Notes RBG Edinb. 40(1):205–211 (1982)

A CHEMOTAXONOMIC SURVEY OF THE GENERA SORBUS AND MICROMELES IN ASIA

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ABSTRACT. Vitexin (apigenin 8-C-glucoside) occurs in most species of Asian *Sorbus* subgenus *Aria* and vitexin + flavone O-glycosides occur in some species of Asian subgenus *Sorbus* (*Aucuparia*). Vitexin + one single flavone O-glycoside (luteolin 7-O-glucoside) occur in some species of the Asiatic genus *Micromeles*. The chemotaxonomic survey has helped to diagnose the probable parentage of certain hybridogeneous species of Asian *Sorbus*.

A recent chemotaxonomic survey of the European species of the genus *Sorbus* has indicated that certain leaf flavonoids are of considerable value as markers of taxonomic relationships within the genus (Challice & Kovanda, 1978a, b). It was found that within the primary sexual species, vitexin (apigenin 8-C-glucoside) is restricted to *Sorbus torminalis* and *S. chamaemespilus*, both of which represent separate monotypic subgenera, *Torminaria* (DC.) C. Koch and *Chamaemespilus* (DC.) C. Koch respectively. Four different flavone O-glycosides, luteolin 7-O-rhamnosylglucoside, luteolin 7-O-diglucoside, luteolin 7-O-glucoside and luteolin 4′-O-glucoside, were found to be restricted to *S. torminalis* alone of the primary sexual species in Europe. The remaining primary sexual species, belonging to the subgenera *Aria* Pers., *Cormus* (Spach) Duchartre and *Sorbus s.str.* (*Aucuparia* Medik.) were found to lack both flavone O- and C-glycosides; thus the parentage of certain European hybridogeneous species, derived from *S. aria* × *S. torminalis* and *S. aria* × *S. chamaemespilus*, could be confirmed. Occasionally apigenin 7-O-glucoside was found to accompany the luteolin O-glucosides in *S. torminalis* and its hybrids, but this occurrence did not appear to have any taxonomic significance.

Now the survey of *Sorbus* flavonoids has been extended to include a large number of species from Asia and also the closely related Asian genus *Micromeles* (Decaisne) Koehne which is often included within *Sorbus*. Species representing all of Gabrielian's sections and subsections of *Sorbus* from her recent monograph (Gabrielian, 1978) have been examined and the results now provide fresh insights into the taxonomy of the genus; the flavonoid occurrences in a large number of herbarium leaf specimens are summarised in Tables 1 to 3. A list of the specimens studied is given in the appendix.

Of the 24 Asian species from the subgenus *Sorbus* (*Aucuparia*), 11 contain vitexin and/or flavone O-glucosides whilst 13 species appear to lack both of these flavonoid types. Interestingly, a preliminary survey of all of the few endemic N American species of *Sorbus* (all of which are referable to subgenus *Sorbus*) has shown a complete lack of both flavone C- and O-glycosides in *S. scopulina*, *S. sitchensis*, *S. decora*, *S. californica*, *S. occidentalis*, and *S. americana* (Challice & Kovanda, 1979). The finding of vitexin and/or flavone O-glycosides in Asian species of subgenus *Sorbus* highlighted the fact that our previous survey of European *S. aucuparia* included specimens from UK (England) and Czechoslovakia only; now it has been established that specimens from Norway,

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TABLE 1

Distribution of flavonoids in Asian *Sorbus* subgen. *Sorbus (Aucuparia)*

	Number examined	*Vitexin*	*Flavone O-glycosides*
S. ursina (Wenzig) Hedl.	3	+	0
S. sargentiana Koehne	1	0	+(?)
S. pohuashanensis (Hance) Hedl.	1	0	+(?)
S. randaiensis (Hayata) Koidz.	1	+	+
S. wilsoniana Koehne	1	+	+
S. gracilis (Sieb. & Zucc.) C. Koch	1	+	+
S. pteridophylla Hand.-Mazz.	2	+	0
S. foliolosa (Wall.) Spach	1	0	+
S. wallichi (Hook. f.) Yü	1	0	+
S. microphylla Wenzig	3	+	+(?)
S. prattii Koehne	2	+	0
S. helenae Koehne	1	+	0

From this group, 13 species appear to lack both vitexin and flavone O-glycosides. These are (number of specimens examined are in parentheses): *S. cashmiriana* Hedl. (1), *S. himalaica* Gabr. (1), *S. tianshanica* Rupr. (4), *S. hupehensis* C. K. Schneid. (1), *S. esserteuiana* Koehne (1), *S. commixta* Hedl. (5), *S. matsumurana* Makino (1), *S. rufo-ferruginea* (C. K. Schneid.) C. K. Schneid. (1), *S. sambucifolia* Roem. (2), *S. scalaris* Koehne (1), *S. glomerulata* Koehne (1), *S. rehderiana* Koehne (1), *S. koehneana* C. K. Schneid. (2), *S. vilmorinii* C. K. Schneid. (1), *S. filipes* Hand.-Mazz. (1), *S. insignis* (Hook. f.) Hedl. (3).

Note: Not all specimens of the same species were found to contain the flavonoids listed above. The actual specimen containing the flavonoid(s) in question is indicated by an asterisk in the appendix.

Sweden, Finland, USSR (Moscow), Bulgaria, Greece, Turkey, Austria, Switzerland, Spain, Portugal and UK (Wales) also lack both flavone C- and O-glycosides (Challice & Kovanda, 1979). Thus we can now be far more certain that these flavonoids are completely absent from European *S. aucuparia*.

In the part of the subgenus *Aria* which is designated by Gabrielian as section *Lobatae*, distinct from her section *Aria* and consisting largely of hybridogeneous species, either vitexin or flavone O-glycosides occur in some species, but interestingly they were found not to occur together in the same specimen. In Table 2 Gabrielian's section *Lobatae* species are indicated by the suffix [L]. Of all the Asian species of *Sorbus* and *Micromeles* examined in the present survey, the rare luteolin 4′-O-glucoside appears to be restricted to *S. armeniaca* and to the Turkish specimen of *S. takhtajanii*. Elsewhere in *Sorbus*, this particular flavone glucoside was previously found only in *S. torminalis* together with some of its hybrids (Challice & Kovanda, 1978b). In the remainder of subgenus *Aria*, vitexin was found in most species, generally unaccompanied by flavone O-glycosides.

In the genus *Micromeles* (Table 3) it will be noted that vitexin and/or one particular flavone O-glycoside (luteolin 7-O-glucoside) occur in some of the species, with the occurrence of intraspecific variation as indicated.

The subgenera *Torminaria*, *Cormus* and *Chamaemespilus* (all monotypic taxa) are European and have thus been adequately covered by our previous survey (Challice & Kovanda, 1978a, b).

The finding of vitexin and flavone O-glycosides in the Asian species of *Sorbus*, particularly in subgenus *Sorbus s.str.* was unexpected; the European representatives of these taxa evidently evolved from the more primitive Asian

TABLE 2

Distribution of flavonoids in Asian *Sorbus* subgen. *Aria*

	Number examined	*Vitexin*	*Flavone O-glycosides*
S. lanata (D. Don) Schauer	2	+	0
S. cuspidata (Spach) Hedl.	5	+	0
S. thibetica (Cardot) Hand.-Mazz.	3	+	0
S. pallescens Rehder	4	+	0
S. subfusca (Ledeb.) Boiss.	1	+	0
S. umbellata (Desf.) Fritsch	10	+	0
S. graeca (Spach) Hedl.	6	+	0
S. hajastana Gabr.	1	+	0
S. zahlbruckneri C. K. Schneid.	1	+	0
S. turkestanica (Franchet) Hedl. [L]	2	+	0
S. armeniaca Hedl. [L]	2	0	+
S. takhtajanii† Gabr. (Armenia) [L]	1	+	0
S. takhtajanii† Gabr. (Turkey) [L]	1	0	+
S. persica Hedl. [L]	4	+	0
S. shirinensis Hadač & Chrtek	1	+	0
S. luristanica† (Bornm.) Schönbeck-Temesy [L]	2	+	0

From this group 5 species appear to lack both vitexin and flavone O-glycosides. These are (number of specimens examined are in parentheses): *S. megalocarpa* Rehder (2), *S. roopiana*† Bordz. [L] (1), *S. tamamschjanae*† Gabr. [L] (1), *S. caucasica* Zinserl. [L] (1), *S. kusnetzovii*† Zinserl. [L] (5).

† = hybridogeneous species, [L] = referred by Gabrielian (1978) to a separate taxon, 'section *Lobatae*'.

Note: Not all specimens of the same species were found to contain the flavonoids listed above. The actual specimen containing the flavonoid(s) in question is indicated by an asterisk in the appendix.

forms, accompanied by a loss of the ability to synthesize vitexin and flavone O-glycosides. The subgenera *Sorbus s.str.* and *Torminaria*, whilst they are in some important morphological aspects evolutionarily quite advanced, are in some other morphological aspects and in a chemical sense quite primitive. We evidently have here what Gabrielian (1978) refers to as 'an evolutionary heterobathmy of characters'.

One obvious way of solving the problem of the phylogenetic origins of *Sorbus* would be to assign polyphyletic status to all subgenera, i.e. to postulate that all subgenera evolved independently from primitive *Crataegus* with in all instances the loss of orientin (luteolin 8-C-glucoside) (Nikolov, 1977). A similar situation could exist in *Micromeles*. Alternatively it could be postulated that there once existed a primitive Asian *Aria* group containing both vitexin and flavone O-glycosides which evolved directly from primitive *Crataegus* with loss of orientin. All other subgenera of *Sorbus* and possibly *Micromeles* could then be derived more or less independently from this primitive *Aria* group by a series of loss-mutations of the flavonoids previously mentioned.

The present study seems to go some way towards solving the long standing problem of the parentage of the apomictic Scandinavian hybridogeneous species *S. intermedia*. Morphologically the evidence indicates a parentage of *S. aria* × *S. aucuparia* but this was seemingly contradicted by the chemical evidence which indicated that *S. torminalis* was involved in its parentage (Challice & Kovanda, 1978b). Now it seems quite probable that *S. intermedia* originated in Scandinavia with vitexin and flavone O-glycosides deriving from primitive members of either

TABLE 3

Distribution of flavonoids in Asian *Micromeles*

	Number examined	*Vitexin*	*Luteolin 7-O-glucoside*
M. aronioides (Rehder) Kovanda & Challice (China: *Yü*)	4	+	0
M. corymbifera (Miq.) Kalkman (China)	1	0	+
" " (Vietnam)	1	0	+
" " (Malaya)	2	+	0
" " (Sumatra)	1	+	+
M. keissleri C. K. Schneid.	2	+	0
M. folgneri C. K. Schneid.	3	+	0
M. hemsleyi C. K. Schneid.	1	+	0
M. epidendron (Hand.-Mazz.) Kovanda & Challice			
(China: *Forrest*)	1	0	+
" (China: *Rock*)	1	+	0
" (China: *McLaren's collectors*)	1	0	0

From this group, five species appear to lack both vitexin and the flavone O-glycoside, luteolin 7-O-glucoside (the only flavone O-glycoside in *Micromeles*). These are (number of specimens examined are in parentheses): *M. alnifolia* (Sieb. & Zucc.) Koehne (7), *M. caloneura* Stapf. (1), *M. japonica* (Decaisne) Koehne (4), *M. meliosmifolia* (Rehder) Kovanda & Challice (1), *M. ferruginea* (Wenzig) Koehne (1).

M. corymbifera is the correct name for the species known as *M. granulosa* (Bertol.) C. K. Schneid. or *S. granulosa* (Bertol.) Rehder as shown by Kalkman (1973).

Note: Not all specimens of the same species were found to contain the flavonoids listed above. It will be noted that *Micromeles* is particularly prone to intraspecific variation in respect of flavonoid content. The actual specimen containing the flavonoid(s) in question is indicated by an asterisk in the appendix.

or both of the parental species. Chemically, there is no need to involve *S. torminalis*.

In our previous survey (Challice & Kovanda, 1978a, b) *S. umbellata* was found to lack vitexin but a more detailed examination of 10 specimens has revealed the presence of vitexin in 8 instances. However, this is hardly surprising since *S. umbellata s.l.* is basically a SW Asian species which in Europe extends only to the Balkans and S Italy.

Further examination of the quite closely related, but basically European, *S. graeca* (six specimens) revealed the presence of vitexin in two instances. Evidently the genes for vitexin biosynthesis do not have an over-meticulous respect for floristic boundaries! In fact both *S. umbellata* and *S. graeca* exhibit a considerable degree of polymorphism and require further detailed study in order to clarify their taxonomic status — see Gabrielian (1978) and Kovanda (1961) for reviews of this topic.

Chemically it seems that the hybridogeneous species *S. takhtajanii* is derived from *S. armeniaca* × *S. persica*; this is supported by inspection of the dendrogram in the numerical taxonomic study of *Sorbus* by Gabrielian & Gambarian (1972). Chemically, the Armenian specimen of *S. takhtajanii* resembles the supposed *S. persica* parent, whilst the Turkish specimen strongly resembles the supposed *S. armeniaca* parent. It is interesting that two specimens of one species should display such marked segregation of the parental genes for

flavonoid biosynthesis; a similar situation has been encountered in a supposedly hybridogeneous species of *Pyrus* (Challice & Westwood, 1973).

Full experimental details are given in Challice (1974) and Challice & Kovanda (1978b). Challice (1981) up-dates the review section of Challice (1974) in view of the important advances during the past seven years. The morphological aspects of this work will be investigated in a subsequent publication. A paper re-establishing *Micromeles* as a separate genus has recently been published (Kovanda & Challice, 1981).

Thanks are due to the curators of the Edinburgh, Kew, British Museum (Natural History) and Prague herbaria for kindly providing herbarium leaf material for analysis, and to Dr H. McAllister for material from the Liverpool University Botanic Garden, Ness. Thanks are also due to the British Council and to the Czechoslovak Academy of Sciences for financing travel between Czechoslovakia and the UK by the authors, under the academic links with Eastern Europe Scheme. We also thank Mr W. J. Redmond for the translation of Russian papers.

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*It should be noted that 'Zapadnoiy' is mistranslated as eastern instead of western in the title given to the English summary.

APPENDIX

List of specimens examined

An asterisk denotes the specimens actually containing the characteristic flavonoid(s). A list giving more data of the specimens is lodged at the library of the Royal Botanic Garden, Edinburgh.

Micromeles

M. alnifolia. China: Hupeh, *Ho-Chang Chow* s.n. 1934 (E); Shantung, *Niu Shu Tai, Lao Shan & C. Y. Chiao* 2692 (E). Japan: *Murata, Mimoro & Tsugaru* s.n. 1973 (K), *Tamura* s.n. 1965 (E), *Wilson* 7584 (K). Korea: *Tamura* 24224 (E). USSR: nr Vladivostok, *anon.* s.n. 1920 (PR).
M. aronioides. China: Szechuan, *Wilson* 4867 (K); Yunnan, *Forrest* 24420 (E), *McLaren's collectors* 1933 59C (E), *T. T. Yü* 16218 (E)*.
M. caloneura. China: Hupeh, *Wilson* 470 (E).
M. corymbifera. Burma: *Lace* s.n. 1909 (K). China: Yunnan, *Henry* 10136 (K)*. Malaya: *Corner* s.n. 1937 (K)*, *Wray & Robinson* 5520 (BM)*. Sumatra: *de Wilde & de Wilde-Duyfjes* s.n. 1972 (K)*. Vietnam: *Poilane* s.n. 1929 (E)*.
M. epidendron. China: Yunnan, *Forrest* 23255 (E)*, *McLaren's collectors* 1932 55 (PR), *Rock* 5386 (E)*.
M. ferruginea. China: Yunnan, *Forrest* 24465 (E).
M. folgneri. China: Anhwei, *Ren-Chang Ching* 2869 (E)*; Szechuan, *Fang* 1928 (E, K).
M. hemsleyi. China: Hupei, *Ho-Ch'ang Chow* 864 (E)*.
M. japonica. Japan: *Ichinotani* s.n. (K), *Naito* 721056 (E), *Takoda* s.n. 1904 (K), *anon.* s.n. 1904 (PRC).
M. keissleri. China: Szechuan, *Fang* 1377 (E); Yunnan, *Forrest* 17509 (E)*.
M. meliosmifolia. China: Szechuan, *Chu* 2910 (E).

Sorbus

S. armeniaca. Iran: *Parsa* 1941 32 (K)*. USSR: Caucasia, *Gabrielian* s.n. 1962 (E)*.
S. cashmiriana. NW Himalaya, *Baden-Powell* 124 (K).
S. caucasica. USSR: Kavkaz, *Gabrielian* s.n. 1953 (E).
S. commixta. Japan: *Faurie* 6691 (BM), *Naruhashi* 2663 (E), *Togashi & Yamazaki* 6647 (E). USSR: Sachalin, *Vašák & Jegorova* s.n. 1968 (PR); Kuril Islands, *Vašák* s.n. 1968 (PR).
S. cuspidata. Bhutan: *Ludlow, Sherriff & Hicks* 20236 (E)*. Nepal: *Polunin, Sykes & Williams* 1010 (BM)*, 2125 (E)*, 3082 (E)*, *Stainton, Sykes & Williams* 8619 (E)*.
S. esserteuiana. Cultivated, *McAllister* W1 (LIVU).
S. filipes. China: NW Yunnan, *Rock* 10070 (E).
S. foliolosa. Nepal: *Stainton, Sykes & Williams* 5107 (E)*.
S. glomerulata. China: Szechuan, *Fang* 836 (K).
S. gracilis. Japan: *Kawano, Ohashi & Ihara* 9596 (K)*.
S. graeca. Cyprus: *Economides* 1235 (K)*, *Young* s.n. 1961 (E). Turkey: *Baytop* s.n. 1968 (E), *Davis & Hedge* 31499 (E)*, *McNeill* 561 (E). USSR: Armenia, *Gabrielian* s.n. 1952 (E).
S. hajastana. USSR: Armenia, *Gabrielian* s.n. 1948 (E)*.
S. helenae. Cultivated, *McAllister* Q6 (LIVU)*.
S. himalaica. N India: *Parmanand* 1027 (E).
S. hupehensis. China: Szechuan, *Fang* 5506 (K).
S. insignis. NE Burma: *Forrest* 24481 (K). China: W Yunnan, *Forrest* 26778 (E). SE Tibet: *Rock* 22068 (E).
S. koehneana. China: Szechuan, *Rock* 24553 (K).
S. kusnetzovii. Turkey: *Davis* 13042 (E), 13446 (E), *Davis & Hedge* 31695 (E). USSR, Armenia: *Gabrielian* s.n. 1952 (E), s.n. 1960 (PR).
S. lanata. Kashmir: *A. P. Young* s.n. 1884 (BM)*. Nepal: *Polunin, Sykes & Williams* 4820 (E)*.
S. luristanica. Turkey: *Davis* 45007 (E)*. USSR, Armenia: *Gabrielian* s.n. 1952 (E)*.
S. matsumurana. Japan: *Faurie* 6691 (BM).
S. megalocarpa. China: Kweichow Province, *Steward, Chiao & Cheo* 414 (K); W Szechuan, *Wilson* 956 (K).
S. microphylla. Bhutan: *Ludlow, Sherriff & Hicks* 17472 (E). Nepal: *Polunin, Sykes & Williams* s.n. 1952 (E)*. Sikkim: *J. D. Hooker* s.n. 1887 (K).

S. pallescens. China: Szechuan, *Schneider* 1193 (E)*, *Wilson* 1255 (K)*; Yunnan, *Forrest* 19782 (E)*, *T. T. Yü* 20899 (E)*.
S. persica. Iraq: *Agnew, Hadač & Haines* 6084 (PR)*. Turkey: *Davis & Polunin* 23153 (E)*. USSR, Armenia: *Gabrielian* s.n. 1952 (E)*; Kazachstan, *Goloskokov* s.n. 1963 (E)*.
S. pohuashanensis. Mongolia: *Przewalsky* s.n. 1871 (E).
S. prattii. China: Szechuan, *Fang* 7690 (K); Yunnan, *McLaren's collectors* s.n. 1932 (PR)*.
S. pteridophylla. China: Yunnan, *McLaren's collectors* s.n. 1932 (PR)*. SE Tibet: *Rock* 23186 (E).
S. randaiensis. Taiwan: *Kanehira & Sasaki* 21811 (K)*.
S. rehderiana. Cultivated, *McAllister* N34 (LIVU).
S. roopiana. USSR, Armenia: *Gabrielian* s.n. 1952 (E).
S. rufo-ferruginea. Japan: *Mizushima* 10181 (K).
S. sambucifolia. Aleutian Islands: *Soule* 216 (K). Kamchatka: *Komarov* s.n. 1908 (K).
S. sargentiana. China: Szechuan, *Fang* 2216 (E)*.
S. scalaris. Cultivated, *McAllister* H2 (LIVU).
S. shirinensis. Iraq: *Agnew, Hadač & Haines* 6084 (PR)*.
S. subfusca. USSR, Armenia: *Gabrielian* s.n. 1952 (E)*.
S. takhtajanii. Turkey: *Davis & Polunin* 22270 (E)*. USSR: Armenia, *Gabrielian* s.n. 1952 (E)*.
S. tamamschjanae. Turkey: *McNeill* 594 (E).
S. thibetica. Bhutan: *Ludlow, Sherriff & Hicks* 16173 (E)*. China: Mekong-Salween divide, *Forrest* 13399 (K)*; Yunnan, *McLaren's collectors* 295 (PR)*.
S. tianschanica, E Tibet: *Rock* 13998 (E). USSR: Distr. Alma-Ata, *Vašák* s.n. 1972 (PR); Kazachstan, *Roldugin* 4412 (E, K).
S. turkestanica. Afghanistan: *Koelz* 13028 (E)*. USSR: Tadzhikistan, *Browicz* s.n. 1976 (E)*.
S. umbellata, Iraq: *Hadač & Faisal abd'el Kadar* 5687 (PR), *Haines* 512 (E), *Kass & Nuri* 27459 (K)*. Lebanon: *Samuelsson* s.n. 1933 (K)*. Turkey: *Davis & Coode* 37100 (E)*, 38873 (E)*, *McNeill* s.n. 1956 (E)*, *Polunin* 14014 (E)*, *Temmaz* 5218 (E)*. USSR: Georgian SSR, *Gabrielian* s.n. 1953 (E)*.
S. ursina. Nepal: *Shrestha & Joshi* 174 (BM), *Stainton, Sykes & Williams* 461 (E)*. Cultivated, *McAllister* H1 (LIVU)*.
S. vilmorinii. China: NW Yunnan, *Forrest* 19510 (K).
S. wallichii. Nepal: *Williams* 547 (BM)*.
S. wilsoniana. China: Kweichow, *Ping, Shan, Steward, Chiao & Cheo* 512 (K)*.
S. zahlbruckneri. China: Ahnwei, *Ren-chan Ching* 3223 (K)*.