Taxonomic revision of *Sorbus* subgenus *Aria* occurring in the Czech Republic

Taxonomická revize jeřábů z podrodu *Aria* vyskytujících se v České republice

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Results of a taxonomic revision of *Sorbus* subg. *Aria* occurring in the Czech Republic are presented in a central-European context. Flow cytometry and multivariate morphological analyses were employed to assess the taxonomic diversity within the group. Diploid, triploid and tetraploid taxa were detected. Diploids are represented by a single species, *Sorbus aria*, which is morphologically very variable. This extensive variability is specific to this species and separates it, among other characters, from polyploid taxa. An epitype for *S. aria* is designated here. In the Czech Republic, *S. aria* has been recorded only in southern Moravia, and published records from Bohemia relate to other polyploid taxa of the subg. *Aria*. Native occurrencies previously recorded for *S. austriaca* and *S. carpatica* in the Czech Republic are erroneous and relate to individuals of *S. aria* with lobed leaves. Three new triploid species are described: *S. cucullifera* M. Lepší et P. Lepší from the Podyjí and Thaytal National Parks between the towns of Znojmo and Vranov nad Dyjí, and *S. moravica* M. Lepší et P. Lepší and *S. pontis-satani* M. Lepší et P. Lepší from the Moravian Karst area near the city of Brno. Tetraploid taxa include *S. danubialis* and two newly distinguished taxa: *S. thayensis* M. Lepší et P. Lepší and *S. collina* M. Lepší, P. Lepší et N. Meyer. *Sorbus thayensis* is endemic to the Podyjí and Thayatal National Parks and in a similar manner as a triploid species varies very little morphologically, which indicates that these polyploid taxa reproduce apomictically. All these new species are assumed to have originated from interbreeding between *S. danubialis* and *S. aria*. Up until now, *Sorbus collina* has been referred to as *S. aria* in the Czech Republic, as *S. pannonica* in Germany and as *S. graeca* in Austria and Hungary. Records refering to *S. graeca* in southern Moravia (Czech Republic) do not belong to *S. collina*, but are untypical individuals of *S. danubialis*. In the Czech Republic, *S. collina* occurs in central and north-western Bohemia. *Sorbus danubialis* is confined to central and north-western Bohemia and southern Moravia, and is taxonomically uniform. Old records of the existence of diploid individuals of *S. danubialis* in Bohemia are incorrect. Detailed distribution maps for all stenoendemics, photographs of the type specimens and line drawings of all polyploid species known from the Czech Republic are presented.

Keywords: apomixis, DAPI flow cytometry, hybridization, multivariate morphometrics, *Rosaceae*, subg. *Aria*, taxonomy

Introduction

European members of the genus *Sorbus* are traditionally classified into five subgenera – *Aria*, *Chamaemespilus*, *Cormus*, *Sorbus* and *Torminaria* (Kutzelnigg 1995, Rich et al. 2010). The first subgenus includes the diploid amphimictic *Sorbus aria*, possibly also the diploid and amphimictic *S. umbellata* and an intricate complex of many transitional taxa between these two species, which are believed to be apomictic and polyploid. The remaining subgenera are monotypic in Europe and comprise diploid amphimictic species with the exception of subg. *Chamaemespilus* in which diploids, triploids and tetraploids are reporeted (Warburg & Kárpáti 1968, Meyer et al. 2005). Subgenus *Chamaemespilus* is represented by *S. chamaemespilus*, subg. *Cormus* by *S. domestica*, subg. *Sorbus* by *S. aucuparia* and subg. *Torminaria* by *S. torminalis*. All of these monotypic subgenera except for subg. *Cormus* hybridize relatively frequently with subg. *Aria* and produce polyploid intersubgeneric taxa that are largely viewed as separate apomictic species (Meyer et al. 2005, Cornier 2008, Rich et al. 2010, Grundt & Salvesen 2011, Németh 2012, Vít et al. 2012).

Despite relatively common intersubgeneric hybridization, modern phylogenetic studies indicate that at least some of the subgenera should be treated as independent genera. The substantial extent of crossbreeding is ascribed to weak barriers to hybridization rather than close evolutionary relationships (Robertson et al. 1991, Li et al. 2012). In other words, the traditional subgeneric division probably does not satisfactorily reflect the phylogeny of *Sorbus* within the *Pyrinae* (Robertson et al. 1991, Potter et al. 2007, Li et al. 2012, Lo & Donoghue 2012). It is already clear that pinnate-leaved (*Sorbus*, *Cormus*) and simple-leaved (*Aria*, *Torminaria* and *Chamaemespilus*) species form two distinct monophyletic groups (Potter et al. 2007, Lo & Donoghue 2012). However, the relationships within these two groups are not sufficiently understood and deserve further investigation. Therefore, the traditional broad delimitation of *Sorbus* in Europe still remains in use in systematics and taxonomy (Cornier 2008, Lepší et al. 2009, Németh 2012, Pellicer et al. 2012, Raimondo et al. 2012, Velebil 2012, Ludwig et al. 2013, Meyer et al. 2014, Rich et al. 2014) as well as in national and supranational botanical compendia and databases (e.g. Király 2009, Kurtto 2009, Rich et al. 2010, Grundt & Salvesen 2011, Jäger 2011, Danihelka et al. 2012), and is adopted in this study.

From the taxonomic and evolutionary perspective, the most challenging group of the genus *Sorbus* in Europe is subg. *Aria*. It is distinguished from other subgenera of the genus *Sorbus* in Europe by the following combination of characters: leaves simple, serrate or shallowly lobed, greenish-grey to snowy white tomentose on lower surface, with craspedodromous venation (with veins running directly from the midrib and ending at the leaf margin); flowers proterogynous; petals white to yellowish-white, patent; styles 2–3 connate or free and tomentose at base; ovary semi-inferior, tomentose; fruit medium-sized or large, orange, red to dark red, with lenticels and persistent sepals, with heterogeneous mesocarp and cartilaginous endocarp and without sclereids.

Subgenus *Aria* is widely distributed in Europe and Asia, and comprises about 20–130 species, depending on the subgeneric and species delimitation (Gabrielian 1978, Phipps et al. 1990, Aldasoro et al. 2004, Kurtto 2009). The narrow species concept adopted already by Hedlund (1901) has recently dominated (Meyer et al. 2005, Cornier 2008, Grundt & Salvesen 2011, Castellano et al. 2012, Németh 2012, Raimondo et al. 2012,

Velebil 2012, Lepší et al. 2013a, Rich et al. 2014); however, some authors do not treat apomictic lineages as independent species and advocate broader species delimitations (cf. Aldasoro et al. 2004).

Members of the subg. *Aria* are classified into seven sections based mainly on morphological and anatomical characters (Aldaroso et al. 2004). All European species of the subg. *Aria* are assigned to the section *Aria*; the other sections occur in East Asia and adjacent regions (Aldaroso et al. 2004). Depending on the species delimitation, the section *Aria* includes 11 (Aldaroso et al. 2004) to 48 species (Phipps et al. 1990). In Europe, about 30 species are distinguished within this section when the narrow species concept is used, i.e. when apomictic species are accepted (Kurtto 2009).

Subg. *Aria* plays a crucial role in microspeciation within the genus, and due to the high diversity of its taxa and ongoing evolution, causes significant taxonomic problems in Europe. Hybridization with members of the subgenera *Torminaria*, *Sorbus* and *Chamaemspilus* has produced numerous intersubgeneric apomictic taxa. However, even more taxonomic diversity has been generated by extensive hybridization within the subgenus. The weak reproductive barriers between its members have resulted in cases of great local diversity and complicated taxonomic situations (Feulner et al. 2013). It is therefore not surprising that, compared to other groups of the genus, subg. *Aria* is the least understood European group of the genus *Sorbus*.

It is hypothesized that most species distinguished within the subg. *Aria* in Europe stem from auto- or allopolyploidization of two basic species: the south-to-central-European species *S. aria* and the south-European and west-Asiatic species *S. umbellata* (Liljefors 1953, Kutzelnigg 1995). Polyploids originating from hybridization or polyploidization of these two basic species may have relatively large distribution areas, as is the case, for example, of the north-to-west-European endemic *S. rupicola*, known from Scandinavia and the British Islands. Other such polyploids can be confined to very small areas, such as *S. cheddarensis* L. Houston et Ashley Robertson, an endemic in the Cheddar Gorge in England (Rich et al. 2010). Local endemics are generally considered to be the results of hybridization between widely distributed polyploids and *S. aria* s. str. (Rich et al. 2010). For example, the above mentioned *S. cheddarensis* is supposed to have arisen from hybridization between *S. aria* and *S. porrigentiformis* E. F. Warb., a species with a scattered distribution in England and Wales (Rich et al. 2010).

A similar scenario is described for central Europe by the author of the fundamental *Sorbus* monograph of the region (Kárpáti 1960). He distinguished several basic (widely distributed) species connected by many morphologically transitional taxa. His concept influenced *Sorbus* taxonomy in central Europe for many years and is still at least partially accepted in many national compendia (Kovanda 1992, 2002, Májovský 1992, Fischer 2008, Király 2009, Jäger 2011). However, most of his taxonomic conclusions are based only on morphology, i.e. with little or no knowledge of the ploidy structure or genetic variability of delimited taxa. His treatments may therefore be to some extent burdened by subjectivity and therefore require revision using modern biosystematic methods.

The lack of the use of more objective methods in the taxonomy of subg. *Aria* also applies to the Czech Republic. Initially, only two species were reported from this country – *S. danubialis* and *S. aria* (Klika 1937, Kovanda 1961, 1992). Both were reported from Bohemia and Moravia, and both were regarded as species with relatively little variability (Kovanda 1992). Kovanda (1961) distinguished *S. danubialis* var. *apiculata*, a leaf

morphotype confined mainly to Bohemia, and assigned most plants of *S. aria* from Bohemia to var. *cyclophylla* Beck, stating that they differ from the Moravian population (Kovanda 1992). Later, Kovanda (1997a) reports, again based on leaf morphology only, *S. graeca* from Moravia. Finally, Šefl (2007) recognized triploid individuals transitional between *S. aria* and *S. danubialis* in Moravia. In 2009, we started a taxonomic revision of the group and revealed several taxonomic novelties and serious misinterpretations.

The goal of this paper is to clarify the taxonomy of subg. *Aria* within the Czech Republic based on a combination of classical taxonomic approaches and modern biosystematic methods and provide a basis for further modern biosystematic research of this challenging group in central Europe.

Material and methods

Plant material and field work

Samples for morphometric analyses, flow cytometry and herbarium specimens were collected between 2009 and 2014, following the recommendations of Meyer et al. (2005), Rich et al. (2010) and papers published by Lepší et al. (2008, 2009). Flowering and fructiferous parts were collected in mid-May and September, respectively, and stored in 70% ethanol.

A revision of relevant *Sorbus* material kept in the following herbarium collections was undertaken: BRNM, BRNL, BRNU, CB, CHEB, CHOM, Herbarium of the Museum of Ústí nad Labem, HOMP, HR, LIM, LIT, MP, OL, OLM, OP, PL, PR, PRA, PRC, ROZ, SOKO, ZMT. For abbreviations of public herbaria, see Holmgren et al. (1990). Species nomenclature was unified according to Danihelka et al. (2012) except for *Sorbus* names, which follow Kutzelnigg (1995); otherwise, authorities are provided. Phytosociological nomenclature follows Chytrý et al. (2001).

Multivariate analyses

Multivariate morphometric analyses were used to reveal the species-specific characters of all the species delimited. For numbers and localities of the individuals sampled, see Table 1. A set of 16 quantitative and 2 qualitative characters was chosen on the basis of published determination keys and floras (e.g. Kutzelnigg 1995, Meyer et al. 2005, Rich et al. 2010), including those used in our previous studies (Lepší et al. 2008, 2009, Vít et al. 2012). The characters are: AT – angle of the lamina top, AB – angle of the laminar base, AV – angle between the third lateral vein from the laminar base and the midrib, A3L – angle of the tooth in which the 3rd lateral vein terminates, FL – length of fruit, FW – width of fruit, INC – depth of the incision between the 2nd and the 3rd lateral vein from the laminar base, LL – length of lamina, LL/LW – lamina length/width ratio, LW – width of lamina, NL – number of lenticels per 25 mm^2 of fruit, NT3L – number of teeth between the 2nd and 3rd lateral vein, NV – number of lateral laminar veins, PET – length of petiole, PL – length of petals, PW – width of petals, WP – the distance along the main nerve from the laminar base to the widest laminar width, WP/LL – ratio of the distance along the main nerve from the laminar base to the widest laminar width/length of lamina. Only well developed, mature and intact leaves from the centre of short sterile shoots were

Table 1. – Locality details of populations of *Sorbus* subg. *Aria* included in morphometric analyses.

Taxon	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Number of individuals analysed
S. aria	Czech Republic/Austria – Podyjí and Thayatal National Parks, Dyje/Thaya river valley around Hardegg	48°51'20"N, 15°51'40"E	330–540	20
S. collina	Czech Republic, Bohemian Karst, Beroun, SE of the town	49°55'40"N, 14°07'40"E	350–380	10
S. collina	Czech Republic, Horní Povltaví region, valley of Vltava and Sázava rivers around Štechovice	49°49'50"N, 14°27'20"E	250–400	10
S. cucullifera	Czech Republic/Austria – Podyjí and Thayatal National Parks, Dyje/Thaya river valley around Hardegg	48°51'20"N, 15°51'40"E	310–390	20
S. danubialis	Czech Republic, Moravian Karst, Blansko, E–NE of the town	49°21'60"N, 16°42'50"E	400–500	20
S. moravica	Czech Republic, Moravian Karst, Blansko, Suchý žleb gorge	49°21'40"N, 16°42'50"E	400–490	20
S. pontis-satani	Czech Republic, Moravian Karst, Blansko, Suchý žleb gorge	49°21'40"N, 16°42'50"E	410–470	17
S. thayensis	Czech Republic/Austria – Podyjí and Thayatal National Parks, Dyje/Thaya river valley around Hardegg	48°51'20"N, 15°51'40"E	310–440	20

collected, flattened, dried and scanned at 300 dpi using Epson scan 1.11E software, and then measured using tpsDig software (Rohlf 2006). Reproductive organs (fruit, flowers) were analysed separately and used only for separating triploid species because characters of leaves overlapped considerably within this group. Flowers were measured manually using a stereo zoom microscope and fruit using a digital vernier calliper.

One measurement of each character per individual was recorded and used as the value for the individual in all morphometric analyses. Non-parametric Pearson correlation coefficients were calculated for pairs of characters of each species and for the whole dataset in order to reveal relationships among characters. Principal component analyses (PCA) were performed to provide an insight into the overall pattern of morphological variation and to reveal potential separation of the ploidy groups analysed. Prior to the PCA, the data were log-transformed and standardized to have a zero mean and unit standard deviation.

Linear discrimination analyses (LDA), which maximize differences between a priori defined groups (cytotypes and species characterized by SSR patterns, Vít et al., in prep.), were used to test the discriminating power of morphometric characters, following the methodology described by Lepš & Šmilauer (2003) using forward selection of characters with non-parametric Monte Carlo permutation tests (999 permutations; only axes with P-level < 0.05 were considered). A cross-validated classificatory linear discriminant analysis based on probabilities using only characters selected as discriminating variables by the previous analysis was performed in R version 2.12.2 (R Development Core Team 2011) using the "lda" function in the MASS package (Venables & Ripley 2002). PCA and LDA were carried out using CANOCO (Lepš & Šmilauer 2003). Univariate statistics

Table 2. – Overall results of flow cytometric analyses of all taxa of *Sorbus* subg. *Aria* delimited in this study. *Bellis perennis* was used as the internal standard.

Taxon	*S. aria*	*S. cucullifera*	*S. moravica*	*S. pannonica*	*S. pontis-satani*	*S. collina*	*S. danubialis*	*S. thayensis*
Number of individuals analysed	53	26	8	5	6	45	51	13
Average sample:standard ratio	0.37	0.56	0.56	0.55	0.56	0.75	0.75	0.74
Average coefficient of variation of the sample	3.65	2.87	2.55	3.17	2.39	2.69	2.66	2.73
Average coefficient of variation of the standard	1.82	1.54	1.66	1.57	1.68	1.99	1.83	1.61
Estimated DNA ploidy level	2n~2x	2n~3x	2n~3x	2n~3x	2n~3x	2n~4x	2n~4x	2n~4x

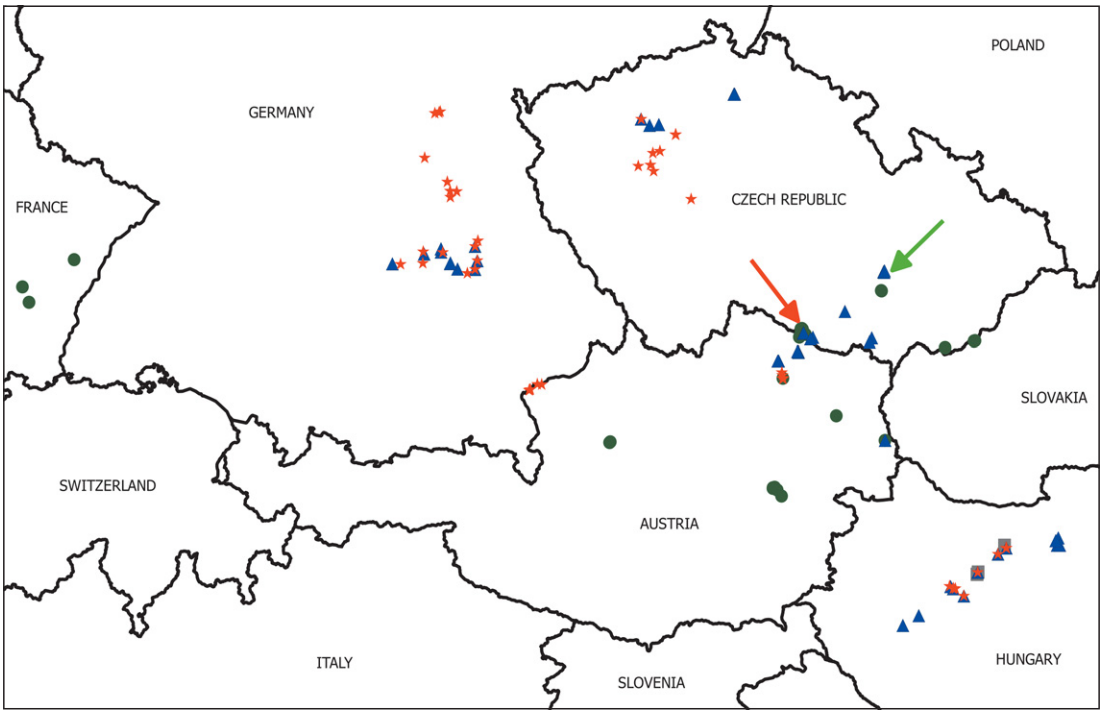


Fig. 1. – Map showing the distribution of the localities of members of *Sorbus* subg. *Aria* sampled for this study. ▲ *S. danubialis*, ● *S. aria*, ★ *S. collina*, ■ *S. pannonica*, → *S. cucullifera* and *S. thayensis*, → *S. moravica* and *S. pontis-satani*.

(minimum, maximum, quartiles) of quantitative characters of all individuals were calculated and used in the description of the species.

DNA ploidy level estimation

DAPI flow cytometry was used to assess DNA ploidy levels (Suda et al. 2006) of members of the subg. *Aria*. Bulked samples from 207 individuals were analysed (i.e. up to four

individuals simultaneously) following the methodology described in Lepší et al. (2008). *Bellis perennis* L. (2C=3.38 pg; Schönswetter et al. 2007) was used as the internal standard. The numbers of individuals per species are summarized in Table 2. The general distribution of cytotypes is apparent from the map in Fig. 1, and locality details are given in Appendix 1.

Results

Based on extensive field observations and a detailed investigation of herbarium material, we delimited seven taxa within the subg. *Aria* in the Czech Republic. Results of flow cytometry and morphometric analyses are congruent with each other and support this taxonomic solution.

Ploidy level

The DAPI flow cytometry screening revealed that there are diploids, triploids and tetraploids in subg. *Aria* in the Czech Republic. The diploid level is represented by a single taxon, and triploids and tetraploids each comprise three taxa (see Table 2 for details). Null intraspecific variation was detected.

Morphometric analyses

No highly correlated characters ($r > |0.95|$) were found and all characters were used in the multivariate analyses. PCA of leaf characters indicated a certain level of morphological differentiation between diploids and polyploids. In addition, diploids turned out to be morphologically more variable than polyploids (Fig. 2). Tetraploids and triploids overlapped considerably when 36 individuals of 12 predominantly singular triploids, which we do not treat taxonomically here, were included in the analyses (data not shown). PCAs of individuals delimited here as species (i.e. without singular triploids) revealed that triploids and tetraploids are morphologically different (Fig. 2). The characters contributing most to the morphological distinctiveness of triploids and tetraploids (i.e. the most tightly correlated characters with the first component axis) were: angle of laminar base (AB), ratio length of lamina/width of lamina (LL/LW), angle between the third lateral vein from the laminar base and the midrib (AV), width of lamina (LW) and angle of lamina top (AT). The most strongly correlated characters with the second component axis, which separated diploids from polyploids, were: length of lamina (LL), number of lateral laminar veins (NV), number of teeth between the 2nd and 3rd lateral vein (NT3L) and width of lamina (LW). The subsequent LDA also showed these three groups to be morphologically distinct. No overlap of the canonical scores of diploids and triploids was detected. Both diploids and triploids overlapped slightly with tetraploids (Fig. 3). The forward selection procedure identified 8 characters with a significant conditional effect – length of lamina (LL), width of lamina (LW), angle between the third lateral vein from the laminar base and the midrib (AV), number of teeth between the 2nd and 3rd lateral vein (NT3L), number of lateral laminar veins (NV), length of petiole (PET), angle of laminar base (AB) and ratio of the distance along the main nerve from the laminar base to the widest laminar width/length of lamina (WP/LL); all characters had significant marginal effects

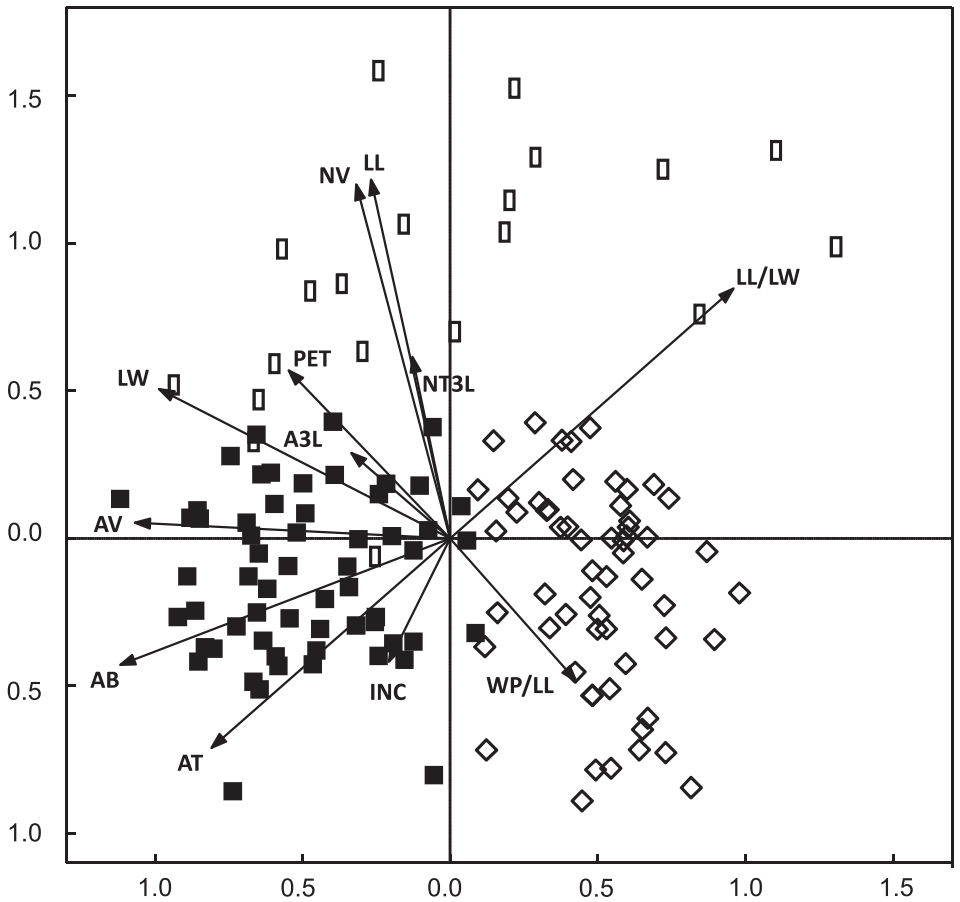


Fig. 2. – Results of the principal component analysis based on twelve morphological characters of leaves of the three ploidy groups of *Sorbus* subg. *Aria*: ▯ diploids; ◇ triploids; ■ tetraploids. The first and second ordination axes are displayed. These explain 30.3% and 22.3% of the overall variation, respectively. Individually occurring triploids, which are not treated taxonomically here, were excluded from this analysis. For abbreviation of characters, see the Material and methods.

(Table 3). The classificatory discriminant analysis resulted in an incorrect classification only in three out of a total of 140 cases (2.1%; Table 4).

The LDA of the three triploid taxa showed that the two sympatrically occurring species, *S. moravica* and *S. pontis-satani*, are clearly separated along the first discriminant axes and that they can be distinguished primarily using the number of lateral laminar veins (NV), the angle of the tooth in which the 3rd lateral vein terminates (A3L) and the length of lamina (LL), characters that have higher values in *S. moravica*. The morphological separation of *S. cucullifera* from the remaining triploids is not so clear. This species falls between the other two species and overlaps somewhat with both of them (Fig. 4). However, *S. cucullifera* differs in fruit and flower morphology, as confirmed by a separate LDA (Table 3). This species has fewer lenticels on fruits (NL) and smaller petals (PL, PW).

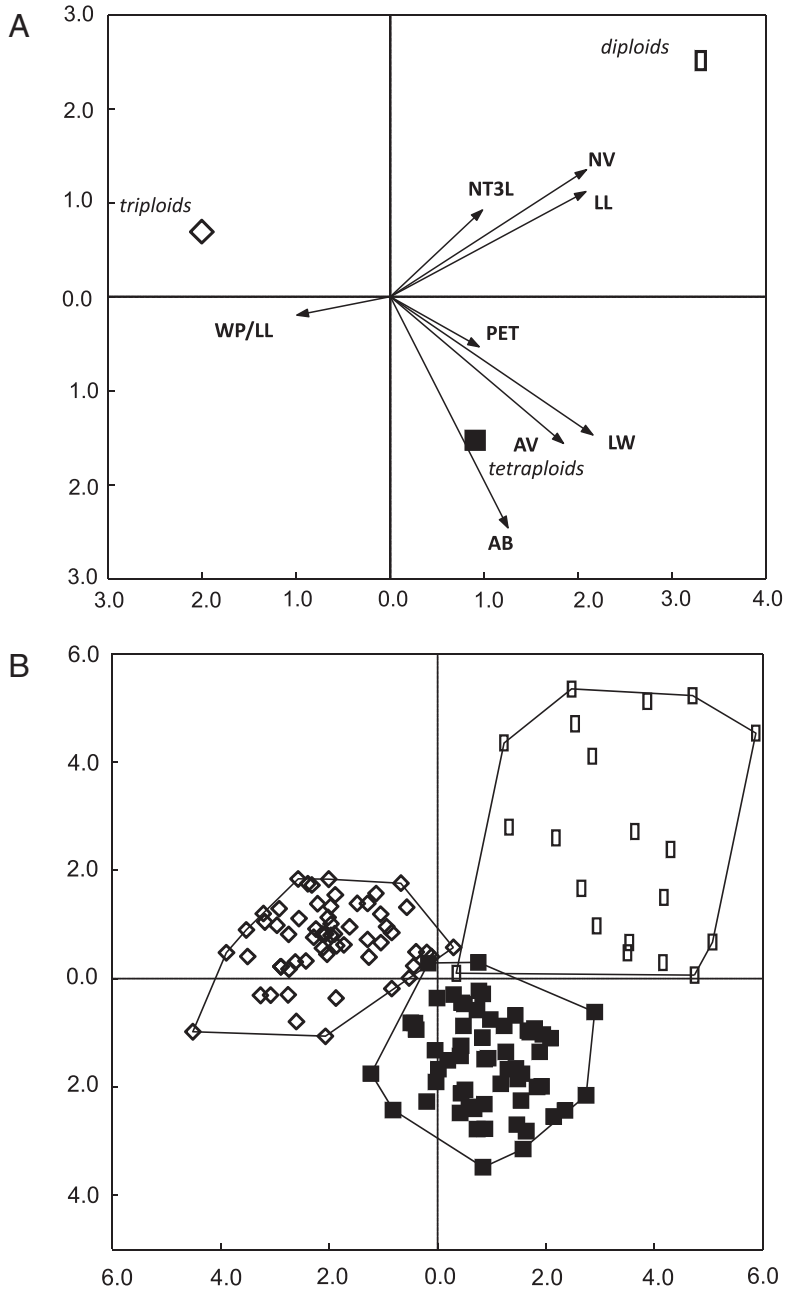


Fig. 3. – Results of the linear discriminant analysis based on 8 morphological characters of leaves of the three ploidy groups of *Sorbus* subg. *Aria*. The characters were selected in a forward selection procedure, and only characters with significant discriminating power for separating the three ploidy groups were used. The first and second canonical axes are displayed, and explain 39.2% and 33.9% of the variation, respectively. The top diagram (A) shows the discriminating characters and centroids of classes and the bottom one (B) the canonical scores of individual plants on the first two discriminating axes. For abbreviation of characters, see the Material and methods.

Table 3. – Morphological characters of cytotypes of *Sorbus* subg. *Aria* with a significant conditional effect (i.e. the effect of the variable in addition to other variables already included in the model) in forward selection of four separate linear discriminant analyses: (i) leaf characters of all cytotypes (diploid, triploid, tetraploid), (ii) leaf characters of triploid taxa (*S. cucullifera*, *S. moravica*, *S. pontis-satani*), (iii) reproductive characters of triploid taxa and (iv) leaf characters of tetraploids taxa (*S. danubialis*, *S. collina*, *S. thayensis*). Individuals were used as OTUs in all LDAs. Significance was tested using the Monte Carlo permutation test (999 permutations). λ – eigenvalue, i.e. discriminant force of a particular character, P – significance level (conditional effect), marg. – characters with significant marginal effects (i.e. the effect of the variable when alone in the model) are given. The contributions of characters to the ordination axes for particular analyses are depicted in Figs 3B, 4B and 5B.

	All			Triploids			Triploids reproductive organs			Tetraploids	
Character	λ	P		λ	P		λ	P		λ	P
LL	0.6	0.001	NV	0.77	0.001	NL	0.78	0.001	AT	0.74	0.001
LW	0.54	0.001	A3L	0.33	0.001	PL	0.37	0.001	LL	0.69	0.001
AV	0.2	0.001	LL	0.13	0.002	PW	0.08	0.031	PET	0.13	0.001
NT3L	0.05	0.001	WP/LL	0.08	0.006	-	-	-	AB	0.06	0.001
NV	0.03	0.023	LL/LW	0.06	0.01	-	-	-	LL/LW	0.05	0.001
PET	0.02	0.005	NT3L	0.04	0.044	-	-	-	NT3L	0.03	0.007
AB	0.02	0.036	-	-	-	-	-	-	NV	0.02	0.015
WP/LL	0.01	0.04	-	-	-	-	-	-	AV	0.02	0.041
marg.: all			marg.: all			marg.: all except for FL			marg.: all except for WP/LL, NV		

Table 4. – Results of cross-validated linear discriminant analyses using only morphological characters selected as discriminating variables in the forward selection procedure (see Table 3). Four separate analyses were conducted: (i) leaf characters of all cytotypes (diploid, triploid, tetraploid), (ii) leaf characters of triploid taxa (*Sorbus cucullifera*, *S. moravica*, *S. pontis-satani*), (iii) reproductive characters of triploid taxa and (iv) leaf characters of tetraploids taxa (*S. danubialis*, *S. collina*, *S. thayensis*).

All				Triploids				Reproductive organs of triploids				Tetraploids			
	Diploids	Triploids	Tetraploids		*S. cucullifera*	*S. moravica*	*S. pontis-satani*		*S. cucullifera*	*S. moravica*	*S. pontis-satani*		*S. danubialis*	*S. collina*	*S. thayensis*
Diploids	19	1	0	*S. cucullifera*	18	1	1	*S. cucullifera*	15	0	0	*S. danubialis*	20	0	0
Triploids	0	59	1	*S. moravica*	2	18	0	*S. moravica*	1	12	2	*S. collina*	0	20	0
Tetraploids	0	1	59	*S. pontis-satani*	1	0	19	*S. pontis-satani*	0	3	12	*S. thayensis*	0	0	20
Total			140				60				45				60

Moreover, the range in the most distinctive character, the number of lenticels (NL) does not overlap with the ranges in either of the other two species, *S. moravica* or *S. pontis-satani* (see the descriptions of these species). The results of the classificatory discriminant analysis of all three triploid taxa were similar to those of the LDA: incorrect classification was detected in five out of a total of 60 cases (8.3%) in terms of leaf characters and in six out of a total of 45 (13.3%) cases in fruit and flower characters (Table 4).

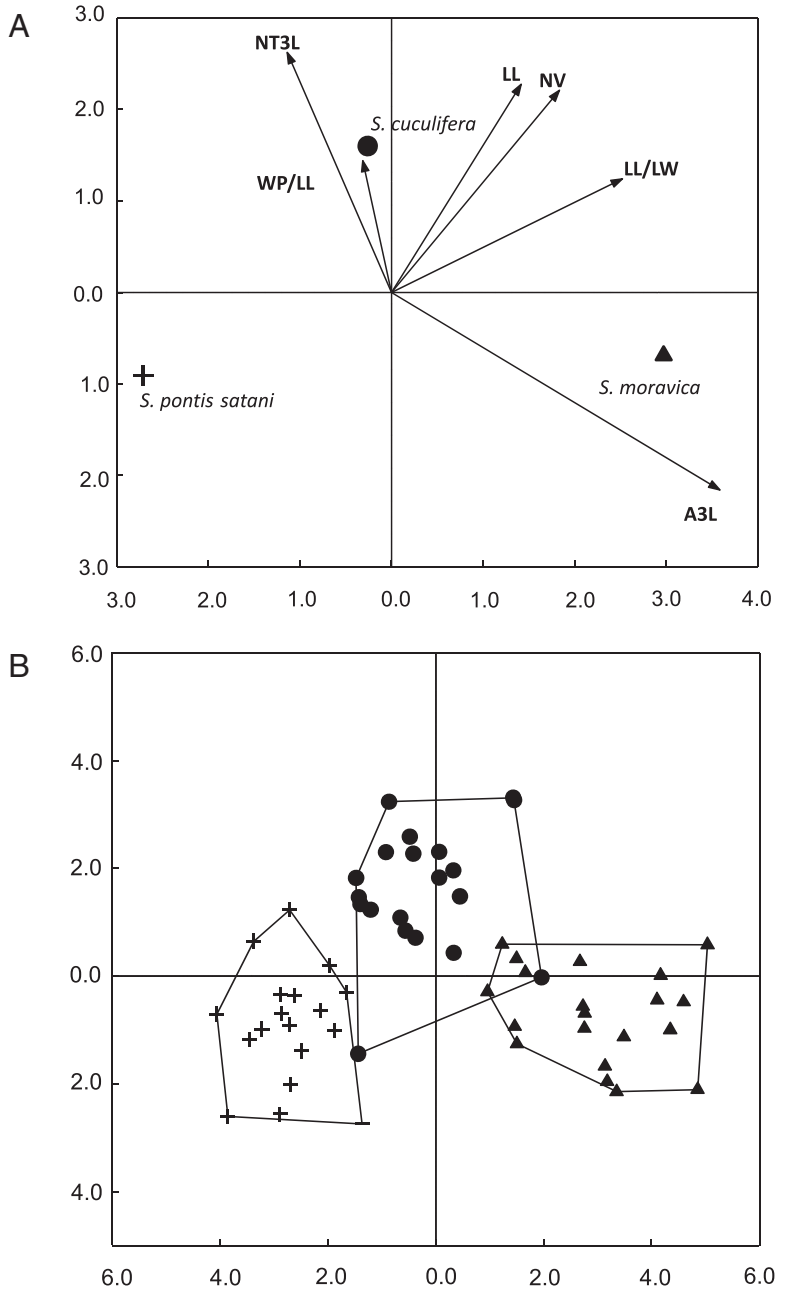


Fig. 4. – Results of the linear discriminant analysis based on 6 morphological characters of leaves of the three triploid taxa of *Sorbus* subg. *Aria*. The characters were selected in a forward selection procedure, and only those that were significantly different and could be used to distinguish the three taxa were used. The first and second canonical axes are displayed, and explain 42.2% and 28.2% of the variation, respectively. The top diagram (A) shows the discriminating characters and centroids of classes and the bottom one (B) canonical scores of individual plants on the first two discriminating axes. For abbreviation of characters, see the Material and methods.

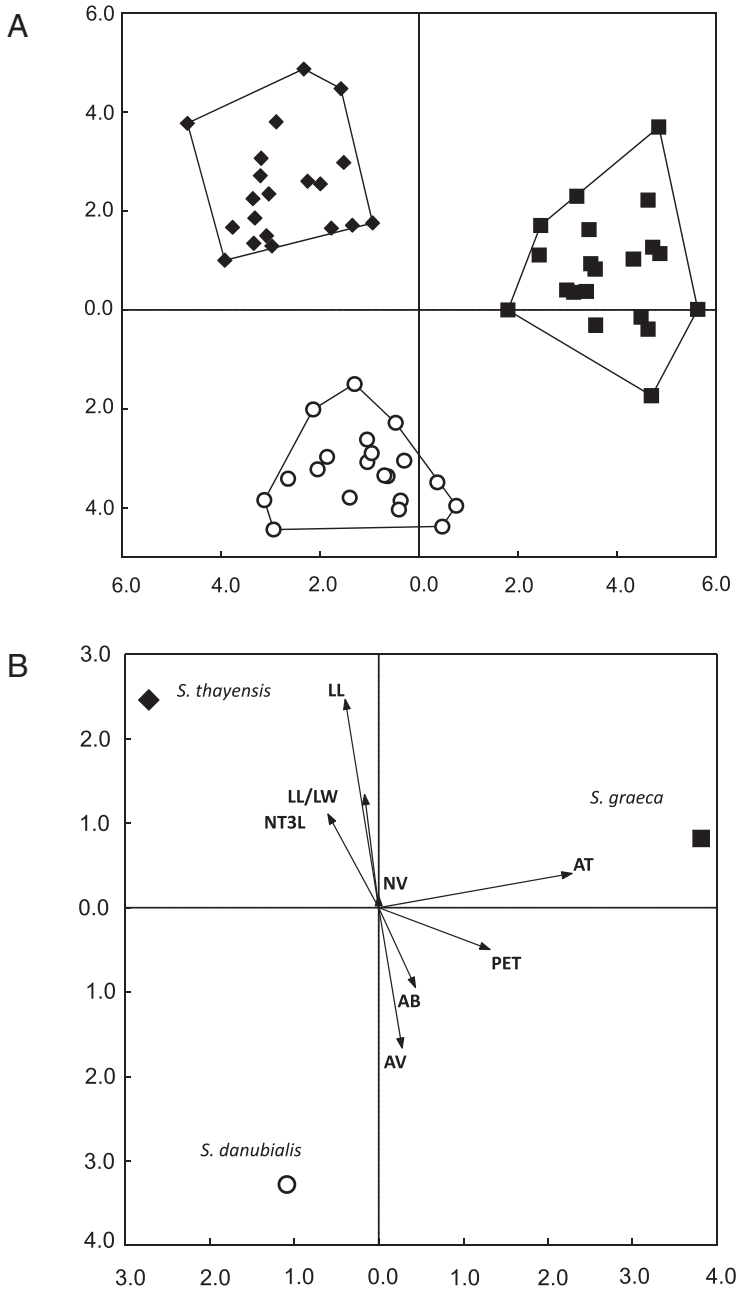


Fig. 5. – Results of the linear discriminant analysis based on 8 morphological characters of leaves of three tetraploid taxa of *Sorbus* subg. *Aria*. The characters were selected in a forward selection procedure, and only those that were significantly different and could be used to distinguish the three taxa were used. The first and second canonical axes are displayed, and explain 44.3% and 42.7% of the variation, respectively. The top diagram (A) shows the discriminating characters and centroids of classes and the bottom one (B) the canonical scores of individual plants on the first two discriminating axes. For abbreviation of characters, see the Material and methods.

The LDA of the three delimited tetraploid taxa (*S. collina*, *S. danubialis*, *S. thayensis*) confirmed their clear morphological separation. No overlap of the canonical scores of the species was detected (Fig. 5, Table 3). The classificatory discriminant analysis using these characters resulted in correct classification in all cases (Table 4).

Discussion and taxonomic treatment

Results of all biosystematic methods employed in this study are congruent with results of SSR analyses, which are part of a broader study on genetic variation in the genus *Sorbus* and will be published elsewhere (Vít et al., in prep.). With respect to the present study, all taxa described below possess different genotypes and are clearly separated.

Diploid species

Diploid members of the subg. *Aria* are relatively rare in the Czech Republic. We detected their occurrence only in three regions of Moravia (Fig. 1). They occur scattered in the Podyjí National Park between the towns of Znojmo and Vranov nad Dyjí, very rarely on the Moravian Karst near the city of Brno, and rarely in the Bílé Karpaty Mts near the villages of Javorník and Starý Hrozenkov. The populations analysed were both morphologically (Figs 2, 3) and genetically (Vít et al., in prep.) very diverse even at the same sites, and this feature combined with their ploidy level confirms the finding that these diploid plants belong to the amphimictic *S. aria* s. str.

This taxon is known to be an extremely variable and sexually reproducing diploid species (Liljefors 1953, 1955, Robertson et al. 2010, Feulner et al. 2013) distributed in central and southern Europe from Spain to the Balkans with outlying localities along the Black Sea coast and in northern Africa (Meusel et al. 1965). *Sorbus aria* is also cultivated for ornamental purposes and reported as a naturalized alien species in many European countries (Lepší et al. 2013b).

Sorbus aria s. str. has been reported as a native species in several areas of the Czech Republic with the alleged centre of its distribution in Bohemia (Kovanda 1992, 2002, Kutzelnigg 1995). Our results, however, do not support this claim. We show that all Bohemian members of the subg. *Aria* are tetraploids and that *S. collina*, a common species of warm and rocky areas of Bohemia (newly described below), has been mistaken for the diploid *S. aria* s. str. The only region where *S. aria* is native in the Czech Republic is Moravia. However, some other records from Moravia may also be dubious, such as the record from the valley of the river Jihlava (Kutzelnigg 1995), which probably actually refer to *S. danubialis*, the only member of the subg. *Aria* known to us in this area. Localities of *S. aria* in the Podyjí National Park and on the Moravský Karst appear as exclaves – they are isolated from each other and from the continuous distribution areas in the Alpine and Carpathian regions, where the species is rather common. The localities in Bílé Karpaty Mts lie probably at the western border of a scattered distribution of this species in Slovakia. All Moravian populations are small except in the Podyjí National Park. It should be added that *S. aria* can occasionally be found in the wild in Bohemia, but they are plants that have escaped from cultivation (e.g. Liberec, Mladá Boleslav, Mcely, Klecany, Nové Hrady).

In the past, the exceptional variability of *S. aria* was overestimated or improperly understood. Many taxa were recognized at the specific and lower levels (Kárpáti 1960), but considering the continuous and reticulate morphological variation in the structure of these taxa, their delimitation is of little if any value. On the other hand, underestimating the range of morphological variation in these species has lead to several other misidentifications. For example, some individuals of *S. aria* from the Podyjí National Park (Czech Republic) were mistakenly determined as *S. austriaca* and *S. carpatica* because of their lobed or conspicuously double serrate leaves (Kovanda 1996, 1997b, 2002). These two transitional taxa between the subg. *Aria* and subg. *Sorbus* were described from Austria and Slovakia, respectively, and do not, to our knowledge occur naturally in the Czech Republic. In addition, *S. austriaca* was recently found to be tetraploid (M. Lepší & P. Lepší, unpublished data).

In addition to their ploidy level, a conspicuous feature that distinguishes *S. aria* from polyploid members of the subgenus is the considerable variation in fruit and leaf morphology that is recorded in every population. Polyploids, by contrast, are morphologically uniform due to prevailing apomixis. There is no universal morphological character that would allow a clear separation of *S. aria* from polyploids within the whole of Europe, but its determination is mostly possible at the regional level. For example, Czech polyploids differ from the dominant morphotype of *S. aria* in having smaller and leathery leaves with fewer veins, while the common features of most individuals of *S. aria* in the Czech Republic are relatively large, thin and elliptic to longish leaves with many veins. However, there are rare individuals that do not fit this pattern and cannot be identified without establishing their ploidy levels (e.g. in the Podyjí National Park). In addition to Moravia, we confirmed the occurrence of *S. aria* in France and Austria (Fig. 1, Appendix 1).

In some regions, the exceptional morphological variability of *S. aria* causes problems with distinguishing this species from polyploids, which in some cases is quite impossible without testing for polyploidy (see Rich et al. 2010), the Czech Republic being no exception (Figs 2, 3). This fact may have some bearing on the nomenclature of this species because its type specimen comes from a tree of unknown origin and ploidy level that was cultivated in G. Clifford's garden in Holland in the 18th century. Despite the fact that the type specimen corresponds morphologically quite well to diploid morphotypes, which are recently uniformly called *S. aria* in Europe, we consider it advisable to select an interpretative epitype of known ploidy from a wild population. In this way, we hope to stabilize the nomenclature of this species in the future.

Sorbus aria (Linnaeus) Crantz, Stirp. Austr. 2: 46, 1763. (Fig. 6)

Basionym: *Crataegus aria* L., Sp. Pl. 1: 475, 1753.
≡ *Mespilus aria* (L.) Scop., Fl. Carniol., ed. 2, 1: 345, 1771.
≡ *Pyrus aria* (L.) Ehrh., Beitr. Naturk. 4: 26, 1789.
≡ *Hahnia aria* (L.) Medik., Geschich. Bot. 81, 1793.
≡ *Azarolus aria* (L.) Borkh., Handb. Forstbot. 2: 1229, 1803.
= *Aria nivea* Host, Fl. Austriac. 2: 8, 1831.

Lectotype: Hortus Cliffordianus 187, BM, No. 000628615, designated by Aldasoro et al. (2004).

E p i t y p e: Lower Austria, Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 m SE of bridge over Dyje river, pine forest with *Sesleria*; 390 m a.s.l., 48°51'4.1"N, 15°51'52.16"E; scattered; tree ca 7 m high; 12. 9. 2011 leg. M. Lepší, P. Lepší; 2n ~ 2x – DNA ploidy level was determined using the flow cytometer Partec PA II

(DAPI fluorochrome); ratio with the internal standard (*Bellis perennis* L.) is 0.375; Analysed 19. 9. 2011, Department of Botany, University of South Bohemia, Č. Budějovice (**epitype designated here:** CB, No. 79814, Fig. 6).

Names previously used for this taxon in the Czech Republic: *Sorbus austriaca* sensu Kovanda, Acta Mus. Morav., Sci. Nat. 81: 202, 1997 p.p.; sensu Kovanda, Klíč ke květeně ČR: 385, 2002 p.p. – *S. carpatica* sensu Kovanda, Verh. Zool.-Bot. Ges. Österreich 133: 360 p. p; sensu Kovanda, Klíč ke květeně ČR: 385, 2002 p.p.

D e s c r i p t i o n: Small tree or shrub up to 12 m high. Bark grey to dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, glabrous to sparsely tomentose when young, glabrous or glabrescent when mature, with pale brown to ochraceous lenticels. Buds turbinate or ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas elliptical to broadly elliptical, oblong elliptical, ovate to oblong ovate, (9.6–) 11.5–12.7 (–15.6) cm long and (5.0–) 6.3–7.8 (–8.4) cm wide, (1.4–) 1.5–2.1 (–2.5) times as long as wide, widest at (43–) 49–54 (–64)% of the lamina length (from the base), with broadly acute, acute to acuminate apex with angle (70–) 85–115 (–135)°, cuneate to broadly cuneate and partly serrate at base, with angle of base (50–) 70–95 (–115)°, usually flat at margins, regularly finely to coarsely simply or double (to triple) serrate or dentate, or deeply serrate to shallowly lobed, with broadly acute, acute or acuminate teeth terminating the main veins (other teeth somewhat smaller), with (6–) 9–12 (–16) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins of (50–) 60–85 (–95)°, with incision between the 2nd and the 3rd main vein from the base of (0.7–) 1.6–3.0 (–5.6) mm, thin, more or less glossy, pale or dark green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (8–) 11–12 (–13) veins on each side, with the 3rd vein at an angle of (20–) 30–40 (–45)° to midrib; petioles (11–) 14–18 (–20) mm long, tomentose. Leaf laminas on short fertile shoots similar in shape and size. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acute or acuminate, tomentose on both surfaces, patent or reclinate at flowering, erect, persistent and dry at fruiting. Petals (5.0–) 6.5–7.5 (–8.5) mm long and (3.8–) 5.0–6.0 (–6.5) mm wide, broadly elliptical to rotund, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow. Ovary semi-inferior. Styles 2 (–3), free or connate and tomentose at base. Fruit ellipsoid to subglobose, (11.5–) 12.5–14.5 (–16.0) mm long and (9.0–)11.5–13.5(–15.0) mm wide, red to dark red, rarely orange-red when ripe, tomentose at top and base, otherwise glabrescent, glossy, with (1–) 4–9 (–23) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: diploid (inferred using FCM). Reproduction sexual. Flowering V.

D i a g n o s t i c c h a r a c t e r s: Individuals in every population are very variable in their fruit and leaf morphology, with almost every individual morphologically unique. Common characters of most Czech plants of this species are relatively thin, large and elliptical to oblong elliptical leaves with relatively many veins on short sterile shoots.

Triploid species

Triploids occur in two Moravian regions in the Czech Republic (Fig. 1). We revealed three morphologically (Fig. 4) and genetically (Vít et al., in prep.) distinct lineages: one

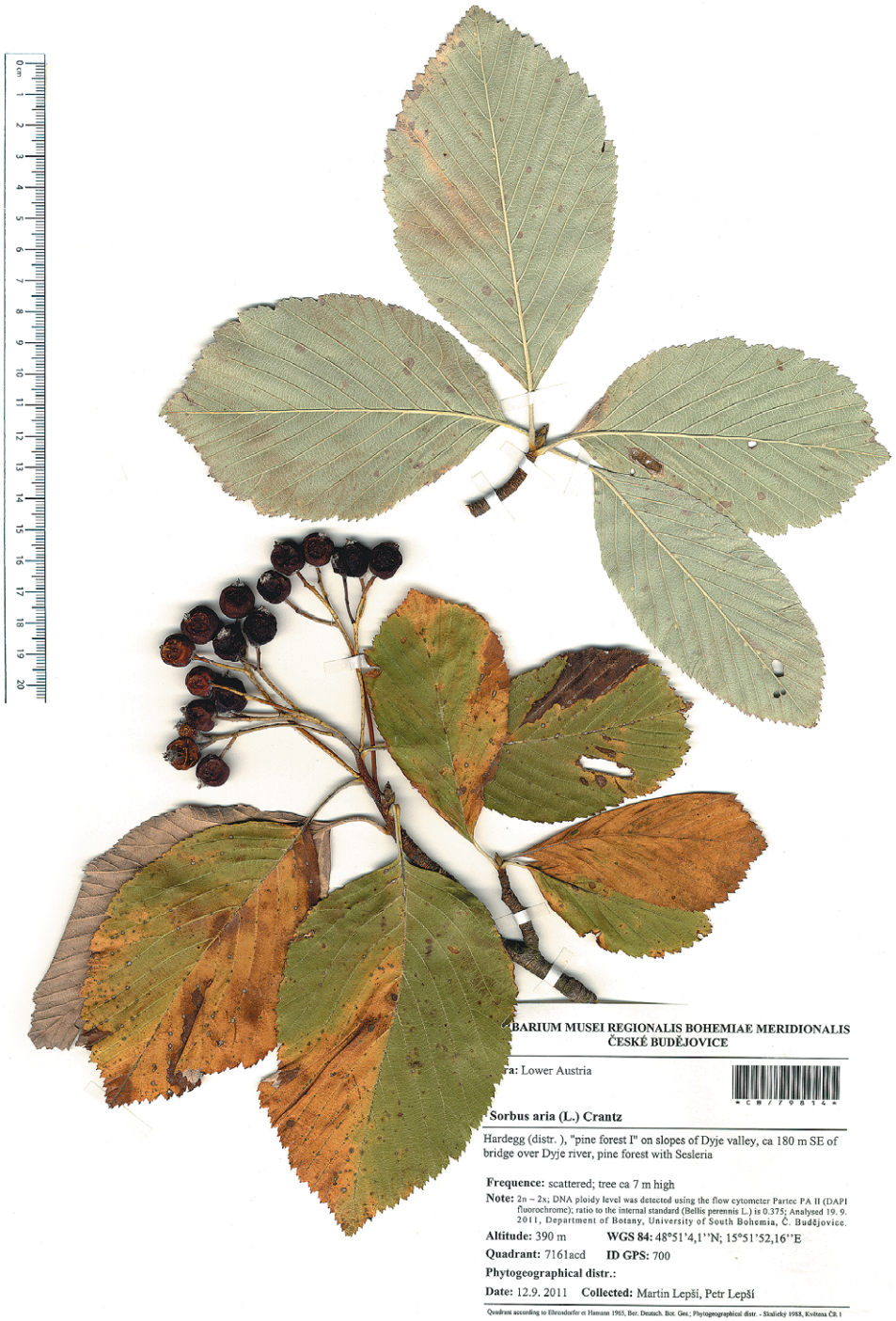


Fig. 6. – Epitype of *Sorbus aria.*

in the Podyjí National Park and two on the Moravian Karst. Below, we describe each of these lineages as a separate species because they are morphologically and genetically uniform, and exhibit all the characteristics of apomictic species. In addition, we detected about 40 triploid individuals in the Podyjí National Park and four on the Moravian Karst associated with the three taxa delimited but clearly differing from them in their morphology and genetic structure (Vít et al., in prep.). Because these triploids occurr usually as single or very rare individuals and do not form significant populations, we do not treat them as separate species. We suppose that they are products of hybridization between tetraploid *S. danubialis* and diploid *S. aria* or in the Podyjí National Park the tetraploid parent might be also *S. thayensis*. This hypothesis is probably valid at least in the case of the Podyjí National Park, where the supposed parental species are present. The situation on the Moravian Karst is not so clear, because *S. aria* does not occurr in this area, and only tetraploid *S. danubialis* and two triploid species are found there. The four triploid individuals might either be the results of former hybridizations between *S. aria* and *S. danubialis* when *S. aria* occurred at this locality, or may be the descendants of crosses between *S. danubialis* and the two triploid species. The third, but less probable, option is that these taxa could have originated somewhere else and later spread by birds or other agents to this locality. A similar scenario applies to the origin of the two triploid species described below, *S. moravica* and *S. pontis-satani*. They could have either evolved at this locality as a result of hybridization between *S. aria* and *S. danubialis* in the past, or less likely, reached there by dispersal.

The first record of the occurrence of subg. *Aria* triploids in the Czech Republic is for the Podyjí National Park (Šefl 2007). The author assigned these plants to *S. subdanubialis* (Soó) Kárpáti, a transitional taxon between *S. aria* and *S. danubialis* described from Hungary. However, *S. subdanubialis* differs from the triploids in the Podyjí National Park in having longer triangular leaf apices, fewer teeth between the 2nd and 3rd main veins from the base and coarsely serrate leaf margins (cf. Kárpáti 1960, Király 2009).

Sorbus cucullifera M. Lepší et P. Lepší, **spec. nova** (Figs 7–8)

D e s c r i p t i o n: Shrub or rarely small tree up to 12 m high. Bark grey or dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple, when in the sun held more or less upright and overlapping each other; laminas more or less (broadly) elliptical to obovate, (7.2–) 8.4–8.9 (–10.5) cm long and (4.7–) 5.0–5.5 (–6.2) cm wide, (1.5–) 1.6–1.7 (–1.8) times as long as wide, widest at (51–) 54–60 (–65)% of the lamina length (from the base), with acuminate apex with an angle of 100–115 (–125)°, cuneate and partly serrate at base, with angle of base (65–) 70–80 (–85)°, usually flat to slightly undulate margins, regularly, finely, double to triple serrate, with acute teeth terminating the main veins (other teeth somewhat smaller), with (7–) 9–10 (–12) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins (40–) 45–65 (–75)°, with incision between the 2nd and the 3rd main vein from the base (1.5–) 2.0–3.0 (–4.0) mm long, leathery, more or less



Fig. 7. – Holotype of *Sorbus cucullifera*.



Fig. 8. – *Sorbus cucullifera*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

matt, pale green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (8–) 9–10 (–11) veins on each side, with the 3rd vein at an angle of (20–) 25–35° to midrib; petioles (12–) 14–16 (–17) mm long, tomentose. Leaf laminas on short fertile shoots relatively broader, broadly elliptical and more distinctively undulate at margin. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acute or acuminate, tomentose on both surfaces, patent at flowering, erect, persistent and dry at fruiting. Petals (5.5–) 6.5–7.0 (–7.5) mm long and (4.2–) 5.0–5.5 (–6.2) mm wide, broadly ovate or broadly elliptical, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow or pale rose. Ovary semi-inferior. Styles 2, connate and tomentose at base. Fruit ellipsoid to almost subglobose, (11.0–) 12.0–13.0 (–13.5) mm long and 10.5–12.0 (–13.5) mm wide, never wider than long, red when ripe, tomentose at top and base, otherwise glabrescent, matt, with (1–) 3–4 (–7) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: triploid (inferred using FCM). Reproduction probably apomictic. Flowering V.

H o l o t y p e: southern Moravia, Čížov (distr. Znojmo), Dyje valley, Sloní hřbet ridge, ca 2.1 km SSE of chapel in village, on cliff; 340 m a.s.l., 48°51'39.53"N, 15°52'40.48"E; scattered; small trees ca 7 m high; 13. 6. 2011 leg. Martin Lepší, Petr Lepší; CB, No. 83095 (Fig. 7). – I s o t y p e s: PR, 83095/a; PRA, 83095/b; W, 83095/c.

Name previously used for this taxon in the Czech Republic: *Sorbus subdanubialis* sensu Šefl, Thayensia 7: 139, 2007 p.p.

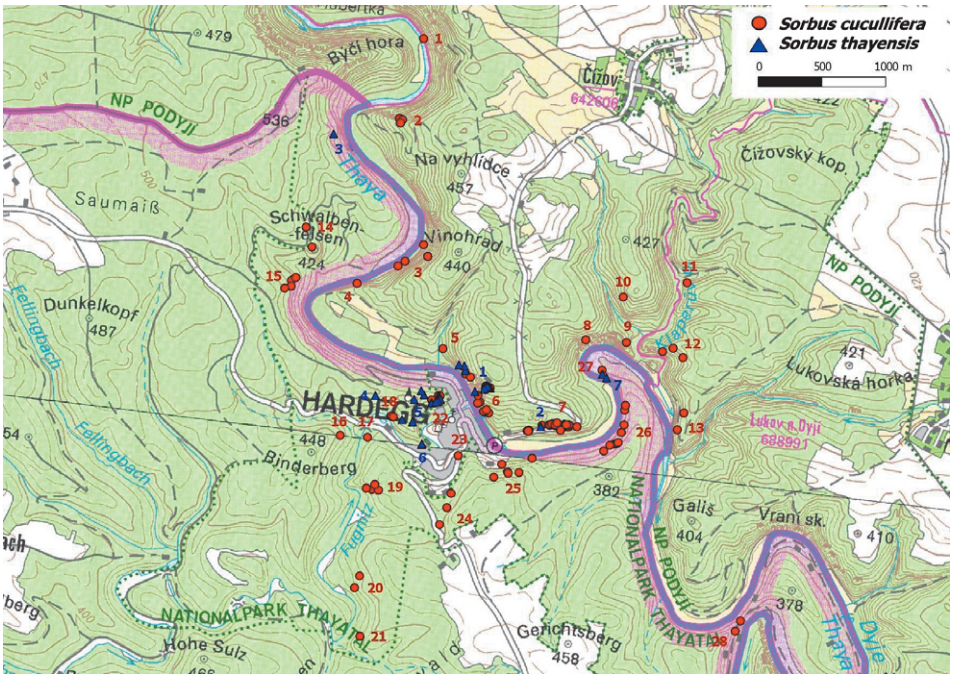


Fig. 9. – Map showing the distribution of *Sorbus cucullifera* and *S. thayensis* (map source © ČÚZK 2014).

D i a g n o s t i c c h a r a c t e r s: Leaf laminas on short sterile shoots more or less (broadly) elliptical to obovate, relatively small, regularly, finely, double (to triple) serrate. Flowers relatively small. Fruit ellipsoid to almost subglobose, never wider than long, red, only with (1–) 3–4 (–7) lenticels per 25 mm^2. Leaves on short sterile shoots of individuals at sunny sites are held more or less upright and overlap each other and therefore resemble a cornet.

E t y m o l o g y: The epithet "*cucullifera*" refers to the characteristic arrangement of leaves on short sterile shoots of individuals at sunny sites that resemble cornets (in Latin *cucullus*). We propose the name "kornoutolistý" for the Czech name.

E c o l o g y: *Sorbus cucullifera* is a light-demanding species that prefers open habitats such as forest-steppes, rocky steppes, shrubs, open thermophilous oak forests and their fringes. Less often it occurs in other types of open forests and also on rocks and screes. The species grows mainly on calcareous soils on limestone, but frequently also on acid bedrocks such as gneisses and schists. In phytosociologal terms, vegetation with common occurrence of *S. cucullifera* belongs to peri-Alpidic basiphilous thermophilous oak forests (*Quercion pubescenti-petraeae*), central-European thermophilous oak forests (*Quercion petraeae*), tall xeric scrub (*Berberidion*), narrow-leaved continental dry grasslands (*Festucion valesiacae*) and vegetation of dry herbaceous forest fringes (*Geranion sanguinei*). Less often, this species is recorded in vegetation in oak-hornbeam forests (*Carpinion*), ravine forests (*Tilio-Acerion*), rock pine forests (*Dicrano-Pinion*), peri-Alpidic basiphilous pine forests (*Erico-Pinion*), acidophilous oak forests (*Genisto germanicae-Quercion*), and low xeric scrub (*Prunion spinosae*).

Distribution and population size: *Sorbus cucullifera* was recorded at 28 localities in the wide surroundings of the town Hardegg, which is located on the border between Lower Austria and southern Moravia (Czech Republic). This species occurs in the valley of the river Dyje and that of its tributary, Fugnitz. Along with *S. aria* it is the most abundant species in the subg. *Aria* in this area. The distance between the two most remote localities, which are Umlaufberg hill (Austria) in the south and Pašerácká stezka trail (Czech Republic) in the north, is almost 5.4 km (Fig. 9). The total number of individuals is estimated to be around 150 in the Czech Republic and 300 in Austria. Some populations consist of about 40 or more individuals (localities 6, 7, 19, 26). *Sorbus cucullifera* is recorded in two quadrants (7161a and 7161c) of the central-European mapping grid (Ehrendorfer & Hamann 1965). All localities are situated in a moderately warm climatic region (Quitt 1971) with a mean annual temperature of about 8–9 °C and mean annual precipitation of 450–500 mm (Tolasz et al. 2007). Czech localities are in the supracolline vegetation belt (Chytrý 2012) in the phytogeographical district of Moravské podhůří Vysočiny (Skalický 1988). The altitudinal range of this species spans from 300 (near Pašerácká stezka trail, Czech Republic) to 420 m a.s.l. (Schwalbenfelsen cliff, Austria).

Herbarium specimens

Czech Republic, southern Moravia, 68. Moravské podhůří Vysočiny, 7161a: 1. Pašerácká stezka path: Čížov village, Dyje valley, Pašerácká stezka path, ca 1.7 km WNW of chapel in village, acidophilous oak forest, shrub ca 5 m high, 48°52'50.9"N, 15°51'00.4"E, 330 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79750). **2. Na Vyhlídce hill:** Čížov village, slopes on left-hand bank of Dyje river, ca 400 m W of summit Na Vyhlídce hill, a gap in Pine wood, two juvenile plants, 48°52'29.0"N, 15°50'55.4"E, 400 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74000). – Čížov village, Dyje valley, NW slopes of Na Vyhlídce hill, ca 1.8 km WSW of chapel in village, edge of scree and scree forest, rare, tree ca 2 m high, 48°52'30.1"N, 15°50'54.7"E, 380 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79762). – Čížov village, Dyje valley, NW slopes of Na Vyhlídce hill, ca 1.8 km WSW of chapel in village, rocky acidophilous oak forest, rare, tree ca 2 m high, 48°52'29.9"N, 15°50'56.0"E, 390 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79764). – Čížov village, Dyje valley, NW slopes of Na Vyhlídce hill, ca 1.8 km WSW of chapel in village, gap in acidophilous oak forest, rare, shrub ca 1.5 m high, 48°52'28.9"N, 15°50'55.3"E, 390 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79763). **3. Vinohrad hill I:** Čížov village, Dyje valley, NW slopes of Vinohrad hill, ca 2 km SW of chapel in village, oak-hornbeam forest on steep slope, tree ca 4 m high, 48°51'59.1"N, 15°51'09.6"E, 360 [315] m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79766). – Čížov village, Dyje valley, NW slopes of Vinohrad hill, ca 2.3 km SW of chapel in village, steep woody slope, ca 3 m high, 48°51'52.9"N, 15°51'00.8"E, 300 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79767). – Čížov village, slopes above Dyje river between Vinohrad hill and Ledové sluje chasm, oak forest, 48°51'54.4"N, 15°51'03.3"E, 350 [330] m a.s.l. (leg. ML et PL 5. 8. 2009, CB 73719). – Čížov village, slopes above Dyje river between Vinohrad hill and Ledové sluje chasm, oak forest, 48°51'56.3"N, 15°51'11.7"E, 360 m a.s.l. (leg. ML et PL 5. 8. 2009, CB 73744–73745). **4. Vinohrad hill II:** Čížov village, Dyje valley, NW slopes of Vinohrad hill, ca 2.6 km SW of chapel in village, acidophilous oak forest with abundant *Pinus sylvestris*, only two individuals, ca 6 m high, 48°51'47.4"N, 15°50'46.0"E, 310 m a.s.l. (leg. ML et PL 8. 5. 2011, CB 79768). **5. Hardeggská vyhlídka outlook I:** Čížov village, Dyje valley, ca 0.5 km SE of summit of Vinohrad hill, pine-oak forest, tree ca 5 m high, 48°51'33.5"N, 15°51'21.7"E, 330 m a.s.l. (leg. ML 21. 8. 2011, CB 79613). **6. Hardeggská vyhlídka outlook II:** Čížov village, slopes with rocks and scree below Hardeggská vyhlídka outlook, ca 0.5 km NE of centre of Hardegg, 48°51'19.4"N, 15°51'41.0"E, 340 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73673). – Čížov village, slopes with rocks and scree below Hardeggská vyhlídka outlook, ca 0.5 km NE of centre of Hardegg, 48°51'24.9"N, 15°51'41.5"E, 390 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73672). – Čížov village, Hardeggská vyhlídka outlook, ca 260 m NNW of bridge over Dyje river, edge of oak forest and steppe, scattered, shrub ca 3 m high, 48°51'18.6"N, 15°51'42.1"E, 330 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79675). – Čížov village, Hardeggská vyhlídka outlook, ca 280 m NNW of bridge over Dyje river, forest-steppe, scattered, tree ca 3 m high, 48°51'18.8"N, 15°51'40.4"E, 310 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79847). – Čížov village, Hardeggská vyhlídka outlook, ca 280 m NNW of bridge over Dyje river, rocky forest-steppe, scattered, tree ca 3.5 m high, 48°51'18.9"N, 15°51'40.0"E, 310 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79693). – Čížov village,

Hardeggská vyhlídka outlook, ca 350 m NNW of bridge over Dyje river, limestone cliff, shrub ca 2 m high, 48°51'20.8"N, 15°51'37.4"E, 350 [315] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79687). – Čížov village, Hardeggská vyhlídka outlook, ca 360 m NNW of bridge over Dyje river, scattered, 48°51'21.1"N, 15°51'38.2"E, 360 [340] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79692, CB 79846). – Čížov village, Hardeggská vyhlídka outlook, ca 410 m NNW of bridge over Dyje river, rocky forest-steppe, scattered, shrub ca 4 m high, 48°51'22.8"N, 15°51'37.2"E, 340 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79689). – Čížov village, Hardeggská vyhlídka outlook, ca 450 m NNW of bridge over Dyje river, scree, shrub ca 3 m high, 48°51'24.5"N, 15°51'39.7"E, 390 m a.s.l. (leg. ML et PL 10. 9. 2011, CB 79806). – Čížov village, Hardeggská vyhlídka outlook, ca 470 m NNW of bridge over Dyje river, scree, shrub ca 7 m high, 48°51'25.4"N, 15°51'39.7"E, 380 m a.s.l. (leg. ML et PL 14. 5. 2011, CB 79849). – Čížov village, Hardeggská vyhlídka outlook, ca 470 m NNW of bridge over Dyje river, oak forest on cliff, shrub ca 3.5 m high, 48°51'25.3"N, 15°51'40.2"E, 400 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79683). – Čížov village, Hardeggská vyhlídka outlook, ca 560 m NNW of bridge over Dyje river, rocky forest-steppe, rare, shrub ca 2 m high, 48°51'27.1"N, 15°51'33.5"E, 380 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79678). – Čížov village, Hardeggská vyhlídka outlook, ca 600 m NNW of bridge over Dyje river, pine forest on acidophilous rock, shrub ca 1 m high, 48°51'27.8"N, 15°51'31.5"E, 340 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79690). **7. Hardeggská stráň hillside:** Čížov village, limestone NE of custom house (leg. B. Trávníček 20. 6. 1991, OL 26154, 26155, 26157). – Čížov village, calcareous slopes above Dyje river ca 400 [560] m SE of the 417 m a.s.l. spot height with Hardeggská vyhlídka outlook, above road to Hardegg, edge of shrubs and steppe, 1 individual ca 2.5 m high, 48°51'17.8"N, 15°52'06.6"E, 350 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74004). – Čížov village, calcareous slopes above Dyje river ca 500 [600] m SE of spot height of 417 m with Hardeggská vyhlídka outlook, above road to Hardegg, steppe, scaterred, 48°51'17.6"N, 15°52'08.1"E, 350 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74017). – Čížov village, calcareous slopes above Dyje river ca 500 [600] m SE of spot height of 417 m with Hardeggská vyhlídka outlook, above road to Hardegg, steppe, scaterred, 48°51'17.8"N, 15°52'08.5"E, 350 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74018). – Čížov village, slopes above Dyje river ca 0.5 to 0.9 km SE of Hardegg, open oak forests on southern slope, 48°51'15.3"N, 15°51'58.0"E, 340 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73696). – Čížov village, slopes above Dyje river ca 0.5 to 0.9 km SE of Hardegg, open oak forests on southern slope, 48°51'17.6"N, 15°52'07.9"E, 360 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73692). – Čížov village, slopes above Dyje river ca 0.5 to 0.9 km SE of Hardegg, open oak forests on southern slope, 48°51'18.2"N, 15°52'08.6"E, 370 [350] m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73682). – Čížov village, Hardeggská stráň hillside, above road ca 300 m ENE of bridge over Dyje river, open forest, scattered, shrub ca 6 m high, 48°51'15.3"N, 15°51'57.6"E, 320 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79674). – Čížov village, Hardeggská stráň hillside, above road ca 600 m ENE of bridge over Dyje river, open thermophilous oak forest, plentiful, tree ca 5.5 m high, 48°51'18.0"N, 15°52'12.2"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79671). – Čížov village, Hardeggská stráň hillside, above road, ca 300 m ENE of bridge over Dyje river, open forest, scattered, shrub ca 6 m high, 48°51'15.5"N, 15°51'58.2"E, 320 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79673). – Čížov village, Hardeggská stráň hillside, above road, ca 400 m ENE of bridge over Dyje river, forest-steppe, plentiful, tree ca 3 m high, 48°51'17.2"N, 15°52'02.9"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79662). – Čížov village, Hardeggská stráň hillside, above road, ca 470 m ENE of bridge over Dyje river, forest-steppe, plentiful, 48°51'17.4"N, 15°52'05.9"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79666). – Čížov village, Hardeggská stráň hillside, above road, ca 500 m ENE of bridge over Dyje river, forest-steppe, plentiful, tree ca 2 m high, 48°51'17.5"N, 15°52'05.5"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79665). – Čížov village, Hardeggská stráň hillside, above road, ca 500 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 5 m high, 48°51'17.8"N, 15°52'06.8"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79667). – Čížov village, Hardeggská stráň hillside, above road, ca 500 m ENE of bridge over Dyje river, forest-steppe, plentiful, tree ca 3 m high, 48°51'17.6"N, 15°52'07.4"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79668). – Čížov village, Hardeggská stráň hillside, above road, ca 520 m ENE of bridge over Dyje river, forest-steppe, plentiful, ca 4 m high, 48°51'17.5"N, 15°52'08.3"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79669). – Čížov village, Hardeggská stráň hillside, above road, ca 530 m ENE of bridge over Dyje river, forest-steppe, scattered, shrub ca 3 m high, 48°51'17.4"N, 15°52'09.1"E, 360 [340] m a.s.l. (leg. ML et PL 14. 5. 2011, CB 79850). – Čížov village, Hardeggská stráň hillside, above road, ca 600 m ENE of bridge over Dyje river, forest-steppe, scattered, tree ca 6 m high, 48°51'18.0"N, 15°52'12.2"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79851). – Čížov village, Hardeggská stráň hillside, above road, ca 620 m ENE of bridge over Dyje river, forest-steppe, plentiful, tree ca 3.5 m high, 48°51'18.1"N, 15°52'13.3"E, 360 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79672). – Čížov village, Hardeggská stráň hillside, below road ca 550 m ENE of bridge over Dyje river, open oak forest, rare, shrub ca 4 m high, 48°51'16.4"N, 15°52'10.2"E, 320 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79659). – Čížov village, Hardeggská stráň hillside, below road ca 680 m ENE of bridge over Dyje river, forest-steppe, scattered, tree ca 5 m high, 48°51'17.8"N, 15°52'16.3"E, 310 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79848). – Čížov vil-

lage, Hardeggská stráň hillside, ca 520 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 4 m high, 48°51'17.6"N, 15°52'08.5"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79649). – Čížov village, Hardeggská stráň hillside, ca 530 m ENE of bridge over Dyje river, forest-steppe, scattered, 48°51'17.6"N, 15°52'08.5"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79722). – Čížov village, Hardeggská stráň hillside, ca 530 m ENE of bridge over Dyje river, forest-steppe, scattered, shrub ca 3.5 m high, 48°51'17.4"N, 15°52'09.1"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79721). – Čížov village, Hardeggská stráň hillside, ca 550 m ENE of bridge over Dyje river, forest-steppe, plentiful, 48°51'17.4"N, 15°52'09.5"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79647). – Čížov village, Hardeggská stráň hillside, ca 550 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub 4 m high, 48°51'17.6"N, 15°52'09.9"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79650). – Čížov village, Hardeggská stráň hillside, ca 550 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 3.5 m high, 48°51'17.7"N, 15°52'09.9"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79646). – Čížov village, Hardeggská stráň hillside, ca 550 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 4 m high, 48°51'17.7"N, 15°52'10.7"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79651). – Čížov village, Hardeggská stráň hillside, ca 550 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 4 m high, 48°51'17.6"N, 15°52'11.1"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79652). – Čížov village, Hardeggská stráň hillside, ca 570 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 4 m high, 48°51'18.0"N, 15°52'11.4"E, 360 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79653). – Čížov village, Hardeggská stráň hillside, ca 600 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 5 m high, 48°51'17.9"N, 15°52'11.7"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79654). – Čížov village, Hardeggská stráň hillside, ca 600 m ENE of bridge over Dyje river, forest-steppe, plentiful, shrub ca 3.5 m high, 48°51'17.6"N, 15°52'12.4"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79655). – Čížov village, Hardeggská stráň hillside, ca 600 m ENE of bridge over Dyje river, open oak forest, plentiful, shrub ca 5.5 m high, 48°51'17.6"N, 15°52'13.0"E, 350 m a.s.l. (leg. ML et PL 6. 5. 2011, CB 79656). – Podyjí region, slope above road from Hardegg to Čížov village, ca 400 m ENE of bridge over Dyje river, 48°51'16.2"N, 15°52'03.5"E (leg. J. Brabec 29. 5. 2012, CHEB). **8. Kozí stezky cliff I:** Čížov village, Dyje valley, Kozí stezky slopes, ca 2 km SSW of chapel in village, open forest on rocky slopes, rare, 48°51'39.9"N, 15°52'15.8"E, 360 m a.s.l. (leg. ML 22. 5. 2011, CB 79792). **9. Kozí stezky cliff II:** Čížov village, ca 2 km S of chapel in village, ridge between Dyje river and Klaperův potok brook, rocky oak forest, rare, shrub ca 5 m high, 48°51'40.5"N, 15°52'31.4"E, 350 m a.s.l. (leg. ML et PL 15. 6. 2012, CB 82893). **10. Mufloní kopec hill:** Čížov village, ca 1.6 km S of chapel in village, Mufloní kopec hill, edge of scree, rare, shrub ca 6 m high, 48°51'51.8"N, 15°52'28.2"E, 410 [380] m a.s.l. (leg. ML et PL 15. 6. 2012, CB 82892). **11. Urbanova cesta road:** Čížov village, ca 1.6 km SE of chapel in village, above Urbanova cesta road, oak-hornbeam forest, rare, tree ca 6 m high, 48°51'57.3"N, 15°52'51.9"E, 360 m a.s.l. (leg. ML et PL 15. 6. 2012, CB 82891). **12. Sloní hřbet hill:** Čížov village, S slopes ca 0.4 km N of confluence of Klaperův potok brook (leg. B. Trávníček 3. 9. 1992, OL 26177). – Čížov village, Dyje valley, Sloní hřbet ridge, ca 2.1 km SSE of chapel in village, edge of pine and oak-hornbeam forest, three individuals, shrub ca 7 m high, 48°51'38.3"N, 15°52'53.7"E, 360 m a.s.l. (leg. ML 22. 5. 2011, CB 79796). – Čížov village, Dyje valley, Sloní hřbet ridge, ca 2.1 km SSE of chapel in village, forest-steppe, scattered, shrub ca 3.5 m high, 48°51'40.4"N, 15°52'49.5"E, 360 m a.s.l. (leg. ML 22. 5. 2011, CB 79795). – Čížov village, on Sloní hřbet ridge, ca 2.2 km SSE of centre of village, forest-steppe, scattered, 48°51'39.3"N, 15°52'45.6"E, 330 m a.s.l. (leg. ML 3. 6. 2011, CB 79595). – Podyjí region, Čížov village, Sloní hřbet ridge, ca 1.4 km NE of bridge over Dyje river in Hardegg, 48°51'39.8"N, 15°52'40.3"E (leg. J. Brabec 29. 5. 2012, CHEB, leg. D. Abazid 29. 5. 2012, CHEB). **13. Mouth of Lukovský potok:** Čížov village, ca 2.8 [2.6] km SSE of centre of village, western steep slopes of spur between Dyje river and Lukovský potok brook, by a rock in oak-hornbeam forest, scattered, 48°51'24.4"N, 15°52'56.5"E, 330 m a.s.l. (leg. ML 3. 6. 2011, CB 79593). – Čížov village, ca 2.8 km SSE of centre of village, western steep slopes of spur between Dyje river and Lukovský potok brook, edge of oak-hornbeam forest and open patch, scattered, tree ca 5 m high, 48°51'20.1"N, 15°52'54.8"E, 330 m a.s.l. (leg. ML 3. 6. 2011, CB 79592).

Austria, Lower Austria: 14. Schwalbenfelsen hill I, 7161a: Hardegg, Dyje valley, Schwalbenfelsen cliff, ca 2.1 km NW of bridge over Dyje river, on cliff, ca 10 individuals, shrub ca 3 m high, 48°51'55.2"N, 15°50'27.1"E, 430 m a.s.l. (leg. ML et PL 15. 6. 2011, CB 79612). – Hardegg, Schwalbenfelsen in Dyje valley ca 2.2 km NW of bridge over Dyje river, on cliff in ravine forest, shrub ca 2.5 m high, 48°52'00.0"N, 15°50'24.0"E, 420 m a.s.l. (leg. ML 1. 6. 2012, CB 82853). **15. Schwalbenfelsen hill II, 7161a:** Hardegg, Dyje valley between Hardegg and Felling gamekeepers lodge, ca 2 km NW of bridge over Dyje river, oak-hornbeam forest on rock ridge, rare, tree ca 10 m high, 48°51'46.2"N, 15°50'20.9"E, 420 m a.s.l. (leg. ML et PL 15. 6. 2011, CB 79704). – Hardegg, Dyje valley, ca 2 km NW of bridge over Dyje river, oak-hornbeam forest, shaded tree ca 4 m high, 48°51'47.1"N, 15°50'22.4"E, 400 m a.s.l. (leg. ML et PL 25. 7. 2012, CB 82909). **16. Binderberg hill, 7161a:** Hardegg, Binderberg hill, ca 1.2 km W of bridge over Dyje river, slopes above

Fugnitz stream, acidophilous oak forest, tree ca 3 m high, 48°51'08.6"N, 15°50'46.4"E, 400 m a.s.l. (leg. ML et PL 13. 9. 2011, CB 79632). **17. Fugnitz brook I, 7161a:** Hardegg, W slopes of Fugnitz valley opposite Binderberg hill, ca 990 m W of bridge over Dyje river, edge of scree and *Fagus* and *Carpinus* forest, tree ca 6 m high, 48°51'08.9"N, 15°50'56.9"E, 340 m a.s.l. (leg. ML et PL 12. 6. 2011, CB 79731). **18. Above swimming pool, 7161a:** Hardegg, S slopes of Maxplateau hill above swimming pool, ca 830 m WNW of bridge over Dyje river, rock steppe, scattered, shrub ca 4 m high, 48°51'14.9"N, 15°51'04.9"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79770). – Hardegg, S slopes of Maxplateau hill above swimming pool, ca 830 m WNW of bridge over Dyje river, rocky forest-steppe, scattered, tree ca 3 m high, 48°51'14.8"N, 15°51'05.9"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79700). – Hardegg, S slopes of Maxplateau hill, above swimming pool, ca 800 m WNW of bridge over Dyje river, rock steppe, scattered, shrub 4.5 m high, 48°51'15.1"N, 15°51'05.1"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79643). **19. Fugnitz brook II, 7161c:** Hardegg, slopes of Fugnitz valley opposite Binderberg hill, ca 1 km SW of bridge over Dyje river, forest-steppe, scattered, shrub ca 3 m high, 48°50'56.0"N, 15°51'00.9"E, 400 m a.s.l. (leg. ML et PL 12. 6. 2011, CB 79730). **20. Fugnitz brook III, 7161c:** Hardegg, Kreuzmaiss, slopes above Fugnitz stream, ca 1.5 km SSW of bridge over Dyje river, shrubby edge of rock steppe, shrub ca 2.5 m high, 48°50'30.7"N, 15°50'58.7"E, 380 m a.s.l. (leg. ML et PL 9. 5. 2011, CB 79781). – Hardegg, slopes of Fugnitz valley ca 1.5 km SW of bridge over Dyje river, *Bromion*, tree ca 6 m high, 48°50'33.8"N, 15°51'00.1"E, 390 m a.s.l. (leg. ML et PL 9. 5. 2011, CB 79769). **21. Kreuzmaiss, 7161c:** Hardegg, Kreuzmaiss, slopes above Fugnitz stream, ca 1.8 km SSW of bridge over Dyje river, edge of cliff, shrub ca 1 m high, 48°50'18.7"N, 15°51'02.9"E, 380 m a.s.l. (leg. ML et PL 9. 5. 2011, CB 79779). **22. Maxplateau hill, 7161a:** Hardegg, Maxplateau hill, ca 550 [600] m NW of bridge over Dyje river, oak-hornbeam forest, tree ca 3 m high, 48°51'20.3"N, 15°51'19.7"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79639). – Hardegg, Maxplateau hill, ca 570 m NW of bridge over Dyje river, rocky forest-steppe, scattered, shrub ca 8 m high, 48°51'21.6"N, 15°51'22.1"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79702). – Hardegg, Maxplateau hill, ca 570 m NW of bridge over Dyje river, rock, tree ca 5 m high, 48°51'21.5"N, 15°51'22.8"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79701). **23. Hardegg East, 7161a:** Hardegg, ca 300 m SW of bridge over Dyje river, small rock above road, shrub ca 3 m high, 48°51'07.1"N, 15°51'32.3"E, 320 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79644). **24. Hardegg South, 7161c:** Hardegg, ca 500 m SW of bridge over Dyje river, mixed forest, several individuals, 48°50'57.3"N, 15°51'31.3"E, 380 m a.s.l. (leg. ML et PL 13. 9. 2011, CB 79631). – Hardegg, ca 600 m SW of bridge over Dyje river, *Pinus nigra* plantation on limestone, rare, tree ca 12 m high, 48°50'53.6"N, 15°51'30.4"E, 410 m a.s.l. (leg. ML et PL 13. 9. 2011, CB 79628). – Hardegg, ca 750 m SW of bridge over Dyje river, mixed forest, scattered, ca 6 m high, 48°50'49.1"N, 15°51'28.3"E, 420 m a.s.l. (leg. ML et PL 13. 9. 2011, CB 79629). **25. Hardegg above bridge, 7161a**: Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 m SE of bridge over Dyje river, pine forest with *Sesleria*, scattered, shrub ca 3 m high, 48°51'06.2"N, 15°51'49.4"E, 350 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79859). – Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 [230] m SE of bridge over Dyje river, pine forest with *Sesleria*, scattered, shrub ca 7 m high, 48°51'04.5"N, 15°51'51.9"E, 380 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79858). – Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 [250] m SE of bridge over Dyje river, pine forest with *Sesleria calcaria*, tree ca 5 m high, 48°51'04.1"N, 15°51'52.2"E, 390 m a.s.l. (leg. ML et PL 12. 9. 2011, CB 79813). – Hardegg, "pine forest II" on slopes of Dyje valley, ca 300 m SE of bridge over Dyje river, pine forest with *Sesleria*, scattered, shrub ca 6 m high, 48°51'04.6"N, 15°51'56.3"E, 400 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79860). – Hardegg, ca 250 m SSE of bridge over Dyje river, pine forest with *Anthericum*, tree ca 10 m high, 48°51'02.7"N, 15°51'46.9"E, 400 m a.s.l. (leg. ML 29. 5. 2012, CB 82833). – Hardegg, slopes above Dyje river, ca 320 m ESE of bridge over Dyje river, on rock in forest, tree ca 5 m high, 48°51'08.6"N, 15°52'00.6"E, 300 m a.s.l. (leg. ML et PL 12. 9. 2011, CB 79808). **26. Thayatalweg path, 7161a:** Hardegg, slopes above Dyje river ca 0.87 km E of bridge over Dyje river, cliff with dom. *Sesleria*, shrub ca 6 m high, 48°51'12.5"N, 15°52'27.6"E, 350 m a.s.l. (leg. ML 29. 5. 2012, CB 82841). – Hardegg, slopes above Dyje river ca 0.9 km ENE of bridge over Dyje river, oak-hornbeam forest, shrub ca 4 m high, 48°51'14.2"N, 15°52'29.7"E, 340 m a.s.l. (leg. ML 29. 5. 2012, CB 82840). – Hardegg, slopes above Dyje river ca 1 km ENE of bridge over Dyje river, cliff with dom. *Anthericum*, sapling ca 2 m high, 48°51'17.7"N, 15°52'33.5"E, 340 m a.s.l. (leg. ML 29. 5. 2012, CB 82838). – Hardegg, slopes above Dyje river ca 1.1 km ENE of bridge over Dyje river, edge of forest and rocky steppe, tree ca 5 m high, 48°51'19.7"N, 15°52'34.2"E, 320 m a.s.l. (leg. ML 29. 5. 2012, CB 82837). – Hardegg, slopes above Dyje river ca 1.1 km ENE of bridge over Dyje river, foot of cliff in oak-hornbeam forest, tree ca 8 m high, 48°51'23.4"N, 15°52'33.8"E, 330 m a.s.l. (leg. ML 29. 5. 2012, CB 82836). – Hardegg, slopes above Dyje river ca 1.1 km ENE of bridge over Dyje river, cliff with *Sesleria*, tree ca 5 m high, 48°51'24.7"N, 15°52'33.9"E, 330 m a.s.l. (leg. ML 29. 5. 2012, CB 82835). – Hardegg, slopes above Dyje river, ca 0.9 km ENE of bridge over Dyje river, cliff in forest, scattered, tree ca 7 m high, 48°51'14.6"N, 15°52'31.4"E, 360 m a.s.l. (leg. ML et PL 9. 5. 2011, CB 79773). – Hardegg, slopes above Dyje river, ca 0.9 km ENE of bridge over

Dyje river, oak-hornbeam forest, scattered, tree ca 5 m high, 48°51'14.9"N, 15°52'32.4"E, 360 m a.s.l. (leg. ML et PL 9. 5. 2011, CB 79774). – Hardegg, slopes above Dyje river, ca 1 km NE of bridge over Dyje river, oak-hornbeam forest, tree ca 4 m high, 48°51'15.1"N, 15°52'32.8"E, 360 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79835). **27. Einsiedler, 7161a:** Hardegg, open woodland on right-hand bank of Dyje river (near tourist footpath), ca 1.5 km E of town (leg. B. Trávníček 25. 5. 1990, OL 26164). – Hardegg, slopes above Dyje river, ca 1 km NE of bridge over Dyje river, on rock, scattered, shrub ca 3.5 m high, 48°51'31.9"N, 15°52'23.5"E, 310 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79852). **28. Umlaufberg hill, 7161c:** Hardegg, Umlaufberg hill, acid rock, *Cotoneasteretum*, rarely, shrub ca 1.5 m high, 48°50'31.1"N, 15°53'25.9"E, 340 m a.s.l. (leg. ML 30. 5. 2012, CB 82846). – Hardegg, Umlaufberg hill, on cliff in oak forest, 48°50'33.8"N, 15°53'27.4"E, 320 m a.s.l. (leg. ML 30. 5. 2012, CB 82845).

Sorbus moravica M. Lepší et P. Lepší, **spec. nova** (Figs 10–11)

D e s c r i p t i o n: Shrub or small tree up to 12 m high. Bark grey or dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas elliptical to oblong elliptical, (7.0–) 8.1–9.2 (–10.4) cm long and (3.9–) 4.7–5.6 (–6.2) cm wide, (1.5–) 1.7–1.8 (–1.9) times as long as wide, widest at (50–) 53–56 (–59)% of the lamina length (from the base), with acute to acuminate apex with an angle of (75–) 100–110 (–125)°, cuneate and partly serrate at base, with angle at base (65–) 70–85 (–90)°, usually flat at margins, regularly, double to triple serrate, with acute teeth terminating the main veins (other teeth also acute but somewhat smaller), with (5–) 6–8 (–11) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins (60–) 70–90 (–100)°, with incision between the 2nd and the 3rd main vein from the base (1.4–) 1.9–2.6 (–3.3) mm long, leathery, more or less glossy, green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (8–) 9 (–10) veins on each side, with the 3rd veins at an angle of (20–) 25–35° to midrib; petioles (9–) 12–15 (–17) mm long, tomentose. Leaf laminas on short fertile shoots more or less the same size and shape as leaf laminas on short sterile shoots. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acute to acuminate, tomentose on both surfaces, patent or rarely bent to hypanthium at flowering, erect, persistent and dry at fruiting. Petals broadly ovate to broadly elliptical, (6.5–) 7.5–8.5 (–9.5) mm long and (5.0–) 6.0–6.5 (–7.0) mm wide, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow. Ovary semi-inferior. Styles 2 (–3), free and tomentose at base. Fruit more or less subglobose, (10.5–) 11.5–12.5 (–13.5) mm long and (10.5–) 11.5–12.5 (–13.5) mm wide, slightly wider than long or slightly longer than wide, red at maturity, tomentose at top and base, otherwise glabrescent, matt, with (10–) 13–18 (–24) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: triploid (inferred using FCM). Reproduction probably apomictic. Flowering V.

H o l o t y p e: southern Moravia, Lažánky (distr. Blansko), Suchý žleb gorge, S slopes, edge of forest and cliff; 440 m a.s.l., 49°21'46.55"N, 16°43'3.11"E; scattered; tree ca 8 m high; 22. 7. 2011 leg. Martin Lepší; CB, No. 79868 (Fig. 10). – I s o t y p e: PR, 79868/a.

Name previously used for this taxon in the Czech Republic: *Sorbus aria* sensu Kovanda, Acta Mus. Morav., Sci. Nat., 81: 196, 1997.



Fig. 10. – Holotype of *Sorbus moravica*.



Fig. 11. – *Sorbus moravica*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

D i a g n o s t i c c h a r a c t e r s: Leaf laminas on short sterile shoots are elliptical to oblong elliptical, regularly, double (to triple) serrate, with (5–) 6–8 (–11) teeth between the 2nd and 3rd main veins from the base. Fruit are more or less subglobose, slightly wider than long or slightly longer than wide, red.

E t y m o l o g y: The name "*moravica*" is derived from the Latin name of the Czech land Morava (Moravia), where the species occurs. We propose the epithet "moravský" for the Czech name.

E c o l o g y: *Sorbus moravica* is a light-demanding species that prefers sunny or at least partly open habitats such as cliffs, screes, ravines and steep woody or shrubby slopes of canyons in karst areas. Besides semi-natural to relic vegetation, it also grows in *Picea abies* and *Pinus nigra* plantations or in their clearings. This species occurs on calcareous, dry and shallow soils developed on limestone, and inhabits slopes of all aspects (most individuals were found on slopes facing south, northeast or northwest). This species was mainly recorded in a mixture of communities associated with cliffs and rocky slopes, i.e. in *Sesleria* grasslands (*Diantho lumnitzeri-Seslerion albicantis*), tall xeric scrubs (*Berberidion*), chasmophytic vegetation on calcareous cliffs and screes (*Cystopteridion*) and dry herbaceous fringes (*Geranion sanguinei*). It is also common in ravines, screes and rock forests (*Tilio-Acerion*) or in fringes and gaps in limestone beech forests (*Cephalanthero-Fagenion*). Rarely it was found in broad-leaved dry grasslands (*Bromion erecti*).

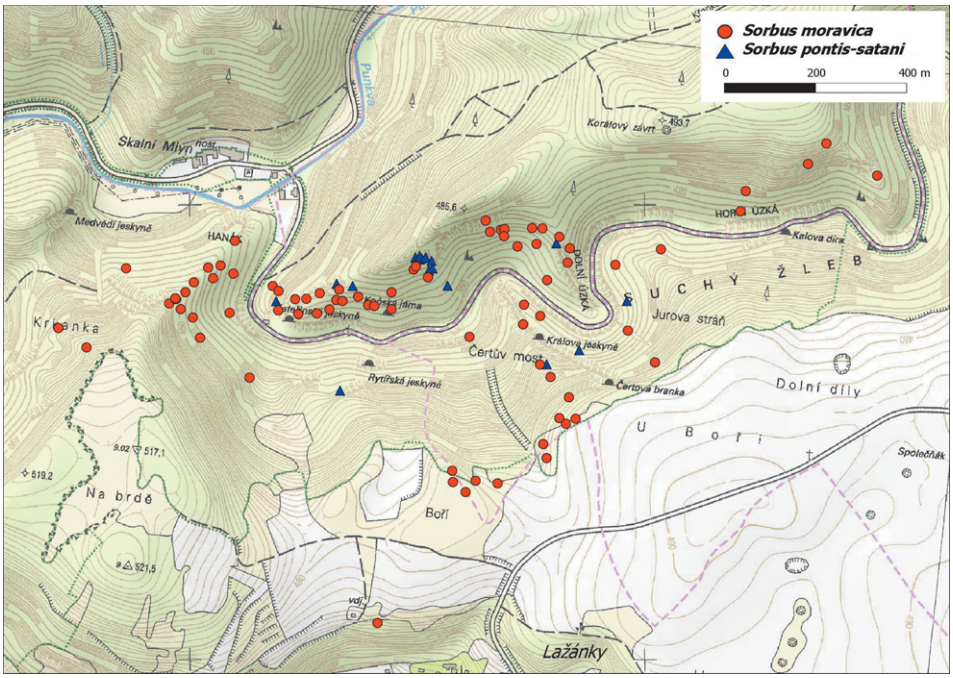


Fig. 12. – Map showing the distribution of *Sorbus pontis-satani* and *S. moravica* (map source © ČÚZK 2014).

Distribution and population size: *Sorbus moravica* is a stenoendemic in the Suchý Žleb gorge by the village of Lažánky (distr. Blansko) on the Moravian Karst (quadrant 6666a of the central-European grid mapping, Ehrendorfer & Hamann 1965). About 200 trees and shrubs are known in the western part of the gorge and the adjacent valley of the Punkva River. A few individuals also occur on the plateau between the gorge and Lažánky (Fig. 12). Most individuals are confined to southern slopes in the Suchý žleb gorge between the settlement of Skalní Mlýn and Chobot hill. Despite being locally abundant, it was not found in adjacent areas such as the Pustý žleb, Lažánecký žleb and Veselý žleb gorges and Punkevní údolí valley. It is even absent in the northern part of the Suchý žleb gorge where there are many suitable habitats. The altitudinal range of this species spans from 360 to 490 m a.s.l. In terms of Czech phytogeography and climatology, the distribution area is in the supracolline vegetation belt (Chytrý 2012), the phytogeographical district Moravian Karst (Skalický 1988) and a moderately warm climatic region (Quitt 1971) with a mean annual temperature of about 7–8 °C and mean annual precipitation of 550–600 mm (Tolasz et al. 2007).

Herbarium specimens

Czech Republic, southern Moravia, 70. Moravský kras, 6666a: Moravian Karst, Vilémovice, W of village (leg. K. Kubát 14. 7. 1980, LIT 1884/41878). – Moravian Karst, edge of arable field above village of Vilémovice (leg. Nováková 14. 7. 1980, MP). – Lažánky village, NE edge of village, fringe of *Pinus sylvestris* plantation, a tree ca 5 m high, 49°21'17.5"N, 16°42'50.9"E, 480 m a.s.l. (leg. ML 12. 5. 2012, CB 82950). – Lažánky village, N-facing slopes of Suchý žleb gorge, top of cliff in *Fagus* and *Picea* forest, rare, tree ca 8 m

high, 49°21'46.0"N, 16°43'17.3"E, 410 m a.s.l. (leg. ML 12. 5. 2012, CB 82953). – Lažánky village, N-facing slopes of Suchý žleb gorge, open *Picea abies* plantation, rare, tree ca 8 m high, 49°21'40.0"N, 16°43'14.6"E, 410 m a.s.l. (leg. ML 12. 5. 2012, CB 82958). – Lažánky village, N-facing slopes of Suchý žleb gorge, cliff with *Sesleria* in *Fagus* and *Picea* forest, rare, tree ca 4 m high, 49°21'33.9"N, 16°42'34.2"E, 430 m a.s.l. (leg. ML 12. 5. 2012, CB 82954). – Lažánky village, Skalní Mlýn mill, ca 200 m SSE of mill, bushy cliff, scattered, tree ca 6 m high, 49°21'43.5"N, 16°42'31.1"E, 410 m a.s.l. (leg. ML et PL 28. 8. 2011, CB 79909). – Lažánky village, Skalní Mlýn mill, ca 300 m SW of mill, edge of scree, tree ca 13 m high, 49°21'40.7"N, 16°42'19.6"E, 410 m a.s.l. (leg. ML et PL 28. 8. 2011, CB 79906). – Lažánky village, Skalní Mlýn mill, ca 500 m SW of mill, in beech forest with *Pinus sylvestris*, tree ca 15 m high, 49°21'34.8"N, 16°42'16.2"E, 480 m a.s.l. (leg. ML et PL 28. 8. 2011, CB 79900). – Lažánky village, Skalní Mlýn mill, ca 500 m SW of mill, pine forest with *Sesleria caerulea*, tree ca 5 m high, 49°21'35.9"N, 16°42'13.0"E, 470 m a.s.l. (leg. ML et PL 28. 8. 2011, CB 79902). – Lažánky village, Skalní Mlýn mill, rock ridge ca 300 m SSW of mill, on rock, scattered, tree ca 7 m high, 49°21'38.8"N, 16°42'25.4"E, 470 m a.s.l. (leg. ML et PL 28. 8. 2011, CB 79907). – Lažánky village, Suchý žleb gorge, N edge of gorge, clearing, tree ca 12 m high, 49°21'28.8"N, 16°42'57.2"E, 480 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82928). – Lažánky village, Suchý žleb gorge, N edge of gorge, *Pinus nigra* and *Pinus sylvestris* plantation, tree ca 6 m high, 49°21'28.2"N, 16°43'02.3"E, 480 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82927). – Lažánky village, Suchý žleb gorge, N edge of gorge, scrub at forest edge, tree ca 5 m high, 49°21'33.4"N, 16°43'09.9"E, 490 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82926). – Lažánky village, Suchý žleb gorge, N slopes, scrub in clearing, tree ca 8 m high, 49°21'37.9"N, 16°43'17.9"E, 480 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82925). – Lažánky village, Suchý žleb gorge, S slopes, bushy clearing, tree ca 3.5 m high, 49°21'54.8"N, 16°43'33.9"E, 480 m a.s.l. (leg. ML 22. 7. 2011, CB 79875). – Lažánky village, Suchý žleb gorge, S slopes, edge of *Pinus* plantation, scattered, a small tree, 49°21'53.2"N, 16°43'32.2"E, 480 m a.s.l. (leg. ML 22. 7. 2011, CB 79876). – Lažánky village, Suchý žleb gorge, S slopes, *Corylus* scrub, scattered, 49°21'45.4"N, 16°43'07.4"E, 420 m a.s.l. (leg. ML 27. 8. 2011, CB 79867). – Lažánky village, Suchý žleb gorge, S slopes, edge of forest and cliff, scattered, tree ca 8 m high, 49°21'46.5"N, 16°43'03.1"E, 440 m a.s.l. (leg. ML 22. 7. 2011, CB 79868). – Lažánky village, Suchý žleb gorge, S slopes, ravine forest with *Tilia*, tree ca 7 m high, 49°21'46.8"N, 16°42'57.9"E, 440 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79898). – Lažánky village, Suchý žleb gorge, S slopes, rock ridge with *Corylus* and steppe, shrub ca 4.5 m high, 49°21'46.2"N, 16°43'06.1"E, 440 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79899). – Lažánky village, Suchý žleb gorge, S slopes, gap in forest, shrub ca 4 m high, 49°21'50.8"N, 16°43'25.8"E, 460 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82923). – Lažánky village, Suchý žleb gorge, S slopes, beech forest on cliff, tree ca 3 m high, 49°21'44.4"N, 16°43'07.3"E, 410 m a.s.l. (leg. ML 27. 8. 2011, CB 79871). – Lažánky village, Suchý žleb gorge, S slopes, edge of basiphilous beech forest and cliff, scattered, tree ca 6 m high, 49°21'38.8"N, 16°42'36.5"E, 400 [360] m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79880). – Lažánky village, Suchý žleb gorge, S slopes, rock ridge, scattered, tree ca 6 m high, 49°21'39.8"N, 16°42'38.3"E, 400 [380] m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79881). – Lažánky village, Suchý žleb gorge, S slopes, bushy cliff, scattered, tree ca 4 m high, 49°21'39.9"N, 16°42'39.4"E, 410 [390] m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79883). – Lažánky village, Suchý žleb gorge, S slopes, cliff, scattered, tree ca 6 m high, 49°21'40.4"N, 16°42'40.8"E, 420 [390] m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79884). – Lažánky village, Suchý žleb gorge, S slopes, edge of limestone beech forest and rocky steppe, scattered, multi-trunk tree ca 7 m high, 49°21'40.8"N, 16°42'42.9"E, 430 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79886). – Lažánky village, Suchý žleb gorge, S slopes, edge of beech forest and scrub on scree, scattered, shrub ca 6 m high, 49°21'42.7"N, 16°42'50.7"E, 460 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79891).

Sorbus pontis-satani M. Lepší et P. Lepší, **spec. nova** (Figs 13–14)

D e s c r i p t i o n: Shrub or small tree up to 12 m high. Bark grey or dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas broadly elliptical, (5.8–) 6.5–7.8 (–8.8) cm long and (3.8–) 4.4–5.1 (–6.1) cm wide, (1.3–) 1.5–1.6 times as long as wide, widest at (50–) 54–57 (–61)% of the lamina length (from the base), with acute to acuminate apex with angle (100–) 110–125 (–140)°, cuneate and partly serrate at base, with angle at base of (70–) 75–85 (–95)°, usually undulate to



Fig. 13. – Holotype of *Sorbus pontis-satani*.

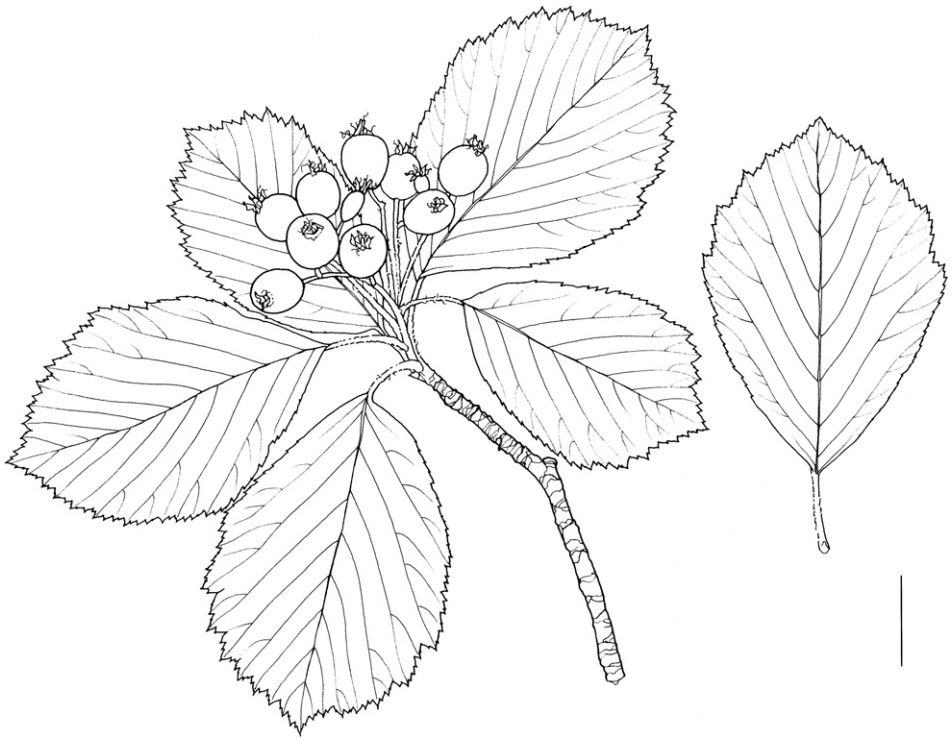


Fig. 14. – *Sorbus pontis-satani*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

crispate at margins apically, regularly, finely double to triple serrate, with acute teeth terminating the main veins (other teeth also acute but somewhat smaller), with (6–) 8–10 (–11) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins (35–) 45–55 (–65)°, with incision between the 2nd and the 3rd main vein from the base (2.1–) 2.7–3.5 (–5.0) mm long, leathery, more or less glossy, green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (7–) 8 (–9) veins on each side, with the 3rd veins at an angle of 25–30 (–35)° to midrib; petioles (9–) 10–14 (–17) mm long, tomentose. Leaf laminas on short fertile shoots relatively wider than leaf laminas on short sterile shoots. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acuminate, tomentose on both surfaces, patent or rarely bent to hypanthium at flowering, erect, persistent and dry at fruiting. Petals broadly elliptical, (5.5–) 7.0–8.2 (–8.5) mm long and (5.0–) 5.5–6.0 (–6.5) mm wide, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow. Ovary semi-inferior. Styles 2, free and tomentose at base. Fruit more or less subglobose, (7.0–) 11.0–12.5 (–13.5) mm long and (5.0–) 10.5–12.0 (–12.5) mm wide, slightly wider than long or slightly longer than wide, red when mature, tomentose at top and base, otherwise glabrescent, matt, with (2–) 7–10 (–16) lenticels per 25 mm^2;

mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: triploid (inferred using FCM). Reproduction probably apomictic. Flowering V.

H o l o t y p e: southern Moravia, Lažánky (distr. Blansko), S slope of Suchý žleb gorge, above entrance of Kateřinská jeskyně cave; 390 m a.s.l., 49°21'38.8"N, 16°42'33.9"E; rarely; shrub ca 5 m high; 16. 8. 2013 leg. Martin Lepší; CB, No. 83096 (Fig. 13). – I s o t y p e: PR, 83096/a.

Name previously used for this taxon in the Czech Republic: *Sorbus austriaca* sensu Kovanda, Acta Mus. Morav., Sci. Nat. 81: 201, 1997 p.p.

D i a g n o s t i c c h a r a c t e r s: Leaf laminas on short sterile shoots broadly elliptical, usually undulate to crispate at margins apically, regularly and finely double (to triple) serrate. Fruit more or less subglobose, slightly wider than long or slightly longer than wide, red.

E t y m o l o g y: The name "*pontis-satani*" relates to a natural bridge called Čertův most (Devil's bridge) in whose surroundings the species occurs. We propose the epithet "čertův" for the Czech name.

E c o l o g y: *Sorbus pontis-satani* appears to have very similar ecological demands as the sympatric species, *S. moravica*. It is a light-demanding, rupicolous and calcareous species that prefers semi-natural or relic vegetation on cliffs or their close surroundings, but rarely grows in open *Picea abies* plantations or man-made clearings. It was mostly recorded on south-facing and west-facing slopes, exceptionally also on slopes with a northern aspect. It occurs in vegetation consisting of tall xeric shrubs (*Berberidion*), *Sesleria* grasslands (*Diantho lumnitzeri-Seslerion albicantis*), ravine forests (*Tilio-Acerion*) and gaps in limestone beech forests and their fringes (*Cephalanthero-Fagenion*).

D i s t r i b u t i o n a n d p o p u l a t i o n s i z e: This species occurs in the Suchý žleb gorge by the village of Lažánky (distr. Blansko) on the Moravian Karst (quadrant 6666a; sensu Ehrendorfer & Hamann 1965). Most of the 30 known individuals of different ages occur mainly on south-facing slopes opposite the Čertův most natural bridge and are very rare on north-facing slopes (Fig. 12). The altitudinal range of this species spans from 380 to 450 m a.s.l. The phytogeographical and climatic data for the distribution of this species are the same as for *S. moravica*.

H e r b a r i u m s p e c i m e n s

Czech Republic, southern Moravia, 70. Moravský kras, 6666a: Lažánky village, N-facing slopes in Suchý žleb gorge, open *Picea abies* plantation, rare, tree ca 8 m high, 49°21'42.1"N, 16°43'14.2"E, 400 m a.s.l. (leg. ML 12. 5. 2012, CB 82959). – Lažánky village, N-facing slopes in Suchý žleb gorge, wooded rocky steep slopes, rare, 49°21'38.3"N, 16°43'09.6"E, 410 m a.s.l. (leg. ML 12. 5. 2012, CB 82956). – Lažánky village, N-facing slopes in Suchý žleb gorge, rocky slopes, rare, 49°21'33.7"N, 16°42'44.2"E, 440 m a.s.l. (leg. ML 12. 5. 2012, CB 82955). – Lažánky village, Suchý žleb gorge, N edge of gorge, cliff in clearing, tree ca 2 m high, 49°21'37.0"N, 16°43'05.8"E, 430 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82929). – Lažánky village, Suchý žleb gorge, S slopes, on cliff, scattered, tree ca 8 m high, 49°21'45.7"N, 16°43'05.9"E, 440 m a.s.l. (leg. ML 22. 7. 2011, CB 79869). – Lažánky village, Suchý žleb gorge, S slopes, shrub-steppe, 49°21'42.8"N, 16°42'52.4"E, 425 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82931). – Lažánky village, Suchý žleb gorge, S slopes, edge of forest and shrub, tree ca 4 m high, 49°21'43.5"N, 16°42'52.6"E, 425 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82930). – Lažánky village, Suchý žleb gorge, S slopes, forest-steppe, tree ca 6 m high, 49°21'43.6"N, 16°42'51.5"E, 460 m a.s.l. (leg. ML 22. 7. 2011, CB 79870). – Lažánky village, Suchý žleb gorge, S slopes, cliff, shrub ca 5 m high, 49°21'39.5"N, 16°42'36.3"E, 390 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79879). – Lažánky village, Suchý žleb gorge, S slopes, in beech forest, tree ca 3 m high, 49°21'41.2"N, 16°42'42.6"E, 420 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79887). – Lažánky village, Suchý žleb gorge, S slopes, thermophilous

shrubs, tree ca 3.5 m high, 49°21'41.1"N, 16°42'44.4"E, 440 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79888). – Lažánky village, Suchý žleb gorge, S slopes, on rock ridge, tree ca 6 m high, 49°21'43.3"N, 16°42'50.9"E, 470 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79892). – Lažánky village, Suchý žleb gorge, S slopes, edge of ravine forest, scattered, tree ca 5.5 m high, 49°21'43.6"N, 16°42'50.8"E, 470 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79893). – Lažánky village, Suchý žleb gorge, S slopes, edge of rocky forest-steppe, scattered, tree ca 7 m high, 49°21'43.8"N, 16°42'51.3"E, 470 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79894). – Lažánky village, Suchý žleb gorge, S slopes, gap in limestone beech forest, tree ca 5 m high, 49°21'43.5"N, 16°42'51.3"E, 470 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79895). – Lažánky village, Suchý žleb gorge, S slopes, gap in limestone beech forest, tree ca 7 m high, 49°21'43.7"N, 16°42'51.9"E, 460 m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79896). – Lažánky village, Suchý žleb gorge, S slopes, rocky forest-steppe, scattered, shrub ca 8 m high, 49°21'42.9"N, 16°42'52.8"E, 450 [420] m a.s.l. (leg. ML et PL 27. 8. 2011, CB 79897). – Lažánky village, Suchý žleb gorge, S slopes, in beech forest, tree ca 2 m high, shaded, 49°21'41.9"N, 16°42'54.6"E, 410 m a.s.l. (leg. ML et PL 26. 7. 2012, CB 82918).

Tetraploid species

According to our investigation, the most common ploidy level in the subg. *Aria* in the Czech Republic is tetraploid (Fig. 1). They occur in two separate regions. The first and larger area is situated in central and north-western Bohemia, and the second in southern Moravia. Tetraploids are usually confined to climatically warm regions and inhabit relic habitats such as cliffs and rocky slopes with steppe vegetation. Their local abundance closely depends on the presence and range of these habitats. Tetraploids seem to have played a crucial role in speciation of the Czech *Sorbus* by hybridising with diploid members of other subgenera giving rise to apomictic microspecies. Up until now, there are 13 hybridogenous miscrospecies in the Czech Republic (Danihelka et al. 2012, Lepší et al. 2013a), and each of them probably have genes of a tetraploid of the subg. *Aria* (e.g. Challice & Kovanda 1978, 1986).

Based on the results of our field investigation and morphological analyses, we distinguished three taxa among Czech tetraploids – two widespread species, *S. danubialis* and *S. collina*, and one stenoendemic, *S. thayensis*. The latter two species are for the first time described below as new taxa. *Sorbus danubialis* is a traditionally recognized and widely accepted species in central Europe (Kovanda 1992, Májovský 1992, Kutzelnigg 1995, Meyer et al. 2005, Fisher 2008, Király 2009, Kurtto 2009, Jäger 2011). To verify the classification of Czech plants treated as *S. danubialis*, we analysed the ploidy levels and morphology of four individuals from the type locality (Sas-hegy hill, Budapest, Hungary; Kováts 1998). All of them turned out to be tetraploid, and morphologically similar to Czech plants in PCA (data not shown).

In the Czech Republic, *S. danubialis* is reported from Bohemia and Moravia (Kovanda 1992, 2002), and our findings are mostly in accordance with this general knowledge. However, there are some erroneous records, which deserve closer attention because they were accepted in national compendia such as determination keys or the Red List of the Flora of the Czech Republic (Holub & Procházka 2000, Kovanda 2002). All records of *S. graeca* in the Czech Republic (Podyjí National Park and Moravian Karst) cited by Kovanda (1997a, 2002) apply in reality to untypical, round-leaved individuals of *S. danubialis*, and in a similar way, records of *S. austriaca* from the Moravian Karst (Kovanda 1997b) are partly based on misidentification of shaded individuals of *S. danubialis*. Other errors concern the ploidy level of the species. *Sorbus danubialis* is reported to be a diploid based on an analysis of plants from Hradiště hill in the Lounsko-Labské středohoří phytogeographical district (Jankun & Kovanda 1987, Kovanda 1992).

This region is located in Bohemia, where we did not find any diploid members of the subg. *Aria* (except several escaped plants of *S. aria*). We therefore conclude that *S. danubialis* is tetraploid and that Jankun's and Kovanda's records are incorrect. An erroneous ploidy level is reported by the same authors also for *S. eximia* (Vít et al. 2012).

Sorbus danubialis exhibits a certain level of morphological variation within the Czech Republic. Plants from the Moravian Karst and Bohemian Karst have more rounded leaf laminas compared to most plants from other regions. Individuals from the Dolní Povltaví region and the České středohoří Mts are described as var. *apiculata* due to markedly rhombic leaves (Kovanda 1961), and some individuals from the České středohoří Mts are remarkable in having deeply serrate to shallowly lobed laminas, yet they occur sympatrically with the dominant typical morphotype. This variability can be explained either as a reaction of the species to diverse ecological conditions or a result of genetic variation caused by facultative sexuality or mutation. However, we have not observed any significant variability which would demand taxonomic classification, so we conclude that it is not essential to delimit infraspecific taxa within *S. danubialis* in the Czech Republic. In addition to the Czech Republic, we studied *S. danubialis* also in Bavaria, Lower Austria and Hungary (see Fig. 1 and Appendix 1).

Several different names were used for the second widespread tetraploid *S. collina* in the past. In the Czech Republic, this species was believed to be diploid *S. aria*, as is apparent not only from herbarium specimens, but also from descriptions of its distribution (Klika 1937, Kovanda 1961, 1992, 2002) and a drawing in the Flora of the Czech Republic (Kovanda 1992).

In Bavaria, this taxon was at first called *S. graeca* (Bornmüller 1918). Later, Bresinsky (1978) introduced the name *S. pannonica* following Düll's evaluation of this taxon as a transitus and translating Düll's name "*S. aria* ssp. (*aria-cretica*)" into Karpati's nomenclatural system (Kárpáti 1960). This approach was finally adopted by recent authors (Meyer et al. 2005, Feulner et al. 2013). In fact, *S. pannonica* is the name for the transitional species between tetraploid *S. graeca* and diploid *S. aria* (Kárpáti 1960). We have analysed two populations of *S. pannonica* from Hungary and shown them to be triploid (Table 2, and Appendix 1), which supports the initially suggested origin (Kárpáti 1960). In Austria and Hungary, *S. collina* along with other similar taxa are classified as *S. graeca* (Király 2009, Jäger 2011).

Sorbus graeca is a widespread species distributed in central and southern Europe, Northern Africa and Asia Minor. It is a very variable complex of mutually similar tetraploid and also diploid taxa (cf. Gabrielian 1961, Kutzelnigg 1995, Kurtto 2009, Gabrielian & Balayan 2013). Central-European plants are all tetraploid and morphologically fit within the broadly delimited *S. graeca*. On the other hand, they are more or less morphologically uniform and well separated from *S. graeca* s. str., including several taxa that are regarded as taxonomic synonyms (for details, see Table 5). Based on our thorough comparative study of type material, protologues and other relevant sources on these related taxa, we conclude that the central-European populations represent a unique and well defined apomictic taxon, which deserves delimitation at the species level. To this end the new species *Sorbus collina* is described below. The species *Sorbus danubialis* was separated from the aggregate of *S. graeca* in a similar way (Kovanda 1992). Intraspecific variation within *S. collina* is insignificant in the Czech Republic, Bavaria and the regions of Austria sampled. Hungarian plants differ slightly from this main

Table 5. – Principal values and character states allowing the separation of *S. collina* from *S. graeca* and other taxa that are regarded as synonyms.

Species	Principal differences between taxa and *S. collina*	Characters of *S. collina*	Source
S. graeca var. *cuneifolia* Zinserl.	fruit red with few lenticel located only at the base, petioles 3–15 mm long	fruit dark red with scattered and evenly distributed lenticels, petioles (13–) 16–20 (–22) mm long	protologue, Zinserling 1939, Gabrielian 1961
S. cretica (Lindley) Fritsch et Rech.	leaf lamina 4.2–6.2 cm long, coarsely serrate	leaf lamina (8.4–) 9.0–9.9 (–12.5) cm long, serrate to finaly serrate	lectotype in CGE, No. 06506
S. cyclophylla Gand.	leaf lamina 2–3 cm wide	leaf lamina (5.7–) 7.0–7.5 (–9.8) cm wide	protologue, Gandoger 1875
S. graeca (Loddiges ex Spach) Loddiges ex Schauer	leaf lamina 5.0–6.6 cm long, elliptical subrhomboidal	leaf lamina (8.4–) 9.0–9.9 (–12.5) cm long, broadly elliptical to almost rotund	lectotype in P, No. P00680357
S. graeca var. *orbiculata* Gabr.	fruit red, petioles 3–15 mm long, leaf lamina base rounded to broadly cuneate, 2n = 34	fruit dark red, petioles (13–) 16–20 (–22) mm long, leaf lamina base cuneate to broadly cuneate, 2n = 68	protologue, Zinserling 1939, Gabrielian 1961, Gabrielian & Balayan 2013
S. meridionalis Guss.	petioles 10–13 mm long, leaf lamina base narrowly cuneate	petioles (13–) 16–20 (–22) mm long, leaf lamina base cuneate to broadly cuneate	comparison chart, Castellano et al. 2012
S. migarica Zinserl.	leaf lamina 4–5 cm long	leaf lamina (8.4–) 9.0–9.9 (–12.5) cm long	protologue, Zinserling 1939
S. obtusidentata Zinserl.	leaf lamina obovate, teeth more or less obtuse to crenate	leaf lamina broadly elliptical to almost rotund, teeth acute	protologue, Zinserling 1939
S. schemachensis Zinserl.	leaf lamina with 7–9 pairs of veins	leaf lamina with 9–10 pairs of veins	protologue, Zinserling 1939
S. stankovii Juz.	leaf lamina lobate and crispate at margins	leaf lamina regularly simply or double (to triple) serrate, flat at margins	protologue, Juzepczuk 1950

morphotype in leaf morphology. *Sorbus collina* occurs very often with *S. danubialis* at the same localities, but no transitional plants were observed. This species occasionally hybridizes with *S. aria*, generating transitional morphotypes between the two species (Hungary, Bavaria).

For the sake of completeness, it should be pointed out that *S. graeca* is also reported from the Czech Republic. These records, however, do not relate to *S. collina*. The first reports of the occurrence of *S. graeca* in the Czech Republic were published by Kovanda (1997a). He reported the species from two regions in southern Moravia (the Moravian Karst and Podyjí National Park) and soon these records were included in national compendia (Holub & Procházka 2000, Kovanda 2002). We revised all the herbarium specimens that this author collected (deposited in PRA) and subsequently carried out a detailed field survey of all reported localities, which indicate he mistakenly assigned some untypical individuals of *S. danubialis* to *S. graeca*. Incorrect information on the distribution of

S. graeca in the Czech Republic is presented also in the Flora of Central Europe (Flora von Mitteleuropa; Kutzelnigg 1995). It is obvious that this author did not distinguish *S. danubialis* correctly and reports *S. graeca* from localities where we were later able to confirm only *S. danubialis* occurs (e.g. all localities in Moravia).

The third tetraploid detected, *S. thayensis*, is an endemic species in the Podyjí National Park and is described below.

Sorbus danubialis (Jávorka) Kárpáti, Borbásia Nova 25: 23, 1944. (Fig. 15)

Basionym: *Sorbus cretica* f. *danubialis* Jávorka, Bot. Közl. 14: 104, 1915.
≡ *S. aria* subsp. *cretica* var. *danubialis* (Jávorka) Soó, Acta Geobot. Hung. 1 (2): 223, 1937.
≡ *S. cretica* subsp. *danubialis* (Jávorka) Jávorka, Magyar flóra, 481, 1924.
≡ *S. cretica* var. *danubialis* (Jávorka) Soó, Tisia 2: 223, 1937.
≡ *S. graeca* var. *danubialis* (Jávorka) Kovanda, Dendrol. Sborn. 3: 58, 1961.
= *S. graeca* var. *apiculata* G. Beck ex Kovanda, Dendrol. Sborn. 3: 60, 1961.
= *S. apiculata* (G. Beck ex Kovanda) Mikoláš, Thaiszia 13 (2): 130, 2004.

Neotype: Budapest: in monte Sashegy. 5. 5. 1911 herbarium S. Jávorka; BP, No 562679 (Kováts 1998).

Names previously used for this taxon in the Czech Republic: *Sorbus aria* subsp. *cretica* sensu Dostál, Klíč k úplné květeně ČSR: 319, 1958. – *S. austriaca* sensu Kovanda, Acta Mus. Morav., Sci. Nat. 81: 201, 1997 p.p. – *S. cretica* sensu Klika, Sborn. Čs. Akad. Zeměď. 12: 202, 1937. – *S. graeca* sensu Dostál, Nová Květena ČSR 1: 497, 1989 p.p. – *S. graeca* sensu Kovanda, Verh. Zool.-Bot. Ges. Österreich 134: 306, 1997 p.p.; sensu Kovanda, Klíč ke květeně ČR: 384, 2002 p.p.

D e s c r i p t i o n: Shrub or small tree up to 10 m high. Bark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas almost rotund less often broadly elliptical or rounded rhombic, (6.5–) 7.4–8.6 (–10.8) cm long and (5.2–) 5.8–6.6 (–7.9) cm wide, (1.1–) 1.2–1.3 (–1.5) times as long as wide, widest at (45–) 50–56 (–62)% of the lamina length (from the base), with broadly acute to obtuse apex with an angle of (95–) 110–130 (–145)°, broadly cuneate and partly serrate at base, with angle at base of (75–) 90–105 (–120)°, usually undulate at margins, coarsely and often deeply serrate or double (to triple) serrate (rarely shallowly lobed), with more or less acute teeth terminating the main veins (other teeth smaller), with (4–) 6–8 (–12) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins (55–) 65–80 (–95)°, with incision between the 2nd and the 3rd main vein from the base (1.7–) 2.7–3.4 (–4.5) mm, leathery, more or less glossy, dark green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (8–) 9–10 (–11) veins on each side, with the 3rd vein at an angle of (30–) 35–45 (–50)° to midrib; petioles (11–) 13–16 (–21) mm long, tomentose. Leaf laminas on short fertile shoots rounded rhombic, less often broadly elliptical to almost rotund, more distinctively undulate and more deeply serrate at margin. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acute or acuminate, tomentose on both surfaces, patent at flowering, erect, persistent and dry at fruiting. Petals (7.0–) 7.5–8.2 (–8.8) mm long and (4.5–) 5.3–6.0 (–6.5) mm wide, broadly elliptical to almost rotund, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale

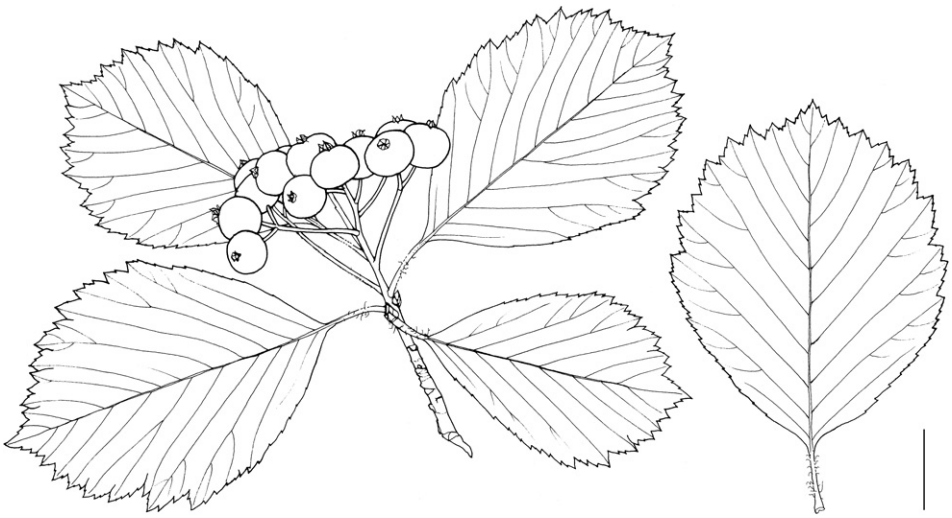


Fig. 15. – *Sorbus danubialis*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

yellow or pale rose. Ovary semi-inferior. Styles 2, free or connate and tomentose at base. Fruit subglobose, (10.5–) 11.0–12.5 (–13.0) mm long and (12.0–) 12.5–14.0 (–15.0) mm wide, always wider than long, dark red at maturity, tomentose at top and base, otherwise glabrescent, matt, with (1–) 3–5 (–9) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: tetraploid (inferred using FCM). Reproduction probably mostly apomictic. Flowering V.

Diagnostic characters: leaf lamina on short sterile shoots almost rotund, less often broadly elliptical or rounded rhombic, relatively small, with broadly acute to obtuse apex, undulate and coarsely and often deeply serrate or double (to triple) serrate (rarely shallowly lobed) at margins, with only (4–) 6–8 (–12) teeth between the 2nd and 3rd main veins from the base; leaf lamina on fertile short shoots often rounded rhombic with acute apex; fruit always wider than long, dark red when ripe.

Sorbus collina M. Lepší, P. Lepší et N. Meyer, **spec. nova** (Figs 16–17)

Description: Shrub or small tree up to 18 m high. Bark grey to dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas broadly elliptical to almost rotund, (8.4–) 9.0–9.9 (–12.5) cm long and (5.7–) 7.0–7.5 (–9.8) cm wide, (1.2–) 1.3–1.4 (–1.5) times as long as wide, widest at (49–) 52–58 (–64)% of the lamina length (from the base), with obtuse, rounded or truncate apex with an angle of (130–) 140–160 (–170)°, cuneate to broadly cuneate and partly serrate at base, with angle at base of (85–) 90–105 (–120)°, flat at margins, regularly simply or double (to triple) serrate, with acute teeth terminating the main veins (other teeth smaller),



Fig. 16. – Holotype of *Sorbus collina*.

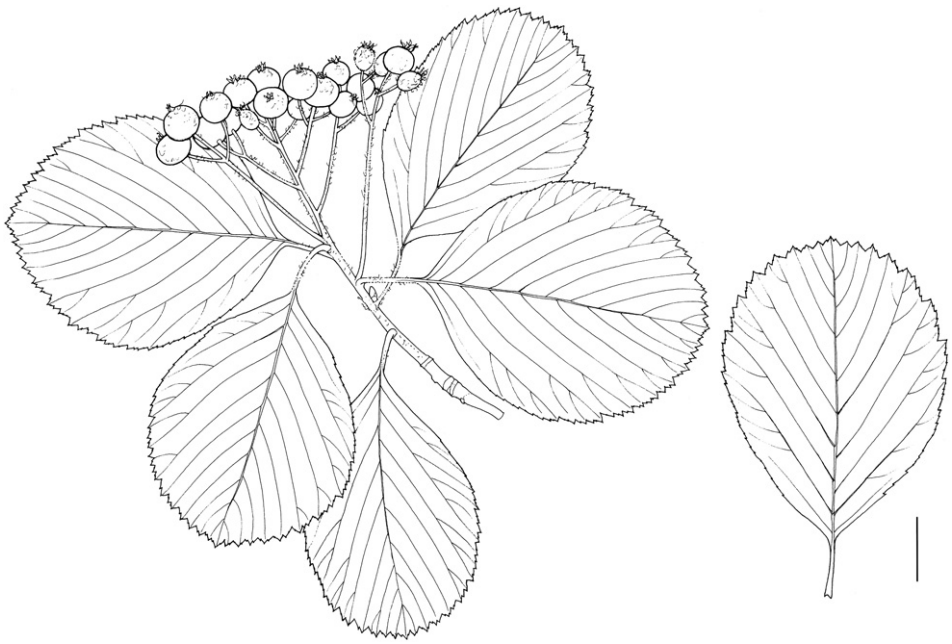


Fig. 17. – *Sorbus collina*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

with (5–) 8–9 (–10) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main veins (60–) 65–85 (–100)°, with incision between the 2nd and the 3rd main vein from the base (1.3–) 1.8–2.8 (–3.7) mm, leathery, more or less glossy, dark green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with 9–10 veins on each side, with the 3rd veins at an angle of 30–40 (–45)° to the midrib; petioles (13–) 16–20 (–22) mm long, tomentose. Leaf laminas on short fertile shoots almost rotund with acute to rounded acute apex. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acute or acuminate, tomentose on both surfaces, patent at flowering, erect, persistent and dry at fruiting. Petals (6.0–) 6.5–7.5 (–8.0) mm long and (4.0–) 4.5–5.0 (–5.5) mm wide, broadly elliptical, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow, pale rose or rose. Ovary semi-inferior. Styles 2, free or connate and tomentose at base. Fruit subglobose, (10–) 11–12 (–13) mm long and (10.5–) 12.5–13.5 (–14.5) mm wide, always wider than long, dark red when ripe, cobwebby tomentose at top and base, otherwise usually glabrescent, matt or glossy, with (3–) 5–11 (–15) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: tetraploid (inferred using FCM). Reproduction probably mostly apomictic. Flowering V.

H o l o t y p e: Central Bohemia, Nalžovické Podhájí (distr. Příbram), ca 130 m NNE of summit of Na Vyhlídce hill, edge of woodland; 390 m a.s.l., 49°43'30.9"N, 14°22'13.2"E; scattered; tree ca 7 m high; 7. 8. 2013 leg. Martin Lepší, Petr Lepší; CB, No. 83296 (Fig. 16). – I s o t y p e s: BP, 83296/f; LI, 83296/e; M, 83296/g; PR, 83296/a; PRA, 83296/b; PRC, 83296/c; W, 83296/d.

Names previously used for this taxon in the Czech Republic: *Sorbus aria* sensu Klika, Sborn. Čs. Akad. Zeměď. 12: 204 p.p.; sensu Dostál, Klíč k úplné květeně ČSR: 319, 1958 p.p.; sensu Dostál, Nová Květena ČSR 1: 497, 1989 p.p.; sensu Kovanda, Květena ČR 3: 476, 1992 p.p. – *S. aria* var. *cyclophylla* sensu Klika, Sborn. Čs. Akad. Zeměď. 12: 205; sensu Kovanda, Květena ČR 3: 476, 1992 p.p. – *S. graeca* sensu Dostál, Nová Květena ČSR 1: 497, 1989 p.p.

D i a g n o s t i c c h a r a c t e r s: Leaf lamina on short sterile shoots relatively large, broadly elliptical to almost rotund, resembling a tennis racket, with obtuse, rounded or truncate apex, uniserrate to biserrate (to triserrate), with flat margins; fruit wider than long, dark red.

E t y m o l o g y: The Latin name refers to the dominant shape of the relief within the distribution area of the species. We propose the epithet "chlumní" for the Czech name.

E c o l o g y: *Sorbus collina* prefers open or semi-open habitats such as cliffs, screes, steppes, rocky slopes, woodland and shrubby fringes, open woodlands and their gaps or clearings. It is recorded in a wide range of different types of vegetation in open mesophilous to thermophilous broadleaved and coniferous forests and shrubs, including contact or transitional vegetation in non-forest communities. It favours natural (often relic) or semi-natural habitats, but also grows in pine and spruce plantations. This species occurs on both acidic and base-rich bedrocks. The centre of its occurrence lies in hilly lands at medium altitudes, but exceptionally reaches the submontane vegetation belt. The altitudinal range of this species spans from 220 (river Kamp, Lower Austria) to 800 m a.s.l. (Milešovka mountain, northwestern Bohemia).

D i s t r i b u t i o n a n d p o p u l a t i o n s i z e: *Sorbus collina* is recorded in large areas of central, north-eastern, eastern, south-eastern Bavaria, central, western and north-western Bohemia, in the valleys of the rivers Kamp in Lower Austria and Salzach in Upper Austria, and in the north-western part of Hungary (Central Transdanubia; for individuals sampled, see Fig. 1 and Appendix 1). This species is also rarely cultivated for ornamental purposes in the Czech Republic (e.g. in Domažlice, Strakonice, Rojšín near Křemže, Třebíč, Kuřim). A comprehensive description of this species' distribution in the Czech Republic, including a distribution map and list of herbarium specimens revised, will be published in a separate paper (Lepší et al. in prep.).

Sorbus thayensis M. Lepší et P. Lepší, **spec. nova** (Figs 18–19)

D e s c r i p t i o n: Shrub or rarely a small tree up to 6 (–10) m high. Bark grey or dark grey, smooth when young, with fissures (particularly at the trunk base) when mature. Twigs thick, brownish-grey; young shoots brown, tomentose when young, glabrescent when mature, with pale brown to ochraceous lenticels. Buds ovoid, pointed; scales green, glabrescent, with narrow brown sparsely tomentose margins. Leaves on short sterile shoots simple; laminas more or less broadly elliptical to almost rotund, (9.0–) 10.0–11.6 (–12.8) cm long and (6.3–) 7.1–8.3 (–9.5) cm wide, (1.2–) 1.3–1.5 times as long as wide, widest at (46–) 51–55 (–62)% of the lamina length (from the base), with broadly acute to obtuse apex with an angle of (100–) 110–125 (–140)°, cuneate to broadly cuneate and partly serrate at base, with angle at base (70–) 80–100 (–115)°, flat at margins, regularly, finely, sharply, double to triple serrate, with more or less acute teeth terminating the main veins (other teeth acute and somewhat smaller), with (6–) 8–11 (–15) teeth between the 2nd and 3rd main veins from the base, with angle of the teeth terminating the 3rd main



Fig. 18. – Holotype of *Sorbus thayensis*.



Fig. 19. – *Sorbus thayensis*: short fructiferous shoot (left) and leaf from the middle part of a short sterile shoot (right). Scale bar 2 cm. Drawn by A. Skoumalová.

veins (30–) 45–65 (–75)°, with incision between the 2nd and the 3rd main vein from the base (2.2–) 3.0–4.4 (–6.5) mm long, leathery, more or less glossy, dark green, sparsely tomentose when young, later glabrescent on upper surface, evenly greenish-grey-tomentose on lower surface, with (8–) 9–10 (–11) veins on each side, with the 3rd vein at an angle of (25–) 30–35 (–40)° to the midrib; petioles (9–) 12–14 (–19) mm long, tomentose. Leaf laminas on short fertile shoots relatively broader, almost rotund, with broadly acute apex, undulate margins apically. Inflorescences compact, convex, with tomentose branchlets. Sepals triangular, acuminate to acute, tomentose on both surfaces, patent at flowering, erect, persistent and dry at fruiting. Petals broadly elliptical rarely almost rotund, (7.0–) 7.5–8.0 (–9.0) mm long and (5.0–) 5.5–6.0 (–6.5) mm wide, concave, white, patent, sparsely tomentose at base of upper surface, glabrous on lower surface, with a short claw. Stamens ca 20; anthers pale yellow. Ovary semi-inferior. Styles 2, free or connate and tomentose at base. Fruit ellipsoid to almost subglobose, (13.0–) 13.5–14.5 (–15.0) mm long and (11.0–) 12.5–14.0 (–14.5) mm wide, never wider than long, dark red when ripe, tomentose at top and base, otherwise glabrescent, matt, with (1–) 4–6 (–10) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. DNA ploidy level: tetraploid (inferred using FCM). Reproduction probably apomictic. Flowering V.

H o l o t y p e: southern Moravia, Čížov (distr. Znojmo), Hardeggská vyhlídka outlook, ca 630 m NNW of bridge over Dyje river, acid cliff; 350 m a.s.l., 48°51'28.69"N, 15°51'31.25"E; rare; shrub ca 4 m high; 15. 6. 2011 leg. Martin Lepší, Petr Lepší; CB, No. 83094 (Fig. 18). I s o t y p e s: PR, 83094/a; PRA, 83094/b.

D i a g n o s t i c c h a r a c t e r s: Leaf laminas on short sterile shoots broadly elliptical to almost rotund, relatively large, regularly finely, sharply, double (to triple) serrate. Flowers relatively large. Fruit large, ellipsoid to almost subglobose, never wider than long, dark red, only with (1–)4–6(–10) lenticels per 25 mm^2.

E t y m o l o g y: The name "*thayensis*" refers to the Czech-Austrian border river whose German name is Thaya and Czech name is Dyje. This species is confined to the valley of this river. We propose the epithet "podyjský" for the Czech name.

E c o l o g y: This species frequently occurs in open habitats such as fringes and steppes with cliffs; less often it grows in open thermophilous forests and on screes. It is mainly recorded in vegetation of low xeric shrubs on cliffs (*Prunion spinosae*), forest-steppe (mixture of *Quercion pubescenti-petraeae*, *Geranion sanguine*, *Festucion valesiacae*) and open oak-hornbeam forests (*Carpinion*). Occasionally it occurs in ravine forest communities (*Tilio-Acerion*), acidophilous oak forests (*Genisto germanicae-Quercion*) and on open screes (*Asplenion septentrionalis*). *Sorbus thayensis* is tolerant of a range of soils as it grows in both acidic (gneisses) and base-rich (limestone) soils. It is recorded on slopes of all aspects.

D i s t r i b u t i o n a n d p o p u l a t i o n s i z e: *Sorbus thayenis* appears to be confined to the valley of the river Dyje (= Thaya) in the surroundings of Hardegg (quadrant 7161a of the central-European grid mapping; Ehrendorfer & Hamann 1965). A total of 33 individuals of various ages were mapped at seven localities. Two of these localities are located in the Czech Republic and five in Austria. The northernmost locality by the Heimatkreuz outlook and the southernmost by the place called Einsiedler are 3.2 km apart, and both are in Austria (Fig. 9). The main population, consisting of about 20 individuals, is on Maxplateau hill (Austria). A smaller population of about 10 individuals occurs by the Hardeggská vyhlídka outlook (Czech Republic). At the remaining localities, one or two individuals are found. The phytogeographical and climatic data for the distribution of this species are the same as for *S. cucullifera*. The altitudinal range of this species spans from 310 (Einsiedler, Austria) to 440 m a.s.l. (Heimatkreuz, Austria).

H e r b a r i u m s p e c i m e n s

Czech Republic, southern Moravia, 68. Moravské podhůří Vysočiny, 7161a: 1. Hardeggská vyhlídka outlook: Čížov village, Hardeggská vyhlídka outlook, ca 450 m NNW of bridge over Dyje river, open scree, rare, shrub ca 2.5 m high, 48°51'25.0"N, 15°51'41.2"E, 390 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79681). – Čížov village, Hardeggská vyhlídka outlook, ca 450 m NNW of bridge over Dyje river, edge of scree, scattered, shrub ca 2.5 m high, 48°51'24.6"N, 15°51'39.2"E, 380 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79685). – Čížov village, Hardeggská vyhlídka outlook, ca 450 m NNW of bridge over Dyje river, oak-hornbeam forest, scattered, tree ca 1.5 m high, 48°51'23.7"N, 15°51'35.9"E, 320 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79686). – Čížov village, Hardeggská vyhlídka outlook, ca 460 m NNW of bridge over Dyje river, open scree, shrub ca 6 m high, 48°51'24.9"N, 15°51'41.2"E, 390 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79679, 12. 6. 2011, CB 79726). – Čížov village, Hardeggská vyhlídka outlook, ca 460 m NNW of bridge over Dyje river, scattered, tree ca 1 m high, 48°51'25.1"N, 15°51'40.9"E, 400 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79682). – Čížov village, Hardeggská vyhlídka outlook, ca 470 m NNW of bridge over Dyje river, rocky oak forest, scattered, tree ca 3.5 m high, 48°51'25.3"N, 15°51'40.2"E, 390 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79684). – Čížov village, Hardeggská vyhlídka outlook, ca 630 m NNW of bridge over Dyje river, acidic rock, scattered, shrub ca 4 m high, 48°51'28.7"N, 15°51'31.3"E, 350 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79676). – Čížov village, Hardeggská vyhlídka outlook, ca 660 m NNW of bridge over Dyje river, oak-hornbeam forest, sapling ca 1.5 m high, 48°51'29.8"N, 15°51'30.7"E, 360 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79688). – Čížov village, Hardeggská vyhlídka outlook, ca 680 m NNW of bridge over Dyje river, oak forest, scattered, sapling ca 0.75 m high, 48°51'29.9"N, 15°51'28.6"E, 350 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79691). – Čížov village, slopes

with cliffs and screes below Hardeggská vyhlídka outlook, ca 0.5 km SE of the centre of Hardegg, 48°51'24.9"N, 15°51'41.5"E, 390 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73679). – Podyjí region, cliff close to Hardeggská vyhlídka outlook, ca 60 m SE of gazebo, 48°51'25.1"N, 15°51'41.8"E (leg. J. Brabec 29. 5. 2012, CHEB). **2. Hardeggská stráň hillside:** Čížov village, Hardeggská stráň hillside, ca 420 m ENE of bridge over Dyje river, forest-steppe, a shrub ca 6 m high, 48°51'16.8"N, 15°52'02.5"E, 340 m a.s.l. (leg. ML et PL 11. 6. 2011, CB 79723).

Austria, Lower Austria, 7161a: 3. Heimatkreuz: Hardegg, Dyje valley by Heimatkreuz outlook, ca 2.7 km NNW [NW] of bridge over Dyje river, rocky oak forest, shrub ca 2 m high, 48°52'24.3"N, 15°50'30.3"E, 440 [400] m a.s.l. (leg. ML et PL 15. 6. 2011, CB 79606). **4. Below Hardegger Rundweg path:** Hardegg, Maxplateau hill, ca 990 m WNW of bridge over Dyje river, acidophilous oak forest, tree ca 5 m high, 48°51'19.7"N, 15°50'58.1"E, 400 m a.s.l. (leg. ML et PL 12. 6. 2011, CB 79732). **5. Maxplateau hill:** Hardegg, SE slopes of Maxplateau hill at W edge of town, edge of woody and rocky steppe, shrub ca 2.5 m high, rare, 48°51'20.3"N, 15°51'21.9"E, 360 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74020). – Hardegg, SE slopes of Maxplateau hill at W edge of town, rocky terraces, individual ca 5 m high, 48°51'20.0"N, 15°51'22.2"E, 350 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74019). – Hardegg, SE slopes of Maxplateau hill at W edge of town, on limestone cliff, shrub ca 5 m high, rare, 48°51'20.0"N, 15°51'21.6"E, 350 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74021). – Hardegg, SE slopes of Maxplateau hill at W edge of town, close to rocky spur with outlook, on shaded cliff, one individual ca 6 m high, 48°51'14.2"N, 15°51'13.5"E, 360 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74023). – Hardegg, Maxplateau hill, ca 550 m NW of bridge over Dyje river, edge of forest and rocky steppe, scattered, 48°51'20.8"N, 15°51'22.7"E, 360 [330] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79697). – Hardegg, Maxplateau hill, ca 550 m NW of bridge over Dyje river, edge of forest and rocky steppe, scattered, 48°51'20.8"N, 15°51'23.0"E, 350 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79696). – Hardegg, Maxplateau hill, ca 550 m NW of bridge over Dyje river, in *Junipero-Cotoneasteretum* on rock, scattered, 48°51'20.1"N, 15°51'22.3"E, 350 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79638). – Hardegg, Maxplateau hill, ca 560 m NW of bridge over Dyje river, edge of forest and rocky steppe, scattered, shrub ca 3 m high, 48°51'20.4"N, 15°51'22.0"E, 350 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79695). – Hardegg, Maxplateau hill, ca 560 m NW of bridge over Dyje river, limestone cliff, scattered, shrub ca 4 m high, 48°51'19.9"N, 15°51'21.4"E, 360 [340] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79694). – Hardegg, Maxplateau hill, ca 570 m NW of bridge over Dyje river, edge of gap in oak-hornbeam forest, scattered, 48°51'21.4"N, 15°51'22.4"E, 360 [330] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79698–79699, CB 79817). – Hardegg, Maxplateau hill, ca 650 m NW of bridge over Dyje river, ravine forest, tree ca 15 m high, 70 cm DBH, 48°51'21.3"N, 15°51'16.6"E, 380 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79640). – Hardegg, Maxplateau hill, ca 650 m NW of bridge over Dyje river, ravine forest, shrub 6 m high, 48°51'22.3"N, 15°51'15.3"E, 370 m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79641). – Hardegg, Maxplateau hill, ca 650 m WNW of bridge over Dyje river, cliff, shrub ca 5 m high, 48°51'14.2"N, 15°51'13.3"E, 360 m a.s.l. (leg. ML et PL 14. 5. 2011, CB 79818). – Hardegg, Maxplateau hill, ca 700 m NW of bridge over Dyje river, on rock, shrub ca 4 m high, 48°51'19.9"N, 15°51'13.0"E, 420 [380] m a.s.l. (leg. ML et PL 7. 5. 2011, CB 79642). – Hardegg, E rocky slopes of Maxplateau hill, forest-steppe, 48°51'19.5"N, 15°51'19.8"E, 350 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73703–73704). **6. Reginafelsen:** Hardegg, SE slopes of Maxplateau hill at W edge of town, below outlook on rocky spur, small cliff in wood, one shrub ca 3 m high, 48°51'08.7"N, 15°51'17.7"E, 320 m a.s.l. (leg. ML et PL 23. 7. 2010, CB 74025). – Hardegg, E rocky slopes of Maxplateau hill, forest-steppe, 48°51'08.9"N, 15°51'17.9"E, 320 m a.s.l. (leg. ML et PL 6. 8. 2009, CB 73705–73706). **7. Einsiedler:** Hardegg, slopes above Dyje river, ca 1 km NE of bridge over Dyje river, oak forest, tree ca 8 m high, 48°51'31.8"N, 15°52'23.7"E, 310 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79815). – Hardegg, slopes above Dyje river, ca 1 km NE of bridge over Dyje river, edge of scree, sapling ca 1 m high, 48°51'31.0"N, 15°52'25.4"E, 310 m a.s.l. (leg. ML et PL 15. 5. 2011, CB 79816).

Conservation

All four stenoendemic species were found in protected areas, *Sorbus cucullifera* and *S. thayensis* in the Podyjí and Thayatal National Parks, and *S. moravica* and *S. pontis-satani* in the Výměry Punkvy National Nature Reserve, which is part of the Moravian Karst protected landscape area. Despite this, the protection of these species is insufficient because all of these protected areas are currently being left unmanaged and left to spontaneous succession. The species prefer open forests, which were previously provided by traditional management of woodlands. The shady conditions that prevail in recent woodlands

are unfavourable for the long-term survival and regular reproduction of light-demanding *Sorbus* species. The general colonization of open (rocky and steppe) habitats by trees is another serious threat to these endemics. Moreover, populations of *S. thayensis* and *S. pontis-satani* are so sparse that they may be endangered even by a random event such as a rock or tree fall. The reproduction and establishment of these species should therefore be supported by restoration or simulation of traditional landscape management, at least at selected localities. All four species should be included among the critically endangered plants of the Czech flora (C1; sensu Grulich 2012) and critically endangered species (Table 6) according to the IUCN (2001). *Sorbus cucullifera* and *S. thayensis* should be added to the Red List of Austrian Flora among the most endangered species (Category 1 sensu Niklfeld & Schratt-Ehrendorfer 1999). The widely distributed *S. collina* meets the criteria for vulnerable species according to the IUCN (2001), and the same level of endangerment is applicable in the Czech Republic (C3; sensu Grulich 2012) and Germany (3; sensu Korneck et al. 1996). The level of threat faced by these species in other regions is unknown, due to the lack of distribution data.

Table 6. – Threatened categories assigned to the newly delimited taxa of *Sorbus* subg. *Aria* according to the IUCN (2001) and their degree of endangerment in the Czech Republic according to Grulich (2012).

Taxon	IUCN 2001	Grulich 2012
S. collina	VU A4abce; C2a (i)	C3
S. cucullifera	CR B1b (i,iii)	C1b
S. moravica	CR B2ab (i,iii,iv,v); C2a (ii)	C1r
S. pontis-satani	CR B2b (i,iii,iv,v); D	C1r
S. thayensis	CR B2b (i,iii,iv,v); D	C1r

Key for identification of the species of Sorbus subg. Aria occurring in the Czech Republic.

For safe identification, it is essential to use mean values of 3–5 measurements of the same character from the same individuals. Leaves have to be from middle part of short sterile shoots unless stated otherwise.

1a Leaf lamina more or less thin, relatively large, (9.6–) 11.5–12.7 (–15.6) cm long, veins on each side (8–) 11–12 (–13) ..... ***S. aria***

1b Leaf lamina more or less stiff, smaller, (5.8–) 6.5–11.6 (–12.8) cm long, veins on each side (7–) 8–10 (–11) 2

2a Leaf lamina (3.8–) 4.4–5.6 (–6.2) cm wide, elliptical to broadly elliptical, oblong elliptical, ovate, obovate; fruit red, sometimes dark red 3

2b Leaf lamina (5.2–) 5.8–8.3 (–9.8) cm wide, broadly elliptical to almost rotund; fruit always dark red 7

3a Leaf lamina undulate and coarsely and often deeply serrated or double (to triple) serrated (rarely shallowly lobed) at margins; leaf laminae from fertile short shoots often rounded rhombic with acute apex ..... ***S. danubialis***

3b Leaf lamina flat and finely or shalowlly serrated at margins, if undulate then finely serrated; leaf laminae from fertile short shoots of differend shape 4

4a Fruit with (2–) 7–18 (–24) lenticels per 25 mm^2, Moravský kras Karst only 5

4b Fruit with (1–) 3–6 (–10) lenticels per 25 mm^2, Podyjí National Park only 6

5a Leaf lamina broadly elliptical, regularly finely double (to triple) serrated, angle of tooth in which the 3rd lateral vein terminates (35–) 45–55 (–65)°, usually undulate to crispate at margins apically, with (6–) 8–10 (–11) teeth between the 2nd and 3rd main veins from the laminar base, incision between the 2nd and 3rd lateral vein from the laminar base (2.1–) 2.7–3.5 (–5.0) mm long ..... ***S. pontis-satani***

5b Leaf lamina elliptical to oblong elliptical, regularly double (to triple) serrated, angle of tooth in which the 3rd lateral vein terminates (60–) 70–90 (–100)°, mostly flat at margins apically, with (5–) 6–8 (–11) teeth between the 2nd and 3rd main veins from the laminar base, incision between the 2nd and 3rd lateral vein from the laminar base (1.4–) 1.9–2.6 (–3.3) mm long ..... ***S. moravica***

6a Leaf lamina (broadly) elliptical to obovate, (7.2–) 8.4–8.9 (–10.5) cm long, (4.7–) 5.0–5.5 (–6.2) cm wide, (1.5–) 1.6–1.7 (–1.8) times as long as wide, cuneate at base, with angle at base (65–) 70–80 (–85)°; leaves on short sterile shoots of plants growing at sunny sites held more or less upright and overlapping and resembling cornets; fruit medium-sized, (11.0–) 12.0–13.0 (–13.5) mm long, 10.5–12.0 (–13.5) mm wide, red ..... ***S. cucullifera***

6b Leaf lamina (broadly) elliptical to almost rotund, (9.0–) 10.0–11.6 (–12.8) cm long, (6.3–) 7.1–8.3 (–9.5) cm wide, (1.2–) 1.3–1.5 times as long as wide, cuneate to broadly cuneate at base, with angle at base (70–) 80–100 (–115)°; leaves on short sterile shoots of plants growing at sunny sites more or less patent; fruit large, (13.0–) 13.5–14.5 (–15.0) mm long, (11.0–) 12.5–14.0 (–14.5) mm wide, dark red ..... ***S. thayensis***

7a Leaf lamina relatively small, (6.5–) 7.4–8.6 (–10.8) cm long (those of exposed plants even smaller), especially in upper half undulate and coarsely and often deeply serrated or double (to triple) serrated (rarely shallowly lobed) at margins; leaf laminae from fertile short shoots often rounded rhombic with acute apex ..... ***S. danubialis***

7b Leaf lamina large, (8.4–) 9.0–11.6 (–12.8) cm long, flat and regularly serrated to biserrated (to triserrated) at margins, leaf laminae from fertile short shoots almost rotund, with broadly acute to rounded acute apex 8

8a Leaf lamina serrated or double (to triple) serrated at margins, incision between the 2nd and 3rd lateral vein from the laminar base (1.3–) 1.8–2.8 (–3.7) mm long, with obtuse, rounded or truncate apex with angle of (130–) 140–160 (–170)°; fruit medium-sized, (10–) 11–12 (–13) mm long, always wider than long, Bohemia only ..... ***S. collina***

8b Leaf lamina double (to triple) serrated at margins, incision between the 2nd and 3rd lateral vein from the laminar base (2.2–) 3.0–4.4 (–6.5) mm long, with broadly acute to obtuse apex with an angle of (100–) 110–125 (–140)°; fruit large, (13.0–) 13.5–14.5 (–15.0) mm long, never wider than long, Podyjí National Park only ..... ***S. thayensis***

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Souhrn

V příspěvku jsou představeny výsledky taxonomické revize jeřábů podrodu *Aria* v České republice. Prezentované taxonomické závěry jsou podpořeny výsledky průtokové cytometrie a mnohorozměrných morfologických analýz. V rámci studované skupiny byly detekovány diploidní, triploidní a tetraploidní taxony, které se vzájemně liší i morfologicky. Diploidní skupina je reprezentovaná pouze jedním druhem – *Sorbus aria*, který vykazuje vysokou morfologickou variabilitu a to dokonce i v rámci jedné populace. Tato vlastnost je druhově specifická a mimo jiné odlišuje druh od polyploidních zástupců podrodu. *Sorbus aria* byl zaznamenán na území jižní Moravy (Podyjí, Moravský kras, Bílé Karpaty), údaje dříve publikované z ostatních oblastí státu (Kovanda 1992, 2002, Kutzelnigg 1995) se vztahují k polyploidním taxonům z podrodu *Aria*. *Sorbus aria* se běžně

v ČR pěstuje a příležitostně zplaňuje. Dříve byly v Podyjí někteří jedinci *S. aria* s laločnatými listy mylně považovány za *S. austriaca* a *S. carpatica* (Kovanda 1996, 1997b, 2002), taxony, které se v ČR dle našich poznatků přirozeně nevyskytují. V rámci triploidních jeřábů byly rozlišeny a nově popsány 3 druhy – *S. cucullifera* M. Lepší et P. Lepší (jeřáb kornoutolistý) z Podyjí a *S. moravica* M. Lepší et P. Lepší (j. moravský) a *S. pontis-satani* M. Lepší et P. Lepší (j. čertův) z Moravského krasu. Tetraplodní jeřáby jsou zastoupeny třemi druhy *S. thayensis* M. Lepší et P. Lepší (jeřáb podyjský), *S. collina* M. Lepší, P. Lepší et N. Meyer (j. chlumní) a *S. danubialis*. *Sorbus thayensis* a *S. collina* jsou zde popsány jako nové druhy. *Sorbus thayensis* je endemický druh Podyjí a stejně jako zmíněné triploidní druhy vykazuje minimální morfologickou variabilitu, což ukazuje na apomiktický způsob reprodukce těchto polyploidních taxonů. *Sorbus collina* byl doposud v ČR považován za *S. aria*, v Německu za *S. pannonica* a v Rakousku a Maďarsku za *S. graeca*. Údaje o výskytu *S. graeca* z jižní Moravy (Kovanda 1997a, 2002) se nevztahují k *S. collina*, ale k netypickým exemplářům *S. danubialis*. *Sorbus collina* se na území ČR vyskytuje pouze ve středních a severozápadních Čechách a velmi vzácně je pro okrasu pěstován. Pozorovaná mírná morfologická vnitrodruhová variabilita v rámci středoevropského prostoru pravděpodobně nezasluhuje taxonomické hodnocení. *Sorbus danubialis* je svým výskytem vázaný na střední a severozápadní Čechy a jižní Moravu. V rámci studovaného území vykazuje jistou morfologickou variabilitu, které však nepřisuzujeme žádný taxonomický význam. Údaje o diploidním počtu chromosomů rostlin z Čech jsou mylné. Nové druhy vykazují malou morfologickou variabilitu a jsou dobře diferencované vzájemně i od ostatních v ČR se vyskytujících zástupců podrodu. Nově popsané endemické jeřáby z Moravy navrhujeme zařadit mezi kriticky ohrožené taxony ČR a druh *S. collina* do kategorie C3 (podle Grulich 2012). Všechny jeřáby z podrodu *Aria* jsou v ČR ohroženy zarůstáním světlých lesů a lesostepních biotopů, které byly dříve udržovány tradičním obhospodařováním krajiny. K odlišení jednotlivých druhů na území ČR poslouží následující klíč (čepel listů musí pocházet ze střední části sterilních brachyblastů, je vhodné používat průměrné hodnoty získané z 3–5 různých orgánů stejného jedince).

1a Čepel listu ± tenká, velká, (9,6–) 11,5–12,7 (–15,6) cm dlouhá, žilek na každé straně (8–) 11–12 (–13) ..... ***S. aria***

1b Čepel listu ± tuhá, menší, (5,8–) 6,5–11,6 (–12,8) cm dlouhá, žilek na každé straně v počtu (7–) 8–10 (–11) 2

2a Čepel listu (3,8–) 4,4–5,6 (–6,2) cm široká, eliptická až široce eliptická, podlouhle eliptická, vejčitá, obvejčitá; plody červené, někdy tmavě červené 3

2b Čepel listu (5,2–) 5,8–8,3 (–9,8) cm široká, široce eliptická až téměř okrouhlá; plody vždy tmavě červené 7

3a Čepel listu na okraji, obzvláště v horní polovině, zprohýbaná a hrubě, často zastřihovaně 1–2 (–3)× pilovitá (vzácně až mělce laločnatá); čepel listů fertilních brachyblastů často zaokrouhleně kosočtverečná ..... ***S. danubialis***

3b Čepel listu na okraji plochá, jemně pilovitá nebo mělce pilovitá, pokud zprohýbaná, pak jemně pilovitá; čepel listů fertilních brachyblastů jiného tvaru 4

4a Lenticely na plodech v počtu (2–) 7–18 (–24) na 0,25 cm^2, Moravský kras 5

4b Lenticely na plodech v počtu (1–) 3–6 (–10) na 0,25 cm^2, Podyjí 6

5a Čepel listu široce eliptická, pravidelně jemně 2 (–3)× pilovitá, s vrcholovým zubem na konci třetí žilky od báze o úhlu (35–) 45–55 (–65)°, na okraji zpravidla zprohýbaná až kadeřavá, se (6–) 8–10 (–11) zuby mezi 2. a 3. žilkou od báze čepele, zářez mezi 2. a 3. žilkou od báze (2,1–) 2,7–3,5 (–5,0) mm dlouhý ..... ***S. pontis-satani***

5b Čepel listu eliptická až podlouhle eliptická, pravidelně 2 (–3)× pilovitá, s vrcholovým zubem na konci třetí žilky od báze o úhlu (60–) 70–90 (–100)°, na okraji plochá, se (5–) 6–8 (–11) zuby mezi 2. a 3. žilkou od báze čepele, zářez mezi 2. a 3. žilkou od báze (1,4–) 1,9–2,6 (–3,3) mm dlouhý ..... ***S. moravica***

6a Čepel listu (široce) eliptická až obvejčitá, (7,2–) 8,4–8,9 (–10,5) cm dlouhá, (4,7–) 5,0–5,5 (–6,2) cm široká, (1,5–) 1,6–1,7 (–1,8)× delší než široká, na bázi klínovitá o úhlu (65–) 70–80 (–85)°; listy na osluněných větvích vztyčené, tvořící „kornoutky"; plody, středně velké, (11,0–) 12,0–13,0 (–13,5) mm dlouhé, 10,5–12,0 (–13,5) mm široké, červené ..... ***S. cucullifera***

6b Čepel listu široce eliptická až téměř okrouhlá, (9,0–) 10,0–11,6 (–12,8) cm dlouhá, (6,3–) 7,1–8,3 (–9,5) cm široká., (1,2–) 1,3–1,5× delší než široká, na bázi klínovitá až široce klínovitá o úhlu (70–) 80–100 (–115)°; listy na osluněných větvích nejsou vztyčené a netvoří kornoutky; plody velké, (13,0–) 13,5–14,5 (–15,0) mm dlouhé, (11,0–) 12,5–14,0 (–14,5) mm široké, tmavě červené ..... ***S. thayensis***

7a Čepel listu poměrně malá, (6,5–) 7,4–8,6 (–10,8) cm dlouhá (u více osluněných jedinců i menší), na okraji, obzvláště v horní polovině, zprohýbaná a hrubě, často zastřihovaně, 1–2 (–3)× pilovitá (vzácně až mělce laločnatá); čepel listů fertilních brachyblastů často zaokrouhleně kosočtverečná se špičatým vrcholem ..... ***S. danubialis***

7b Čepel listu větší, (8,4–) 9,0–11,6 (–12,8) cm dlouhá, na okraji plochá, nikdy zastřihovaně pilovitá, čepel listů fertilních brachyblastů téměř okrouhlá, s tupě špičatým až zaokrouhleně špičatým vrcholem 8

8a Čepel listu na okraji 1–2(–3)× pilovitá, se zářezem mezi 2. a 3. žilkou od báze (1,3–) 1,8–2,8 (–3,7) mm dlouhým, s hrotitým, zaokrouhleným nebo až uťatým vrcholem o úhlu (130–) 140–160 (–170)°; plody středně velké, (10–) 11–12 (–13) mm dlouhé, vždy širší než dlouhé, Čechy ..... ***S. collina***

8b Čepel listu na okraji ostře 2 (–3)× pilovitá, se zářezem mezi 2. a 3. žilkou od báze (2,2–) 3,0–4,4 (–6,5) mm dlouhým, s tupě špičatým až hrotitým vrcholem o úhlu (100–)110–125 (–140)°; plody velké, (13,0–)13,5–14,5 (–15,0) mm dlouhé, nikdy širší než dlouhé, Podyjí ..... ***S. thayensis***

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Appendix 1. – List of localities of *Sorbus aria*, *S. danubialis*, *S. collina* and *S. pannonica* analysed using flow cytometry during this study. Localities are sorted according to taxa and subsequently according to countries. The localities from the Czech Republic are further sorted according to the regional-phytogeographical classification system (Skalický 1988). The format of the data is: Town or village, localization, habitat, height of individual, abundance, quadrant of the Central-European mapping grid according Ehrendorfer & Hamann (1965), coordinates of WGS-84, altitude (collector, collection date); number of individuals analysed; in *Sorbus collina* accession number of specimens. The specimens of all analysed trees are deposited in herbarium CB. Abbreviations of collectors: ML – Martin Lepší, PL – Petr Lepší, GM – Gábor Mészáros, NM – Norbert Meyer.

Sorbus aria

Austria. Gmunden, Traunstein Mt., W base of mountain, rocky slopes, tree ca 10 m high, 8148b, 47°51'34.0"N, 13°48'58.8"E, 550 m a.s.l. (ML 7. 8. 2011); 1. – Gmunden, Traunstein Mt., W base of mountain, open forest, tree ca 3 m high, 8148b, 47°52'32.7"N, 13°48'50.8"E, 430–550 m a.s.l. (ML 7. 8. 2011); 2 – Gmunden, Traunstein Mt., W slopes of mountain, 8148b, 47°51'54.7"N, 13°49'22.2"E, 860–1140 m a.s.l. (ML 7. 8. 2011); 4. – Hainburg an der Donau, NW slopes of Hundsheimer Berg, 7867d, 48°08'07.8"N, 16°55'58.5"E, 350–380 m a.s.l. (ML, PL 16. 7. 2011); 3. – Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 m SE of bridge over Dyje river, 7161a, 48°51'05.4"N, 15°51'49.6"E, 350–400 m a.s.l. (ML, PL 15. 5. 2011); 3. – Hardegg, "pine forest II" on slopes of Dyje valley, ca 300 m SE of bridge over Dyje river, tree ca 12 m high, 7161a, 48°51'04.9"N, 15°51'57.6"E, 400 m a.s.l. (ML, PL 15. 5. 2011); 1. – Hardegg, Dyje valley, ca 2 km NW of bridge over Dyje river, cliff in oak-hornbeam forest, tree ca 10 m high, 7161a, 48°51'46.6"N, 15°50'20.3"E, 420 m a.s.l. (ML, PL 25. 7. 2012); 1. – Hardegg, Dyje valley, ca 2.8–2.9 km NW of bridge over Dyje river, 7161a, 48°52'26.1"N, 15°50'26.5"E, 420–440 m a.s.l. (ML, PL 17. 6. 2012); 2. – Hardegg, Dyje valley, Schwalbenfelsen ca 2.1 km NW of the bridge over Dyje river, on cliff, shrub ca 4 m high, 7161a, 48°51'54.8"N, 15°50'28.1"E, 390 m a.s.l. (ML, PL 15. 6. 2011); 1. – Hardegg, Kreuzmaiss, slopes above Fugnitz stream, ca 1.8 km WSW of bridge over Dyje river, edge of rock, tree ca 2.5 m high, 7161c, 48°50'18.4"N, 15°51'02.9"E, 370 m a.s.l. (ML, PL 9. 5. 2011); 1. – Hardegg, Maxplateau hill, ca 700 m WNW of bridge over Dyje river, on rock in forest, tree ca 7 m high, 7161a, 48°51'21.6"N, 15°51'14.2"E, 400 m a.s.l. (ML, PL 14. 5. 2011); 1. – Hardegg, S slopes of Maxplateau hill above swimming pool, ca 830 m WNW of bridge over Dyje river, forest-steppe, scattered shrub ca 7 m high, 7161a, 48°51'14.6"N, 15°51'06.9"E, 360 m a.s.l. (ML, PL 14. 5. 2011); 1. – Hardegg, slopes above Dyje river, ca 0.9 km ENE of bridge over Dyje river, oak-hornbeam forest, shrub ca 5 m high, 7161a, 48°51'14.6"N, 15°52'31.4"E, 360 m a.s.l. (ML, PL 9. 5. 2011); 1. – Hardegg, slopes of Fugnitz valley opposite of Binderberg hill, ca 1 km SW of bridge over Dyje river, rocky forest-steppe, shrub ca 3.5 m high, 7161c, 48°50'55.5"N, 15°50'59.1"E, 380 m a.s.l. (ML, PL 12. 6. 2011); 1. – Hardegg, Umlaufberg hill, edge of scree and acidophilous oak forest, tree ca 6 m high, 7161c, 48°50'41.4"N, 15°53'33.7"E, 330 m a.s.l. (ML 30. 5. 2012); 1. – Heufurth, near quarry at W edge of village, scrub, tree ca 6 m high, 7160d, 48°49'08.8"N, 15°49'32.4"E, 390 m a.s.l. (ML, PL 15. 6. 2012); 1. – Heufurth, woody slopes above village, 7160d, 48°49'24.1"N, 15°49'34.3"E, 390–430 m a.s.l. (ML, PL 15. 6. 2012); 5. – Klosterneuburg, S slopes of Leopoldsberg hill, 7764a, 48°16'35.9"N, 16°20'56.9"E, 310–330 m a.s.l. (ML, PL 16. 7. 2011); 5. – Prein an der Rax, below the Preiner Wand cliff, in a growth of *Pinus mugo*, rarely a tree ca 4 m high, 8360a, 47°41'51.6"N, 15°44'26.1"E, 1420 m a.s.l. (ML, PL 18. 9. 2010); 1. – Prein an der Rax, ca 0.5 km NE of the Waxriegelhaus, 8360a, 47°41'34.4"N, 15°43'20.2"E, 1470 m a.s.l. (ML, PL 18. 9. 2010); 1. – Prein an der Rax, close by the Waxriegelhaus, a *Picea abies* and *Larix decidua* forest, a tree ca 5 m high, 8360a, 47°41'17.1"N, 15°43'20.6"E, 1380 m a.s.l. (ML, PL 18. 9. 2010); 1. – Prein an der Rax, the N periphery of the village, along a road, scattered, 8360b, 47°40'49.8"N, 15°46'20.3"E, 780 m a.s.l. (ML, PL 18. 9. 2010); 1. – Semmering, in the southern part of the village, an edge of a forest, scattered, a tree ca 8 m high, 8360d, 47°38'22.0"N, 15°49'46.3"E, 940 m a.s.l. (ML, PL 19. 9. 2010); 1. – Schönberg am Kamp, in valley of Kamp river (right-hand bank), ca 600 m NE of summit of Kogelberg hill, rocky and shrubby slopes, rarely, 7460c, 48°30'19.7"N, 15°41'27.1"E, 260 m a.s.l. (ML, PL 14. 8. 2010); 1.

Czech Republic. 19. Bílé Karpaty stepní: Velká nad Veličkou, Javorník, shrubby slope near railway stop Javorník nad Veličkou, mosaic of shrubs and *Bromion* grasslands, 7171a, 48°51'43.4"N, 17°31'13.3"E, 345 m a.s.l. (PL 20. 5. 2013); 3. – **68. Moravské podhůří Vysočiny:** Čížov, Dyje valley, NW slopes of Na Vyhlídce hill, ca 1.8 km WSW of chapel in village, 7161a, 48°52'29.3"N, 15°50'55.6"E, 370–410 m a.s.l. (ML, PL 15. 5. 2011); 4. – Čížov, Dyje valley, Pašerácká stezka path, ca 1.5 km W of chapel in village, 7161a, 48°52'49.3"N, 15°51'05.8"E, 380–470 m a.s.l. (ML, PL 11. 9. 2011); 4. – Čížov, Hardeggská stráň hillside, below road, ca 560 m ENE of bridge over Dyje river, open oak forest, scattered, 7161a, 48°51'16.3"N, 15°52'10.7"E, 320 m a.s.l. (ML, PL 6. 5. 2011); 1. – Čížov, Hardeggská vyhlídka outlook, ca 280 m NNW of bridge over Dyje river, 7161a, 48°51'19.2"N, 15°51'40.9"E, 320–330 m a.s.l. (ML, PL 7. 5. 2011); 3. – Čížov, calcareous left-hand bank slopes of Dyje river valley, ca 400–500 m SE of spot height of 417 m with Hardegg outlook, edge of shrub and steppe, a small tree, 7161a, 48°51'18.4"N, 15°52'08.6"E, 330–360 m a.s.l. (ML, PL 23. 7. 2010); 3. – Čížov,

near ridge in meander of Dyje river (left-hand bank), ca 250 m WSW of obelisk above Ledové sluje chasms, ravine forest, tree ca 6 m high, 7161a, 48°53'00.5"N, 15°50'32.1"E, 400 m a.s.l. (ML, PL 23. 7. 2010); 1. – Čížov, rocky slope on left-hand bank of Dyje river, ca 100 m WNW of obelisk above Ledové sluje chasms, rocky woodland with dominant lime tree, individual ca 9 m high, 7161a, 48°53'04.9"N, 15°50'36.6"E, 390 m a.s.l. (ML, PL 23. 7. 2010); 1. – Čížov, summit area of Býčí hora hill, edge of forest road, one individual ca 7 m high, 7161a, 48°52'35.8"N, 15°50'12.8"E, 540 m a.s.l. (ML, PL 23. 7. 2010); 1. – Vranov nad Dyjí, ca 550 m NNW of summit of Býčí hora hill, on cliff, one small tree, 7160b, 48°52'45.8"N, 15°49'57.6"E, 510 m a.s.l. (ML, PL 21. 7. 2010); 1. – Vranov nad Dyjí, right-hand bank slopes of Dyje river valley, opposite meander with place called Ledové sluje chasms, ca 0.7 km NW of summit of Býčí hora hill, woodland on rocky slope, one small tree ca 2 m high, 7160b, 48°52'51.7"N, 15°49'56.4"E, 420 m a.s.l. (ML, PL 21. 7. 2010); 1. – **70. Moravský kras:** Horákov, ca 400 m SE of summit of Hornek hill, cliff in forest, ca 20 individuals, 6766c, 49°13'43.8"N, 16°43'11.1"E, 350–360 m a.s.l. (ML 13. 5. 2012); 7. – Horákov, summit of Hornek hill, upper edge of former quarry, shrub ca 1 m high, 6766c, 49°13'51.9"N, 16°42'56.2"E, 410 m a.s.l. (ML 13. 5. 2012); 1. – **78. Bílé Karpaty lesní:** Starý Hrozenkov, Vyškovec village, between settlements Kykula and Vlčí, fringe of broadleaves forest, near road ca 800 m SE of bell tower (near sharp curve), trees with many trunks, 7073c, 48°55'51.4"N, 17°50'55.2"E, 660 m a.s.l. (PL 24.5. 2013); 2. – Starý Hrozenkov, Vyškovec village, Vlčí settlement, in shrubby growth along road, ca 1.5 km E of bell tower (near sharp curve), shrub ca 2 m high, 7073c, 48°56'02.1"N, 17°51'33.7"E, 560 m a.s.l. (PL 24. 5. 2013); 1.

France. Barr, the close surroundings of the castle of Landsberg, a rock in an oak forest, rarely, 7510d, 48°25'11.4"N, 07°25'20.3"E, 580 m a.s.l. (ML, PL 28. 7. 2010); 1. – Gérardmer, ca 1.5 km S of Gerbépal village, a clearing by the road, rarely, 7807c, 48°07'57.6"N, 06°54'56.8"E, 710 m a.s.l. (ML, PL 27. 7. 2010); 1. – Gérardmer, the area between the summit of le Hohneck Mountain and le Petit Hohneck Mountain, subalpine open shrubs, rarely, a tree ca 10 m high, 7908c, 48°02'02.0"N, 07°01'42.4"E, 1180 m a.s.l. (ML, PL 29. 7. 2010); 1.

Sorbus danubialis

Austria. Lower Austria: Hainburg an der Donau, NW slopes of Hundsheimer Berg, 7867d, 48°08'10.7"N, 16°56'04.6"E, 370 m a.s.l. (ML, PL 16. 7. 2011); 1. – Hardegg, "pine forest I" on slopes of Dyje valley, ca 180 m SE of bridge over Dyje river, pine forest with *Sesleria caerulea*, shrub ca 4 m high, 7161a, 48°51'5.58"N, 15°51'50.22"E, 360 m a.s.l. (ML, PL 12. 9. 2011); 1. – Hardegg, "pine forest II" on slopes of Dyje valley, ca 300 m SE of bridge over Dyje river, pine forest with *Sesleria*, rarely tree ca 7 m high, 7161a, 48°51'04.5"N, 15°51'56.1"E, 400 m a.s.l. (ML, PL 15. 5. 2011); 1. – Pulkau, Pulkau valley, young forest of *Carpinus* and *Quercus* on left-hand bank of Pulkau river, ca 2.3 km NW of Pulkau town, rarely, tree ca 6 m high, 7260d, 48°42'53.3"N, 15°49'58.9"E, 370 m a.s.l., (PL 26. 9. 2012); 1. – Pulkau, Pulkau valley, open forest of *Quercus pubescens* on left-hand bank of Pulkau river, ca 2.1 km WNW of Pulkau town, above Peschtamühle, rarely, tree ca 4 m high, 7261c, 48°42'39.9"N, 15°50'02.8"E, 370 m a.s.l. (PL 26. 9. 2012); 1. – Pulkau, Pulkau valley, open forest on left-hand bank of Pulkau river, ca 1.9 km WNW of Pulkau town, rarely, shrub ca 2 m high, 7261c, 48°42'32.6"N, 15°50'07.8"E, 316 m a.s.l. (PL 26. 9. 2012); 1. – Pulkau, Pulkau valley, upper edge of scree on right-hand bank of Pulkau river, ca 2.9 km SE of Theras village, near Hammerschmiede, rarely, shrub ca 2 m high, 7260d, 48°42'54.3"N, 15°49'22.0"E, 346 m a.s.l. (PL 26. 9. 2012). – Rosenburg, wodded slope in valley of Kamp river, ca 1 km WNW of castle in village, rock in woodland, rarely, one individual ca 3 m high, 7359d, 48°37'43.7"N, 15°37'08.6"E, 350 m a.s.l. (ML, PL 14. 8. 2010); 1. – Rosenburg, in valley of Kamp river, ca 1.8 km W of castle in village, top of cliff, rarely, 7359d, 48°37'38.2"N, 15°36'32.5"E, 330 m a.s.l. (ML, PL 14. 8. 2010); 1.

Czech Republic. 6. Džbán: Třeboc, ca 1–2 km NE of village, Babí hora hill, *Larix* plantation and edge of clearing, scattered, 5748d, 50°13'13.4"N, 13°45'43.9"E, 490–510 m a.s.l. (ML 30. 6. 2011); 3. – Třeskonice, ca 1.3 km S of village, on Výrov hill, 5747b, 50°15'26.1"N, 13°39'04.3"E, 480–520 m a.s.l. (ML 30. 6. 2011); 3. – Zbečno, Milská stráň nature reserve, forest-steppe and open forest on S slope, scattered, 5749c, 50°14'10.6"N, 13°52'15.2"E, 450 m a.s.l. (ML 30. 6. 2011); 3. – **16. Znojemsko-brněnská pahorkatina:** Moravský Krumlov, slopes of Rokytná river at N edge of town, cliff, 6963d, 49°02'51.5"N, 16°19'10.1"E, 300 m a.s.l. (ML, PL 5. 7. 2011); 2. – Znojmo, valley of Dyje river, ca 1.5 km N of former mill called Papírna, oak woodland, one individual ca 1.5 m high, 7161d, 48°49'49.7"N, 15°58'54.3"E, 270 m a.s.l. (ML, PL 22. 7. 2010); 1. – Znojmo, valley of Dyje river (right-hand bank) ca 1.5 km W of centre of area called Šóbes, pine-oak woodland, several individuals, 7161d, 48°49'00.9"N, 15°57'21.3"E, 380 m a.s.l. (ML, PL 22. 7. 2010); 1. **17b. Pavlovské kopce:** Pavlov, northern part of ruin castle Dívčí hrady (Děvičky) west of village, edge of shrubs, shrub ca 2 m high, 7165b, 48°52'34.3"N, 16°39'43.9"E, 420 m a.s.l. (PL 16. 9. 2014); 1. – Klentnice, rocks on the west part of castle ruin Sirotčí hrádek west of village, limestone cliff, 7165d, 48°50'43.1"N, 16°38'24.9"E, 425 m a.s.l. (PL 17. 9. 2014); 2. – **52. Ralsko-bezdězská tabule:** Bezděz, Malý Bezděz hill, base of S slope, edge of clearing, shrub ca 6 m high, 5454c, 50°32'15.5"N, 14°42'45.4"E, 420 m a.s.l. (ML, PL 17. 5. 2011); 1. – Bezděz,

Velký Bezděz hill, SE slopes, on cliff, scattered, 5454c, 50°32'23.8"N, 14°43'17.7"E, 560–590 m a.s.l. (ML, PL 16. 5. 2011); 5. – Bezděz, Velký Bezděz hill, SW slopes, scattered, 5454c, 50°32'17.4"N, 14°43'03.5"E, 530–540 m a.s.l. (ML, PL 16. 5. 2011); 4. – **68. Moravské podhůří Vysočiny:** Čížov, Hardeggská stráň hillside, above road, ca 550 m ENE of bridge over Dyje river, forest-steppe, rarely, shrub ca 2 m high, 7161a, 48°51'17.5"N, 15°52'08.9"E, 370 m a.s.l. (ML, PL 14. 5. 2011); 1. – Čížov, calcareous slopes above Dyje river (left-hand bank), ca 500 m SE of spot height of 417 m with Hardeggská vyhlídka outlook, above road to Hardegg, steppe, shrub ca 2 m high, rarely, 7161a, 48°51'17.6"N, 15°52'08.9"E, 350 m a.s.l. (ML, PL 23. 7. 2010); 1. – **70. Moravský kras:** Lažánky, near Blansek castle ruine, 6666a, 49°22'14.8"N, 16°43'12.4"E, 440–470 m a.s.l. (ML 23. 7. 2011); 3. – Lažánky, Suchý žleb gorge, S slopes, 6666a, 49°22'02.8"N, 16°43'40.0"E, 420–460 m a.s.l. (ML 22. 7. 2011); 5. – Vilémovice, Pustý žleb gorge, Koňský spád cliff, 6666a, 49°22'44.6"N, 16°43'45.5"E, 480–490 m a.s.l. (ML 23. 7. 2011); 3.

Germany. Dietfurt, ca 1.5 km NW of centre of village, 6935c, 49°02'26.9"N, 11°33'51.2"E, 460 m a.s.l. (ML 27. 6. 2011); 1. – Essing, rocky slopes above village, 7036d, 48°56'20.7"N, 11°47'11.8"E, 410–440 m a.s.l. (ML 28. 6. 2011); 3. – Gundelshausen, slopes of Danube ca 1.5 km NNW of centre of village, 7037b, 48°57'31.8"N, 11°59'14.0"E, 340 m a.s.l. (ML 28. 6. 2011); 1. – Hebersdorf, ca 0.3 km E of centre of village, 6935a, 49°03'50.0"N, 11°33'27.6"E, 490–580 m a.s.l. (ML 27. 6. 2011); 2. – Heitzenhofen, Naab valley, woody slopes at NW edge of village, 6837d, 49°07'37.8"N, 11°56'37.7"E, 390–410 m a.s.l. (ML 26. 6. 2011); 3. – Kinding, NW of village, forest-steppe, 6934c, 49°00'13.9"N, 11°22'27.9"E, 450 m a.s.l. (ML, NM 24. 6. 2011); 1. – Regensburg, ca 0.7 km SSE of the centre of the village of Goldberg, in the valley of the Naab river, in a woody edge, rarely, 6937d, 49°01'31.0"N, 11°59'51.3"E, 360 m a.s.l. (ML, PL 26. 7. 2010); 1. – Riedenburg, E edge of town, open pine forest, 7036a, 48°58'06.9"N, 11°41'29.4"E, 500 m a.s.l. (ML, NM 24. 6. 2011); 2. – Riedenburg, slopes NE of town, 7036a, 48°58'26.8"N, 11°41'33.7"E, 460 m a.s.l. (ML 28. 6. 2011); 2. – Schönfeld, ca 1.5 km SW of centre of village, 7132a, 48°53'20.3"N, 11°01'51.6"E, 450–470 m a.s.l. (ML, NM 26. 6. 2011); 2. – Thalheim, ca 1.7 km SE of centre of village, 6935a, 49°03'51.1"N, 11°33'27.9"E, 510 m a.s.l. (ML 27. 6. 2011); 1.

Hungary. Balatongyörök, Balaton region, ca 3.5 km NNW of centre of village, 9270a, 46°47'18.6"N, 17°20'12.4"E, 260–270 m a.s.l. (ML, PL, GM 21. 7. 2011); 2. – Budapest, Kecske hegy, 8479d, 47°32'12.3"N, 18°59'36.7"E, 310 m a.s.l. (ML, PL, GM 17. 7. 2011); 3. – Budapest, Ördög oron, 8579b, 47°28'55.1"N, 18°59'13.2"E, 280 m a.s.l. (ML, PL, GM 17. 7. 2011); 1. – Budapest, Sas hegy, 8580a, 47°28'59.2"N, 19°01'01.3"E, 230–270 m a.s.l. (ML, PL, GM 17. 7. 2011); 4. – Budapest, Tündér hegy, 8479d, 47°30'54.2"N, 18°58'03.2"E, 370–390 m a.s.l. (ML, PL, GM 17. 7. 2011); 3. – Csákvár, Vértes Mts, Nagy-Vasak hegy, 8576c, 47°25'50.3"N, 18°24'58.4"E, 390 m a.s.l. (ML, PL, GM 18. 7. 2011); 1. – Csákvár, Vértes Mts, Szedres völgy, 8675b, 47°22'49.1"N, 18°19'44.0"E, 360 m a.s.l. (ML, PL, GM 19. 7. 2011); 1. – Szentkirályszabadja, Balaton region, Malomvölgy, 8973d, 47°02'57.6"N, 17°59'09.9"E, 260 m a.s.l. (ML, PL, GM 20. 7. 2011); 2. – Tapolca, Balaton region, Csobánc hill, 9171a, 46°52'21.7"N, 17°30'12.2"E, 340 m a.s.l. (ML, PL, GM 21. 7. 2011); 1. – Várpalota, Bakony Mts, N of town, 8774d, 47°13'58.1"N, 18°07'05.8"E, 290–380 m a.s.l. (ML, PL, GM 19. 7. 2011); 3. – Veszprém, ca 3.8 km W of centre of town, 8973a, 47°05'43.1"N, 17°51'36.9"E, 280 m a.s.l. (ML, PL, GM 20. 7. 2011); 1. – Veszprém, Márkó, Malom hegy, 8872d, 47°06'33.3"N, 17°49'43.0"E, 360 m a.s.l. (ML, PL, GM 20. 7. 2011); 1.

Sorbus collina

Austria. Upper Austria: Braunau am Inn, in valley of Salzach river (right-hand bank) ca 0.5 km SSW of bridge in Heiligen Kreuz village, wooden slopes, 7842d, 48°08'54.4"N, 12°49'17.5"E, 420 m a.s.l. (ML, M. Hohla 12. 10. 2014, CB 83297); 2. – Braunau am Inn, in valley of Salzach river (right-hand bank) ca 0.5 km ESE of bridge in Heiligen Kreuz village, wooden slopes, 7842b, 48°09'05.5"N, 12°49'44.2"E, 420 m a.s.l. (ML, M. Hohla 12. 10. 2014, CB 83298–83300); 3. – Braunau am Inn, in valley of Salzach river (right-hand bank) S edge of Duttendorf village, cliff, 7843a, 48°09'20.0"N, 12°50'05.6"E, 413 m a.s.l. (ML, M. Hohla 12. 10. 2014, CB 83301); 3. – Braunau am Inn, in valley of Salzach river (right-hand bank) ca 2.3 km ENE of Überackern village, small cliff, 7743c, 48°12'07.8"N, 12°54'13.6"E, 370 m a.s.l. (ML, M. Hohla 12. 10. 2014, CB 83302–83304); 3. – Braunau am Inn, in valley of Inn river (right-hand bank) ca 1 km WSW of Oberrothenbuch village, wooded slope, 7743d, 48°12'19.9"N, 12°57'13.3"E, 380 m a.s.l. (ML, M. Hohla 12. 10. 2014, CB 83305); 2. – **Lower Austria:** Plank am Kamp, in valley of Kamp river (right-hand bank) ca 0.6 km NE of church in village Thürneustift, wooded cliff, tree ca 6 m high, 7460c, 48°32'47.2"N, 15°40'16.8"E, 250 m a.s.l. (ML, PL 14. 8. 2010, CB 74060); 1. – Schönberg am Kamp, in valley of Kamp river (right-hand bank), ca 1.6 km NW of church in village, top of cliff in rocky and shrubby slope of valley, shrub ca 4 m high, 7460c, 48°31'36.6"N, 15°40'49.7"E, 300 m a.s.l. (ML, PL 14. 8. 2010, CB 74058); 1. – Schönberg am Kamp, in valley of Kamp river (right-hand bank), ca 350 m NE of summit of Kogelberg hill, dry and rocky slope above river,

tree ca 6 m high, scattered in the surroundings, 7460c, 48°30'00.4"N, 15°41'30.5"E, 220 m a.s.l. (ML, PL 13. 8. 2010, CB 74047); 1. – Schönberg am Kamp, in valley of Kamp river (right-hand bank), ca 600 m NE of summit of Kogelberg hill, rocky and shrubby slopes of valley, rarely, 7460c, 48°30'19.5"N, 15°41'25.9"E, 280 m a.s.l. (ML, PL 14. 8. 2010, CB 74050); 1.

Czech Republic. 6. Džbán: Třeskonice, ca 1.3 km S of village, on Výrov hill, scattered, 5747b, 50°15'23.8"N, 13°39'12.8"E, 510–520 m a.s.l. (ML 30. 6. 2011, CB 82672–82674); 3. – **7c. Slánská tabule:** Kladno, Vinařická hora nature reserve, ca 750 m NW of centre of village, marlstone slope, ca 30 individuals shrub ca 3 m high, 5850b, 50°10'49.2"N, 14°5'3.6"E, 350 m a.s.l. (ML 17. 5. 2011, CB 79944); 1. – Kladno, Vinařická hora nature reserve, ca 700–750 m NW–NNW of centre of village, 5850b, 50°10'53.9"N, 14°05'15.8"E, 380–400 m a.s.l. (ML 17. 5. 2011, CB 79942–79943); 2. – **32. Křivoklátsko:** Branov, Berounka valley, ca 0.9 km NE of centre of village, Nezabudické skály nature reserve, 5949c, 50°01'15.8"N, 13°50'49.9"E, 250–270 m a.s.l. (ML 29. 6. 2011, CB 82657–82659); 3. – Broumy, 2.7 km SSW of centre of village, Jouglovka nature reserve, rarely, 6049c, 49°55'54.2"N, 13°50'19.3"E, 540–560 m a.s.l. (ML 29. 6. 2011, CB 82657–82659); 3. – Terešov, 1.5 km N of centre of village, V Horách nature reserve, rarely, 6048c, 49°54'36.3"N, 13°41'50.4"E, 430 m a.s.l. (ML 29. 6. 2011, CB 82654–82656); 3. – Točník, Točník hill, below castle, 6149a, 49°53'23.4"N, 13°53'11.4"E, 430 m a.s.l. (ML 29. 6. 2011, CB 82647–82649); 3. – Zbečno, Berounka valley, cliffs above town, scattered, 5949d, 50°2'35.5"N, 13°55'38.6"E, 400–410 m a.s.l. (ML 29. 6. 2011, CB 82660–82662); 3.

Germany. Böhming, ca 1.3 km SE of village, cliff, 7034c, 48°56'05.7"N, 11°22'38.5"E, 480–490 m a.s.l. (ML, NM 24. 6. 2011, CB 82557–82559); 3. – Dietfurt, slopes above town, 6935d, 49°2'25.84"N, 11°35'8.38"E, 460–480 m a.s.l. (ML 28. 6. 2011, CB 82625–82627); 3. – Gundelshausen, slopes of Danube ca 1.5 km NNW of centre of village, 7037b, 48°57'33.4"N, 11°59'15.2"E, 340–360 m a.s.l. (ML 28. 6. 2011, CB 82637–82639); 3. – Hartmannshof, slopes at N edge of town, 6535a, 49°29'50.8"N, 11°32'54.5"E, 400–420 m a.s.l. (ML 27. 6. 2011, CB 82613–82615); 3. – Heitzenhofen, Naab valley, woody slopes at NW edge of village, 6837d, 49°7'36.2"N, 11°56'39.8"E, 370–400 m a.s.l. (ML 26. 6. 2011, CB 82602–82603, CB 82605); 3. – Högen, edge of forest ca 2 km NE of centre of village, 6435d, 49°30'09.3"N, 11°37'37.9"E, 460–470 m a.s.l. (ML 27. 6. 2011, CB 82611–82612, CB 82641); 3. – Kallmünz, Naab valley, slopes ca 1.2 km NW of centre of town, 6837b, 49°10'16.5"N, 11°57'59.3"E, 370–390 m a.s.l. (ML 26. 6. 2011, CB 82608–82610); 3. – Kelheim, slopes of Danube NE of centre of town, 7037c, 48°55'15.9"N, 11°54'24.8"E, 350–380 m a.s.l. (ML 28. 6. 2011, CB 82634–82636); 3. – Kinding, 2.8 km NW of centre of village, forest-steppe, 6934c, 49°01'09.59"N, 11°21'33.08"E, 440 m a.s.l. (ML, NM 24. 6. 2011, CB 82554); 1. – Leutenbach, ca 1.2 km SE of town, 6233c, 49°42'14.1"N, 11°11'13.6"E, 480 m a.s.l. (ML, NM 25. 6. 2011, CB 82581, CB 82583); 2. – Obereichstätt, slopes above village, 7132b, 48°53'50.1"N, 11°07'30.7"E, 460–470 m a.s.l. (ML, NM 26. 6. 2011, CB 82595–82596); 2. – Regensburg, ca 0.7 km SSE of the centre of the village of Goldberg, in the valley of the Naab river, an open forest and a dry grassland, scattered, 6937d, 49°01'35.3"N, 11°59'51.0"E, 390–410 m a.s.l. (ML, PL 26. 7. 2010, CB 79558–79559); 2. – Thalheim, ca 1.4–1.7 km SE of centre of village, 6535a, 49°27'10.6"N, 11°33'48.4"E, 420–460 m a.s.l. (ML 27. 6. 2011, CB 82619–82620, CB 82777); 3. – Vorra, slopes at E edge of town, 6434b, 49°33'35.6"N, 11°29'53.4"E, 420–460 m a.s.l. (ML 27. 6. 2011, CB 82616–82618); 3. – Wallersberg, slopes below village, 5933c, 50°02'32.2"N, 11°12'52.7"E, 390–400 m a.s.l. (ML, NM 25. 6. 2011, CB 82570–82571); 2. – Wunkendorf, ca 1.9 km NE of village, 5933b, 50°03'41.2"N, 11°16'27.7"E, 500 m a.s.l. (ML, NM 25. 6. 2011, CB 82578–82580); 3. – Wunkendorf, ca 600 m NE of village, 5933b, 50°03'10.7"N, 11°15'41.4"E, 460 m a.s.l. (ML, NM 25. 6. 2011, CB 82573, CB 82575–82576); 3.

Hungary. Csákvár, Vértes Mts, Nagy-Vasak hegy (NW of village), 8576c, 47°25'44.799"N 18°25'11.571"E, 380–410 m a.s.l. (ML, PL, GM 18. 7. 2011, CB 82513–82514, CB 82448, CB 82450, CB 82453, CB 82455); 7. – Csákvár, Vértes Mts, Szedres völgy, 8675b, 47°22'47.7"N, 18°19'42.5"E, 360–370 m a.s.l. (ML, PL, GM 19. 7. 2011, CB 82517–82519); 3. – Várpalota, Bakony Mts, ca 2.5–4.1 km N–E of town, 8774d, 47°12'57.4"N 18°06'54.0"E, 260–380 m a.s.l. (ML, PL, GM 19. 7. 2011, CB 82462–82463, CB 82469, CB 82524); 4. – Veszprém, Bakony Mts, rock at N edge of town, 8973a, 47°05'50.7"N, 17°53'00.4"E, 240 m a.s.l. (ML, PL, GM 20. 7. 2011, CB 82479); 1. – Veszprém, Bakony Mts, Tekeres völgy, 8973a, 47°05'53.8"N, 17°51'39.4"E, 260–270 m a.s.l. (ML, PL, GM 20. 7. 2011, CB 82535, CB 82537); 2. – Veszprém, Márkó, Malom hegy, 8872d, 47°06'38.7"N, 17°48'59.8"E, 310–360 m a.s.l. (ML, PL, GM 20. 7. 2011, CB 82472, CB 82528); 2. – Szentkirályszabadja, Balaton region, Malomvölgy, 8973d, 47°02'57.0"N, 17°59'9.04"E, 240–250 m a.s.l. (ML, PL, GM 20. 7. 2011, CB 82474–82477); 4. – Veszprém, N of town, 8973a, 47°05'43.3"N, 17°51'36.9"E, 270 m a.s.l. (ML, PL, GM 20. 7. 2011, CB 82449); 1.

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Hungary. Csákvár, Vértes Mts, Fejér megye, Köhányás, Németh-völgy, 8576c, 47°26'58.3"N, 18°23'39.7"E, 360–370 m a.s.l. (ML, PL, GM 19. 7. 2011); 3. – Várpalota, Bakony Mts, N of town, 8774d, 47°13'06.1"N, 18°06'43.2"E, 280 m a.s.l. (ML, PL, GM 19. 7. 2011); 2.