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Sorbus oravica (Rosaceae), a new remarkable endemic of *Sorbus* subgen. *Soraria* from Slovakia

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Abstract

A newly discovered species, *Sorbus oravica*, from northern and east-central Slovakia is described and illustrated, with a detailed account of its distribution. It is classified within the *Sorbus* subgen. *Soraria* and identified as an apomictic tetraploid species. The separation of *S. oravica* from related taxa was supported by molecular analyses (nuclear microsatellite markers) and extensive morphological comparisons. In addition, a determination key including all *S.* subgen. *Soraria* taxa occurring in Slovakia is provided.

Key words: apomictic taxa, chorology, flora, Europe, geographical distribution, hybridogenous species, Rosaceae, taxonomy, vascular plants

Introduction

Sorbus subgen. *Soraria* Májovský & Bernátová (2001: 21) is one of twelve accepted subgenera of the genus *Sorbus* L. (1753a: 477), although the majority of these are sometimes recognised as separate genera (Phipps *et al.* 1990, Májovský & Bernátová 2001, McAllister 2005, Rich *et al.* 2014, Sennikov & Kurtto 2017, Kurtto *et al.* 2018). The geographical distribution of members of this subgenus encompasses Europe and western Asia. Within Europe, it stretches from Spain in the west to Ukraine in the east and from Norway in the north to Greece in the south. Beyond European borders, its distribution extends from Turkey in the west to Kazakhstan in the east and from the Caucasus in Russia in the north to Iran in the south (Kurtto *et al.* 2018, POWO 2025). The distribution of representatives of this subgenus is predominantly confined to mountainous regions or more northerly areas characterised by an oceanic climate. They are derived from crosses between *S.* subgen. *Aria* Pers. (1806: 38) and *S. aucuparia* L. (1753a: 477), a member of *S.* subgen. *Sorbus*. To date, 50 species have been recognised (Kurtto *et al.* 2018, Sennikov & Kurtto 2017, Levin *et al.* 2018, POWO 2025). These species arise polytopically and are usually stabilized by an agamospermous mode of reproduction (apomixis). The existence of apomictic triploids and tetraploids has been documented, along with the occurrence of a sexual diploid hybrid between diploid and amphimictic species *S. aria* (L. 1753a: 475) Crantz (1763: 46) s.str. and *S. aucuparia* – *Sorbus* × *thuringiaca* (Nyman 1879: 241) Fritsch in Kerner (1896: 16) (Sennikov & Kurtto 2017, Kurtto *et al.* 2018). In terms of morphology, the subgenus is characterised by the following characters: simple, lobed, semi-pinnate, or pinnate leaf laminas with rounded, acute, or acuminate lobes or leaflets; if the leaf is

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pinnate, the terminal leaflet is larger than the lateral ones and usually lobed; laminas tomentose and greyish-green abaxially; fruits red to dark red with a small number of lenticels.

Slovakia, with 36 recorded *Sorbus* species, ranks fourth in *Sorbus* species richness in Europe, after Hungary, the United Kingdom, and Germany (Kurtto *et al.* 2018, Velebil *et al.* 2022). Despite the relatively good knowledge of the representation of individual species in the Slovak flora and their distribution (Májovský 1992, Velebil *et al*. 2022), many questions remain unanswered. To address these taxonomic uncertainties, a systematic survey was initiated in 2015 (see Velebil *et al.* 2022), with a focus on unresolved questions. Despite extensive fieldwork over the last decade, the diversity of the genus in Slovakia appears to be even greater than expected, suggesting the need for further fieldwork coupled with a biosystematic study using modern methods. One of the diversified groups of the Slovak *Sorbus* flora that needs to be studied in more detail is *Sorbus* subgen. *Soraria*. Field surveys revealed that the species richness of this subgenus is significantly underestimated, and that several populations, which may represent new species, require taxonomic evaluation.

To contemporary knowledge, six taxa of *Sorbus* subgen. *Soraria* are recognise in Slovakia (Kurtto *et al.* 2018). These include *S. buekkensis* (Soó 1937: 222) Soó (in Jávorka & Soó 1951: 248), *S. hazslinszkyana* (Soó 1937: 218) Boros (1949: 154), *S. hornadensis* Mikoláš (2015: 22), *S. pekarovae* Májovský & Bernátová (1996: 25), *S. scepusiensis* Kovanda (1986: 119) and *S.* × *thuringiaca*. At the very beginning of our research in Slovakia we encountered numerous populations of an unknown biotype of this subgenus. A more detailed study revealed that these populations, despite their unusually wide distribution, belong to a single species, which is described below.

Material and methods

Plant material and field work

Plant material was sampled between 2015 and 2024 following the recommendations of Meyer *et al.* (2005) and Rich *et al.* (2010) and papers published by Lepší *et al.* (2008, 2009). Mature and well-developed individuals were used for the study of phenotypic, cytological and genetic variation. For the morphological description, only well-developed, mature and intact leaves from the centre of short sterile shoots were collected, flattened and dried. Flowering and fructiferous parts were collected in mid-May and July or August, respectively, and stored in the herbarium and/or in 70% ethanol. Prior to flow cytometry analysis, fresh leaves were kept in plastic bags and stored at 4 °C for a few days. For the SSR analyses, fresh leaf tissue samples were collected in the field and rapidly desiccated in silica gel, and additional material from several herbarium specimens was also included, including the holotype of *S. hornadensis* (KO 31137). All analysed taxa and locality details are listed in Table 1. Altitudes and coordinates (WGS 84) were determined using a Garmin GPSMAP 60CSx instrument. For the taxonomic revision of the relevant *Sorbus* material the following public herbarium collections were examined (NYBG 2025): BP, BRA, BRNL, BRNM, BRNU, CB, CHEB, HOMP, KO, KMKV, LI, LIT, OL, PL, PR, PRA, PRC, ROZ, SAV, SLO, SOB, SOKO, SZB, SZU, W and WU. Herbarium specimens in the private collection of J. Velebil stored in Landscape Research Institute in Průhonice are designated as "herb. Velebil". The list of localities in chapter "Additional specimens examined (paratypes)" was arranged according to the phytogeographical division of Slovakia (Futák 1984) and subsequently by individual localities. In special cases, to clarify special terms or local geographic names, information in non-English herbarium labels was translated into English and placed in square brackets. Coordinates missing on herbarium sheets were added using online maps (http://www.mapy.com) and enclosed in square brackets. Acronyms of public herbaria are followed by specimen accession numbers if available. Finally, original determination and any subsequent revisions (if available) are given in square brackets. The identification key below is intended to assist distinguish members of the *Sorbus* subgen. *Soraria* and other morphologically similar taxa occurring in Slovakia, from *Sorbus oravica*.

Due to the lack of a widely accepted consensus on adopting a taxonomic treatment and a revised nomenclatural system that assigns distinct generic names to some or all parental lineage within *Sorbus* s.l. (Sennikov 2018, Sennikov & Kurtto 2017, Mosyakin *et al.* 2025), we adhere to the traditional approach of including all species within *Sorbus*, as has been done in several recent studies (e.g., Lepší *et al.* 2019, Meyer *et al.* 2020, Velebil *et al*. 2022, Németh *et al*. 2025). Similarly, we do not accept the catch-all concept that includes *Sorbus* s.l. together with other related genera (e.g., *Cotoneaster*, *Cydonia*, *Malus*, *Photinia*) into a broadly defined genus *Pyrus* (Christenhusz *et al.* 2018).

TABLE 1. List of analysed individuals from *Sorbus* subgen. *Soraria* and *S.* subgen. *Triparens*, including locality details. Methods used for analysis are abbreviated as follows: FCM—leaves analysed by flow cytometry; FCSS—seeds analysed by flow cytometry; SSRs—molecular analysis using microsatellite markers. Names of the most frequent collectors are abbreviated: DB = D. Bernátová, JV = J. Velebil, ML = M. Lepší, PL = P. Lepší.

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus × *thuringiaca*	*Soraria*	528/20	wild-collected	CB 87347	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57’20.16”N, 20°26’8.23”E	600	24 July 2020	DB, JV, ML	SSRs, FCM
Sorbus × *thuringiaca*	*Soraria*	386/23	wild-collected	CB 90158	SK	Selec, Selecké kamenné more nature reserve, Sokolova skala hill	48°46’45.1”N, 18°1’7.9”E	685	14 August 2023	JV, ML, PL	SSRs, FCM
Sorbus austriaca	*Soraria*	823/17	wild-collected	CB 84498	AT	Puchberg am Schneeberg, Grosser Saugraben valley	47°45’10.2”N, 15°49’32.0”E	1410	1 August 2017	JV, ML, PL	SSRs, FCM
Sorbus austriaca	*Soraria*	825/17	wild-collected	CB 84496	AT	Puchberg am Schneeberg, Puchberg Baumgartner railway stop	47°45’15.0”N, 15°50’44.3”E	1430	1 August 2017	JV, ML, PL	SSRs, FCM
Sorbus austriaca	*Soraria*	826/17	wild-collected	CB 84495	AT	Schneebergdörfl, riparian stand of a brook	47°46’30.4”N, 15°51’24.7”E	760	1 August 2017	JV, ML, PL	SSRs, FCM
Sorbus austriaca	*Soraria*	720/21	wild-collected	CB 88653	AT	Landsee, Landsee castle ruins, top of the castle tower	47°33’47.2”N, 16°20’55.2”E	620	14 August 2021	JV, ML	SSRs, FCM
Sorbus austriaca	*Soraria*	721/21	wild-collected	CB 88652	AT	Landsee, Landsee castle ruins, top of the castle tower	47°33’46.5”N, 16°20’59.3”E	650	14 August 2021	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	BBZ 003	herbarium	CB 89207	SK	Slovenský kras karst, Hačava village, Hájska dolina valley	48°38’36.7”N, 20°50’56.0”E	480	10 September 1986	J. Májovský	SSRs
Sorbus hazslinszkyana	*Soraria*	BBZ 047	herbarium	CB 89217	SK	Slovenský kras karst, Grečov vrch hill	48°39’54.3”N, 20°48’55.9”E	850	25 September 1986	I. Háberová	SSRs
Sorbus hazslinszkyana	*Soraria*	BBZ 049	herbarium	CB 88750	SK	Slovenský kras karst, Bôrka village	48°37’50.1”N, 20°46’10.7”E	590	26 September 1985	J. Májovský	SSRs
Sorbus hazslinszkyana	*Soraria*	BBZ 050	herbarium	CB 88755	SK	Slovenský kras karst, Zádielska dolina gorge	48°37’13.9”N, 20°49’56.6”E	280	26 September 1985	J. Májovský	SSRs

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus hazslinszkyana	*Soraria*	JV 150930	herbarium	Herb. Velebil 150930	SK	Slovenský kras karst, Turňa nad Bodvou village, Veľký Ščob hill	48°37'07.4"N, 20°51'03.6"E	545	6 September 2015	JV	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	66/19	wild-collected	CB 86518	SK	Slovenský kras karst, Turňa nad Bodvou village, Hradná stráň slope	48°36'55.4"N, 20°51'43.4"E	360	9 May 2019	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	476/20	wild-collected	CB 86838	SK	Slovenský kras karst, Turňa nad Bodvou village, Veľký Ščob hill	48°37'7.54"N, 20°51'3.89"E	540	22 July 2020	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	479/20	wild-collected	CB 86835	SK	Slovenský kras karst, Zádielsky kameň rock	48°37'12.97"N, 20°50'22.56"E	560	22 July 2020	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	482/20	wild-collected	CB 86847	SK	Slovenský kras karst, Zádielska dolina gorge	48°37'20.71"N, 20°50'13.85"E	590	22 July 2020	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	484/20	wild-collected	CB 86844	SK	Slovenský kras karst, Zádielska dolina gorge	48°37'22.69"N, 20°50'14.14"E	590	22 July 2020	JV, ML	SSRs, FCM
Sorbus hazslinszkyana	*Soraria*	505/20	wild-collected	CB 86878	SK	Slovenský kras karst, Hačava village, Jelení vrch hill	48°39'47.63"N, 20°49'57.97"E	780	23 July 2020	JV, ML	SSRs, FCM
Sorbus hornadensis	*Soraria*	BBZ 015	herbarium	CB 88855	SK	Kojšov village, Folkmarská skala rock	48°49'44.3"N, 21°0'34.4"E	900	4 July 1996	DB	SSRs
Sorbus hornadensis	*Soraria*	BBZ 016	herbarium	CB 88835	SK	Trebejov village, stone quarry	48°50'5.7"N, 21°13'39.4"E	350	1 October 1997	DB, J. Obuch	SSRs
Sorbus hornadensis	*Soraria*	BBZ 030	herbarium	CB 88834	SK	Trebejov village, stone quarry	48°50'5.7"N, 21°13'39.4"E	350	1 October 1997	DB, J. Obuch	SSRs
Sorbus hornadensis	*Soraria*	JV 150946	herbarium	Herb. Velebil 150946	SK	Obišovce village, an unnamed hill to the south of the village	48°51'23.1"N, 21°14'29.2"E	380	5 September 2015	JV	SSRs, FCM
Sorbus hornadensis	*Soraria*	JV 150947	herbarium	Herb. Velebil 150947	SK	Obišovce village, an unnamed hill to the south of the village	48°51'24.6"N, 21°14'27.8"E	355	5 September 2015	JV	SSRs, FCM
Sorbus hornadensis	*Soraria*	402/23	wild-collected	CB 90174	SK	Letkov village, light oak forest	48°51'4.6"N, 21°13'47.6"E	275	17 August 2023	JV, ML, PL	SSRs, FCM

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus hornadensis	*Soraria*	403/23	wild-collected	CB 90175	SK	Letkov village, light oak forest	48°51'5.0"N, 21°13'48.8"E	290	17 August 2023	JV, ML, PL	SSRs, FCM
Sorbus hornadensis	*Soraria*	404/23	wild-collected	CB 90176	SK	Letkov village, light oak forest	48°51'5.4"N, 21°13'49.4"E	300	17 August 2023	JV, ML, PL	SSRs, FCM
Sorbus hornadensis	*Soraria*	415/23	wild-collected	CB 90187	SK	Letkov village, light oak forest	48°51'4.5"N, 21°13'53.6"E	345	17 August 2023	JV, ML, PL	SSRs, FCM
Sorbus hornadensis	*Soraria*	418/23	wild-collected	CB 90190	SK	Letkov village, light oak forest	48°51'3.8"N, 21°13'53.7"E	290	17 August 2023	JV, ML, PL	SSRs, FCM
Sorbus hornadensis	*Soraria*	KO 31137	herbarium	KO 31137	SK	Kysak village, 0.5–0.6 km ESE of the village	48°51'6.0"N, 21°13'50.0"E	335	15 May 2012	V. Mikoláš	SSRs
Sorbus intermedia	*Triparens*	F-IV-5	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'35.9"N, 14°33'49.6"E	285	15 July 2025	JV	SSRs
Sorbus intermedia	*Triparens*	F-IV-71	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'39.0"N, 14°33'48.5"E	285	15 July 2025	JV	SSRs
Sorbus intermedia	*Triparens*	S-I-10	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'44.7"N, 14°33'47.8"E	290	15 July 2025	JV	SSRs
Sorbus mougeotii	*Soraria*	698/16	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'27.2"N, 14°33'37.9"E	290	15 July 2025	JV	SSRs
Sorbus mougeotii	*Soraria*	699/16	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'27.2"N, 14°33'37.9"E	290	15 July 2025	JV	SSRs
Sorbus mougeotii	*Soraria*	H-I-142	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'38.8"N, 14°33'28.2"E	290	15 July 2025	JV	SSRs
Sorbus oravica	*Soraria*	456/15	herbarium	Herb. Velebil 150916	SK	Vyšný Kubín village, Ostrá skala rock	49°11'31.9"N, 19°19'51.1"E	800	4 September 2015	JV	FCM, FCSS

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus oravica	*Soraria*	457/15	herbarium	Herb. Velebil 150915	SK	Vyšný Kubín village, Ostrá skala rock	49°11'31.5"N, 19°19'50.3"E	810	4 September 2015	JV	FCM
Sorbus oravica	*Soraria*	458/15	herbarium	Herb. Velebil 150914	SK	Vyšný Kubín village, Ostrá skala rock	49°11'29.8"N, 19°19'50.0"E	800	4 September 2015	JV	FCM
Sorbus oravica	*Soraria*	459/15	herbarium	Herb. Velebil 150913	SK	Vyšný Kubín village, Ostrá skala rock	49°11'28.7"N, 19°19'50.4"E	800	4 September 2015	JV	FCM, FCSS
Sorbus oravica	*Soraria*	460/15	herbarium	Herb. Velebil 150912	SK	Vyšný Kubín village, Ostrá skala rock	49°11'34.2"N, 19°19'40.5"E	740	4 September 2015	JV	FCM
Sorbus oravica	*Soraria*	215/16	herbarium	Herb. Velebil 160646	SK	Podbiel village, Biela skala hill	49°17'38.5"N, 19°29'42.7"E	670	8 June 2016	JV	FCM
Sorbus oravica	*Soraria*	216/16	herbarium	Herb. Velebil 160645	SK	Podbiel village, Biela skala hill	49°17'38.9"N, 19°29'42.4"E	680	8 June 2016	JV	FCM
Sorbus oravica	*Soraria*	217/16	herbarium	Herb. Velebil 160644	SK	Podbiel village, Biela skala hill	49°17'42.3"N, 19°29'38.8"E	740	8 June 2016	JV	FCM
Sorbus oravica	*Soraria*	1/1	wild-collected	Herb. Velebil 1707156	SK	Komjatná village, between Hlavačka and Žiar hills	49°08'24.5"N, 19°16'03.1"E	821	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	1/2	wild-collected	Herb. Velebil 1707157	SK	Komjatná village, between Hlavačka and Žiar hills	49°08'24.2"N, 19°16'02.0"E	822	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	1/3	wild-collected	Herb. Velebil 1707158	SK	Komjatná village, between Hlavačka and Žiar hills	49°08'24.5"N, 19°16'01.5"E	826	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	1/4	wild-collected	Herb. Velebil 1707159	SK	Komjatná village, between Hlavačka and Žiar hills	49°08'25.3"N, 19°16'00.6"E	831	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	1/5	wild-collected	Herb. Velebil 1707160	SK	Komjatná village, between Hlavačka and Žiar hills	49°08'25.4"N, 19°15'57.0"E	835	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	10/1	wild-collected	Herb. Velebil 170844	SK	Valaská Dubová, Sokol Mt.	49°08'06.6"N, 19°18'12.3"E	840	11 August 2017	DB	SSRs
Sorbus oravica	*Soraria*	10/2	wild-collected	Herb. Velebil 170843	SK	Valaská Dubová, Sokol Mt.	49°08'06.9"N, 19°18'23.4"E	882	11 August 2017	DB	SSRs

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus oravica	*Soraria*	10/3	wild-collected	Herb. Velebil 170845	SK	Valaská Dubová, Sokol Mt.	49°08'07.7"N, 19°18'23.6"E	887	11 August 2017	DB	SSRs
Sorbus oravica	*Soraria*	10/4	wild-collected	Herb. Velebil 170846	SK	Valaská Dubová, Sokol Mt.	49°08'08.6"N, 19°18'25.9"E	900	11 August 2017	DB	SSRs
Sorbus oravica	*Soraria*	10/5	wild-collected	Herb. Velebil 170847	SK	Valaská Dubová, Sokol Mt.	49°08'08.8"N, 19°18'25.7"E	922	11 August 2017	DB	SSRs
Sorbus oravica	*Soraria*	11/1	wild-collected	Herb. Velebil 170944	SK	Medzihradné village, rocks ESE of the village	49°11'58.2"N, 19°20'11.1"E	701	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	12/1	wild-collected	Herb. Velebil 170949	SK	Krivánska Malá Fatra Mts, Tiesňavy national nature reserve	49°14'41.0"N, 19°02'12.1"E	694	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	12/2	wild-collected	Herb. Velebil 170948	SK	Krivánska Malá Fatra Mts, Tiesňavy national nature reserve	49°14'41.2"N, 19°02'09.6"E	733	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	12/3	wild-collected	Herb. Velebil 170947	SK	Krivánska Malá Fatra Mts, Tiesňavy national nature reserve	49°14'41.0"N, 19°02'08.1"E	745	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	12/4	wild-collected	Herb. Velebil 170946	SK	Krivánska Malá Fatra Mts, Tiesňavy national nature reserve	49°14'40.2"N, 19°02'06.6"E	765	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	12/5	wild-collected	Herb. Velebil 170945	SK	Krivánska Malá Fatra Mts, Tiesňavy national nature reserve	49°14'39.8"N, 19°02'05.9"E	772	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	2/1	wild-collected	Herb. Velebil 1707170	SK	Vyšný Kubín village, Ostrá skala rock	49°11'31.9"N, 19°19'40.0"E	744	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	2/2	wild-collected	Herb. Velebil 1707171	SK	Vyšný Kubín village, Ostrá skala rock	49°11'34.0"N, 19°19'40.0"E	747	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	3/1	wild-collected	Herb. Velebil 1707165	SK	Vyšný Kubín village, Tupá skala rock	49°11'32.4"N, 19°19'33.6"E	800	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	3/2	wild-collected	Herb. Velebil 1707166	SK	Vyšný Kubín village, Tupá skala rock	49°11'32.1"N, 19°19'34.0"E	797	4 July 2017	DB	SSRs

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus oravica	*Soraria*	3/3	wild-collected	Herb. Velebil 1707167	SK	Vyšný Kubín village, Tupá skala rock	49°11'32.1"N, 19°19'32.7"E	798	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	3/4	wild-collected	Herb. Velebil 1707168	SK	Vyšný Kubín village, Tupá skala rock	49°11'31.1"N, 19°19'32.7"E	798	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	3/5	wild-collected	Herb. Velebil 1707169	SK	Vyšný Kubín village, Tupá skala rock	49°11'30.8"N, 19°19'32.6"E	799	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	4/1	wild-collected	Herb. Velebil 1707161	SK	Podbiel village, Biela skala hill	49°17'37.8"N, 19°29'43.5"E	661	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	4/2	wild-collected	Herb. Velebil 1707162	SK	Podbiel village, Biela skala hill	49°17'38.5"N, 19°29'42.8"E	677	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	4/3	wild-collected	-	SK	Podbiel village, Biela skala hill	49°17'38.9"N, 19°29'42.5"E	680	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	4/4	wild-collected	Herb. Velebil 1707163	SK	Podbiel village, Biela skala hill	49°17'39.1"N, 19°29'42.1"E	686	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	4/5	wild-collected	Herb. Velebil 1707164	SK	Podbiel village, Biela skala hill	49°17'39.6"N, 19°29'41.5"E	693	4 July 2017	DB	SSRs
Sorbus oravica	*Soraria*	6/1	wild-collected	Herb. Velebil 1707155	SK	Krivánska Malá Fatra Mts, Biela village, near Malý Rozsutec Mt.	49°14'26.7"N, 19°07'22.2"E	762	14 September 2017	DB	SSRs
Sorbus oravica	*Soraria*	611/17	wild-collected	Herb. Velebil 170611	SK	Chočské vrchy Mts, Šíp Mt.	49°9'55.8"N, 19°10'46.5"E	1155	7 June 2017	DB, JV	SSRs
Sorbus oravica	*Soraria*	613/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'53.8"N, 19°10'45.5"E	1145	7 June 2017	DB, JV	FCM
Sorbus oravica	*Soraria*	614/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'53.0"N, 19°10'46.0"E	1135	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	618/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'52.3"N, 19°10'47.4"E	1110	7 June 2017	DB, JV	SSRs
Sorbus oravica	*Soraria*	619/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'52.3"N, 19°10'47.0"E	1120	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	620/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'52.4"N, 19°10'46.5"E	1125	7 June 2017	DB, JV	SSRs, FCM

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus oravica	*Soraria*	629/17	wild-collected	-	SK	Chočské vrchy Mts, Šíp Mt.	49°9'53.7"N, 19°10'20.8"E	1115	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	630/17	wild-collected	-	SK	Chočské vrchy Mts, Zadný Šíp Mt.	49°9'47.1"N, 19°10'6.6"E	1140	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	631/17	wild-collected	-	SK	Chočské vrchy Mts, Zadný Šíp Mt.	49°9'47.0"N, 19°10'5.9"E	1144	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	632/17	wild-collected	-	SK	Chočské vrchy Mts, Zadný Šíp Mt.	49°9'46.9"N, 19°10'5.8"E	1140	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	633/17	wild-collected	-	SK	Chočské vrchy Mts, Zadný Šíp Mt.	49°9'46.4"N, 19°10'6.0"E	1130	7 June 2017	DB, JV	SSRs, FCM
Sorbus oravica	*Soraria*	BBZ 004	herbarium	CB 89072	SK	Slovenský raj Mts, Gačovská skala Mt.	48°52'27.6"N, 20°22'44.9"E	1100	14 September 1983	A. Petrík	SSRs
Sorbus oravica	*Soraria*	BBZ 009	herbarium	CB 89073	SK	Slovenský raj Mts, Prielom Hornádu nature reserve	48°56'41.9"N, 20°27'35.7"E	650	6 August 2013	D. Blanár	SSRs
Sorbus oravica	*Soraria*	BBZ 014	herbarium	CB 89081	SK	Slovenský raj Mts, Holý Kameň Mt.	48°53'43.4"N, 20°25'37.0"E	1065	2 July 2003	DB	SSRs
Sorbus oravica	*Soraria*	BBZ 020	herbarium	CB 89163	SK	Slovenský raj Mts, Ihrík hill	48°57'17.4"N, 20°26'1.9"E	610	4 July 2003	DB	SSRs
Sorbus oravica	*Soraria*	BBZ 023	herbarium	CB 89080	SK	Slovenský raj Mts, Holý Kameň Mt.	48°53'43.4"N, 20°25'37.0"E	1065	2 July 2003	DB	SSRs
Sorbus oravica	*Soraria*	BBZ 024	herbarium	CB 89076	SK	Slovenský raj Mts, Smižany-Maša village	48°56'50.6"N, 20°29'58.7"E	550	30 May 2013	DB, P. Kučera	SSRs
Sorbus oravica	*Soraria*	BBZ 039	herbarium	CB 88942	SK	Velká Fatra Mts, Kľak Mt.	49°2'47.0"N, 19°6'44.5"E	1394	26 June 1994	J. Kliment	SSRs
Sorbus oravica	*Soraria*	527/20	wild-collected	CB 87348	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57'20.09"N, 20°26'13.49"E	590	24 July 2020	DB, JV, ML	SSRs, FCM
Sorbus oravica	*Soraria*	530/20	wild-collected	CB 86901	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57'19.55"N, 20°26'3.91"E	610	24 July 2020	DB, JV, ML	SSRs, FCM

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TABLE 1. (Continued)

Taxon	Subgenus	Sample code	Sample origin	Accession number of herbarium specimen	Country (abbr.)	Locality	Geographic coordinates (WGS-84)	Altitude (m a.s.l.)	Sampling date	Collector	Methods used
Sorbus oravica	*Soraria*	532/20	wild-collected	CB 86899	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57'18.22"N, 20°25'50.99"E	600	24 July 2020	DB, JV, ML	SSRs, FCM
Sorbus oravica	*Soraria*	533/20	wild-collected	CB 86898	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57'18.61"N, 20°25'25.18"E	630	24 July 2020	DB, JV, ML	SSRs, FCM
Sorbus oravica	*Soraria*	535/20	wild-collected	CB 86896	SK	Slovenský raj Mts, from Letanovský mlyn settlement to Ihrík hill	48°57'16.96"N, 20°25'19.7"E	620	24 July 2020	DB, JV, ML	SSRs, FCM
Sorbus oravica	*Soraria*	G-II-42	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'27.9"N, 14°33'28.1"E	290	13 August 2025	JV	FCM, FCSS
Sorbus pekarovae	*Soraria*	651/17	cultivated	-	SK	Blatnica village, cultivated in the garden; the tree was grown from a type plant from locus classicus	48°56'8.4"N, 18°55'20.1"E	500	8 June 2017	JV	SSRs
Sorbus pekarovae	*Soraria*	JV 160639	herbarium	Herb. Velebil 160639	SK	Velká Fatra Mts, Pekárová Mt.	48°57'25.9"N, 18°57'57.6"E	935	7 June 2016	JV	SSRs, FCM
Sorbus pekarovae	*Soraria*	JV 160641	herbarium	Herb. Velebil 160641	SK	Velká Fatra Mts, Pekárová Mt.	48°57'33.4"N, 18°58'12.7"E	1050	7 June 2016	JV	SSRs, FCM
Sorbus scepusiensis	*Soraria*	BBZ 048	herbarium	CB 88867	SK	Kojšov village, Folkmarská skala rock	48°49'44.3"N, 21°0'34.4"E	900	4 July 1996	DB	SSRs
Sorbus scepusiensis	*Soraria*	G-II-23a	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'28.1"N, 14°33'27.5"E	290	15 July 2025	JV	SSRs
Sorbus scepusiensis	*Soraria*	G-II-23b	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'28.1"N, 14°33'27.7"E	290	15 July 2025	JV	SSRs
Sorbus scepusiensis	*Soraria*	G-II-23c	cultivated	-	CZ	Průhonice village, Dendrological garden of the Landscape Research Institute	50°0'28.1"N, 14°33'27.9"E	290	15 July 2025	JV	SSRs

Estimation of somatic DNA ploidy level

The DNA ploidy level of 59 individuals of *Sorbus* subgen. *Soraria* occurring in Slovakia and *S. intermedia* (Ehrh. 1784: 197) Pers. (1806: 38) was estimated using DAPI (4',6-diamidino2-phenylindole) flow cytometry. *Bellis perennis* L. (1753b: 886; 2C = 3.38 pg; Schönswetter *et al.* 2007) or *Carex acutiformis* Ehrh. (1789: 43; 2C = 0.86 pg; Lipnerová *et al.* 2013) were used as an internal standard. Leaf tissue (0.5 cm^2) of the analysed sample and an appropriate volume of the internal standard were chopped together in a Petri dish containing 0.5 ml Otto I buffer (0.1 M citric acid monohydrate, 0.5% Tween 20; Otto 1990). The nuclear suspension was then filtered through a 42 µm nylon mesh. After 10 min of incubation at room temperature, a staining solution consisting of 1 ml of Otto II buffer (0.4 M $Na_2HPO_4 \cdot 12 H_2O$; Otto 1990) supplemented with DAPI (final concentration 4 µg/ml; Sigma) and 2-mercaptoethanol (2 µl/ml) was added. The relative fluorescence intensity for 3,000 particles was measured on a CyFlow ML (Partec GmbH, Germany, now Sysmex) equipped with a UV LED (365 nm). Fluorescence histograms were further analysed using FloMax 2.0 software (Partec GmbH, Germany, now Sysmex). Ploidy levels were deduced from the sample/standard ratios based on previous karyological studies on the genus *Sorbus* (Lepší *et al.* 2008, 2015). The symbol ~ used in the text below indicates that the ploidy level for the given sample was determined using DAPI flow cytometry.

Flow cytometric seed screen

The mode of reproduction of *Sorbus oravica* was determined using the flow cytometric seed screen methodology (Matzk *et al.* 2000). In total, 20 seeds from three mother trees were successfully analysed. Lateral parts of the seeds were used for the analysis. The rest of the procedure generally copied that used for the leaf analysis. Modes of reproduction were inferred based on DNA ploidy levels of embryos and endosperms following Talent & Dickinson (2007).

Molecular analysis, nuclear microsatellite markers (SSR)

Genomic DNA of 91 individuals of *Sorbus* subgen. *Soraria* (eight species occuring in Slovakia) and *S. intermedia* was extracted from silica-dried leaves following the modified CTAB protocol (Doyle & Doyle 1987, Pfosser *et al.* 2005). Seven microsatellite primer pairs developed for the genera *Sorbus* (Mss5, Ms6g, Mss13, SA03, SA08 and SA191; Oddou-Muratorio *et al.* 2001, Nelson-Jones *et al.* 2002, González-González *et al.* 2010) and *Malus* (CH02D11; Gianfranceschi *et al.* 1998) were used for the genotyping of adult trees. Forward primers were fluorescently labelled with 6-FAM, NED or HEX fluorescent dyes. Two multiplex PCR amplifications using a QIAGEN multiplex PCR kit were performed for each sample. The reaction of the total volume of 12 µl consisted of 6 µl of Qiagen M.mix, 1 µl of DNA (10 ng/µl), ddH_2O and 0.1 µl of each primer (Ms6g, Mss13 and SA03) in multiplex I or 0.1 µl (Mss5, SA08, SA191) and 0.07 µl (CH02D11) in multiplex II. Thermocycling conditions were 95 °C for 15 min; 35 cycles of 94 °C for 30 s, 55 °C for 90 s and 72 °C for 60 s; and a final extension of 60 °C for 30 min. Amplification products were separated using a 3130xl Genetic Analyzer (Applied Biosystems) with a GeneScan ROX 500 size standard (Applied Biosystems). Fragment sizes were scored manually by GeneMarker 1.8.0 (SoftGenetics). Due to different ploidy levels of the analysed samples, the microsatellite patterns were scored as "allele phenotypes" (Becher *et al.* 2000), followed by conversion of the data set to a binary matrix. For differentiation of individual groups (taxa), we plotted genetic distances among individuals using principal coordinate analysis (PCoA) based on Jaccard distance calculated in PAST (v. 2.17; Hammer *et al.* 2001). Intraspecific variation of *S. oravica* was measured using Arlequin ver. 3.5 computer program (Excoffier & Lischer 2010), which computes the average gene diversity of all loci (AGD; Nei 1987).

Results and discussion

Sorbus oravica Velebil, Bernátová, M. Lepší & P. Lepší *sp. nov.* (Figs. 1–3)
Sorbus austriaca auct., *S. hazslinszkyana* auct.

Type:—SLOVAKIA. Distr. Dolný Kubín, Vyšný Kubín, quadrant 6881b, Tupá skala rock, ca 390 m W of summit of Ostrá skala hill, edge of scrub, scattered, tree ca 5 m high, 780 m, 49°11'30.6''N, 19°19'31.4''E, 31 August 2018, *J. Velebil, D. Bernátová, M. Lepší & P. Lepší 459* [holotype: CB 85718! Isotypes: BP, BRA, PR].

FIGURE 1. Holotype of *Sorbus oravica* (CB—No 85718).

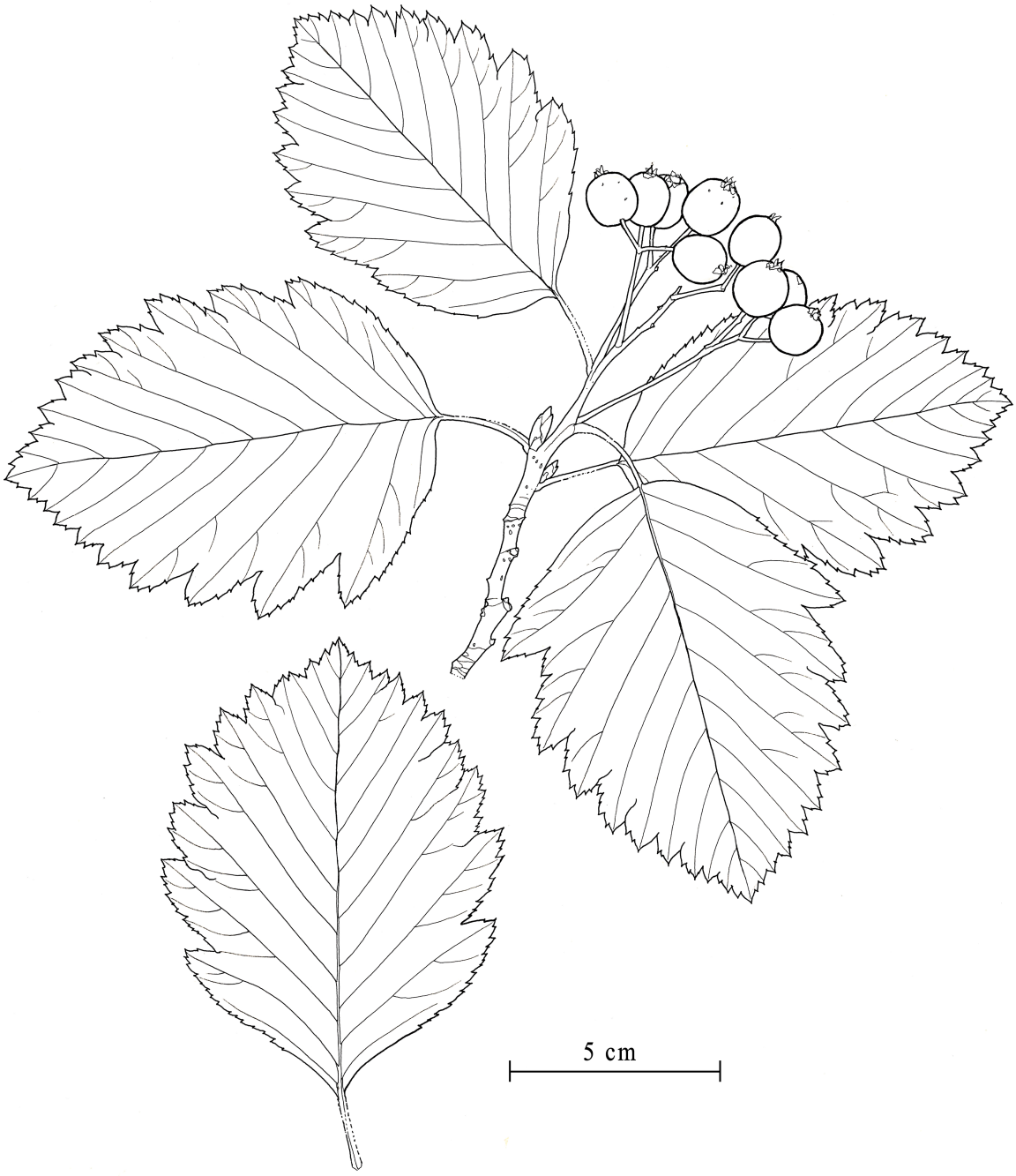

FIGURE 2. *Sorbus oravica*: short fructiferous shoot (top) and leaf from middle part of short sterile shoot (bottom). Drawn by A. Skoumalová.

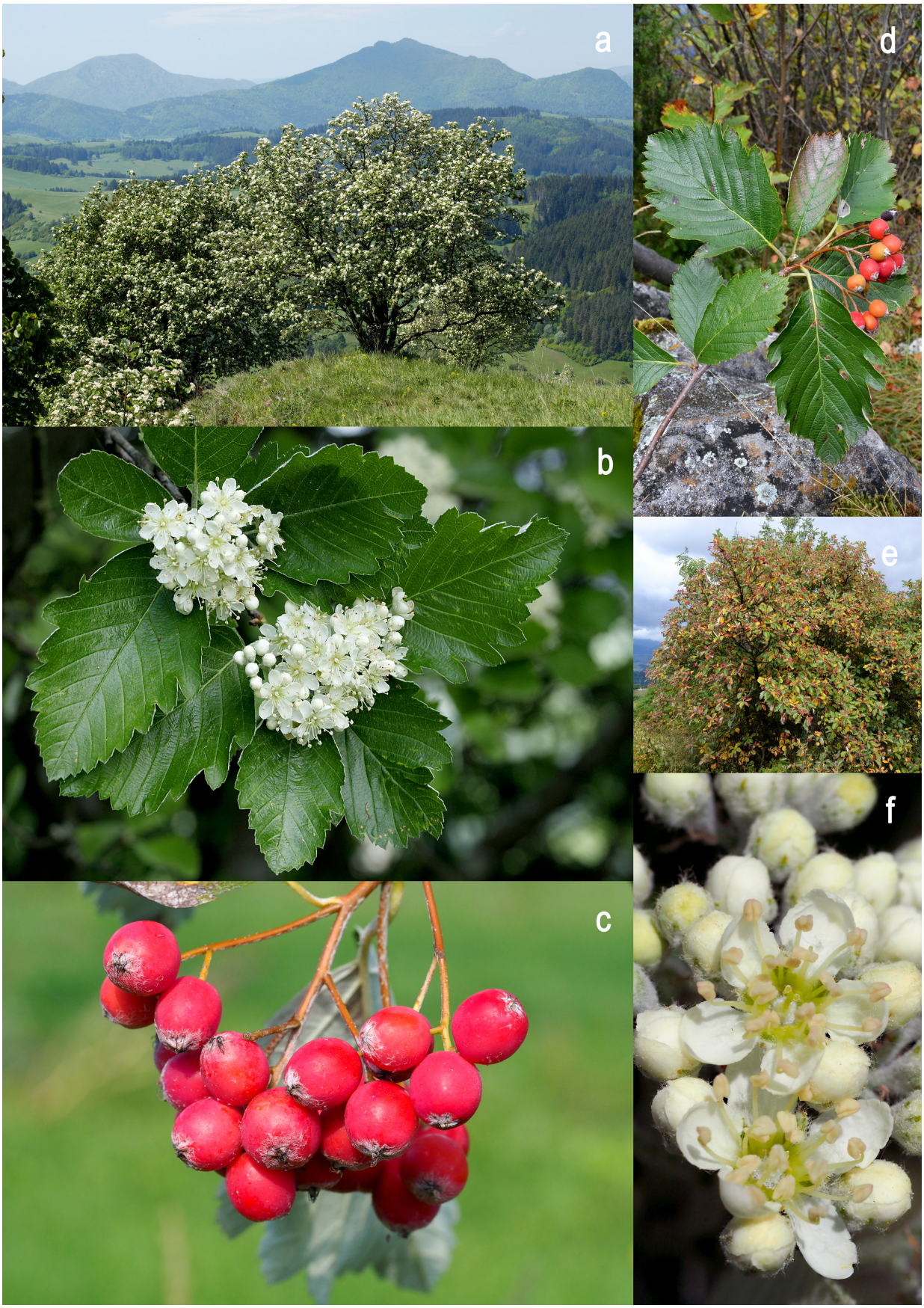

FIGURE 3. *Sorbus oravica*: a) typical habitus, b) flowering short shoots, c) infructescence, d) fructiferous shoot, e) fruiting tree, f) flowers with pinkish tinge and bicoloured anthers. All photos were taken at the locus classicus on the Tupá skala rock (a–b: Z. Vlach, c–f: J. Velebil).

Description:—Large shrubs or polycormic trees with (1–)3–5(–7) trunks up to 12 m high. Bark grey to dark grey, smooth until the old age, with light grey to ochraceous lenticels. Twigs brownish-grey; young shoots brown, sparsely tomentose when young, glabrescent when mature, with numerous elliptical or almost circular, pale brown to ochraceous lenticels. Buds ovoid, narrowly ovoid to turbinate; scales green, with narrow, brown, sparsely tomentose margins. Leaf laminas on short sterile shoots simple, broadly elliptical or sometimes broadly ovate, (8.5–)10–10.5(–11.5) cm long and (6–)7–8(–8.5) cm wide, (1.2–)1.3–1.4(–1.6) times as long as wide, widest at (38–)47–53(–57) % of the lamina length (from the base), with acute apex with an angle of (82–)101–111(–116)°, broadly cuneate and partly serrate at base, with angle of (88–)101–114(–129)°, flat or slightly undulate at margins, regularly lobed (double serrate apically), leathery, ± glossy, dark green, initially sparsely tomentose, later glabrescent on upper surface and evenly greyish-green tomentose on lower surface; main veins (9–)10–11(–12) on each side, terminating in lobes or teeth; the 3rd vein from the laminar base at an angle of (34–)39–44(–48)° to midrib; lobes acuminate, bluntly acute to rounded, serrate or doubly serrate at margins with big acuminate terminal tooth; other teeth of comparable size or smaller, acuminate; external outline of lobes more or less arcuate; laminar margin between tops of the 2nd and 3rd lobe from the base with (6–)7–9(–12) teeth; outline angle of the 3rd lobe (47–)52–56(–64)°; incision between the 2nd and 3rd lobe (5.3–)7.7–9.8(–12.8) mm; petioles (13–)17–21(–24) mm long, tomentose. Leaf laminas on short fertile shoots similar in shape and size but more distinctly undulate at margin, broadly ovate and usually ± rounded at base. Inflorescences compact, convex, with tomentose branchlets. Flowers 1.5–2 cm in diameter. Sepals triangular, acute or acuminate, tomentose on both surfaces, spreading in blossom, erect, persistent and dry on fruit. Petals (5.5–)7–8(–9) mm long and (4.5–)5–6(–6.5) mm wide, broadly ovate or broadly elliptical, concave, white, spreading, sparsely tomentose on upper surface, glabrous on lower surface, with a short claw. Stamens approx. 20; anthers bicoloured, with majority of the surface pale pink and usually deep pink at the side of filament insertion. Ovary semi-inferior. Styles 2–3, free or connate, tomentose at base. Fruits ellipsoidal to sub-globose, (12–)13–14(–15) mm long and (11–)12–12.5(–14) mm wide, longer than wide or as wide as long, dark red, sometimes with a violet-purple tinge at maturity, tomentose at top, otherwise glabrescent, matt, with (2–)4–6(–9) lenticels per 25 mm^2; mesocarp heterogeneous; endocarp cartilaginous. Seeds fuscous. Reproduction apomictic. Flowering V–VI.

Etymology:—The epithet "oravica" is derived from the historical Slovak region of Orava, where the first and abundant populations of the species were discovered. We propose the name "jarabina oravská" for the Slovak name.

Diagnostic characters:—Leaf laminas on short sterile shoots broadly elliptic or sometimes broadly ovate, with acute apex, broadly cuneate at base, with angle of (88–)101–114(–129)°, flat or slightly undulate at margins, rather iregularly lobed (double serrate apically), leathery; petiole (13–)17–21(–24) mm long. Leaf laminas on short fertile shoots more distinctly undulate at margin, broadly ovate and usually ± rounded at base. Fruits ellipsoidal to sub-globose, (12–)13–14(–15) mm long and (11–)12–12.5(–14) mm wide, longer than wide or as wide as long, dark red, sometimes with violet-purple tinge at maturity, with (2–)4–6(–9) lenticels per 25 mm^2.

Taxonomy, similar species and phenotypic variation:—The presence of leaf laminas with blunt lobes in outline and greyish-green indumentum on their abaxial side, in conjunction with dark red fruit with only a few lenticels, enables the classification of *Sorbus oravica* as a member of the *S.* subgen. *Soraria*. In this subgenus, the most similar species in Slovakia is *S. hazslinszkyana*. This species differs mainly in the shape of the leaf laminas of short fertile shoots, which are distinctly widest in the lower third of the lamina length, giving a more broadly ovate shape and are less undulate at the margins. The lobes of the leaf laminas of short sterile shoots of *S. hazslinszkyana* are more rounded and regular in shape and the teeth on the margins of the laminas are less pointed (Fig. 4a). Finally, anthers of *S. hazslinszkyana* are ivory white, yellow, or exceptionally with a pinkish tinge but not conspicuously bicoloured (Fig. 5).

Sorbus oravica may resemble some members of *Sorbus* subgen. *Triparens* M.Lepší & T.C.G.Rich (in Rich *et al.* 2014: 11) which have similar shape of leaf lobes but differ in having yellowish-green leaves abaxially. However, no species of this subgenus has been recorded in Slovakia except for cultivated and escaped *S. intermedia.* Even some members of the *S.* subgen. *Aria* may resemble *S. oravica*, especially those with lobed laminas. Lobed leaves may be present in some individuals of *Sorbus aria* (Fig. 6d), which are distinguished by their thinner and longer laminas and the fact that each individual within the population is morphologically different from any other individual, i.e. they do not form morphologically homogeneous populations, as is the case with the agamospermic species *S. oravica*. *Sorbus javorkana* Somlyay, Sennikov & Vojtkó (Somlyay *et al.* 2017: 230) (Fig. 6e), another member of the *S.* subgen. *Aria*, which is sympatric with *S. oravica*, also may have lobed leaves, but differs in the shape of the laminas, which are narrowly elliptic-obovate to obovate, with an incision between the 2nd and 3rd lobes only 4–7 mm deep, and a narrowly cuneate base.

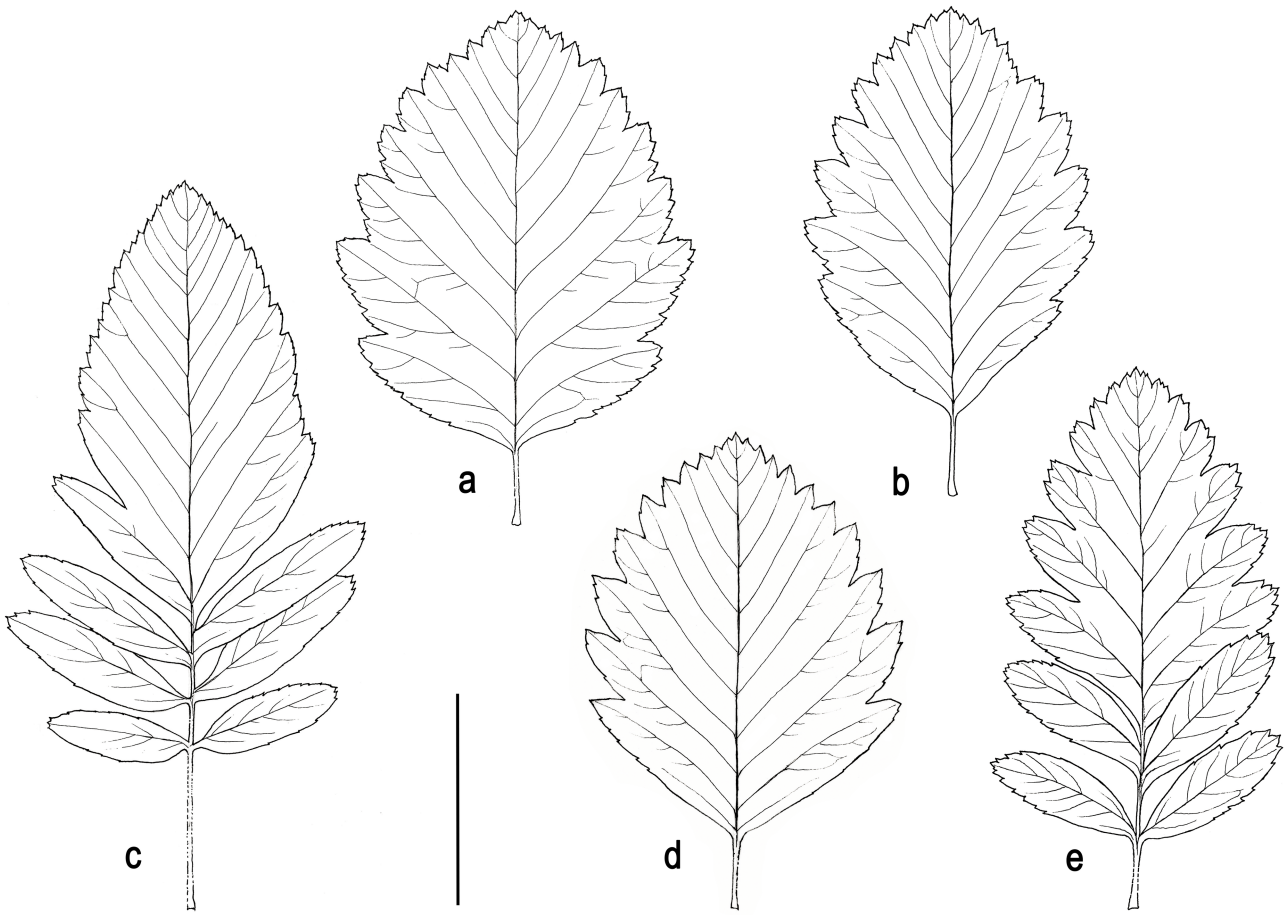

FIGURE 4. Leaves from middle part of short sterile shoots of selected members of *Sorbus* subgen. *Soraria* occurring in Slovakia: a) *S. hazslinszkyana*, b) *S. hornadensis*, c) *S.* × *thuringiaca*, d) *S. pekarovae*, e) *S. hybrida*. Scale bar 5 cm. Drawn by A. Skoumalová.

Morphologically, *Sorbus oravica* is relatively uniform and shows little phenotypic plasticity in relation to the environment. Plants from shaded situations tend to have larger leaves with the lateral veins less numerous and the lobes more rounded. Irrespective of environmental conditions, some leaves from short fertile shoots may exhibit a characteristic concave curvature of one or both sides of the leaf base, on occasion extending to the outer side of the basal lobe (Fig. 2). The intensity of the pink colour on the anthers can vary in some years, depending on the weather, from distinctly deep pink to light pink, and sometimes the anthers are less distinctly bicoloured. No hybridization with other sympatric species was recorded.

Distribution:—*Sorbus oravica* occurs in northern and central-eastern Slovakia. From a biogeographical point of view, this species represents a relict montane West Carpathian endemic. It was recorded in two areas, which are 75 km apart (Fig. 7) and was found in six phytogeographical districts or subdistricts (Futák 1984). The first area stretches from Krivánska Malá Fatra Mts and Chočské vrchy Mts to Západné Beskydy hills. The westernmost locality lies close to Terchová village in the Krivánska Malá Fatra Mts and the north-easternmost occurrence is situated near the village of Podbiel in the Západné Beskydy hills in Orava region. The southernmost locality of this western area is a summit of Kľak Mt. in Veľká Fatra Mts. The most vital and numerous populations occur particularly in the following localities: Tupá and Ostrá skala hills, Šíp Mt., Malý Rozsutec Mt., Veľký Rozsutec Mt., rocks around the village of Valaská Dubová and Biela skala hill. The second area with an occurrence of *S. oravica* is located in the Slovenský raj Mts, with only a slight overlap of the boundaries of this area with one other phytogeographical districts, the Slovenské rudohorie Mts. The most abundant populations were record in the valley of Hornád river in the north and in the vicinity of Dedinky village in the south. The most distant sites within the total distribution of the species are located 110 km apart. The altitudinal range of the species spans from 550 m (valley of Hornád river in Slovesnký raj Mts near the village of Spišské Tomašovce and the base of the Biela skala hill near the village of Podbiel) to approximately 1500 m (the summit of Veľký Rozsutec Mt.). To the best of our current knowledge, the geographical distribution of the species does not coincide with that of any other species in the *S.* subgen. *Soraria*.

FIGURE 5. *Sorbus hazslinszkyana*: flowers with ivory-white and uniformly coloured anthers. Slovakia, Turňa and Bodvou, rocks north-west of the village (J. Velebil).

Research into the full distribution of *Sorbus oravica* is ongoing, but it is likely that the species can be found in several other locations, especially in the areas of Chočské vrchy Mts and Slovenský raj Mts, from where there are dozens of herbarium specimens of *Sorbus* biotypes similar or identical with the species. These occurrences require further investigation in the field. The reasons for the species' occurrence in the two mutually isolated areas are not yet clear. It is unclear whether the species is a remnant of a former widespread distribution, or whether some of the localities have been formed by long-distance dispersal. Further detailed surveys of the area will hopefully provide more information on this matter.

Ecology:—*Sorbus oravica* occurs in the montane and supramontane zones of the Western Carpathians, with sporadic occurrences extending to the subalpine zone. The species' occurrence is associated with rugged, extremely rocky complexes on sharp mountain ridges of the Krivánska Malá Fatra Mts, Chočské vrchy Mts, Slovenský raj Mts, and Západné Beskydy hills. It has also been recorded on isolated limestone outcrops, such as those found on the Tupá and Ostrá skala hills above the town of Vyšný Kubín, and on steep rock formations of the flysch zone, as seen in the Biela skala hill near Podbiel.

The species has been documented in the vegetation of relict calcareous pine forests, as well as in rock communities of open habitats. Notably, it has been observed to persist in distinct and ecologically extreme habitats such as rubble fields and isolated rocks. It also grows on the margins of open, steep limestone beech forests and is rarely a component of relict *Pinus mugo* Turra (1764: 152) stands.

At the "locus classicus" of the Tupá skala rock complex (813.6 m) above Vyšný Kubín village, *Sorbus oravica* contributes to the present structure and composition of the vegetation on the vertical rocky cliffs of the *Festuco pallentis-Aurinietum saxatilis* Klika ex Čeřovský 1949 corr. Gutermann & Mucina 1993 association, while in the overgrown ravines it is integrated into the adjacent shrublands. Near the upper edges of the cliffs, it is found in the vegetation of dry herbaceous margins with *Geranium sanguineum* L. (1753b: 683) and *Anemone sylvestris* L. (1753a: 540). At the summit of Šíp Mt., *S. oravica* was found on the edge of the open vegetation of the association *Seslerio variae-Caricetum approximatae* Bernátová & Kliment 1982, situated on the steep southern slopes below the summit between rock ribs.

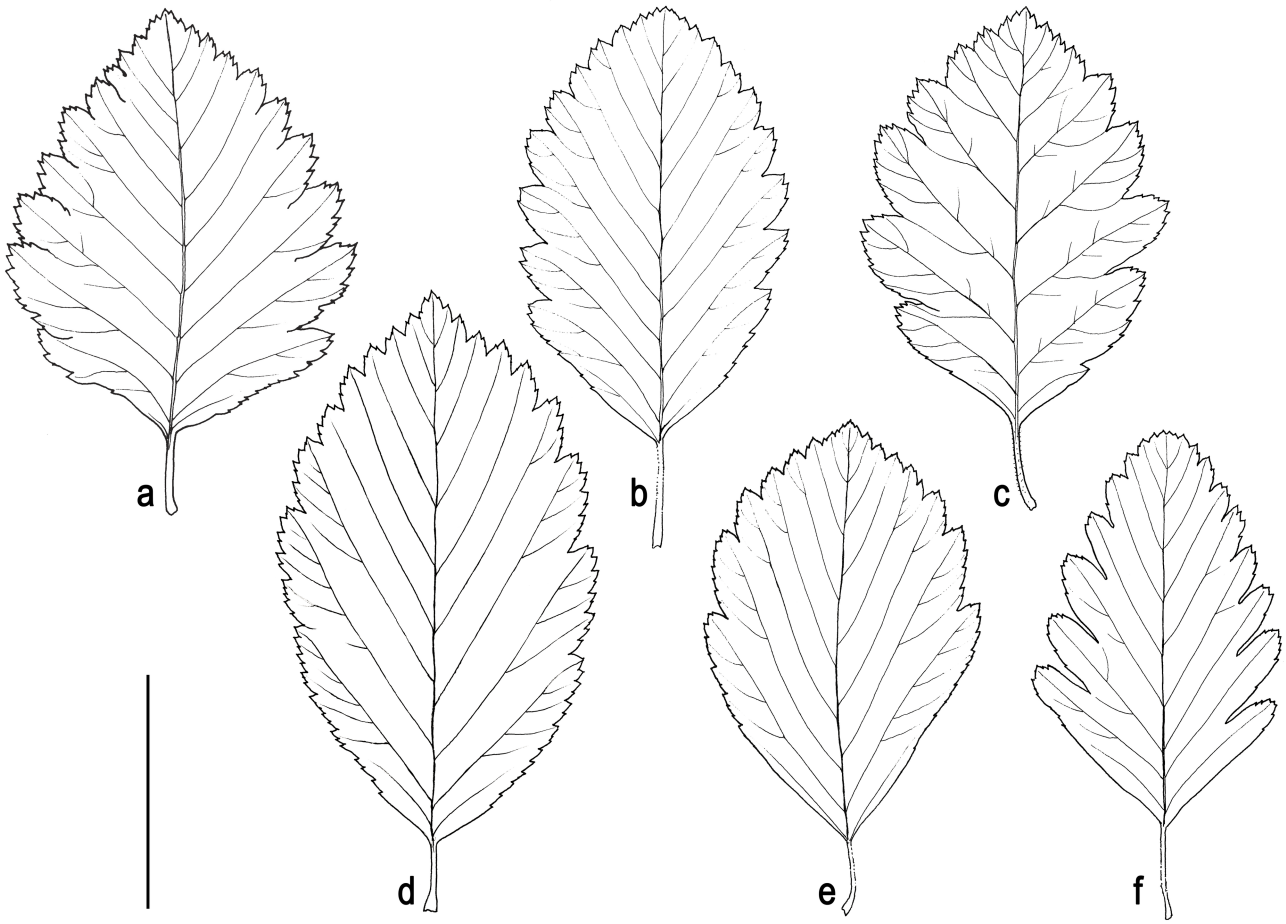

FIGURE 6. Leaves from middle part of short sterile shoots of selected members of *Sorbus* subgen. *Soraria*, *S.* subgen. *Triparens* and *S.* subgen. *Aria* occurring in Slovakia: a) *S. austriaca*, b) *S. mougeotii*, c) *S. intermedia*, d) *S. aria*, e) *S. javorkana*, f) *S. scepusiensis*. Scale bar 5 cm. Drawn by A. Skoumalová.

Historical records:—The oldest herbarium specimen of *Sorbus oravica* dates from 1889. It is stored in the BRNM! and was collected by V. Vraný, a Czech botanist who lived and taught in Slovakia. Unfortunately, the localisation of the collected specimen was given only in general terms as "Oravicza" (Orava region), and instead of a specific location, only the biotope ("auf der Roll" [on rubble]) is described. Two other old specimens, one collected by L. Thaisz and the other by N. Filarszky and J. B. Kümmerle (probably on a joint excursion on the same day) were collected near the village of Dobšiná on 2 June 1906 (BP!).

Some records of *Sorbus austriaca* (Beck 1892: 714) Hayek (1905: 9) from the Choč and Malý Rozsutec mountains mentioned by Klika (1937: 206), most likely refer to *S. oravica*, but no specimens to support this hypothesis were found in the herbaria studied. Similarly, information from Májovský (1992) on the occurrence of *S. hazslinszkyana* from the Slovenský raj Mts, where only *S. oravica* is known, probably refers to this species. In contrast, the records of *S. mougeotii* subsp. *austriaca* from the Slovenský raj Mts (Kovanda 1961: 61) are documented by herbarium specimens and certainly belong to *S. oravica*, and therefore we include them in the list of paratypes below.

A survey of herbarium collections revealed that *Sorbus oravica* was identified as *S. aria* (L. 1753a: 475) Crantz (1763: 46), *S. austriaca*, *S. carpatica* (Soó 1937: 222) Kárpáti (1944: unnumbered page), *S. latifolia* f. *superaria* (?) or *S. mougeotii* pr. *typica* (?). *Sorbus oravica* has been revised by contemporary botanists as *S. austriaca*, *S. austriaca* s.l., *S. hazslinszkyana* s.l. or *S. hornadensis* s.l. Vlastimil Mikoláš, an author of several descriptions of *Sorbus* species used several provisional names for *S. oravica* from the Slovenský raj Mts such as "*S. centralis* Mikoláš ined., *S. circumcideris* Mikoláš ined., *S. laticentralis* Mikoláš ined., *S. paradisi-slovaci* Mikoláš ined. or *S. stratense* Mikoláš ined.". There is even a herbarium specimen in the KO herbarium from 2015 with the name "*Hedlundia paradisi-slovaci* Mikoláš" titled "holotypus" (KO 33390!), but no such name has ever been published.

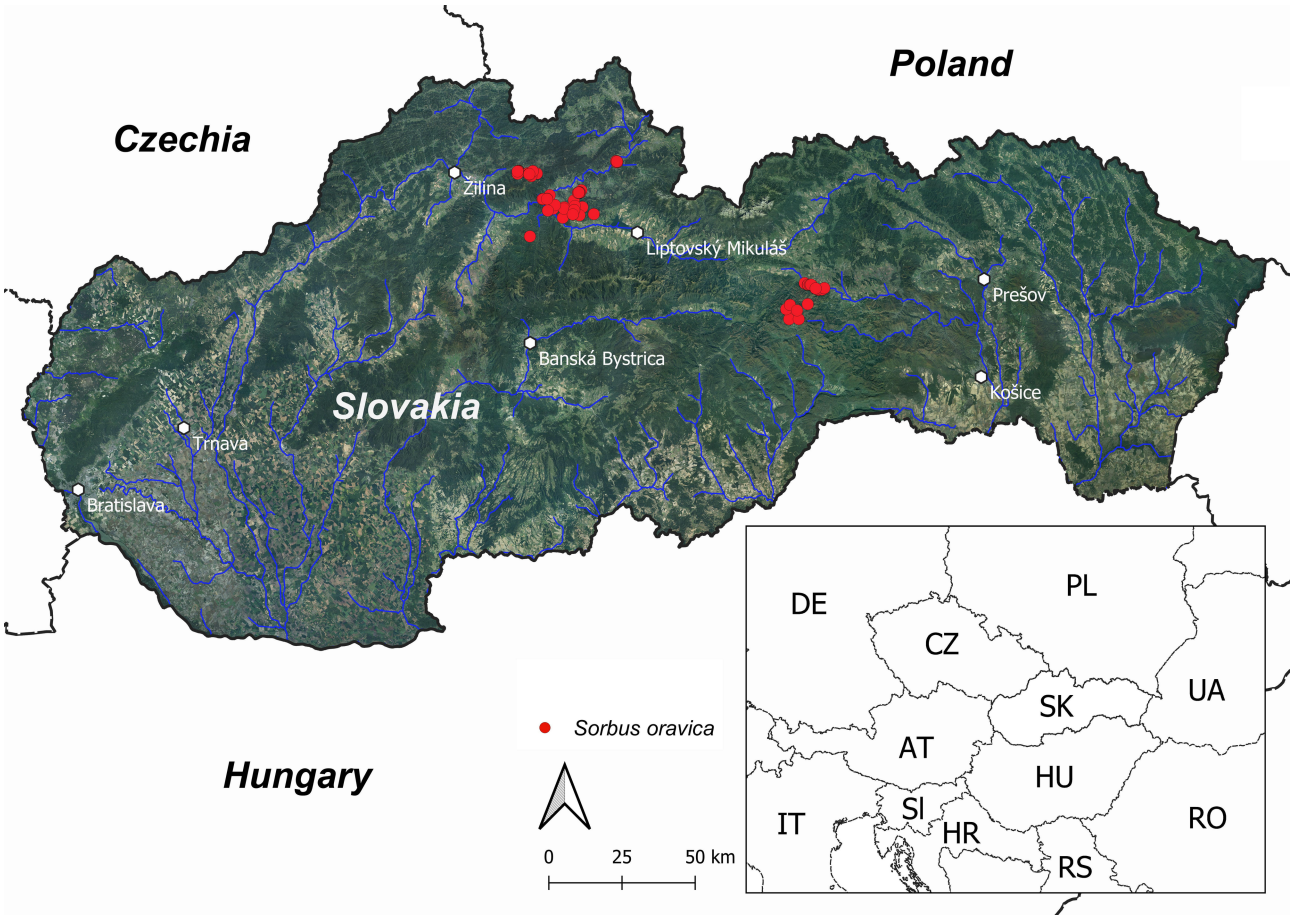

FIGURE 7. Distribution map of *Sorbus oravica* (source © GKÚ Bratislava, NLC).

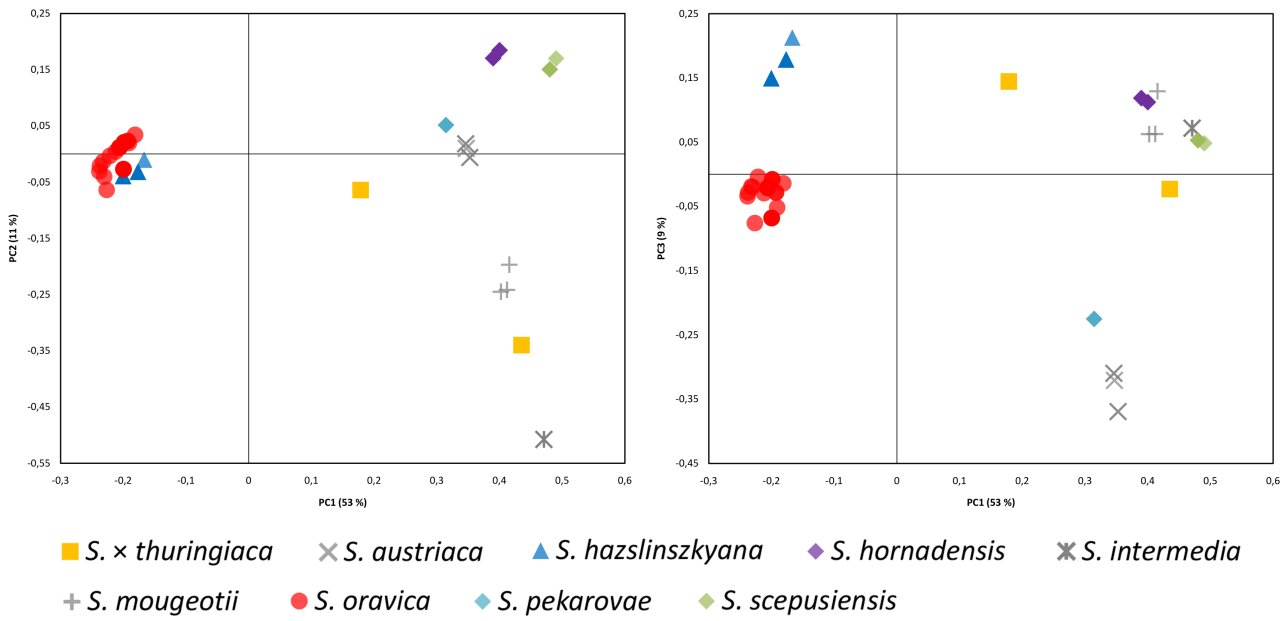

FIGURE 8. Principal coordinate analysis of *Sorbus* microsatellite data based on Jaccard distances of 91 individuals belonging to *S.* subgen. *Soraria* and *S.* subgen. *Triparens* (*S. intermedia*). The first, second and third ordination axes explain 53.2 %, 11.0 % and 9.1 % of the overall variation, respectively. The color intensity of the symbol reflects the number of detected genotypes—darker shades indicate a higher number of identical genotypes.

Despite the fact that numerous expeditions to *Sorbus oravica* localities have been carried out by D. Bernátová since 1983, as evidenced by the numerous specimens in the CB, it was not until 2015 that a systematic study of the species was initiated by J. Velebil. Consequently, employing contemporary biosystematic methodologies, significant insights have been obtained into variability, plasticity, biology and distribution of the species in collaboration with the other authors of the paper.

Additional specimens examined (paratypes):—**SLOVAKIA. Slovenské rudohorie**: Dobšiná, Langenberg [probably Dobšinský kopec hill], [original determination: *S. aria*], [48°50'52.0"N, 20°23'21.5"E], 2 June 1906, *Filarszky & Kümmerle s.n.* (BP 702635!); **Slovenský raj**: Gačovská skala, vrchol, 1100 m a.s.l., [48°52'27.6"N, 20°22'44.9"E], 14 September 1983, *A. Petrík s.n.* (CB 89072!); Bohemoslovacia, Slovacia centr., regio Slovenský raj, opp. Dobšiná, pagus Dedinky: in vallo ferroviae in ripa merid. lacus structilis Palcmanská Maša, contra pagum Dedinky, in peripheria boreal. vici Dobšinská Maša, [original determination: *S. austriaca*], 780 m a.s.l., [48°51'30.0"N, 20°22'0"E], 6 August 1991, *Štěpánek s.n.* (PR 757157!, 757158!); In montibus inter opp. Dobsina [Dobšiná] et pagum Sztraczena [Stratená]. Com. Gömör [Gemersko-malohontská župa], [original determination: *S. mougeotii* pr. *Typica*], [48°50'45.0"N, 20°20'40.1"E], 2 June 1906, *de Thaisz s.n.* (BP 702634!); Slovenský raj: Smižianska Maša, [48°56'50.557"N, 20°29'58.700"E], 30 May 2013, *Bernátová & Kučera s.n.* (CB 89076!, CB 89077!, CB 89078!, CB 89079!); Comit. Szepes [Spiš]: in convalle Hernád áttörése [breakthrough of Hornád] ad p. Káposztafálva [Hrabušice], [original determination: *S. austriaca*, rev. V. Mikoláš – non], [48°57'33.4"N, 20°24'24.4"E], 21 June 1910, *Filarszky & Moesz s.n.* (BRNU 162745!); Slovenský raj, Hrabušice, sestup k Letanovskému mlýnu od Kláštoriska, velká skála, [original determination: *Sorbus* sp.], [48°57'13.9"N, 20°26'30.9"E], 24 August 1961, *Holub s.n.* (PRA s.n.!); Slovenský ráj, Ihrik, [original determination: *S. aria*], [48°57'17.9"N, 20°26'0.9"E], 31 May 1972, *Koblížek & Chmelař s.n.* (BRNL 22568!); Slovenský raj: Hrabušice, 650 m a.s.l., [48°57'17.5"N, 20°25'16.6"E], 21 October 1986, *Leskovjanská s.n.* (SLO s.n.!); Slovenský raj: Ihrík, [original determination: *S. austriaca*, rev. V. Mikoláš – *S. paradisi-slovaci* ined.], 650 m a.s.l., [48°57'18.1"N, 20°26'0.7"E], 3 August 1974, [*illegible*] *s.n.* (SLO s.n.!); Szepes [Spiš]: in convalle Hernád áttörése [breakthrough of Hornád] ad p. Káposztafálva [Hrabušice], [original determination: *S. austriaca*], [48°57'33.4"N, 20°24'24.4"E], 21 June 1910, *Filarszky & Moesz s.n.* (BP 702625!); Holý Kameň, [original determination: *S. austriaca*, rev. V. Mikoláš – *S. laticentralis* ined., *S. paradisi-slovaci* ined.], 1070 m a.s.l., [48°53'43.4"N, 20°25'36.9"E], 13 August 1973, *Pitoniak s.n.* (SLO s.n.!); Slovenský raj: in declivi saxoso australi supra angustias Prielom Hornádu prope montem Zelená hora haud procul opp. Spišská Nová Ves, [48°57'29.6"N, 20°24'24.4"E], 15 August 1958, *Soják s.n.* (PR s.n.!); Slovenský raj: Špišská Nová Ves, Holý kameň, [48°53'43.4"N, 20°25'36.9"E], 2 July 2003, *Bernátová s.n.* (CB 89080!, CB 89081!); Slovenský raj: Špišská Nová Ves, PR Prielom Hornádu, skalnatá dubová lipina, [original determination: *S. austriaca* non (Beck) Hedlund], [48°56'41.9"N, 20°27'35.7"E], 6 August 2013, *Blanár s.n.* (CB 89073!, CB 89074!); Slovenský raj: Špišská Nová Ves, PR Prielom Hornádu, skalnatá dubová lipina, [osobitná populácia zo skupiny; original determination: *S. austriaca* non (Beck) Hedlund], [48°56'41.9"N, 20°27'35.7"E], 6 August 2013, *Blanár s.n.* (CB 89075!); Čingov až Hrdlo Hornádu, [original determination: *S. austriaca*, rev. V. Mikoláš – *S. hornadensis* s.l.], 580 m a.s.l., [48°56'33.4"N, 20°29'25.4"E], 24 May 1974, [*illegible*] *s.n.* (SLO s.n.!); Easter Slovakia, Slovenský raj, village of Spišské Tomášovce, ca 1.5 km S of village, rock formation of Tamášovský výhľad, [original determination: *Hedlundia paradisi-slovaci* Mikoláš], 48°56'42"N, 20°27'35"E, 24 October 2015, *Mikoláš s.n.* (KO 33390!); Nad Lesnicou [Slovenský raj, pri Tomáš. výhľade], [original determination: *S. austriaca*], 550 m a.s.l., [48°56'27.8"N, 20°28'20.2"E], 5 August 1973, [*illegible*] *s.n.* (SLO s.n.!); Nad Letanovským mlynom, ľavá strana Hornádu, [rev. V. Mikoláš – *S. hazslinszkyana* s.l.], 600 m a.s.l., [48°57'17.4"N, 20°26'18.3"E], 16 September 1983, *Pitoniak s.n.* (SLO s.n.!); Prielom Hornádu, [2736, original determination: *S. circumcideris* sp. n.], 48°56'42"N, 20°27'35"E, 23 June 1999, *Mikoláš s.n.* (KO 24330!); Prielom Hornádu, [2703, original determination: *S. hazsliszkyana* agg.], 48°56'42"N, 20°27'35"E, 23 June 1999, *Mikoláš s.n.* (KO 29002!); Regio Slovenský raj: in margo nemoris loco Tomášovská vyhlídka prope pag. Letanovce, colo calcareo, 700 m a.s.l., [48°56'41.9"N, 20°27'35.1"E], June 1954, *Dostál s.n.* (PR 3453/3!); Slov. raj, Spišské Tomašovce, S nad údolím Hornádu u cesty od Čingova na Tomašovský výhled, 600 m a.s.l., [48°56'33.9"N, 20°28'0.9"E], 19 July 1970, *Businský s.n.* (ROZ s.n.!); Slovenia centralis. Slovenský Ráj, v průlomu Hornadu na vápencových skalách, [original determination: *Sorbus* sp.], 650–700 m a.s.l., [48°56'41.5"N, 20°27'28.1"E], 6 June 1931, *Domin & Sillinger s.n.* (PRC s.n.!); Slovenia centralis. Slovenský Ráj, v průlomu Hornadu u Spiš. Tomášovcú, [original determination: *Sorbus* sp.], [48°56'41.5"N, 20°27'28.1"E], 6 June 1932, *Domin & Sillinger s.n.* (PRC s.n.!); Slovenský raj, nad Lesnicou pir Tomáš. výhľade, [original determination: *S. austriaca*, rev. J. Májovský – *S. austriaca*, rev. V. Mikoláš – *S. hazslinszkyana* s.l. (? *S. centralis* ined.)], [48°56'27.8"N, 20°28'20.2"E], 5 August 1943, *Mikoláš s.n.* (SLO s.n.!); Slovenský ráj, Tomašovský výhľad, [original determination: *S. aria*], 680 m a.s.l., [48°56'41.0"N, 20°27'36.5"E], 22 July 1979, *Klimeš s.n.* (PRA s.n.!); Slovenský raj: Čingov – Ľudmanka, [rev. V. Mikoláš – *S. laticentralis* ined., *S. centralis* ined.], 650 m a.s.l.,

[48°56’41.7”N, 20°27’36.7”E], 14 July 1973, *Hubová s.n.* (SAV s.n.!); Slovenský raj: in rup. calcar. ad flum. Hernad pr. p. Letanovce, [original determination: *S. aria* ×, rev. M. Kovanda – *S. austriaca*, rev. R. Düll 1959 – *S. austriaca*, rev. V. Mikoláš 2009 – non], 550 m a.s.l., [48°57’15.7”N, 20°26’17.1”E], 12 June 1930, *Suza s.n.* (BRNU s.n.!); Slovenský raj: Spišské Tomášovce, Ihrík, nad prilomom Hornádu, [48°57’17.9”N, 20°26’0.9”E], 23 June 1994, *Uhlířová s.n.* (CB 89082!); Slovenský raj: Spišské Tomášovce, Ihrík, [48°57’17.9”N, 20°26’0.9”E], 4 July 2003, *Bernátová s.n.* (CB 89163!, CB 89413!, CB 89414!); Slovenský raj: Spišské Tomašovce, Tomaš. výhľad, V okraj, [original determination: *S. paradisi-slovaci* Mikoláš ined.], 663 m a.s.l., [48°56’40.7”N, 20°27’37.3”E], 23 October 2006, *Mikoláš s.n.* (BRNM 711368!); Spišské Tomášovce (Spišská Nová Ves distr.): ca 1.4 km WNW of Letanovský Mlyn mill; in scrub, scattered; tree ca 6 m high, [2n~4x; DNA Ploidy level detected by using the flow cytometer Partec PA II (DAPI fluorochrome!); Analysed 2020, Dep. of Botany, University of S. Bohemia, Č. Budějovice], 630 m a.s.l., 48°57’18.6”N, 20°25’25.2”E, 24 July 2020, *Velebil, Bernátová & Lepší M. 533/20* (CB 86898!); Spišské Tomášovce (Spišská Nová Ves distr.): ca 1.5 km WNW of Letanovský Mlyn mill; rocky forest, scattered; shrub ca 4 m high, [2n~4x; DNA Ploidy level detected by using the flow cytometer Partec PA II (DAPI fluorochrome!); Analysed 2020, Dep. of Botany, University of S. Bohemia, Č. Budějovice], 620 m a.s.l., 48°57’16.9”N, 20°25’19.7”E, 24 July 2020, *Velebil, Bernátová & Lepší M. 535/20* (CB 86896!); Spišské Tomášovce (Spišská Nová Ves distr.): ca 400 m NW of Letanovský Mlyn mill; edge of forest and limestone rock, shrub ca 6 m high, [2n~4x; DNA Ploidy level detected by using the flow cytometer Partec PA II (DAPI fluorochrome!); Analysed 2020, Dep. of Botany, University of S. Bohemia, Č. Budějovice], 590 m a.s.l., 48°57’20.1”N, 20°26’13.5”E, 24 July 2020, *Lepší M., Velebil & Bernátová 527/20* (CB 87348!); Spišské Tomášovce (Spišská Nová Ves distr.): ca 600 m WNW of Letanovský Mlyn mill; in open *Pinus sylvestris* forest, scattered, two-trunk tree ca 8 m high, [2n~4x; DNA Ploidy level detected by using the flow cytometer Partec PA II (DAPI fluorochrome!); Analysed 2020, Dep. of Botany, University of S. Bohemia, Č. Budějovice], 610 m a.s.l., 48°57’19.6”N, 20°26’3.9”E, 24 July 2020, *Velebil, Bernátová & Lepší M. 530/20* (CB 86901!); Spišské Tomášovce (Spišská Nová Ves distr.): ca 850 m WNW of Letanovský Mlyn mill; edge of forest and open limestone slope, scattered; shrub ca 4 m high, [2n~4x; DNA Ploidy level detected by using the flow cytometer Partec PA II (DAPI fluorochrome!); Analysed 2020, Dep. of Botany, University of S. Bohemia, Č. Budějovice], 600 m a.s.l., 48°57’18.2”N, 20°25’50.9”E, 24 July 2020, *Velebil, Bernátová & Lepší M. 532/20* (CB 86899!); Havrania skala, [S 3/5, original determination: *S. austriaca* agg., rev. anonymus], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll.*, *s.n.* (KO 12785!); Havrania skala, [S 4/4, original determination: *S. austriaca* agg., rev. anonymus], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll.*, *s.n.* (KO *s.n.*!); Havrania skala, kota 1158 m, cca 60 m M. Sokol, [S 4/1, original determination: *S. austriaca* agg., rev. V. Mikoláš], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll. s.n.* (KO 12483!); Havrania skala, pod vrcholom, [S 9, original determination: *S. austriaca* agg., rev. V. Mikoláš], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll.*, *s.n.* (KO 12479!); Havrania skala, kota 1158 m, [S 3/2, original determination: *S. austriaca* agg., rev. V. Mikoláš], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll.*, *s.n.* (KO 12501!); Havrania skala, 1158 m, malá skalka vrchol M. Sokol, [S 7/1, original determination: *S. austriaca* agg., rev. anonymus], 48°53’23.6”N, 20°20’40.7”E, 26 July 1962, *s. coll.*, *s.n.* (KO 12553!); Stratená, kaňon, [2668, original determination: *S. stretense* ined.], 48°52’33.7”N, 20°19’40.6”E, 24 June 1999, *Mikoláš s.n.* (KO 24362!); **Krivánska Malá Fatra**: Biele skaly, vrchol 1283, 7 m, Orientácia SV [most likely from the area of Malý Rozsutec], 1230 m a.s.l., [49°14’51.2”N, 19°6’10.6”E], 4 June 1996, *Topercer s.n.* (CB 89493!); Biele skaly, vrchol 1283, 7 m, Orientácia S [most likely from the area of Malý Rozsutec], 1275 m a.s.l., [49°14’49.8”N, 19°6’9.9”E], 4 June 1996, *Topercer s.n.* (CB 89494!); Kriv. M. Fatra, Poludňové skály, nad Štefanovou, [original determination: *S. austriaca*, rev. Č. Deyl – *S. austriaca*, rev. M. Lepší – *S. aria* s.l.], [49°14’16.3”N, 19°5’8.4”E], 24 July 1971, *Šachl s.n.* (ROZ s.n.!); Kriv. Malá Fatra: Terchová, Velký Rozsutec – Poludňové skaly, [original determination: *S. cham.* and *ambiguoid*], 1000 m a.s.l., [49°14’11.4”N, 19°5’7.3”E], 26 May 1997, *Bernátová s.n.* (CB 89377!); Krivánska Malá Fatra, osada Biela, [2n~4x], 762 m a.s.l., [49°14'26.7"N, 19°07'22.2"E], 14 September 2017, *Bernátová 6/1* (herb. Velebil!); Krivánská Malá Fatra, Rozsutec, Poludňové skaly, [49°14’14.9”N, 19°5’16.8”E], 19 July 1996, *Bernátová s.n.* (CB 88940!); Krivánska Malá Fatra, Vrátna dolina, Zbojnický chodník, [2n~4x], 694 m a.s.l., [49°14'41.0"N, 19°02'12.1"E], 14 September 2017, *Bernátová 12/1* (herb. Velebil!); Krivánska Malá Fatra, Vrátna dolina, Zbojnický chodník, [2n~4x], 733 m a.s.l., [49°14'41.2"N, 19°02'09.6"E], 14 September 2017, *Bernátová 12/2* (herb. Velebil!); Krivánska Malá Fatra, Vrátna dolina, Zbojnický chodník, [2n~4x], 745 m a.s.l., [49°14'41.0"N, 19°02'08.1"E], 14 September 2017, *Bernátová 12/3* (herb. Velebil!); Krivánska Malá Fatra, Vrátna dolina, Zbojnický chodník, [2n~4x], 765 m a.s.l., [49°14'40.2"N, 19°02'06.6"E], 14 September 2017, *Bernátová 12/4* (herb. Velebil!); Krivánska Malá Fatra, Vrátna dolina, Zbojnický chodník, [2n~4x], 772 m a.s.l., [49°14'39.8"N, 19°02'05.9"E], 14 September 2017, *Bernátová 12/5* (herb. Velebil!); Krivánska Malá Fatra: dolina Vrátna, Tiesňavy pri Terchovej, [original determination: *S. aria*, rev. V. Mikoláš – *S. austriaca* agg.], 850 m a.s.l., [49°14’38.8”N, 19°1’59.8”E], 8 September 1964, *Futák, Jasičová & Zahradníková s.n.* (SAV s.n.!); Krivánska Malá

Fatra: Štefanová SE [probably Poludňové skaly by Veľký Rozstec], [original determination: *S. austriaca*], 1050 m a. s.l., [49°14'16.8"N, 19°4'54.9"E], 6 October 1983, *Májovský & Murín s.n.* (SLO s.n.!); Krivánska Malá Fatra: Terchová, Tiesňavy, [49°14'34.3"N, 19°1'53.6"E], 28 July 2000, *Bernátová s.n.* (CB 89014!, CB 89015!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, [49°13'54.1"N, 19°5'50.0"E], 17 June 1996, *Bernátová s.n.* (CB 89008!, CB 89009!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, [49°13'54.1"N, 19°5'50.0"E], 17 June 1996, *Bernátová & Obuch s.n.* (CB 89010!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, nad Kremennou dolinou, [49°14'11.5"N, 19°5'25.2"E], 17 June 1996, *Bernátová & Obuch s.n.* (CB 88991, CB 89011!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, Poludňové skaly, [49°14'14.9"N, 19°5'16.8"E], 7 June 1996, *Bernátová s.n.* (CB 88992!, CB 89000!, CB 89001!, CB 89002!, CB 89003!, CB 89004!, CB 89005!, CB 89006!, CB 89007!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, Poludňové skaly, [49°14'14.9"N, 19°5'16.8"E], 19 July 1996, *Bernátová s.n.* (CB 88990!, CB 88993!, CB 88994!, CB 88995!, CB 88996!, CB 88997!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, Poludňové skaly, [49°14'14.9"N, 19°5'16.8"E], 1996, *Topercer s.n.* (CB 88998!); Krivánska Malá Fatra: Terchová, Veľký Rozsutec, V svahy, [49°13'54.1"N, 19°5'50.0"E], 17 June 1996, *Bernátová & Obuch s.n.* (CB 88999!); Malá Fatra: in declivis saxonis et in rupibus (Sokolie) in convalle Vrátná dolina, colo calcareo, 750 m a.s.l., [49°14'8.5"N, 19°1'57.4"E], 4 August 1959, *Klášterský & Měsíček s.n.* (PR s.n.!); Malá Fatra: Terchová, Poludňové skaly, [Orientácia J], 1075 m a. s.l., [49°14'14.4"N, 19°5'14.2"E], 6 June 1996, *Topercer s.n.* (CB 89495!); Rozsutec, pri chodníku vo Štefanovej v strednej časti v bučine, [original determination: *Sorbus* sp.], 900 m a.s.l., [49°14'22.7"N, 19°4'49.0"E], 6 October 1983, *Májovský s.n.* (SLO s.n.!); Terchová, Malý Rozsutec, skalky pod vrcholem, [original determination: *Sorbus* sp., rev. M. Lepší et P. Lepší – *S. hybrida* agg.], 1300 m a.s.l., [49°14'47.2"N, 19°6'5.1"E], 24 June 1994, *Grulich s.n.* (BRNU 535988!); **Veľká Fatra**: Veľká Fatra: Kľak nad Ľubochňou, [1394 m a.s.l., 49°2'47.0"N, 19°6'44.5"E], 26 June 1994, *Kliment s. n.* (CB 88942!); **Chočské vrchy**: Rozhranie Oravy a Liptova, vápencová skala u pravej strany cesty z Jasenovej do Valaskej Dubovej, v krovine, [original determination: *S. aria*, rev. V. Mikoláš – *S. austriaca* s.l.], 780 m a.s.l., [49°9'59.5"N, 19°18'17.5"E], 24 August 1957, *Futák s.n.* (SAV s.n.!); Komjatná, [2n~4x], 821 m a.s.l., [49°08'24.5"N, 19°16'03.1"E], 4 July 2017, *Bernátová 1/1* (herb. Velebil!); Komjatná, [2n~4x], 822 m a.s.l., [49°08'24.2"N, 19°16'02.0"E], 4 July 2017, *Bernátová 1/2* (herb. Velebil!); Komjatná, [2n~4x], 826 m a.s.l., [49°08'24.5"N, 19°16'01.5"E], 4 July 2017, *Bernátová 1/3* (herb. Velebil!); Komjatná, [2n~4x], 831 m a.s.l., [49°08'25.3"N, 19°16'00.6"E], 4 July 2017, *Bernátová 1/4* (herb. Velebil!); Komjatná, [2n~4x], 835 m a.s.l., [49°08'25.4"N, 19°15'57.0"E], 4 July 2017, *Bernátová 1/5* (herb. Velebil!); Nad Komjatnou (okr. Ružomberok), [rev. V. Mikoláš – *S. austriaca* s.l.], 870 m a.s.l., [49°08'36"N, 19°15'44"E], 14 July 1951, *Májovský s.n.* (SLO s.n.!); Ľubochňa, hora Havran severových. od Ľubochne, [49°7'45.7"N, 19°11'11.1"E], 10 June 1970, *Holub s.n.* (PRA s.n.!); Ľubochňa, hora Ostré severových od Ľubochně, [49°8'10.4"N, 19°12'36.2"E], 10 June 1970, *Holub s.n.* (PRA s.n.!); Bohemoslovacia, Slovacia boreal., montes Chočské vrchy, opp. Ružomberok, pagus Valaská Dubová; in rupibus calcar. in decl. occid. sub loco Gulovisko, ad pedem occid. montis Zadný Choč (1288 m), ca 2 km situ ± orient. a pago Valaská Dubová, [original determination: *S. aria* agg.], 1000–1100 m a.s.l., [49°8'18.6"N, 19°19'7.6"E], 15 July 1989, *Štěpánek s.n.* (PR 721877!, 721876!); Chočská Fatra, jižně od hory Radičina mezi obcí Studničná a Ružomberokem, [original determination: *Sorbus* sp.], [49°6'40.0"N, 19°15'31.9"E], 11 June 1970, *Holub s.n.* (PRA s.n.!); Chočské vrchy, Ružomberok, Lúčky, [49°7'47.8"N, 19°23'55.3"E], 6 October 1993, *Bernátová & Májovský s.n.* (CB 88943!, CB 88944!, CB 88945!); Chočské vrchy, Ružomberok, Predný Choč; výstup od hradu Likavka, [original determination: *Sorbus* sp.], [49°7'20.6"N, 19°20'11.5"E], 23 September 1971, *Holub s.n.* (PRA s.n.!); Ružomberok: vápencové stráně při stezce z Valašské Dubové na Velký Choč, smíšený listnatý les, [original determination: *S. latifolia* f. *superaria*], 950 m a.s.l., [49°8'56.7"N, 19°18'45.3"E], 11 July 1961, *Černoch s.n.* (BRNM 295612!); Ružomberok: západní skalnaté svahy Šípu u Stankovan, [original determination: *Sorbus* sp.], 800–900 m a.s.l., [49°9'48.9"N, 19°9'38.7"E], 6 August 1959, *Soják s.n.* (PR 564040!, 564069!); Chočské pohorie: Stankovany, vrch Šíp, jz. svah, [original determination: *S. aria*], 850 m a.s.l., [49°9'48.9"N, 19°9'38.7"E], 4 June 1974, *Hubová s.n.* (SAV s.n.!); Chočské pohorie: Šíp, po hlavný hrebeň, 1100 m a.s.l., [49°9'53.6"N, 19°10'22.4"E], 22 June 1963, *Futák, Jasičová & Zahradníková s.n.* (SAV s.n.!); Chočské vrchy, hora Šíp nad Stankovany, [original determination: *S. austriaca*], [49°9'52.9"N, 19°10'44.7"E], 2 June 1969, *Holub s.n.* (PRA s.n.!); Chočské vrchy, Stankovany, Podšíp, [49°9'50.4"N, 19°9'40.3"E], 22 August 1995, *Bernátová s.n.* (CB 88936!); Chočské vrchy: Stankovany, Podšíp, [49°9'49.2"N, 19°9'26.8"E], 22 August 1995, *Bernátová s.n.* (CB 88840!, CB 88841!, CB 88842!, CB 88843!, CB 88845!, CB 88846!); Chočské vrchy: Stankovany, Podšíp, [49°9'49.2"N, 19°9'26.8"E], 26 June 1996, *Májovský et al. s.n.* (CB 88847!); Chočské vrchy: Stankovany, Podšíp, [49°9'49.2"N, 19°9'26.8"E], 26 June 1996, *Bernátová s.n.* (CB 88848!, CB 88849!, CB 88850!, CB 88851!, CB 88852!); Chočské vrchy: Stankovany, vrchol Šípu při kříži, [49°9'54.9"N, 19°10'44.5"E], 22 August 1995, *Bernátová s.n.* (CB 88836!); Chočské vrchy: Stankovany, vrchol Šípu při kříži, [49°9'54.9"N, 19°10'44.5"E], 22 August 1995, *Bernátová s.n.* (CB 88837!); Chočské vrchy: Stankovany, vrchol Šípu

při kříži, [49°9’54.9”N, 19°10’44.5”E], 22 August 1995, *Bernátová s.n.* (CB 88844!); Chočské vrchy: Stankovany, vrcholové části Šípu, [original determination: *S. austriaca*], [49°9’55.8”N, 19°10’44.0”E], 3 July 1983, *Bernátová s. n.* (CB 88853!, CB 88854!); In monte Šíp supra Stankovany. Substr. calcareo. In margine fagetorum, [original determination: *S. carpatica* Borbás (*aria-austriaca*)], 1000 m a.s.l., [49°09’49”N, 19°09’52”E], 4 June 1940, *Scheffer s.n.* (SLO s.n.!); Kraľovany, vrch Šíp SV od obce, [49°9’52.9”N, 19°10’44.7”E], 31 August 2002, *Boublík s.n.* (CB 65406!); M. Fatra, in declivis montis Šíp, solo calcareo, 1100 m a.s.l., [49°9’52.8”N, 19°10’44.8”E], 6 August 1959, *Klášterský & Měsíček s.n.* (PR s.n.!); Slovak Republic, Stankovany (Ružomberok distr.), a saddle between Zadný Šíp (1152 m) and Šíp (1169 m) peaks 2 km N of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 1100 m a.s.l., 49°09'53.7"N, 19°10'20.8"E, 7 June 2017, *Velebil & Bernátová s.n.* (herb. Velebil 170610!); Slovak Republic, Stankovany (Ružomberok distr.), near the top of the Šíp mountain (1169 m) 2.2 km NNE of the village, 1155 m a.s.l., 49°09’55.8”N, 19°10’46.5”E, 7 June 2017, *Velebil & Bernátová s.n.* (herb. Velebil 170611!); Slovak Republic, Stankovany (Ružomberok distr.), S sunny hillside of the Šíp mountain (1169 m) 2 km NNE of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 1140 m a.s.l., 49°09'53.0"N, 19°10'46.0"E, 7 June 2017, *Velebil & Bernátová s.n.* (herb. Velebil 170612!); Stankovany u Ružomberoku, hřeben východně od vrcholu hory Šíp, směrem na Žaškovské sedlo, [original determination: *S. austriaca*], [49°9’56.5”N, 19°10’57.6”E], 8 June 1970, *Holub s.n.* (PRA s.n.!); Dubová [Valaská Dubová], vápencové skalky pred dedinou (Orava), [original determination: *S. austriaca*], 875 m a.s.l., [49°08’47”N, 19°18’06”E], October 1954, *Májovský s.n.* (SLO s.n.!); Chočské vrchy, Valaská Dubová, Komjatná, [Hlavačka-Kostoly rock complex], 850 m a.s.l., 49°8’21.6”N, 19°15’40.6”E, 30 July 2014, *Bernátová s.n.* (CB 88773!); Chočské vrchy, Valaská Dubová, Komjatná, [Hrdošná skala rock], 950 m, 49°8’53.7”N, 19°13’5.4”E, 23 June 2014, *Bernátová s.n.* (CB 88774!, CB 88775!); Chočské vrchy, Valaská Dubová: Havran, [49°7’46.2”N, 19°11’12.3”E], 30 July 2014, *Bernátová s.n.* (CB 88780!, CB 88781!); Chočské vrchy, Valaská Dubová: Kramáriská, [Soliská rock complex] [49°8’59.2”N, 19°18’41.8”E], 17 September 1993, *Bernátová s.n.* (CB 88777!, CB 88778!, CB 88779!, CB 88937!); Chočské vrchy, Veľký Choč, skal. bralá od Lúčok, [49°8’59.2”N, 19°18’41.8”E], 21 June 1994, *Bernátová, Obuch & Topercer s.n.* (CB 88776!); Chočské vrchy, vrch Sokol nad Valaskou Dubovou, [2n~4x], 840 m a.s.l., [49°08'06.6"N, 19°18'12.3"E], 11 August 2017, *Bernátová 10/1* (herb. Velebil!); Chočské vrchy, vrch Sokol nad Valaskou Dubovou, [2n~4x], 882 m a.s.l., [49°08'06.9"N, 19°18'23.4"E], 11 August 2017, *Bernátová 10/2* (herb. Velebil!); Chočské vrchy, vrch Sokol nad Valaskou Dubovou, [2n~4x], 887 m a.s.l., [49°08'07.7"N, 19°18'23.6"E], 11 August 2017, *Bernátová 10/3* (herb. Velebil!); Chočské vrchy, vrch Sokol nad Valaskou Dubovou, [2n~4x], 900 m a.s.l., [49°08'08.6"N, 19°18'25.9"E], 11 August 2017, *Bernátová 10/4* (herb. Velebil!); Chočské vrchy, vrch Sokol nad Valaskou Dubovou, [2n~4x], 922 m a.s.l., [49°08'08.8"N, 19°18'25.7"E], 11 August 2017, *Bernátová 10/5* (herb. Velebil!); Chočské vrchy, výstup na Chočské sedlo mezi Velkým a Malým Chočem od východu, [original determination: *S. austriaca*], [49°8’53.4”N, 19°20’50.2”E], 18 July 1967, *Holub s.n.* (PRA s.n.!); Chočské vrchy: Sokol nad Valaskou Dubovou, sute pod skal. stenami, [49°8’13.9”N, 19°18’34.5”E], 3 June 1991, *Bernátová & Obuch s.n.* (CB 88784!); Chočské vrchy: sute pod skalným komplexom vrcholu Sokol při Valaskej Dubovej, [plody odlišné od *S. pekarovae*, rub listu viac plstnatý, malvice s vyšším počtem lenticel], [49°8’13.9”N, 19°18’34.5”E], 1 October 1991, *Bernátová & Obuch s.n.* (CB 88785!); Chočské vrchy: Valaská Dubová, vrchol Sokol, [49°8’13.9”N, 19°18’34.5”E], 17 May 1993, *Bernátová s.n.* (CB 88782!, CB 88786!); Chočské vrchy: Valaská Dubová, vrchol Sokol, [49°8’13.9”N, 19°18’34.5”E], 17 May 1996, *Bernátová & Obuch s.n.* (CB 88783!); Chočské vrchy: Žaškov, Záškovský Šíp, skaly výra, [49°10’38.0”N, 19°11’25.6”E], 18 May 1994, *Bernátová & Obuch s.n.* (CB 88838!, CB 88839!); **Západné Beskydy**: Dolný Kubín, Vyšný Kubín: Ostrá a Tupá skala, [49°11’33.0”N, 19°19’39.1”E], 25 August 2004, *Somogyi & Kučera s.n.* (CB 88938!); Dolný Kubín, Vyšný Kubín: Ostrá a Tupá skala, [49°11’33.0”N, 19°19’39.1”E], 25 August 2004, *Somogyi & Kučera s.n.* (CB 89013!); Dolný Kubín: Vyšný Kubín, Tupá skala, [49°11’29”N, 19°19’29”E], 19 June 2019, *Bernátová s.n.* (CB 89503!, CB 89504!, CB 89506!); Medzihradné (Dolný Kubín distr.), [2n~4x], 701 m a.s.l., [49°11'58.2"N, 19°20'11.1"E], 4 July 2017, *Bernátová 11/1* (herb. Velebil!); Slovakia septentrionalis distr. Dolný Kubín, montes Oravská vrchovina, in locis saxonis calcareis sub cacumine montis Ostrá skala, situ austr.-orient. ab opp. Dolný Kubín, [original determination: *S. aria* (L.) Cr.], 790 m a.s.l., [49°11’31.7”N, 19°19’49.8”E], 21 May 1973, *Chrtek & Křísa s.n.* (PRC s.n.!); Biela u Podbiel, vápenec, skala, SW, 600 m a.s.l., [49°17’48.1”N, 19°29’22.9”E], 18 July 1951, *s. coll. s.n.* (BRNM s.n.!); Bielska skala nad Podbielom, [2n~4x], 661 m a.s.l., [49°17'37.8"N, 19°29'43.5"E], 4 July 2017, *Bernátová 4/1* (herb. Velebil!); Bielska skala nad Podbielom, [2n~4x], 677 m a.s.l., [49°17'38.5"N, 19°29'42.8"E], 4 July 2017, *Bernátová 4/2* (herb. Velebil!); Bielska skala nad Podbielom, [2n~4x], 686 m a.s.l., [49°17'39.1"N, 19°29'42.1"E], 4 July 2017, *Bernátová 4/4* (herb. Velebil!); Bielska skala nad Podbielom, [2n~4x], 693 m a.s.l., [49°17'39.6"N, 19°29'41.5"E], 4 July 2017, *Bernátová 4/5* (herb. Velebil!); Krivá na Orave (okr. Dolný Kubín), [original determination: *S. austriaca*, rev. V. Mikoláš – *S. austriaca* s.l.], 725 m a.s.l., [49°17’40”N, 19°29’40”E], 2 August 1955, *Májovský s.n.* (SLO s.n.!); Orava, Biela skala medzi Podbielom a Krivou,

kroviny, vápenec, [original determination: *S. aria*, rev. V. Mikoláš – *S. austriaca* s.l.], 700 m a.s.l., [49°17'42.6"N, 19°29'38.0"E], 22 August 1957, *Futák s.n.* (SAV s.n.!); Orava, o. Trstená, stráň ? obce Krivá, [original determination: *S. aria*, rev. V. Mikoláš – *S. austriaca* s.l.], 550 m a.s.l., [49°17'33.7"N, 19°29'32.3"E], 8 July 1959, *Futák s.n.* (SAV s.n.!); Orava, Podbiel, Biela skala pri Podbieli, [49°17'42.9"N, 19°29'37.3"E], 15 August 1995, *Bernátová & Obuch s.n.* (CB 88941!); Orava, Podbiel, Bielska skala, [49°17'42.9"N, 19°29'37.3"E], 2004, *Somogyi s.n.* (CB 88939!); Orava, Trstená, Podbiel, Biela skala, [49°17'43.2"N, 19°29'36.8"E], 27 June 1996, *Bernátová & Obuch s.n.* (CB 88787!, CB 88788!); Orava: Podbiel, Biela skala, 700 m a.s.l., [49°17'42.6"N, 19°29'38.2"E], 24 June 1963, *Futák, Jasičová & Michalko s.n.* (SAV s.n.!); Orava: Trstená, Biela skala pri Podbieli, [49°17'43.2"N, 19°29'36.8"E], 15 August 1995, *Bernátová & Obuch s.n.* (CB 88793!, CB 88797!); Orava: Trstená, Podbiel, Biela skala, [vo *Festucetum pallentis* s *Aster alpinus*], [49°17'43.2"N, 19°29'36.8"E], 11 August 1995, *Obuch s.n.* (CB 88789!, CB 88790!); Orava: Trstená, Podbiel, Biela skala, [49°17'43.2"N, 19°29'36.8"E], 27 June 1996, *Bernátová & Obuch s.n.* (CB 88791!, CB 88792!, CB 88796!); Orava: Trstená, Podbiel, Biela skala, [49°17'43.2"N, 19°29'36.8"E], 30 July 2013, *Bernátová s.n.* (CB 88794!); Orava: Trstená, Podbiel, Biela skala, horná hrana, [49°17'43.2"N, 19°29'36.8"E], 30 July 2013, *Bernátová s.n.* (CB 88795!); Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.5 km SSE from centre of the village, [2n~4x], 740 m a.s.l., 49°17'42.3"N, 19°29'38.8"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160644!); Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.6 km SSE from centre of the village, [2n~4x], 690 m a.s.l., 49°17'38.9"N, 19°29'42.4"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160645!); Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.6 km SSE from centre of the village, [2n~4x], 680 m a.s.l., 49°17'38.5"N, 19°29'42.7"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160646!); Slovak Republic, Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.5 km SSE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 740 m a.s.l., 49°17'42.3"N, 19°29'38.8"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160644!); Slovak Republic, Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.6 km SSE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 690 m a.s.l., 49°17'38.9"N, 19°29'42.4"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160645!); Slovak Republic, Podbiel (Tvrdošín distr.), an edge of the precipice on the S slope of the Biela skala hill (750 m) 1.6 km SSE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 680 m a.s.l., 49°17'38.5"N, 19°29'42.7"E, 8 June 2016, *Velebil s.n.* (herb. Velebil 160646!); Západné Beskydy: Bielska pri Podbieli, [original determination: *S. austriaca*, rev. V. Mikoláš – *S. austriaca* s.l.], 700 m a.s.l., [49°17'42.6"N, 19°29'38.2"E], 20 July 1981, *Májovský, Murín & Mičieta s.n.* (SLO s.n.!); Orava, Tupá skala, [2n~4x], 800 m a.s.l., [49°11'32.4"N, 19°19'33.6"E], 4 July 2017, *Bernátová 3/1* (herb. Velebil!); Orava, Tupá skala, [2n~4x], 797 m a.s.l., [49°11'32.1"N, 19°19'34.0"E], 4 July 2017, *Bernátová 3/2* (herb. Velebil!); Orava, Tupá skala, [2n~4x], 798 m a.s.l., [49°11'32.1"N, 19°19'32.7"E], 4 July 2017, *Bernátová 3/3* (herb. Velebil!); Orava, Tupá skala, [2n~4x], 798 m a.s.l., [49°11'31.1"N, 19°19'32.7"E], 4 July 2017, *Bernátová 3/4* (herb. Velebil!); Orava, Tupá skala, [2n~4x], 799 m a.s.l., [49°11'30.8"N, 19°19'32.6"E], 4 July 2017, *Bernátová 3/5* (herb. Velebil!); Ostrá skala nad Vyšným Kubínom, [2n~4x], 744 m a.s.l., [49°11'31.9"N, 19°19'40.0"E], 4 July 2017, *Bernátová 2/1* (herb. Velebil!); Ostrá skala nad Vyšným Kubínom, [2n~4x], 747 m a.s.l., [49°11'34.0"N, 19°19'40.0"E], 4 July 2017, *Bernátová 2/2* (herb. Velebil!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), a rocky slope on the S side of the Ostrá skala hill (814 m) 1.4 km from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 795 m a.s.l., 49°11'29.8"N, 19°19'50.0"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150914!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), a saddleback between the Ostrá skala (814 m) and Tupá skala (ca 785 m) hills 1.4 km NE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 740 m a.s.l., 49°11'34.2"N, 19°19'40.5"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150912!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), a steep rocky slope near the top of the Ostrá skala hill (814 m) 1.5 km from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 805 m a.s.l., 49°11'31.5"N, 19°19'50.3"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150915!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), a steep rocky slope near the top of the Ostrá skala hill (814 m) 1.5 km from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 800 m a.s.l., 49°11'31.9"N, 19°19'51.1"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150916!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), an edge of the precipice on the S side of the Ostrá skala hill (814 m) 1.4 km NE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 770 m a.s.l., 49°11'28.7"N, 19°19'50.4"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150913!); Slovak Republic, Vyšný Kubín (Dolný Kubín distr.), an edge of the precipice on the SE side of the Tupá skala hill (ca 785 m) 1.2 km NE from centre of the village, [DNA ploidy level was detected using the flow cytometry, 2n~4x], 775 m a.s.l., 49°11'30.4"N, 19°19'31.6"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150911!); Slovakia septentr.-occ., distr. Dolný Kubín, montes Oravská vrchovina, in locis fruticosis sub cacumine montis Ostrá skala situ

septentr. a pago Vyš. Kubín, solo calcareo, 800 m a.s.l., [49°11’31.7”N, 19°19’49.8”E], 18 August 1971, *Chrtek & Křísa s.n.* (PRC s.n.!); Ungarn: Oravicza, auf der Roll, [original determination: *S. aria*], [49°11’30.4”N, 19°19’31.6”E], June 1889, *Vraný s.n.* (BRNM 00553/34!); Vyšný Kubín (distr. Dolný Kubín): Tupá skala rock, ca 360 m W of summit of Ostrá skala hill; scrub at upper edge of rock, scattered, 770 m a.s.l., 49°11’31”N, 19°19’32”E, 31 August 2018, *Velebil, Bernátová, Lepší M. & Lepší P. s.n.* (CB 85719!, herb. Velebil!); Vyšný Kubín (distr. Dolný Kubín): Tupá skala rock, ca 400 m W of summit of Ostrá skala hill; edge of scrub, scattered, two-trunk tree 8 m high, 780 m a.s.l., 49°11’29”N, 19°19’30”E, 31 August 2018, *Velebil, Bernátová, Lepší M. & Lepší P. s.n.* (CB 85717!, herb. Velebil!); Vyšný Kubín (distr. Dolný Kubín): Tupá skala rock, ca 670 m WSW of summit of Ostrá skala hill; upper edge of rock scattered, shrub ca 8 m high, 765 m a.s.l., 49°11’27”N, 19°19’17”E, 31 August 2018, *Velebil, Bernátová, Lepší M. & Lepší P. s.n.* (CB 85716!, herb. Velebil!); Vyšný Kubín (distr. Dolný Kubín): Tupá skala rock, ca 360 m W of summit of Ostrá skala hill; edge of scrub at upper edge of rock, scattered tree ca 3.5 m high, 770 m a.s.l., 49°11’31.7”N, 19°19’33.0”E, 31 August 2018, *Velebil, Bernátová, Lepší M. & Lepší P. s.n.* (CB 85720!); Vyšný Kubín (distr. Dolný Kubín): Tupá skala rock, ca 390 m W of summit of Ostrá skala hill; edge of scrub, scattered, tree ca 5 m high, 780 m a.s.l., 49°11’30.62”N, 19°19’31”E, 31 August 2018, *Velebil, Bernátová, Lepší M. & Lepší P. 459* (CB 85718!) [Holotype]; Vyšný Kubín (Dolný Kubín distr.), a rocky slope on the S side of the Ostrá skala hill (814 m) 1.4 km from centre of the village, [2n~4x], 795 m a.s.l., 49°11'29.8"N, 19°19'50.0"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150914!); Vyšný Kubín (Dolný Kubín distr.), a saddleback between the Ostrá skala (814 m) and Tupá skala (ca 785 m) hills 1.4 km NE from centre of the village, [2n~4x], 740 m a.s.l., 49°11'34.2"N, 19°19'40.5"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150912!); Vyšný Kubín (Dolný Kubín distr.), a steep rocky slope near the top of the Ostrá skala hill (814 m) 1.5 km from centre of the village, [2n~4x], 805 m a.s.l., 49°11'31.5"N, 19°19'50.3"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150915!); Vyšný Kubín (Dolný Kubín distr.), a steep rocky slope near the top of the Ostrá skala hill (814 m) 1.5 km from centre of the village, [2n~4x], 800 m a.s.l., 49°11'31.9"N, 19°19'51.1"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150916!); Vyšný Kubín (Dolný Kubín distr.), an edge of the precipice on the S side of the Ostrá skala hill (814 m) 1.4 km NE from centre of the village, [2n~4x], 770 m a.s.l., 49°11'28.7"N, 19°19'50.4"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150913!); Vyšný Kubín (Dolný Kubín distr.), an edge of the precipice on the SE side of the Tupá skala hill (ca 785 m) 1.2 km NE from centre of the village, [2n~4x], 775 m a.s.l., 49°11'30.4"N, 19°19'31.6"E, 4 September 2015, *Velebil s.n.* (herb. Velebil 150911!).

Conservation status:—The majority of *Sorbus oravica* sites are located within either large-scale protected areas, such as national parks, or small-scale protected areas, including nature reserves. The species is estimated to comprise several thousand individuals. Although population size and threat status at individual localities were not assessed in detail, some populations appeared abundant and widespread. Therefore, based on these preliminary observations, the species could be classified as Near Threatened (NT; sensu Eliáš *et al*. 2015 and IUCN 2012). However, more comprehensive studies are required for an accurate assessment.

Ploidy level and modes of reproduction:—Among all studied specimens of *Sorbus oravica*, only tetraploid individuals were identified, with no detected intraspecific variation. All analysed seeds were of pseudogamous origin. Polar nuclei were mainly fertilazed by tetraploid pollen contribution (17 seeds) and, in three cases, a diploid pollen contribution was involved. The averages of sample/standard ratios, coefficients of variation (CV) for both sample and standards are listed in Tables 2 and 3.

TABLE 2. Average values of sample/standard ratio, estimated ploidy level and coefficients of variation measured by flow cytometry for *Sorbus oravica*. In total 33 leaves from 33 individuals were measured with *Bellis perennis* or *Carex acutiformis* as standards.

	***Sorbus oravica* leaves**	
Standard used	*Bellis*	*Carex*
Number of individuals analysed	17	16
Average sample:standard ratio	0.751	2.497
Average CV of the sample	2.22	3.02
Average CV of the standard	2.98	3.03
Estimated DNA ploidy level	2n~4x	2n~4x

TABLE 3. Results of Flow Cytometric Seed Screen. Average values of sample/standard ratio, estimated ploidy levels and coefficients of variation measured for *Sorbus oravica*. In total 20 seeds from 2 individuals were measured with *Carex acutiformis* as a standard.

	***Sorbus oravica* seeds**	
Mode of reproducton	pseudogamy (2x pollen)	pseudogamy (4x pollen)
Number of individuals analysed	3	17
Average embryo:standard ratio	2.53	2.59
Average endosperm:standard ratio	6.26	7.64
Average CV of the embryo	2.24	3.22
Average CV of the endosperm	2.50	3.07
Average CV of the standard	2.86	3.66
Estimated DNA ploidy level for embryo and endosperm	4x:10x	4x:12x

Molecular analyses, nuclear microsatellite markers:—All tested species (eight from *Sorbus* subgen. *Soraria* and one from *S*. subgen. *Triparens*) showed successful amplification of all applied microsatellite loci. A total of 65 alleles were recorded across 91 individuals, with 30 multilocus phenotypes identified. Allelic phenotypes clearly differentiate all species from one another. As shown in the PCoA plot (see Fig. 8), a distinct separation is evident between the main group of the *S*. subgen. *Soraria* and the species pair *S. oravica* and *S. hazslinszkyana*. This finding is consistent with morphological data, as these two species are also the most similar in phenotype. Furthermore, using molecular markers, they are clearly distinguishable from each other (see the third coordinate).

The two individuals of *S.* × *thuringiaca* are widely separated in the PCoA, which is consistent with the fact that this diploid hybrid originated sexually and polytopically from variable sexual species. *Sorbus intermedia*, the species representing the *S*. subgen. *Triparens*, although clearly distinct, appears closely related to the main cluster of species within *S*. subgen. *Soraria*, which may reflect the presence of a related or identical parent of these hybridogenous species. The sample of the holotype of *S. hornadensis* clusters with other individuals of this species (both from herbarium specimens and our own collections), forming a coherent group and representing a distinct apomictic lineage.

In *Sorbus oravica* we detected seven genotypes (among 50 individuals sampled), and the AGD was 0.0081 ± 0.0076. A similar rate of molecular variability was observed in apomictic *Sorbus* species in related studies (Lepší *et al*. 2009, Vít *et al*. 2012, Feulner *et al*. 2013).

Determination key:—Determination key for identifying members of the *Sorbus* subgen. *Soraria* occurring in Slovakia including morphologically close taxa such as the alien *S. intermedia* of the *S.* subgen. *Triparens* and *S. aria* and *S. javorkana* of the *S.* subgen. *Aria*. Unless otherwise specified, the leaves mentioned in the text refer to those of sterile short shoots. The taxonomic classification, circumscription, and distribution of *Sorbus buekkensis*—mentioned in the introduction as belonging to *S.* subgen. *Soraria* and occurring in Slovakia—are unclear and require clarification. For this reason, it is not included in the key.

1a Leaves semi-pinnate, usually with 1–3 pairs of leaflets at base 2
1b Leaves simple 3
2a Leaf lamina oblong-ovate to oblong-elliptical, with (0–)1–3(–7) pairs of leaflets or basal segments incised up to the midrib, with (10–)11–13(–15) lateral veins on each side; fruits as long as wide or longer than wide, red; diploid, 2n=34; occurring individually or in small numbers within populations of the parent species ..... ***S.* × *thuringiaca*** (Fig. 4c)
2b Leaf lamina ovate to broadly elliptical, with 2–3 pairs of leaflets or basal segments incised up to the midrib, with (7–)8–9(–11) lateral veins on each side; fruits mostly wider than long, dark red; tetraploid, 2n=68; native to Scandinavia and the Baltic region; occasionally cultivated as an ornamental tree ..... ***S. hybrida*** (L. 1761: 557) L. (1762: 684) (Fig. 4e)
3a Leaf lamina with 7–9(–10) veins on each side 4
3b Leaf lamina with (9–)10–11(–13) veins on each side 6
4a Leaf lamina narrowly elliptic-obovate to obovate, the incision between the 2nd and 3rd lobes from the base 4–7 mm deep, base of blade narrowly cuneate; triploid, 2n=51; central-eastern and south-eastern Slovakia and adjacent northern Hungary, subendemic to Slovakia ..... ***S. javorkana*** (Fig. 6e)
4b Leaf lamina elliptical, broadly elliptical or ovate, the incision between the 2nd and 3rd lobes from the base (6–)9–16(–20.5) mm deep, base of blade broadly cuneate to rounded 5
5a Leaf lamina greenish-gray abaxially, the incision between the 2nd and 3rd lobes from the base (11–)12–16(–20.5) mm deep; fruits blood-red. – Leaf lamina small, 6–7.5 cm long and 3–4.5 cm wide, elliptical to ovate, with 7–9(–10) lateral veins, lobes

deeply incised, elongated; fruits ellipsoidal to globose, 9–11 mm long and 8–10 mm wide; triploid, 2n~51; Volovské vrchy hills, Folkmárska and Murovaná skala rocks, endemic to Slovakia ..... ***S. scepusiensis*** (Fig. 6f)

5b Leaf lamina yellowish-greenish-gray abaxially, the incision between the 2nd and 3rd lobes from the base (6–)9–12(–16) mm deep; fruits orange-red to red. – Leaf lamina larger, (7.8–)8.9–9.9(–10.8) cm long and (5.4–)6–6.7(–7.4) cm wide, broadly elliptical to ovate, with 7–9 lateral veins; fruits ellipsoidal, 13.5–14 mm long and 12–12.5 mm wide; tetraploid, 2n=68; native to southern Scandinavia and the Baltic region; occasionally cultivated as an ornamental tree (recorded as early as the mid-19th century in Prešov), sometimes escaping (first record: Košice, 2020) .....***S. intermedia*** (Fig. 6c)

6a Leaf lamina more or less thin, relatively large, (9.6–)11.5–12.7(–15.6) cm long, within population very variable, predominantly with elliptical shape; diploid, 2n=34; native in Europe and NW Africa .....lobed morphotypes of ***S. aria*** (Fig. 6d)
Sorbus aria is usually regularly simply to double (to triple) serrate at the edge of the leaf laminas. However, lobed morphotypes sometimes occur in populations.

6b Leaf lamina more or less stiff, smaller, (6.5–)9.1–10.5(–11.5) cm long, within population uniform, broadly ovate, broadly elliptical or nearly rotund 7

7a Lobes of the leaves acuminate, entire on the upper side or rarely with one tooth. – Leaf lamina broadly elliptical or broadly ovate, sometimes nearly round, slightly rhombic, 7.5–11.5 cm long and 5.5–9 cm wide; fruits globose, 9–12 mm long, blood-red, glossy, with very sparse lenticels; tetraploid, 2n~68; Veľká Fatra Mts, very rare (Pekárová Mt.), endemic to Slovakia..... .....***S. pekarovae*** (Fig. 4d)

7b Lobes of the leaves rounded or bluntly acute to acuminate, usually with 1–3 teeth on the upper side 8

8a Leaf lamina broadly ovate to nearly rotund, undulate at margin, ± irregularly pinnately-lobed to pinnately-parted, with basal lobes overlapping each other, broadly cuneate at base [with an angle of (105–)135(–145)°]; fruits nearly globose or wider than long. – Leaf blade with (10–)11(–13) lateral veins; fruits dark red; tetraploid, 2n=68; native to Austria (distribution insufficiently known); reports of its native occurrence in Slovakia are erroneous; occasionally cultivated as an ornamental tree..... .....***S. austriaca*** (Fig. 6a)

8b Leaf lamina broadly elliptical, ovate, or broadly ovate, with a ± flat margin, regularly pinnately lobed, with lobes not overlapping each other (lobes can overlap in herbarium), base cuneate or broadly cuneate [with an angle of (90–)95–110(–115)°]; fruits nearly globose or longer than wide 9

9a Leaf lamina cuneate at the base, with an angle mostly 90–95(–110)° 10

9b Leaf lamina broadly cuneate at the base, with an angle mostly 100–115(–129)° 11

10a Incision between the 2nd and 3rd lobes from the base (6.5–)9.5–11(–14) mm deep. – Leaf lamina broadly elliptical to broadly ovate, with (9–)10(–11) lateral veins; fruits ellipsoidal, 11–13.5 mm long and 9.5–12.5 mm wide; tetraploid, 2n=68; Stredné Pohornádie hills, rare, endemic to Slovakia .....***S. hornadensis*** (Fig. 4b)

10b Incision between the 2nd and 3rd lobes from the base (3.1–)4–7.5(–9.3) mm deep. – Leaf lamina ovate to broadly elliptical, with 10–11(–12) lateral veins; fruits broadly ellipsoidal to ± spherical, usually longer than wide, 10.5–11.5 mm long; tetraploid, 2n=68; native to the Pyrenees to the Western Alps; occasionally cultivated as an ornamental tree..... .....***S. mougeotii*** Soy.-Will. & Godr. in Godron (1859: 447) (Fig. 6b)

11a Leaf laminas of short fertile shoots broadly ovate, undulate at the margins especially when exposed to the sun, with slightly irregular and les rounded lobes; teeth on lamina margins distinctly pointed; sometimes one or both sides of lamina base with concave curvature; anthers bicoloured, very light pink on most of the surface and deep pink at the side of filament insertion; tetraploid, 2n~68; mainly in the Krivánska Malá Fatra Mts, Chočské vrchy Mts, Západné beskydy hills, Slovenský raj Mts, rarely to scattered, locally abundant, endemic to Slovakia.....***S. oravica*** (Fig. 1, 2, 3)

11b Leaf laminas of short fertile shoots distinctly broadly ovate, less undulate at the margins, with regular and more rounded lobes; teeth on lamina margins less pointed; both sides of lamina base without concave curvature; anthers ivory-white, yellow, or exceptionally with a pinkish tinge; tetraploid, 2n~68; Slovenský kras karst, Aggteleki Nemzeti Park in Hungary (?), rarely ....***S. hazslinszkyana*** (Fig. 4a, 5)

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