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Monograph

A revision of the genus *Malus* Mill. (Rosaceae)

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Abstract. A revision of the wild species in the genus *Malus* Mill. (Rosaceae) is presented based on numerical analyses and specimens from herbaria around the world, while cultivated species such as *Malus domestica* (Suckow) Borkh. are not included because of their complicated domestication history. Infra- and interspecific morphological variation and species delimitation are clarified based on Principal Component Analyses (PCA) and Cluster Analyses (UPGMA). We found that several morphological characters traditionally used to distinguish species have limited taxonomic value because of high phenotypic variation or plasticity. There is a substantial conflict between traditional morphological and genetic taxonomic concepts, and as a result species lineages are often morphologically indistinguishable. None of the analyses supports the recognition of infraspecific categories in *Malus transitoria* (Batalin) C.K.Schneid. and interspecific categories between *Malus doumeri* (Bois) A.Chev. and *Malus leiocalyca* S.Z.Huang. Based on our analyses, we recognize 26 wild species in the genus, and propose seven new synonymies.

Keywords. Herbarium specimens, morphological variation, numerical analyses, revision, taxonomy.

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Introduction

The genus *Malus* Mill. (Rosaceae, *Maleae*), occurring mostly in the temperate Northern Hemisphere, is of economic and ecological importance. Some species are cultivated for their fruits such as apple (*Malus domestica* (Suckow) Borkh.) and *M. asiatica* Nakai, or as ornamentals such as *M. micromalus* Makino, *M. hupehensis* (Pamp.) Rehder, *M. spectabilis* (Aiton) Borkh., *M. yunnanensis* (Franch.) C.K.Schneid., and *M. halliana* Koehne. Species in the genus are deciduous trees or shrubs with a basal chromosome number of x = 17. The genus was described by Miller (1754) to include a number of species previously placed in the genus *Pyrus* L. (Linnaeus 1753). *Malus* can be distinguished from *Pyrus*, *Cydonia* Mill., and *Sorbus* L. mainly by the styles that connate at the base, the 2 ovules in each locule, the pome often

not containing the stone cells, and usually white filaments and yellow anthers in stamens. Although Christenhusz *et al.* (2018) recently suggested expanding the genus *Pyrus* s. lat. to include species of *Pyrus*, *Malus*, and other fruit crops in Rosaceae, this taxonomic proposal is not broadly accepted. The number of accepted species in *Malus* varies considerably in different studies. For example, Likhonos (1974) considered only eight species, while Ponomarenko (1986) recognized 78 species. Disagreements over species boundaries and diversity are also reflected in the recognition of various subspecies resulting from cross-compatibility in intraspecific and interspecific hybridization, and apomixis ubiquitous during the evolution of the genus (Robinson *et al.* 2001). Furthermore, a narrow species concept held by some Chinese taxonomists during the 1980s resulted in additional confusion regarding species boundaries (Hus & Gu 1986; Hus 1998).

The taxonomy of *Malus* has been revised several times (e.g., Koehne 1890; Zabel 1903; Koidzumi 1934b; Rehder 1949; Yu & Yen 1956; Chen 1959; Langenfeld 1991; Robertson *et al.* 1991; Li 1996; Qian 2005; Christenhusz *et al.* 2018). Morphological characteristics such as habit, sepals, leaf form, bud folding form, and stone cells have been mostly used in morphological classifications of *Malus*, but different researchers disagree on the categories, the taxonomic ranks, and the placement of some species. For example, *Malus* was divided into five sections, sect. *Chloromeles* (Decne.) Rehder (6 species), sect. *Docyniopsis* C.K.Schneid. (1 species), sect. *Eruolobus* (DC.) C.K.Schneid. (1 species), sect. *Eumalus* Zabel (7 species), and sect. *Sorbomalus* Zabel (8 species) (Rehder 1940). However, some important wild species such as *Malus sylvestris* (L.) Mill., *M. sieversii* (Ledeb.) M.Roem., *M. doumeri* (Bois) A.Chev., and *M. sikkimensis* (Wenz.) Koehne ex C.K.Schneid. were not included. Langenfeld (1971, 1991) presented a new taxonomic system, which is regarded as an extension of Rehder's classification. It comprises six sections including sect. *Sorbomalus*, sect. *Eriolobus* (C.K.Schneid.) Langenf., sect. *Docyniopsis* (C.K.Schneid.) Langenf., sect. *Chloromeles*, sect. *Gymnomeles* Koehne, and sect. *Malus* Langenf. Cultivars without a natural distribution area were no longer included in this system, but the addition of seven monotypic series made the system more complex. Robertson *et al.* (1991) proposed a new classification system, excluding the sections *Eriolobus* and *Docyniopsis* from the genus. Since then, a large number of new species has been described (e.g., Yu *et al.* 1980; Jiang 1991; Qian & Tang 2005; Liu *et al.* 2020), merely based on the quintessential difference between new samples and type specimens of existing species, without considering evidence from molecular, ecological or geographical data. The above mentioned taxonomic revisions lacked an evaluation of character distribution by numerical analyses, and the delimitation of some species remains unsatisfactory.

Incongruence between morphological and genetic data has been apparent in recent taxonomic studies (Yu 2000; Robinson *et al.* 2001; Forté *et al.* 2002; Huh 2007; Potter *et al.* 2007; Lo *et al.* 2012). For example, amplified fragment length polymorphism (AFLP) was employed for estimating genetic relationships within *Malus*, resulting in thirty-three species being classified into four and five groups by the UPGMA and Wanger method, respectively (Yu 2000). These results broadly support Rehder's system; however, samples of *Malus hupehensis* (Pamp.) Rehder, *M. toringo* (Siebold) Siebold ex de Vriese, and *M. baccata* (L.) Borkh. from different localities did not group together. Phylogenetic analysis based on internal transcribed spacer (ITS) and chloroplast *matK* gene sequences divided *Malus* into three clades (i.e., section *Malus* group, section *Sorbomalus* group, and basal taxa) (Robinson *et al.* 2001). Sections *Eriolobus* and *Docyniopsis* were included to ensure the monophyly of the genus. Unfortunately, the results remain ambiguous because of the low levels of sequence divergences and the incongruence between the two data sets.

Nikiforova *et al.* (2013) and Jin (2014) proposed a new molecular phylogenetic framework of *Malus*, based on chloroplast genome data. Their results indicated that *Docynia* Decne. and *Cydonia* are the closest sister genera of *Malus*. Within *Malus*, seven clades were recognized which are compatible with the geographical distribution. However, these phylogenomic results differed considerably from previous

morphological classification systems, and the authors did not offer the identifiable morphological traits of each clade. Savelyeva *et al.* (2017) reconstructed the phylogenetic relationships of species of *Malus* by sequence-specific amplified polymorphism (S-SAP), classifying 131 samples of *Malus* into three groups (Group A–C) and one subgroup (Group C1). Interestingly, two samples of *Malus florentina* C.K.Schneid. belonged to different groups, and the position of *M. sikkimensis* was unstable and dependent on the algorithm used. Overall, these studies indicate support for genetic distinctiveness of part of traditionally recognized groups, but do not find support for genetic differentiation of every currently recognized species within each group. As such, there is an urgent need to evaluate the extensive intraspecific variation within and among species.

The present study aims to: 1) analyze multivariate morphometric traits to clarify rudimentary macromorphological patterns of variation among and within the wild species of *Malus*; 2) evaluate the role of traditional taxonomic characters for identification or separation of taxa; and 3) determine relationships of species based on numerical analyses and specimens from herbaria around the world.

Material and methods

Material

This study is based mainly on digital herbarium specimens from the following herbaria (acronyms according to Thiers B. (continuously updated) http://sweetgum.nybg.org/science/ih/): A, AU, BJFC, BM, BNU, CAF, CCAU, CDBI, CSFI, CSH, CVH, CZH, DAO, DD, E, ECON, FI, FJSI, GFS, GH, GNNU, GNUG, GXMG, GZAC, GZTM, HBNU, HEAC, HENU, HGAS, HHBG, HIB, HIMC, HITBC, HNWP, HSIB, HTC, HUST, HWA, IBK, IBSC, IFP, IMC, IND, JIU, JJF, JXAU, K, KUN, LBG, LE, LECB, LINN, M, MO, MW, NAS, NCU, NDG, NEFI, NKU, NO, NYA, NY, P, PAL, PE, PEY, QNUN, QYTC, RIJKS, SABG, SAU, SDFGR, SM, SXU, SYS, SZ, SZG, TASH, TCD, TIE, US, WCSBG, W, WU, WUK, XBGH, XJBI, XZ, and ZM.

Material for numerical analyses

We checked large numbers of digital specimens spanning the main distribution areas, but not all images were suitable for this study. This was mainly due to the poor resolution, missing scale bar, and folded foliage and flowers of some specimens. The present study encompassed more than 370 adult specimens from 61 wild species (including subspecies, varieties and synonyms) and subspecies of *Malus*, covering ca 87% of the known taxa in the genus. Type specimens were regarded as the standard to select samples, which would ensure taxonomic controversies observed were not caused by hybridization. The number of specimens examined for each taxon ranged from 1 to 15 depending on the availability of vegetative and reproductive characters. The names of the investigated species, specimen barcodes, and collection information are listed in Appendix 1. Most of the type specimens were also included. These specimens are preserved in the herbaria of A, BM, BNU, CDBI, CSFI, DAO, E, GH, GXMG, HENU, HNWP, HTC, IBK, IBSC, IND, IFP, JXAU, K (QIN), KUN, LBG, LINN, M, NAS, NCU, NDG, NO, NY (NYBG), P, PE, SZG, SXU, TCD, US, and WU. Most digital images were downloaded from the Chinese Virtual Herbarium (http://www.cvh.ac.cn/), the Muséum national d'histoire naturelle (https://science.mnhn.fr/), and JSTOR Global Plants (https://plants.jstor.org/plants/browse).

Morphological measurements

A total of 28 morphological characters, traditionally used to distinguish species (Chen *et al.* 2014; Kumar *et al.* 2018) were chosen for analysis, including qualitative and quantitative traits in mature and intact leaves, flowers and fruits. The details and definitions of the traits are presented in Table 1 and Fig. 1. For each specimen, measurements of all pomes and flowers were included, and no less than five leaves (with a few exceptions). All specimens were broadly assigned to two groups ('florescence' group, 'fruiting season' group) based on their reproductive characteristics. The 'florescence' group incorporates samples

Table 1. Description of the quantitative and qualitative morphological parameters of species of *Malus* Mill.

No.	Morphological characteristics	
	Quantitative trait	**Unit of measurement**
1	Petiole length (PL)	mm
2	Blade length (BL)	mm
3	Blade width (BW)	mm
4	BL/BW	ratio
5	Length from the widest point to the base of the leaf (LWB)	mm
6	LWB/BL	ratio
7	Leaf area (LA)	mm^2
8	Angle of apex (AA)	°
9	Angle formed by lateral nerve and main nerve (ALM)	°
10	Angle of the base (AB)	°
11	Tooth length (TL)	mm
12	Tooth width (TW)	mm
13	TL/TW	ratio
14	Pedicel length (pLF)	mm
15	Petal length (Pl)	mm
16	Petal width (Pw)	mm
17	Pl/Pw	ratio
18	Carpopodium length (CL)	mm
19	Pome length (pl)	mm
20	Pome width (pw)	mm
21	pl/pw	ratio
22	CL/pl	ratio
23	Pome area (the projection area of pome on two-dimension plane) (PA)	mm^2
	Qualitative trait	**Description**
24	Piliferous blade (PB)	0-Absence; 1-Partial presence; 2-Presence
25	Piliferous petiole (PP)	0-Absence; 1-Presence
26	Leaf division (LD)	0-Undivided; 1-Incised; 2-Lobed; 3-Parted; 4-Divided
27	Leaf margins (LM)	0-Edentate; 1-Erose; 2-Serrate; 3-Crenate; 4-Serrate and Crenate
28	Piliferous pedicel (Pp)	0-Absence; 1-Presence

collected from March to August with flowers, while the 'fruiting season' group includes samples collected from September to November with fruits. The terminology of the morphological characterization of species of *Malus* followed the works of Hickey (1973), Sun *et al.* (1997), and Harris & Harris (2001). Characters of each specimen were measured by ImageJ ver. 1.52a (https://imagej.nih.gov/ij/index.html).

Statistical analysis

Data from each specimen was processed with reference to Sokal & Sneath (1963) and Kumar *et al.* (2018). Data processing and analysis of the frequency distribution for each qualitative morphological parameter was prepared by R ver. 3.5.2 (http://www.R-project.org/) and Excel 2016. The pooled quantitative data were taken for calculating minimum, maximum, mean, standard error of the mean (SE mean), variance, standard deviation (SD), and coefficient of variance (CV) using the R package. Limited by the number of samples, Kolmogorov-Smirnov tests, Q-Q plots, and Bartlett tests of homogeneity of variances were used to verify data normal distribution after standardization. R packages were employed for one-way analysis of variance (ANOVA) followed by the LSD test (F value and p-value, package 'agricolae'). Although the entire data is normally distributed, the simple correlation of coefficients among the studied variables using the Spearman correlation coefficient method was calculated because of the existing outliers in each variable. Cluster analysis, principal component analysis (PCA), and additional principal coordinates analysis (PCoA) were performed using both R and PAST ver. 3.21 (Hammer *et al.* 2001). The dendrogram was constructed using the UPGMA method (the Gower similarity index, Bootstrap N =

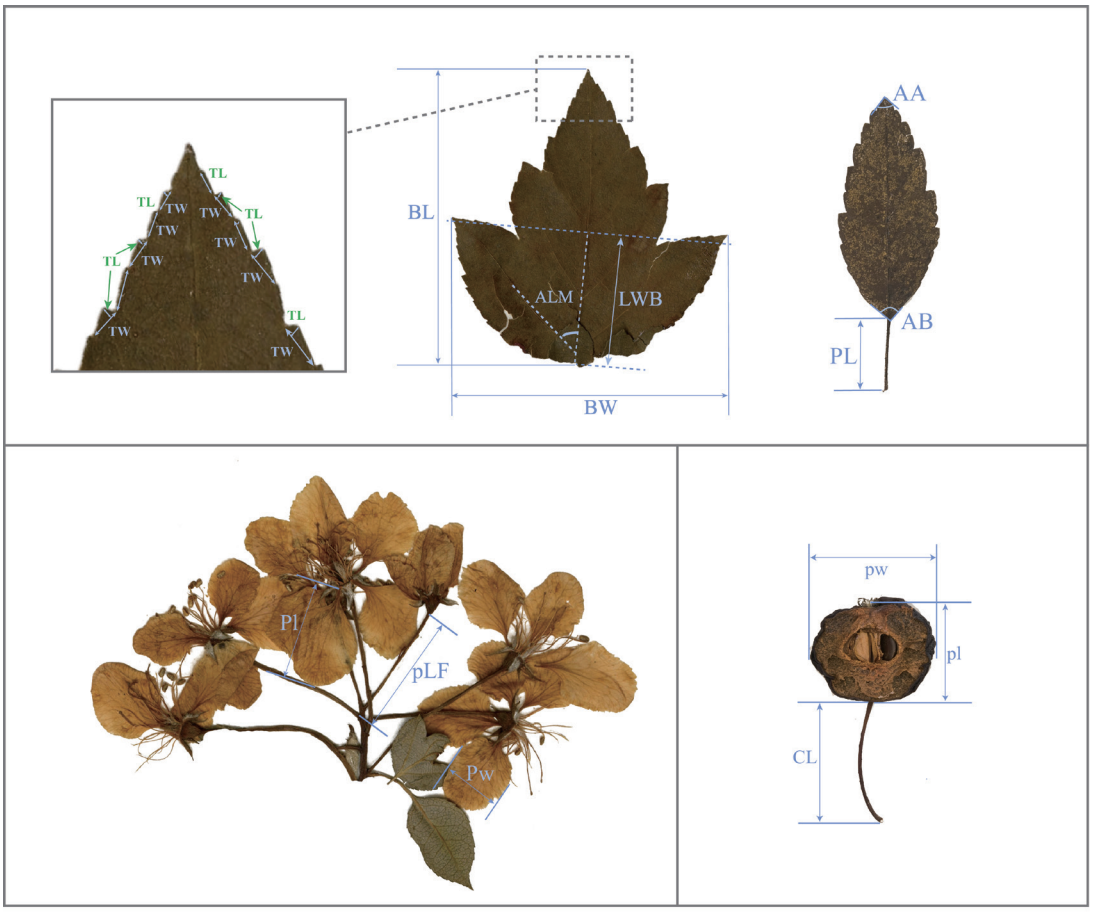

Fig. 1. Schematic for definition of morphological parameters for species of *Malus* Mill. (material from NYBG02812600, A00026590, and A00026604).

500). PCA, which won the approval of the Kaiser-Meyer-Olkin (KMO) measure and the Bartlett test of sphericity, was performed according to the correlation matrix, and factors with eigenvalues >1 were chosen in accordance with the Kaiser criteria (Kaiser 1960).

Results

Morphometric analyses

Frequency distribution of qualitative morphological parameters

Our results showed the extent of morphological variation within the distribution ranges of species. There was considerable diversity for qualitative characters related to leaf, petiole and pedicel in selected species of *Malus*, even though they showed quite distinct differences within a single species. The frequency of the abaxially glabrous leaf blade (59%) was higher than that of the abaxially piliferous leaf blade (29%), and approximately 12% of the samples had a partially piliferous blade. More than 59% of the selected species had all of the leaf traits mentioned above, and less than 41% of the species only possessed one trait. Conversely, the frequency of the glabrous petiole (42%) and pedicel (45%) was lower than the frequency of the piliferous petiole and pedicel (58% and 55%, respectively). Furthermore, 51% and 61% of species and subspecies were either glabrous or piliferous, respectively. The undivided leaves were the most common, while divided leaves were the rarest. Additionally, lobed leafs were the most common type in the species with other than the undivided leaves. The most and the least frequent types of the leaf margin were serrate and erose, respectively. See Appendix 2.

Statistics of quantitative morphological parameters

The morphology of leaves, flowers, and fruits in *Malus* presented by quantitative parameters varied significantly among different species. The coefficient of variation (CV) of all quantitative traits exceeded 10% in both 'florescence' and 'fruiting season' groups, indicating a high level of morphological variation. In line with data of the 'fruiting season' group, the value of CV of the pome area (PA) reaching up to 117% is the highest of all parameters, while the lowest is 13% based on the angle formed by the lateral nerve and main nerve (ALM). The largest average PA (1027.09 mm^2) was observed in *Malus coronaria* var. *hoopesii* Rehder, while the smallest was in *M. muliensis* T.C.Ku (28.00 mm^2). Coincidentally, the value of the CV of ALM that is presented in the 'florescence' group is 14%, which is only slightly more than the CV of the ratio of petal length and width (Pl/Pw, 13%). Additionally, there are two quantitative parameters called leaf area (LA) and tooth length (TL) with CV values exceeding 50%. The maximum average of these two parameters both occurs in *Malus fragrans* var. *elongata* Rehder. It is interesting to notice that *M. trilobata* (Labill. ex Poir.) C.K.Schneid. revealed the longest average petiole length (PL, 42.09 mm) in the 'florescence' group, but the lowest value in the 'fruiting season' group (8.34 mm). In contrast, the shortest average blade length (BL), length from the widest point to the base of the leaf (LWB), and the minimum average leaf area (LA) were measured in *M. transitoria* var. *glabrescens* T.T.Yu & T.C.Ku in both the 'florescence' and the 'fruiting season' groups. The remaining values of studied morphological characteristics for *Malus* and the significant differences examined by the one-way ANOVA are presented in Supp. file 1. The least significant difference (LSD) was applied to test the slight distinctions among species, particularly those that have been treated as synonyms in previous studies. Our results revealed that there is no significant difference between synonyms and their accepted species. Therefore, we follow the recognition of synonyms of previous studies.

Cluster analysis

The scores of cophenetic correlation for two diagrams are 0.76 and 0.85, respectively. The diagrams produced by the cluster analysis of the 'florescence' group data and the 'fruiting season' group data are partly similar. Eight and five main clusters were displayed by cluster analysis based on 17 and 19 quantitative morphological characteristics, respectively, although each clade was identified with poor

resolution (Fig. 2). *Malus trilobata* occupies a separate cluster both in Cluster II (BP = 25%) (Fig. 2A) and Cluster I (BP = 100%) (Fig. 2B), while *M. doumeri*, *M. leiocalyca*, and *M. melliana* (Hand.-Mazz.) Rehder gather on the same branch in the midst of Cluster III (BP = 88%) (Fig. 2B). We compared all samples of these three species and found that their positions were similar in the principal component analysis and principal coordinates analysis (Fig. 3). The information of collection location was also mapped on the dendrograms, but the results revealed no clear patterns.

Moreover, *Malus baccata* and *M. mandshurica* (synonym: *M. manshurica* (Maxim.) Kom. ex Skvortsov) grouped together not only in the cluster tree of the 'florescence' group (BP = 66%) (Fig. 2A) but also in that of the 'fruiting season' group (BP = 73%) (Fig. 2B). Species with the status 'unresolved' or 'unknown' in Appendix 1 grouped with different species in these two cluster trees. For example, *M. xiaojinensis* M.H.Cheng & N.G.Jiang, *M. manshurica*, and *M. sylvestris* form a group in Fig. 2A (BP = 51%), while *M. xiaojinensis* groups with *M. toringoides* (Rehder) Hughes and *M. daochengensis* C.L.Li in Fig. 2B (BP = 46%).

Principal component analysis

Seventeen and nineteen quantitative characters were employed for the PCA analysis, and the result presents a similar pattern as described above. Eleven traits showed an eigenvalue > 1, which illustrates that the species are morphologically very close. The variance of eleven major traits (> 1 eigenvalue) PCs varies from 1.3% to 31.3% and 1.7% to 27.0%, respectively (Bootstrap N = 100).

Based on data of the 'florescence' group, the first six principal components accounted for 84.2% of the total variance, wherein the first and second axis occupied 31.3% and 17.1%, respectively (Table 2). Factor loadings of > 0.60 and < -0.60 were considered as significant. Six characters showed the highest correlation

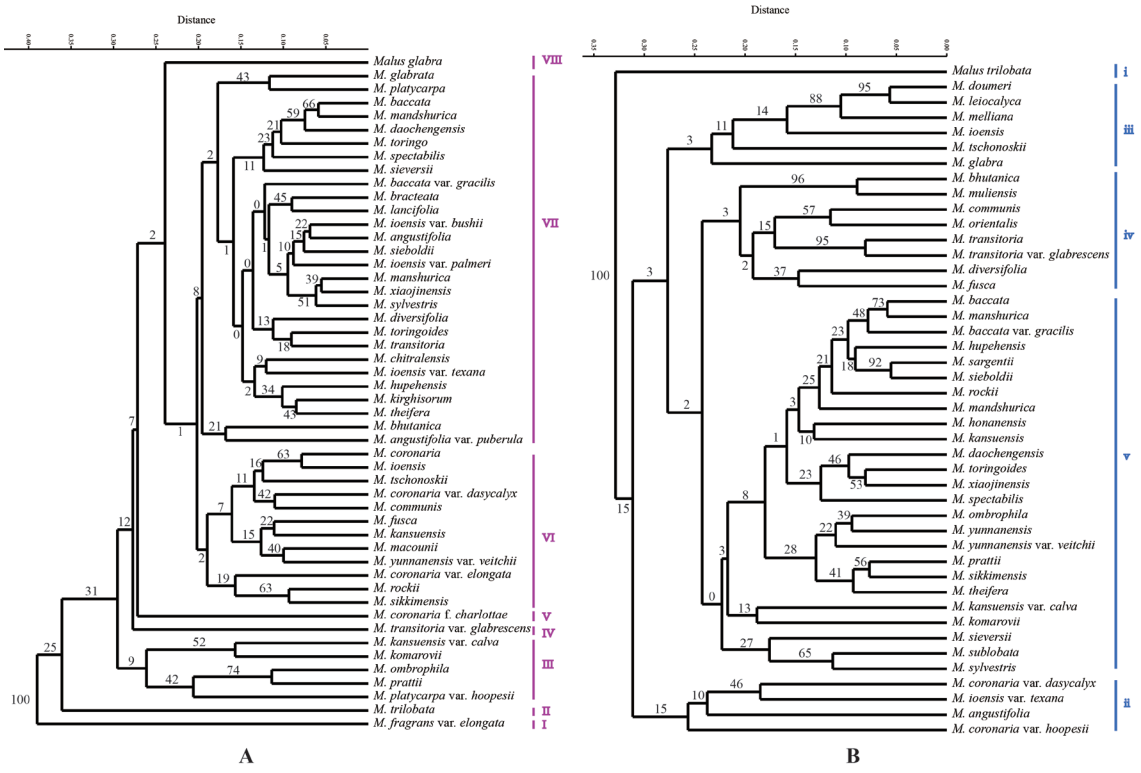

Fig. 2. Cluster analysis (UPGMA method of classification and Gower's general similarity coefficient). **A**. 'Florescence' group (17 quantitative characters). **B**. 'Fruiting season' group (19 quantitative characters).

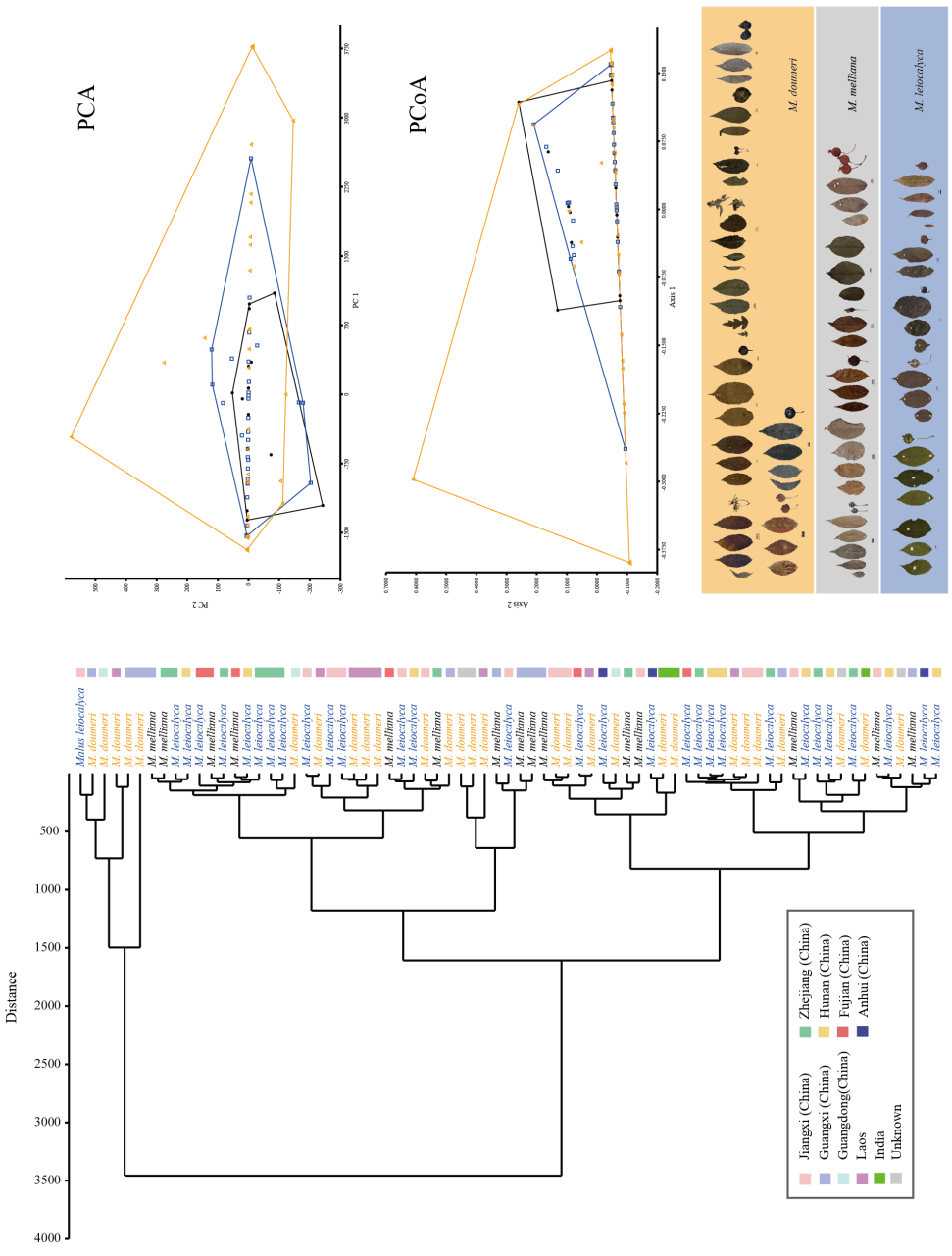

Fig. 3. Cluster analysis (UPGMA method) and PCA performed on all studied quantitative characters in *Malus doumeri* (Bois) A.Chev., *M. melliana* (Hand.-Mazz.) Rehder, and *M. leiocalyca* S.Z.Huang. The images come from the following specimens. *M. doumeri*: A00032498 (isotype of *Pyrus melliana* Hand.-Mazz.), CSFI033248, P00781055 (syntype), P00781056, P00781058 (lectotype of *Pyrus laosensis* Cardot), P03144755, P03144777, P03144789, PE00004596 (holotype of *M. asiatica* var. *argutiserrata* Hu & F.H.Chen), PE00927581, and QIN05067; *M. melliana*: P03144393, PE01460689, JXAU0004023, JXAU0004034, IBK00197341, and IBK00197343; *M. leiocalyca*: CSFI012166, CSFI012188, PE00952771, PE00952776, PE00952780 (paratype), PE00952781 (isotype), and IBK00367917.

Table 2. Eigenvalues and variance (%) obtained from PCA.

	'Florescence' group		'Fruiting season' group	
PC	**Eigenvalue**	**% variance**	**Eigenvalue**	**% variance**
1	5.32006	31.294	5.12367	26.967
2	2.90037	17.061	3.94129	20.744
3	2.33684	13.746	2.31301	12.174
4	1.54953	9.1149	1.63536	8.6071
5	1.33725	7.8662	1.4507	7.6353
6	0.872894	5.1347	1.21412	6.3901
7	0.829107	4.8771	0.978654	5.1508
8	0.632907	3.723	0.643663	3.3877
9	0.449899	2.6465	0.601675	3.1667
10	0.331654	1.9509	0.448599	2.361
11	0.227082	1.3358	0.319202	1.68

Table 3. Factor loadings for the first six principal components obtained from PCA based on 17 quantitative characters for the 'florescence' group of the selected species of *Malus* Mill.

	PC 1	**PC 2**	**PC 3**	**PC 4**	**PC 5**	**PC 6**
PL	**0.76899**	0.22424	-0.23856	-0.29677	0.013239	0.16545
BL	**0.85849**	-0.06006	0.3643	-0.16325	-0.09479	-0.21533
BW	**0.91466**	0.13167	-0.23145	0.051663	-0.13774	0.040662
BL/BW	-0.39891	-0.12255	**0.63488**	-0.43377	0.004424	-0.30506
LWB	**0.68773**	-0.18322	**0.61537**	0.016119	0.064921	-0.19813
LWB/BL	-0.18546	-0.24645	**0.61793**	0.29608	0.32172	-0.06665
LA	**0.93642**	-3.84E-05	0.14597	0.045115	-0.16591	-0.07754
AA	-0.39007	0.12001	0.14345	**0.7437**	-0.15675	0.15025
ALM	-0.0301	0.11309	0.29895	0.28121	**-0.74523**	0.018803
AB	0.51348	0.34684	-0.57099	0.056569	-0.15766	-0.23679
TL	**0.76357**	-0.15936	0.23147	0.33598	0.21341	0.23526
TW	0.54431	0.41802	0.42534	0.14706	-0.0888	0.13659
TL/TW	0.42439	**-0.60097**	-0.18696	0.2612	0.45895	0.2057
pLF	0.21342	**0.60578**	0.14549	-0.26817	0.3959	0.14857
Pl	-0.16404	**0.9107**	0.17374	0.11388	0.2099	-0.02234
Pw	-0.12903	**0.86285**	-0.00828	0.28162	0.26103	-0.24539
Pl/Pw	-0.21557	0.26489	0.38974	-0.38953	-0.1899	**0.6137**

Note: Factor loadings (>0.60 and <-0.60) are given in bold. For character abbreviations, see Table 1.

with PC1, four with PC2, three with PC3, and one each with PC4, PC5, and PC6 (Table 3). Fourteen characters had high positive factor loadings (>0.60) on the first six axes, and two had high negative factor loadings (<-0.60), which could help to distinguish between specimens of subspecies and varieties.

For data of the 'fruiting season' group, the first and second principal components hold 27.0% and 20.7%, respectively (Table 2). Only one factor loading exceeded 0.60. Hence factor loadings of >0.30 and <-0.30

Table 4. Factor loadings for the first six principal components obtained from PCA based on 19 quantitative characters for the 'fruiting season' group of the selected species of *Malus* Mill.

	PC 1	PC 2	PC 3	PC 4	PC 5	PC 6
PL	0.11881	0.28328	0.10312	-0.2316	-0.19672	**0.39471**
BL	**0.30837**	**0.30718**	0.17548	0.1009	-0.05519	-0.08283
BW	0.27113	0.29575	-0.28556	0.13855	-0.09964	0.093014
BL/BW	0.01778	0.016381	**0.56146**	-0.06223	0.10675	-0.24239
LWB	**0.3502**	0.16696	0.20509	-0.06324	-0.17505	0.1749
LWB/BL	0.14224	-0.22367	0.044993	**-0.35095**	-0.21371	**0.45383**
LA	**0.31008**	**0.32163**	-0.0447	0.16544	-0.08945	-0.04049
AA	-0.06988	**-0.32029**	-0.29672	0.23197	-0.08101	0.13641
ALM	0.15024	0.063338	0.21898	0.072871	0.096343	-0.0835
AB	0.07346	0.253	**-0.36209**	**0.352**	-0.04334	-0.14378
TL	0.18558	0.10538	-0.25434	**-0.48125**	**0.31751**	-0.24469
TW	0.23514	-0.1239	0.15562	-0.08997	0.21001	-0.2995
TL/TW	-0.02261	0.19365	**-0.36126**	**-0.46637**	0.24621	-0.0779
CL	7.96E-05	0.11784	0.048816	0.22614	**0.64926**	**0.41621**
pl	**0.34754**	-0.23438	-0.0253	0.15926	0.1411	-0.00062
pw	**0.34439**	-0.28761	-0.04763	0.058596	0.12861	0.054186
pl/pw	-0.23715	0.19512	0.095807	0.16335	0.064524	-0.15176
CL/pl	-0.25307	0.23744	0.11641	0.033711	**0.33555**	**0.35171**
PA	**0.30851**	-0.27524	-0.03404	0.10293	0.23369	0.083445

Note: Factor loadings (> 0.30 and <-0.30) are given in bold. For character abbreviations, see Table 1.

were considered as significant in Table 4. Seventeen characters had high positive factor loadings and six had high negative factor loadings on the first six principal components. The relationship among species of *Malus* was exhibited in the scatter plot constructed by PC1 and PC2 (Fig. 4). Neighbouring species on the diagram revealed a very close relationship in morphology.

Based on the morphological information available in our study, combined with protologue, and genetic, ecological and geographical evidence for species delimitation, twenty-six wild species and two varieties are confirmed in the genus. Nonetheless, the evaluation of diagnostic characters to identify some species is still difficult due to the lack of collections from certain regions or countries. Although herbaria host rich collections of *Malus*, some species are represented by a few specimens only. For example, the Chinese endemic species *Malus muliensis* was collected only once in 1983 (19 Aug. 1983; *Expedition Qinghai-Xizang 12983*; PE[01685058] and PE[01862281]), and *M. sublobata* Rehder only has one specimen in Kew (K[000758473]) with little information. In addition, the taxonomic position of *M. daochengensis* C.L.Li is still unclear because DNA sequence data are lacking. Therefore, *M. muliensis*, *M. sublobata* and *M. daochengensis* are not involved in this revision.

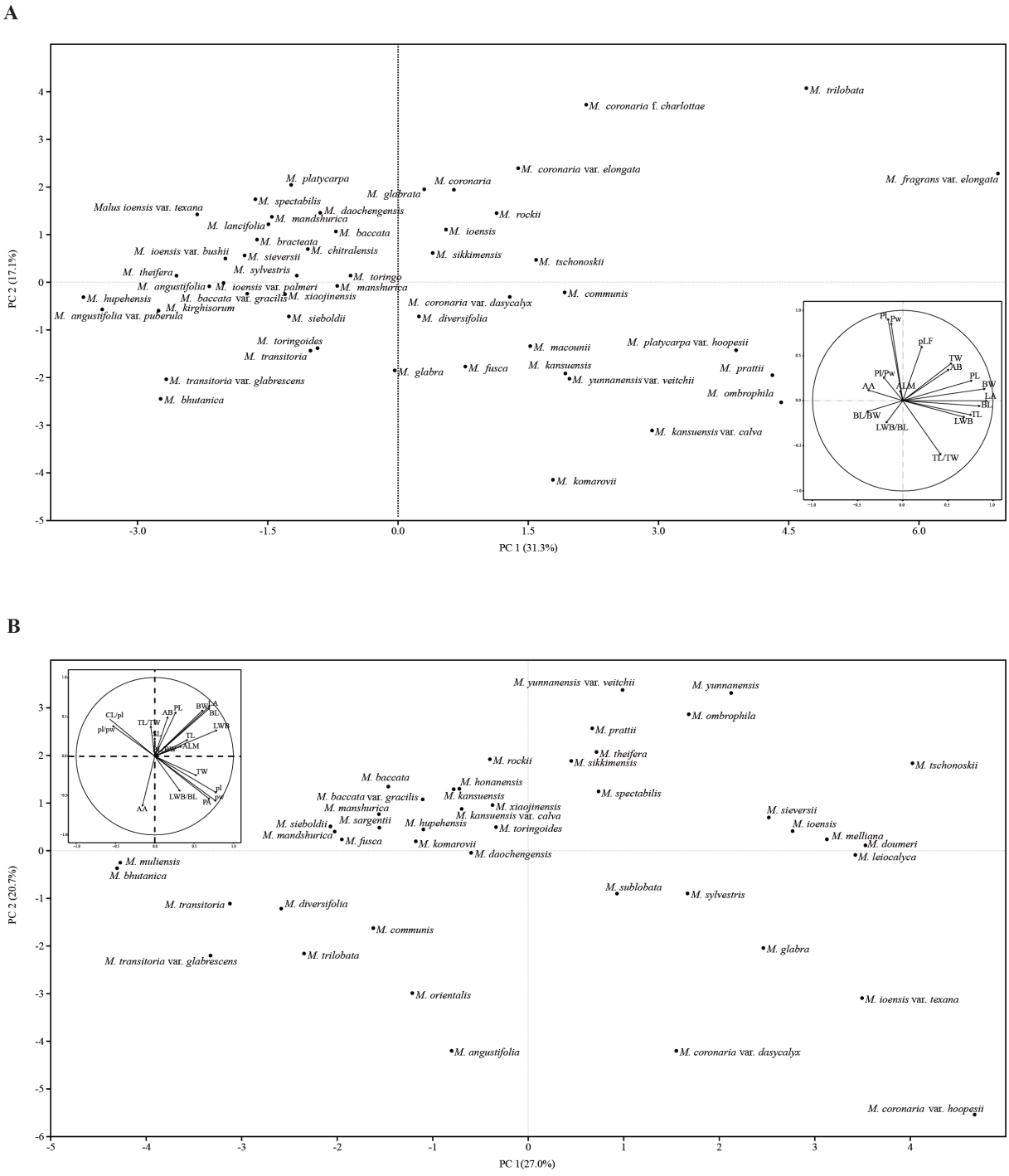

Fig. 4. Principal component analysis (PCA). **A**. 'Florescence' group (17 quantitative characters). **B**. 'Fruiting season' group (19 quantitative characters).

Taxonomy

Class Magnoliopsida Brongn.
Order Rosales Bercht. & Presl
Family Rosaceae Juss.

Genus ***Malus*** Mill.

Gardeners Dictionary Abridged, 4th Ed., Vol. 2: Malus (Miller 1754).

Pyrus sect. *Malus* Tourn., *Institutiones Rei Herbariae Vol. 3*: tab. 406 (Tournefort 1700). – *Pyrus* sect. *Malus* Tourn. ex DC., *Prodromus Systematis Naturalis Regni Vegetabilis Vol. 2*: 635 (de Candolle 1825). – *Pyrus* subgen. *Malus* (Tourn.) Focke, *Die natürlichen Pflanzenfamilien 3rd Ed., 3 (3)*: 24 (Focke 1888).

Type species

Malus sylvestris (L.) Mill.

Description

Trees or shrubs, deciduous or semi-evergreen. Branches terete, generally unarmed. Leaves unifoliate, alternate, petiolate, stipular. Lamina oval to ovate, margin crenate to serrulate, serrate or lobed. Inflorescence umbellate or corymbose. Flowers usually 3–6, pedicellate. Stamens 15–50, with yellow anthers and white filaments. Hypanthium bowl-shaped, glabrous or pubescent. Petals 5, suborbicular to obovate, white to red, with 5 sepals persistent or caducous. Styles 3–5, connate at base, glabrous or pubescent. Ovary inferior, 3–5-locular, with 2 ovules in each locule. Pome stone cells present in a few species. Seeds semicircular or spindly, black or brown, 1 or 2 in each locule.

Chromosome number

x = 17, usually diploid, triploid, tetraploid, and polyploid.

Distribution

Widely distributed in North temperate zone.

Key to species

1. Microphyll (225–2025 mm^2) most common 2
– Notophyll (2025–4500 mm^2) most common 20

2. Insertion points of lamina base on either side of petiole are symmetrical 3
– Insertion points of lamina base on either side of petiole are asymmetrical 17

3. Leaf margin generally unlobed, or lobed in young leaves 4
– Leaf margin distinctly lobed, or divided 13

4. Lamina base cuneate or rounded 5
– Lamina base rounded, truncate, wide-cuneate or cordate 9

5. Lamina elliptic to ovate, elliptic ovate or triangular ovate 6
– Lamina obovate, oblong to oval or rotund 7

6. Tree; leaf apex retuse to caudate; abaxial blade puberulous or glabrescent; umbel .....
..... **1**. ***M. baccata*** (L.) Borkh.

– Small tree or shrub; leaf apex acute, rounded or obtuse; blade glabrous or villous on midvein, sometimes lobed; corymb ..... **20**. ***M. angustifolia*** (Aiton) Michx.

7. Young leaves piliferous, then glabrescent; small pome, with maximum diameter no more than 4.5 cm 8
– Abaxial blade puberulous in adult leaves; sepals caducous; styles 3 or 4, with dense tomentum at base; pome ca 3.0–8.0 cm in diameter, subglobose or coniform, yellow or green .... **4**. ***M. kirghisorum*** Al.Fed. & Fed.

8. Small tree or shrub; hypanthium densely lanuginous; sepals densely puberulous, persistent; styles 5, rarely 4, basally densely puberulent; pome solitary, ca 2.5–4.5 cm in diameter .... **3**. ***M. sieversii*** (Ledeb.) M.Roem.
– Tree; hypanthium glabrous; sepals abaxially puberulous or glabrous, adaxially densely puberulous, caducous; styles 3–5, glabrous; pome ca 1.0–1.3 cm in diameter .... **11**. ***M. xiaojinensis*** M.H.Cheng & N.G.Jiang

9. Lamina ovate, broadly ovate to elliptic ovate or rotund 10
– Lamina ovate to oblong or triangular ovate 12

10. Leaf margin occasionally lobed, apex acuminate or acute; hypanthium densely lanuginous; styles 5, basally puberulous ..... **14**. ***M. tschonoskii*** (Maxim.) C.K.Schneid.
– Leaf margin unlobed, apex usually acuminate; hypanthium puberulous or glabrous; styles 5, basally glabrous 11

11. Small tree or shrub; lamina glabrous; umbel; pome solitary, ca 2.0–3.5 cm in diameter, subglobose, yellow ..... **7**. ***M. sylvestris*** (L.) Mill.
– Tree; lamina puberulous or glabrous; corymb; pome ca 1.0–1.5 cm in diameter, ellipsoidal, yellow to red, with fruit spots ..... **17**. ***M. prattii*** (Hemsl.) C.K.Schneid.

12. Small tree or shrub; lamina puberulous, sometimes 3-lobed, rarely 5-lobed; umbel; hypanthium puberulous or glabrous; sepals caducous; styles 3–5, basally densely puberulent; pome ca 0.6–0.8 cm in diameter, subglobose or oblate, yellow or red ..... **8**. ***M. toringo*** (Siebold) Siebold ex de Vriese
– Small tree; lamina glabrous or puberulous, sometimes lobed; corymb; hypanthium densely puberulous; sepal persistent; styles 5, pubescent at base; pome ca 2.0–3.0 cm in diameter, subglobose, yellow..... **21**. ***M. ioensis*** (Alph.Wood) Britton

13. Lamina palmately lobed or divided 14
– Lamina pinnately lobed or divided 15

14. Tree; lamina base rounded or cuneate, apex acute, pubescent on abaxial blade, lobed; sepals persistent; styles 5, pubescent at base; pome ca 1.0 cm in diameter, oval or obovate .... **23**. ***M. florentina*** (Zuccagni) C.K.Schneid.
– Small tree or shrub; lamina base cordate or cuneate, apex acute or acuminate, puberulous, 3-lobed; sepals caducous or persistent; styles 4 or 5, glabrous; pome ca 0.8–1.0 cm in diameter, subglobose, yellow to red ..... **26**. ***M. komarovii*** (Sarg.) Rehder

15. Lamina base usually wide-cuneate, sometimes rounded or cordate; umbelliform corymb (appearance resembles umbel) 16
– Lamina base usually rounded or cordate, sometimes cuneate; corymb; sepals abaxially glabrous or puberulous, adaxially densely puberulous, persistent; styles 5, pubescent at base; pome ca 2.5–3.5 cm in diameter, subglobose, yellow ..... **22**. ***M. coronaria*** (L.) Mill.

16. Lamina elliptic to ovate, piliferous, pubescent on midvein, usually 3-lobed or divided, sometimes unlobed; pome ca 1.0–1.3 cm in diameter, ellipsoidal to subglobose, yellow .... **10**. ***M. toringoides*** (Rehder) Hughes
– Lamina oval to ovate, puberulous when young, then abaxially glabrescent, usually 3–5-divided; pome ca 0.6–0.8 cm in diameter, subglobose, yellow to red ..... **12**. ***M. transitoria*** (Batalin) C.K.Schneid.

17. Indumentum on young leaves, then glabrescent 18
– Indumentum on abaxial blade or midvein, sometimes glabrous 19

18. Lamina oval to ovate, usually aubergine in young leaves, base cuneate, rarely rounded, apex acuminate, rarely retuse, discolorous; umbel; styles 3, rarely 4, basally puberulent; pome ca 0.8–0.9 cm in diameter, subglobose, yellow to red ..... **2**. ***M. hupehensis*** (Pamp.) Rehder
– Lamina elliptical to oval, base cuneate or cordate, oblique, apex acuminate or acute, rarely obtuse, sporadically 3-lobed; umbelliform corymb; styles 2–5 (3–4), glabrous; pome ca 1.5–2.0 cm in diameter, coniform, yellow to red ..... **6**. ***M. fusca*** (Raf.) C.K.Schneid.

19. Lamina oblong to orbicular, base cuneate; styles 5, glabrous or with dense tomentum at base, stigma clavate; pome ca 2.0–3.0 cm in diameter, subglobose or coniform, yellow or red .... **5**. ***M. orientalis*** Uglitzk. ex Juz.
– Lamina elliptic to ovate, base rounded, cordate or cuneate; styles 4 or 5, basally crinite; pome ca 1.0–1.5 cm in diameter, subglobose, tapering, red ..... **9**. ***M. rockii*** Rehder

20. Insertion points of lamina base on either side of petiole are symmetrical 21
– Insertion points of lamina base on either side of petiole are asymmetrical; lamina oblong to ovate, base rounded or cuneate, apex acute or acuminate, pubescent when young then glabrescent, or glabrous; styles 5, pubescent at base; pome ca 2.5–5.5 cm in diameter, subglobose, yellow to red .... **25**. ***M. doumeri*** (Bois) A.Chev.

21. Leaf margin generally unlobed, sometimes lobed or divided 22
– Leaf margin distinctly lobed, or divided, occasionally unlobed 23

22. Small tree; lamina oval to ovate, base rounded, pubescent on midvein and abaxial blade; styles 4, glabrous; pome ca 1.5–2.0 cm in diameter, subglobose or pyriform, yellow to red .... **13**. ***M. sikkimensis*** (Wenz.) Koehne ex C.K.Schneid.
– Tree; lamina oval to oblong, base cordate, rounded or truncate, villous on abaxial blade, rarely 3–5-lobed; styles 3–5, glabrous; pome ca 1.5–2.0 cm in diameter, subglobose, red or yellow, with fruit spots ..... **19**. ***M. ombrophila*** Hand.-Mazz.

23. Lamina palmately lobed or divided, ovate, base cordate, pubescent on abaxial blade; umbel; styles 5, pubescent at base; pome ca 1.0–2.0 cm in diameter, subglobose or ellipsoidal, red .... **24**. ***M. trilobata*** (Labill. ex Poir.) C.K.Schneid.
– Lamina pinnately lobed or divided 24

24. Sepals persistent 25
– Sepals caducous, abaxially glabrous, adaxially puberulous; lamina oval to ovate, base rounded, truncate or cordate, puberulous or glabrous, usually 3-lobed; styles 3, rarely 2 or 4, glabrous or puberulous; pome ca 1.0–1.5 cm in diameter, ellipsoidal, yellow to red, with fruit spots .... **16**. ***M. kansuensis*** (Batalin) C.K.Schneid.

25. Small tree or shrub; lamina usually oval, sometimes elliptical, base rounded, truncate or cordate, apex acute or obtuse, with dense pubescence on midvein, usually 3–6-lobed; styles 3 or 4, glabrous;

pome ca 0.8 cm in diameter, subglobose, yellow to red, with white fruit spots .... **15**. ***M. honanensis*** Rehder

– Tree; lamina oval to oblong, base cordate, rounded or truncate, apex acuminate, acute or obtuse, pubescent on abaxial blade, usually 3–5-lobed; styles 5, glabrous; pome ca 1.0–1.5 cm in diameter, subglobose, oblate or oval, red, with white fruit spots .... **18**. ***M. yunnanensis*** (Franch.) C.K.Schneid.

1. ***Malus baccata*** (L.) Borkh.
Figs 5–6

Theoretisches-praktisches Handbuch der Forstbotanik und Forsttechnologie Vol. 2: 1280 (Borkhausen 1803).

Description

Tree or small tree. Branches terete, piliferous or glabrous. Leaves petiolate, petiole puberulous or glabrescent. Lamina oval to ovate, base cuneate, apex retuse to caudate, margin crenate to serrulate, blade abaxially piliferous or glabrescent. Inflorescence umbellate. Pedicel piliferous or glabrous. Hypanthium glabrous. Sepals lanceolate, abaxially glabrous, adaxially puberulous, caducous. Petals white, obovate. Stamens 15–20, unequal. Styles 3–5, longer than stamens, glabrous. Pome subglobose. Carpopodium piliferous or glabrous.

Distribution

Widely distributed in Asia (Fig. 5).

Chromosome number

2n = 34.

Key to varieties of *Malus baccata* (L.) Borkh.

1. Trees, 10–15 m; styles 4 or 5 2
– Small trees, 4–6 m; branchlets pendulous; styles 3 or 4 ..... **b**. var. ***gracilis*** (Rehder) T.C.Ku

2. Branchlets, leaf, sepals, pedicel and calyx tube pubescent .... **c**. var. ***mandshurica*** (Maxim.) C.K.Schneid.
– Branchlets, leaf, sepals, pedicel and calyx tube glabrous ..... **a**. var. ***baccata***

Fig. 5. Distribution of *Malus baccata* (L.) Borkh.

Fig. 6. Morphological characters of *Malus baccata* (L.) Borkh.; LINN-HL647-4 (lectotype), M0213676, P03324193, P03324196, P03324219, P03324220, P03339997, KUN0659908, KUN0755632, KUN0889035. Scale bars = 10 mm.

1a. ***Malus baccata*** var. ***baccata***

Pyrus baccata L., *Mantissa Plantarum: Generum editionis VI. et specierum editionis II*: 75 (Linnaeus 1767). – *Malus sibirica* Borkh., *Archiv für die Botanik (Leipzig)* 1 (3): 89 (Borkhausen 1798), nom. inval., nom. nov. of *Pyrus baccata* L. – *Pyrus baccata* var. *sibirica* Maxim., *Bulletin de l'Académie impériale des Sciences de Saint-Pétersbourg* 19: 170 (Maximowicz 1874). – *Malus baccata* var. *sibirica* (Maxim.) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 720 (Schneider 1906b). – *Malus sibirica* (Maxim.) Kom., *Key for the Plants of the Far Eastern Region of the USSR. Part 2*: 638 (Komarov & Klobukova-Alisova 1932, non Borkhausen 1798). – **Type**: COUNTRY UNKNOWN • locality unknown; s.d.; fl; *Linnaeus s.n.*; holotype: LINN[LINN-HL647-4]!

Malus rossica Medik., *Geschichte der Botanik unserer Zeiten*: 78 (Medikus 1793), nom. inval.

Malus pallasiana Juz., *Flora USSR Vol. 9*: 370 (Juzepczuk 1939). – **Type**: RUSSIA • Transbaikalia; s.d.; *Anonymous s.n.*; type: LE, designated by Juzepczuk 1939: 370.

Malus chamardabanica Vartapetyan & Solovjeva, *Byulleten' moskovskogo Obshchestva Ispytatelei Prirody, Otdel biologicheskii* 85 (5): 82 (Vartapetyan & Solovjeva 1980). – *Malus baccata* f. *chamardabanica* (Vartapetyan & Solovjeva) Ponom., *Botanical Magazine* 73 (1): 83. (Ponomarenko 1988), syn. nov. – **Type**: RUSSIA • 20 Sep. 1978; fr; *Вартапетян В. [Vartapetyan V.] s.n.*; holotype: MW[MW0592212]!; isotype: MW[MW0592213]!

Examined specimens

CHINA – **Beijing** • Baihua Mountain; Jun. 1996; fl; *Q.R. Liu 06719*8; BNU • ibid.; 8 Jul. 1988; fr; *H.X. Gao 018414*; BNU • Mentougou; 21 May 1974; fl; *K.J. Guan 74-097*; PE. – **Chongqing** • Chengkou; 18 May 2005; fr; *Z.Y. Liu 2050152*; IMC • Kaixian; 5 Sep. 2002; fr; *Z.Y. Liu 2023209-01*; IMC. – **Fujian** • Xiamen; 14 Jul. 1981; fr; *G. Yao et al. 8149*; FJSI. – **Gansu** • Lien hoa_shan, Hako, slopes of Mt.; Oct. 1926; fr; *J.F. Rock. 13498*; IBSC, AU • Tianshui; Apr. 1960; fl; *Anonymous 00052*; PE • Pingliang; 15 May 2014; fl; *Y. He & J.S. Hao GSL2014050511*; BNU. – **Guangdong** • Ruyuan; 10 Apr. 1934; fl; *X.P. Gao 54069*; BNU • same collection data as for preceding; fl, fr; *X.P. Gao 54078*; BNU. – **Guizhou** • Tungtze; 18 May 1930; fr; *Y. Tsiang 4909*; IBSC. – **Hebei** • Xinglong; 12 May 1951; fl; *Y. Liu 15269*; IBK • Pohuashan; 21 Jul. 1930; *W.Y. Hsia 2202*; IBSC. – **Henan** • Xinxiang; Jul. 1959; fr; *F.Q. Li 23704*; HENU • Luanchuan; 18 Apr. 2015; fl; *W.G. Yang 150418026 06*; HEAC. – **Heilongjiang** • Haerbin; 11 Jul. 1956; fr; *Lin 11 51*; NEFI • Huma; 29 Jul. 1961; fl; *Z. Lu 90083*; NEFI. – **Hubei** • Yingshan; 28 Apr. 2015; fl; *L. Chen CB08794*; CSH • Luotian; 19 May 2015; fl; *L. Chen CB09123*; CSH • locality unknown; 1930; fr; *H.F. Chow 41023*; LBG. – **Hunan** • Yangmingshan; 12 Apr. 1942; st; *Y. Jiang & S.Q. Chen 699*; IBK. – **Inner Mongolia** • Humeng; 30 Jun. 1963; fl, fr; *Anonymous 164*; PE • Chahameng; 9 Sep. 1949; fl, fr; *Y.W. Cui 00883*; PE. – **Jilin** • Antu; 4 Sep. 1959; fl, fr; *P.Y. Fu 1364*; PE • Changbaishan; 6 Aug. 2012; fr; *H.C. Zhou ZhouHC1078*; KUN. – **Jiangxi** • Lushan; 26 Jul. 1922; fr; *A.N. Steward 4522*; PEY. – **Liaoning** • Fengcheng; 18 May 1960; fl; *Y.C. Deng & Q.H. Feng 220*; IBK • Qianshan; 23 Jul. 1958; fr; *F.M. Luo et al. GUO818*; PE. – **Qinghai** • Huzhu; Sep. 1980; fr; *G.B. Shi 161*; IBSC. – **Shandong** • Kunyushan; 8 May 1959; fl; *T.Y. Zhou et al. 0718*; NAS • Qingdao; 6 Aug. 1958; fr; *Z.L. Yan 115*; PE. – **Shanxi** • Zhongyang; 12 Jun. 1955; fr; *Zhongyangyidui 0011*; PE • Mozhanggou; 8 Jun. 1956; fl; *W.Z. Wang et al. 486*; PE. – **Shaanxi** • Taipaishan; 21 Apr. 1939; fl; *K.T. Fu 2972*; PE. – **Shanghai** • Taochuan; 26 Apr. 1956; fl; *Anonymous 00014*; PE • Yanan; 13 Sep. 1954; fr; *K.J. Fu 8159*; PE. – **Sichuan** • Lixian; 7 Aug. 1958; fr; *Z.L. Wu 33576*; CAF • Mt. Gibboh; May 1928; fl; *J. Rock 016003*; IBSC. – **Tianjin** • Jixian; 1 Aug. 1972; fr; *Jipudui 409*; PE. – **Tibet** • Gongbujiangdaxian; 6 Aug. 2014; fr; *X.C. Chen 6090*; HNWP • Lhasa; 15 May 1980; fl; *Z.C. Ni 79248*; PE, XZ. – **Xinjiang** • Aertai; 25 Aug. 1956; fr; *R.C. Qin xin2337*; PE. – **Yunnan** • Chao-tung Hsien; 18 May 1932; fl; *H.T. Tsai 50905*; IBK, PE, NAS • Hills around La-chu pa; Sep. 1924; fr; *G. Forrest 25074*; PE. – **Zhejiang** • Anji; 8 Oct. 1989; fr; *Zhihangbiao 003355*; HHBG.

RUSSIA – **Tschita** • Schilka; 25 Jun. 1977; fr; *N. Alianskaia & T. Sofejkova 145*; PE.

SOUTH KOREA – **Incheon** • Hyeolgusan; 24 Jul. 2011; fr; *G.-N. Jeon 201111-0052*; PE. – **Jeora-Nam-Do** • Gu-Rae-Gun; 23 Jun. 2004; fr; *C.S. Chang et al. sky0334*; PE. – **Kyeong-Sang-Nam-Do** • San-Cheong-Gun; 21 May 2004; fl; *C.S. Chang & K.S. Lee sky0099*; PE.

UNITED STATES – **New York** • Ontario, cultivated; 28 Sep. 1990; fr; *Zhen-long Yan 1034*; PE.

Description

Tree, 10–15 m high. Leaves petiolate, petiole 1.1–4.2 cm long, puberulous or glabrescent. Lamina 3.9–9.8 × 1.6–5.2 cm, oval to ovate, base cuneate, apex retuse to caudate, margin crenate to serrulate, blade abaxially puberulous or glabrescent. Inflorescence umbellate, with 3–5 flowers. Pedicel 1.6–4.4 cm long, pubescent when young, glabrescent. Petals ca 0.9–1.8 × 0.5–1.0 cm, white, obovate. Pome ca 0.7 × 0.6 cm, subglobose, yellow to red. Carpopodium ca 3.3 cm long, glabrous.

Phenology

Flowers from April to September. Mature fruits from September to October.

Habitat

Terrestrial, seasonally green, growing in miscellaneous wood forests on slopes and in valleys; up to 1500 m a.s.l.

Distribution

Bhutan, China (Beijing, Chongqing, Fujian, Gansu, Guangdong, Guizhou, Hebei, Henan, Heilongjiang, Hubei, Hunan, Jiangxi, Jilin, Liaoning, Nei Mongol, Qinghai, Shandong, Shanxi, Shaanxi, Sichuan, Tianjin, Tibet, Xinjiang, Yunnan, Zhejiang), India (Kamoon), Japan (Aomori, Nagano), Kashmir, South Korea (Inchon, Jeollanam-do, South Gyeongsang), Mongolia, Nepal, and Russia (Siberia).

Chromosome number

2n = 34.

1b. ***Malus baccata*** var. ***gracilis*** (Rehder) T.C.Ku

Figs 7–8

Flora of China 9: 181 (Ku & Spongberg 2003).

Malus baccata f. *gracilis* Rehder, *Journal of the Arnold Arboretum* 2 (1): 49 (Rehder 1920). – **Type**: CHINA • Shaanxi, Yenan Fu; 14 May 1919; fl; *Purdom 327*; type: A[A00026586]!

Examined specimens

CHINA – **Gansu** • Heshui; 21 Jul. 1954; fr; *Yellow River Investigation Team 163*; PE[PE00927499] • Pingliang; 8 Aug. 1956; fr; *Yellow River Investigation Team 2051*; PE[PE00927502] • Yen Kwan; s.d.; fr; *Fenzel & Pai 2826*; PE. – **Qinghai** • Xining; 8 May 1990; fl; *Z.H. Zhang et al. 5559*; HNWP[HNWP160546]. – **Shaanxi** • Ganquan Laoshan; 10 May 1953; fl; *Y.W. Cui 10001*; PE[PE00927495] • ibid.; 23 May 1953; fl; *Y.W. Cui 10077*; PE • Meixian; 15 Oct. 1953; fr; *Y.W. Cui 10937*; PE.

Description

Small tree, 4–6 m high; branches terete, pendulous. Pedicel ca 3 cm long. Petals ca 1.0 × 0.6 cm, white, obovate. Styles 3 or 4. Pome ca 0.7 × 0.8 cm.

Distribution

China (Gansu, Qinghai, Shaanxi) (Fig. 7).

Chromosome number

2n = 34.

1c. ***Malus baccata*** var. ***mandshurica*** (Maxim.) C.K.Schneid.
Figs 9–10

Illustriertes Handbuch der Laubholzkunde Vol. 1: 721 (Schneider 1906b).

Pyrus baccata var. *mandshurica* Maxim. (*Pirus baccata* β *mandshurica* Maxim.), *Bulletin de l'Académie impériale des Sciences de Saint-Pétersbourg* 19: 170 (Maximowicz 1874). – *Malus mandshurica* (Maxim.) Kom. ex Skvortsov, *Izvestiya glavnogo botaniceskago Sada SSSR* 25: 146 (Skvortsov 1926). – *Malus baccata* subsp. *mandshurica* (Maxim.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 28 (Likhonos 1974). – **Type**: CHINA • Mandshurica austro-orientalis, Bay Guérin sinus Victoriae; 1860; fl, fr; *Maximowicz s.n.*; lectotype: NY[NY00415893]!, **here designated**; isolectotype: P[P03339959]!

Malus sachalinensis Juz., *Flora USSR Vol. 9*: 371 (Juzepczuk 1939). – *Malus baccata* subsp. *sachalinensis* (Juz.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 28 (Likhonos 1974). – *Malus mandshurica* subsp. *sachalinensis* (Juz.) Likhonos, *Trudy po prikladnoi botanike, genetike i selektsii* 52 (3): 28 (Likhonos 1974). – *Malus mandshurica* var. *sachalinensis* (Juz.) Ponomar., *Botanicheskii Zhurnal (Moscow & Leningrad)* 62 (6): 829 (Ponomarenko 1977). – **Type**: RUSSIA • Sakhalinskaya Oblast, Insula Sachalin; Jun. 1860; fr; *Fridericus Schmidt s.n.*; lectotype: LE[LE01082068]!, **here designated**; isolectotype: LE[LE01082066]!

Examined specimens

CHINA – **Anhui** • Jinzhai; 18 May 1985; fl; *G. Yao 9007*; NAS • Huangshan; 16 May 1979; fl; *M.B. Deng & G. Yao 79179*; NAS • Shexian; 16 May 1959; fr; *Anonymous 1749*; NAS. – **Beijing** • Wofosi; 24 Apr.

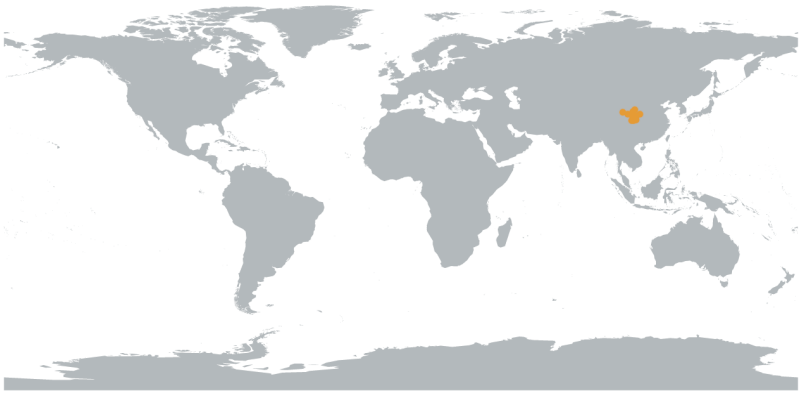

Fig. 7. Distribution of *Malus baccata* (L.) Borkh. var. *gracilis* (Rehder) T.C.Ku.

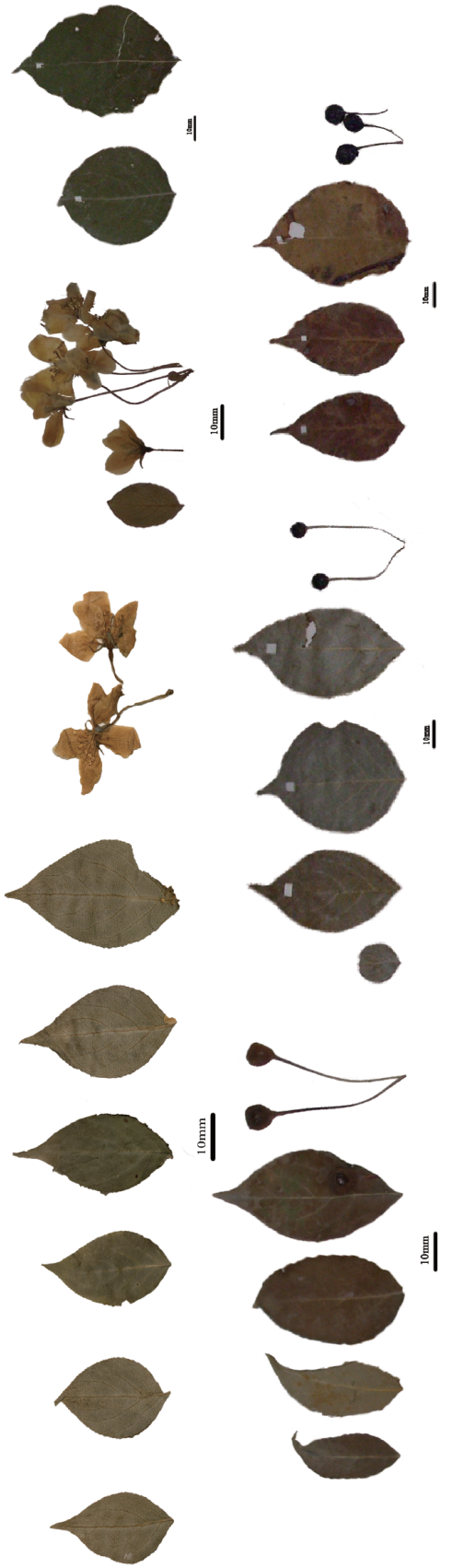

Fig. 8. Morphological characters of *Malus baccata* (L.) Borkh. var. *gracilis* (Rehder) T.C.Ku; A00026586 (type), HNWP160546, HNWP262000, PE00927497, PE00927499, PE00927502. Scale bars = 10 mm.

1962; fl; *Renguo 34*; PE. – **Chongqing** • Beibei; 8 Apr. 1996; fl; *S.Y. Jiang 96004*; CDBI • Wulong; 17 Jun. 2012; fr; *Wulong Team 500232-307*; IMC. – **Gansu** • Changxian; 23 Aug. 1939; fl, fr; *W.Y. Hsia 6294*; PE. – **Guangdong** • Ruyuan; 10 Apr. 1934; fl; *X.P. Gao 54078*; NAS. – **Guizhou** • Suiyang; 26 Apr. 1989; fl; *K.M. Lan 8900890*; GZAC • Wudang; 22 Jul. 2004; fr; *Wudang Team 14722-520112140722045LY*; GZTM. – **Hebei** • Shexian; 3 May 2014; fl; *Team 16 130426140503012LY*; HBNU. – **Henan** • Lingbao; 12 Jun. 2016; fl; *C.S. Zhu et al. 150512013*; AU • ibid.; 10 Aug. 2014; fr; *C.S. Zhu et al. 14081067*; AU. – **Heilongjiang** • Haerbin; 1 Jun. 2004; fr; *C.M. Tan et al. HEI014*; JJF • locality unknown; 28 May 1950; fl, fr; *C.Y. Wu 180*; PE • Northeast agronomical forest farm; 18 May 1951; fl, fr; *W. Wang & Z. Wang 225*; PE. – **Hubei** • Huanggang; 28 Apr. 2015; fl; *Z.W. Wang WZW01358*; CSH • 28 Apr. 2015; fr; *B.J. Ge et al. GBJ04557*; CSH • Wuhan; 1983; fr; *C.Q. Wang 72*; CCAU. – **Jilin** • Antu; 8 Jun. 1960; fr; *C.S. Wang et al. 4684*; IBK • Changbaishan; 1955; fr; *Genxin team 24*; CAF. – **Liaoning** • Jinxian; 1 May 1984; fl, fr; *J.Q. Deng 7*; PE. – **Qinghai** • Xining; 19 May 1990; fl; *Z.H. Zhang 5938*; HNWP • ibid.; 4 Aug. 1990; fr; *Z.H. Zhang 5464*; HNWP. – **Shandong** • Xiashan; 17 Jul. 2012; fr; *S.H. Hui & H. Ming 223*; SDFGR • Weihai; 13 Apr. 2012; fl; *Y.M. Fang 070*; SDFGR • Qingdao; 16 Aug. 2012; fr; *D.K. Zang 121413*; SDFGR. – **Shanxi** • Taiyuan; 26 Apr. 1990; fl; *Z.Y. Li & H.Q. Li 904001-2*; SXU[SXU-SD00014345] • Luyashan; 28 Aug. 1959; fr; *X.Y. Liu 15919*; HSIB. – **Shaanxi** • T'aipeishan; 18 Jul. 1933; fl, fr; *T.P. Wang 1495*; PE, NAS, NKU • Taipaishan; 21 Apr. 1939; fl; *K.T. Fu 2972*; IBK • ibid.; 15 May 1937; fl; *T.P. Wang 6759*; IBK. – **Shanghai** • Xuhui; 16 Jun. 2011; st; *H.Q. Li et al. SDP02865*; CSH • Changning; 13 Apr. 1950; fl; *F.X. Liu & J.X. Tan 56*; NAS. – **Sichuan** • Bazhong; 23 Apr. 2015; fl; *Y. He & H. Tian GWS201504121, GWS201504139*; BNU • Emeishan; Oct. 1931; fr; *F.T. Wang 23671*; NAS. – **Zhejiang** • Tianmushan; 21 Jun. 1957; fr; *X.Y. He 22345*; NAS, HHBG • ibid.; 20 May 1957; fl; *Deng et al.* 4007; NAS.

JAPAN – **Shinano** • Kakuma Osa-son; 16 Sep. 1952; fr; *Miyoshi Furuse 25712*; PE.

RUSSIA – **Primorakaja** • Wladiwostok; 20 May 1906; fl; *Н.А. Пальчевєкій [N.A. Pal'chyevyekiy] 2357*; PE.

SOUTH KOREA – **locality unknown**; 18 May 1911; fl; *G. Palph & M.D. Mills s.n.*; PE • ibid.; 20 May 1909; fl; *G. Palph & M.D. Mills s.n.*; PE.

Description

Tree, 10–15 m high; branches terete, densely pubescent when young, glabrescent. Leaves petiolate, petiole 1.8–4.1 cm long, puberulous. Lamina ca 5.8 × 3.3 cm, oval to ovate, base cuneate, apex retuse to caudate, margin crenate to serrulate, blade abaxially puberulous or glabrescent. Inflorescence umbellate, with

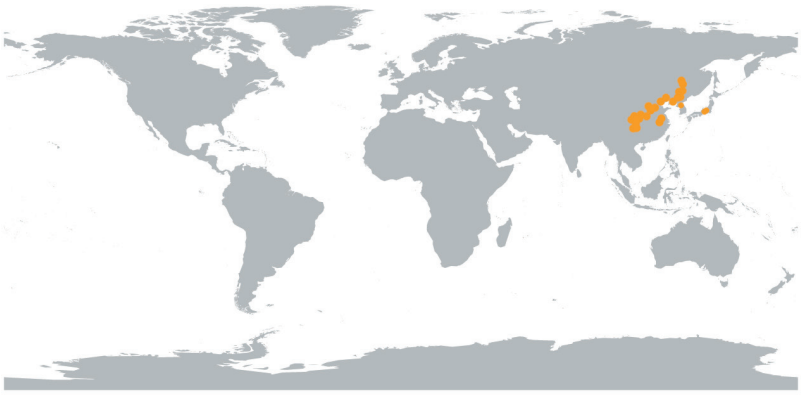

Fig. 9. Distribution of *Malus baccata* (L.) Borkh. var. *mandshurica* (Maxim.) C.K.Schneid.

Fig. 10. Morphological characters of *Malus baccata* (L.) Borkh. var. *mandshurica* (Maxim.) C.K.Schneid.; BNU000964, BNU002220, GXMG0029941, NY00415893 (lectotype), P00993789, P03144392, PE02026701, SXU-SD00014341, SXU-SD00014342, SXU-SD00014343, QIN05041, QIN05042, K000758414, K000758415 / K000758416, PE00952851, PE00952873, PE00952882, PE01460677, PE01460827. Scale bars = 10 mm.

3–6 flowers. Pedicel 1.4–4.8 cm long, usually puberulous. Hypanthium glabrous or puberulous. Sepals lanceolate, abaxially glabrous, adaxially puberulous, caducous. Petals ca 1.2 × 6.7 cm, white, obovate. Stamens 15–20, unequal. Styles 4 or 5, longer than stamens, glabrous. Pome ca 0.7×0.6 cm, subglobose, red. Carpopodium ca 3.3 cm long, majority puberulous.

Phenology

Flowers from May to June. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in mixed forest on slopes, mountain summits and in valleys; 100–2000 m a.s.l.

Distribution

China (Anhui, Beijing, Chongqing, Gansu, Guangdong, Guizhou, Hebei, Henan, Hubei, Heilongjiang, Jilin, Liaoning, Nei Mongol, Qinghai, Shandong, Shanxi, Shaanxi, Sichuan, Zhejiang), Japan (Nagano, Shinano), North Korea, South Korea, and Russia (Fig. 9).

Chromosome number

2n = 34.

Note

The Latin word ‘manshurica’ is used by some herbaria, but we unified it to ‘mandshurica’ according to the priority principle (i.e., *Malus baccata* var. *mandshurica* = *Malus mandshurica* = *Malus manshurica*). In addition, the lectotype designated by Langenfeld (1991: 158) (RUSSIA • Novik Bay on the Russian island, near Vladivostok; 25 May and 28 Aug. 1860; fl, fr; *Maximowicz s.n.*; lectotype: LE) is invalid, so we designated a new one here on the basis of Maximowicz’s record.

2. ***Malus hupehensis*** (Pamp.) Rehder
Figs 11–12

Journal of the Arnold Arboretum 14 (3): 207 (Rehder 1933).

Pirus communis Pavol., *Nuovo Giornale botanico italiano* 15: 415 (Pavolini 1908, non Linnaeus 1753). – *Pirus hupehensis* Pamp., *Nuovo Giornale botanico italiano* 17: 291 (Pampanini 1910). – *Malus domestica* var. *hupehensis* (Pamp.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 30 (Likhonos 1974). – *Sinomalus hupehensis* (Pamp.) Rushforth, *Phytologia* 100 (4): 245 (Rushforth 2018). **– Type**: CHINA • Hubei, Sian-men-kou; alt. ca 900 m; 1 May and 10 Jul. 1906; fl, fr; C. *Silvestri 939*; syntype: A[A00026649], photo!

Malus theifera Rehder, *Plantae Wilsonianae Vol. 2 (2)*: 283 (Rehder 1915). – *Pyrus theifera* (Rehder) L.H.Bailey, *Rhodora* 18: 155 (Bailey 1916a). **– Type**: CHINA • Hubei, Ichang; alt. 1000–1600 m; 27 May and Nov. 1907; fl, fr; *E.H. Wilson 451*; lectotype: A[A00026656]!, **here designated**; isolectotype: A[A00026658]!, GH[GH00026657, GH00026659]!, K[K000758418, K000758419]!.

Examined specimens

CHINA – **Anhui** • Jinzhai; 18 May 2005; fr; *M. Liu et al. A100139*; PE • Huoshan; 20 Jun. 2005; fr; *M. Liu et al. A50170*; PE • Yuexi; 14 Aug. 1997; fr; *Z.W. Xie & L. Zheng 97031*; PE. – **Beijing** • Beijing botanical garden; Aug. 2003; st; *L.C. Zhao s.n.*; BJFC • 28 Aug. 1962; fl, fr; *Renguo 22*; PE. – **Chongqing** • Shizhu; 20 Sep. 1983; fl, fr; *N.G. Jiang & L.C. Wang 139*; PE • Wushan; 11 May 2008; fl; *Zhiwusuo Sanxia*

Expedition 1460; PE. – **Fujian** • Chongan; 15 Sep. 1980; fr; *Wuyi Expedition 2102*; NAS • Taining; 5 Oct. 2017; fr; *X.L. Hou 90987*; AU • locality unknown; 25 Mar. 2016; fl; *X.X. Su CSH15120*; AU. – **Gansu** • Gannan; 5 Sep. 1958; st; *Z.Y. Zhang 467*; IBK • ibid.; 13 Aug. 1963; fr; *Z.Y. Zhang 16584*; PE • ibid.; 8 May 1957; fl; *P. Zhang & L.F. Qi 914*; PE. – **Guangdong** • Liannan; 9 Aug. 1958; fr; *P.X. Tan 58919*; KUN, PE, NAS, IBK, IBSC, SZ. – **Guangxi** • Xingan; 11 Sep. 1957; fr; *Y.B. Xu 10689*; IBK • Linchuan; 4 May 2015; fr; *Zhang et al. 2015-148*; PE • Min Shan; 13 Jun. 1928; fr; *R.C. Ching 5935*; IBSC, PE. – **Guizhou** • Songtao; 7 Jul. 1959; fr; *Qianbei Team 1357*; IBK, NAS, PE • Guiyang; 24 Mar. 1959: fl; *Qiannan Team 0086*; PE. – **Henan** • Lingbao; 11 May 2015; fl; *Zhu et al. 150511032*; AU • Xixia; 16 Jul. 1960; fr; *K.J. Guan & T.L. Dai 1132*; PE. – **Hong Kong** • locality unkonwn; 20 Aug. 1929; fr; *C. Wang 3209*; NAS. – **Hubei** • Badong; 22 Nov. 1997; fr; *C.M. Tan 971816*; IBSC, JJF • Xinshan; 8 Aug. 2008; fr; *Zhao et al. EX1632*; PE • Shennongjia; 29 Apr. 1987; fl; *L.Q. Chen IV050001*; CCAU. – **Hunan** • Hengshan; 1 Jun. 1943; fr; *S.Q. Chen 3456*; KUN, IBSC • Xinshao; 26 Apr. 2005; fl; *B.Y. Li 6072*; PE, HITBC, HUST. – **Jilin** • Fusong; 18 Sep. 1956; fr; *C.S. Wang 629*; IBK. – **Jiangsu** • Longche; 17 Aug. 1929; fr; *Y.K. Keng 2421*; IBSC • Nanjing; 9 Apr. 2012; fl; *Y.N. Xiong & Z.X. Ma 4416*; NAS. – **Jiangxi** • Wuning; 10 Aug. 1996; fr; *C.M. Tan 9608050*; IBSC • Lushan; 11 May 1953; fl; *M.J. Wang 01518*; LBG. – **Shandong** • Qingdao; 7 Jun. 1959; fr; *T.Y. Zhou 1150*; NAS • Kunyushan; 29 May 1957; fl; *C.J. Liu & Q.S. Yan 151*; PE. – **Shaanxi** • Langaoxian; 2 Aug. 2006; fr; *Chen et al. 4727*; WUK • T'aipeishan; 17 Apr. 1937; fl; *T.P. Wang 6516*; PE, IBK. – **Shanghai** • Chenshan; 16 Jun. 2011; fr; *Li et al. SDP02735*; CSH. – **Sichuan** • Liangshan; 16 Apr. 1983; fl; *Fu et al. s.n.*; PE • Emeishan; 21 Jul. 1952; fr; *Xiong et al. 32123*; IBK. – **Yunnan** • Kunming; 17 Aug. 1955; fr; *J.S. Xin 50929*; IBSC • Jianchuan; Jun. 1923; fl; *G. Forrest 23523*; PE. – **Zhejiang** • Andong; 27 Jun. 1987; fr; *S.H. Xu L8532-138*; IBSC • locality unknown; 5 May 1924; fl; *R.C. Qin 1395*; IBSC • Tianmushan; 14 May 1935; fl; *H. Migo s.n.*; PE.

UNITED STATES – **Massachusetts** • Arnold Arboretum, cultivated; 27 Oct. 1973; fr; *Shiu Ying Hu 13328*; PE • ibid.; 12 May 1981; fl; *S. Davis, C. Warren & M. Wolcott 81-286*; PE. – **New York** • Ontario, cultivated; 25 Sep. 1990; st; *Prof. Zhen-long Yan 1114*; PE.

Description

Small tree or shrub, up to 8 m high. Branches terete, densely pubescent when young, glabrescent. Leaves petiolate, petiole ca 2 cm long, glabrescent. Lamina ca 6.6 × 3.6 cm, oval to ovate, usually aubergine in young leaves, base cuneate, rarely rounded, usually oblique, apex acuminate, rarely retuse, margin crenate to serrulate, blade abaxially puberulous or glabrescent, discolorous. Inflorescence umbellate, with 3–6 flowers. Pedicel ca 2.1 cm long, glabrous or puberulent. Hypanthium usually glabrous. Sepals lanceolate to ovate triangular, abaxially glabrous, adaxially puberulous, caducous, rarely persistent. Petals ca 1.2 × 0.7 cm, white to red, obovate. Stamens 15–20, unequal. Styles 3, rarely 4, longer than stamens,

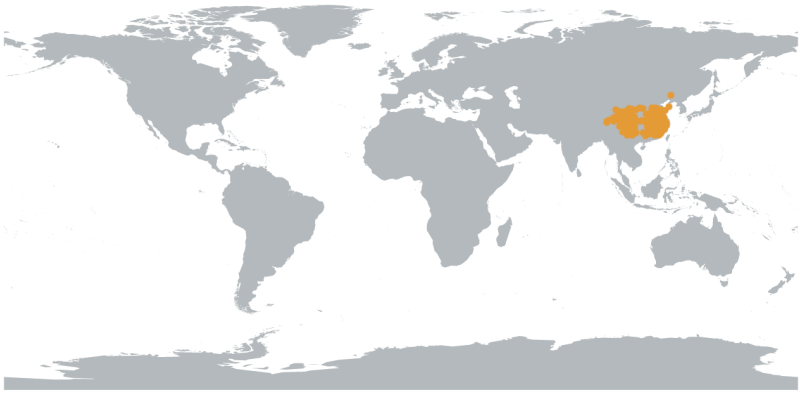

Fig. 11. Distribution of *Malus hupehensis* (Pamp.) Rehder.

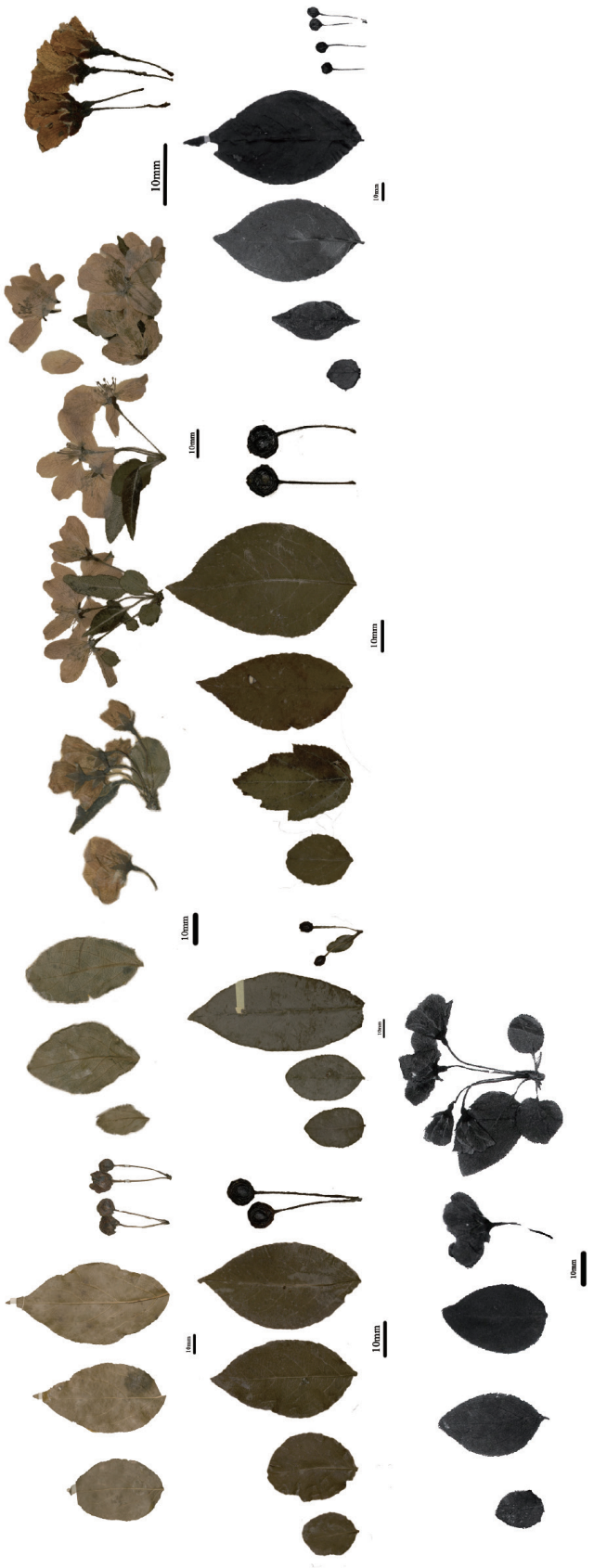

Fig. 12. Morphological characters of *Malus hupehensis* (Pamp.) Rehder; A00026649 (syntype), K000758418 (isolectotype of *Malus theifera* Rehder), K000758419 (isolectotype of *M. theifera*), QIN05044, QIN05045, P03144395, P03144440, P03144445, P03144446, A00026656 (lectotype of *M. theifera*), A00026658 (isolectotype of *M. theifera*), E00010837 (isolectotype of *M. theifera*), GH00026659 (isolectotype of *M. theifera*). Scale bars = 10 mm.

basally puberulent. Pome ca 0.8–0.9 cm in diameter, subglobose, yellow to red. Carpopodium ca 2.9 cm long, glabrous or puberulent at base.

Phenology

Flowers from April to May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in forest on slopes or in valleys; 50–2600 m a.s.l.

Note

The syntypes of *Pyrus hupehensis* Pamp. were collected in Sian-men-kou (*Silvestri 939*) and Ma-pau-scian (*Silvestri 940, 940a*), Hubei (Hupeh), China. However, there are photographs from as early as 1932 in the Biondi herbarium at the Botanical Museum in Florence according to the record of Rehder, and now a scan of *Silvestri 939* is available online in herbarium of Arnold Arboretum. Langenfeld designated a lectotype in 1991: 160 (CHINA • Fujian, Chongan, Sanghan-Tinmu-Guan; 11 Aug. 1952; *Zhou Zhenying 239*; lectotype: LE), but it is invalid because the type specimens have not been lost.

Distribution

China (Anhui, Chongqing, Fujian, Gansu, Guangxi, Guizhou, Henan, Hubei, Hunan, Jilin, Jiangsu, Jiangxi, Shandong, Shanxi, Shaanxi, HongKong, Yunnan, Zhejiang) (Fig. 11).

Chromosome numbers

2n = 34, 51, 68.

3. ***Malus sieversii*** (Ledeb.) M.Roem.
Figs 13–14

Familiarum Naturalium Regni Vegetabilis Synopses Monographicae 3, Rosiflorae: 216 (Roemer 1847).

Pyrus sieversii Ledeb., *Flora Altaica Vol. 2*: 222 (Ledebour 1830). – **Type**: CHINA • Xinjiang, Tarbagatai, near Ust-Kamenogorsk (Kazakhstan); s.d.; fr; *Dr. Sieverss s.n.*; lectotype: LE[LE01053104]!; isolectotype: LE[LE01053105, LE01053106]!, designated by Langenfeld 1991: 171.

Malus niedzwetzkyana Dieck., *Neuheiten-Offerte des National-Arboretums zu Zöschen*: 16 (Dieck 1891). – *Malus sieversii* f. *niedzwetzkyana* (Dieck.) Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 171 (Langenfeld 1991).

Malus hissarica Kudr., *Plodovii Shakhrisyabza*: 158 (Kudrjaschev 1950). – *Malus sieversii* subsp. *hissarica* (Kudr.) Langenf., *Daildarznieciba* 8: 15 (Langenfeld 1971), without basionym ref. – *Malus sieversii* subsp. *hissarica* (Kudr.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 24 (Likhonos 1974). – *Malus sieversii* var. *hissarica* (Kudr.) Ponomar., *Botanicheskii Zhurnal (Moscow & Leningrad)* 61 (7): 998 (Ponomarenko 1976). – **Type**: UZBEKISTAN • North slopes of the Hissar Range, bass. R. Kashka-Daria. Northern coures of the river. Tankhas, above K. Chopuh; 1 Aug 1937; *Kudryashev 1330*; holotype: TASH, designated by Langenfelds 1991: 172.

Malus chitralensis Vassilcz., *Flora Iranica 66*: 38. (Browicz *et al.* 1969). – *Malus sieversii* var. *chitralensis* (Vassilcz.) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 7 (Ponomarenko 1992). – **Type**: PAKISTAN • Chitral, Rumbour; alt. 7500 ft; 8 May 1958; fl; *S.A. Bowes Lyon 679*; isotype: BM[BM000602198]!, E[E00010842]!

Malus sieversii f. *cerea* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *flava* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 14 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *flavorosea* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *flavorubens* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *gilva* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 17 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *insipida* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 17 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *laetevirida* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *media* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *ochrorubra* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *pomacea* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *purpureofasciata* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *rubrifasciata* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *rubrolateralis* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 17 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *suffusa* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *viridicerea* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 15 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *viridifasciata* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *viridirubra* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 14 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *viridis* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 14 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *viridula* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 17 (Korovina & Chernomorskaya 1978), nom. nud.

Malus sieversii f. *xanthella* Bondarenko ex Korovina & Chernom., *Byulleten' Vsesoyuznogo Ordena Lenina i Ordena Druzhby Narodov Instituta Rastenievodstva Imeni N.I. Vavilova* 81: 16 (Korovina & Chernomorskaya 1978), nom. nud.

Malus caspiriensis Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 181 (Langenfeld 1991), nom. illeg. – *Malus sieversii* var. *caspiriensis* (Langenf.) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 8 (Ponomarenko 1992). – **Type**: INDIA • Jammu-Kashmir, Sunagai; 9 Aug. 1891; fr.; *G.A. Gammi s.n.*; holotype: DD, designated by Langenfeld 1991: 181.

Malus sieversii f. *linczevskii* (Poljakov) Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 172 (Langenfeld 1991), nom. nud.

Malus sieversii f. *longicarpa* (B.Bykov) Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 172 (Langenfeld 1991), nom. nud.

Examined specimens

CHINA – **Qinghai** • Xining; 10 May 1990; fl; *Z.H. Zhang 5950*; HNWP • ibid.; 8 May 1990; fl; *Z.H. Zhang et al. 5743*; HNWP. – **Xinjiang** • Aletai; 18 Jul. 1964; fr; *G.S. Qin 89*; PE • Xinyuan; 3 Sep. 1959; fr; *Beijiang Team 1978*; PE • ibid.; 21 Aug. 1959; st; *Beijiang Team 133*; PE • ibid.; 23 Aug. 1959; st; *Beijiang Team 161*; PE • Gongliu; 1 Sep. 1959; fr; *Beijiang Team 182*; PE • ibid.; 4 Sep. 1959; fr; *Beijiang Team 200*; PE • ibid.; 11 May 1959; fl; *Beijiang Team 18*; PE • ibid.; 30 Apr. 1959; fl; *Beijiang Team 8*; PE • ibid.; 11 Jul. 1965; fl, fr; *Wang et al. 2631*; PE • ibid.; 5 May 1959; fl; *A.R. Li & J.N. Zhu 10302*; PE • Yili; 16 Apr. 1963; fl; *Xinjiang Institute for Agricultural Sciences s.n.*; PE • ibid.; 12 May 1958; fl; *S.H. Yang 0142*; PE • Huocheng; 23 Jul. 1991; st; *Shimizu et al. 135*; PE • Suiding; 1 Sep. 1957; fl, fr; *K.J. Guan 4146*; PE, XJBI • Tulufan; 17 Sep. 1976; fr; *Lu, Gu & Li 71*; PE • Kuerle; 22 May 1959; fr; *Xindong 00083*; PE • locality unknown; 1974; fl, fr; *Y.R. Lin 74847*; PE.

INDIA – **Kashmir** • Nurla; 13 Oct. 1932; fl, fr; *T.N. Liou 5495*; PE • ibid.; 13 Oct. 1932; fl, fr; *T.N. Liou 5499*; PE.

Fig. 13. Distribution of *Malus sieversii* (Ledeb.) M.Roem.

Fig. 14. Morphological characters of *Malus sieversii* (Ledeb.) M.Roem.; KUN0662683, KUN1254057, BM000602198 (isotype of *Malus chitralensis* Vassilcz.), E00010842 (isotype of *M. chitralensis*), LE01053104 (lectotype), LE01053107, LE01053109. Scale bars = 10 mm.

KYRGYZSTAN – **Dzhalal-abad** • Aktasch; 25 Sep. 1944; fr; *An. Fedorov & E. Iljina 49*; PE • ibid.; 17 Aug. 1945; fl; *An. Fedorov & E. Iljina 416*; PE • Karavan; 25 Aug. 1945; fl; *Lyssova 12*; PE • Balyktysai; 17 Oct. 1944; fr; *An. Fedorov & E. Iljina 210*; PE • Sarai; 24 Aug. 1945; fl; *An. Fedorov & E. Iljina 445*; PE.

UZBEKISTAN – **Tieu-Shan** • Chatkal Mt. Chimgan; 16 May 2014; fl; *H. Sun et al. 17642*; KUN • Chofkae Rande Raffasai; 13 May 2014; fl; *H. Sun et al. 17558*; KUN • ibid.; 15 May 2014; fl; *H. Sun et al. 17581*; KUN.

Description

Small tree or shrub, 2–8 m high. Branches terete, densely pubescent when young, glabrescent. Leaves petiolate, petiole ca 3.3 cm long, puberulous. Lamina ca 6.3 × 5.2 cm, elliptical to obovate, base cuneate, usually equilateral, apex acuminate or obtuse, margin crenate to serrulate, blade glabrescent. Inflorescence umbellate, with 3–5 flowers. Pedicel ca 3 cm long, puberulent. Hypanthium densely lanuginous. Sepals lanceolate to triangular-ovate, densely puberulous, persistent. Petals ca 1.5 × 1.0 cm, obovate. Stamens 20, unequal. Styles 5, rarely 4, as long as or longer than stamens, basally densely puberulent. Pome solitary, ca 2.5–4.5 cm in diameter, subglobose or oblate, yellow-green, red or fuchsia. Carpopodium ca 2.5–4.0 cm long, puberulent.

Phenology

Flowers from April to May. Mature fruits from August to October.

Habitat

Terrestrial, seasonally green, growing in the forest on slopes, mountaintop or in valleys near rivers; 1000–2500 m a.s.l.

Distribution

Central Asia, including China (Qinghai, Xinjiang), Kashmir, Kazakhstan, Kyrgyzstan, Russia, and Uzbekistan (Fig. 13).

Chromosome number

2n = 34.

4. ***Malus kirghisorum*** Al.Fed. & Fed.
Figs 15–16

Trudy Yuzhno-Kirgizskoy ekspedicii 1: 220 (Fedorov & Fedorov 1949).

Malus sieversii subsp. *kirghisorum* (Al.Fed. & Fed.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 23 (Likhonos 1974). – *Malus sieversii* var. *kirghisorum* (Al.Fed. & Fed.) Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 174 (Langenfeld 1991). – **Type**: KYRGYZSTAN • Dzhalalabad, Toi-taipan, on the right bank of the river Aktasch in a juglandin forest; 25 Sep. 1944; *Al. Theodorov s.n.*; lectotype: LE, designated by Langenfeld 1991: 174.

Examined specimens

UNITED STATES – **Illinois** • Lisle; 30 Apr. 2001; fl; *S. Packard & P. Steinhouse 9243V01*; KUN[KUN0937410]. (Seeds wild collected from Tien Shan Kirgiz, SSR, USSR, cultivated in the Morton Arboretum, Lisle, Illinois, USA.

Description

Tree, 10–14 m high. Branches terete; annotinal bud with sparse spines, pubescent when young, glabrescent. Leaves petiolate, petiole ca 0.9 cm long, puberulous. Lamina 8.0–10.0 × 4.0–6.0 cm, oblong to oval, base cuneate, equilateral, apex acuminate or obtuse, margin crenate to serrulate, blade abaxially puberulous. Inflorescence umbellate, with 3–5 flowers. Pedicel ca 3.0 cm long, pubescent when young, glabrescent. Hypanthium densely lanuginous. Sepals triangular-lanceolate to triangular, longer than calyx tube, puberulous, caducous. Petals ca 1.3 × 0.8 cm, white or light pink, obovate. Stamens 15–20, unequal. Styles 3 or 4, longer than stamens, with dense tomentum at base. Pome ca 3.0–8.0 cm in diameter, subglobose or coniform, yellow or green.

Fig. 15. Distribution of *Malus kirghisorum* Al.Fed. & Fed.

Fig. 16. Morphological characters of *Malus kirghisorum* Al.Fed. & Fed.; KUN0937410.

Phenology

Flowers from April to May. Mature fruits from July to October.

Habitat

Terrestrial, seasonally green, growing at the edge of the forest on slopes or in valleys.

Distribution

Afghanistan, Kyrgyzstan and Tajikistan (Fig. 15).

5. ***Malus orientalis*** Uglitzk. ex Juz.
Figs 17–18

Flora USSR Vol. 9: 362, 492 (Juzepczuk 1939).

Malus sylvestris subsp. *orientalis* (Uglitzk.) Browicz, *Flora of Turkey and the East Aegean Islands Vol. 4*: 158 (Browicz 1972b). – **Type**: TURKEY • Tekirdag, 3 miles S of Inecik; 30 Jun. 1965; *M.J.E Coode & B.M.G Jones 2868*; lecotype: E[E00439202]!, **here designated**.

Malus montana Uglitzk., *Trudy severo-kavkazskogo Instituta spetsialnykh i tekhnicheskikh Kul'tur* 1 (3): 18 (Uglitzkich 1932). – *Malus orientalis* subsp. *montana* (Uglitzk.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 23 (Likhonos 1974), without basionym page. – *Malus orientalis* var. *montana* Langenf., *Yablonya. Morfologichyeskaya evolyutziya, filogyeniya, geografiya, sistyematika roga*: 179 (Langenfeld 1991), without basionym page. – *Malus orientalis* var. *montana* (Uglitzk.) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 7 (Ponomarenko 1992), nom. illeg. – **Type**: AZERBAIJAN • Ismailly, inter pagos Baskae et Njudzhi, in silva declivitalis orientalis, alt. ca 1200 m; 22 Aug. 1940; *L. Prilipko & G. Gurvitsh. s.n.*; type: BAK.

Malus orientalis var. *subalpina* Ponomar., *Botanicheskii Zhurnal (Moscow & Leningrad)* 60 (1): 58 (Ponomarenko 1975), nom. nud.

Examined specimens

AFGHANISTAN – **Herat** • Kuh e Darunta; 11 May 1969; fl; *I. Hedge, P. Wendelbo & L. Ekberg W7844*; E[E00439227].

Fig. 17. Distribution of *Malus orientalis* Uglitzk. ex Juz.

Fig. 18. Morphological characters of *Malus orientalis* Uglitzk. ex Juz.; E00439219, E00439220, E00439225, E00439202 (lecotype of *Malus sylvestris* subsp. *orientalis* (Uglitzk.) Browicz). Scale bars = 10 mm.

ARMENIA – **Caucasus** • locality unknown; 8 Sep. 1931; st; *Карягин [Karyagin] s.n.*; MW • ibid.; 6 Aug. 1978; st; *Тахтаджян [Tahtadjian] s.n.*; MW. – **Tsekhadzor** • Mt. Tehenis; 17 Sep. 1976; fr; *Thomas S. Elias 3081*; PE.

AZERBAIJAN – **locality unknown**; 4 Aug. 1934; st; *Петров [Petrov] s.n.*; MW • ibid.; 27 May 1932; st; *Карягин [Karyagin] s.n.*; MW • ibid.; 26 Jun. 1931; st; *Шипчинский [Shipchinsky] 355*; MW.

RUSSIA – **Krasnodar Krai & Adygea** • locality unknown; 15 Jun. 1959; st; *Гроссет [Grosset] 296*; MW. – **Moscow** • locality unknown; 2 Sep. 1982; st; *Куваев & Шелгунова [Kuvaev & Shelgunova] 108-3*; MW • ibid.; 28 Jun. 1981; st; *Куваев & Шелгунова [Kuvaev & Shelgunova] 108-14*; MW. – **Stavropol Krai, Karachay-Cherkessia & Kabardino-Balkaria** • locality unknown; 28 Apr. 1966; st; *Михеев [Mikheyev] 284*; MW.

TURKEY – **Hakkari** • Baskale; 3 Aug. 1954; st; *Davis, Polunin 23836*; E[E00439224]. – **Kastamonu** • Seydiler to Kure; 30 Jul. 1962; fr; *Davis D38468*; E[E00439219]. – **Zonguldak** • Balikisik; 22 Jul. 1962; st; *Davis, Coode & Yaltirik D37530*; E[E00439220] • Eregli; 15 Jul. 1962; st; *Davis, Coode & Yaltirik D37530*; E[E00439225].

Description

Tree, 8–15 m high. Branches terete, dark brown or gray; annotinal bud lanuginous, dark brown. Leaves petiolate, petiole ca 0.5–3 cm long, puberulous. Lamina 4.6 × 2.5 cm, oblong to orbicular, base cuneate, oblique, apex acuminate or cuspidate, margin crenate to serrulate, blade glabrescent. Inflorescence umbellate, with 4–6 flowers. Pedicel ca 0.8–1.2 cm long, glabrescent. Hypanthium densely lanuginous. Sepals triangular, short, puberulous, persistent. Petals ca 1.5 × 1.0 cm, white or light pink, obovate. Stamens ca 20, unequal. Styles 5, as long as or longer than stamens, glabrous or with dense tomentum at base, stigma clavate. Pome ca 2.0–3.0 cm in diameter, subglobose or coniform, yellow or red. Carpopodium ca 1.0–2.5 cm long, puberulent.

Phenology

Flowers from April to May. Mature fruits from August to October.

Habitat

Terrestrial, seasonally green, growing at the edge of the forest on slopes or in valleys; 1000–2200 m a.s.l.

Distribution

Afghanistan, Azerbaijan, Ciscaucasia, Georgia (Caucasus), Turkey and Iran (Fig. 17).

Chromosome number

2n = 34.

6. ***Malus fusca*** (Raf.) C.K.Schneid.
Figs 19–20

Illustriertes Handbuch der Laubholzkunde Vol. 1: 723 (Schneider 1906b).

Pyrus fusca Raf., *Medical Flora or, Manual of the Medical Botany of the United States of North America Vol. 2*: 254 (Rafinesque 1830). – *Malus baccata* subsp. *fusca* (C.K.Schneid.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 28 (Likhonos 1974). – **Type**: USA • Alaska, outside the town of Junean, on the side of a woody alpine; 58°30′ N, 135°5′ W; 5 Sep. 1913; *S.J. Enander s.n.*; neotype: RIJKS, designated by Langenfeld 1991: 148.

Pyrus diversifolia Bong., *Mémoires de l'Academie imperiale des Sciences de St.-Pétersbourg. Sixieme Serie. Sciences mathematiques, physiques et naturelles* 2 (2): 133 (Bongard 1832). – *Malus diversifolia* (Bong.) M.Roem., *Familiarum Naturalium Regni Vegetabilis Synopses Monographicae 3, Rosiflorae*: 215 (Roemer 1847), nom. illeg. – *Malus fusca* var. *diversifolia* (Bong.) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 724 (Schneider 1906b), nom. inval. – *Pyrus fusca* var. *diversifolia* (Bong.) L.H.Bailey, *The Standard Cyclopedia of Horticulture Vol. 5*: 2876 (Bailey & Bailey 1916b). – **Type**: RUSSIA • Sitcha, s.d.; *Mertens s.n.*; lectotype: LECB[LECB0001455]!, **here designated**; isolectotype: M[M0213668]!

Pyrus rivularis Douglas ex Hooker, *Flora Boreali-Americana, or, the Botany of the Northern Parts of British America Vol. 1 (4)*: 203, tab. 68 (Hooker 1832). – *Malus rivularis* (Douglas) M.Roem., *Familiarum Naturalium Regni Vegetabilis Synopses Monographicae 3, Rosiflorae*: 215 (Roemer 1847), nom. illeg. – **Type**: CANADA • Columbia, illegible common near the Confluence of the Columbia and its southern brameky drown t. 68; s.d.; *Douglas s.n.*; lecotype: K[K000758454, K000758455]!, **here designated**.

Pyrus rivularis var. *levipes* Nutt., *The North American Sylva Vol. 2*: 24 (Nuttall 1849). – *Malus rivularis* var. *levipes* (Nutt.) Koehne, *Deutsche Dendrologie*: 262 (Koehne 1893). – *Malus fusca* var. *levipes* (Nutt.) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 724 (Schneider 1906b), nom. inval. – **Type**: USA • The North West coast; s.d.; *Menzies s.n.*; herbarium unknown.

Examined specimens

CANADA – **British Columbia** • Oak Park; 23 Jun. 1920; fr; *A. Eastwood 9729*; A • District of Renfrew; Jun.–Jul. 1901; st; *C.O. Rosendahl & C.J. Brand 72*; GH • Vancouver Island; 1858; fl, fr; *D. Lyall s.n.*; GH.

UNITED STATES – **Alaska** • Fort Wrangel; 25 Aug. 1897; st; *C.S. Sargent s.n.*; A • Wrangell; 27 Jul. 1914; fr; *A. Eastwood 992*; A • Traitors Gove, North of Ketchikan; 6 Jun. 1967; fl; *G.W. Frame 16*; NY. – **California** • Lat; 1858; fl, fr; *D. Lyall s.n.*; GH • Big Lagoon; 21 Jul. 1932; fr; *H.L. Mason 7101*; GH. – **New York** • Ontario; 10 Sep. 1990; fr; *Professor Zhen-long Yan 1046*; PE • ibid.; 28 Sep. 1990; fr; *Professor Zhen-long Yan 1032*; PE. – **Washington** • Grays Harbor; 1 Jun. 1987; fr; *D.E. Boufford & E.W. Wood 23784*; PE • Cascade Mountains; 16 Jun.–15 Sep. 1896; fl, fr; *O.D. Allen 213*; P.

Description

Tree, 10–12 m high, sometimes shrub under artificial culture. Branches terete, villous when young, glabrescent. Leaves petiolate, petiole ca 1.5–2.5 cm long, occasionally puberulous in mature leaf. Lamina 6.0 × 3.1 cm, elliptical to oval, base cuneate or cordate, oblique, apex acuminate or acute, rarely obtuse, margin crenate to serrulate, sporadically 3-lobed, blade abaxially pubescent when young, glabrescent.

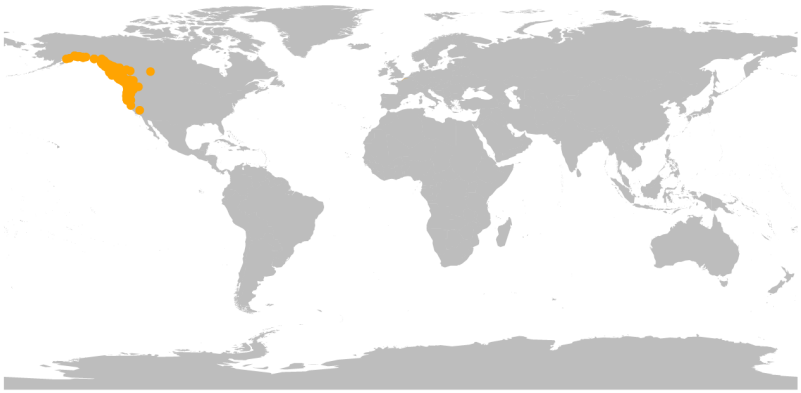

Fig. 19. Distribution of *Malus fusca* (Raf.) C.K.Schneid.

Fig. 20. Morphological characters of *Malus fusca* (Raf.) C.K.Schneid.; K000758454 / K000758455 (lectotype of *Pyrus rivularis* Douglas ex Hooker), K000758456, K000758457, K000758458, P03240223, P03240225, P03240226, P03240227, US01074641 (*Malus diversifolia* (Bong.) M.Roem.), US01074643 (*M. diversifolia*), US01074645 (*M. diversifolia*). Scale bars = 10 mm.

Inflorescence umbelliform corymb, with 6–10 flowers. Pedicel ca 2–3 cm long, puberulous. Hypanthium puberulous. Sepals lanceolate to triangular, glabrous, caducous. Petals ca 0.9 × 0.6 cm, white, rarely pink, obovate. Stamens 16–20, unequal. Styles 2–5 (3–4), as long as or longer than stamens, glabrous. Pome ca 1.5–2.0 cm in diameter, coniform, yellow to red. Carpopodium ca 2.1 cm long, puberulous.

Distribution

Canada and United States (Fig. 19).

Chromosome number

2n = 34.

7. ***Malus sylvestris*** (L.) Mill.
Figs 21–22

Gardeners Dictionary, 8th Ed.: Malus no. 1 (Miller 1768).

Pyrus malus var. *sylvestris* L., *Species Plantarum Vol. 1*: 479 (Linnaeus 1753). – *Malus communis* var. *sylvestris* (L.) Desf., *Histoire des Arbres et Arbrisseaux Vol. 2*: 140 (Desfontaines 1809), nom. illeg. – *Malus sylvestris* Moench, *Methodus Plantas Horti Botanici et Agri Marburgensis Vol. 2*: 682 (Moench 1794, non Miller 1768), nom. illeg. – *Pyrus sylvestris* Gray, *A Natural Arrangement of British Plants Vol. 2*: 562 (Gray 1821). – **Type**: SWEDEN • Uppsala, locality unknown; s.d.; *Linnaeus s.n.*; lectotype: LINN[LINN-897.3]!, **here designated**.

Malus acerba Mérat, *Nouvelle Flore des Environs de Paris Vol. 1*: 187 (Mérat 1812) [*Malus acerta* Mérat, spelling variant], nom. inval. – *Pyrus acerba* DC., *Prodromus Systematis Naturalis Regni Vegetabilis Vol. 2*: 635 (de Candolle 1825). – **Type**: FRANCE • Ile-de-France, Fontainebleau Forest; fl, fr; s.d.; *Mérat s.n.*; lectotype: P[P04345284]!, **here designated**.

Malus sylvestris var. *microphylla* Browicz, *Notes from the Royal Botanic Garden, Edinburgh* 31 (2): 323 (Browicz 1972a). – **Type**: TURKEY • Sulucre, about 30 km, NW of Ama Forest remnants, grey soil, alt. 630 m; 10 Jul. 1963; *M. Zohary 10413*; holotype: E[E00326781], photo!

Malus bulgarica Dimitrov, *Nauchni Trudove, Vissh Selskostopanski Institut Vasil Kolarov. Plovdiv* 25 (4): 33 (31–33), figs 1–2 (Dimitrov 1980), nom. inval. – *Malus sylvestris* var. *bulgarica* (Dimitrov) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 6 (Ponomarenko 1992), nom. inval.

Malus rhodopaea Dimitrov, *Nauchni Trudove, Vissh Selskostopanski Institut Vasil Kolarov. Plovdiv* 25 (4): 36 (34–36), figs 3–4 (Dimitrov 1980), nom. inval. – *Malus sylvestris* var. *rhodopaea* (Dimitrov) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 6 (Ponomarenko 1992), nom. inval.

Examined specimens

AUSTRIA – locality unknown; s.d.; fl; *A. Keraer 2438*; PE.

BELGIUM – **Namur** • Between Yvoir and Godinne; 10 Oct. 1979; fr; *D.K. Ferguson 1168*; PE • ibid.; 18 May 1979; fl; *D.K. Ferguson 1145*; PE.

DENMARK – **Silkeborg** • Gjessø; 4 Jun. 1980; fl; *I. Nielsen, P. Bro Christensen, T. Hvid* & *L.B. Petersen 851*; PE, IBSC. – **Århus** • Søby Fredskov; 28 May 1978; fl; *P. Frost-Olsen 24, 1504*; PE, IBSC, NAS.

FRANCE – **60 Oise** • Senlis; 22 May 1926; st; *P. Jovet 21503*; P • ibid.; 30 Sep. 1925; st; *P. Jovet 20306*; P • ibid.; 8 Oct. 1925; st; *P. Jovet 20303*; P • ibid.; 6 Apr. 1926; st; *P. Jovet 22359*; P. – **75 Paris** • 18e arr.; 30 Sep. 1944; st; *P. Jovet 75018*; P.

GERMANY – **Thüringen** • Kyffhäuser; 7 Sep. 1960; fr; *Danert 506*; KUN.

HUNGARY – **Austria inferior** • Vindobonensi; s.d.; fl; *A. Kerner 2438*; PE[01702120].

POLAND – **Lesser Poland** • Dołęga near Szczurowa; 21 Apr. 2009; fl; *J. Żelazny s.n.*; PE.

UNITED STATES – **Illinois** • Lisle, cultivated; 6 Aug. 1999; st; *H. Oleari 8986V99*; KUN[KUN0937826]. – **New York** • Westchester, cultivated; 8 May 1996; fl; *J.B. Walker 1874*; NY.

Description

Small tree or shrub, 4–10 m high, rarely 13 m. Branches terete, puberulous or glabrous when young. Leaves petiolate, petiole ca 2.5 cm long, puberulous or glabrous. Lamina 6.5 × 4.3 cm, oval to orbicular, base rounded, rarely cuneate, equilateral, apex usually acute, rarely obtuse or retuse, margin crenate to serrulate, blade glabrous. Inflorescence umbellate, with 2–5 flowers. Pedicel ca 1.9 cm long, puberulous at base. Hypanthium puberulous or glabrous. Sepals triangular, abaxially glabrous, adaxially puberulous, persistent. Petals ca 1.3 × 0.8 cm, white or pink, rarely red or mauve, obovate. Stamens ca 20, unequal, yellow. Styles 5, longer than stamens, glabrous. Pome solitary, about 20 g, ca 2.0–3.5 cm in diameter, subglobose, yellow. Carpopodium ca 1.8 cm long, glabrous.

Phenology

Flowers from May to June. Mature fruits from October to November.

Habitat

Terrestrial, seasonally green, growing at the edge of mixed forests or broad-leaf forests on south slopes or floodplains.

Distribution

Austria, Belgium, British Isles, Czechia, Denmark, France, Germany, Hungary, Italy, Moldova (Kishinev), Poland, Russia (Karel'skij peresheyek, Vologda, Perm', Ufa, Ural'sk, Volgograd), Ukraine (Mariupol), Scandinavian Peninsula, Spain, and Switzerland (Fig. 21).

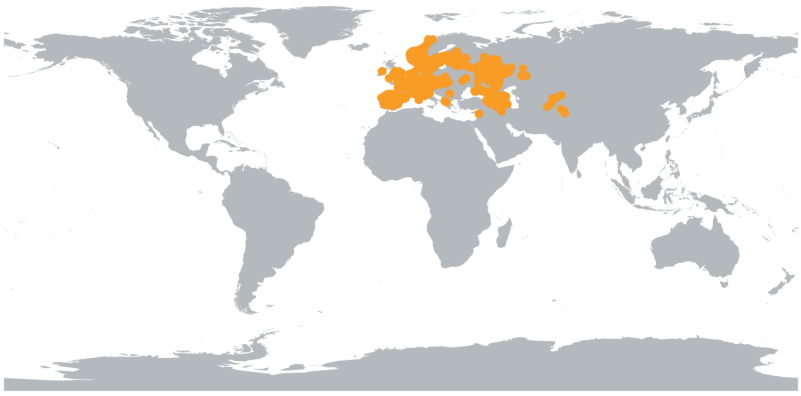

Fig. 21. Distribution of *Malus sylvestris* (L.) Mill.

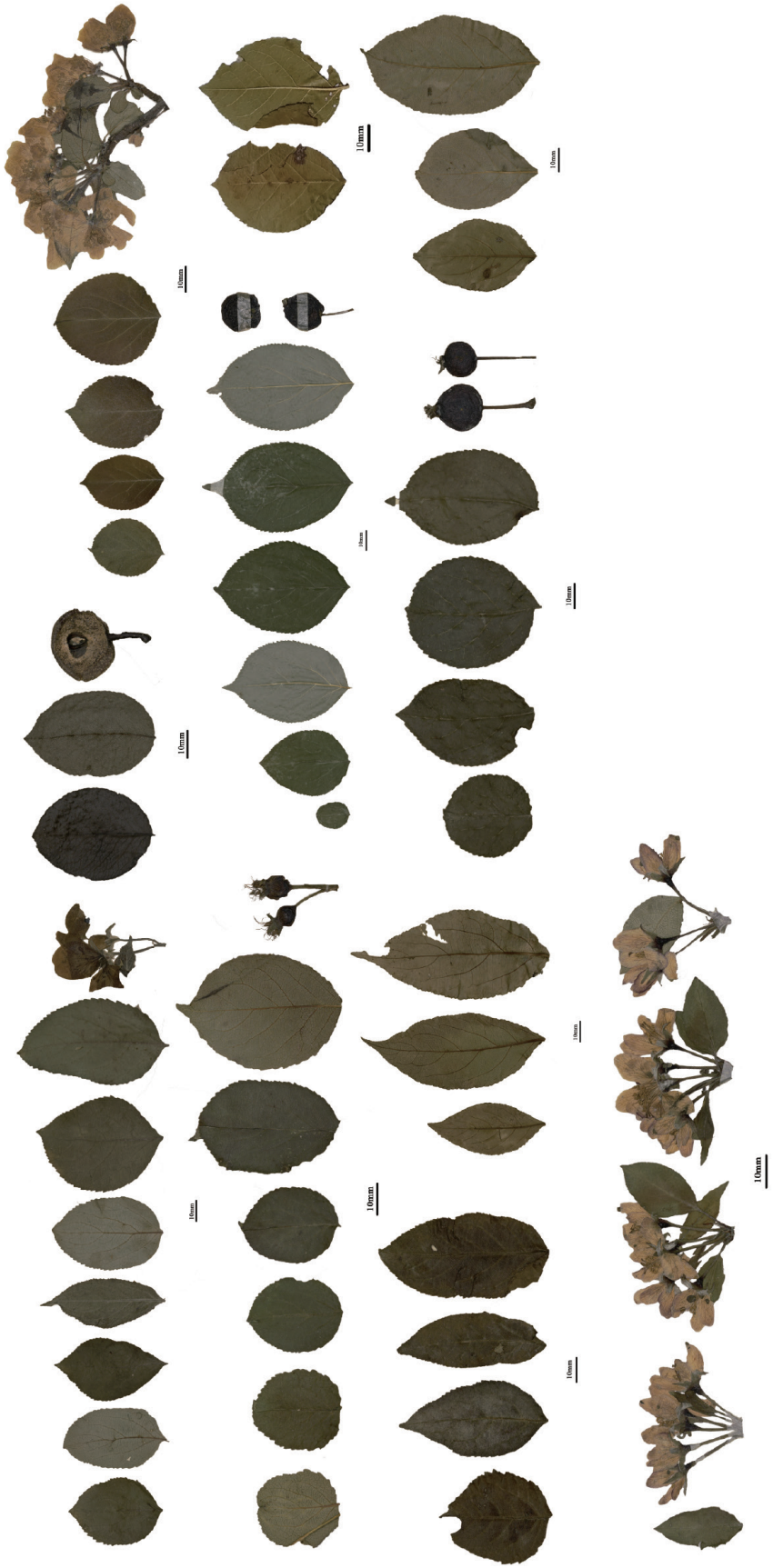

Fig. 22. Morphological characters of *Malus sylvestris* (L.) Mill.; P03140433 (*Malus acerba* Mérat), P03207281 (*M. acerba*), P03302812 (*M. acerba*), P03302813 (*M. acerba*), P03302815 (*M. acerba*), P03302816 (*M. acerba*), P03240520, P03240522, P03240523, P03302809, KUN0937826. Scale bars = 10 mm.

Chromosome numbers

2n = 34, 51.

8. ***Malus toringo*** (Siebold) Siebold ex de Vriese
Figs 23–24

Tuinbouw-Flora van Nederland en zijne overzeesche Bezittingen Vol. 3: 368 (de Vriese 1856).

Sorbus toringo Siebold, *Jaarboek van de koninklijke nederlandsche Maatschappij tot Aanmoediging van den Tuinbouw* 1848: 47 (Siebold 1848), nom. nud. – *Pyrus toringo* (Siebold) Miq., *Annales Musei Botanici Lugduno-Batavi. Amsterdam* 3 (2): 41 (Miquel 1867). – *Pyrus rivularis* var. *toringo* (Siebold) Wenz., *Linnaea* 38 (1): 39 (Wenzig 1874). – *Malus microcarpa* var. *toringo* (Siebold) Carrière, *Étude générale du Genre pommier*: 61, fig. 11 (Carrière 1883). – *Malus baccata* subsp. *toringo* (Siebold) Koidz., *Botanical Magazine (Tokyo)* 25 (290): 76 (Koidzumi 1911). – **Type**: JAPAN • Honshu, Nagano, on the way from Senjongahara to Mt. Mikuni yama, Azusa yama, Kawakami-mura, Minamisaku-gun; alt. 1700 m; 25 May 1963; *M. Hotta 12195*; neotype: LE, designated by Langenfeld 1991: 143.

Pyrus sieboldii Regel, *Index Seminum quae Hortus Botanicus Imperialis Petropolitanus pro Mutua Commutatione Offert*: 51 (Regel 1859). – *Malus sieboldii* (Regel) Rehder, *Plantae Wilsonianae Vol. 2 (2)*: 293 (Rehder 1915), nom. illeg.

Malus sargentii Rehder, *Trees & Shrubs Vol. 1 (2)*: 71 (Rehder 1903a). – *Malus toringo* subsp. *sargentii* (Rehder) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 33 (Likhonos 1974). – *Malus toringo* var. *sargentii* (Rehder) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 9 (Ponomarenko 1992). – **Type**: JAPAN • Hokkaido, brackish marsh near Mororan; 25 Sep. 1892; *C.S. Sargent s.n.*; type: A[A00026654]!

Crataegus cavaleriei H.Lév. & Vaniot, *Bulletin de la Société botanique de France* 55: 58 (Léveillé 1908). **– Type**: CHINA • Kouy Tcheou, Pin-fa; 23 Jul. 1902; *J. Cavalerie 93*; lectotype: E[E00010841]!, **here designated**; isolectotype: E[E00284743]!

Photinia rubrolutea H.Lév., *Repertorium Novarum Specierum Regni Vegetabilis* 9: 460 (Léveillé 1911). – **Type**: CHINA • Kouy Tcheou; 13 Nov. 1907; *J. Cavalerie 3303*; type: K[K000758420]!

Pyrus esquirolii H.Lév., *Repertorium Novarum Specierum Regni Vegetabilis* 12: 189 (Léveillé 1913). – **Type**: CHINA • Kouy-Tcheou, Pin-Fa; 2 Apr. 1902; fl; *J. Cavalerie 1304*; lectotype: E[E00010840]!, **here designated**; isolectotype: GH[GH 00032495]!

Malus sieboldii var. *arborescens* Rehder, *Plantae Wilsonianae Vol. 2 (2)*: 294 (Rehder 1915). – **Type**: JAPAN • Hondo, Lake Chuzenji; alt. 5000 ft; 3 Jun. 1914; fl; *E.H. Wilson 6800*; lectotype: A[A00368650]!, **here designated**.

Malus sieboldii var. *calocarpa* Rehder, *Plantae Wilsonianae Vol. 2 (2)*: 294 (Rehder 1915). – **Type**: JAPAN • cultivated at the Arnold Arboretum; 1890; *Dr W.S. Bigelow s.n.*; type: A[A00106229, A00106231]!

Malus sieboldii var. *incisa* Koidz., *Botanical Magazine (Tokyo)* 30 (358): 331 (Koidzumi 1916), nom. nud.

Malus toringo var. *koringo* Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4): 183 (Koidzumi 1934b). – *Malus toringo* f. *koringo* (Koidz.) T.Shimizu, *Journal of Phytogeography and Taxonomy* 37 (2): 120 (Shimizu 1989).

Malus sieboldii var. *sargentii* (Asami) Langenf., *Daildarznieciba* 8: 13 (Langenfeld 1971), without basionym ref.

Examined specimens

CHINA – **Anhui** • Yuexi; 24 Aug. 1986; fr; *Plant survey Team Da0586*; PE • Jinzhai; 6 Aug. 1986; fr; *Plant survey Team Da0225*; PE. – **Beijing** • Haidian; 21 Aug. 1962; fr; *Renguo 49*; PE • ibid.; 23 Apr. 1962; fl; *Renguo 41*; PE • ibid.; 26 Apr. 1957; st; *H.X. An et al. 229257*; PE. – **Chongqing** • Chengkou; 6 Jul. 2008; fr; *Bashan coll. Team 0008*; PE • Wushan; 26 May 1989; fl; *L.Q. Chen Chuanhua-258*; PE, CCAU. – **Hubei** • Lichuan; 5 Jun. 1958; fr; *W.B. Lin 235*; PE, HIB • Shennongjia; 14 Aug. 2008; fr; *Yu et al. 080176*; PE • Guangshui; 27 Jun. 2009; st; *Y.Z. Luo 3038*; HENU. – **Hunan** • Nanyu; 8 Aug. 1948; fr; *Y. Liu 570*; NAS • Hengshan; 24 May 1944; fr; *H.D. Zhang 3185*; IBK, IBSC • Qianyang; 22 Jun. 1954; fr; *Z.T. Li 2450*; IBSC • Xinning; 18 Jul. 1979; fr; *Q.Z. Lin 10078*; IBSC, CSFI • Sangzhi; 26 Apr. 2009; fl; *B. Zhang & X. Xiang 090426033*; PE. – **Gansu** • Pingliang; 16 May 2014; st; *Y. He & J.C. Hao GSL 2014050597*; BNU • Gannan; 25 Jun. 1956; fr; *B.Z. Guo 3108*; HNWP • ibid.; 13 May 1956; fr; *Yellow River Investigation Team 3629*; HNWP, KUN, PE. – **Guangdong** • Lianshan; 5 Dec. 1996; fr; *B.H. Chen 234*; IBSC • Lechang; 26 Oct. 1986; fr; *Nanling Team 3157*; IBSC • ibid.; 25 Oct. 1987; fr; *Nanling Team 4086*; IBSC • Renhua; 21 May 1936; fr; *W.T. Tsang 26450*; IBSC • Ruyuan; 10 Apr. 1934; fl; *X.P. Gao 54078*; IBK, IBSC, KUN, NAS, PE, SZ. – **Guangxi** • Damiaoshan; 9 Jul. 1959; fr; *Q.H. Lv 3499*; HITBC, IBSC, PE • Xingan; 23 Jul. 2014; fr; *Xinganxian survey Team 450325140723009LY*; GXMG • Ziyuan; 23 May 1982; fr; *G.Z. Li 11600*; IBK • Quanzhou; 12 Oct. 2014; fr; *Quanzhouxian survey Team 450324141012045LY*; GXMG, IBK. – **Guizhou** • Yunyan; 15 Sep. 2002; fr; *Q.R. Liu et al. LCG2002072*; BNU • Jinping; Jun. 1964; fr; *Y.M. Wang 64-1068*; GFS • Kaili; 23 May 1959; fl, fr; *Qiannan Team 2122*; PE, HGAS, NAS • Liziba; 20 Nov. 1927; fr; *B.Q. Zhong 309*; PE, GFS, KUN. – **Liaoning** • Anshan; 28 Sep. 1950; fr; *Q.T. Li 2569*; IFP • Jinxian; 1 May 1984; fl; *J.Q. Deng 4*; PE • Shenyang; 7 Jul. 1966; fr; *Y.M. Huang s.n.*; IFP. – **Jiangxi** • Chongyi; 19 Jun. 1965; fr; *M.X. Nie et al. 08863*; LBG • Suichuan; 22 Apr. 2015; fr; *D.G. Zhang & G.X. Chen LXP-064550*; JIU • Lushan; 18 Sep. 1984; fr; *J.Y. Liu 8400213*; TIE • Dayuxian; 17 Jun. 1962; st; *J.S. Yue et al. 1315*; NAS • Jian; 21 May 2016; fr; *Zhang et al. LXP-13-17760*; SYS • locality unknown; 4 Sep. 2016; fr; *T.J. Liang LS20160070*; CSH. – **Jiangsu** • Nanjing; 21 Sep. 1982; fr; *G. Yao 8388*; NAS • ibid.; 18 Aug. 1981; fr; *G. Yao et al. 8216*; FJSI • Suzhou; 23 Aug. 1958; fr; *F.X. Liu 10803*; HHBG. – **Qinghai** • Xining; 25 May 1990; fl; *Z.H. Zhang et al. 5709*; HNWP • ibid.; 20 May 1991; fr; *R.H. Zhang s.n.*; HNWP • ibid.; 20 May 1991; fl; *W. Li s.n.*; HNWP. – **Shandong** • Qingdao; 1982; fr; *D.J. Yu 40*; PE • ibid.; 7 Jul. 2013; *X.B. Ma 10175*; SDFRG • Zhangjiashan; 30 May 2012; fl; *Y.M. Fang 170*; SDFRG • Laiyang; 3 May 1955; fl; *F.S. Zhang 511*; PE. – **Shaanxi** • Baoji; 1 Aug. 1989; fr; *Y.S. Lian et al. 96133*; PE • Ningshan; 24 Jul. 1982; fr; *Anonymous 4-170*; PE • ibid.; 18 ul. 2007; fr; *Q.R. Liu QL028*; BNU • Wugong; 21 Jun. 1955; st; *D.J. Yu 46*; PE • Langao; 29 Jun. 2004; fr; *Chen et al. 562*; WUK. – **Sichuan** • Maoxian; 9 Jul. 1959; fr; *Maowen Group 5105*; CDBI, SM • Songgang; 25 May 1957; fl; *X. Li 70851*; PE, IBSC, IFP, KUN, NAS, SZ • Qingchuan; 25 Aug. 1930; fr; *F.T. Wang 22361*; PE. – **Yunnan** • Weixi; 11 Sep. 1974; st; *P. Zhang 74058*; PE • Lijiang; 21 Aug. 1974;

Fig. 23. Distribution of *Malus toringo* (Siebold) Siebold ex de Vriese.

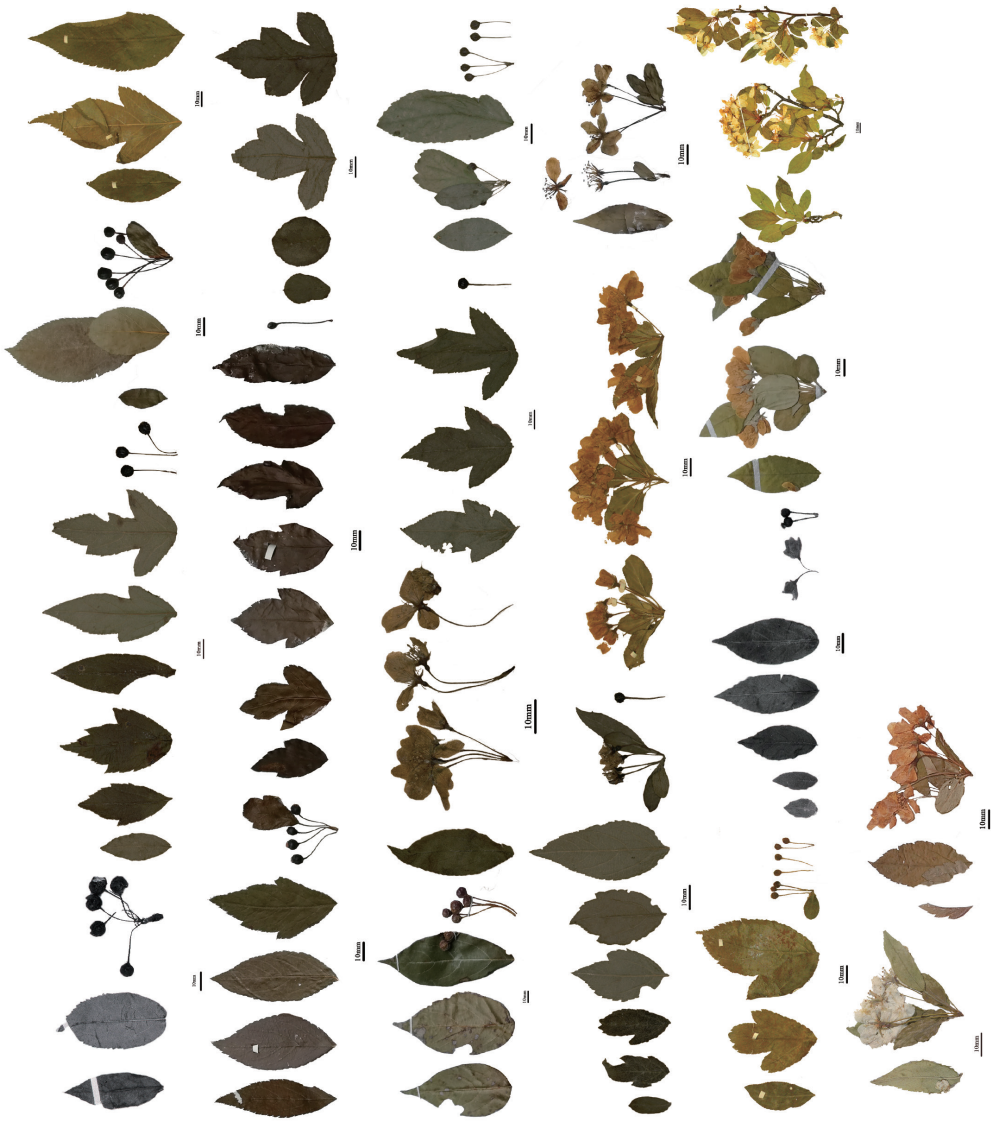

Fig. 24. Morphological characters of *Malus toringo* (Siebold) Siebold ex de Vriese; QIN05051, P03144354 (*M. sargentii*), KUN0937887 (*M. sargentii*), KUN0662678 (*M. sieboldii* (Regel) Rehder), KUN0662696 (*M. sieboldii*), KUN1301749 (*M. sieboldii*), QIN05054 / QIN05055, P03132499 (*M. sieboldii*), P03132500 (*M. sieboldii*), P03132503 (*M. sieboldii*), P03132504 (*M. sieboldii*), P03302835 (*M. sieboldii*), PE00953561 (*M. sieboldii*), PE00953606 (*M. sieboldii*), PE00953693 (*M. sieboldii*), P00783340, PE01504803, KUN0118326, KUN0813805, KUN1261369. Scale bars = 10 mm.

st; *P. Zhang 74002*; PE. – **Zhejiang** • Hangzhou; 27 Jun. 2002; fr; *Zhu & Liu 443*; PE, HITBC, IBSC • ibid.; 27 Jun. 2002; fr; *Q.G. Zhu & Q.W. Liu 56*; HITBC, IBSC • ibid.; 5 May 1973; fl, fr; *Anonymous s.n.*; PE[00953581] • Chunan; 1 Jun. 1959; fr; *M.L. She et al. 27770*; NAS.

JAPAN – **Shinano** • Nagano; 14 Jun. 1965; fl; *Miyoshi Fufuse 43178*; PE • ibid.; 16 Sep. 1952; fr; *Miyoshi Fufuse 25713*; PE • ibid.; 8 May 1948; fl; *Miyoshi Fufuse 19023*; PE.

SOUTH KOREA – **Chollabuk-do** • Wanju-gun, cultivated; 8 Aug. 1992; fr; *D.E. Boufford et al. 25818*; PE. – **Gyeongsangbuk-do** • Uiseong-gun; 13 Apr. 2011; fl; *Nagtong-90*; PE.

UNITED STATES – **Maryland** • Prince George, cultivated; 16 Oct. 1982; fr; *Steven R. Hill 12497*; PE, NAS. – **Massachusetts** • Arnold Arboretum; 2 Oct. 1916; fr; *H.H. Chung 4013*; PE.

Description

Small tree or shrub, 4–6 (6–8) m high. Branches terete, aculeolate and pendulous, pubescent when young, glabrescent. Leaves petiolate, petiole ca 2.3 cm long, puberulous. Lamina 5.9 × 3.0 cm, elliptic to ovate, base rounded or cuneate, equilateral, apex acute or acuminate, margin crenate to serrulate, blade puberulous, sometimes 3-lobed, rarely 5-lobed. Inflorescence umbellate, with 4–8 flowers. Pedicel ca 3.0 cm long, puberulous or glabrous. Hypanthium puberulous or glabrous. Sepals triangular, abaxially glabrous, adaxially densely puberulous, caducous. Petals ca 1.2 × 0.7 cm, pink, obovate. Stamens ca 20, unequal, yellow. Styles 3–5, longer than stamens, basally densely puberulent. Pome ca 0.6–0.8 cm in diameter, subglobose or oblate, yellow or red. Carpopodium ca 2.5 cm long, glabrous.

Phenology

Flowers from April to May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in the mixed forests or shrubs in plains or valleys, rarely in forests in mountain areas; 600–1700 m a.s.l.

Distribution

North Korea, South Korea, Japan and China (Liaoning, Shandong, Shaanxi, Gansu, Jiangxi, Zhejiang, Hubei, Hunan, Sichuan, Guizhou, Fujian, Guangdong, Guangxi, Qinghai, Zhejiang, Yunnan) (Fig. 23).

Chromosome numbers

2n = 34, 51, 68, 85.

9. ***Malus rockii*** Rehder
Figs 25–26

Journal of the Arnold Arboretum 14 (3): 206 (Rehder 1933).

Pyrus rockii (Rehder) M.F.Fay & Christenh., *Plant Gateway's The Global Flora*: *A Practical Flora to Vascular Plant Species of the World. Vol. 4*: 118 (Christenhusz *et al.* 2018). – **Type**: CHINA • Yunnan, west of Talifu, Mekong watershed, on the road to Young-chang and Tengyueh beyond Lampba, along watercourses; alt. 7000 ft; Sep.-Oct. 1922; fr; *J.F. Rock 6842*; type: A[A00026653]!; isotype: US[US00097446]!

Pyrus baccata γ *himalaica* Maxim., *Bulletin de l'Académie impériale des Sciences de Saint-Pétersbourg* 19: 171 (Maximowicz 1874). – *Malus baccata* var. *himalaica* (Maxim.) C.K.Schneid., *Illustriertes*

Handbuch der Laubholzkunde Vol. 1: 721, fig. 397s (Schneider 1906b). – *Malus baccata* subsp. *himalaica* (Maxim.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 28 (Likhonos 1974).

Examined specimens

CHINA – **Chongqing** • Shizhu; 1 May 1978; fr; *W.H. Wang 309*; CDBI • Nanchuan; 20 Apr. 1996; fl; *Z.Y. Chen 17984*; PE • Chengkou; 1 Jul. 1958; fr; *T.L. Dai 105708*; CDBI. – **Guangxi** • Quanzhou; 1 Jun. 2005; fr; *Q. Li 0654*; PE. – **Shaanxi** • Foping; 7 Jul. 1952; fr; *B.Z. Guo 1592*; CDBI • ibid.; 1 Jun. 1952; fr; *K.J. Fu 4541*; CDBI. – **Sichuan** • Kangding; 19 May 1961; fl; *S. Jiang et al. 2860*; PE • Ganzi; 18 Jul. 1961; fr; *S. Jiang et al. 9448*; PE • Zhaojue; 2 Apr. 1982; fl; *Jiang et al. 19A*; PE • Longquanshan; 1 Mar. 1979; fl; *B.C. Gao 8775*; CDBI • Yanyuan; 25 Apr. 2007; fl; *Y.Y. Gen, D.H. Zhu & X.J. Li 20070223*; WCSBG. – **Tibet** • Jilong; 7 Sep. 1990; fr; *B.S. Li et al. 13565*; PE • Chayu; 28 Jul. 1980; fr; *Ni et al. 0877*; PE • Bomi; 27 Jun. 1965; fr; *J.S. Ying & D.Y. Hong 650338*; PE • ibid.; 11 May 1976; fl; *Qingzang Zhibei Group 11655*; PE • Jilong; 2 Jun. 1972; fl; *Xizhang zhongcaoyao Expedition 84*; PE. – **Yunnan** • Deqin; s.d.; fr; *G. Forrest 12846*; IBSC • Weixi; 20 Jul. 1981; fr; *Institute of Beijing botany Hengduanshan Team 01720*; PE • ibid.; 20 Sep. 1974; fr; *P. Zhang 74084*; PE • Zhongdian; 14 Jun. 1981; fl; *Qingzang-Hengduanshan Team 1028*; PE • Jingdong; 24 Jul. 2003; fr; *G.P. Yang 117*; PE • Dali; 17 Sep. 2009; fr; *Z.J. Yin et al. 2419*; PE.

Description

Tree, 8–10 m high. Branches terete, crinite when young, glabrescent. Leaves petiolate, petiole ca 2.3 cm long, crinite. Lamina 5.3–7.2 (12) × 2.9–3.7 cm, elliptic to ovate, base rounded, cordate or cuneate, oblique, apex acuminate, margin serrulate, blade puberulous abaxially or on midvein. Inflorescence umbellate, with 4–8 flowers. Pedicel ca 3.3 cm long, lanuginous. Hypanthium densely puberulous. Sepals lanceolate-triangular, abaxially puberulous or glabrous, adaxially densely puberulous, caducous. Petals ca 1.4 × 0.9 cm, white, obovate. Stamens 20–25, unequal. Styles 4 or 5, longer than stamens, basally crinite. Pome ca 1.0–1.5 cm in diameter, subglobose, tapering, red. Carpopodium ca 3.8 cm long, puberulous.

Phenology

Flowers from May to June. Mature fruits in September.

Habitat

Terrestrial, seasonally green, growing in mixed forests on slopes or in valleys; 1500–3800 m a.s.l.

Fig. 25. Distribution of *Malus rockii* Rehder.

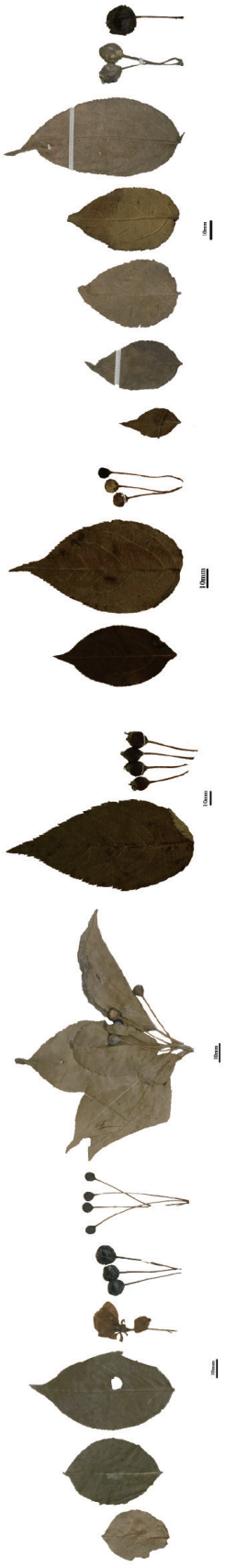

Fig. 26. Morphological characters of *Malus rockii* Rehder. US00097446 (isotype), K000758448, K000758450, NAS00002410, NAS00002396. Scale bars = 10 mm.

Distribution

China (Chinging, Guangxi, Shaanxi, Sichuan, Tibet, Yunnan) (Fig. 25).

Chromosome numbers

2n = 34, 51, 54, 68.

Note

Flora of China (Ku & Spongberg 2003) considered *Pyrus baccata* var. *himalaica* Maxim. and *Malus rockii* Rehder as nomenclatural synonyms. We agree with this treatment.

10. ***Malus toringoides*** (Rehder) Hughes, nom. cons.
Figs 27–28

Bulletin of Miscellaneous Information, Royal Gardens, Kew 6: 205 (Hughes 1920), nom. cons.

Malus transitoria var. *toringoides* Rehder, *Plantae Wilsonianae Vol. 2 (2)*: 286 (Rehder 1915). – *Pyrus transitoria* var. *toringoides* (Rehder) L.H.Bailey, *Rhodora* 18: 155 (Bailey 1916a). – *Pyrus toringoides* (Rehder) Osborn, *The Gardeners' Chronicle, Ser. 3* 73: 89, fig. 42 (Osborn 1923). – *Sinomalus toringoides* (Rehder) Koidz., *Acta Phytotaxonomica et Geobotanica* 1 (1): 11 (Koidzumi 1932). **– Type**: CHINA • Szechuan, Kangding, west of Tachien-lu; alt. 3300 m; Oct. 1904; *E.H. Wilson 1285*; holotype: A[A00020423]!; isotype: US[US00097450]!

Pyrus bhutanica W.W.Sm., *Records of the Botanical Survey of India* 4: 265 (Smith 1911). – *Malus bhutanica* (W.W.Sm.) J.B.Phipps, *Edinburgh Journal of Botany* 51 (1): 100 (Phipps 1994). **– Type**: BHUTAN (actually from Tibet, CHINA) • Lalung Gumpa; 27 Jun. 1906; *J.C. White s.n.*; type: K[K000758452, K000758453]!

Examined specimens

CHINA – **Gansu** • Lanzhou; 15 Nov. 1920; fr; *Anonymous 6021*; P, TIE • T'ao River basin; Jun. 1925; st; *J.F. Rock 12478*; IBSC • ibid.; Jul. 1925; fr; *J.F. Rock 13133*; IBSC • Gannan; 9 May 1957; fl; *P. Zhang & L.F. Qi 915*; PE • Zhengning; 10 Aug. 1991; fr; *L.P. Liu 910065*; QYTC. – **Hunan** • Mangshan; 10 Aug. 1957; fr; *L.H. 926*; PE. – **Qinghai** • Huzhu; 28 Jul. 1992; fr; *G.X. Liu s.n.*; PE[00953998]. – **Sichuan** • Luhuo; 25 Jun. 1974; fl, fr; *Q.S. Zhao, Y.H. Guo & Z.M. Tan 111266*; PE • Xikang; 12 Jul. 1951; fr; *Y.W. Cui 4349*; PE • Aba; 2 Oct. 1957; fr; *X. Li 74941*; PE, IBSC, KUN, NAS, SZ • Xiaojin; 2 Aug.

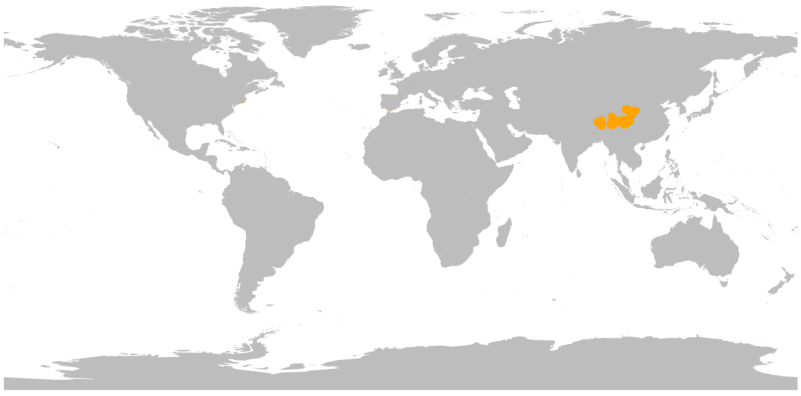

Fig. 27. Distribution of *Malus toringoides* (Rehder) Hughes.

Fig. 28. Morphological characters of *Malus toringoides* (Rehder) Hughes. A00020423 (holotype of *M. transitoria* var. *toringoides* Rehder), QIN05060, QIN05061, US00097450 (isotype), K000758425, P03240524, P03240525, P03240527, KUN0662723, KUN0662724, KUN0662725, K000758452 (type of *M. bhutanica* (W.W.Sm.) J.B.Phipps), K000758453 (type of *M. bhutanica*), PE00927493 (*M. bhutanica*). Scale bars = 10 mm.

1958; fr; *X.S. Zhang & Y.X. Ren 6397*; PE • Lixian; 13 Jun. 1959; fl; *S. Jiang et al. 00773*; PE • Xinlong; 25 Aug. 2006; fr; *D.E. Boufford et al. 37290*; PE • ibid.; 25 Aug. 2006; fr; *D.E. Boufford et al. 37284*; PE • Maoxian & Lixian; 1952; fl; *T. He & Z.L. Zhou 14048*; PE • Hongyuan; 24 Aug. 1983; fr; *Z.X. Tang 1785*; PE • Suining; 2 Aug. 1974; fr; *Sichuan Zhibei Team 5838*; CDBI. – **Tibet** • Jiangda; 1 Jun. 1974; fr; *Sichuan Zhibei Team 6996*; CDBI, PE • Lhasa; 26 May 1975; fl; *Qinggan Expedition 75-84*; PE • ibid.; 10 Sep. 1965; fr; *Y.T. Zhang & K.Y. Lang 2685*; PE • Changdu; 7 May 1976; fl; *Qingzang Team 7679*; PE • ibid.; 19 Sep. 2008; *D.C. Zhang et al. ZhangDC-07ZX-1293*; KUN • Linzhi; 23 Sep. 2009; fr; *H. Sun et al. SunH-07ZX-2546*; KUN • Mangkang; 12 Sep. 2008; fr; *T. Zhang et al. 08CS650*; KUN.

UNITED STATES – **Massachusetts** • Arnold Arboretum; 17 Oct. 1973; fr; *S.Y. Hu 13327*; IBSC.

Description

Small tree or shrub, 3–10 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.8–2.9 cm long, puberulous. Lamina 3.9–6.8 × 1.5–3.6 cm, elliptic to ovate, base rounded, cordate or cuneate, equilateral, apex obtuse or retuse, margin crenate, blade piliferous, pubescent on midvein, usually 3-lobed or divided, sometimes unlobed. Inflorescence umbelliform corymb, with 3–6 flowers. Pedicel ca 2.0 cm long, puberulous. Hypanthium puberulous. Sepals lanceolate-triangular or narrow-triangular, abaxially puberulous, adaxially densely puberulous, caducous, rarely persistent. Petals ca 0.7–0.9 × 0.5–0.7 cm, white, obovate, puberulous or glabrous. Stamens ca 20, unequal. Styles 3, rarely 4 or 5, shorter than stamens, glabrous. Pome ca 1.0–1.3 cm in diameter, ellipsoidal to subglobose, yellow. Carpopodium ca 2.3–2.8 cm long, puberulous.

Phenology

Flowers from April to May. Mature fruits in September.

Habitat

Terrestrial, seasonally green, growing in forests on slopes; 1500–3700 m a.s.l.

Distribution

China (Gansu, Shaanxi, Qinghai, Sichuan, Tibet) (Fig. 27).

Chromosome numbers

2n = 31, 34, 51, 54, 68.

11. ***Malus xiaojinensis*** M.H.Cheng & N.G.Jiang
Figs 29–30

Journal of Southwestern Agricultural College 4: 53–55, figs 1–3 (Cheng *et al.* 1983).

Malus baccata var. *xiaojinensis* (M.H.Cheng & N.G.Jiang) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 8 (Ponomarenko 1992), nom. inval. – Type: CHINA • Sichuan, Xiaojin; Dashuigou, wet hillside; alt. 3000 m; 7 Oct. 1981; fr; *N.G.Jiang, M.H.Cheng & Q.Shi 128*; lectotype: HWA[HWA00061036]!, **here designated**; isolectotype: CDBI[CDBI0043871, CDBI0003872]!, PE[PE00964203]!, HWA[HWA00061037]!

Examined specimens

CHINA – **Sichuan** • Xiaojin; 7 May 1984; fr, st; *Q. Shi et al. 840025*; PE[PE00964204] • ibid.; 7 Oct. 1981; fr; *M.H. Chen & N.G. Jiang 128*; CDBI, PE • ibid.; 2 Jul. 1958; fr; *Sichuan agricultural college 6320*; CDBI • ibid.; 2 Aug. 1958; fr; *Sichuan agricultural college 6320*; CDBI • Kangding; 1 Sep. 1982;

fr; *Sichuan vegetation group 29803*; CDBI • ibid.; 3 May 1974; fl; *F.Y. Qiu 4406*; CDBI • Jinchuan; 2 Jul. 1975; fr; *Sichuan vegetation group 9447*; CDBI • Heishui; 7 May 1959; fl; *Chuanjingzhi Heishui group 1054*; PE, SM • ibid.; 30 Jul. 1957; fr; *X. Li 73880*; PE, IBSC • Lixian; 23 Jun. 1958; fr; *S.Y. Chen 5296*; NAS, SM • ibid.; 23 Jun.; 1958; fr; *M.F. Zhong, T. He & S.Y. Chen 5296*; SM • Maerkang; 2 May 1957; fl; *X. Li 70352*; NAS, IBSC, KUN, PE[PE00964011], SZ • ibid.; 19 May 1957; fl, fr; *X. Li 70724*; IBSC, NAS, PE, SZ • ibid.; 7 Jul. 1957; fr; *Z.Y. Zhang & H.F. Zhou 22649*; PE.

Description

Tree, 8–12 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.6–2.7 cm long, puberulous. Lamina 3.7–7.5 × 2.1–3.2 cm, oval, oblong or orbicular, base rounded or cuneate, equilateral, apex acuminate or caudate, margin crenate to serrulate, blade puberulous when young, glabrescent, 3–5-lobed in sapling and base of mature tree. Inflorescence umbellulate, with 3–7 flowers. Pedicel ca 2.0–3.0 cm long, puberulous. Hypanthium glabrous. Sepals lanceolate-triangular, abaxially puberulous or glabrous, adaxially densely puberulous, caducous. Petals ca 1.0–1.2 × 0.8–1.0 cm, white, obovate. Stamens ca 20, unequal. Styles 3–5, longer than stamens, glabrous. Pome ca 1.0–1.3 cm in diameter, ellipsoidal to subglobose, yellow. Carpopodium ca 1.0–1.5 cm long.

Habitat

Terrestrial, seasonally green, growing at the edge of forests, river banks or gullies; 2600–3000 m a.s.l.

Distribution

China (Sichuan) (Fig. 29).

12. ***Malus transitoria*** (Batalin) C.K.Schneid.
Figs 31–32

Illustriertes Handbuch der Laubholzkunde Vol. 1: 726 (Schneider 1906b).

Pyrus transitoria Batalin, *Trudy imperatorskago S.-Peterburgskago botanicheskago Sada* 13 (1): 95–96 (Batalin 1893). – *Sinomalus transitoria* (Batalin) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4): 196 (Koidzumi 1934b). – **Type**: CHINA • Kansa (Gansu), the eastern ridge of the Sodis-kruxum; 16 (28) May 1873; fl; 20 Aug. (1 Sep.) 1873; fr; *Przewalsky 55*; lectotype: LE[LE01015142]!, K[K000758424]!, P[P03240528]!, designated by Batalin 1893: 95–96 and Langenfeld 1991: 138–139.

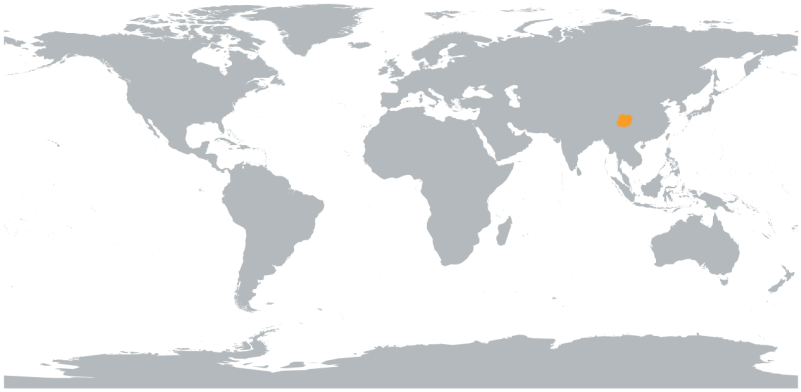

Fig. 29. Distribution of *Malus xiaojinensis* M.H.Cheng & N.G.Jiang.

Fig. 30. Morphological characters of *Malus xiaojinensis* M.H.Cheng & N.G.Jiang; CDBI0043872, PE00964204, PE00964011, PE00964012. Scale bars = 10 mm.

Malus centralasiatica Vassilcz., *Botanicheskie Materialy Gerbariya botanicheskago instituta imeni V.L. Komarova Akademii nauk SSSR* 19: 202 (Vassilczenko 1959). – *Malus transitoria* var. *centralasiatica* (Vass.) T.T.Yu, *Flora Reipublicae Popularis Sinicae Vol. 36*: 394 (Yu 1974), syn. nov. – **Type**: CHINA • Gansu, Xining, La Che Tze Shan Mountains; alt. 3900 m (actually alt. 2200–2850 m); 3 Aug. 1923; fr; *R.C. Ching 724*; holotype: LE; isotype: A[A00368974]!, PE[PE00953983]!, SYS[SYS00074312]!.

Malus transitoria var. *glabrescens* T.T.Yu & L.T.Lu, *Acta Phytotaxonomics Sinica* 18 (4): 496 (Yu *et al.* 1980), syn. nov. – **Type**: CHINA • Tibet, Qamdo (Changdu); alt. 3550 m; 26 Apr. 1976; *Qing-Zang Exped. Veg. Group 10023*; holotype: PE[PE00964002]!

Malus transitoria var. *calycomeles* Cheng, Zeng & Jin, *Journal of Southwest Agricultural University* 17 (1): 1 (Cheng *et al.* 1995), syn. nov. – **Type**: CHINA • Sichuan, Ruoergai; alt. 2500 m; *M.H. Cheng et al. 91–87*; lectotype: HWA, **here designated**.

Examined specimens

CHINA – **Beijing** • Haidian; 13 Aug. 1962; fr; *Renguo 12*; PE. – **Gansu** • Diebuxian; 30 Sep. 2005; fr; *A. Aiello et al. 080*; PE • Lanzhou; 21 Sep. 2003; fr; *C.M. Tan et al. Lanzhou005*; JJF, SZG • Ningxian; 15 May 2014; fl; *X.Y. Xu 20140515047*; QYTC • ibid.; 15 May 2014; fl; *W. Hui 20140515052*; QYTC • Heshui; 28 Jun. 1954; fr; *Yellow River Investigation Team 113*; PE • Jinchi; 27 Jul. 1990; fr; *L.P. Liu 00019*; QYTC • Gannan; 1 Sep. 2012; st; *S.Q. Guo & P. Du LiuJQ-2012-GN-185*; KUN • ibid.; 21 Sep. 1957; fr; *Z.L. Yan & P. Zhang 1063*; PE • ibid.; 29 May 1956; st; *Yellow River Investigation Team 4152*; PE • ibid.; 1 Sep. 1960; fr; *Qinggan Team 3400*; PE • T'ao River basin; Jun. 1925; fl; *J.F. Rock 12188*; PE. – **Inner Mongolia** • Alashan; 23 Jun. 1962; fl; *He group 85*; NAS • ibid.; 2 Aug. 2011; fr; *Beijing Normal University Ningxia Team HL114*; BNU • Helanshan; Sep. 1956; fl; *W.Z. Fang s.n.*; NAS • ibid.; 30 Aug. 2008; fr; *Y.Z. Zhao & S.Q. Zhou 2423*; HIMC • ibid.; 23 Jun. 1962; fl; *Biology department senior year 85*; PE, HIMC. – **Ningxia** • Helanshan; 18 Jun. 1973; fr; *Ningxia Yaojiansuo 73-0167*; PE. – **Qinghai** • Xunhua; 27 Jun. 1981; st; *B.Z. Guo 25400*; HNWP • Yushu; 12 Aug. 1981; fr; *Z.K. Wei 22383*; HNWP • Hualong; 6 Jun. 2004; fl; *Y.H. Wu 28576*; HNWP • Huzhu; 10 Sep. 1980; fr; *R.F. Huang & Y.C. Yang 1747*; HNWP • Tongren; 28 Jul. 1970; fr; *L.H. Zhou & H.H. Zhang 1295*; HNWP. – **Shaanxi** • Jingbian; 23 Jun. 1952; fr; *J.M. Liu 11636*; PE • Yanan; 19 Jun. 1993; fl; *L.R. Xu 1670*; PE • Shanbei; 4 Sep. 1953; fr; *Shanbei Team 10652*; CDBI • Huashan; 14 Sep. 1978; fr; *Z.Y. Zhang 18227*; IBSC. – **Sichuan** • Kangding; 14 Jun. 1980; fl; *Z.Y. Chen et al. 112699*; PE • Hongyuan; 14 Sep. 1957; fr; *X. Li 74662*; PE • Daofu; 23 Jul. 1959; fr; *S. Jiang et al. 002352*; PE • Xikang; 8 Aug. 1951; fr; *Y.W. Cui 5198a*; PE • Aba; 2 Aug. 1975; fr; *Sichuan zhibei Team 10487*; CDBI • Dege; 1 Jun. 1977; fr; *Sichuan zhibei Team 15073*; CDBI. – **Tibet** • Changdu; 26 Aug. 1973; fr; *Tibet Expedition Team 2248*; HNWP • ibid.; 26 Sep. 2008; fr; *Y.H. Zhang, G.D. Li & X.X. Wang SunH-07ZX-1761*; KUN • ibid.; 24 Sep. 2008; fr; *C.R. Zaxi, L. Xi & Y.P. Geng ZhongY752*; KUN.

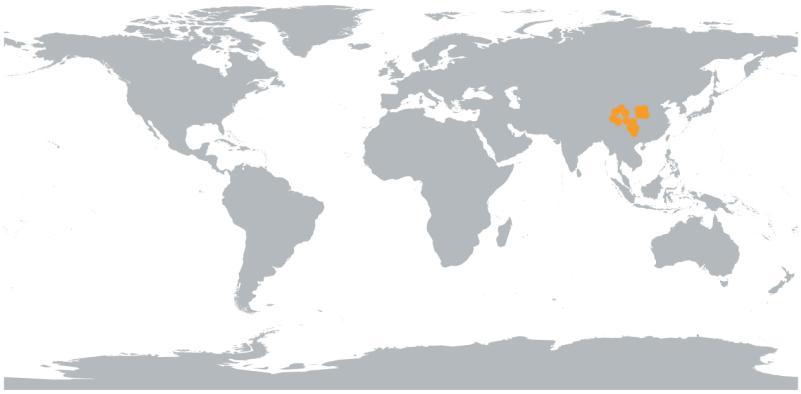

Fig. 31. Distribution of *Malus transitoria* (Batalin) C.K.Schneid.

Fig. 32. Morphological characters of *Malus transitoria* (Batalin) C.K.Schneid.; HNWP95806, K000758422 (type), KUN0662715, QIN05058, QIN05059, P03240529, P03240530, PE00953973, PE00953979, PE00953981, PE00964002 (holotype of *M. transitoria* var. *glabrescens* T.T.Yu & T.C.Ku), PE00964003 (paratype of *M. transitoria* var. *glabrescens*), PE00964004 (paratype of *M. transitoria* var. *glabrescens*), SZG00026156. Scale bars = 10 mm.

Description

Small tree or shrub, 3–5 m high, rarely 8 m. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 0.8–1.9 cm long, densely lanuginous. Lamina 3.4–6.8 × 2.3–3.6 cm, oval to ovate, base rounded, cuneate or cordate, equilateral, apex acuminate or obtuse, margin crenate to serrulate, blade puberulous when young, then abaxially glabrescent, usually 3–5 divided. Inflorescence umbelliform corymb, with 3–6 flowers. Pedicel ca 1.7–2.0 cm long, puberulous. Hypanthium lanuginous. Sepals triangular, densely puberulous, caducous, rarely persistent. Petals ca 0.7–0.9 × 0.4–0.6 cm, white, obovate or oblong. Stamens 20–25, unequal. Styles 3–5, longer than stamens, glabrous. Pome ca 0.6–0.8 cm in diameter, subglobose, yellow to red. Carpopodium ca 2.3–2.8 cm long, puberulous.

Phenology

Flowers from April to May. Mature fruits in September.

Habitat

Terrestrial, seasonally green, growing in forests on slopes or loess hills; 1500–3900 m a.s.l.

Distribution

China (Inner Mongolia, Ningxia, Qinghai, Shaanxi, Gansu, Sichuan, Yunnan, Tibet) (Fig. 31).

Chromosome numbers

2n = 34, 51.

Note

There are plentiful morphological variations within this species. Varieties that have been defined on the basis of a few characters and locations are unjustified because such unique phenotypic characters have probably been affected by the environment. Therefore, three new synonyms are proposed in this study (*Malus transitoria* var. *glabrescens*, *M. transitoria* var. *calycomeles*, and *M. transitoria* var. *centralasiatica*).

The vertical vicariance of *Malus kansuensis* (distribution below 3000 m), *M. toringoides* (2600–3050 m) and *M. transitoria* (above 3000 m) is very remarkable, and there are no obvious reproductive barriers between them. As a consequence, hybrids that show characters of both parents could be found in the contact zones; for example, the specimens from Maerkang (Sichuan, China) exhibit continuous morphological variation between *M. transitoria* and *M. toringoides*.

13. ***Malus sikkimensis*** (Wenz.) Koehne ex C.K.Schneid.
Figs 33–34

Illustriertes Handbuch der Laubholzkunde Vol. 1: 719 (Schneider 1906b).

Pyrus pashia var. *sikkimensis* Wenz., *Linnaea* 38 (1): 49 (Wenzig 1874). – *Pyrus sikkimensis* Hook. f., *Flora of British India Vol. 2 (5)*: 373 (Hooker 1879). – *Malus baccata* subsp. *sikkimensis* (Wenz.) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 28 (Likhonos 1974). – **Type**: INDIA • Sikkim, Himalaya, alt. 7000–10 000 ft; s.d.; fl; *J.D. Hooker s.n.*; isosyntype: K[K000758445]!, M[M0213666]!

Examined specimens

BHUTAN – Guni Sa; 14 May 1949; fl; *F. Ludlow, G. Sherriff & J.H. Hicks 16231*; PE.

CHINA – **Sichuan** • Butuo; 6 Aug. 1979; st; *Pucha Team 0682*; SM. – **Tibet** • Milin; 19 Oct. 1984; fr; *G. Yao et al. 132*; NAS • ibid.; 29 Jul. 1989; fr; *G. Yao et al. 1834*; NAS • ibid.; 13 Sep. 2003; fr; *X.F. Gao et al. 7425*; CDBI • ibid.; 28 Jul. 1975; fr; *Qingzhang Budian Group 750912*; PE • Chayu; 7 Oct. 2007; fr; *Z.D. Fang, G. He & Q.R. Yang XZ-689*; SABG • Bomi; 3 Sep. 1982; fr; *B.S. Li et al. 0518*; PE • Yadong; 9 Sep. 1974; fr; *Qingzang Team 2108*; PE • Linzhi; 2 Jul. 1989; fr; *G. Yao et al. 1443*; NAS • Shannan; 11 Sep. 2017; fr; *PE-Xizang Team PE6349*; PE. – **Yunnan** • Deqin; 25 May 1975; fl; *Yunnan Deqinxian Nongyeju s.n.*; PE • 18 May 1975; fl; *Yunnan Deqinxian Nongyeju s.n.*; PE • ibid.; 2 Sep. 1974; fr; *P. Zhang 74050*; PE • Wenshan; 26 Mar. 2009; st; *Y.L. Wang et al. 09-129*; SZG • Weixi; 12 Sep.1974; fr; *P. Zhang 74061*; PE.

INDIA – **Sikkim** • Himalaya; 4 Aug. 1849; fl, fr; *J.D. Hooker s.n.*; K[000758444] • ibid.; 26 May 1849; fl, fr; *J.D. Hooker s.n.*; K[000758443] • ibid.; 28 May 1849; fl; *J.D. Hooker s.n.*; K[000758446] • ibid.; 4 Jun. 1849; fl; *J.D. Hooker s.n.*; K[000758445] • ibid.; 16 Aug. 1844; fr; *J.D. Hooker s.n.*; K[000758442] • locality unknown; 6 Jul. 1849; fr; *Anonymous s.n.*; K.

MYANMAR – East Himalaya; Aug. 1837; fl, fr; *Griffith* 2081; K.

Description

Small tree, up to 8 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.3–2.2 cm long, densely lanuginous. Lamina 5.6–8.3 × 2.6–4.1 cm, oval to ovate, base rounded, equilateral, apex acuminate or acute, margin serrulate, blade pubescent abaxially and on midvein. Inflorescence corymbose, with 5–8 flowers. Pedicel ca 3.7 cm long, densely lanuginous. Hypanthium densely lanuginous or glabrous. Sepals lanceolate-triangular, abaxially glabrous, adaxially densely puberulous, caducous, rarely persistent. Petals ca 1.1 × 0.9 cm, white, obovate. Stamens 25–50, unequal. Styles 4, as long as or longer than stamens, glabrous. Pome ca 1.5–2.0 cm in diameter, subglobose or pyriform, yellow to red. Carpopodium ca 2.6 cm long, lanuginous.

Phenology

Flowers in May. Mature fruits in September.

Habitat

Terrestrial, seasonally green, growing in alpine forests; 2000–3000 (3900) m a.s.l.

Fig. 33. Distribution of *Malus sikkimensis* (Wenz.) Koehne ex C.K.Schneid.

Fig. 34. Morphological characters of *Malus sikkimensis* (Wenz.) Koehne ex C.K.Schneid.; M0213776 (syntype of *Sorbus sikkimensis* Wenz.), M0213809 (syntype of *Sorbus sikkimensis*), K000758444, K000758446, K000758447. Scale bars = 10 mm.

Distribution

Bhutan, China (Sichuan, Yunnan, Tibet), India (Sikkim), Nepal and Sri Lanka (Fig. 33).

Chromosome numbers

2n = 34, 51, 54, 68.

Note

Sorbus sikkimensis Wenz. (including *Malus sikkimensis* (Wenz.) N.P.Balakr.) was mistakenly treated as a synonym of *Malus sikkimensis* by Hassler (2020), but it actually is a synonym of *Sorbus corymbifera* (Miq.) T.H.Nguyên & Yakovlev according to the original literature and type specimen *Sorbus sikkimensis* Wenz. *Linnaea* 38 (1): 58 (Wenzig 1874). – **Type**: INDIA • India orientalis; 1843; *Griffith 2077/1*; syntype: M[M0213809, M0213776]!; isosyntype: E[E00145673]!, GH[GH00112876, GH00135439]! (Note on the sheet: lectotype, designated by Aldasoro *et al.* 2004: 57). In addition, because the type *Hooker f. & Thomson s.n.* of *M. sikkimensis* cited by Wenzig (1874: 49) still exist, the neotype *G. King s.n.* designated by Langenfeld (1991: 129) is invalid.

14. ***Malus tschonoskii*** (Maxim.) C.K.Schneid.
Figs 35–36

Repertorium Novarum Specierum Regni Vegetabilis 3: 179 (Schneider 1906a).

Pyrus tschonoskii Maxim., *Bulletin de l'Académie impériale des Sciences de Saint-Pétersbourg* 19: 169 (Maximowicz 1874). – *Pyrus tschonoskii* β *hoggii* (= *Pyrus hoggii*) Franch. & Sav., *Enumeratio plantarum japonicarum Vol. 2*: 349 (Franchet & Savatier 1878). – *Eriolobus tschonoskii* Rehder, *Trees & Shrubs Vol. 2 (1)*: 73, tab. 37 (Rehder 1903b). – *Cormus tschonoskii* Koidz., *Botanical Magazine (Tokyo)* 23 (272): 171 (Koidzumi 1909). – *Macromeles tschonoskii* Koidz., *Florae Symbolae Orientali-Asiaticae*: 53 (Koidzumi 1930). – *Docyniopsis tschonoskii* (Maxim.) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (3): 162 (Koidzumi 1934a). – **Type**: JAPAN • Honshu, Kyoto, near Ebidani, Hiyoshicho, Funaigun; alt. 400 m; 3 May 1963; fl; *G. Murata 18042*; lectotype: LE, designated by Langenfeld 1991: 126; isolectotype: P[P03240535]!

Examined specimens

JAPAN – **Honshu** • Kanagawa; 12 Aug. 1967; fr; *Miyoshi Furuse 45632*; KUN, PE • ibid.; 4 May 1927; fl; *T. Sawada s.n.*; PE • ibid.; s.d.; st; *Savatier 3425*; P • Kyoto; 12 Sep. 1949; fr; *Miyoshi Furuse 21572*;

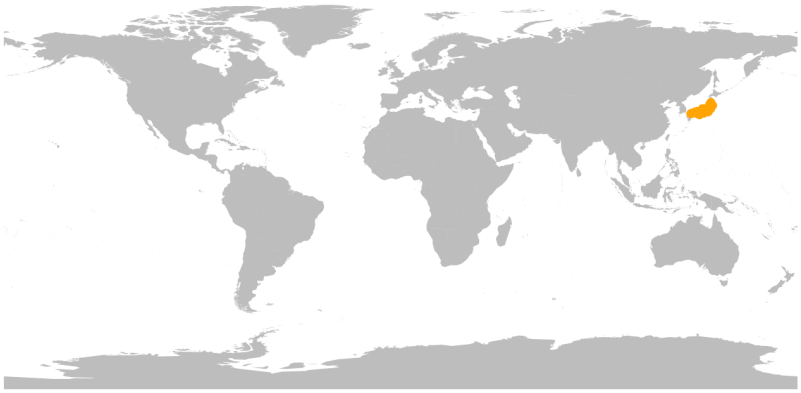

Fig. 35. Distribution of *Malus tschonoskii* (Maxim.) C.K.Schneid.

Fig. 36. Morphological characters of *Malus tschonoskii* (Maxim.) C.K.Schneid.; QIN05066, P03240531, P03240532, P03240533, P03240534, P03240535 (isolectotype), KUN0662716, KUN0760817, KUN0867804. Scale bars = 10 mm.

PE • ibid.; 3 May 1963; fr; *G. Murata 18042*; P, PE • Settsu; 18 Jun. 1961; fr; *G. Murata 14068*; PE • Saitama; 3 Jun. 1949; st; *Miyoshi Furuse 20634*; PE • Shinano; 3 May 1960; fl; *Miyoshi Furuse 36737*; PE • Shiga; 2 Oct. 1983; st; *Miyoshi Furuse 52215*; PE • Miyagi; 5 May 1987; fl; *H. Hoshi et al. 2240*; HIMC • North of Japan; 1866–1874; fl; *Savatier 3709*; P.

UNITED STATES – **Massachusetts** • Boston; 5 May 1981; fl; *S. Davis et al. 81-299*; PE • ibid.; 5 Sep. 1979; fr; *K. Clausen et al. 79-77*; PE.

Description

Tree, 10–15 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 2.6–3.0 cm long, densely lanuginous. Lamina 5.7–8.7 × 3.6–6.7 cm, oval to ovate, base rounded or cordate, equilateral, apex acuminate or acute, margin crenate to serrulate, blade densely pubescent on midvein and young leaf, occasionally lobed. Inflorescence corymbose, with 2–5 flowers. Pedicel ca 1.9 cm long, densely lanuginous. Hypanthium densely lanuginous. Sepals triangular, puberulous, persistent. Petals ca 1.2 × 0.7 cm, white, obovate. Stamens 20–30, unequal. Styles 5, as long as or shorter than stamens, basally puberulous. Pome ca 1.8–2.1 cm in diameter, subglobose, yellow to red. Carpopodium ca 2.7 cm long, lanuginous.

Phenology

Flowers from April to May. Mature fruits from October to November.

Habitat

Terrestrial, seasonally green, growing in foothill forests; sea level to 1000 m a.s.l.

Distribution

Japan (Fig. 35).

Chromosome number

2n = 34.

15. ***Malus honanensis*** Rehder
Figs 37–38

Journal of the Arnold Arboretum 2 (1): 51 (Rehder 1920).

Sinomalus honanensis (Rehder) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4): 196 (Koidzumi 1934b). –*Pyrus honanensis* (Rehder) M.F.Fay & Christenh., *Plant Gateway's The Global Flora*: *A Practical Flora to Vascular Plant Species of the World. Vol. 4*: 107 (Christenhusz *et al.* 2018). – **Type**: CHINA • Henan, Song Xian, Shi-zi-miao (Shih Tze Miao); 26 May 1919; fl; *J. Hers 489*; type: A[A00026648]!

Examined specimens

CHINA – **Beijing** • Haidian; 21 Aug. 1962; fr; *Guoren 16*; PE • ibid.; 5 May 1962; fl; *Renguo 66*; PE. – **Gansu** • Heshui; 7 Sep. 1990; st; *L.P. Liu 77*; QYTC • Zhengning; 18 May 1991; fl; *L.P. Liu 910029*; QYTC • Zhongwan; 15 May 1985; fl; *L.P. Liu 151*; QYTC • Wenxian; 9 May 2007; fl; *Baishuicaiji Team 4570*; PE • Wushan; 19 May 1956; fl; *Anonymous 00039*; PE • Dangchang; 7 Aug. 1951; fr; *Z.B. Wang 14743*; PE • Kangxian; 16 Jul. 1963; fr; *Z.Y. Zhang 16893*; PE. – **Guizhou** • YinKiang; 8 Aug. 1931; fr; *Anonymous 51519*; IBK. – **Hebei** • Shexian; 23 May 1979; fl; *Anonymous 20842*; BNU • ibid.; 15 Jun. 1958; st; *K.J. Guan 5455*; PE • ibid.; 23 Jun. 1958; fr; *K.J. Guan 5585*; PE • Wuan; 13 Sep. 1979;

fr; *Anonymous 21282*; BNU • ibid.; 17 May 1973; fl; *K.J. Guan et al. 47*; PE • ibid.; 17 Jul. 1972; fr; *WU225*; PE • ibid.; 17 Jul. 1972; fr; *WU227*; PE • Cixian; 22 Jul. 1935; fr; *H.F. Zhou* 43276; PE. – **Henan** • Lushi; 11 May 1975; fl; *Y.H. Guo 426*; IBSC • ibid.; 4 Jul. 2005; fr; *M. Liu H20195*; PE • ibid.; 14 Jul. 1935; fr; *K.M. Liou 4761*; PE • Xinyang; Jun. 1959; fl; *X.H. Wang 347*; HENU • ibid.; 3 May 1959; fr; *X.H. Wang 342*; HENU • Neixiang; 25 Aug. 1982; fr; *Institute of Henan Biology Botanical Expedition 056*; PE • Luanchuan; 1959; fr; *Puchabiaoben 21104*; PE • Tiantanshan; Jul. 1997; fr; *Z.H. Xin 049*; HENU • Shaoyuan; Jul. 1995; fr; *X.M. Fan 0010*; HENU • Nanyang; Aug. 1959; fr; *S.Y. Wang 13*; HENU • Songshan; 24 Apr. 1921; fl, fr; *J. Hers 195*; AU. – **Hunan** • Hupingshan; May 1981; fl; *Y.C. Fang & X.P. Wang 051*; NYA • ibid.; 8 Jun. 1987; st; *C.L. Long 87413*; CSFI. – **Qinghai** • Xining; 24 May 1990; st; *Z.H. Zhang et al. 5691*; HNWP. – **Shanxi** • Lingchuan; 26 Jul. 1980; fr; *S.Y. Bao & S.J. Yan 373*; HSIB • ibid.; 7 Jul. 1980; fr; *S.Y. Bao & S.J. Yan 54*; HSIB • Qinyuan; 20 Sep. 2002; fr; *K. Bachtell et al. 043*; PE • Yuanqu; 19 May 1960; fl; *X.Y. Liu & F. Zhao 20078*; PE • Yangcheng; 3 Jun. 1982; fr; *T.W. Liu & S.B. Zeng 270*; HSIB • Yucheng; 14 May 1957; st; *Fenhe Team 226*; IBK. – **Shaanxi** • Zhouzhi; 2 Aug. 2016; fr; *Qinling Botanical Expedition-Team 354*; NAS • Taibai; 23 Jun. 1958; st; *58-Qinling Team 10064*; PE • Taibai; 6 May 1939; fl; *K.T. Fu 2612*; IBK • ibid.; 26 Jun. 1958; st; *Z.P. Wei 935*; HHBG. – **Sichuan** • Nanchong; 12 Jun. 1972; fr; *Pucha Team 72N-936*; SM • Daxian; 23 Aug. 1978; fr; *Tongjiangpucha Team 1031*; SM • Nanping; 26 May 1979; fr; *Pucha Team 0254*; SM • Zhaojue; 10 May 1979; fr; *Zhaopu Team 0258*; SM • Jinyang; 9 May 1959; st; *Southwest Normal University Department of Biology 02569*; SM.

Description

Small tree or shrub, 5–7 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.9 cm long, densely lanuginous. Lamina ca 6.4 × 4.6 cm, usually oval, sometimes elliptical, base rounded, truncate or cordate, equilateral, apex acute or obtuse, margin crenate to serrulate, blade lanuginous, densely pubescent on midvein, usually 3–6-lobed. Inflorescence corymbose, with 5–10 flowers. Pedicel ca 2.0 cm long, pubescent when young, glabrescent. Hypanthium puberulous. Sepals triangular, abaxially glabrous, adaxially densely puberulous, persistent. Petals ca 0.8 × 0.7 cm, white, obovate. Stamens ca 20, unequal. Styles 3 or 4, longer than stamens, glabrous. Pome ca 0.8 cm in diameter, subglobose, yellow to red, with white fruit spots. Carpopodium ca 2.4 cm long, glabrous.

Phenology

Flowers in May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in forests on slopes or in valleys; 800–1000 m a.s.l.

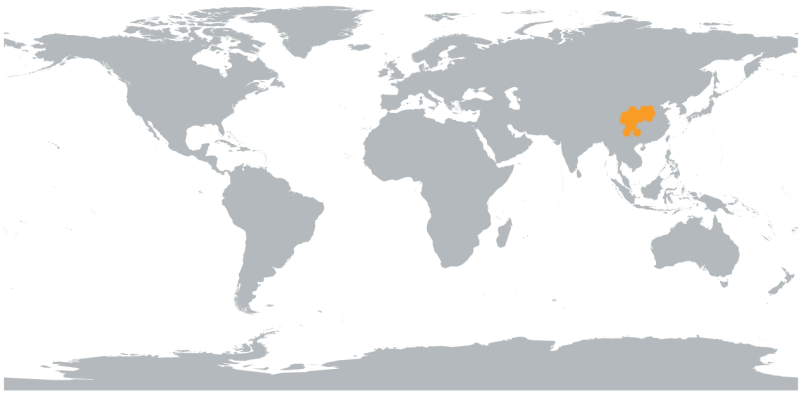

Fig. 37. Distribution of *Malus honanensis* Rehder.

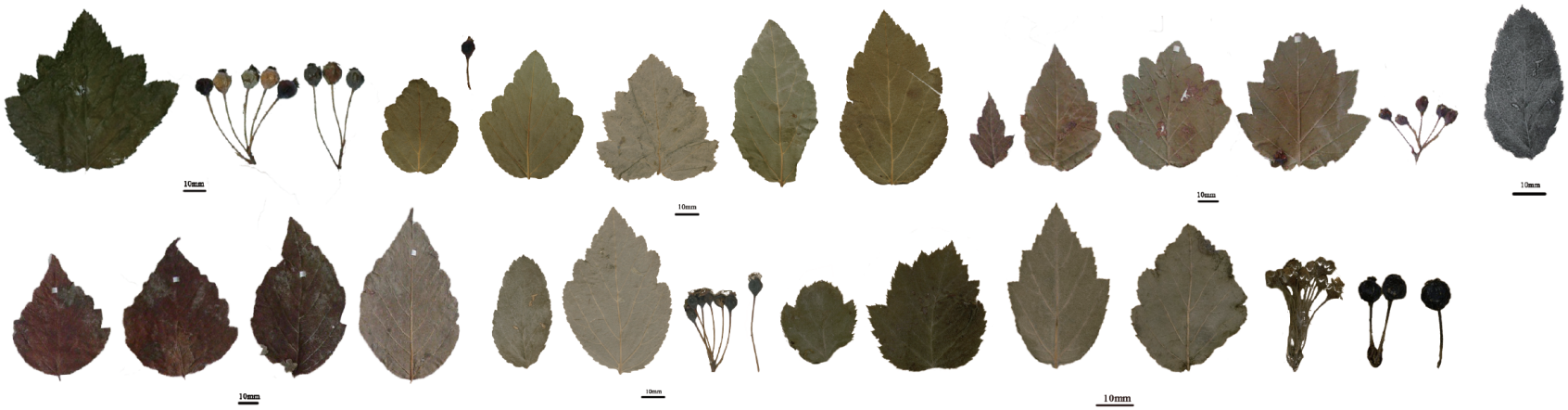

Fig. 38. Morphological characters of *Malus honanensis* Rehder; A00026648/K000758432, QIN05070, K000758433, P03144438, PE00927715, PE00927742, HENU1008050. Scale bars = 10 mm.

Distribution

China (Gansu, Guizhou, Hebei, Henan, Hunan, Shanxi, Shaanxi, Sichuan) (Fig. 37).

Chromosome number

2n = 34.

16. ***Malus kansuensis*** (Batalin) C.K.Schneid.
Figs 39–40

Repertorium Novarum Specierum Regni Vegetabilis 3: 178 (Schneider 1906a).

Pyrus kansuensis Batalin, *Trudy imperatorskago S.-Peterburgskago botanicheskago Sada* 13 (1): 94 (Batalin 1893). – *Eriolobus kansuensis* C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 726 (Schneider 1906b). – **Type**: CHINA • Sichuan, septentrianale vallis fl. Honton; 12 Aug. 1885; fr; *Potanin s.n.*; lectotype: LE, designated by Langenfeld 1991: 137; isolectotype: K[K000758428]!, PE[PE00020669]!

Malus kansuensis f. *calva* Rehder, *Journal of the Arnold Arboretum* 2 (1): 50 (Rehder 1920), syn. nov. – *Malus kansuensis* var. *calva* (Rehder) T.C.Ku & Spongberg, *Flora of China* 9: 186 (Ku & Spongberg 2003). **– Type**: CHINA • Hubei, Fang Xian; alt. 2300 m (7000 ft); 28 May 1907; fl; *E.H. Wilson 264*; type: A[A00026651]!, K[K000758430]!

Malus komarovii var. *funiushanensis* S.Y.Wang, *Flora Henanensis Vol. 2*: 201, fig. 994 (Wang 1988). **– Type**: CHINA • Henan, Luanchuan, Laojunshan; *Anonymous 14080*; type: HNAC.

Examined specimens

CHINA – **Anhui** • Huangshan; 8 Aug. 1936; fr; *P.C. Tsoong s.n.*; PE. – **Chongqing** • Chengkou; 4 Apr. 1960; fl; *Dabashan workgroup 00759*; CDBI • ibid.; 20 Jul. 1958; fr; *T.L. Dai 101347*; CDBI, IBK • ibid.; 1 Jul. 2004; fr; *Y. S. Chen et al. 640*; WUK • Wuxi; 1 Jun. 1962; fl; *B.C. Ni Ni000268*; CDBI • ibid.; 25 Aug. 1989; fr; *Y.D. Chen et al. 2441*; PE • ibid.; 16 Sep. 1958; fr; *G.H. Yang 58523*; PE • Wushan; 26 May 1989; fl; *L.Q. Chen Chuanhua-245*; CCAU. – **Gansu** • Zhouqu; 19 Sep. 1958; fr; *Y.Q. He 645*; PE • ibid.; 17 Jul. 1998; fr; *Bailongjiang Expedition Team 243*; PE • Tianshui; 19 Sep. 1951; fr; *J.M. Liu 10586*; PE • ibid.; 21 May 1963; fl; *Q.X. Li 207*; PE • Between Yaruku, Yarugomba and Lupassu; Aug. 1925; *J.F. Rock 131172*; IBSC • Huicheng; 13 Sep. 1958; fr; *Z.Y. Zhang 782*; IBSC, HIB, NAS • Lintan; 11 Jul. 1957; fl; *Taohe Team 3347*; IBK, IBSC, KUN • Wenxian; 21 May 2007; fl; *D.E. Boufford*

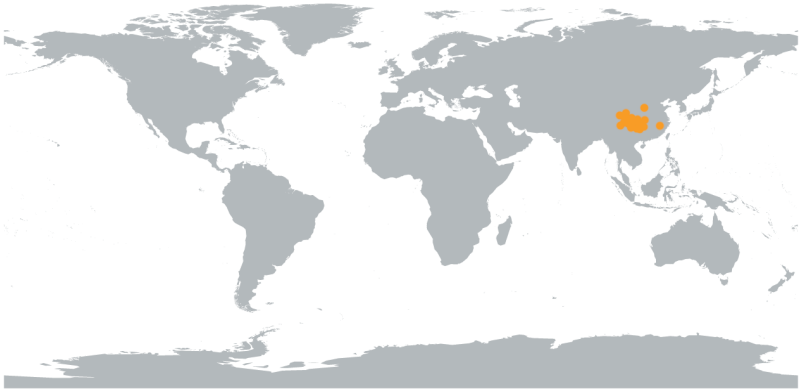

Fig. 39. Distribution of *Malus kansuensis* (Batalin) C.K.Schneid.

Fig. 40. Morphological characters of *Malus kansuensis* (Batalin) C.K.Schneid.; K000758427, K000758428 (isolectotype), PE00020669 (isolectotype), QIN05062, QIN05063, KUN0662441, P03144405, P03144408, A00026651 (type of *Malus kansuensis* var. *calva* (Rehder) T.C.Ku & Spongberg), K000758430 (type of *M. kansuensis* var. *calva*). Scale bars = 10 mm.

et al. 37822; PE • ibid.; 16 May 2007; fl; *D.E. Boufford et al. 37822*; PE • Ling Tan Shen; 19 Sep. 2005; fr; *A. Aiello et al. 019*; PE. – **Henan** • Lingbao; 7 Aug. 2014; fr; *J.M. Li et al. 140807133*; HEAC • ibid.; 1959; fr; *Puchabiaoben 14082*; PE • Lushi; 9 Jul. 1959; fr; *Anonymous 34485*; PE • Songxian; 14 Sep. 1960; fr; *K.J. Guan & T.L. Dai 2605*; PE • Xixia; 18 Jul. 1960; st; *K.J. Guan & T.L. Dai 1204*; PE • ibid.; 2 Jun. 1959; st; *Anonymous 705*; PE. – **Hubei** • Shennongjia; 19 Jun. 1976; fr; *E-Shennongjia Botanical Expedition 10427*; PE, HIB • ibid.; 9 Sep. 1980; fr; *1980-Sino-American Botanical Expedition 893*; NAS • ibid.; 27 Aug. 1980; fr; *1980-Sino-American Botanical Expedition 397*; NAS • Badong; 24 Jul. 1957; fl; *G.X. Fu & Z.S. Zhang 1049*; PE • ibid.; 24 Jul. 1957; fr; *M.X. Nie & Q.H. Li 1049*; LBG. – **Hunan** • Qianyang; 7 May 1959; fr; *P.X. Tan 60537*; IBSC. – **Jiangxi** • Shangyouxian; 20 Aug. 1971; fr; *Jiangxi Team 552*; PE • Suichang; 14 May 1970; fr; *236 renwuzu 758*; PE. – **Ningxia**: Liupanshan; 28 Jul. 2012; fr; *BNU LPS116*; BNU • Longde; 10 Jul. 1942; fr; *Z.B. Wang 13102*; PE. – **Qinghai** • Xunhua; 6 Jun. 1981; fl; *B.Z. Guo & W.Y. Wang 2506*; HNWP • ibid.; 1 Jun. 2004; fl; *Y.H. Wu 28184*; HNWP. – **Shanxi** • Xingxian; 31 Aug. 1955; st; *Yellow-River Expedition second Team 2194*; PE. – **Shaanxi** • Langao; 12 Jun. 2005; fr; *Y.S. Chen et al. 2466*; WUK • ibid.; 28 Jun. 2004; fr; *Y.S. Chen et al. 425*; WUK • Pingli; 22 Jun. 2005; fr; *Y.S. Chen et al. 2941*; WUK • Nangao; 20 Jul. 1958; fr; *T.L. Dai 101347*; PE, SZ. – **Sichuan** • Kangding; 30 May 1930; st; *Z.P. Huang 1142*; IBSC • ibid.; 21 May 1953; fl; *X.L. Jiang 35649*; IBK • Pingwu; 31 Jul. 1958; fr; *H.L. Tsiang* 10940; IBSC • Maerkang; 27 Aug. 1957; fl; *X. Li 72299*; PE • ibid.; 13 Sep. 2004; fr; *C.S. Chang et al. SI0388*; PE. – **Tibet** • Lhasa; 4 Aug. 1970; fr; *B.Z. Guo et al. 22270*; NAS.

Description

Small tree or shrub, 3–8 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.9–2.6 cm long, pubescent when young, puberulous or glabrescent. Lamina ca 4.9–5.4 × 3.6–3.9 cm, oval to ovate, base rounded, truncate or cordate, equilateral, apex acute or acuminate, margin crenate to serrulate, blade puberulous or glabrous, usually 3-lobed. Inflorescence corymbose, with 4–10 flowers. Pedicel ca 2.2–2.9 cm long, glabrous or pubescent when young then glabrescent. Hypanthium puberulous or glabrous. Sepals triangular, abaxially glabrous, adaxially puberulous, caducous. Petals ca 0.7 × 0.5 cm, white, obovate. Stamens ca 20, unequal. Styles 3, rarely 2 or 4, longer than stamens, glabrous or puberulous. Pome ca 1.0–1.5 cm in diameter, ellipsoidal, yellow to red, with fruit spots. Carpopodium ca 2.6–3.6 cm long, glabrous or puberulous.

Phenology

Flowers from May to June. Mature fruits from July to August.

Habitat

Terrestrial, seasonally green, growing in mixed forests or shrubs; 1500–3300 m a.s.l.

Distribution

China (Anhui, Chongqing, Gansu, Henan, Hubei, Hunan, Jiangxi, Ningxia, Qinghai, Shanxi, Shaanxi, Sichuan, Tibet) (Fig. 39).

Chromosome number

2n = 34.

17. ***Malus prattii*** (Hemsl.) C.K.Schneid.
Figs 41–42

Illustriertes Handbuch der Laubholzkunde Vol. 1: 719 (Schneider 1906b).

Pyrus prattii Hemsl., *Bulletin of Miscellaneous Information, Royal Gardens, Kew* 1895 (97): 16 (Hemsley 1895). – *Docyniopsis prattii* (Hemsl.) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4):

196 (Koidzumi 1934b). – **Type**: CHINA • Sichuan, west Szechuen and Tibetan frontier, chiefly near Tachienlu; alt. 9000–13 000 ft; Dec. 1890; *A.E. Pratt 93*; lectotype: K[K000758434]!, **here designated**; isolectotype: P[P01819343]!

Malus baoshanensis G.T.Deng, *Journal of Sichuan Agricultural University* 9 (1): 47 (Deng *et al.* 1991). – **Type**: CHINA • Yunnan, Baoshan, Shabaxiang, Lijiasi; 29 May 1990; fl; *G.T. Deng 9002*; type: SAU.

Malus prattii var. *glabrata* G.Z.Qian, *Bulletn of Botanical Research* 25 (2): 132 (Qian & Tang 2005). – **Type**: CHINA • Sichuan, Baoxing, Daqiangpeng; alt. 2750 m; 14 Apr. 1983; fl; *X.S. Zhang & Y.X. Ren 5385*; holotype: CDBI[CDBI10043762]!; isotype: CDBI[CDBI10043763, CDBI10043764, CDBI10043765]!, PE[00953187]!, SZ[00203448]!, SAU.

Examined specimens

CHINA – **Chongqing** • Nanchuan; 1 Oct. 1957; fr; *J.H. Xiong & Z.L. Zhou 93784*; PE • ibid.; 29 Sep. 1957; fr; *J.H. Xiong & Z.L. Zhou 93722*; PE • ibid.; 9 Jul. 1957; fr; *G.F. Li 62561*; NAS, PE, IBSC, SZ. – **Guizhou** • Fan-tsing Shan; 9 Aug. 1931; fr; *S.S. Sin 51519*; IBSC • Songtao; 7 Jul.1959; fr; *Qianbei Team 1357*; SHM. – **Sichuan** • Luding; 12 Aug. 2010; fr; *J.I. Jeon et al. SI1473*; PE • ibid.; 21 Jun. 1980; fr; *Z.A. Liu 22579*; IBSC • Tianquan; 29 Aug. 1963; fr; *Chuangxi Team* (*K.J. Guan & W.C. Wang et al.*) *2105*; PE • ibid.; 15 jun. 1959; fr; *Chuanjingzhi-Sichuan College of Agriculture Botany (58) 00990*; PE • ibid.; 4 Aug. 1982; fr; *D.Y. Peng 45926*; IBSC • ibid.; 19 Sep. 1953; fr; *X.L. Jiang 37826*; IBK • Mianning; 20 Jul. 1959; fr; *S.G. Wu 2043*; PE • Shimian; 1955; fr; *C.J. Xie 41965*; IBSC • ibid.; 1955; fr; *C.J. Xie 42054*; PE • Emeishan; 1 Jul. 1952; fr; *J.H. Xiong, X.S. Zhang & X.L. Jiang 31408*; IBK • ibid.; 6 Aug. 1957; fr; *G.H. Yang 56463*; PE, SZ • ibid.; 27 Aug. 1935; fr; *T.H. Tu 683*; PE • Baoxing; 1 Jun. 1958; fl; *Sichuan College of Agriculture 5385*; CDBI • Ebian, 13 Oct. 1939; fr; *T.N. Liou & C. Wang 1420*; PE • Yaan; 19 Aug. 1978; fr; *Lushan Team 78-0768*; SM • Congzhou; 30 Jul. 2015; fr; *W.B. Ju et al. AZH00382*; CDBI. – **Yunnan** • Weixi; 11 May 1982; fl, fr; *Qingzang Team 6444*; PE • ibid.; 20 May 1940; fl, fr; *K.M. Feng 4041*; PE • ibid.; Aug. 1935; fr; *Q.W. Wang 68174*; PE • ibid.; Jun. 1935; fl, fr; *W.Q. Wu 64070*; PE.

Description

Tree, 8–10 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.9–2.3 cm long, puberulous or glabrous. Lamina ca 8.0–9.1 × 4.3–5.1 cm, oval to oblong, base rounded or truncate, equilateral, apex acuminate, margin crenate to serrulate, blade puberulous or glabrous. Inflorescence corymbose, with 5–8 flowers. Pedicel ca 2.2 cm long, glabrous or puberulous Hypanthium puberulous or glabrous. Sepals triangular, abaxially glabrous, adaxially puberulous, persistent or caducous. Petals ca 0.6 × 0.4 cm, white, orbicular. Stamens ca 20, unequal. Styles 5, rarely 4, as long as stamens,

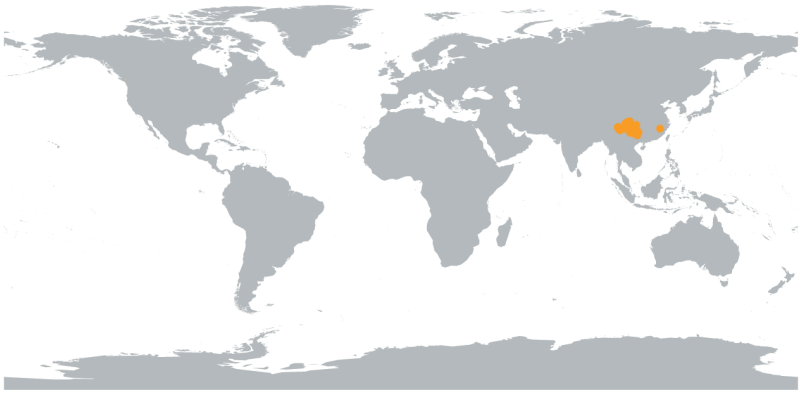

Fig. 41. Distribution of *Malus prattii* (Hemsl.) C.K.Schneid.

Fig. 42. Morphological characters of *Malus prattii* (Hemsl.) C.K.Schneid.; GH00032502 (isolectotype of *Pyrus prattii* Hemsl.), K000758434 (lectotype), QIN05038, P01819339, P01819343 (isolectotype), PE00953094, HHBG-HZ016028. Scale bars = 10 mm.

glabrous. Pome ca 1.0–1.5 cm in diameter, ellipsoidal, yellow to red, with fruit spots. Carpopodium ca 2.6 cm long, glabrous.

Phenology

Flowers in June. Mature fruits in August.

Habitat

Terrestrial, seasonally green, growing in mixed forests; 1400–3500 m a.s.l.

Distribution

China (Chongqing, Guizhou, Sichuan, Yunnan, Zhejiang) (Fig. 41).

Chromosome number

2n = 34.

18. ***Malus yunnanensis*** (Franch.) C.K.Schneid.
Figs 43–44

Repertorium Novarum Specierum Regni Vegetabilis 3: 179 (Schneider 1906a).

Pyrus yunnanensis Franch., *Plantae Delavayanae*: 228 (Franchet 1890). – *Eriolobus yunnanensis* (Franch.) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 727 (Schneider 1906b). – *Cormus yunnanensis* (Franch.) Koidz., *Journal of the College of Science, Imperial University of Tokyo* 34 (Art. 2): 75 (Koidzumi 1913). – *Macromeles yunnanensis* Koidz., *Florae Symbolae Orientali-Asiaticae*: 53 (Koidzumi 1930). – *Docyniopsis yunnanensis* (Franch.) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4): 196 (Koidzumi 1934b). – **Type**: CHINA • Yunnan, LanKong, woods at the Hee-chan-men; alt. 2800 m; 22 May 1886; fl; *J.M. Delavay 2331*; holotype: P[P01819335]!; isotype: K[K000758438, K000758439, K000758440]!, P[P01819336, P01819337, P01819338]!, W[W1962-0013366]!

Pyrus veitchiana hort., *The Gardeners' Chronicle, Ser. 3* 52: 288 (Royal Horticultural Society 1912), nom. nud. – **Type**: CHINA • Sichuan, locality unknown; seeds from China by E.H. Wilson (no. 539), cultivated in Coombe Wood Nursery; 30 Sept. 1912; fr; *Wilson 539*; lectotype: K[K000758472]!, **here designated**; isotype: A[A00106227]!

Pyrus yunnanensis var. *veitchii* Osborn, *The Gardeners' Chronicle, Ser. 3* 78: 227 (Osborn 1925). – *Malus yunnanensis* var. *veitchii* (Osborn) Rehder, *Journal of the Arnold Arboretum* 4 (2): 115 (Rehder 1923). – **Type**: CHINA • Chongqing, Wushan; 26 May 1914; fl; *A. Henry 5638*; lectotype: A[A00026642]! **here designated**; isotype: GH[GH00026663]!

Examined specimens

CHINA – **Chongqing** • Nanchuan; 19 Jul. 1978; fr; *Botanical Geographic Expedition 548*; PE • ibid.; 30 May 1928; fr; *W.P. Fang 1138*; IBSC • ibid.; 26 May 1957; fl; *J.H. Xiong & Z.L. Zhou 90988*; IBSC • ibid.; 4 Jul. 1964; fr; *K.J. Guan, J.W. Wang & C.L. Li 1070*; PE • Wuxi; 7 Oct. 1988; fr; *Y.D. Chen, L.Z. Fu & X.T. Ma 2211*; PE • ibid.; 27 Aug. 1958; *G.H. Yang 59373*; NAS • Chengkou; 25 May 1958; fl; *T.L. Dai 100618*; IBK • ibid.; 31 Jul. 2006; fr; *Y.S. Chen et al. 4680*; WUK • Fuling; 9 Aug. 1962; fr; *Pucha Team 96403*; SM. – **Gansu** • Kangxian; 15 Sep. 1963; fr; *J.Q. Xing 20219*; XBGH • Zhouqu; 17 Sep. 1958; fr; *Z.P. Wei 2489*; HHBG • Wudu; 1 May 1959; fl; *Z.Y. Zhang 1103*; LBG • ibid.; 18 Jun. 1959; fr; *Z.Y. Zhang 5127*; LBG. – **Guizhou** • Songtao; 9 Oct. 1976; fr; *Schneid 135*; HGAS • Yinjiang; 6 Aug. 1963; fr; *C.P. Jian et al. 30532*; PE • ibid.; 5 Oct. 1963; fr; *C.P. Jian et al. 32124*; PE • Jiangkou;

23 Jun. 1988; fr; *Wulingshan Expedition 743*; PE. – **Hubei** • Shennongjia; 19 Sep. 1980; fr; *1980-Sino-American Botanical Expedition 1556*; PE • ibid.; 3 Aug. 1985; fr; *S.X. Yang 475*; IBK • ibid.; 19 Jul. 2011; fr; *D.G. Zhang Zdg2044*; KUN • Hefeng; 8 Aug. 1988; fr; *Y.M. Wang 5803*; PE • Badong; 19 Jul. 1957; *G.X. Fu & Z.S. Zhang 847*; PE. – **Hunan** • Dayong; 18 Jul. 1985; fr; *K.W. Liu 33404*; CSFI • Tianmenshan; 22 Sep. 2007; fr; *F.C. Wu & B.R. Liao SCSB-07102*; KUN • Shimen; 20 Aug. 1987; *Hupingshan Expedition A110*; PE • ibid.; 13 Jul. 1987; fr; *Hupingshan Expedition 1457*; PE. – **Shanxi** • Puxian; 21 Sep. 1934; fr; *T.P. Wang 3780*; IBSC. – **Shaanxi** • Zhenan; 30 May 1973; fl; *X.X. Hou 611*; IBSC • Ziyang; 19 Aug. 1966; fr; *Shaanxi-Qin Expedition 257*; XBGH • Langao; 12 Jun. 2005; fr; *Y.S. Chen et al. 2464*; WUK • Pingli; 27 Jul. 2006; fr; *Y.S. Chen et al. 4403*; WUK. – **Sichuan** • Baoxing; 6 Sep. 1963; fr; *Chuanxi Team 3006*; PE • Muli; 2 Jul. 1978; fr; *Q.S. Zhao 6261*; CDBI • ibid.; 27 May 1937; fr; *T.T. Yu 5780*; PE • Yanyuan; 30 Jul. 1983; fr; *Qingzang Team 12609*; PE • Wenchuan; 28 Aug. 1982; fr; *K.Y. Lang, L.Q. Li & Y. Fei 1339*; PE • Tianquan; 1 May 1956; fl; *H.P. He 43633*; CDBI. – **Tibet** • Chayu; Aug. 1935; st; *Q.W. Wang 65519*; PE, LBG • ibid.; 11 Aug. 1973; st; *J.W. Zhang 1023*; PE • ibid.; 23 Jun. 1982; fl; *Z.J. Ren Ren721*; PE • Milin; 24 Sep. 1974; st; *Anonymous 3402*; PE. – **Yunnan** • Lijiang; 4 Aug. 1981; fr; *Institute of Beijing Hengduanshan Team 02609*; PE • Deqin; 23 Nov. 1940; fr; *K.M. Feng 8854*; PE • Yun-ning; 1 May 1937; fl; *T.T. Yu 5223*; PE • Shangrila; 22 May 1939; fl; *K.M. Feng 972*; PE • Jianchuan; Jul. 1923; fl; *G. Forrest 23482*; PE • Heqing; May 1913; fl; *G. Forrest 10019*; PE • Yulong; 21 Sep. 2015; fr; *J.D. Ya & C. Liu 15CS11203*; KUN.

Description

Tree, 8–13 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 2.0–2.5 cm long, puberulous. Lamina ca 6.0–9.5 × 3.6–5.8 cm, oval to oblong, base cordate, rounded or truncate, equilateral, apex acuminate, acute or obtuse, margin crenate to serrulate, blade abaxially pubescent, usually 3–5-lobed. Inflorescence corymbose, with 8–12 flowers. Pedicel ca 1.8 cm long, glabrous or puberulous. Hypanthium densely puberulous. Sepals triangular, puberulous, persistent. Petals ca 0.6 × 0.4 cm, white, orbicular. Stamens 20–25, unequal. Styles 5, glabrous. Pome ca 1.0–1.5 cm in diameter, subglobose, oblate or oval, red, with white fruit spots. Carpopodium ca 2.3–2.8 cm long, puberulous.

Phenology

Flowers in May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in mixed forests; 1600–3800 m a.s.l.

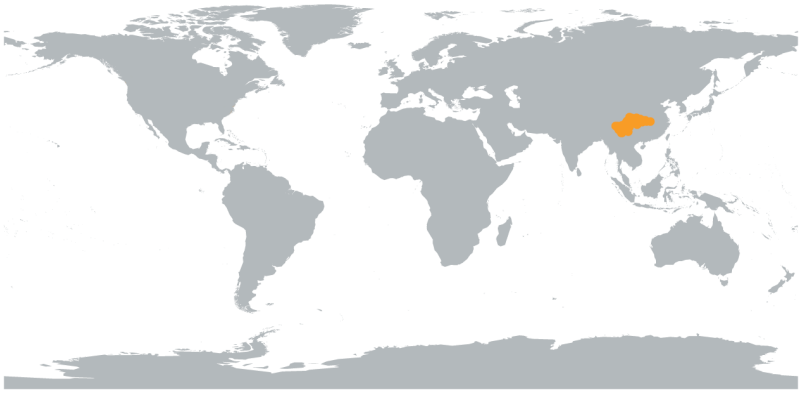

Fig. 43. Distribution of *Malus yunnanensis* (Franch.) C.K.Schneid.

Fig. 44. Morphological characters of *Malus yunnanensis* (Franch.) C.K.Schneid.; GH00032511 (type of *Pyrus yunnanensis* Franch.), K000758438 (isotype), K000758439 (isotype), QIN05064 (type), QIN05065 (K000758437, type), P01819336 (isotype), P03240538, P03240541, P03240542, A00026642 (lectotype of *Malus yunnanensis* var. *veitchii* (Osborn) Rehder), A00106227 (isotype of *M. yunnanensis* var. *veitchii*), CDBI0043927 (*M. yunnanensis* var. *veitchii*), K000758472 (lectotype of *Pyrus veitchiana* hort.), PE00964185 (*M. yunnanensis* var. *veitchii*), PE00964192 (*M. yunnanensis* var. *veitchii*), PE00997404 (*M. yunnanensis* var. *veitchii*), PE01357615 (*M. yunnanensis* var. *veitchii*), PE01357619 (*M. yunnanensis* var. *veitchii*). Scale bars = 10 mm.

Distribution

China (Chongqing, Gansu, Guizhou, Hubei, Hunan, Shanxi, Shaanxi, Sichuan, Tibet, Yunnan) (Fig. 43).

Chromosome number

2n = 34.

Note

Because the syntype specimens *J.M. Delavay 2331* of *M. yunnanensis* still exist, the neotype *Handel–Mazzetti 842* designated by Langenfeld (1991: 133) is invalid.

19. ***Malus ombrophila*** Hand.-Mazz.
Figs 45–46

Anzeiger der Akademie der Wissenschaften in Wien, Mathematische-naturwissenschaftliche Klasse 63: 1, 8 (Handel-Mazzetti 1926).

Pyrus ombrophila (Hand.-Mazz.) M.F.Fay & Christenh., *Plant Gateway's The Global Flora*: *A Practical Flora to Vascular Plant Species of the World. Vol. 4*: 114 (Christenhusz *et al.* 2018). – **Type**: CHINA • Yunnan, toward the end of the Tibeto-Birman river Nu Jiang (Salween) and Dulong Jiang (Djioudjiang), in the warm temperate valley Tjiontson-lumba below Tschamutong; alt. 2250–2650 m; 28 Jun. 1916; fr; *Handel-Mazzetti 9119*; holotype: WU[WU0059445]!

Examined specimens

CHINA – **Beijing** • Haidian; 20 Apr. 1962; fl; *Renguo 67*; PE • ibid.; 28 Aug. 1962; fr; *Renguo 54*; PE. – **Chongqing** • Chengkou; 23 Sep. 1958; fr; *T.L. Dai 106040*; PE. – **Sichuan** • Yanyuan; 9 May 1960; fl; *S. Jiang et al. 5644*; PE • Meigu; 21 Aug. 1959; fr; *Chuanjingzhi 1913*; PE • ibid.; 22 Oct. 1993; fr; *Z.J. Ren 3921*; PE • Luding; 22 Sep. 1953; fr; *X.L. Jiang 37915*; IBK • Leibo; 12 Aug. 1972; fr; *236Renwuzu 0688*; PE • Emeishan; 25 Jul. 1997; fr; *G.Z. Li 15518*; PE • Tah-liang-shan; 1 Sep. 1934; fr; *T.T. Yu 3955*; PE. – **Tibet** • Bomi; 3 Sept 1980; fr; *Ecology Department Plateau Group 14870*; PE • ibid.; 26 Sep. 2009; st; *C.R. Zaxi & L. Xi ZhongY730*; KUN • Motuo; 1 Sep. 1980; fr; *W.L. Chen 14591*; PE • Chayu; 7 Oct. 2007; fr; *Z.D. Fang, G. He & Q.E. Yang XZ-684*; SABG • Milin; 9 Aug. 2012; fr; *Yarlung Zangbo Expedition Team 783*; BJM. – **Yunnan** • Gongshan; 31 Aug. 1940; fr; *K.M. Feng 7209*; PE • ibid.; 25 Jun. 1982; fl, fr; *Qingzang Team 7531*; PE • ibid.; 8 May 2018; fl; *H.B. bai & X. He 533324180508128LY*; SABG • Weixi; 19 Jul. 1981; fr; *Institute of Beijing Hengduanshan Team 01693*; PE • ibid.; Aug. 1935;

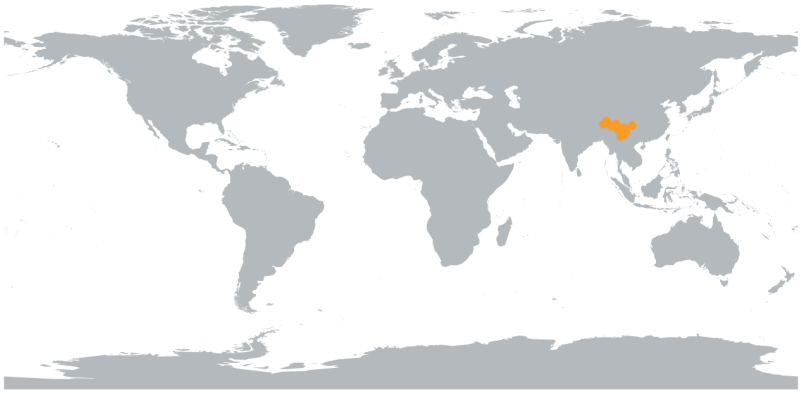

Fig. 45. Distribution of *Malus ombrophila* Hand.-Mazz.

Fig. 46. Morphological characters of *Malus ombrophila* Hand.-Mazz.; WU0059445 (holotype), KUN0662459, PE00953040, PE00953082, PE01494503. Scale bars = 10 mm.

fr; *C.W. Wang 68690*; PE, NAS • ibid.; 13 Jun. 1940; fl; *K.M. Feng 4515*; PE • Lijiang; 7 Nov. 1955; fr; *K.M. Feng 21656*; PE • Kiukiang; 3 Aug. 1937; fr; *T.T. Yu 19595*; PE • Deqin; 16 Jul. 1940; fr; *K.M. Feng 5433*; PE • ibid.; 7 Jun. 1937; fl; *T.T. Yu 8521*; PE.

Description

Tree, 10–15 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 2.1–3.0 cm long, puberulous. Lamina ca 8.1–8.8 × 4.0–4.8 cm, oval to oblong, base cordate, rounded or truncate, equilateral, apex acuminate, acute or obtuse, margin serrulate, blade abaxially villous, rarely 3–5-lobed. Inflorescence corymbose, with 4–12 flowers. Pedicel ca 1.7 cm long, puberulous. Hypanthium densely puberulous. Sepals triangular, puberulous, persistent. Petals ca 0.6 × 0.4 cm, white, ovate. Stamens 15–20, unequal. Styles 3–5, glabrous. Pome ca 1.5–2.0 cm in diameter, subglobose, red or yellow, with fruit spots. Carpopodium ca 2.7 cm long, puberulous.

Phenology

Flowers in June. Mature fruits in August.

Habitat

Terrestrial, seasonally green, growing in mixed forests in valleys; 2000–3500 m a.s.l.

Distribution

China (Chongqing, Sichuan, Tibet, Yunnan) (Fig. 45).

Chromosome number

2n = 34.

20. ***Malus angustifolia*** (Aiton) Michx.
Figs 47–48

Flora Boreali-Americana Vol. 1: 292 (Michaux 1803).

Pyrus angustifolia Aiton, *Hortus Kewensis Vol. 2*: 176 (Aiton 1789). – *Pyrus coronaria* var. *angustifolia* (Aiton) Wenz., *Linnaea* 38 (1): 41 (Wenzig 1874). – *Malus coronaria* var. *angustifolia* (Aiton) Ponomar., *Sbornik nauchnykh Trudov po prikladnoi botanike, genetike i selektsii* 146: 9 (Ponomarenko 1992). – *Malus coronaria* var. *angustifolia* (Aiton) Rehder ex Likhonos, *Kul'turnaya Flora SSSR Vol. 14*: 34 (Likhonos 1983), nom. inval. – **Type**: USA • North Carolina, locality unknown; s.d; *Greene s.n.*; neotype: K[K000758465]!, **here designated**.

Pyrus malus var. *sempervirens* Weston, *Botanicus Universalis et Hortulanus 1*: 230 (Weston 1770), nom. nud. – *Malus sempervirens* Desf., *Tableau de l'École de Botanique du Muséum d'Histoire naturelle*: 173 (Desfontaines 1804), nom. nud.

Malus angustifolia f. *pendula* Rehder, *Journal of the Arnold Arboretum* 2 (1): 53 (Rehder 1920). – **Type**: USA • Southeastern US; 25 Jun. 1914; fl; *T.G. Harbison 129*; holotype: A[A00026578]!

Examined specimens

UNITED STATES – **Delaware** • Sussex; 24 Jun. 1943; st; *R. McVaugh 6527*; NY. – **Florida** • Leon; 1843; fl; *M. Rugel s.n.*; K • ibid.; 7 Aug. 1895; fl; *G.V. Nash 2366*; K. – **Georgia** • Lumpkia; 18 May 1982; st; *X.Q. Chen et al. 817*; NAS, PE • Columbia; 1884; st; *Anonymous s.n.*; P[00380801] • ibid.; Apr. 1945; fl; *J.M. Franklin s.n.*; P. – **Maryland** • Carroll; 13 May 1881; fl; *J.D. Smith s.n.*; P • Worcester; 14 May 1926; fl; *C.E. Moldenke 2818*; NY • Prince George's; 7 May 1943; fl; *R. McVaugh 6619*; NY. – **New**

Jersey • Cape May; 9 Aug. 1914; fl; *K.K. Mackenzie 6132*; NY. – **New York** • Ontario; 1 Oct. 1990; st; *Professor Zhen-Long Yan 1041*; PE • Bronx; 24 May 1915; fl; *J. Hartling 29851*; NY. – **North Carolina** • Orange; 8 Jun. 1986; fr; *Y. Gu et al. 0066*; NAS • Buncombe; 27 Apr. 1994; fl; *A.B. Russell 1490*; PE • locality unknown; s.d.; fl; *Greene s.n.*; K[000758465]. – **Pennsylvania** • Allegheny; May 1871; fl; *S.W. Knipe s.n.*; NY. – **South Carolina** • Richland; 18 Jul. 2003; fr; *J.B. Nelson 23934*; W • Oconee; 16 Apr. 1991; fl; *Som with Botany 831 Class 121*; PE. – **Virginia** • Bedford; 26 May 1893; st; *A.H. Curtiss s.n.*; NY. – **locality unknown** • 1832; fl; *Schweinitz s.n.*; K • ibid.; 1833; fl; *Drummond s.n.*; K[000758467].

Description

Small tree or shrub, 2–3 m or 5–7 (10) m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.0–1.2 cm long, puberulous or glabrous. Lamina ca 3.6–4.0 × 1.2–1.7 cm, oval to ovate, base cuneate or rounded, equilateral, apex acute, rounded or obtuse, margin crenate to serrulate, blade glabrous or villus on midvein, sometimes lobed. Inflorescence corymbose, with 5–8 flowers. Pedicel ca 2.2 cm long, glabrous. Hypanthium glabrous. Sepals triangular, abaxially glabrous, adaxially puberulous, persistent. Petals ca 1.1 × 0.6–0.7 cm, pink or white, obovate to oblong. Stamens ca 20, unequal, with pink anther. Styles 5, longer than stamens, pubescent at base. Pome ca 1.0–3.0 cm in diameter, subglobose, yellow. Carpopodium ca 2.4 cm long, glabrous.

Phenology

Flowers from February to May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in the forests and shrubs in open areas of valleys; 10–700 m a.s.l.

Distribution

United States (Fig. 47).

Chromosome numbers

2n = 34, 68.

Note

The specimen K000758465, collected from North Carolina, conforms to the protologues of Aiton (1789: 176) and Michaux (1803: 292). We therefore consider the neotype designated by Langenfeld (1991: 152) to be incorrect.

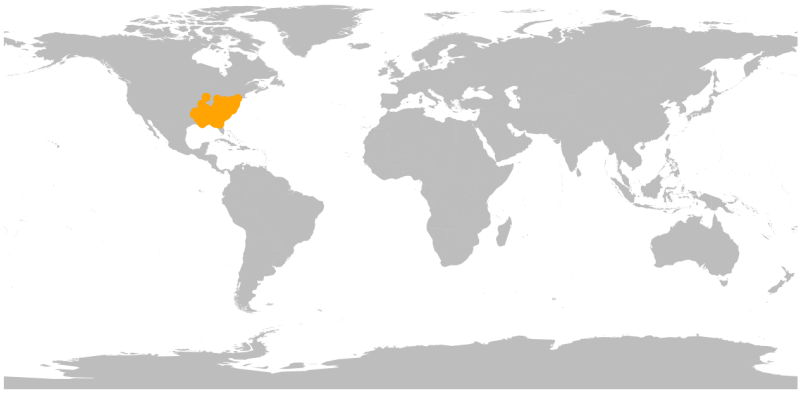

Fig. 47. Distribution of *Malus angustifolia* (Aiton) Michx.

Fig. 48. Morphological characters of *Malus angustifolia* (Aiton) Michx.; A00026578 (holotype of *Malus angustifolia* f. *pendula* Rehder), K000758463/K000758464, K000758465 (neotype), K000758468/K000758469, P03240208, P03240212, NYBG02812600. Scale bars = 10 mm.

21. ***Malus ioensis*** (Alph.Wood) Britton
Figs 49–50

An Illustrated Flora of the Northern United States, Canada and the British possessions Vol. 2: 235, fig. 1980 (Britton & Brown 1897).

Pyrus coronaria β *ioensis* Alph.Wood, *A Class-book of Botany (Ed. 1861)*: 333 (Wood 1861). – *Pyrus ioensis* (Alph.Wood) J.H.Carruth, *Transactions of the Kansas Academy of Science* 5: 48 (Carruth 1877). – *Pyrus ioensis* (Alph.Wood) L.H.Bailey, *American Garden* 12 (8): 473 (Bailey 1891), nom. Carruth 1877. – *Malus coronaria* var. *ioensis* (Alph.Wood) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 724 (Schneider 1906b). – *Malus coronaria* subsp. *ioensis* (Alph.Wood) Likhonos, *Trudy po prikladnoi botanike genetike i selektsii* 52 (3): 24 (Likhonos 1974). – **Type**: USA • Missouri, Daviess, near Pattonsburg, thickets, limestone uplands; 14 Jun. 1924; *E.J. Palmer 25466*; neotype: S, designated by Langenfeld 1991: 153.

Malus ioensis var. *bushii* Rehder, *Trees & Shrubs Vol. 2 (4)*: 232 (Rehder 1913b). – *Pyrus ioensis* var. *bushii* (Rehder) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – **Type**: USA • Missouri, Wayne County, Williamsville; 24 Apr. 1912; fl; *B.F. Bush 6634*; lectotype: A[A00026607]!, **here designated**; isoletotype: A[A00026608]!, GH[GH00026609]!, NY[NY01163652]!, US[US00097444, US00097445]!

Malus ioensis var. *creniserrata* Rehder, *Trees & Shrubs Vol. 2 (4)*: 231 (Rehder 1913b). – *Pyrus ioensis* var. *creniserrata* (Rehder) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – **Type**: USA • Louisiana, Rapides, County, Parish, Pineville; 3 Apr. 1885; fl; *C.S. Sargent s.n.*; lectotype: A[A00026605]!, **here designated**; isolectotype: A[A00026606]!, NY[NY01163668]!

Malus ioensis var. *palmeri* Rehder, *Trees & Shrubs Vol. 2 (3)*: 142 (Rehder 1911b). – *Pyrus ioensis* var. *palmeri* (Sarg.) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – **Type**: USA • Missouri, Jasper, Webb City, woods; 28 Apr. 1909; fl; *E.J. Palmer 1795*; lectotype: A[A00026610]!, **here designated**; isolectotype: A[A00026611, A00026612]!, MO[MO-2217901, MO-2217902]!, NY[NY01163653]!

Malus ioensis var. *spinosa* Rehder, *Trees & Shrubs Vol. 2 (4)*: 231 (Rehder 1913b). – *Pyrus ioensis* var. *spinosa* (Rehder) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – *Malus angustifolia* var. *spinosa* (Rehder) C.F.Reed, *Phytologia* 63 (5): 410 (Reed 1987). – **Type**: USA • Missouri, Dunklin, Campbell, low woods; 22 Apr. 1912; fl; *B.F. Bush 6630*; lectotype: A[A00026613]!, **here designated**; isolectotype: A[A00026614], GH[GH00026615]!, NY[NY1163649]!

Malus ioensis var. *texana* Rehder, *Trees & Shrubs Vol. 2 (3)*: 142–143 (Rehder 1911b). – *Pyrus ioensis* var. *texana* (Rehder) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – **Type**: USA • Texas, Kendall County,

Fig. 49. Distribution of *Malus ioensis* (Alph.Wood) Britton.

Fig. 50. Morphological characters of *Malus ioensis* (Alph.Wood) Britton; P00870194, P03240250, P03240253, P03240254, P03240255, P03240263, P03240264, P03240266, KUN0931115, A00026607 (lectotype of *Malus ioensis* var. *bushii* Rehder), A00026608 (isolectotype of *M. ioensis* var. *bushii*), GH00026609 (isolectotype of *M. ioensis* var. *bushii*), NY01163652 (isolectotype of *M. ioensis* var. *bushii*), US00097444 (isolectotype of *M. ioensis* var. *bushii*), A00026610 (lectotype of *M. ioensis* var. *palmeri* Rehder), A00026611, A00026612 (isolectotype of *M. ioensis* var. *palmeri*), NY01163653 (isolectotype of *M. ioensis* var. *palmeri*), A00026616 (syntype of *M. ioensis* var. *texana* Rehder), A00026617, A00026618, A00283735 (isosyntype of *M. ioensis* var. *texana*). Scale bars = 10 mm.

Boerne; thicks; 25 Mar. 1911; fl; *C.S. Sargent s.n.*; lectotype: A[A000283735]!, **here designated**; isolectotype: A[A000283736]!

Malus ioensis var. *typica* Rehder, *Mitteilungen der deutschen dendrologischen Gesellschaft* 1914: 262 (Rehder 1914), nom. inval.

Malus ioensis f. *plena* Rehder, *Mitteilungen der deutschen dendrologischen Gesellschaft* 1914: 262 (Rehder 1914), nom. inval.

Malus ioensis f. *fimbriata* A.D.Slavin, *American Midland Naturalist* 12 (9): 363 (Slavin 1931).

Examined specimens

UNITED STATES – **Illinois** • locality unknown; s.d.; st; *Anonymous s.n.*; A[01861806] • ibid.; st; *Anonymous s.n.*; A[01861750]. – **Indiana**: Daviess; s.d.; fl; *Anonymous s.n.*; GH[01861773] • ibid.; 6 May 1919; fl; *Chas. C. Deam No.26, 267*; GH. – **Iowa** • Iowa State College; 24 Jul. 1926; st; *A. Haydeu 14143*; PE. – **Massachusetts** • Norfolk; 24 May 1922; fl; *N.T. Kidder s.n.*; ECON. – **Missouri** • Wedd; 28 Apr. 1909; fl; *E.J. Palmer 1795*; A • Williamsville; 24 Apr. 1912; fl; *B.F. Bush 6634*; GH. – **Oklahoma** • Vinita; 5 Aug. 1894; st; *B.F. Bush 325*; A. – **Texas** • near Boerne; 24 Mar. 1911; fl; *C.S. Sargent s.n.*; A • ibid.; 7 Oct. 1910; st; *S.H. Hastings s.n.*; A • Kendall; 27 May 1916; fr; *E.J. Palmer 9911*; A. – **Wisconsin** • Richland; 21 Sep. 1988; st; *M. Nee 36806*; PE.

Description

Small tree, 6–8 (10) m high, or shrub, 4–7 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.0–3.3 cm long, puberulous. Lamina ca 3.3–8.3 × 1.9–4.6 cm, oblong to ovate, base truncate, cuneate or rounded, equilateral, apex acute, rounded or obtuse, margin crenate to serrulate, blade glabrous or puberulous, sometimes lobed. Inflorescence corymbose, with 3–5 flowers. Pedicel ca 1.7–2.2 cm long, puberulous. Hypanthium densely puberulous. Sepals triangular, puberulous, persistent. Petals ca 1.1–1.5 × 0.7–1.1 cm, white, pink or premium pink, obovate to oblong. Stamens ca 20, unequal. Styles 5, as long as stamens, pubescent at base. Pome ca 2.0–3.0 cm in diameter, subglobose, yellow. Carpopodium ca 2.1–2.5 cm long, puberulous.

Phenology

Flowers from April to May. Mature fruits from September to October.

Habitat

Terrestrial, seasonally green, growing in forests and shrubs in open areas of valleys; 100–300 m a.s.l.

Distribution

United States (Fig. 49).

Chromosome numbers

2n = 34, 68.

22. ***Malus coronaria*** (L.) Mill.
Figs 51–52

Gardeners Dictionary, 8th Ed.: Malus no. 2 (Miller 1768).

Pyrus coronaria L., *Species Plantarum Vol. 1*: 480 (Linnaeus 1753). **– Type**: COUNTRY UNKNOWN • s.d.; *Linnaeus s.n.*; holotype: LINN[LINN-HL647-5]!

Malus bracteata Rehder, *Trees & Shrubs Vol. 2 (4)*: 230 (Rehder 1913b). – *Pyrus bracteata* L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – *Malus coronaria* var. *bracteata* (Rehder) Likhonos, *Kul'turnaya Flora SSSR Vol. 14*: 34 (Likhonos 1983). – **Type**: USA • Campbell, Dunklin County; 22 Apr. 1912; fl; *B.F. Bush 6631A*; lectotype: A[A00026590]!, **here designated**; isolectotype: A[00026588]!, GH[GH00026589]!

Malus coronaria var. *dasycalyx* Rehder, *Journal of the Arnold Arboretum* 2 (1): 52–53 (Rehder 1920). – *Pyrus coronaria* var. *dasycalyx* (Rehder) Fernald, *Rhodora* 49: 232 (Fernald 1947). **– Type**: USA • Ohio Toledo, Maumee River bank, Walbridge Park; 28 Sep. 1914; fr; *R.E. Horsey 253*; lectotype: A[A00026594]!, **here designated**; isolectotype: A[A00026593, A00026595]!

Malus coronaria var. *dasycalyx* f. *charlottae* Rehder, *Journal of the Arnold Arboretum* 2 (1): 53 (Rehder 1920). – **Type**: USA • Illinois, Waukegan; 1 Jun. 1919; fl; *E.P. Dewolf s.n.*; lectotype: A[A00026591]!, **here designated**.

Malus coronaria var. *hoopesii* Rehder, *Trees & Shrubs Vol. 2 (3)*: 142 (Rehder 1911b). – *Malus platycarpa* var. *hoopesii* (Rehder) Rehder, *Trees & Shrubs Vol. 2 (4)*: 227 (Rehder 1913b). – *Pyrus platycarpa* var. *hoopesii* L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). **– Type**: USA • Massachussetts, Boston, Jamaica Plain, cultivated at the Arnold Arboretum; 9 Oct. 1903; fr; *Anonymous s.n.*; lectotype: A[00026634]!, **here designated**.

Malus coronaria var. *puberula* Rehder, *Trees & Shrubs Vol. 2 (4)*: 229–230 (Rehder 1913b). – *Malus angustifolia* var. *puberula* (Rehder) Rehder, *Mitteilungen der deutschen dendrologischen Gesellschaft* 23: 261 (Rehder 1914). – *Pyrus angustifolia* var. *puberula* (Rehder) L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). **– Type**: USA • Louisiana, Winnfield, Winn Parish; 6 Apr. 1913; fl; *C.S. Sargent s.n.*; lectotype: A[A00026579]!, **here designated**; isolectotype: A[A00026580]!

Malus fragrans Rehder, *Trees & Shrubs Vol. 2 (4)*: 228 (Rehder 1913b). – **Type**: USA • New York, Ontario County, Canandaigua; 19 May 1911; fl.; *B.H. Slavin 2*; lectotype: A[A01861241]!, **here designated**; isolectotype: A[A01861269]!

Malus fragrans var. *elongata* Rehder, *Trees & Shrubs Vol. 2 (4)*: 229 (Rehder 1913b). – *Pyrus elongata* (Rehder) Ashe, *Journal of the Elisha Mitchell Scientific Society* 34 (3): 139 (Ashe 1918b), nom. nud. – *Malus elongata* (Rehder) Ashe, *Bulletin of the Charleston Museum* 12 (5): 38 (Ashe 1916). – *Malus coronaria* var. *elongata* (Rehder) Rehder, *Mitteilungen der deutschen dendrologischen Gesellschaft* 23: 261 (Rehder 1914). – *Pyrus coronaria* var. *elongata* L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – **Type**: USA • North Carolina, Highlands, Macon County, Highlands; 20 May 1911; fl; *T.G. Harbison 625*; holotype: NCU[NCU00043395]!; isotype: A[A00026601, A00026602]!

Malus glabrata Rehder, *Trees & Shrubs Vol. 2 (4)*: 225, tab. 188 (Rehder 1913a). – *Malus coronaria* var. *glabrata* (Rehder) Likhonos, *Kul'turnaya Flora SSSR Vol. 14*: 33 (Likhonos 1983). **– Type**: USA • North Carolina, Buncombe; 29 Apr. 1911; fl; *T.G. Harbison 522*; holotype: NCU[NCU00043536]!; isotype: A[A00026603, A00026604]!, NCU[NCU00043537]!

Fig. 51. Distribution of *Malus coronaria* (L.) Mill.

Fig. 52. Morphological characters of *Malus coronaria* (L.) Mill.; A00026579 (lectotype of *Malus coronaria* var. *puberula* Rehder), NO0109795 (isotype of *M. coronaria* var. *puberula*), IND0056951, M0213670, M0213671, M0213672, M0213673, P03302829, P03302830, P03302831, A00026591 (lectotype of *M. coronaria* var. *dasycalyx* f. *charlottae*), A00026593 / A00026594 (isolectotype / lectotype of *M. coronaria* var. *dasycalyx* Rehder), A00026595 (isolectotype of *M. coronaria* var. *dasycalyx*), A00026601 (isotype of *M. coronaria* var. *elongata* (Rehder) Rehder), A00026602 (isotype of *M. coronaria* var. *elongata*), A00026634 (syntype of *M. coronaria* var. *hoopesii* Rehder), A00026603 (isotype of *M. glabrata* Rehder), A00026604 (isotype of *M. glabrata*), NCU00043536 (holotype of *M. glabrata*), NCU00043537 (isotype of *M. glabrata*), A00026630 (lectotype of *M. lancifolia* Rehder), NY01163660 (isolectotype of *M. lancifolia*), GH00026631 (isolectotype of *M. lancifolia*), P03240271 (*M. lancifolia*). Scale bars = 10 mm.

Malus glaucescens Rehder, *Trees & Shrubs Vol. 2 (3)*: 139, tab. 187 (Rehder 1911a). – *Malus coronaria* var. *glaucescens* (Rehder) Likhonos, *Kul'turnaya Flora SSSR Vol. 14*: 33 (Likhonos 1983). – **Type**: USA • New York, Rochester, Maple Grove Park; 25 May 1904 and 1905; fl; *J. Dunbar s.n.*; type: A, designated by Rehder 1913: 139.

Malus lancifolia Rehder, *Trees & Shrubs Vol. 2 (3)*: 141, t. 157 (Rehder 1911b). – *Pyrus coronaria* var. *lancifolia* (Rehder) Fernald, *Rhodora* 49: 232 (Fernald 1947). – *Malus coronaria* var. *lancifolia* (Rehder) C.F.Reed, *Phytologia* 63 (5): 410 (Reed 1987). **– Type**: USA • Missouri, Jackson, Courtney; 29 Apr. 1906; *B.F. Bush 3869*; lectotype: A[A00026630]!, **here designated**; isolectotype: GH[GH00026631]!, NY[NY01163660]!

Malus platycarpa Rehder, *Trees & Shrubs Vol. 2 (4)*: 227, pl. 189 (Rehder 1913b). – *Pyrus platycarpa* L.H.Bailey, *Rhodora* 18: 154 (Bailey 1916a). – *Malus coronaria* var. *platycarpa* (Rehder) Likhonos, *Kul'turnaya Flora SSSR Vol. 14*: 33 (Likhonos 1983). – **Type**: USA • North Carolina, Macon County, Franklin, Tennessee Valley; 22 Apr. 1911; fl; T.G. Harbison 503; type: A[A00026632, A00026633]!

– *Malus platycarpa* var. *parvula* Ashe, *Bulletin of the Torrey Botanical Club Bulletin of the Torrey Botanical Club* 49 (9): 268 (Ashe 1922). – **Type**: USA • Georgia, Habersham County; Oct. 1913; *W.W. A s.n.*; herbarium unknown.

Pyrus carolinensis Ashe, *Journal of the Elisha Mitchell Scientific Society* 34 (3): 138 (Ashe 1918b). – *Malus carolinensis* Ashe, *Bulletin of the Charleston Museum* 14 (2): 10 (Ashe 1918a). – **Type**: USA • North Carolina, Transilvana County, Mills River; 26 Sep. 1917; st; *W.W. Ashe 60*; lectotype: NY[NY01163662]!, **here designated**; isolectotype: NCU[NCU00000344, NCU00000345]!

Examined specimens

UNITED STATES – **Alabama** • Valleyhead; 11 Oct. 1911; st; *T.G. Harbison s.n.*; A • Piedmont; 1 Nov. 1941; st; *C. Dorman s.n.*; A. – **Delaware** • New Castle; 15 May 1937; fl; *R.R. Tatnall 3296*; GH • near Stanton; 13 May 1897; fl; *Anonymous s.n.*; A[01861073]. – **Georgia** • Rabun; 2 Jun. 1916; st; *T.G. Harbison H1228*; A. – **Illinois** • Waukegan; 22 Jun. 1920; fl; *E.P. Dewolf s.n.*; A. – **Kentucky** • Olympia Spring; 11 Sep. 1913; st; *C.S. Sargent s.n.*; A. – **Louisiana** • near Winnfield; 6 Apr.; fl; *C.S. Sargent s.n.*; A. – **Michigan** • Oakland; 2 Jun. 1931; fl; *O.A. Farwell 8877*; GH. – **New York** • Ontario; 20 Sep. 1990; fr; *Professor Zhen-Long Yan 1067*; PE. – **North Carolina** • Clay; 18 May 1980; fl; *D.E. Boufford et al. 22098*; HHBG, PE, SZ. – **Ohio** • Lorain; 13 May and 14 Aug. 1913; fl, fr; *F.O. Grover s.n.*; NAS • Fairfield; 24 Sep. 1914; st; *R.E. Horsey 223*; A • Mahoning; 27 May 1917; fl; *R.E. Horsey 631*; A. – **Pennsylvania** • Stromberg; 22 May; fl; *C.S. Sargent s.n.*; A[01861497]. – **Virginia** • Tip Top; 25 May 1914; fl; *T.C. Harbison 1615*; A.

Description

Small tree or shrub, 5–10 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.6–2.3 cm long, puberulous or glabrous. Lamina ca 4.6–5.6 × 2.8–3.5 cm, oblong to ovate, base cordate, rounded or cuneate, equilateral, apex acute, rounded or obtuse, margin biserrate or entire, blade glabrous or puberulous, sometimes lobed. Inflorescence corymbose, with 4–6 flowers. Pedicel ca 2.0–3.3 cm long, crinite or glabrous. Hypanthium puberulous or glabrous. Sepals triangular, abaxially glabrous or puberulous, adaxially densely puberulous, persistent. Petals ca 1.2–1.9 × 0.7–1.3 cm, white, pink or premium pink, obovate to oblong. Stamens ca 20, unequal, with pink or purple anther. Styles 5, as long as or longer than stamens, pubescent at base. Pome ca 2.5–3.5 cm in diameter, subglobose, yellow. Carpopodium ca 1.2–4.0 cm long, puberulous or glabrous.

Phenology

Flowers from April to June. Mature fruits from September to November.

Habitat

Terrestrial, seasonally green, growing in forests and shrubs in open areas of valleys, beside streams or roadsides; 50–1000 m a.s.l.

Distribution

United States (Fig. 51).

Chromosome numbers

2n = 34, 51, 68.

23. ***Malus florentina*** (Zuccagni) C.K.Schneid.
Figs 53–54

Illustriertes Handbuch der Laubholzkunde Vol. 1: 724 (Schneider 1906b).

Crataegus florentina Zuccagni, *Centuria I: Observationum Botanicarum*: 30 (No. 72) (Zuccagni 1806). – *Mespilus florentina* (Zuccagni) Bertol., *Opuscoli Scientifici* 1 (2): 149 (Bertoloni 1817). – *Pyrus*

Fig. 53. Distribution of *Malus florentina* (Zuccagni) C.K.Schneid.

Fig. 54. Morphological characters of *Malus florentina* (Zuccagni) C.K.Schneid. Drawn by J.C. Li.

florentina (Zuccagni) Targ.-Tozz., *Memorie di Matematica e di Fisica della Società italiana delle Scienze desidente in Modena* 20 (2): 302, tab. 5 (Targioni Tozzetti 1829). – *Tormimalus florentina* (Zuccagni) M.Roem., *Familiarum Naturalium Regni Vegetabilis Synopses Monographicae 3, Rosiflorae*: 131 (Roemer 1847). – *Sorbus florentina* (Zuccagni) K.Koch, *Hortus Dendrologicus*: 176 (Koch 1853). – *Cormus florentina* (Zuccagni) Decne., *Nouvelles Annales du Muséum d'Histoire naturelle, Paris, Ser. 1* 10: 157 (Decaisne 1874). – *Eriolobus florentinus* (Zuccagni) Stapf, *Curtis's Botanical Magazine* 156: sub tab. 9305, in obs (Stapf 1933). – *Malosorbus florentina* (Zuccagni) Browicz, *Fragmenta Floristica et Geobotanica* 16: 70 (Browicz 1970). – *Tormimalus* × *florentina* (Zuccagni) Holub, *Preslia* 70 (2): 115 (Holub 1998). – **Type**: ITALY • South Firenze, Mt. Cuccioli; 27 May 1874 and 23 Aug. 1874; fl, fr; *Levier s.n.*; neotype: FI[FI001747]!, designated by K. Browicz 1970: 72; isoneotype: FI[FI001748, FI001749]!

Examined specimens

ITALY – **Abruzzo** • L'Àquila; 1 Jul. 2002; fr; *C. Navarro et al. CN 3928*; PE.

Description

Tree, rarely ramifications. Leaves petiolate, petiole ca 0.5–2.0 cm long, puberulous. Lamina ca 3.0–6.0 cm long, ovate, base rounded or cuneate, equilateral, apex acute, margin crenate to serrulate, blade abaxially pubescent, lobed. Inflorescence corymbose, with 6–8 flowers. Sepals persistent. Petals ca 1.5–2.5 cm in diameter, white, obovate or oval. Stamens 20–30, unequal. Styles 5, pubescent at base. Pome ca 1.0 cm in diameter, oval or obovate.

Distribution

Albania, Greece, Italy, Serbia and Turkey (Fig. 53).

24. ***Malus trilobata*** (Labill. ex Poir.) C.K.Schneid.
Figs 55–56

Repertorium Novarum Specierum Regni Vegetabilis 3: 179 (Schneider 1906a).

Crataegus trilobata Labill. ex Poir., *Encyclopedie Methodique Botanique Supplement 1*: 291 (Poiret 1810). – *Crataegus trilobata* Labill. ex Poir., *Icones Plantarum Syriae Rariorum: Descriptionibus et Observationibus illustratae Vol. 4*: 15 (La Billardière 1812). – *Pyrus trilobata* (Labill. ex Poir.) DC., *Prodromus Systematis Naturalis Regni Vegetabilis Vol. 2*: 636 (de Candolle 1825). – *Sorbus*

Fig. 55. Distribution of *Malus trilobata* (Labill. ex Poir.) C.K.Schneid.

Fig. 56. Morphological characters of *Malus trilobata* (Labill. ex Poir.) C.K.Schneid.; TCD0018096 (type), K000283471. Scale bars = 10 mm.

trilobata (Labill. ex Poir.) Heynh., *Nomenclator Botanicus Hortensis Vol. 1*: 773 (Heynhold 1840). – *Eriolobus trilobata* (Labill. ex Poir.) M.Roem., *Familiarum Naturalium Regni Vegetabilis Synopses Monographicae 3, Rosiflorae*: 216 (Roemer 1847). – *Cormus trilobata* (Labill. ex Poir.) Decne., *Nouvelles Annales du Muséum d'Histoire naturelle, Paris, Ser. 1* 10: 157 (Decaisne 1874). – **Type**: LEBANON • locality unknown; s.d.; *La Billardière s.n.*; isotype, P[P02143277, P02143278]!, FI[FI011067]!

Sorbus trilobata var. *oxyloba* Boiss., *Flora Orientalis Vol. 2*: 657 (Boissier 1872). – *Eriolobus trilobata* var. *oxyloba* (Boiss.) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 726, fig. 402a-b (Schneider 1906b), nom. nud. – **Type**: SYRIA • Beilan; Monte Amano, on the slopes between the vineyards from Beilan to the Kara Tschausch mountain Houd Dagh; alt. 3000 ft; 22 Jun. 1862; fr.; *T. Kotschy s.n.*; lectotype: P[P03776682]!, **here designated**.

Pyrus trilobata var. *rumelica* Dingler, *Flora oder allgemeine botanische Zeitung* 66: 303 (Dingler 1883). – *Sorbus trilobata* var. *rumelica* Boiss., *Flora Orientalis. Supplementum*: 199 (Boissier 1888). **– Type**: GREECE • Maronia; 5 May 1876; *Anonymous 476*; holotype: B[10_0295745]!

Examined specimens

LEBANON – **Bsharre** • Hadet ej Jobbe; 12 Jun. 1933; fl; *G. Samuelsson 5940*; K • Ehden; 16 Jun. 1933; fl; *G. Samuelsson 6119*; K. – **El** • Hermel; 16 Aug. 1945; fr; *P. H. Davis 9858*; K • locality unknown (Bishare?); 30 Jul. 1855; fr.; *Kotschy s.n.*; P,

SYRIA • locality unknown; s.d.; *Kotschy 369*; P.

Description

Small tree or shrub. Leaves petiolate, petiole ca 0.8–4.2 cm long, glabrous. Lamina ca 3.4–5.1 × 4.1–7.4 cm, ovate, base cordate, equilateral, apex acute, margin crenate to serrulate, blade abaxially pubescent, lobed. Inflorescence umbellate, with 6–8 flowers. Pedicel ca 3.2 cm long, puberulous. Hypanthium puberulous or glabrous. Sepals triangular, puberulous, persistent. Petals ca 1.4 × 1.0 cm, white, obovate or oval. Stamens 20–30, unequal. Styles 5, pubescent at base. Pome ca 1.0–2.0 cm in diameter, subglobose or ellipsoidal, red. Carpopodium ca 1.2–4.5 cm long, puberulous.

Phenology

Flowers in May. Mature fruits from September to October.

Distribution

Bulgaria, Greece, Israel, Lebanon, Syria, and Turkey (Fig. 55).

Chromosome number

2n = 34.

Note

The type of *Crataegus trilobata* (*La Billardière s.n.*) still exists, therefore the lectotype (*Juvernalk s.n.*) designated by Langenfeld (1991: 123) is invalid.

25. ***Malus doumeri*** (Bois) A.Chev.
Figs 57–58

Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences 170: 1129 (Chevalier 1920).

Pyrus doumeri Bois, *Bulletin de la Société botanique de France* 51: 113 (Bois 1904). – *Docynia doumeri* C.K.Schneid., *Repertorium Novarum Specierum Regni Vegetabilis* 3: 180 (Schneider 1906a). – *Eriolobus doumeri* (Bois) C.K.Schneid., *Illustriertes Handbuch der Laubholzkunde Vol. 1*: 728 (Schneider 1906b). – *Docynia indica* var. *doumeri* (Bois) A.Chev., *Revue de Botanique appliquée et d'Agriculture tropicale* 22: 379 (Chevalier 1942). **– Type**: VIETNAM • Annam, Lang-bian, on border of forest; alt. 2000 m; st; *M. Auguste d'André s.n.*; type: P[P01819344]!

Malus formosana Kawak. & Koidz., *Botanical Magazine (Tokyo)* 25 (292): 146 (Kawakami 1911). – *Pyrus formosana* Kawak. & Koidz. ex Hayata, *Journal of the College of Science, Imperial University of Tokyo* 30 (Art. 1): 100 (Hayata 1911). – *Pyrus formosanus* Kawak. & Koidz., *A List of Plants of Formosa*: 34 (Kawakami 1910). – *Malus doumeri* var. *formosana* (Kawak. & Koidz.) S.S.Ying, *Memoirs of the College of Agriculture; National Taiwan University* 31 (1): 33 (Ying 1991). **– Type**: CHINA • Taiwan, Hakku-taisan; 1 Sep. 1910; st; *U. Mori s.n.*; lectotype: IT, **here designated**; isotype: IBSC[IBSC0004357]!

Pyrus laosensis Cardot, *Notulae Systematicae (Paris)* 3: 345 (Cardot 1918). – *Malus laosensis* (Cardot) A.Chev., *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* 170: 1129 (Chevalier 1920). – *Docyniopsis laosensis* (Cardot) Koidz., *Acta Phytotaxonomica et Geobotanica* 3 (4): 196 (Koidzumi 1934b). – *Docynia indica* var. *laosensis* (Cardot) A.Chev., *Revue de Botanique appliquée et d'Agriculture tropicale* 22: 379 (Chevalier 1942). **– Type**: LAOS • Xieng Kouang et Napé; s.d.; fr; *C.J. Spire 540*; lectotype: P[P00781058]!, **here designated**; isolectotype: P[P00781059, P00781060]!

Pyrus melliana Hand.-Mazz., *Anzeiger der Akademie der Wissenschaften in Wien, Mathematische-naturwissenschaftliche Klasse* 60: 96 (Handel-Mazzetti 1923). – *Malus melliana* (Hand.-Mazz.) Rehder, *Journal of the Arnold Arboretum* 20 (4): 414 (Rehder 1939). **– Type**: CHINA • Guangdong, Tsatmukngao, Lianping; alt. 500–1000 m; 15 Jul. 1920; fr; *R. Mell 657*; holotype: WU[WU0059420]!; isotype: A[A00032498]!

Malus asiatica var. *argutiserrata* Hu & F.H.Chen, *Acta Phytotaxonomica Sinica* 1 (2): 225 (Hu & Chen 1951). **– Type**: CHINA • Jiangxi, Xiushui Xian; 7 Jul. 1950; fr; *Y.G. Xiong 6669*; holotype: PE[PE00004596]!

Malus leiocalyca S.Z.Huang, *Guihaia* 9 (4): 305 (Huang 1989), syn. nov. – *Pyrus leiocalyca* (S.Z.Huang) M.F.Fay & Christenh., *Plant Gateway's The Global Flora*: *A Practical Flora to Vascular Plant Species of the World. Vol. 4*: 110 (Christenhusz *et al.* 2018). **– Type**: CHINA • Fujian, Chongan Xian, on the way from Yongguan to Huangganshan; alt. 1300 m; 2 May 1981; fl; *Wuyi Expedition 2414*; holotype: IBSC; isotype: FJSI[FJSI01268, FJSI012682]!, IBG, PE[PE00952781]!

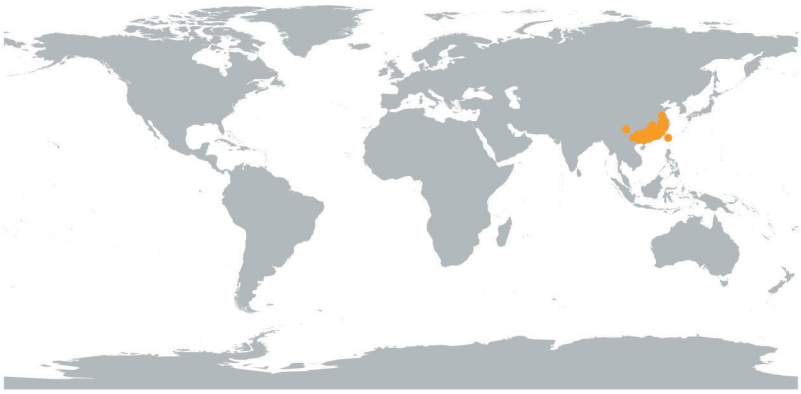

Fig. 57. Distribution of *Malus doumeri* (Bois) A.Chev.

Fig. 58. Morphological characters of *Malus doumeri* (Bois) A.Chev.; A00032498 (isotype of *Pyrus melliana* Hand.-Mazz.), CSF1033248, P00781055 (syntype), P00781056, P00781058 (lectotype of *Pyrus laosensis* Cardot), P03144755, P03144777, P03144789, PE00004596 (holotype of *Malus asiatica* var. *argutiserrata* Hu & F.H.Chen), PE00927581, QIN05067, CSFI012166 (*M. leiocalyca*), CSFI012188 (*M. leiocalyca*), PE00952771 (*M. leiocalyca*), PE00952776 (*M. leiocalyca*), PE00952780 (paratype of *M. leiocalyca*), PE00952781 (isotype of *M. leiocalyca*), IBK00367917 (*M. leiocalyca*), IBK00197343 (*M. melliana*), IBK00197341 (*M. melliana*), JXAU0004023 (*M. melliana*), JXAU0004034 (*M. melliana*), P03144393 (*M. melliana*), PE01460689 (*M. melliana*). Scale bars = 10 mm.

Examined specimens

CHINA – **Fujian** • Wuping; 10 Sep. 1983; fr; *Meihuashan Team 151*; FJSI, IBSC • Congan; 12 Aug. 1979; fr; *Wuyi Exp 00061*; PE • ibid.; 23 Jul. 1974; fr; *236-6 Team 829*; PE • Guangze; 24 Aug. 1981; fr; *P. Lin 8276*; AU • Wuyishan; 19 Aug. 1984; fr; *H.Y. Zou et al. 20058*; CSFI • Yongan; 7 Dec. 1932; st; *T.S. Wang 1304*; AU • Shaowu; 2 Oct. 1936; fr; *H.C. Zhou 5135*; IBSC • Nanping; 21 May 1932; st; *J. He 2035*; PE. – **Guangdong** • Meizhou; 5 Oct. 2004; fr; *X.F. Zeng ZXF00682*; CZH • ibid.; 21 May 2011; st; *X.F. Zeng ZXF11007*; CZH • Gaozhou; 23 Jul. 1959; fr; *P.C. Zhou 10307*; PE • Meixian; 26 Jun. 1957; fr; *X.G. Li 201068*; PE • Dabu; 9 Jun. 1957; fr; *L. Deng 11960*; PE • Ruyuan; 29 Jun. 1957; fr; *Y.G. Liu 000563*; PE • Ta ching; 6 Dec. 1927; st; *W.Y. Chun 4840*; PE • Guangzhou; 9 Feb. 1953; fl; *S.Q. Chen 8199*; PE • Heyuan; 28 Jun. 1958; fr; *Z.F. Wei 120682*; NAS, IBK, KUN, PE. – **Guizhou** • Leigongshan; 5 Sep. 1959; fr; *Qiannan Team 4002*; PE, NAS • Zhenfeng; 24 Oct. 1930; fr; *Y. Tsiang 4399*; PE • Libo; 22 Apr. 2018; fr; *R. Qiu 201810055*; QNUN. – **Hunan** • Pingjiang; 21 Apr. 2012; fl; *J.X. Li et al. 1674*; CSFI • Yizhang; 21 Oct. 1956; fr; *L.H. Liu 198*; NAS • Xinning; 16 Jul. 1980; fr; *Z.C. Luo 391*; PE, HUSF • Zhijiang; 24 May 1959; fr; *P.X. Tan 62505*; FJSI, IBK, IBSC. – **Jiangsu** • Nanjing; 9 May 1983; fr; *D.X. Zuo s.n.*; NAS • Lianyungang; 21 Jul. 1984; fr; *D.X. Zuo et al. 501*; NAS • Fuxi; 17 Aug. 1981; fr; *F.Y. Yuan 11109*; IBK. – **Jiangxi** • Linchi; 19 Jul. 1979; fr; *D.C. Wu 79-023*; PE • Xiushui; 1 Aug. 1947; fr; *Y.G. Xiong 05439*; PE • Suichuan; 24 Sep. 1963; fr; *J.S. Yue et al. 4290*; PE • ibid.; 9 Nov. 1965; fr; *S.S. Lai et al. 5604*; IBSC • Jinggangshan; 23 Sep. 1958; st; *J. Xiong 2716*; PE, LBG • ibid.; 15 Sep. 1979; fr; *S.S. Lai, J.L. Wang & S.C. Zhang 113*; LBG • Wugongshan; 22 Sep. 1954; fr; *Jiangxi Expedition 1457*; PE • Xunwu; 20 Jun. 1956; fr; *Xiertongxue 1096*; IBSC • Xinfeng; 22 Jul. 2018; fr; *Z.B. Tang, W.W. Hu & L. Yang T180722039*; GNNU. – **Sichuan** • Muli; 14 Oct. 1982; fr; *F.D. Pu & G. Yao 143*; NAS. – **Shaanxi** • Luojiacun; 14 May 1931; fr; *Anonymous 22137*; NAS. – **Taiwan** • Xinzhu; 16 Mar. 1999; fl; *G.Z. Yang et al. 5428*; PE • Taizhong; 28 Feb. 2001; fl; *C.W. Wang & C.Y. Li 04716*; PE • ibid.; 5 Jun. 2001; fr; *C.M. Wang 05014*; PE • Sintikusyu Tikutogun; 13 Oct. 1940; st; *Suzuki Tokio ST20727*; PE. – **Yunnan** • Funing; 25 May 1940; fr; *C.W. Wang & Y. Liu 89611*; PE • locality unknown; s.d.; fl, fr; *Anonymous s.n.*; PE[00927626]. – **Zhejiang** • Lonagquan; s.d.; fr; *R.H. Shan et al. 5777*; NAS • ibid.; 4 Dec. 1927; fr; *W.Y. Chun 5840*; NAS • ibid.; 28 Aug. 1957; st; *C.F. Zhang & Z.Z. Huang 37*; PE • Jingning; Nov. 1958; fr; *S.Y. Zhang et al. 24395*; NAS • Kaihua; 2 Jun.1990; fr; *Xu, Mei & Chen 0846*; ZM • Lishui; 18 Apr. 2016; fl; *Q.F. Zahng et al. ZX00141*; CSH • Xianju; 18 May 1960; fr; *Anonymous 7998*; NAS • Wuyi; 4 Jul. 1985; fr; *X.W. Zheng J8313-135*; PE • Suichang; 2 May 1959; fr; *M.L. She et al. 25791*; NAS.

LAOS • Xieng Kouang; s.d.; *Dr. Spire 1568*; P • Tran-ninh; s.d.; *Pidance 2*; P.

Description

Small tree or shrub, 4–10 (15) m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.9 cm long, pubescent when young, glabrescent. Lamina ca 9.4 × 3.8 cm, oblong to ovate, base rounded or cuneate, oblique, apex acute or acuminate, margin crenate to serrulate, blade pubescent when young then glabrescent, or glabrous. Inflorescence corymbose, with 4–5 flowers. Pedicel ca 1.5–3.0 cm long, puberulous. Hypanthium puberulous. Sepals lanceolate, abaxially puberulous, adaxially densely crinite, persistent. Petals yellowish-white, ovate. Stamens ca 30, unequal. Styles 5, pubescent at base. Pome ca 2.5–5.5 cm in diameter, subglobose, yellow to red. Carpopodium ca 2.3 cm long, puberulous or glabrous.

Phenology

Flowers in May. Mature fruits from August to September.

Habitat

Terrestrial, seasonally green, growing in mixed forests in valleys or mountainous regions; 700–2400 m a.s.l.

Distribution

China (Anhui, Fujian, Guangdong, Guangxi, Guizhou, Hunan, Jiangsu, Jiangxi, Sichuan, Shaanxi, Taiwan, Yunnan, Zhejiang) (Fig. 57).

Chromosome number

2n = 34.

26. ***Malus komarovii*** (Sarg.) Rehder
Figs 59–60

Journal of the Arnold Arboretum 2 (1): 51 (Rehder 1920).

Crataegus tenuifolia Kom., *Trudy imperatorskago S.-Peterburgskago botanicheskago Sada* 18: 435 (Komarov 1901), nom. illeg. – *Crataegus komarovii* Sarg., *Plantae Wilsonianae Vol. 1 (2)*: 183 (Sargent 1912), nov. nom. of *Crataegus tenuifolia* Kom.. – *Sinomalus tenuifolia* (Kom.) Koidz., *Acta Phytotaxonomica et Geobotanica* 1 (1): 12 (Koidzumi 1932). – *Sinomalus komarovii* (Sarg.) Honda, *Botanical Magazine (Tokyo)* 47: 297 (Honda 1933). – **Type**: NORTH KOREA • valley Segeelu-Korani; 16 Jun. 1897; fl; *V. Komarov 869*; holotype: LE; isotype: K[K000758431]!

Examined specimens

CHINA – **Jilin** • Antu; 29 Aug. 1959; fr; *P.Y. Fu 1256*; IFP • ibid.; 9 Aug. 1979; fr; *S.D. Zhao 2447*; IFP • Changbai; 26 May 1976; fl; *X.Z. Wang s.n.*; PE • ibid.; 3 Jul. 1958; fl; *F.M. Luo et al. 662*; PE.

NORTH KOREA – **North Hamgyong** • Kilju-gun; 25 Aug. 1942; fr; *Nakashima s.n.*; NAS • locality unknown; 12 Sep. 1962; st; *S.E. Liu & S.X. Li 9191*; IFP.

Description

Small tree or shrub, 3 m high. Branches terete, pubescent when young, glabrescent. Leaves petiolate, petiole ca 1.8–2.0 cm long, puberulous. Lamina ca 3.9–4.2 × 2.9–3.9 cm, ovate, rarely oblong, base

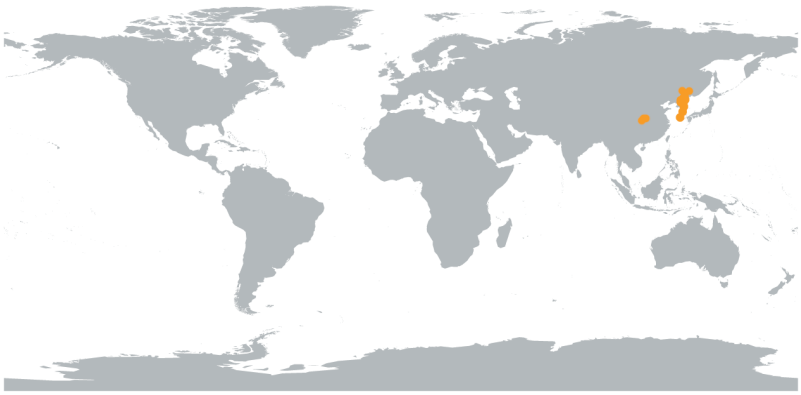

Fig. 59. Distribution of *Malus komarovii* (Sarg.) Rehder.

Fig. 60. Morphological characters of *Malus komarovii* (Sarg.) Rehder; K000758431 (isotype), IFP06828006y0001, PE00952717, PE00952719, PE00952721. Scale bars = 10 mm.

cordate or cuneate, equilateral, apex acute or acuminate, margin serrulate, blade puberulous, 3-lobed. Inflorescence corymbose, with 6–8 flowers. Pedicel ca 1.8 cm long, puberulous. Hypanthium puberulous. Sepals lanceolate, abaxially puberulous or glabrous, adaxially lanuginous, caducous or persistent. Petals white, ovate. Stamens 20–30, unequal. Styles 4 or 5, glabrous. Pome ca 0.8–1.0 cm in diameter, subglobose, yellow to red. Carpopodium ca 1.5 cm long, puberulous.

Phenology

Flowers in May. Mature fruits in September.

Habitat

Terrestrial, seasonally green, growing in shrubs; 1100–1300 m a.s.l.

Distribution

China (Henan, Jilin), North Korea, and South Korea (Fig. 59).

Chromosome number

2n = 34.

Discussion

The aims of this study were to investigate morphological variation within *Malus*, reevaluate the characters traditionally used for species delimitation, and determine the morphological relationships among these species. The PCA and cluster analyses showed a high level of morphological similarity among species, and most of the clades in the diagrams were identified with a low level of resolution.

Inter- and infraspecific variation of morphometric characters

Patterns of morphological variation were found in the length of the blade, the length from the widest point to the base of the leaf, and leaf area. Characters such as petiole length, blade width, tooth length, the length and width of petal and pome, and pome area also made a high contribution in differentiating species. Thus, leaf shape and size could be used for species delimitation. This is consistent with previous studies, for instance; tree habit and the length and width of the leaf blade were indicated as the most informative characters to explain the natural variation of species of *Malus* (Kumar *et al.* 2018). Nevertheless, it is important to point out that, although pomes with approximately the same degree of dryness were selected for measurement after two-dimensionalization, the pome area as a character for classification is still questionable because it may vary depending on the time and year of collection. Chen (2014) filtered out 7 characters related to flower and leaf in spring and 9 characters related to fruit and leaf in autumn to identify species of *Malus*. Indumentum on leaf blade, pedicel and petiole, and the pattern of leaf division were treated as the most effective parameters (Chen 2014). However, these characters, which are quite possibly influenced by the environment (according to our observations), were proven to be taxonomically unstable in our study. For example, in one situation, an indumentum on blade, pedicel and petiole occurs on tender leaves rather than adult leaves (e.g., *Malus communis* Poir., *M. mandshurica*, *M. yunnanensis*). In the other situation, an indumentum could be found on the adult leaves in some specimens but not in the others (e.g., *M. angustifolia*, *M. baccata*, *M. coronaria*). As for the type of leaf division, there is only approximately one-third of wild apple species with leaves that are all lobed, whereas half of the species possess three or more forms of leaf division (e.g., *M. baccata*, *M. coronaria*, *M. daochengensis*). An interesting example is *M. xiaojinensis*, where leaves on young trees and the base branches of adult trees are often 3–5-lobed (PE[PE00964204]), but leaves of adult trees from other locations are undivided (Cheng *et al.* 1983). Moreover, *Malus baccata* and *M. mandshurica* (Maxim.) Kom. ex Juz. manifest variability among the species of *Malus*, covering all forms of leaf division from undivided to divided. The variety

of leaf margins and leaf shape presents similar results. For example, leaf margins of *M. yunnanensis* range from edentate to serrate, and leaf shape changes from cordate, elliptic to ovate in type specimens (see K[K000758438] and K[K000758439], K[QIN05064] and K[QIN05065]). Edentate, erose, serrate, crenate, and serrate-crenate blades were all found in *M. toringoides*, and 69% of the species had two or more types of leaf margin. Besides, since the angle formed by the lateral and main nerve is relatively stable both within and among species, it is unsuited for classification in *Malus*. Similarly, characters such as the ratio of tooth length and width, angle of apex, and angle of the base play a limited role in taxonomy. The above mentioned variations are not exceptions caused by specific environmental factors, but are widespread in abundant specimens that we have checked with a comprehensive sampling that covered the whole distribution area of these species. While these differences in quantitative and qualitative morphological characters could provide evidence for species delimitation, the high degree of intraspecific variation and interspecific similarity in traits remains a challenge for species delimitation.

The role of traditional delimitation traits

While subtle differences in quantitative or qualitative morphological traits can provide evidence for separate species, phenotypic variation is not always associated with genetic differentiation. Owing to the high phenotypic plasticity observed within the *Malus* group, the delimitation of some species needs to be reconsidered. For example, some taxonomists considered the presence or absence of the indumentum as a good diagnostic character to distinguish species. However, the results obtained here suggested that such characters are variable and continuous, casting doubt on their usefulness for species delimitation.

Malus leiocalyca, with characters such as the glabrous petiole, pedicel, sepals, and calyx tube, was traditionally considered as a distinct species, separate from *M. doumeri* and *M. melliana* (Huang 1989; Gu & Spongberg 2003). However, our study revealed that this species is probably not distinct. Statistical methods were employed to clarify the relationship among *M. doumeri*, *M. melliana* and *M. leiocalyca*. Our results showed that all the specimens analyzed converged with each other, representing a continuous morphological variation (Fig. 3). Although *M. melliana* was once considered a distinct species close to *M. doumeri*, the variation between these two species in leaf tooth, calyx tube, pedicel, and fruit size is found to be continuous. Therefore, *M. melliana* is here regarded as a synonym of *M. doumeri*. We have analyzed a large number of specimens (including type specimens) of *M. doumeri* and found that some individuals have one or two conditions that calyx tube, pedicel and fruit are galbrous calyx tube, pedicel and fruit. When compared with *M. leiocalyca*, there is a high level of morphological variation in *M. doumeri*. Moreover, their geographical range, which partly overlaps, increases the possibility that *M. leiocalyca* and *M. doumeri* represent two forms, rather than species. The three species are distributed in the same region from Anhui (China) through Laos to India, and prefer a warm and humid climate. Consequently, we suggest that *M. leiocalyca* is synonymous with *M. doumeri*. However, this requires future molecular evidence. A similar situation is found in *M. transitoria* var. *glabrescens*. This variety only occurs in Qamdo Xian (Tibet) (Yu *et al.* 1980), and features such as glabrous abaxial blade, sparsely pubescent pedicel and calyx tube are unsuitable for identifying as they could be a response to the local climate. Hence, *M. transitoria* var. *glabrescens* might be an ecotype, and thus a synonym of *M. transitoria*, in concordance with The World Flora Online (http://www.worldfloraonline.org/taxon/wfo-0001015968). There is no clear demarcation of *M. mandshuirca* (*M. baccata* var. *mandshurica*) and *M. baccata* in either analysis above. The similar geographical distribution and highly similar morphology of the two species do not support the recognition of *M. mandshurica* as a separate species. In contrast to *M. baccata*, *M. mandshurica* is located at a higher altitude (up to 2100 m) and concentrated north of the Yellow River. The indumentum on the blade, flower and carpopodium is likely the result of the interaction of genes and the environment to conform to the colder weather (e.g., a higher altitude and more northern distribution regions). In addition, there is a tendency in the specimens of *M. mandshurica* to have a larger size of flowers and simpler leaf architecture. Hence, *M. mandshurica* is likely an ecotype of *M. baccata*.

The characters of species of *Malus* traditionally used in taxonomy are variable within and among species, resulting in difficulties in delimiting species based on morphological criteria. Thus, morphological variation and plasticity should be seriously considered when defining species boundaries, especially when material available for species descriptions is limited.

Interspecific relationships of species of Malus

Our morphological clustering confirmed that the morphological traits traditionally used in taxonomy are unsuited for distinguishing the lineages identified in previous phylogenetic studies (Robinson *et al.* 2001; Nikiforova *et al.* 2013; Jin 2014). Despite differences in phylogenetic trees based on different genetic data sets, these studies broadly support a number of clades. The first clade contains *Malus baccata*, *M. baccata* var. *mandshurica* and *M. hupehensis*. The three species have a similar appearance, but the aubergine calyx, pedicel, young leaves, and a distinct red margin of the petals and flower buds can differentiate *M. hupehensis* from the other two. The second clade includes all taxa from ser. *Yunnanenses* Rehder (with the exception of *M. kansuensis*), and the third clade consists of all members of sect. *Chloromeles*. These clades are all supported by both the phylogenetic and traditional morphological classifications. However, the situation is much more complicated in *Malus* as a whole. We roughly divided the species of *Malus* into four groups related to geographical distribution according to the previous phylogenetic studies for convenience (Fig. 61).

Group A includes members from sect. *Malus* (Phipps *et al.* 1990) (with the exception of *Malus fusca*). These species share a number of morphological similarities such as umbel, undivided leaf and subglobose pome. The species are distributed in Eurasia, and are geographical replacement species of each other (i.e., Europe [*M. sylvestris*] → west Asia & Caucasus [*M. orientalis*] → Central Asia [*M. kirghisorum*] → Central Asia – east Asia [*M. sieversii*] → south of the Yellow River [*M. hupehensis*] → north of the Yellow River – Japan [*M. baccata*]). *Malus fusca* differs from the other species in its lobed leaf, oblong pome and corymb, and the pedicels that almost grow from a single point so that they look like the struts of an umbrella. It is usually classified in ser. *Kansuenses* of sect. *Sorbomalus* (e.g., Phipps *et al.* 1990; Lagenfeld 1991; Li 1996), which spreads over the western coast in North America. Our 'fruiting season' group data supports that *M. fusca* shares more similarities with *M. mandshurica* and *M. orientalis*, which corresponds with molecular studies (e.g., Nikiforova *et al.* 2013; Jin 2014). On the other hand, the relationships implied by the analysis of the 'florescence' group data are congruent with traditional morphological classification. Further investigations applying an integrative approach are needed to define boundaries and disentangle the relationships of this clade.

Group B corresponds to some species of sect. *Malus*, sect. *Sorbomalus* and sect. *Docyniopsis* (Phipps *et al.* 1990). Species in this group (*Malus tschonoskii* excluded) are characterized by polyploidy and geographical distribution ranges from China to Japan. The morphological traits traditionally used to define these sections (e.g., style characteristics) become useless. *Malus sieboldii* (revised: *M. toringo*) and *M. rockii* have umbels and a pubescent base of the styles, while *M. sikkimensis*, *M. toringoides*, and *M. transitoria* have corymbs and glabrous styles, and *M. tschonoskii* has a corymb and a pubescent base of the styles. Unfortunately, our results provide limited phenotypic support for differentiation among species within this clade. Group C is the only well-supported clade confirmed both by our morphological analyses and the previous phylogenetic analyses, containing all taxa from ser. *Yunnanenses* and one from ser. *Kansuenses* (Phipps *et al.* 1990; Lagenfeld 1991; Li 1996). The two taxa have a sympatric distribution in southern China. The basal group, Group D, is composed of all members of sect. *Chloromeles* with species restricted to North American, in addition to *M. doumeri* from sect. *Docyniopsis* (distributed in Asia) and *M. trilobata* from sect. *Eruolobus* (distributed from West Asia to Europe) (Phipps *et al.* 1990; Lagenfeld 1991; Li 1996). Contrary to the traditional taxonomic classification, our analyses show that *M. trilobata* and *M. doumeri* share many morphological characters, which is consistent with the preceding works of Nikiforova *et al.* (2013) and Jin (2014). In addition, the leaf shape of *M. tschonoskii* is more similar to

that of the members of Group C, whereas this species has a smaller leaf size. Traditionally, botanists often classified species into series and sections (Koidzumi 1934b; Rehder 1949; Yu & Yen 1956; Chen 1959; Langenfeld 1991; Phipps *et al.* 1990; Lagenfeld 1991; Li 1996; Qian 2005); however, neither our study nor the previous phylogenetic studies support these classifications.

It is very difficult to find unique morphological features characterizing the different lineages. This study and recent molecular phylogenetic studies indicate that morphological characters provide limited information on the systematic relationships among the species of *Malus*. Most species of *Malus* that clustered together on the scatter plots and are thus morphologically similar, are known to be distinct at the molecular level. As phrased by Zhang (2018), "Genotypic and phenotypic evolution could obey different laws". Hybridization, apomixis, incomplete lineage sorting, and the effect of environmental conditions (e.g., precipitation, temperature and human activities) on morphological development could confound the boundaries and relationships of species (Miller & Spooner 1999; Robinson *et al.* 2001; Chen *et al.* 2019). *Malus* provides a good example in which evolutionary rates of morphological and genetic

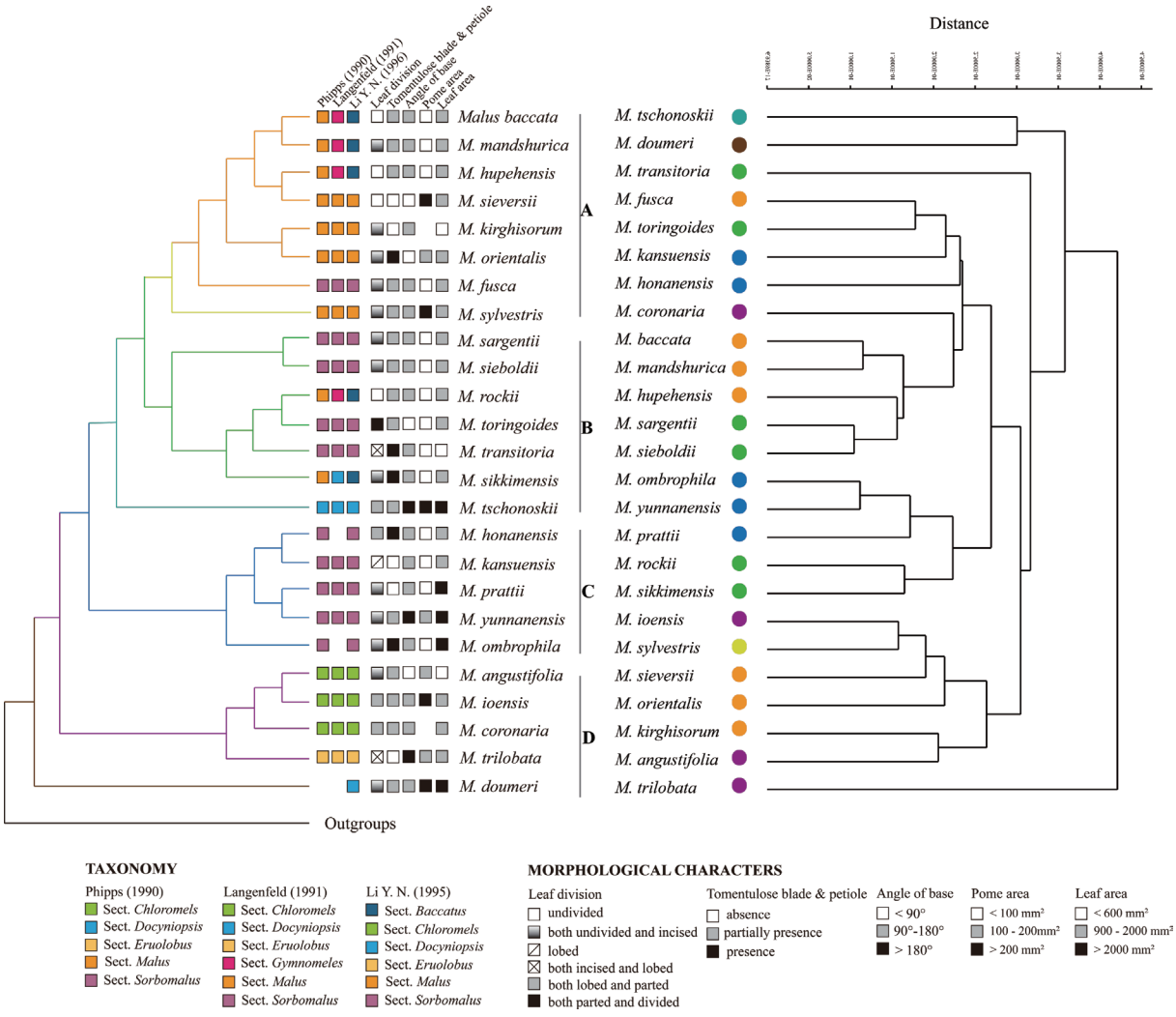

Fig. 61. Mapping the informative characters and traditional taxonomy systems by Phipps (1990), Langenfeld (1991) and Li (1996) on the most recent phylogenetic tree (adapted from Jin, 2014). The UPGMA tree used for comparison is marked with the colour of the corresponding branch. The rest of the information is presented in the legend.

characters could be decoupled. Further research on living plants at the species and population level are needed to further clarify the taxonomy of the genus.

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Supplementary file

Supp. file 1. The quantitative morphological parameters of the species of *Malus* Mill. and their descriptive statistics.
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Appendix 1 (continued on next 18 pages). List of specimens, their barcodes and collection information for the studied taxa of *Malus* Mill.

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus angustifolia (Aiton) Michx.	Accepted	A00026578	*T.G. Harbison 129*	USA	Holotype *Malus angustifolia* f. *pendula* Rehder
		K000758463/ K000758464/ K000758467	*G.V. Nash 2366*	Florida (USA)	
		K000758465	*Greene s.n.*	North Carolina (USA)	Neotype
		K000758468/ K000758469	*Schweinitz s.n./Drummond s.n.*	Louisiana (USA)	
		P03240208	*Arsène 12177*	Louisiana (USA)	
		P03240212	*A. Michaux s.n.*	Carolina (USA)	
		NYBG02812600	*R. McVaugh 6656*	Arlington (USA)	
Malus acerba Mérat	Synonym	P03140433	*L. Chevallier s.n.*	Pays-de-Loire (France)	
		P03302816	*H. Bouby 12346*	Centre (France)	
Malus baccata (L.) Borkh.	Accepted	LINN-HL647-4	*C. Linnaeus s.n.*	–	Lectotype
		M0213676	*Not on Sheet s.n.*	Kamoon (India)	
		P03240222	*R.H. Cheney s.n.*	Massachusetts (USA)	
		P03324193	*Not on Sheet s.n.*	Asia	
		P03324196	*Not on Sheet s.n.*	Sichuan (China)	
		P03324208	*T.Y. Cheo, L. Yen 173*	Shandong (China)	
		P03324211	*Chaffanjon 1353*	Asia	
		P03324219	*Davw s.n.*	Asia	
		P03324220	*Davw s.n.*	Asia	
		P03339997	*F. Karo 77*	Zabaykalsky Krai (Russia)	
		KUN0755631	*G. Forrest 18264*	Yunnan (China)	
		KUN0755632	*G. Forrest 13844*	Yunnan (China)	
		KUN0889035	*LiuJQ-08XZ-125*	Tibet (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus baccata (L.) Borkh.	Accepted	KUN0659908	*Yellow River Team 1045*	Shanxi (China)	
Malus baccata var. *gracilis* (Rehder) T.C.Ku	Accepted	A00026586	*A. Rehder s.n.*	Jamaica Plain, Massachusetts (USA)	Type
		HNWP262000	*Z.H. Zhang et al. 5912*	Qinghai (China)	
		PE00927497	*Y.W. Cui 10937*	Shaanxi (China)	
		PE00927495	*Y.W. Cui 10001*	Shaanxi (China)	
		PE00927502	*Yellow River Investigation Team 2051*	Gansu (China)	
		PE00927499	*Yellow River Investigation Team 163*	Gansu (China)	
		PE00927501	*Yellow River Investigation Team 02113*	Gansu (China)	
		HNWP62063	*Z.H. Zhang et al. 5975*	Qinghai (China)	
		HNWP160546	*Z.H. Zhang et al. 5559*	Qinghai (China)	
Malus bhutanica (W.W.Sm.) J.B.Phipps	Unresolved	K000758452	*J.C. White s.n.*	Myanmar	Type
		K000758453	*J.C. White s.n.*	Myanmar	Type
		PE00927493	*T.Y. Le 5781*	Shaanxi (China)	
Malus bracteata Rehder	Synonym	A00026588	*B.F. Bush 6631a*	Campbell, Missouri (USA)	Type
		A00026590	*B.F. Bush 6631a*	Campbell, Missouri (USA)	Lectotype
		GH00026589	*B.F. Bush 6631a*	Campbell, Missouri (USA)	Type
		K000758460	*T.G. Harbison 1115*	Selma, Alabama (USA)	
		K000758461	*T.G. Harbison 1167*	Georgia (USA)	
		NCU00043524	*W.W. Ashe s.n.*	Campbell, Missouri (USA)	
Malus chitralensis Vassilcz.	Accepted	BM000602198	*Bowes Lyon 679*	Chitral (Pakistan)	Isotype

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus chitralensis Vassilcz.	Accepted	E00010842	*Bowes Lyon, Simon 679*	Chitral (Pakistan)	Isotype
Malus coronaria (L.) Mill.	Accepted	IND0056951	*Not on Sheet s.n.*	India	
		M0213670	*G.H.E. Muhlenberg 115a*	Pensylvania (USA)	
		M0213671	*J.F. Ehrhart 144*	Virginia (USA)	
		M0213672	*J.P. Du Roi s.n.*	Ex horto Harbeccensi	
		M0213673	*J.P. Du Roi s.n.*	Ex horto Harbeccensi	
		P03302829	*Not on Sheet s.n.*	–	
		P03302830	*Not on Sheet s.n.*	–	
		P03302831	*Not on Sheet s.n.*	–	
Malus coronaria f. *charlottae* Rehder	Unknown	A00026591	*E.P. Dewolf s.n.*	Waukegan, Illinois (USA)	Lectotype
Malus coronaria var. *dasycalyx* Rehder	Accepted	A00026593	*R.E. Horsey 253*	Toledo, Ohio (USA)	Isolectotype
		A00026594	*R.E. Horsey 253*	Toledo, Ohio (USA)	Lectotype
		A00026595	*R.E. Horsey 253*	Toledo, Ohio (USA)	Isolectotype
Malus coronaria var. *elongata* (Rehder) Rehder	Synonym	A00026601	*T.G. Harbison 625*	Highlands, North Carolina (USA)	Isotype
		A00026602	*T.G. Harbison 625*	Highlands, North Carolina (USA)	Isotype
Malus coronaria var. *hoopesii* Rehder	Synonym	A00026634	*Not on Sheet s.n.*	Jamaica Plain, Massachusetts (USA)	Syntype
Malus coronaria var. *puberula* Rehder	Accepted	A00026579	*C.S. Sargent s.n.*	Winnfield, Louisiana (USA)	Lectotype
		A00026580	*C.S. Sargent s.n.*	Winnfield, Louisiana (USA)	Type
		K000758459	*C.S. Sargent s.n.*	–	Isotype
		NO0109795	*R.S. Cocks, C.S. Sargent s.n.*	Winnfield, Louisiana (USA)	Isotype

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus communis Poir.	Unresolved	P03302842	*Gérard s.n.*	France	
		P03302843	*Not on Sheet s.n.*	France	
		P03303076	*Not on Sheet s.n.*	France	
		P03140465	*Not on Sheet s.n.*	France	
		P03140478	*Not on Sheet s.n.*	France	
		P03140481	*Not on Sheet s.n.*	France	
		P04345278	*Not on Sheet s.n.*	France	
Malus daochengensis C.L.Li	Accepted	A00026647/ PE00927526	*T.T. Yü 12929/ C.W.Wang 70022*	Yunnan (China)	Isotype/Paratype
		KUN1206901/ PE00927526	*T.T. Yü 12929/ C.W.Wang 70022*	Sichuan (China)	Isotype/Paratype
		PE00934235	*T.T. Yü 12913*	Sichuan (China)	Paratype
		PE00934234	*T.T. Yü 12929*	Sichuan (China)	Isotype
		PE00934206	*T.T. Yü 12929*	Sichuan (China)	Isotype
		PE00927532	*K. M. Feng 975*	Yunnan (China)	Paratype
		PE00927528	*T.T. Yü 10015*	Yunnan (China)	Paratype
		PE00927526	*C.W. Wang 70022*	Yunnan (China)	Paratype
		CDBI0043632	*Sichuan Vegetation Ivestigation Team Dao 2208*	Sichuan (China)	
Malus diversifolia (Bong.) M.Roem.	Synonym	US01074641	*B.W. Evermann 251*	Sitka, Japonsky Island (USA)	
		US01074643	*A. Kellogg 26*	Sitka, Alaska (USA)	
		US01074645	*F.V. Coville & T.H. Kearney 277*	Vancouver Island, British Columbia (Canada)	
		US01074649	*F.V. Coville & T.H. Kearney 203*	Foggy Bay, Alaska (USA)	
Malus doumeri (Bois) A.Chev.	Accepted	A00032498	*R.E. Mell 657*	Guangdong (China)	Isotype (*Pyrus melliana*)

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus doumeri (Bois) A.Chev.	Accepted	PE00004596	*Y.G. Xiong 6669*	Jiangxi (China)	Holotype (*Malus asiatica* var. *argutiserrata*)
		QIN05067	*Not on Sheet s.n.*	–	
		P00781055	*C.J. Spire 1568*	Xien-Kouang (Laos)	Syntype
		P00781056	*Pidance 2*	Région du Tran-ninh (Laos)	
		P00781058	*C.J. Spire 540*	Xieng Kouang et Napé (Laos)	lectotype of *Pyrus laosensis*
		P03144777	*R. Cheiéuillg 7*	India	
		P03144789	*Poilane 15711*	Asia	
		P03144755	*E. Poilane 4011*	Lin Tong (Vietnam)	
		P01819344	*d'André s. n.*	Annam (Vietnam)	
		GXMG0102233	*X.Y. Huang, X.Y. Hu, H.F. Cen, M.Q. Tang 451026131123034LY*	Guangxi (China)	
		LBG00010002	*Q.M. Hu 2772*	Jiangxi (China)	
		CSFI033248	*J.X. Li et al. 1674*	Hunan (China)	
		PE00927581	*Y. Tsiang 4399*	Guizhou (China)	
Malus fusca (Raf.) C.K.Schneid.	Accepted	K000758454 (000758455)	*Scouler & Douglas s.n.*	–	Lectotype *Pyrus rivularis*
		K000758456	*Scouler s.n.*	–	
		K000758457	*s.coll. s.n.*	Canada	
		K000758458	*Scouler s.n.*	Canada	
		P03240223	*Not on Sheet s.n.*	–	
		P03240225	*Not on Sheet s.n.*	–	
		P03240226	*Not on Sheet s.n.*	–	
		P03240227	*Not on Sheet s.n.*	–	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus fragrans var. *elongata* Rehder	Unresolved	NCU00043395	*T.G. Harbison 625, 686*	Highlands, North Carolina (USA)	Holotype
Malus glabra A.Sav.	Unresolved	IBSC0004358	*Wukao Team 585*	Fujian (China)	Type
Malus glabrata Rehder	Synonym	A00026603	*T.G. Harbison 522*	Biltmore, North Carolina (USA)	Isotype
		A00026604	*T.G. Harbison 522*	Biltmore, North Carolina (USA)	Isotype
		NCU00043536	*T.G. Harbison 522*	Buncombe Co., North Carolina (USA)	Holotype
		NCU00043537	*T.G. Harbison 522*	Buncombe Co., North Carolina (USA)	Isotype
Malus honanensis Rehder	Accepted	A00026648	*J. Hers 489*	Henan (China)	Type
		K000758432/ QIN05070	*J. Hers H222*	China	
		K000758433	*J. Hers H573*	China	
		P03144437	*1792*	Henan (China)	
		P03144438	*195*	Henan (China)	
		PE00927742	*K.J. Fu 6123*	Shaanxi (China)	
		PE00927715	*H. Smith 6294*	Shanxi (China)	
		HENU1008051	*Z.H. Xin 049*	Henan (China)	
		HENU1008050	*X.M. Fan 0010*	Henan (China)	
Malus hupehensis (Pamp.) Rehder	Accepted	A00026649	*C. Silvestri 939*	Hubei (China)	Syntype (*Pyrus hupehensis*)
		K000758419	*E.H. Wilson 451*	Hubei (China)	Isolectotype (*Malus theifera*)
		QIN05045	*Not on Sheet s.n.*	–	
		P03144395	*F.T. Wang s.n.*	Sichuan (China)	
		P03144440	*M. Farges s.n.*	Sichuan (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus hupehensis (Pamp.) Rehder	Accepted	P03144445	*R.P. Farges 195*	Sichuan (China)	
		P03144446	*R.P. Farges 989*	Sichuan (China)	
		KUN0938174	*L. DeMInk, J. Pinkard 8653V98*	Lisle, Illinois (USA)	
Malus ioensis (Alph.Wood) Britton	Accepted	P00870194	*M. Nee 61515*	Wisconsin (USA)	
		P03240250	*Not on Sheet s.n.*	–	
		P03240251	*Not on Sheet s.n.*	–	
		P03240253	*Not on Sheet s.n.*	–	
		P03240254	*Not on Sheet s.n.*	–	
		P03240255	*Not on Sheet s.n.*	–	
		P03240264	*Palmer 4808*	Wayne County, Michigan (USA)	
		KUN0931115	*J. Sturner, J. Weber 11550v09*	Lisle, Illinois (USA)	
Malus ioensis var. *bushii* Rehder	Synonym	A00026607	*B.F. Bush 6634*	Williamsville, Missouri (USA)	Lectotype
		A00026608	*B.F. Bush 6634*	Williamsville, Missouri (USA)	Isolectotype
		GH00026609	*B.F. Bush 6634*	Williamsville, Missouri (USA)	Isolectotype
		NY01163652	*B.F. Bush 6634*	Williamsville, Missouri (USA)	Isolectotype
		US00097444	*B.F. Bush 6634*	Williamsville, Missouri (USA)	Isolectotype
Malus ioensis var. *palmeri* Rehder	Synonym	A00026610	*E.J. Palmer 1795*	Webb City, Missouri (USA)	Lectotype
		A00026611	*E.J. Palmer 1795*	Webb City, Missouri (USA)	Isolectotype
		A00026612	*E.J. Palmer 1795*	Webb City, Missouri (USA)	Isolectotype

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus ioensis var. *palmeri* Rehder	Synonym	NY01163653	*E.J. Palmer 1795*	Webb City, Missouri (USA)	Isolectotype
Malus ioensis var. *texana* Rehder	Synonym	A00026616	*S.H. Hastings 2*	Texas (USA)	
		A00026617	*B. Mackensen s.n.*	Texas (USA)	
		A00026618	*J. Reverchon 1649*	Texas (USA)	
		A00283735	*C.S. Sargent s.n.*	Texas (USA)	Isosyntype
Malus kansuensis (Batalin) C.K.Schneid.	Accepted	K000758428	*Potanin s.n.*	Sichuan (China)	Isolectotype
		PE00020669	*Potanin s.n.*	China	Isolectotype
		QIN05062	*Not on Sheet s.n.*	–	
		QIN05063	*Not on Sheet s.n.*	–	
		K000758427	*A. Henry 6754A*	Hubei (China)	
		K000758429	*Potanin s.n.*	Sichuan (China)	
		P03144405	*A.E. Pratt 476*	Tibet (China)	
		P03144408	*A. Henry s.n.*	Hubei (China)	
		KUN0662441	*Anonymous 327*	–	
Malus kansuensis var. *calva* (Rehder) T.C.Ku & Spongberg	Synonym	A00026651	*E.H. Wilson 264*	Hubei (China)	Type
		K000758430	*E.H. Wilson 264*	Hubei (China)	Type
Malus kirghisorum Al.Fed. & Fed.	Accepted	KUN0937410	*S. Packard, P. Steinhouse 9243V01*	Lisle, Illinois (USA)	
Malus komarovii (Sarg.) Rehder	Accepted	K000758431	*V. Komarov 869*	South Korea	Isotype
		IFP06828006y0001	*S.E. Liu 9190*	North Korea	
		IFP06828006y0002	*S.E. Liu 9191*	North Korea	
		PE00952721	*F.M. Luo, Z.R. Wu, J.J. Jin 665*	Jilin (China)	
		PE00952718	*F.M. Luo, Z.R. Wu, J.J. Jin 665*	Jilin (China)	
		PE00952719	*P.Y. Fu et al. #1256*	Jilin (China)	
		PE00952717	*X.Z. Wang s.n.*	Jilin (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus lancifolia Rehder	Synonym	A00026630	*B.F. Bush 3869*	Courtney, Missouri (USA)	Lectotype
		NY01163660	*B.F. Bush 3869*	Courtney, Missouri (USA)	Isolectotype
		GH00026631	*B.F. Bush 3869*	Courtney, Missouri (USA)	Isolectotype
		P03240271	*B.F. Bush 100478*	Missouri (USA)	
Malus leiocalyca S.Z.Huang	Synonym	PE00952780	*Wuyi Expedition 00854*	Fujian (China)	Paratype
		PE00952781	*Wuyi Expedition 2414*	Fujian (China)	Isotype
		PE00952758	*Y.L Keng 283*	Zhejiang (China)	
		PE00952776	*M.J. Wang, S.Z. Huang 2321*	Jiangxi (China)	
		PE00952767	*S.R. Zhang 3685*	Zhejiang (China)	
		PE00952771	*Q.M. Hu 3283*	Jiangxi (China)	
		PE00952762	*S.R. Zhang 4008*	Zhejiang (China)	
		PE00952741	*M.B. Deng e al. 1880*	Anhui (China)	
		HTC0003087	*Anonymous 5502*	Zhejiang (China)	
		CSFI012188	*Forestry College 77-0165*	Hunan (China)	
		CSFI012166	*Forestry College 77-0164*	Hunan (China)	
		IBK00367917	*M.X. Nie & S.S. Lai 3825*	Jiangxi (China)	
Malus macounii Greene	Unresolved	DAO000418341	*J.M. Macoun 34368*	Chilliwack Valley, British Columbia (Canada)	Syntype
		GH00026631	*J.M. Macoun 34372*	Chilliwack Valley, British Columbia (Canada)	Syntype
		K000758471	*J.M. Macoun 34368*	Chilliwack Valley, British Columbia (Canada)	
		NDG22007	*J.M. Macoun 34372*	Chilliwack Valley, British Columbia (Canada)	Syntype
		NDG22008	*J.M. Macoun 34368*	Chilliwack Valley, British Columbia (Canada)	Syntype
Malus mandshurica (Maxim.) Kom. ex Skvortsov	Synonym	NY00415893	*Not on Sheet s.n.*	–	Lectotype

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus mandshurica (Maxim.) Kom. ex Skvortsov	Synonym	QIN05041	*Not on Sheet s.n.*	–	
		QIN05042	*Not on Sheet s.n.*	–	
		P00993789	*K. Hori s.n.*	Sorachi (Japan)	
		P03144392	*D. Basargin, K. Ulanova 1980V25*	Russia	
		BNU000964	*Y. He, J.S. Hao, GSL2014050403*	Shaanxi (China)	
		BNU002220	*Y. He, J.S. Hao GSL2014050019*	Shaanxi (China)	
		SXU-SD00014345	*Z.Y. Li, H.Q. Li 904001-2*	Shanxi (China)	
		SXU-SD00014343	*Z.Y. Li, H.Q. Li 904001-5*	Shanxi (China)	
		SXU-SD00014341	*Z.Y. Li, H.Q. Li 904001-1*	Shanxi (China)	
		SXU-SD00014342	*Z.Y. Li, X.M. Zhou 904011*	Shanxi (China)	
		PE02026701	*Changping Team 0098*	Beijing (China)	
		PE00952851	*Zhongyang Jia Team 408*	Shanxi (China)	
		PE01460827	*Anonymous s.n.*	Gansu (China)	
		GXMG0029941	*Y.T. Hou 11151*	Shandong (China)	
Malus manshurica (Maxim.) Kom. ex Juz.	Synonym	K000758414	*Maximowicz 143*	–	
		K000758415 (000758416)	*Maximowicz s.n.*	–	
		PE00952897	*Yellow River Investigation Team 4639*	Gansu (China)	
		PE00952873	*D.J. Yu 166*	Shaanxi (China)	
		PE00952882	*Yellow River Investigation Team 3763*	Gansu (China)	
		PE01460677	*Anonymous 00046*	Gansu (China)	
Malus melliana (Hand.-Mazz.) Rehder	Synonym	P03144393	*R.C. Ching 1784*	Zhejiang (China)	
		PE01460689	*Anonymous 106*	Fujian (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus melliana (Hand.-Mazz.) Rehder	Synonym	JXAU0004023	*Y.G. Sun 740221*	Jiangxi (China)	
		JXAU0004034	*Agriculture Plant and Forestry Team 88149*	Jiangxi(China)	
		IBK00061542	*Q.H. Lv (Liuzhou Team) 2769*	Guangxi (China)	
		IBK00197343	*Dayaoshan Expedition team 810976*	Guangxi (China)	
		IBK00197341	*Exp. Dayaoshan 811375*	Guangxi (China)	
Malus muliensis T.C.Ku	Accepted	PE01685058/ PE01862281	*Qinhai & Tibet Team 12983*	Sichuan (China)	Isotype/ Holotype
Malus ombrophila Hand.-Mazz.	Accepted	WU0059445	*Handel-Mazzetti 9119*	Yunnan (China)	Holotype
		PE00953082	*K.M. Feng 6020*	Yunnan (China)	
		PE00953040	*T.T. Yü 5434*	Yunnan (China)	
		PE01494507	*W.L. Chen 14591*	Tibet (China)	
		PE00953022	*D.A. P 41913*	Yunnan (China)	
		PE01147846	*Beijing Hengduan Mountain Team 02609*	Yunnan (China)	
		PE01140200	*Chin-Sung Chang, Hui Kim, Hyo-In Lim, et al. SI0304*	Sichuan (China)	
		PE00953048	*P.Y. Mao 00425*	Yunnan (China)	
		PE01494503	*Ecological Office Plateau Team 14870*	Tibet (China)	
		KUN1305594	*H.J. Dong, F. Zhao WM-0462*	Yunnan (China)	
		KUN0662459	*Q.X. Wang 64070*	Yunnan (China)	
Malus orientalis Uglitzk. ex Juz.	Accepted	E00439219	*D.P. Hadland D38468*	Turkey	
		E00439220	*D.P. Hadland; C.M.J. Elgar & F. Yaltirik D37962*	Baskale (Turkey)	
		E00439224	*D.P. Hadland & O.V. Polunin 23836*	Baskale (Turkey)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus orientalis Uglitzk. ex Juz.	Accepted	E00439225	*D.P. Hadland & C.M.J. Elgar D37530*	Eregli (Turkey)	
		E00439227	*P. Wendelbo; I. Hedge & L. Ekberg W7844*	Kuh e Darunta (Afghanistan)	
Malus prattii (Hemsl.) C.K.Schneid.	Accepted	GH00032502	*A.E. Pratt 93*	Sichuan (China)	Isolectotype
		K000758434	*A.E. Pratt 93*	China	Lectotype
		QIN05038	*Not on Sheet s.n.*	–	
		K000758435	*A.E. Pratt 824*	China	
		K000758436	*A.E. Pratt 825*	China	
		P01819339	*A.E. Pratt 824*	Tibet (China)	
		P01819343	*A.E. Pratt 93*	West Sichuan and Tibet Frontier (China)	Isolectotype
		PE00953094	*Q.S. Zhao 0394*	Sichuan (China)	
		HHBG-HZ016028	*X.Y. He 2034*	Zhejiang (China)	
Malus platycarpa Rehder	Synonym	A00026632	*T.G. Harbison 503*	Franklin, North Carolina (USA)	Type
		A00026633	*T.G. Harbison 503*	Franklin, North Carolina (USA)	Type
		K000758462	*T.G. Harbison 742=504*	Franklin, North Carolina (USA)	
Malus platycarpa var. *hoopesii* (Rehder) Rehder	Unresolved	A00106224	*Not on Sheet s.n.*	Massachusetts (USA)	Type
		P03240273	*S.F. Blake 10831*	Virginia (USA)	
Malus rockii Rehder	Accepted	A00026653	*J.F. Rock 6842*	Yunnan (China)	Type
		US00097446	*J.F. Rock 6842*	Yunnan (China)	Isotype
		K000758448	*R. Strachey, J.E. Winterbottom 7*	India	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus rockii Rehder	Accepted	K000758449, K000758450	*Falconer 393*	India	
		K000758451	*H. Royle s.n.*	India	
		NAS00002410	*G. Yao, G.G. Tang, W.L. Zheng, G.Pan 389*	Tibet (China)	
		NAS00002396	*G. Yao, G. G. Tang, W.L. Zheng, G. Pan 1834*	Tibet (China)	
Malus sargentii Rehder	Synonym	QIN05051	*Not on Sheet s.n.*	–	
		P03144354	*6277*	Japan	
		KUN0937887	*L. DeMink, S. Kirt, J. Pinkard 8513V98*	Lisle, Illinois (USA)	
		PE00953561	*F.S. Zhang 511*	Shandong (China)	
		PE00953606	*Yeshengsuo 8576*	Hunan (China)	
Malus sieboldii (Regel) Rehder	Synonym	A00023545	*J. Cavalerie 93*	Guizhou (China)	Holotype (*Crataegus cavaleriei*)
		A00245460	*J. Cavalerie 93*	Guizhou (China)	Holotype (*Crataegus cavaleriei*)
		K000758420	*J. Cavalerie 3303*	China	Type
		QIN05054/ QIN05055	*Not on Sheet s.n.*	–	
		P03302835	*Jin-Kui Liu 501*	Hunan (China)	
		P03132499	*2080*	Asia	
		P03132500	*Not on Sheet s.n.*	Asia	
		P03132503	*Not on Sheet s.n.*	Asia	
		P03132504	*2857*	Asia	
		PE00953693	*W. Zhang et al. 50191*	Guizhou (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus sieboldii (Regel) Rehder	Synonym	KUN0804500	*M. Ono, S. Kobayashi 133059*	Tochigi (Japan)	
		KUN0662696	*H.T. Im 4750*	Yamanashi (Japan)	
		KUN1301749	*Y. Cho, H. Na WR-20130902-193*	Jeonnam (South Korea)	
		KUN0662678	*M.Y. Nie, X.H. Lu, X.D. Song, S.L. Yu 08773*	Jiangxi (China)	
Malus sieversii (Ledeb.) M.Roem.	Accepted	KUN0662683	*G.K. Qin 87*	Xinjiang (China)	
		KUN1254057	*H. Sun, T. Deng, S. Volis, Z. Zhou, T. Komiljon 17642*	Chimgan (Uzbekistan)	
		LE01053107	*Хасанов 659 [Xacanov 659]*	Xinjiang (China)	
		LE01053109	*Хасанов 659 [Xacanov 659]*	Xinjiang (China)	
Malus sikkimensis (Wenz.) Koehne ex C.K.Schneid.	Accepted	M0213665	*J.D. Hooker s.n.*	India	Isosyntype
		M0213666	*J.D. Hooker s.n.*	India	Isosyntype
		K000758441	*Griffith 2081*	Myanmar	
		K000758442	*J.D. Hooker s.n.*	Sikkim (India)	
		K000758443	*J.D. Hooker s.n.*	Sikkim (India)	
		K000758444	*J.D. Hooker s.n.*	Sikkim (India)	
		K000758446	*J.D. Hooker s.n.*	Sikkim (India)	
		K000758447	*s.coll. s.n.*	India	
Malus spectabilis (Aiton) Borkh.	Unresolved	M0154380	*P.F. von. Siebold s.n.*	Japonia (Japan)	
		M0154381	*P.F. von. Siebold s.n.*	Japonia (Japan)	
		M0213667	*Not on Sheet s.n.*	Japonia (Japan)	
		P03132533	*Not on Sheet s.n.*	Asia	
		P03132534	*M.A. Sontag s.n.*	South Korea	
		P03132535	*Not on Sheet s.n.*	Shandong (China)	
		P03132540	*Not on Sheet s.n.*	Asia	
		P03132541	*Not on Sheet s.n.*	China	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus sublobata Rehder	Unresolved	K000758473	*Anonymous s.n.*	–	
Malus sylvestris (L.) Mill.	Accepted	P01000498	*F. Fournié s.n.*	Forêt de Sénart (France)	
		P03240520	*M. Miévill 1921*	Asia	
		P03240521	*M. Miévill 1921*	Asia	
		P03240522	*M. Miévill 1921*	Asia	
		P03240523	*M. Miévill 1921*	Asia	
		P03302809	*Not on Sheet s.n.*	Asia	
		P03302812	*Not on Sheet 5110*	France	
		P03302813	*Not on Sheet 9008*	France	
		P03302815	*Not on Sheet 2927*	France	
		P03207281	*Not on Sheet s.n.*	France	
		KUN0937826	*H. Oleari 8986V99*	Lisle, Illinois (USA)	
Malus sylvestris subsp. *orientalis*	Unknown	E00439202	*M.J.E. Coode, B.M. G.Jones #2868*	Inecik (Turkey)	Lecotype
Malus theifera Rehder	Synonym	US00097447	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		E00284935	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		E00010837	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		CAS0008195	*E.H. Wilson 451*	Hubei (China)	Isosyntype
		K000758418	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		GH00026659	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		GH00026657	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		A00026658	*E.H. Wilson 451*	Hubei (China)	Isolectotype
		A00026656	*E.H. Wilson 451*	Hubei (China)	Lectotype
Malus toringo (Siebold) Siebold ex de Vriese	Accepted	P00783340	*F. Konta 35823*	Honshu (Japan)	
		PE01504803	*K. Inagaki CBM105283*	Hokkaido (Japan)	
		KUN1261369	*F. Konta 35832*	Mount Fuji (Japan)	
		KUN0813805	*Y. Tateishi 14876*	Mikamine (Japan)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus toringo (Siebold) Siebold ex de Vriese	Accepted	KUN0118326	*T. Yahara, T. Kato, Y. Watano, T. Kubo, H.T. Im, T. Kawahara, K. Kitajima, J. Murata 7242*	Gumma (Japan)	
Malus toringoides (Rehder) Hughes	Accepted	A00020423	*E.H. Wilson 1285*	Sichuan (China)	Holotype
		QIN05060	*Not on Sheet s.n.*	–	
		US00097450	*E.H. Wilson 1285*	Sichuan (China)	Isotype
		K000758425	*E.H. Wilson 3494*	China	
		P03240524	*N.E. Kawn 6021*	China	
		P03240525	*J.F. Rock 15074*	Jiangsu (China)	
		P03240527	*J.F. Rock 12483*	Jiangsu (China)	
		KUN0662723	*X.Li 70553*	Sichuan (China)	
		KUN0662724	*Qinhai & Tibet Team 73-988*	Tibet (China)	
		KUN0662725	*Qinhai & Tibet Team 73-988*	Tibet (China)	
Malus transitoria (Batalin) C.K.Schneid.	Accepted	K000758422	*Przewalsky 754*	China	Type
		QIN05058	*Not on Sheet s.n.*	–	
		QIN05059	*Not on Sheet s.n.*	–	
		K000758424	*Przewalsky 754*	China	
		P03240528	*Przewalsky 55*	Jiangsu (China)	
		P03240529	*R.C. Ching 724*	Jiangsu (China)	
		P03240530	*J.F. Rock 13539*	Jiangsu (China)	
		PE01461312	*Anonymous s.n.*	Shaanxi (China)	
		HNWP95806	*R.F. Huang, Y.C. Yang 1747*	Qinghai (China)	
		PE00953981	*Yellow River Investigation Team 4152*	Gansu (China)	
		PE00953979	*T.Y. Le s.n.*	Shaanxi (China)	

Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus transitoria (Batalin) C.K.Schneid.	Accepted	PE00953984	*Yellow River Investigation Team 3531*	Gansu (China)	
		PE00953973	*Huanghe Exp. Team 4272*	Gansu (China)	
		KUN0662713	*Yellow River Investigation Team 3376*	Gansu (China)	
		KUN0662715	*Qinhai & Tibet Team 73-26*	Tibet (China)	
Malus transitoria var. *glabrescens* T.T.Yu & T.C.Ku	Synonym	PE00964003/ PE00964001	*Anonymous 76-66*	Tibet (China)	Paratype
		PE00964004	*Y.W. Tsui 5553*	Tibet (China)	Paratype
		SZG00026156	*C.M. Tan, G.H. Yi, F.F. Chen, Lanzhou 005*	Gansu (China)	
		PE00964002	*Qing-Zang Exped. Veg. Group 10023*	Tibet (China)	Holotype
Malus trilobata (Labill. ex Poir.) C.K.Schneid.	Accepted	TCD0018096	*R.H. Webb s.n.*	Orient Liban (Lebanon)	Type
		K000283471	*G. Samuelsson 5940*	Bsharre Hadet ej Jobbe (Lebanon)	
		K000283474	*P.H. Davis 9858*	El Hermel Hermel (Lebanon)	
Malus tschonoskii (Maxim.) C.K.Schneid.	Accepted	QIN05066	*Not on Sheet s.n.*	–	
		P03240531	*Savarier 3709*	Asia	
		P03240532	*Savarier 3709*	Asia	
		P03240533	*Savarier 3425*	Asia	
		P03240534	*Savarier 3425*	Asia	
		P03240535	*G. Murata 18042*	Honshu (Japan)	Isolectotype
		KUN0662716	*J. Murata, H.T. Im, N.Murakami 105261*	Gunma (Japan)	

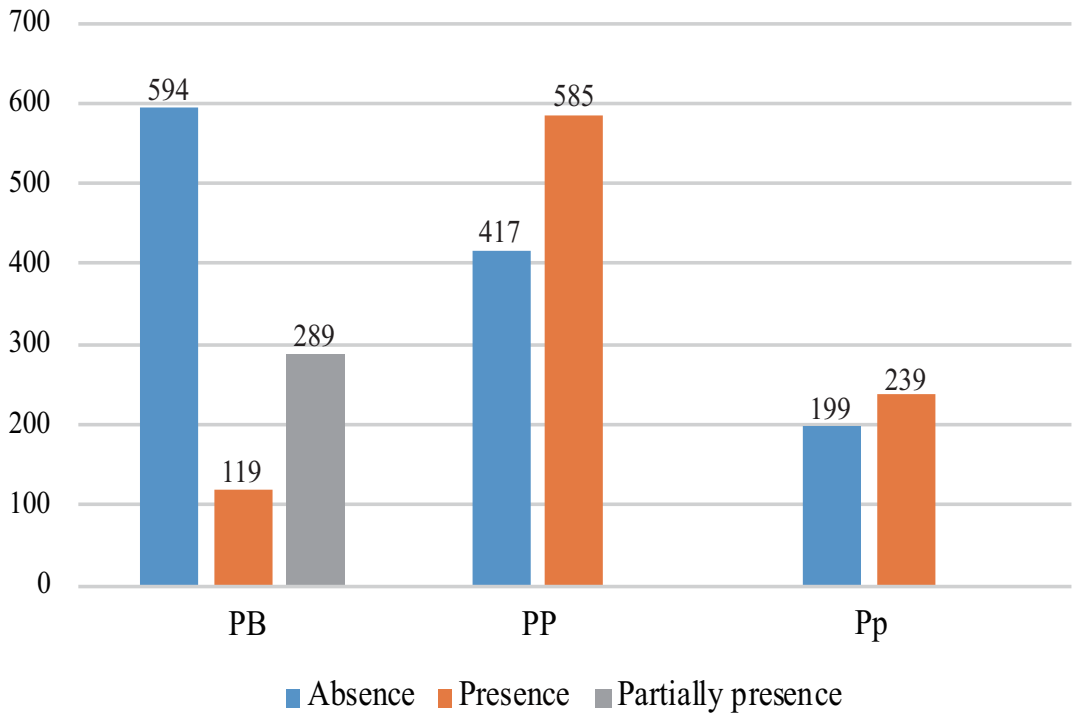
Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus tschonoskii (Maxim.) C.K.Schneid.	Accepted	KUN0760817	*M. Furuse 45632*	Sagami (Japan)	
		KUN0867803	*M. Furuse 45632*	Sagami (Japan)	
		KUN0867804	*M. Furuse 45632*	Sagami (Japan)	
Malus xiaojinensis M.H.Cheng & N.G.Jiang	Unresolved	CDBI0043876	*Sichuan Vegetation Group 9447*	Sichuan (China)	
		CDBI0043872	*G.N. Jiang et al. 128*	Sichuan (China)	
		PE00964204	*Q. Shi et al. 840025*	Sichuan (China)	
		PE00964011	*X. Li 70352*	Sichuan (China)	
		PE00964012	*S. Jiang et al. 9448*	Sichuan (China)	
		PE00964208	*Q. Shi et al. 840025*	Sichuan (China)	
		PE00964008	*Chuanjingzhi Heishui Group 1054*	Sichuan (China)	
		CDBI0043884	*F.Y. Qiu 4405*	Sichuan (China)	
		CDBI0043883	*F.Y. Qiu 4406*	Sichuan (China)	
Malus yunnanensis (Franch.) C.K.Schneid.	Accepted	GH00032511	*J.M. Delavay s.n.*	Yunnan (China)	Type
		K000758438	*J.M. Delavay 2331*	Yunnan (China)	Isotype
		K000758439	*J.M. Delavay 2331*	Yunnan (China)	Isotype
		QIN05064	*Not on Sheet s.n.*	–	Type
		QIN05065 (K000758437)	*J.M. Delavay 2331*	Yunnan (China)	Type
		P01819335	*J.M. Delavay 2331*	Yunnan (China)	Type
		P01819336	*J.M. Delavay 2331*	Yunnan (China)	Isotype
		P01819338	*J.M. Delavay 2331*	Yunnan (China)	
		P03240536	*M.Fr. Ducloux 6797*	Yunnan (China)	
		P03240538	*R.P. Farges 791*	Sichuan (China)	
		P03240539	*F. Ducloux 6197*	Yunnan (China)	

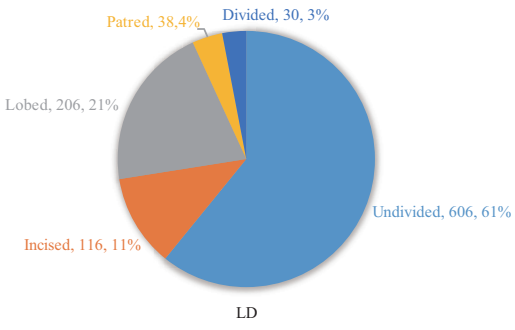
Appendix 1 (continued).

Taxon	Status	Barcode	Collection number	Locality	Type status
Malus yunnanensis (Franch.) C.K.Schneid.	Accepted	P03240541	*R.P. Farges s.n.*	Sichuan (China)	
		P03240542	*R.P. Farges 133*	Sichuan (China)	
Malus yunnanensis var. *veitchii* (Osborn) Rehder	Synonym	A00026642	*Not on Sheet s.n.*	Jamaica Plain, Massachusetts (USA)	Lectotype
		A00106227	*W.J. Bean s.n.*	Kew (UK)	Isotype
		K000758472	*Anonymous W539*	–	Lectotype *Pyrus veitchiana*
		PE00964186	*J.H. Xiong, Z.L. Zhou 90818*	Chongqing (China)	
		PE00997404	*Hubei Shennongjia Expedition Team 32514*	Hubei (China)	
		PE00964185	*J.H. Xiong, Z.L. Zhou 91138*	Chongqing (China)	
		PE01357619	*Y.M. Wang 5803*	Hubei (China)	
		PE00964192	*K.J. Guan, J.W. Wang, C.L. Li 1156*	Chongqing (China)	
		CDBI0043927	*K.J. Guan, J.W. Wang, C.L. Li 1157*	Chongqing (China)	
		PE01357615	*Hupingshan Expedition Team 1457*	Hunan (China)	

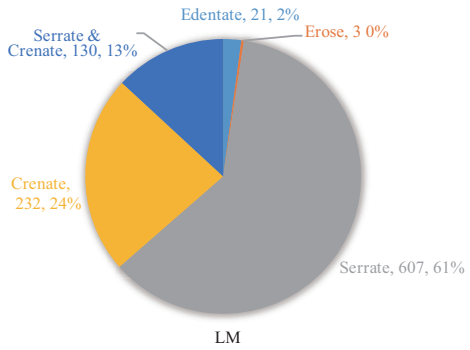
Appendix 2. Frequency distribution of qualitative morphological parameters.



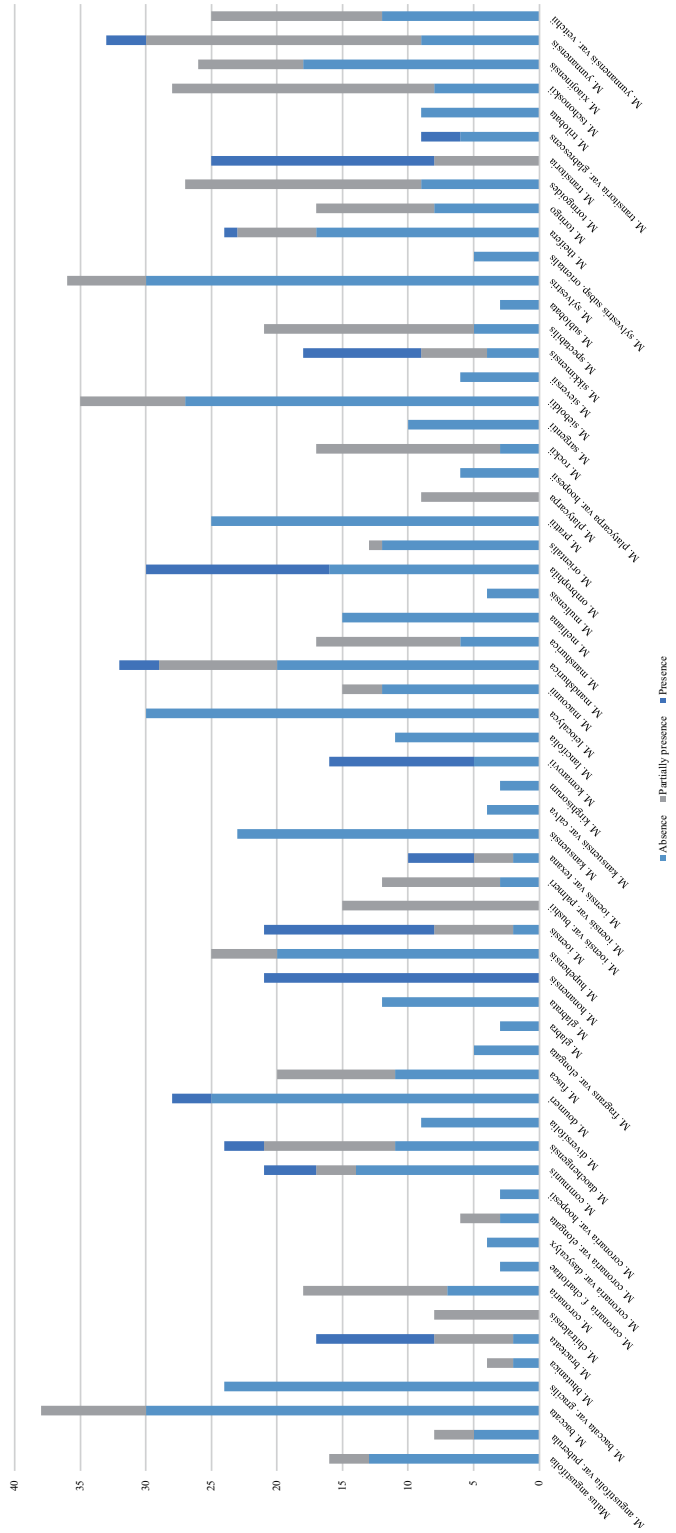
The condition of indumentum in piliferous blade (PB), piliferous petiole (PP) and piliferous pedicel (Pp).



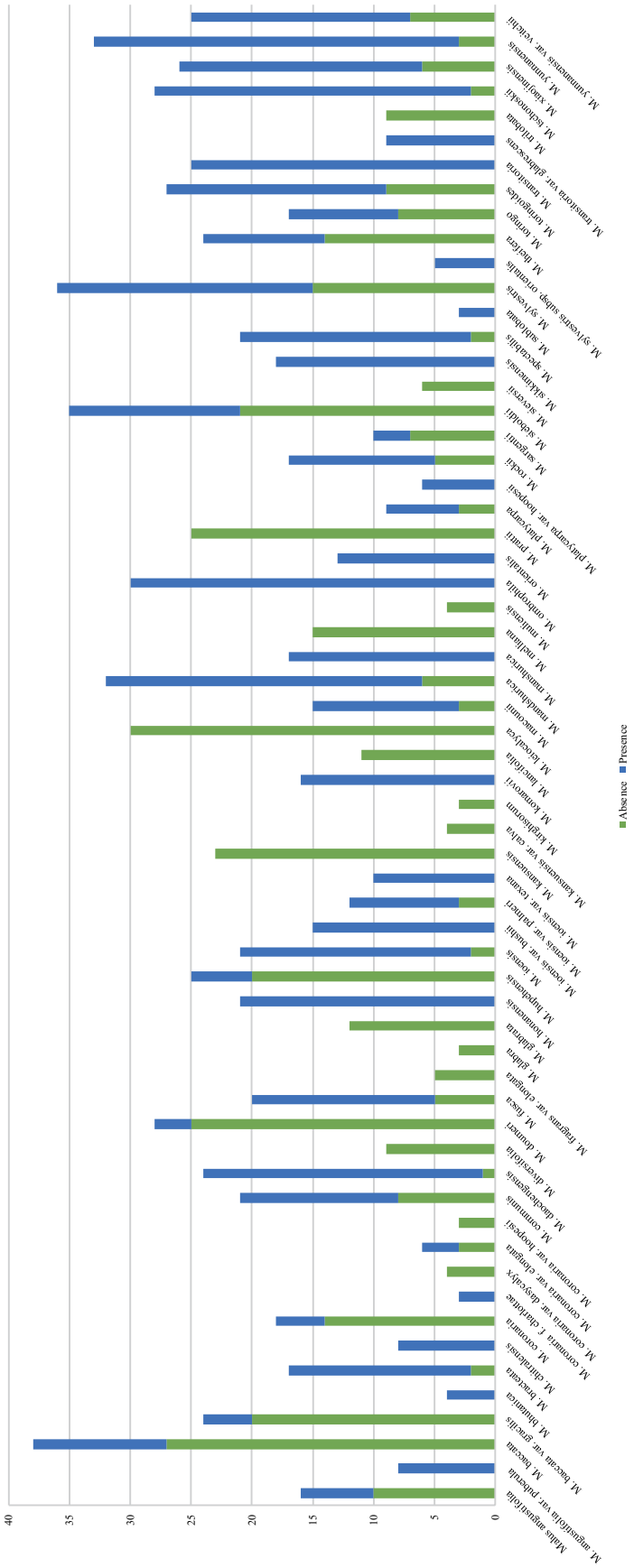
Frequency distribution of leaf division (LD).



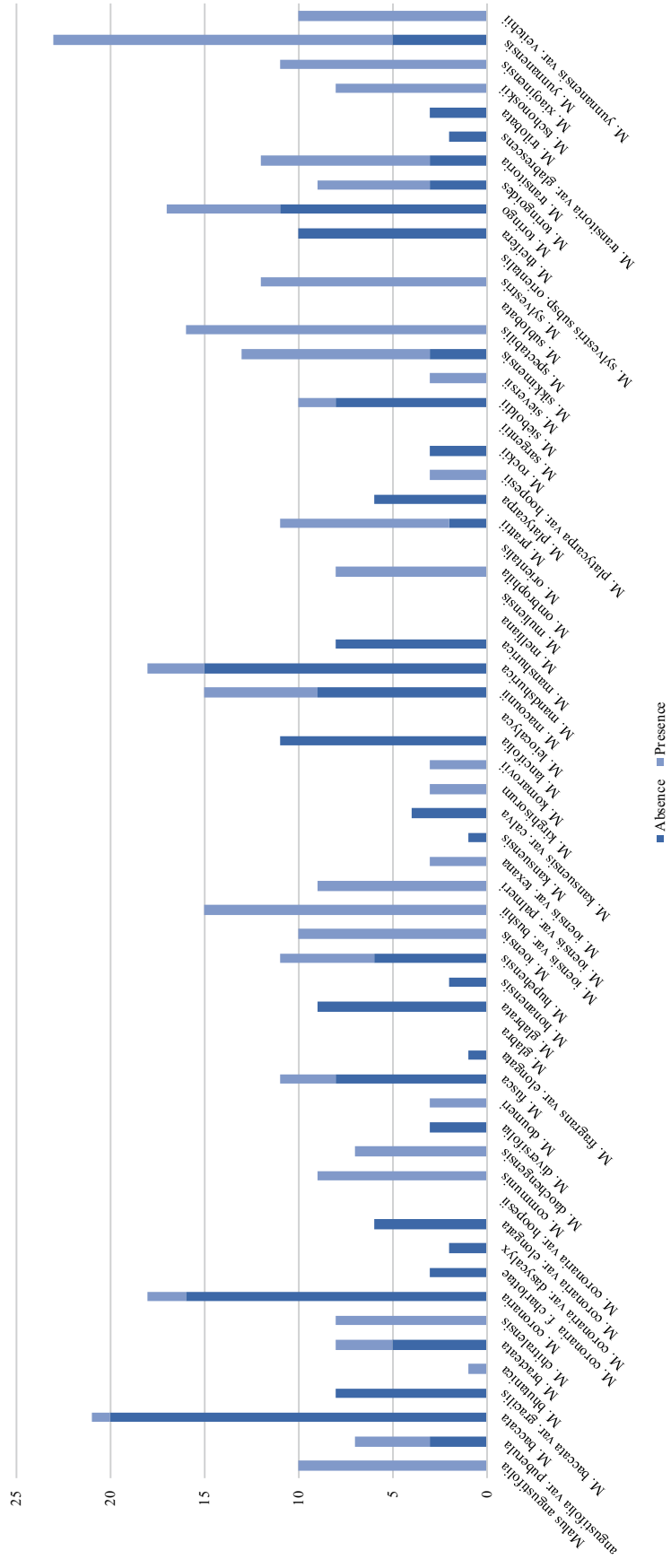
Frequency distribution of leaf margins (LM).



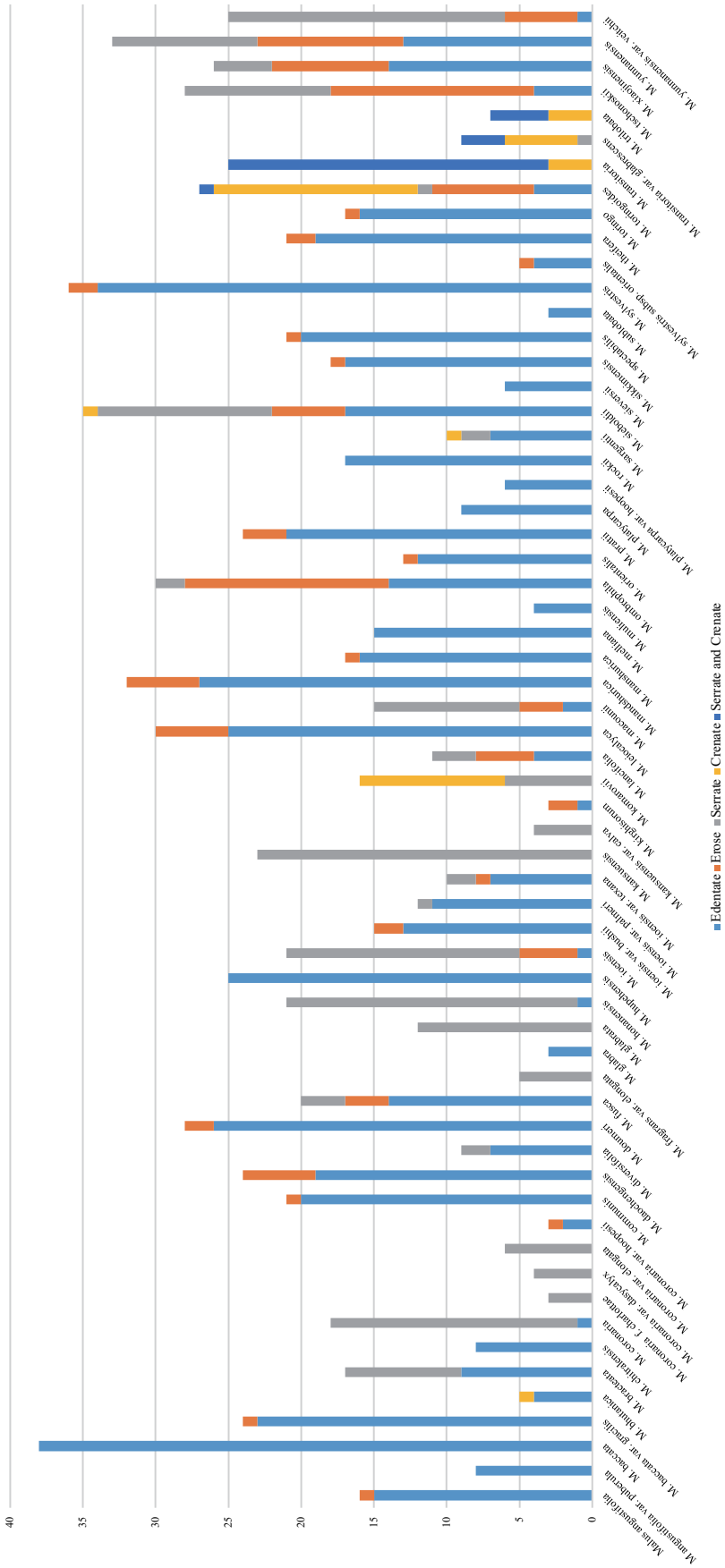
The condition of piliferous blade (PB) in each of the selected species.



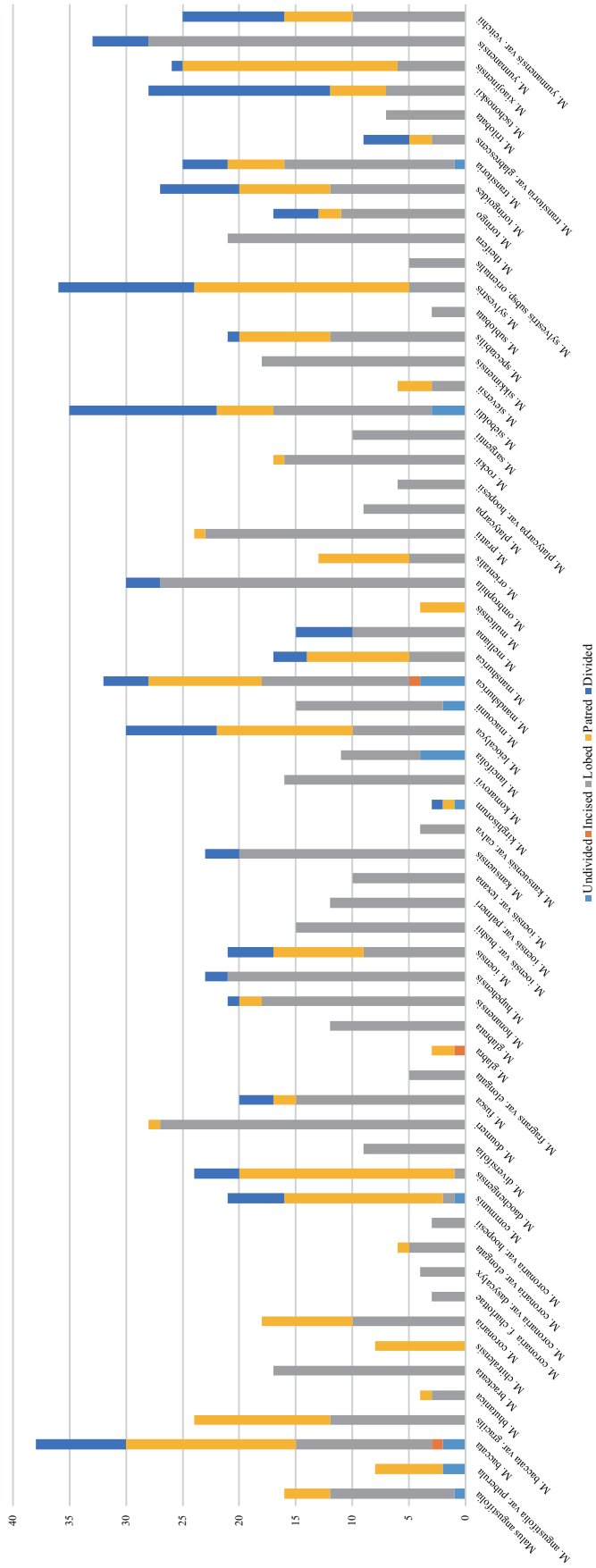
The condition of piliferous petiole (PP) in each of the selected species.



The condition of piliferous pedicel (Pp) in each of the selected species.



The condition of leaf division (LD) in each of the selected species.



The condition of leaf margins (LM) in each of the selected species.