 3: Herbarium specimen of flowering and postfloral *Pulsatilla styriaca* from Styria (Austria), rocks near Gratwein, leg. Fürstenwärther (GJO). — **Abb. 3:** Herbarbelege eines blühenden und eines postfloralen Exemplars der *Pulsatilla styriaca* aus der Steiermark (Österreich), Felsen bei Gratwein, leg. Fürstenwärther (GJO).

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Fig. 4: Herbarium specimens of flowering and fruiting *Pulsatilla styriaca* from Styria (Austria), Peggau (GJO). — **Abb. 4:** Herbarbelege blühender und fruchtender *Pulsatilla styriaca* aus der Steiermark (Österreich), Peggau (GJO).

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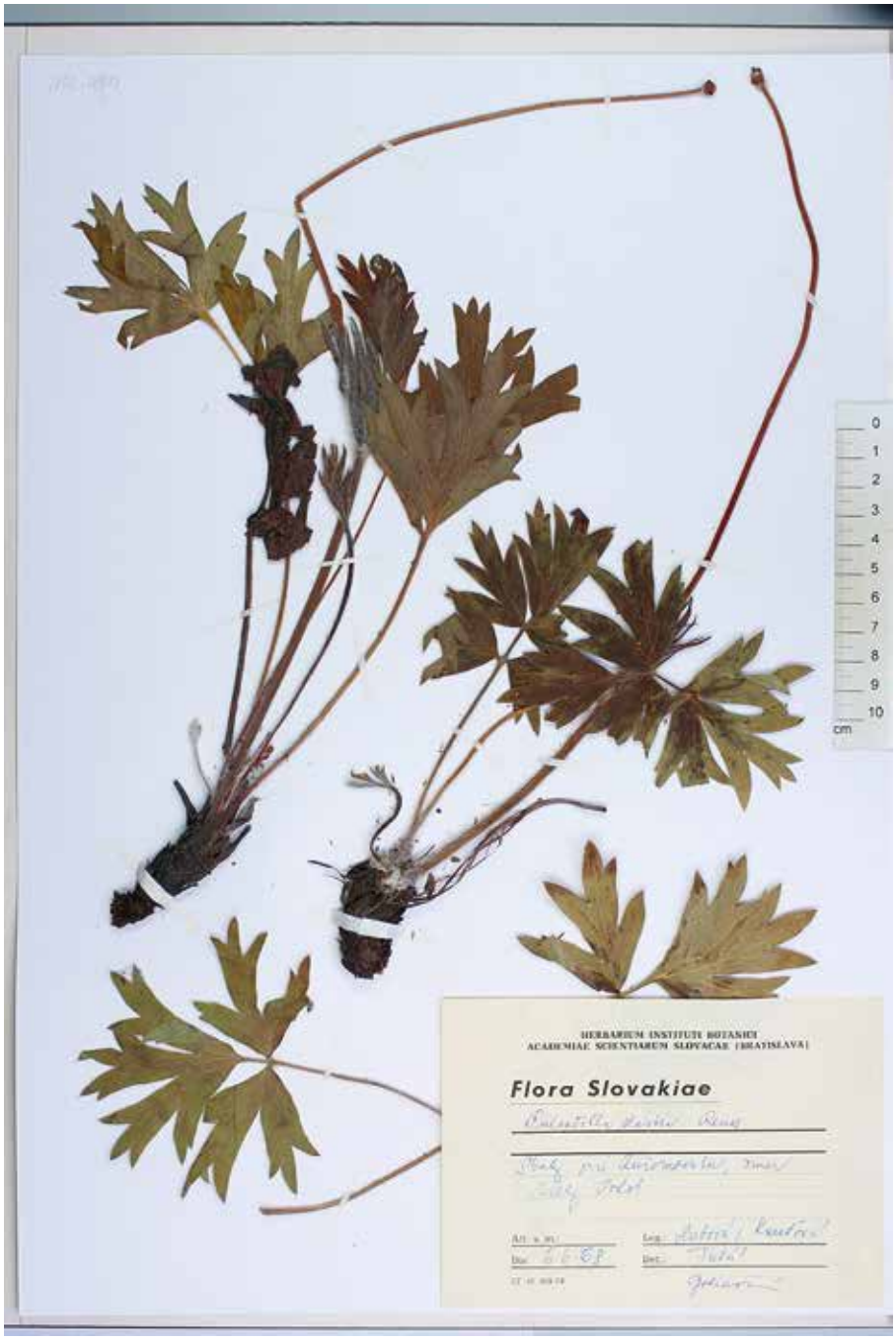

Fig. 5: Herbarium specimen of fruiting *Pulsatilla slavica* from Slovakia, leg. Hubová, Kmêtová and Futák (SAV). — **Abb. 5:** Herbarbeleg einer fruchtenden *Pulsatilla slavica* aus der Slowakei, leg. Hubová, Kmêtová and Futák (SAV).

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Fig. 6: Herbarium specimen of fruiting *Pulsatilla slavica* from Slovakia, leg. Fabianková (SAV). — **Abb. 6:** Herbarbeleg einer fruchtenden *Pulsatilla slavica* aus der Slowakei, leg. Fabianková (SAV).

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Fig. 7: Herbarium specimen of fruiting *Pulsatilla slavica* from Slovakia, leg. Fabianková (SAV). — **Abb. 7:** Herbarbeleg einer fruchtenden *Pulsatilla slavica* aus der Slowakei, leg. Fabianková (SAV).

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Fig. 8: Herbarium specimen of a vegetative *Pulsatilla styriaca (*"*P. subslavica*"*)* from Slovakia, leg. & det. as *P. slavica*, later rev. as *P. subslavica* by J. Futák (SAV). — **Abb. 8:** Herbarbeleg einer vegetativen *Pulsatilla styriaca (*"*P. subslavica*"*)* aus der Slowakei, leg. & det. als *P. slavica*, später rev. als *P. subslavica* von J. Futák (SAV).

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Fig. 9: Herbarium specimens of vegetative *Pulsatilla styriaca (*"*P. subslavica*"*)* from Slovakia (SAV). — **Abb. 9:** Herbarbelege von vegetativen *Pulsatilla styriaca (*"*P. subslavica*"*)* aus der Slowakei (SAV).

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Fig. 10: Herbarium specimens of vegetative *Pulsatilla styriaca (*"*P. subslavica*"*)* from Slovakia, from the same locality as the specimen in Fig. 14, but with narrower leaf segments, leg. & det. as *P. slavica*, later rev. as *P. subslavica* by J. Futák (SAV). — **Abb. 10:** Herbarbelege von vegetativen *Pulsatilla styriaca (*"*P. subslavica*"*)* aus der Slowakei, von derselben Fundstelle wie das Exemplar in Abb. 14, aber mit schmäleren Laubblattabschnitten, leg. & det. als *P. slavica*, später rev. als *P. subslavica* von J. Futák (SAV).

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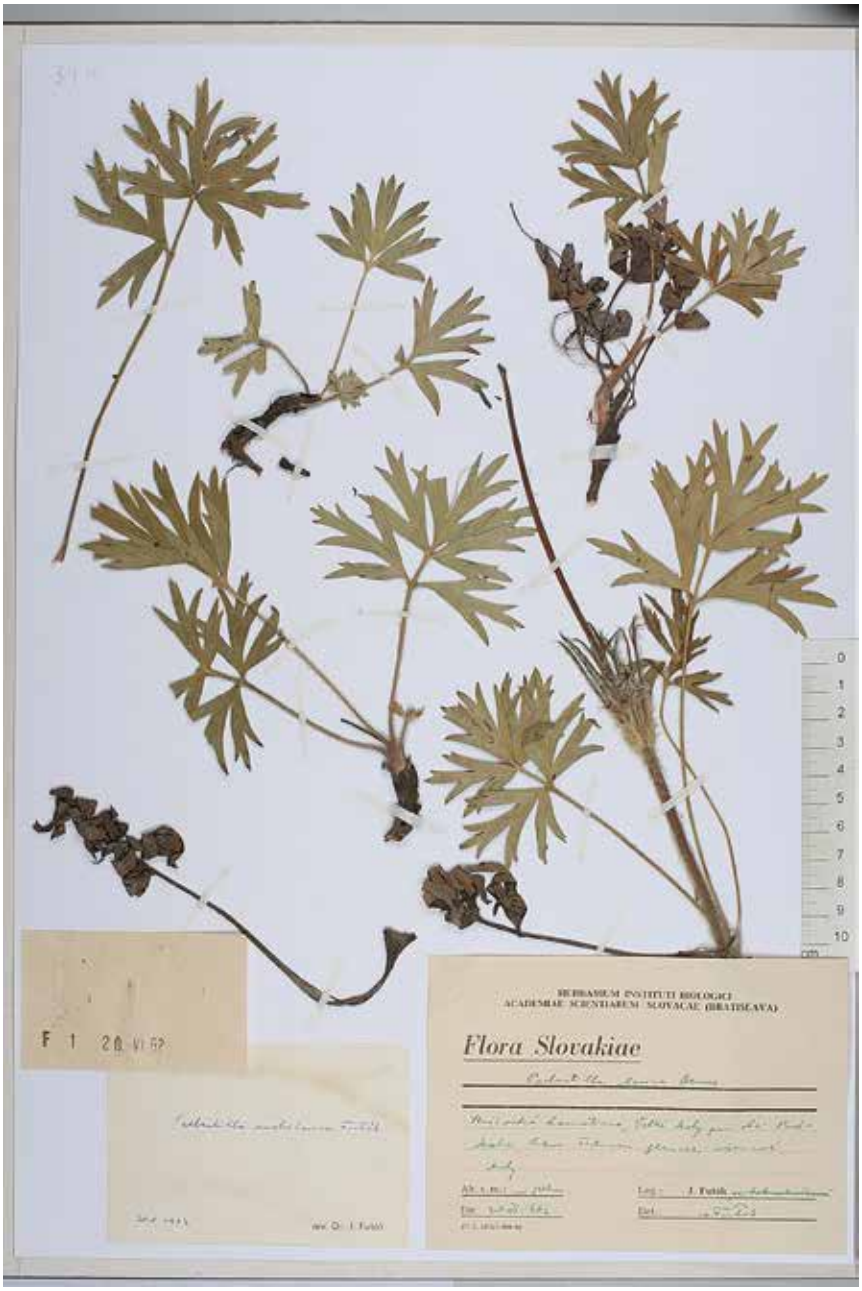

Fig. 11: Herbarium specimens of vegetative *Pulsatilla styriaca (*"*P. subslavica*"*)* from Slovakia, from the same locality as specimens in Fig. 13, but with wider leaf segments, leg. & det. as *P. slavica*, later rev. as *P. subslavica* by J. Futák (SAV). — **Abb. 11:** Herbarbelege von vegetativen *Pulsatilla styriaca (*"*P. subslavica*"*)* aus der Slowakei, von derselben Fundstelle wie die Exemplare in Abb. 13, aber mit breiteren Laubblattabschnitten, leg. & det. als *P. slavica*, später rev. als *P. subslavica* von J. Futák (SAV).

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Differential characters between *P. styriaca*, *P. subslavica* and *P. slavica* according to taxonomic and floristic literature

Tutin & Akeroyd (1993: 266) as *P. halleri subsp. styriaca:* "Like *subsp.* [*halleri*] [i. e.: plants usually more than 5 cm at anthesis; primary divisions of the basal leaves usually 5; lamina with fewer than 50 lobes, more or less lanate], but the lamina of the basal leaves 5–11 cm. 2*n* = 32." *P. subslavica* is not mentioned even in synonymy.

Maurer (1996: 88) describes the leaves of *P. styriaca* as 1-pinnate with 7–20 lobes, 6–11 mm wide.

Damboldt & Zimmermann (1974: 221): *P. halleri subsp. styriaca* in contrast to *subsp. halleri:* Plants in flower usually about 10 cm high (*subsp. halleri:* usually below 10 cm); tepals usually longer than 35 mm (*h.:* usually shorter than 35 mm); cauline leaves at average 35–45 mm long (*h.:* 25–30 mm), hairs on flower and leaf 4–5 mm (*h.:* on upper side of basal leaves after flowering and at fruiting time about 4 (2–4) mm long). – The authors draw attention to the fact that "*subsp. styriaca*" is (because of gene exchange) genetically more close to the geographically adjacent *P. grandis* than to the geographically and altitudinally distant "*subsp. halleri*", and that be a similar situation like the contacts between *P. grandis* and *subsp. slavica* in the Carpathians.

Hayek (1902: 479) writes: The characters of "*Anemone Styriaca*" are intermediate between "*A. Halleri*" und "*A. grandis*": The leaves are distinctly pinnate with usually three pairs of segments of 1st order, but the terminal segment is often sessile and therefore not distinctly separated from the uppermost segments of 1st order; the lobes are wider than in *A. grandis* and, when young, densely silky villous, and when old still amply hairy, particularly the petioles are fairly strongly hairy even when old. There is no difference in the flower between all three species.

Hayek (1908: 371, as *Anemone stiriaca*) in his Styrian Flora mentions: Stems up to 30 cm high, patently villous; basal leaves long petiolate, imparipinnate with usually two (rarely one) pairs of segments [pinnae], terminal leaflet usually sessile and palmately 3–7-fid with deeply dentate segments, the lateral ones usually bifid with multifid deeply dentate segments, segments of last order [lobes] 4–8 mm wide; young leaves silky villous, when adult hairs densely appressed; flower erect. – *Pulsatilla halleri* is not treated because absent from Styria.

Aichele & Schwegler (1957: 168, 178–182) present detailed descriptions well comparable with those of *P. slavica* and *P. halleri*. Differences between *P. styriaca* and *P. slavica*, in our opinion, are minute and by far not sufficient for accepting two different species (Tab. 2). Their summary (on p. 181) that *P. styriaca* is "well separable" from the other species "morphologically as well as before all geographically" seems to us justified only in respect to "geographically".

Pulsatilla slavica, according to in Aichele & Schwegler (1957), comprises two varieties: *var. slavica* (basal leaves with 2–3 narrow[1] segment pairs) and *var. wahlen-*

1 misprint on p. 175: "laciniis foliorum latis" should read – according to the German text – "… angustis"

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Table 2: Differential characters mentioned by KRAUSE (1958: 34–35, 41) between three infraspecific taxa of her "*P. halleri*": *P. styriaca* and the two races within "*P. slavica*" (s. lat.). — **Tab. 2:** Unterscheidungsmerkmale zwischen den drei infraspezifischen Taxa der „*P. halleri*" nach KRAUSE (1958: 34–35, 41): *P. styriaca* und die beiden Rassen innerhalb ihrer „*P. slavica*" (s. lat.).

	subsp. styriaca	*subsp. slavica var. slavica* = ***P. subslavica*** sensu GOLIÁŠOVÁ (1981, 1985) and FUTÁK (1982)	*subsp. slavica var. wahlenbergii* = ***P. slavica*** sensu GOLIÁŠOVÁ (1981, 1985) and FUTÁK (1982)
Plant size	low height: max.: 14 cm in flower, 34 cm in fruit	18 cm: higher in flower, but lower in fruit	17 cm: higher in flower, but lower in fruit
Leaf length at begin of flowering	4.0 cm	3.2	2.0
Hairs on involucrum and flower	short	longer	longer
Leaf indument, especially in fruit	strong	less strong	less strong
Ratio tepal width/length	0.32, i. e., narrower	0.37, i. e., wider	0.40, i. e., wider
Inner tepals	usually shorter than outer	not shorter?	not shorter?
Ratio leaf width/length	1.3	1.2	1.4
Number of leaf lobes	47	55	37
2-pinnate leaves	10%	no	no
Width of lobes	38 mm	37 mm	50 mm
Petiolule of lowest leaf segments	4.8 mm	3.5 mm	1.4 mm
Length of lowest rhachis "internode"	26 mm	27 mm	16 mm

bergii (basal leaves with 1–2 segment pairs). *Pulsatilla slavica var. slavica* is said to hold an intermediate position between *P. slavica var. wahlenbergii* and *P. styriaca*.

KRAUSE (1958) emphasizes the differences between "*P. Halleri subsp. styriaca*" and "*P. Halleri subsp. slavica*": Table 2. Also her values show that "*styriaca*" holds an intermediate position between "*slavica*" and "*wahlenbergii*".

It is important to note that the mean values in Tables 2 and 3 are rather insignificant because variance in all values is generally very high as clearly shown especially by KRAUSE (1958) who, in her statistical tables, presents the amplitudes as well.

Table 3: Comparison of diagnostic features in Styrian *Pulsatilla styriaca*, Bulgarian *P. styriaca* and Slovakian *P. subslavica* (= *P. styriaca* in our opinion). Numbers in square brackets are specimens studied; bold numbers in round brackets are arithmetic means. Literature data in the 4th and 6th columns. Lobes = ultimate (smallest) segments of a leaf; pedicel = internode between involucrum and flower; scape = internode below involucrum; involucrum = whorl of anaphylls below the flower = "stem leaves"; rhachidula = petiolulus. — **Tab. 3:** Vergleich diagnostischer Merkmale zwischen steirischer *Pulsatilla styriaca*, bulgarischer *P. styriaca* und slowakischer *P. subslavica* (= *P. styriaca* unserer Meinung). Zahlen in eckigen Klammern: untersuchte Exemplare; Zahlen in runden Klammern im Fettdruck: arithmetische Mittelwerte. Daten aus der Literatur in der 4. und 6. Spalte. Lobes = Laubblattzipfel; pedicel = Internodium (Stängelabschnitt) zwischen Hochblatthülle und Blüte; scape = Stängelabschnitt unter der Hochblatthülle; involucrum = Hochblatthülle (= „Stängelblätter"); rhachidula = Blättchenstiel.

Character parameter	*P. styriaca* from Styria	*P. styriaca* from Bulgaria	*P. halleri subsp. styriaca* data by Krause (1958) = *P. styriaca*	*P. subslavica* from Slovakia	*P. var. slavica* data by Krause (1958) = *P. subslavica*
Number of specimens studied	66	4	about 100	62	about 100
Height of flowering plant [mm]	90–260 **(154)** [42]	140–160 **(150)** [2]	70–200 **(135)**	68–205 **(144)** [17]	70–240 **(175)**
Heigth of stem in fruit [mm]	155–410 **(305)** [15]	340–350 **(345)** [2]	–	210–495 **(334)** [35]	–
Length of leaves (LB) [mm] when first flower appears	0–110 **(45)** [42] 8 LB <20 = **19%** 6 LB 20–40 = **14%** 28 LB >40 = **67%**	0–0 **(0)** [2] 2 LB <20 = **100%** (leaf buds!)	10–70 **(40)**	0–55 **(16)** [16] 10 LB <20 = **63%** 3 LB 20–40 = **19%** 3 LB >40 = **19%**	10–60 **(32)**
Length of leaf lamina [mm]	28–115 **(68)** [23]	105–115 **(110)** [2]	50–180 **(83)**	50–130 **(82)** [45]	50–180 **(91)**
Width of leaf lamina [mm]	40–160 **(88)** [23]	120–125 **(123)** [2]	49–220 **(110)**	55–150 **(99)** [45]	60–180 **(109)**
Number of lobes	30–65 **(47)** [23]	37–64 **(51)** [2]	15–100 **(47)**	27–90 **(49)** [45]	20–130 **(55)**
Number of 1st-order-segments	1–3 pairs **(1.9)** [21] 1 pair: 4× = **19%** 2 pairs: 16× = **76%** 3 pairs: 1× = **4.8%**	2–3 pairs **(2.5)** [2] 2 pairs: 1× = **50%** 3 pairs: 1× = **50%**	–	1–3 pairs **(2.2)** [45] 1 pair: 1× = **2.2%** 2 pairs: 32× = **71%** 3 pairs: 12× = **27%**	–
Degree of pinnate leaf division (1× = 1-pinnate, 2× = 2-pinnate, 3× = 3-pinnate)	1–2× **(1.5)** [23] 1×: 12× = **52%** 2×: 11× = **48%**	2–2× **(2)** [2] 2×: 2× = **100%**	2–4 **(3.3)**	1–3× **(1.9)** [45] 1×: 7× = **16%** 2×: 37× = **82%** 3×: 1×= **2.2%**	3–4 **(3.5)**

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Width of 1st-order-segments [mm]	5–17 **(10)** [23]	8–10 **(9)** [2]	5–22 **(11)**	4–20 **(11)** [45]	5–15 **(10)**
Length of petiole [mm]	50–210 **(122)** [23]	90–160 **(125)** [2]	50–300 **(154)**	70–240 **(151)** [45]	50–250 **(139)**
Length of lowest rhachis "inter-nodium" [mm]	4–40 **(21)** [23]	35–50 **(43)** [2]	0.1–70 **(26)**	10–45 **(24)** [45]	0.1–80 **(27)**
Length [mm] of lowest rhachidula "internodium"	0–10 **(1.1)** [23]	3–3 **(3)** [2]	0–24 **(1)**	0–13 **(1.4)** [45]	0–4 **(0.5)**
Width of terminal lobe of lowest segments [mm]	1.5–4 **(2.8)** [23]	4–4 **(4)** [2]	2–9 **(3.8)**	2–6 **(3.5)** [45]	2–6 **(3.7)**
Length of petiolule of lowest 1st-order-segment [mm]	0–12 **(3.2)** [23]	5–14 **(9.5)** [2]	0–25 **(4.8)**	0–15 **(2.5)** [45]	0–21 **(3.5)**
Opposite 1st-order-segments	22 [out of 23] **96%**	1 [out of 2] **50%**	–	11 [out of 45] **24%**	–
Alternate 1st-order-segments	1 [out of 23] **4.4%**	1 [out of 2] **50%**	1.5%	34 [out of 45] **76%**	0%
Upper section of rhachis present	15 [out of 23] **65%**	2 [out of 2] **100%**	70%	30 [out of 45] **67%**	45%
Length of leaf hairs [mm]	2–4 **(2.3)** [23]	3–3 **(3)** [2]	3	0–2.5 **(1.6)** [45]	2.5
Length of scape (in fruit) [mm]	60–150 **(94)** [15]	110–110 **(110)** [2]	50–200 **(100)**	40–190 **(121)** [35]	50–220 **(105)**
Length of involucrum (at anthesis [mm]	20–50 **(34)** [42]	26–38 **(32)** [2]	20–57 **(36)**	20–37 **(31)** [18]	25–65 **(45)**
Length of involucrum hairs [mm]	3–5 **(4)** [57]	5–6 **(5.8)** [4]	3–6 **(4)**	2–6 **(4.3)** [53]	4–10 **(6)**
Length of pedicel [mm]	90–315 **(210)** [15]	230–240 **(235)** [2]	120–400 **(240)**	115–370 **(213)** [35]	120–330 **(210)**
Length of tepals [mm]	25–50 **(37)** [42]	42–48 **(45)** [2]	20–54 **(38)**	30–45 **(38)** [18]	30–65 **(45)**
Width of tepals [mm]	9–18 **(13)** [42]	12–12 **(12)** [2]	8–23 **(13)**	9–19 **(14)** [17]	8–23 **(16)**
Length of tepal hairs [mm]	2–4 **(2.7)** [39]	4–5 **(4.5)** [2]	1–6 **(2.5)**	1.4–4 **(2.6)** [17]	2–8 **(5)**
Length of anthers [mm]	1–1.5 **(1.1)** [20]	2–2 **(2)** [1]	–	1–1.8 **(1.3)** [16]	1.3–2.2 **(1.8)**

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Pulsatilla slavica (s. str.) sensu Futák *(P. halleri subsp. slavica var. wahlenbergii)* differs by its distinctly wider leaf segments as shown by photographs in Krause (1958: Taf. 1. Abb. 69) and the drawing by Mereďa & Hodálová (2011: 104).

Tutin & Akeroyd (1993: 266) characterize *P. halleri subsp. slavica* by "primary divisions of the basal leaves usually 3, sessile; lamina with usually fewer than 50 lobes, more or less lanate". – *Pulsatilla subslavica* is missing as a taxon as well as a synonym.

Krause (1958: 45–47) describes *P. halleri subsp. slavica var. wahlenbergii* (= *P. slavica* sensu Futák) in her keys to the infraspecific taxa of *P. halleri*: Second leaf rhachis "internodium" usually missing, segments usually wider than 15 mm, tepals usually longer than 42 mm, ungainly ("plump") with width/length 42.2 in average, anthers suborbicular.

In contrast, *P. halleri subsp. slavica var. slavica (= P. subslavica)* is described by second leaf rhachis "internodium" usually present, segments usually narrower than 15 mm, terminal leaf segment narrower than 4 mm (wider in *styriaca*), leaf lamina at least 9 cm long in average (shorter in *styriaca*), relatively narrow (in comparison to *styriaca*), segments (5–)10(–15) mm wide, with more than 50 lobes, tepals usually longer than 42 mm, to "slender" width/length of tepals 35.5 in average, anthers "oblong".

Pulsatilla subslavica (Figs. 8–11) comprises populations with leaves the segments of which are narrower than in *P. slavica* s. str. (= sensu Futák 1982) but wider than in *P. grandis*. Most of the herbarium specimens studied by the second author, in respect to this character, exhibit the same variation amplitude like in *P. styriaca*. Almost all specimens of *P. slavica* s. str., however, show distinctly wider segments than in *P. styriaca*.

In the key by Futák (1982: 111), *P. subslavica*, *P. slavica*, and *P. grandis* are compared in parallel:

Pulsatilla subslavica: Basal leaves not more than 2-pinnate or -pinnatisect, lobes 7–12 mm wide; segment pairs usually 3.

Pulsatilla slavica: Basal leaves 1-pinnate, lobes 12–25 mm wide; segment pairs 1 or 2.

Pulsatilla grandis: Basal leaves 2–3-pinnate or -pinnatisect, lobes 2–6(–7) mm wide; segment pairs 4 or 5.

The description of *P. subslavica* in Futák (1982) reads: Basal leaves at anthesis usually not developed, reaching their definite shape towards end of summer. Leaf lamina ± broadly ovate in outline, length like in *P. slavica* [no length given there], tomentose when young, later dispersedly hairy, unpaired pinnate with usually 4 pairs of leaflets, the lower leaflets sometimes 2-pinnate at base, terminal leaflet usually stalked, 3-partite, segments ± 3-lobed, lateral leaflets opposite, very rarely alternate, sessile, rarely stalked [petiolulate], 3–5 times rather irregularly pinnatisect to pinnatilobe, lobes 7–12 mm wide. Otherwise like *P. slavica*. (Translated from Slovak.)

Goliášová (1981) has investigated in detail that *P. slavica* shows abundant introgressive hybridization to *P. grandis* as well as to *P. subslavica* (see also Futák 1982: 119–129 and Mereďa & Hodálová 2011: 98–99, 104–107). *Pulsatilla grandis*, in Slovakia, is disjunctly distributed with centres in SW Slovakia and E Slovakia. *Pulsatilla slavica* has its distribution centre in eastern central Slovakia, reaching to western Tatra mts. in Poland. *Pulsatilla subslavica* is endemic to Slovakia, mainly distributed in west-

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ern central Slovakia, adjacent to and overlapping with the range of *P. grandis* in western and in eastern parts of the country. For large regions both *P. subslavica* and *P. slavica* are growing sympatrically and forming hybrids.

Other closely related taxa are *P. rhodopaea* and *P. halleri* (*P. taurica*, *P. macedonica*, and *P. velezensis*[1] being omitted here):

Pulsatilla rhodopaea *(= P. halleri subsp. rhodopaea)*: according to Tutin & Akeroyd (1993: 266) rarely taller than 5 cm at anthesis; lamina of basal leaves with 50–100 lobes, primary segments usually 5, often petiolate, densely lanate. Balkan Peninsula. (See Figs. 12 and 13.) – According to Krause (1958: 46): Leaf lobes usually more than 65, lowermost rhachis "internodium" usually longer than 4 cm, primary segments (6–)11(–24) mm wide. – Description by Jordanov & Kožuharov (1970: 108): "dolnite mežduvăzlija na priosnovnite lista po-dălgi ot 2 cm; listnite delčeta 60–70. Sredni Rodopi (Asenovgradsko)." *Subsp. halleri:* "… po-kăsi ot 2 cm; … 40–45. U nas ne se srešta." (Lower internodes [= leaf rhachis segments] of the basal leaves longer than 2 cm; leaf segments 60–70. Central Rodops (Asenovgrad district). *Subsp. halleri:* … shorter than 2 cm; … segments 40–45. Not present in our country [Bulgaria].)

In Bulgaria, *P. rhodopaea* occurs in eastern Stara planina and in the central Rhodopes (see Figs. 12 and 13). *Pulsatilla slaviankae*, included in *P. rhodopaea* by "Flora Europaea" (Tutin & Akeroyd 1993), is endemic to Slavianka mts. (SW edge of Bulgaria) according to Jordanov & Kožuharov (1970).

***Pulsatilla halleri* s. str.** *(= P. halleri subsp. halleri)* differs from *P. styriaca* according to Tutin & Akeroyd (1993: 266): Plants usually taller than 5 cm in anthesis, lamina of basal leaves 3–7 cm long, primary segments usually 5, sessile, usually with fewer than 50 lobes, more or less lanate. – According to Krause (1958: 46): Plant at anthesis usually lower than 10 cm, hairs on leaves 4–5 mm long (Damboldt & Zimmermann 1974: 221 further characters: hairs on upper side of leaves after anthesis and in fruit about 4 mm long, rarely 2–4 mm), lobes usually fewer than 45, lowest petiolule longer than 2 mm, tepals shorter than 35 mm, stem leaves (involucral leaves) 25–30 mm on average; hairs on flowers usually shorter than 4 mm. SW Alps up to S Switzerland.

Pulsatilla grandis is rather close, though not included in *P. halleri* s. lat. (= *P. halleri* agg.). According to Tutin & Akeroyd (1993: 264–265) *P. vulgaris* s. lat. (i. e. including *P. grandis*) differs from *P. halleri* s. lat. by basal leaves 3- or 4-pinnatisect, with 7–9 primary segments, plants at first sericeous, becoming glabrous. The trait of *P. grandis* that leaves appear after flowers is common with *P. halleri* s. lat. – According to Damboldt & Zimmermann (1974: 217) *P. grandis* differs from *P. halleri* s. lat. (i. e. including *styriaca*) by leaf lobes (2–)4(–11) mm wide and involucrum lobes ca. 20 in *P. grandis* vs. leaf lobes (2–)6–11(–22) mm wide in *P. halleri* s. lat. – Krause (1958: 34–35), in her character table of different taxa within *P. halleri* (s. lat.), includes *P. grandis*. The figures there do not show any conspicuous differences against *P. halleri* s. lat.

1 included in *subsp. rhodopaea* by Tutin & Akeroyd (1993)

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Fig. 12: Herbarium specimen of fruiting *Pulsatilla rhodopaea* from the central Rhodopes in Bulgaria, reserve "Červenata stena" [The Red Wall], A. Tashev, 16 Apr. 1999. — **Abb. 12:** Herbarbeleg einer fruchtenden *Pulsatilla rhodopaea* aus den Zentralrhodopen (Bulgarien), Schutzgebiet "Červenata stena" [Rote Wand], A. Tashev, 16. April 1999.

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Fig. 13: Herbarium specimen of *Pulsatilla rhodopaea* from the central Rhodopes in Bulgaria, near the village Dobrostan, *Pinus pallasiana* forest, 1235 m a. s. l., A. Tashev, 1 May 2008. — **Abb. 13:** Herbarbeleg der *Pulsatilla rhodopaea* aus den Zentral-Rhodopen (Bulgarien), nächst dem Dorf Dobrostan, *Pinus-pallasiana*-Wald, 1235 msm, A. Tashev, 1. Mai 2008.

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Comparison of *P. styriaca* with *P. subslavica*

Table 3 shows virtually no significant differences between *P. styriaca* from Styria and from Bulgaria and *P. subslavica* from Slovakia. Before all, the large variation amplitude within all three "taxa" is obvious. The first-glance impression that all these specimens belong to the same species is corroborated by detailed measuring of the character parameters traditionally considered taxonomically significant. (Figs. 1–4, 8–11)

The leaves show conspicuous ontogenetic heterophylly: The number of lobes increases strongly from the first leaves up to adult leaves developed only much after anthesis, towards fruiting time. Krause (1958) mentions that lobe number increases by doubling from one to the following leaf. Usually specimens are collected when in flower, that is why study of herbarium material is difficult. Comparisons suffer also from the fact that we had only few specimens from Bulgaria because of the poor populations there.

Habitats of *P. subslavica* in Slovakia

Dry, grassy places on calcareous ground from the colline (ca. 350 m s. m.) up to the montane zone (1000 m s. m.). Coenology: alliances Seslerio-Asterion alpini, Seslerio-Festucion duriusculae, Quercion pubescentis-petraeae, Erico-Pinion, Festucion valesiacae and suballiance Cephalanthero-Fagion (Futák 1982: 128).

Pulsatilla styriaca in Bulgaria

The comparison of the herbarium specimens of *P. styriaca* from Bulgaria (Figs. 14–17) and Austria (W, WU, WHB, WFBVA) by the first author proved their complete identity (Figs. 1–4, 15–17).

Bulgaria, western Sredna Gora (Ihtimanska Sredna Gora):

(1) North-west from Belovo, northern from the Maritza river bed, between Momina Klisura village and Belovo. The slope is of south-eastern exposition and the rock is limestone. Collected with flowers; 380 m a. s. l.; N 42°13′27.6″, E 23°59′56.4″; GM-57; 26 Apr. 1998, coll. Alexander Tashev (SOM 164107).

Same locality, 385 m a. s. l.; N 42°13′27.7″, E 23°59′55.9″; GM-57; 11 May 2008, coll. Alexander Tashev (W 2009-0003619; http://herbarium.univie.ac.at/database/detail.php ?ID=136481).

The locality is situated in the central Rhodopean low-mountaineous climatic district of the Transitional continental climatic sub-region of the European Continental climatic region (Sabev & Stanev 1963; Velev 2005). According to the forest regionalization, it is located in the Thracian forest region, lower plain and hilly oak forests (Zahariev & al. 1979), and – according to the regionalization of vegetation in Bulgaria – in the belt of

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Fig. 14: Flowers of *Pulsatilla styriaca* in western Sredna Gora; A. Tashev, 24 Feb. 2008. — **Abb. 14:** Blühendes Individuum von *Pulsatilla styriaca* im westlichen Balkan-Gebirge; A. Tashev, 24. Feb. 2008.

Fig. 15: Specimen of *Pulsatilla styriaca* with fully developed leaves close to a tree of *Ostrya carpinifolia*; western Sredna Gora; A. Tashev, 6 June 2008. — **Abb. 15:** Exemplar der *Pulsatilla styriaca* mit voll entwickelten Laubblättern, neben einer Hopfenbuche (*Ostrya carpinifolia*); westliches Balkan-Gebirge; A. Tashev, 6. Juni 2008.

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Fig. 16: Herbarium specimen of fruiting *Pulsatilla styriaca* from western Sredna Gora in Bulgaria, near Belovo, 450 m a. s. l.; A. Tashev, 10 May 2009. — **Abb. 16:** Herbarbeleg einer fruchtenden *Pulsatilla styriaca* vom westlichen Balkan-Gebirge, bei Belovo, 450 m s. m.; A. Tashev, 10. Mai 2009.

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Fig. 17: Herbarium specimen of fruiting *Pulsatilla styriaca* from western Sredna Gora in Bulgaria, near Belovo, 385 m a. s. l.; A. Tashev, 11 May 2009. — **Abb. 17:** Herbarbeleg einer fruchtenden *Pulsatilla styriaca* vom westlichen Balkan-Gebirge, bei Belovo, 385 m s. m.; A. Tashev, 11. Mai 2009.

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xerophyte and mesoxerophyte, microthermic and mesothermic vegetation in the xerothermic oak belt and in hilly plains (Bondev 1991). According to the floristic regionalization of the country it is in the floristic region western Sredna Gora (Bondev 1966).

The habitat was identified as "Arborescent matorral with *Juniperus* spp." (HD-Code 5210; PAL.CLASS.: 32.131) or "[*Juniperus oxycedrus*] arborescent matorral" (EUNIS: F5.1311; PAL.CLASS.: 32.1311).), which is a habitat of European importance ("Interpretation Manual for the habitats in the European Union", Eur 2002).

The habitat is situated at the lower part of a 25° slope. The bedrock is limestone and the soil is stony, shallow, poor and very dry. The soil type is rendzic leptosols. The original secondary plant community dominated by[1] *Quercus pubescens* with participation of *Ostrya carpinifolia* (Fig. 15) and *Fraxinus ornus*, where *P. styriaca* was found, had reached its final stage of degradation. Therefore, in 1955 it was afforested by Black Pine *(Pinus nigra)* and single individuals of Scots Pine *(Pinus sylvestris).* At the moment there are still several survived individuals or small groups of Black Pine in the lower part and very few Scots Pine individuals. Also, single trees of *Quercus pubescens*, *Qu. frainetto*, *Qu. dalechampii*, *Ostrya carpinifolia*, *Fraxinus ornus*, *Pistacia terebinthus*, *Pyrus pyraster* participate in the tree composition. There are also small groups or single individuals of shrubs: *Juniperus deltoides*, *Carpinus orientalis*, *Paliurus spina-christi*, *Cotinus coggygria*, *Coronilla emerus subsp. emeroides*, *Rhamnus rhodopaeus*, *Prunus spinosa*, *Rosa obtusifolia*, *Amelanchier ovalis* etc.

The herbaceous layer is formed by more than 50 species, the most typical being *Chrysopogon gryllus*, *Poa badensis*, *Stipa pennata*, *Koeleria nitidula*, *Carex humilis*, *Teucrium polium*, *Jurinea consanguinea*, *Achillea clypeolata*, *Anthemis argyrophylla*, *Convolvulus cantabrica*, *Erysimum diffusum*, *Onosma taurica*, *Minuartia rhodopaea*, *Inula ascherssoniana*, *Sedum kostovii*, *Silene flavescens*, *Scorzonera austriaca*, *Salvia argentea*, *Stachys recta*, *Hypericum rumeliacum*, *Anthyllis vulneraria subsp. polyphylla*, *Thesium ramosum (Th. arvense)*, *Helianthemum nummularium*, *Fumana procumbens*, *Cytisus (Corothamnus) procumbens*, *Ononis pusilla*, *Globularia bisnagarica (G. aphyllanthes)* etc. A clear trend to more dry conditions during the vegetation period was observed during the years of monitoring, and most probably this is the reason of the many dried individuals of *Juniperus deltoides.* It is also possible that the proximity of the Pulp and paper plant "Belana" has also influenced the process.

Full inventory of the individuals of *P. styriaca* was performed on 7 May 1998, and partial inventory on 6 May 2000 and 11 May 2003. The plants grow at south-eastern and south-western exposition and there is a small group in the gully that separates them. The total area where the individuals grow was roughly estimated to about 20,000 m².

Most individuals were recorded on the south-eastern slope, at altitude 385 m and geographic coordinates in the center of the group: N 42°13′28.0″, E 23°59′56.1″. Sixty-four individuals were recorded in 1998 and 40 of them had generative stems. There were 17 micro-groups consisting of more than 1 individual – 1 group of 5 individuals, 2 groups

1 taxonomy and nomenclature of the taxa mentioned follow Dimitrov (2002)

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of 6 individuals, 3 groups of 3 individuals and 2 groups of 2 individuals each. The remaining 20 individuals were solitarily distributed. In 2000 the total number of individuals was 59 and 5 of them had generative stems. There were 14 groups consisting of more than 1 individual: 1 group of 8 individuals, 1 group of 5 individuals, 1 group of 3 individuals, and 9 groups of 2 individuals each. The remaining 16 individuals grew solitary. In 2003 the population consisted of 39 individuals and only 1 had a generative stem. There were 9 groups of more than 1 individual – 1 group of 5 individuals, 2 groups of 4 individuals and 6 groups of 2 individuals each. The remaining 14 individuals grew solitary.

These observations show how the number of individuals on the south-eastern slope has decreased considerably during a 5-year period from 64 to 39, and the individuals with generative stems from 40 to 1. The same is valid also for the spot in the gully, where the number of individuals decreased two times. During the period of monitoring, many damages caused by domestic animals were found, especially on the generative stems.

(2) In the gully, under the canopy of trees of tertiary relic *Ostrya carpinifolia*, at an altitude 380 m and geographic coordinates N 42°13′27.5″, E 23°59′56.3″ in the centre of the group: six plants were recorded in 1998, all of them with generative stems. Only 3 individuals remained in 2003 and none had a generative stem.

(3) Two other spots of *P. styriaca* were found on the south-western slope. The first spot was at 378 m a. s. l. and had coordinates N 42°13′26.6″, E 23°59′59.6″. Five individuals were recorded in 1998 within a group of *Juniperus deltoides* and below *Pinus nigra* canopy and three of them had generative stems. The second one was at 440 m a. s. l. and had coordinates N 42°13′30.6″, E 24°00′00.7″. In total 14 individuals were found there, under *Pinus nigra* canopy and near *Fraxinus ornus*. Nine of them had generative stems. At the same place six individuals were found in 2003 – all of them with generative stems.

Subsequent observations up to 2007 confirmed the trend of decreasing population size. In total 42 individuals having 58 generative stems were found in the locality during the last inventory (24 Feb. 2008).

Conservancy of the Bulgarian sites of *Pulsatilla styriaca*

The species closest to *P. styriaca* in the Bulgarian flora, *P. halleri*, is considered to be of high conservation importance in Bulgaria. It is listed in the Red Data Book of P. R. Bulgaria (Velchev 1984) in the category "rare species" and was protected in 1961 under the name *Anemone rhodopaea* ("Journal of the Presidium of the National Assembly", 63, 1961). Its protection status was confirmed by inclusion in the new list of the protected species under its present name ("State Gazette", 56, 1989). Finally, it was included in Appendix 3 of the "Biodiversity Act of Bulgaria" (2002). In the Red Lists of the higher plants in Bulgaria elaborated in 2005, *Pulsatilla halleri* was listed as "endangered" (EN) species (Petrova & Vladimirov 2009). The species is included under the same status in the new Red Data Book of the Republic of Bulgaria (Peev 2011).

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The state of *P. styriaca* population in the locality has been destroyed during the last decade, as shown by the results of the periodical observations. Several reasons could be hypothesized: regular grazing by goats, which is rather common in the region; the evident xerophytization of the climate during the monitoring period, and the negative influence by the pulp and paper plant "Belana", which is close to the locality. Also, high rainfalls could cause possible torrents that could destroy the scree, where the locality is situated. Therefore, it is proposed the locality to be given a status of protected site. This necessity is underlined by the fact that most part of the locality of *P. styriaca* overlaps with the unique locality of the critically endangered *Anthemis argyrophylla*.

Distribution and habitats of *Pulsatilla styriaca* in Styria

The habitats of both the Bulgarian and the Styrian sites of *P. styriaca* (Figs. 1–4) resemble each other as to bedrock (calcareous) and altitude, while, evidently, accompanying species are different. The Bulgarian habitat is a submediterranean *Quercus pubescens* and *Ostrya carpinifolia* forest with a number of thermophilic balkan-illyric elements (see above). The *Pulsatilla* sites in Styria are characterized by Maurer (1981: 112 and 1996: 88) as "lichte blaugrasreiche Rotföhrenwälder an steilen felsigen Hängen und an Felswänden; submontan bis montan; auf Kalk und Dolomit, nur ausnahmsweise auch auf benachbarte Tonschiefer übergehend, von 390 bis 1650 m" (*Pinus sylvestris* forests rich in *Sesleria caerulea (S. varia)* on steep slopes on cliffs; submontane to montane, on calcareous and dolomitic bedrocks, exceptionally on adjacent tonschiefer, 390 to 1650 m s. m.). According to Eggler (1951) is *Pulsatilla styriaca* a characteristic species of the "relictic pine-forest with *Sesleria*". – Habitat type according to HD-Code (FFH-Richtlinie): carbonate-rock-steppes (FFH-LRT 6210, 6240) of the Upper Mur valley and the Grazer Bergland (calcareous mountain range north of Graz) and partly also "Karbonat-Rotföhrenwälder" (Scots pine forests on carbonate bedrocks).

The Styrian habitats belong to HD-Code (FFH-Lebensraumtypen) Karbonat-Felstrockenrasen (HD-Code 6210 p. p. = Naturnahe Kalktrockenrasen und deren Verbuschungsstadien, 6240 p.p. = Subpannonische Steppentrockenrasen) des Oberen Murtales und Grazer Berglandes und teilweise auch zum Karbonat-Rotföhrenwald (Erico-Pinetum sylvestris p. p.; no HD-Code).

Krause (1958: 12–13; translated from German) mentions in a phytosociological relevé:

Locality (1): "Vorberg der Gfäller Wand" near Mautern in Steiermark [Liesing valley]: steep rocky slope with humus pockets, slope 50° S-SE, coverage 50%, rocks 40%, open soil 10%, 1400 m s. m., 50 m below der timberline: *Pulsatilla* "*Halleri subsp. styriaca*" [= *P. styriaca*], *Sesleria caerulea (= S. varia)*, *Carex humilis*, *Globularia cordifolia*, *Euphorbia cyparissias*, *Galium* sp., *Teucrium chamaedrys*, *Cerastium arvense*, *Sempervivum montanum* (in rock crevices only), *Helianthemum* sp., *Achillea clavennae*, *Thymus* sp., *Lotus corniculatus*, *Senecio doronicum*.

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Locality (2): 100 m above "Hochleitnerhof" between the villages Kammern and Mautern in Steiermark: Mesobrometum on slope of calcareous scree; strongly humose with several calcareous stones, slope 20° S; coverage 95%; A-horizon ca 20 cm; relevé area 15 m²: *Pulsatilla Halleri subsp. styriaca*, *Bromus erectus*, *Festuca* "*longifolia*" [=?], *Juniperus communis*, *Carex montana*, *Carex ornithopoda*, *Carex alba*, *Asperula cynanchica*, *Helianthemum* sp., *Lotus corniculatus*, *Euphorbia cyparissias*, *Hippocrepis comosa*, *Prunella grandiflora*, *Polygonatum* "*officinale*" [= *P. odoratum*], *Potentilla heptaphylla*, *Alectorolophus minor* [= *Rhinanthus minor*], *Biscutella laevigata*, *Trifolium montanum*, *Teucrium chamaedrys*, *Orobanche teucrii*, *Plantago media*, *Plantago lanceolata*, *Helleborus niger*, *Thuidium tamariscinum*, *Hylocomium rugosum*.

Maurer (1981; translated from German) enumerates from a site near Stübing, Gratwein and Peggau (Mur valley north of Graz) as frequently accompanying: Tree- and shrub layer[1]: *Pinus sylvestris*, *Viburnum lantana*, *Ligustrum vulgare*, *Amelanchier ovalis*, *Rhamnus cathartica*; herb layer: *Sesleria caerulea (= S. varia)*, *Potentilla arenaria* [= *P. incana*], *Carex humilis*, *Erysimum sylvestre*, *Seseli austriacum*, *Leontodon incanus*, *Thymus praecox*, *Anthericum ramosum*. – At the Peggauer Wand (near the town Peggau) additionally: *Arthemisia campestris*, *Scorzonera austriaca*, *Melica ciliata*, *Geranium sanguineum*, *Thalictrum foetidum*, *Geranium rotundifolium* und *Minuartia setacea*. – Near the town Stübing additionally *Euphorbia verrucosa*, *Pulsatilla pratensis subsp. nigricans* and *Pulsatilla nigricans* × *P. styriaca (= P. ×weberi).*

Discussion of the ecological and phytogeographic position of *P. styriaca* by Maurer (1981: 79–80; translated from German): "The preference of xerothermic habitats on calcareous rocks in the Mur valley with a touch of subcontintental climate points to relationship with mit continentally spread taxa in eastern Europe and Asia Minor. According to Niklfeld (1973 and 1979), the phytochoria of species at the eastern edge of the Alps are in accordance to the comparatively insignificant pleistocene glaciation of the mountains at the eastern edge of the Alps and agree also with the benefits of locally sunny, warm slopes in the steep valleys of calcareous mountains." In such climatically favoured habitats on calcareous bedrocks are also stands of *Quercus pubescens*.

Distribution in Styria

The distribution of *P. styriaca* in Styria (see also Maly 1838, 1864, Maly 1868, Hayek 1908, Eggler 1951, Melzer 1963, Ehrendorfer F. & Niklfeld H. 1967, Maurer 1981, Zimmermann & al. 1989, Essl 2009) is verbally summarized by Maurer (1996: 88): "… endemisch im Grazer Bergland beiderseits der Mur von Gratkorn bis Gratwein bei Graz nordwärts bis zum Röthelstein und zur Roten Wand bei Mixnitz; weiter nördlich gegen Aflenz im Thörlgraben, nördlich Leoben im Vordernberggraben und einigen Seitentälern, besonders bei St. Peter-Freienstein sowie westlich von Leoben

1 taxonomy and nomenclature follow Fischer & al. (2008)

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bis St. Michael und den südlichen Ausläufern des Reiting bei Kammern und Mautern." (See Fig. 18.)

Conservancy of *Pulsatilla styriaca* in Styria

Zimmermann & al. (1989: 178, 200) categorize *P. styriaca* in Styria as "vulnerable" (rank 3). It is endangered by forestry managements, construction activities, quarries and collecting; species protection and conservation of biotopes are recommended.

The "Rote Liste gefährdeter Pflanzen Österreichs" (Red List of threatened plants in Austria) by Niklfeld & Schratt-Ehrendorfer (1999) ranks *P. styriaca* as "gefährdet" (vulnerable = rank 3).

According to the Styrian Law for the Protection of Nature ("Steiermärkisches Naturschutzgesetz") of 1976 and the Prescription of Species Protection ("Artenschutzverordnung") of 2007, *Pulsatilla styriaca* is "partially protected" by § 2. (This means,

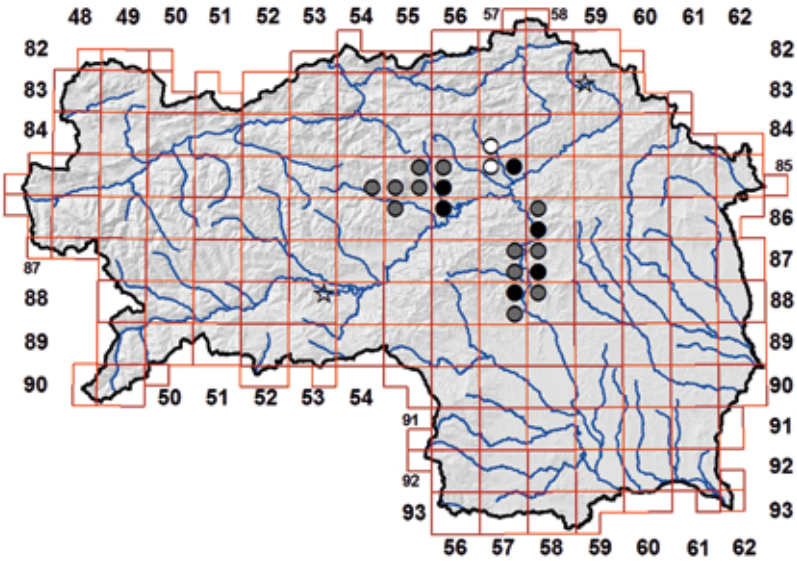

Fig. 18: Distribution grid map of *Pulsatilla styriaca* in Styria: black circles: records since 1990, currently confirmed; gray circles: records 1945–1989, currently not confirmed; white circles: records prior to 1945, currently not confirmed; ☆: 8853/2 (near Judenburg, Melzer 1963) and 8359/1 (Neuberg an der Mürz, Essl 2009). – According to: Floristic Mapping of Austria (H. Niklfeld & L. Schratt-Ehrendorfer, University of Vienna). — **Abb. 18:** Rasterverbreitungskarte von *Pulsatilla styriaca* in der Steiermark: schwarze Kreise: Meldungen seit 1990, aktuell bestätigt; graue Kreise: Meldungen 1945–1989, aktuell nicht bestätigt; weiße Kreise: Meldungen vor 1945, aktuell nicht bestätigt; ☆: Ansalbungen: 8853/2 (bei Judenburg, Melzer 1963) und 8359/1 (Neuberg an der Mürz, Essl 2009). – Nach: Floristische Kartierung Österreichs (H. Niklfeld & L. Schratt-Ehrendorfer, Universität Wien).

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leaf rosettes and underground plant parts must not be removed, whereas a single bundle of flowers in one hand ("Handstrauß") is allowed ("von den nicht geschützten Teilen der Pflanzen ist die Entnahme von mehr als einem Handstrauß verboten").

Results and Discussion

Krause (1958: 3): "Experimentell sind die einzelnen Formen gut miteinander kreuzbar; natürlicherweise verhindert aber die räumliche Isolation jeglichen Genaustausch (abgesehen von *slavica* [= *subslavica*]—*Wahlenbergii* [= *slavica*]). […] Jedes dieser Taxa hat charakteristische Eigentümlichkeiten; das weist auf eine selbständige Geschichte hin. Da alle Taxa relativ kleine Areale besiedeln, kann der zufällige Allelverlust, die sog. 'genetic drift', besonders leicht eintreten; auch Mutationen haben Sippendifferenzierungen begünstigt. Die Rassen sind jedoch so polymorph, […] die Übergänge also gleitend sind." (In the experimental garden the taxa hybridize, in nature, however, geographical isolation prevents gene flow between *slavica* [= *subslavica*] and *Wahlenbergii* [= *slavica*]. […] Each taxon has characters of its own, indicating independent history. As all these taxa inhabit relatively small areas, loss of alleles by genetic drift easily can happen, together with mutations. The taxa are rather polymorphic, […] variation is continuous."

Goliašová (1985), in her investigation on the variability of *P. slavica*, *P. grandis* and *P. subslavica*, states that *P. subslavica* exhibits, by morphological and anatomical characters of the vegetative and generative organs, an intermediate position between *P. slavica* and *P. grandis*. She concludes that *P. subslavica* probably originated by hybridization towards the end of Pleistocene, when both parents came into contact. Today, *P. slavica* forms distinct and pure populations in northern Slovakia, mainly in the Fatra mts. region but also further east; this species ranges from montane to subalpine altitudes. *Pulsatilla grandis* shows equally pure populations in southern Slovakia ranging up to eastern Slovakia east of Košice, where *P. slavica* is missing (maps by Futák 1982: 125, Goliašová 1985: 94, 160 and Mereďa & Hodálová 2011: 104). Its habitats range from lowland (colline) to submontane altitudes. However, in all contact zones of the parental species there is ample introgressive hybridization. *Pulsatilla subslavica* shows an intermediate position in respect to its vertical range from colline to montane.

The strong similarity, i. e. the broad congruence in all characters considered of taxonomic relevance leads us to the conclusion that *P. subslavica* and *P. styriaca*, including the newly discovered Bulgarian populations must be treated as conspecific. Therefore, the geographic range of this emended species is split into three regions: a small one in the West (central Styria), another, even smaller one in the east (Ihtimanska Sredna Gora in central Bulgaria) and a comparatively large one in central Slovakia which is, however, likewise disrupted because consisting of a large area in western Slovakia and several fragments further in the east. Thus, the whole species range is remarkably disjunct. The reason for this disjunction could be traced back to Quaternary period. Why the species survived only in these splitted refugial area – ranging from Austria in the

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west to Bulgaria in the east, remains unclear. Theoretically, however, polytopic origins of *P. styriaca* s. lat. cannot be excluded and would need confirmation or exclusion by genetic data.

As to the distribution of the Bulgarian populations, further studies in the region should be performed, particularly because there exists information provided by local people that this plant could be found also in other places in the region. There is high probability of finding new localities in similar habitats. Also, the monitoring of those rare and isolated Bulgarian populations must be continued.

Pulsatilla styriaca (s. lat.) seems to be an element within a network of closely related taxa exhibiting geographical differentiation (different main areas) but phenetically close and – if geography allows – connected by hybrid zones. In sympatric areas hybridization seems to be abundant. Typical populations of these taxa, however, are rather distinct and characterized by a set of – though variable – features (leaf shape, size of flower, indumentum of plant, phenology); furthermore, there is also ecological differentiation as to altitude (gradient from subalpine to colline: *halleri* s. str. – *slavica* – *styriaca* s. lat. – *grandis*); *P. halleri* s. str. and *P. rhodopaea* represent dwarfy mountain ecotypes, evidently. This is enough reason for several authors to attribute specific rank to these entities, because otherwise all of them would have to be lumped into one single polymorphic species. Distinction of two species groups (aggregates: Gutermann & Niklfeld 1973) or two species (e. g. by Tutin & Akeroyd 1993) hardly seems acceptable to us. Therefore we rather follow Damboldt & Zimmermann (1974) proposing a large "*P. vulgaris* Artengruppe" complying with *P. sect. Pulsatilla subsect. Vulgares* sensu Aichele & Schwegler (1957).

This network includes at least seven taxa, all of them tetraploid (see Fig. 19). (The diploid species *P. patens*, *P. pratensis*, and *P. montana* are excluded.)

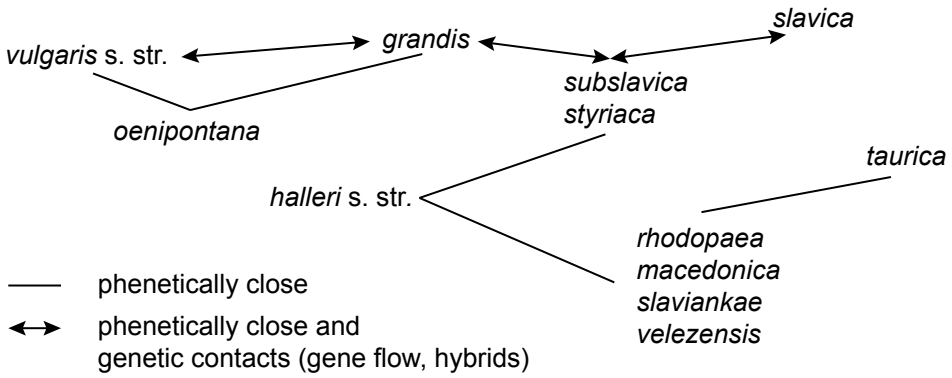

Fig. 19: Reticulate relations within the tetraploid *Pulsatilla vulgaris* s. latiss. group. — **Abb. 19:** Beziehungen innerhalb der tetraploiden Gruppe der *Pulsatilla vulgaris* s. latiss.

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