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Research article

Taxonomic revision of *Bergera* J.Koenig ex L. (Rutaceae) based on the molecular phylogeny and morphology

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Abstract. Several phylogenetic studies have revealed that *Murraya* s. lat. is not monophyletic, suggesting that it should be split into two genera, namely *Murraya* s. str. and *Bergera* J.Koenig ex L. Here, the genus *Bergera* is comprehensively revised based on molecular and morphological data. The genus consists of 11 species in total, including all species previously placed in *Murraya* sect. *Bergera* and an additional species previously placed in *Murraya* sect. *Murraya*. Ten new combinations are proposed, namely *Bergera alternifolia* (Kurz) F.J.Mou comb. nov., *B. crenulata* (Turcz.) F.J.Mou comb. nov., *B. euchrestifolia* (Hayata) F.J.Mou comb. nov., *B. glabra* (Guillemin) F.J.Mou comb. nov., *B. kwangsiensis* (C.C.Huang) F.J.Mou comb. nov., *B. macrophylla* (C.C.Huang) F.J.Mou comb. nov., *B. microphylla* (Merr. & Chun) F.J.Mou comb. nov., *B. siamensis* (Craib) F.J.Mou comb. nov., *B. stenocarpa* (Drake) F.J.Mou comb. nov., and *B. tetramera* (C.C.Huang) F.J.Mou comb. nov. An identification key of the 11 species and morphological descriptions are provided, as well as illustrations of diagnostic characteristics. Phylogenetic relationships of the species in *Bergera* are discussed.

Keywords. *Bergera*, *Murraya*, revision, Rutaceae.

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Introduction

The genus *Bergera* J.Koenig ex L. was first published based on *Bergera koenigii* L., while the genus *Murraya* J.Koenig ex L. was founded based on *Murraya* ("*Murraea*") *exotica* L. (Linnaeus 1771). Later, *Bergera koenigii* was transferred to *Murraya* by Sprengel (1825), which was accepted by most subsequent researchers. Though the generic name *Chalcas* L. was earlier described by Linnaeus (1767) based upon *C. paniculata* L. of Caminium of Rumphius (Rumpf 1747), most people accepted the name *Murraya* and it was proposed to be conserved by Mabberley (2016, 2017). Based on several flower characteristics,

Tanaka (1929) divided species of *Chalcas* (an earlier name than *Murraya*) into two sections, namely *Chalcas* sect. *Bergera* comprising taxa with many small flowers and dilated filaments, and *Chalcas* sect. *Euchalcas* including species with a few large flowers with filiform filaments. But *et al.* (1986) also proposed that eight species of *Murraya* in China could be divided into two groups, namely *Murraya* sect. *Bergera* and *Murraya* sect. *Murraya* based on a few morphological characteristics and phytochemicals. *Murraya* sect. *Bergera* was characterized by dark-brown stems and root bark, oil glands distributed in and at the margins of leaflet blades, smaller petals (4–7 mm long), purplish black or red globular to ellipsoid fruits, and a membranous and glabrous testa, while *Murraya* sect. *Murraya* was characterized by straw-coloured to light greyish-yellow old branches and root bark, oil glands distributed throughout leaflet blades, relatively larger petals (10–20 mm long), red and ellipsoid fruits, and a hard testa covered with greyish hairs (But *et al.* 1986; Zhang *et al.* 2008). Species of section *Bergera* were characterized by the presence of carbazoles and absence of prenylcoumarins, while those in section *Murraya* were found to contain only yuehchukene and prenylcoumarins but no carbazoles (But *et al.* 1986). The evidences of phytochemical data from other studies (But *et al.* 1986; Kong *et al.* 1986; Li *et al.* 1988; Kinoshita 2014) also supported the taxonomical subdivision of the genus.

The genus *Murraya* s. lat. is not monophyletic based on independent lines of evidence. Section *Bergera* is much closer to the genus *Micromelum* Blume (Tanaka 1929; Kong *et al.* 1986, 1988a, 1988b; Kinoshita 2014) or *Clausena* Burm.f. (Samuel *et al.* 2001; Mou *et al.* 2018) in that carbaxoles were found in the plants of both genera, while section *Murraya* is close to *Merrillia* Swingle of the tribe Citreae Meisn. based on morphological and phytochemical data (Tanaka 1929; Kong *et al.* 1986, 1988a, 1988b; Kinoshita 2014). This conclusion is also well supported by the palynological morphology (Mou & Zhang 2009), heterochromatin banding patterns in the karyotype (Guerra *et al.* 2000), and DNA sequence evidence (Samuel *et al.* 2001; Bayer *et al.* 2009; Morton 2009; Mou *et al.* 2018). Several authors indicated that the dichotomy of *Murraya* s. lat. should be generic rather than sectional (Mou & Zhang 2009; Kinoshita 2014). It was suggested to divide *Murraya* s. lat. into two genera, *Bergera* and *Murraya* s. str. and to reinstate the generic name *Bergera* L. (Mou *et al.* 2018; Appelhans *et al.* 2021). The morphological and phytochemical differences between the two genera are listed in Table 1.

Mou *et al.* (2021) revised the genus *Murraya* s. str. world-wide, including eight species that belonged formerly to *M.* sect. *Murraya*. In this paper, we provide a revision of *Bergera*, which is a key step forward towards completing the revision of *Murraya* s. lat. and species delimitations worldwide. The main objectives of this paper were to (1) clarify the taxonomy of the genus *Bergera* world-wide; (2) provide keys for all species of *Bergera*; (3) evaluate morphological and anatomical features for classifying members of *Bergera*; and (4) provide a molecular phylogenetic framework for guiding the taxonomy of the group.

Material and methods

Sampling and morphological observations

Plant materials were collected from China (Yunnan, Guangxi, Guizhou, Guangdong, Hainan, and Taiwan provinces), Vietnam, and Myanmar during fieldwork from 2014 to 2020. In addition, specimens deposited in the herbaria IBSC, KUN, IBK, HITBC, GXMI, GXMG, SYS, SWFC, YUKU and the digital images of specimens deposited in PE, SM, NAS, LBG, N, AU, HGAS, BNU, SZ, GZTM, TAI, HAST, TI, L, P, K, G, C, MO, NY, US, A, B, BM, E, LE, CAL, and KW were comprehensively examined. Specimens examined from digital images are indicated by the word 'image!'. Acronyms of herbaria follow Index Herbariorum (Thiers continuously updated). All type specimens of species were examined. Additionally, other specimens collected from China and neighbouring countries were checked according to the relevant literatures (Tanaka 1928, 1929; Huang 1959, 1997; Swingle & Reece 1967; Zhang *et al.* 2008). All specimens collected during the study were deposited in IBSC (Herbarium, South China Botanical Garden,

Table 1. The morphological and biochemical differences between two genera *Murraya* J.Koenig ex L. and *Bergera* J.Koenig ex L.

Characters	*Murraya*	*Bergera*	References
Plant	straw-colored to whitish stem, old branches and root bark	dark brown stems and root bark	Tanaka 1929; But *et al.* 1986; Kubitzki 2011; Mou *et al.* 2021
Leaf	leaflets distributing with oil glands	leaflets with oil glands in and at margin of leaflets	
Inflorescence	cymes few (–10)-flowered, larger petals 1–2 cm long, and filaments filiform	cymes many-flowered, smaller petals 4–7 mm long, and filaments dilated	
Fruit	fruits red and ellipsoid, seeds villous	fruits purplish black or red globular to ellipsoid, membranous testa glabrous	
Phytochemistry	coumarin, 3-prenylindole yuehchukene, 8-prenycoumarins	carbazoles, girinimbine	But *et al.* 1986; Kong *et al.* 1986; Li *et al.* 1988; Kinoshita 2014

Chinese Academy of Sciences) and SWFC (Herbarium, Southwest Forestry University). Morphological characteristics were obtained and photographed in the field and laboratory studies, such as paraffin section of ovaries. The measurements were done under a microscope using a vernier calliper and a ruler. In the morphological description, most data are based on at least 20 measurements for the leaf, flower, and fruit characteristics.

Molecular phylogenetic analysis

Taxa sampling

The sampled species were from the genus *Bergera* in China and Vietnam, along with five species from *Clausena*. Some species have multiple accessions that were sampled from different populations due to their prominent morphological differences. Two species from *Merrillia* and *Murraya* were selected as outgroups based on the phylogeny of the tribe Clauseneae Wight & Arn. (Mou *et al.* 2018). The list of taxa and vouchers is provided in Table 2.

DNA extraction, amplification, and sequencing

Fresh leaves or silica-dried leaves collected in the field or greenhouse were used to extract total genomic DNA. Considering high levels of polyphenol in the leaves of species of *Bergera*, leaf powders were preprocessed five times after being ground in liquid nitrogen before extraction, referring to the modified CTAB method (Doyle & Doyle 1987; Tian 2014). The primers of one nuclear marker (ITS) and five chloroplast markers (*trn*L-F, *atp*B-*rbc*L, *mat*K, *psb*H-*pet*B, and *psb*A-*trn*H) for amplification are listed in Table 3.

The PCR amplification was performed in 25 µl volumes, with the following PCR protocol: an initial denaturation step at 95°C for 5 min, followed by 38–40 cycles of denaturation at 95°C for 1.0–1.5 min, primer annealing at 53–58°C for 1.0–1.5 min, and DNA strand extension at 72°C for 1.5 min, with a final extension of 8 min at 72°C. The PCR products were subjected to electrophoresis in 1.2% agarose gels. The PCR products and the PCR primers were used for cycle sequencing reactions with BigDye ver. 3.1 in 10 µl volumes. Cycle sequencing conditions started at 96ºC for 1 min, followed by 30 cycles of 96ºC for 10 sec, 50ºC for 5 sec, 60ºC for 2 min, and a final extension of 60ºC for 2 min.

Table 2. Voucher information of *Bergera* J.Koenig ex L. and *Murraya* J.Koenig ex L. species in phylogenic studies.

Taxa	Locality	Voucher
Bergera euchrestifolia (syn. *Murraya euchrestifolia*)	Baidu, Napo, China (GXNPBD-1)	*F.J. Mou 499*, SWFC
Bergera euchrestifolia	Yacha, Longlin, Guangxi, China (GXLL)	*F.J. Mou 508*, SWFC
Bergera euchrestifolia	Pingmeng, Napo, Guangxi, China (GXNPPM)	*F.J. Mou 544*, SWFC
Bergera euchrestifolia	Baidu, Napo, Guangxi, China (GXNPBD-2)	*F.J. Mou 553*, SWFC
Bergera koenigii	Mengyuan, Mengla, Yunnan, China (YNMLMY)	*F.J. Mou 446*, SWFC
Bergera koenigii	Menglun, Mengla, Yunnan, China (YNMLML)	*F.J. Mou 567*, SWFC
Bergera koenigii	Cuiyun, Simao, Yunnan, China (YNSM)	*F.J. Mou 569*, SWFC
Bergera kwangsiensis (syn. *Murraya kwangsiensis*)	South China Botanical Garden(cultivated fromFuning, Yunnan) (SCBG(YNFN))	*F.J. Mou 525*, SWFC
Bergera kwangsiensis	South China Botanical Garden (cultivated from Longzhou, Guangxi) (SCBG(GXLZNG))	*F.J. Mou 526*, SWFC
Bergera kwangsiensis	South China Botanical Garden (cultivated from Longzhou, Guangxi) (SCBG(GXNH))	*F.J. Mou 527*, SWFC
Bergera kwangsiensis	Guichao, Funing, Yunnan, China (YNFN)	*F.J. Mou 545*, SWFC
Bergera macrophylla (syn. *Murraya macrophylla*)	Pingmeng, Napo, Guangxi, China (GXNPPM-1)	*F.J. Mou 543*, SWFC
Bergera macrophylla	Pingmeng, Napo, Guangxi, China (GXNPPM-2)	*F.J. Mou 550*, SWFC
Bergera macrophylla	Wude, Longzhou, Guangxi, China (GXLZ)	*X.F. Deng 10571*, IBK
Bergera microphylla (syn. *Murraya microphylla*)	South China Botanical Garden, Guangzhou, China (cultivated from Wanning, Hainan) (SCBG(HNWN))	*F.J. Mou 528*, SWFC
Bergera microphylla	Xuwen, Guangdong, China (GDXW)	*D. Liang et al. WP136*, IBSC
Bergera stenocarpa (syn. *Murraya stenocarpa*)	Hoang Hoa Tham, Hai Duong, Vietnam (VN)	*F.J. Mou 573*, SWFC
Bergera tetramera (syn. *Murraya tetramera*)	Wadie, Yuanjiang, Yunnan, China (YNYJ)	*F.J. Mou 464*, SWFC
Bergera tetramera	Wenshan, Yunnan, China (YNWS)	*F.J. Mou 547*, SWFC
Bergera tetramera	Shilin, Yunnan, China (YNSL)	*F.J. Mou 548*, SWFC
Bergera tetramera	Mengzi, Yunnan, China (YNMZ)	*F.J. Mou 558*, SWFC
Bergera tetramera	Pihe, Fugonng, Yunnan, China (YNFG)	*F.J. Mou 562*, SWFC
Bergera unifolia	Guangxi Academy of Specialty Crops (introduced from Dahua), Guilin, Guangxi, China (GXGL(GXDH))	*F.J. Mou 595*, SWFC
Murraya elongata	Shilai, Libo, Guizhou, China (GZLB)	*F.J. Mou 542*, SWFC

Table 3. The sequence of all primers in phylogenic studies.

Sequences Name	Primer name	Primer Sequence	Annealing temperature	References
ITS	ITS4	5'-TCCTCCGCTTATTGATATGC-3'	55°C	White *et al.* 1990
	ITS5	5'-GGAAGTAAAAGTCGTAACAAGG-3'		
*trn*L-F	A50272	5'-ATTTGAACTGGTGACACGAG-3'	53°C	Taberlet *et al.* 1991
	B49317	5'-CGAAATCGGTAGACGCTACG-3'		
*atp*B-*rbc*L	Oligo2	5'-TACAGTTGTCCATGT ACCAG-3'	54°C	Manen *et al.* 1994
	Oligo5	5'-GAAGTAGTAGGATTGATTCTC-3'		
*mat*K	matK1F	5'-ACCGTATCGCACTATGTATC-3'	53°C	Penjor *et al.* 2013
	matK1R	5'-GAACTAGTCGGATGGAGTAG-3'		
*psb*H-*pet*B	7L	5'-ATGTTGACATGAGGAGGAAC-3'	54°C	Reverdatto *et al.* 1989
	7U	5'-GGCTACACAAACCGTTGAAG-3'		
*psb*A-*trn*H	psbAF	5'-GTTATGCATGAACGTAATGCTC-3'	58°C	Sang *et al.* 1997
	trnHR	5'-CGCGCATGGTGGATTCACAAATC-3'		

Sequence assembly, alignment, and phylogenetic analysis

The data set for phylogenetic analysis of ITS contained 29 accessions, including eight species of *Bergera*, five species of *Clausena*, *Murraya elongata* DC. ex Hook.f. and *Merrillia caloxylon* Swingle downloaded from GenBank; the data set for five cpDNA markers comprised 31 accessions, in addition to *B. siamensis* (Craib) F.J.Mou (syn. *Murraya siamensis* Craib). Most sequences in this study were generated anew and a few sequences were downloaded from GenBank, including *Bergera siamensis*, five species of *Clausena*, and *Merrillia caloxylon* (Samuel *et al.* 2001; Bayer *et al.* 2009; Morton 2009). A full list of GenBank accessions is provided in Table 4.

Base confirmation and editing of raw sequences were performed using Sequencher ver. 4.9 (Gene Codes Corp., Ann Arbor, MI, USA). Sequences were aligned by ClustalW in MEGA ver. 7.0.21 (Kumar *et al.* 2016) and adjusted manually where needed. Some accessions are relatively incomplete and have extensive missing data due to the fact that sequencing was not successful for some fragments using the available herbarium specimens, or sequences were not available from GenBank for all six DNA regions. Those were encoded as missing data in the matrix. Five cpDNA alignments were concatenated using the software MEGA ver. 7.0.21. The incongruence length difference (ILD) test (Farris *et al.* 1995) was used to test for incongruence between the genes.

Bayesian inference (BI) and Maximum likelihood (ML) methods were used to reconstruct the phylogenetic trees based on data matrices containing the combination of ITS and five cpDNA markers, using MrBayes ver. 7 (Ronquist & Huelsenbeck 2003) and PhyML 3.0 (Guindon *et al.* 2010), respectively. For BI analysis, two independent Markov Chain Monte Carlo (MCMC) runs were conducted simultaneously, each with four linked chains, for 1 000 000 generations, sampling one tree every 100 generations, and starting with a random tree. PhyML analysis was conducted with automatic model selection by SMS (Lefort *et al.* 2017), and BioNJ start tree (http://www.atgc-montpellier.fr/phyml/).

Table 4. GeneBank accession numbers for sequences of species of *Bergera* J.Koenig ex L. , *Clausena* Burm.f., *Murraya elongata* DC. ex Hook.f. and *Merrillia caloxylon* Swingle used in this study.

Taxon	ITS	*trn*L-F	*atp*B-*rbc*L	*mat*K	*psb*H-petB	*psb*A-*trn*H
Bergera euchrestifolia-499	OK574473	OK574495	OK574517	OK574563	OK574585	OK574606
Bergera euchrestifolia-508	OK574474	OK574496	OK574518	OK574564	OK574586	OK574607
Bergera euchrestifolia-544	OK574475	OK574497	OK574519	OK574565	OK574587	OK574608
Bergera euchrestifolia-553	OK574476	OK574498	OK574520	–	OK574588	OK574609
Bergera koenigii-446	OK574477	OK574499	OK574521	OK574566	OK574589	OK574610
Bergera koenigii-567	OK574478	OK574500	OK574522	OK574567	OK574590	OK574611
Bergera koenigii-569	OK574479	OK574501	OK574523	OK574568	OK574591	OK574612
Bergera kwangsiensis-525	OK574480	OK574502	OK574524	OK574569	OK574592	OK574613
Bergera kwangsiensis-526	OK574481	OK574503	OK574525	OK574570	OK574593	OK574614
Bergera kwangsiensis-527	OK574482	OK574504	OK574526	OK574571	OK574594	OK574615
Bergera kwangsiensis-545	OK574483	OK574505	OK574527	OK574572	OK574595	OK574616
Bergera macrophylla-543	OK574484	OK574506	OK574528	OK574573	OK574596	OK574617
Bergera macrophylla-550	OK574485	OK574507	OK574529	OK574574	OK574597	–
Bergera macrophylla-10571	–	–	OK574530	OK574575	–	–
Bergera microphylla-528	OK574486	OK574508	OK574531	OK574576	OK574598	OK574618
Bergera microphylla-WP136	OK574487	OK574509	OK574532	OK574577	OK574599	OK574619
Bergera siamensis	–	–	AF320866	–	–	–
Bergera stenocarpa	OK574488	OK574510	OK574533	OK574578	OK574600	OK574620
Bergera tetramera-464	OK574489	OK574511	OK574534	OK574579	OK574601	OK574621
Bergera tetramera-547	OK574490	OK574512	OK574535	OK574580	OK574602	OK574622
Bergera tetramera-548	OK574491	OK574513	OK574536	OK574581	OK574603	OK574623
Bergera tetramera-558	OK574492	OK574514	OK574537	OK574582	–	OK574624
Bergera tetramera-562	OK574493	OK574515	OK574538	OK574583	OK574604	OK574625
Bergera unifolia	OK574494	OK574516	OK574539	OK574584	OK574605	OK574626
Clausena anisata	KU193661	KU193626	AF320851	–	–	AM500899
Clausena anisum-olens	JX144181	JX144222	JX144140	MZ460583	MZ460583	MZ460583
Clausena excavata	JX144188	JX144230	AF320849	KU949003	KU949003	KU949003
Clausena lansium	MN318339	JX144232	AF320891	OL944012	OL944012	OL944012
Clausena lenis	JX144191	JX144233	JX144151	–	–	KR533453
Merrillia caloxylon	FJ434149	AY295296	AF320871	AB762388	KU949006	KU949006
Murraya elongata	MZ824488	MZ824503	MZ824519	MZ824565	MZ824550	MZ824580

Results

Phylogenetic analyses of Bergera

The phylogenetic trees inferred from the ITS and five cpDNA data showed that species of *Bergera* formed a strongly supported monophyletic group, sister to *Clausena* (Fig. 1, Clade A; Fig. 2, Clade E). Based on nuclear ITS data, four accessions of *B. tetramera* (C.C.Huang) F.J.Mou from different localities in Yunnan Province cluster together and are close to another clade consisting of four accessions of *B. euchrestifolia* (Hayata) F.J.Mou from Guangxi Province (Fig. 1, Clade B). DNA data can resolve the taxonomic problem between two confused species, *B. euchrestifolia* and *B. tetramera*. The species *B. macrophylla* (C.C.Huang) F.J.Mou forms a separate lineage in the phylogeny, rather than clustering in a clade with *B. kwangsiensis* (C.C.Huang) F.J.Mou, and has a close relationship with an accession of *B. kwangsiensis* (527-SCBG-GXNH), *B. stenocarpa* (Drake) F.J.Mou, and *B. unifolia* C.L.Deng & F.J.Mou (Fig. 1, Clade C). Three accessions of *B. kwangsiensis* from Guangxi Province and Yunnan Province clustered together (Fig. 1, Clade D). *Bergera koenigii* and *B. microphylla* (Merr. & Chun) F.J.Mou are two distinct species (Fig. 1, Clade E).

Based on the cpDNA phylogenetic tree, three species, *Bergera koenigii*, *B. siamensis* and *B. microphylla* are grouped in a clade (Fig. 2, Clade A). However, the cpDNA data wasn't able to resolve some species delimitations, such as *B. kwangsiensis B. macrophylla*, *B. euchrestifolia* and *B. tetramera* (Fig. 2, Clade B–D).

Taxonomy

Class Magnoliopsida Brongn.
Order Sapindales Juss. ex Bercht. & J.Presl
Family Rutaceae Juss.
Subfamily Aurantioideae Engl.

Genus ***Bergera*** J.Koenig ex L.

Mantissa Plantarum Vol. 2: 555, 563 (Linnaeus 1771).

Type species

Bergera koenigii L.

Description

Shrubs or small trees. Unarmed trees; stems and root bark dark-brown. Leaves are odd-pinnate, with alternate leaflets or unifoliolate; leaflet margins entire or crenate. Cymes are axillary or terminal, with many flowers. Flower buds are cylindrical or long-ovoid; flowers small, 4- or 5-merous; calyxes 4- or 5-lobed, and ovate or lanceolate; sepals united at the base or only in the lower third; petals 4 or 5, less than 8 mm long, lanceolate or linear, and imbricate. Stamens are free, 8 or 10, and elongate; filaments dilated, alternately unequal in length; anthers small, broadly elliptic or oval. Disks are short, annular, and cushion-shaped or cylindrical. Ovaries are ovoid, with 2 locules, each with 2 or 1 superimposed or almost collateral ovules; styles rather long and slender, deciduous in fruit or sometimes basal portion persistent; stigmas capitate. Berries are small, ovoid or subglobose, with mucilaginous pulp. Seeds are medium-sized, glabrous with membranous testa; cotyledons with plano-convex oil glands.

The genus *Bergera* includes all species previously in *Murraya* sect. *Bergera*, in addition to one species (syn. *Murraya alternans* Swingle) in *Murraya* sect. *Murraya* (But *et al.* 1986).

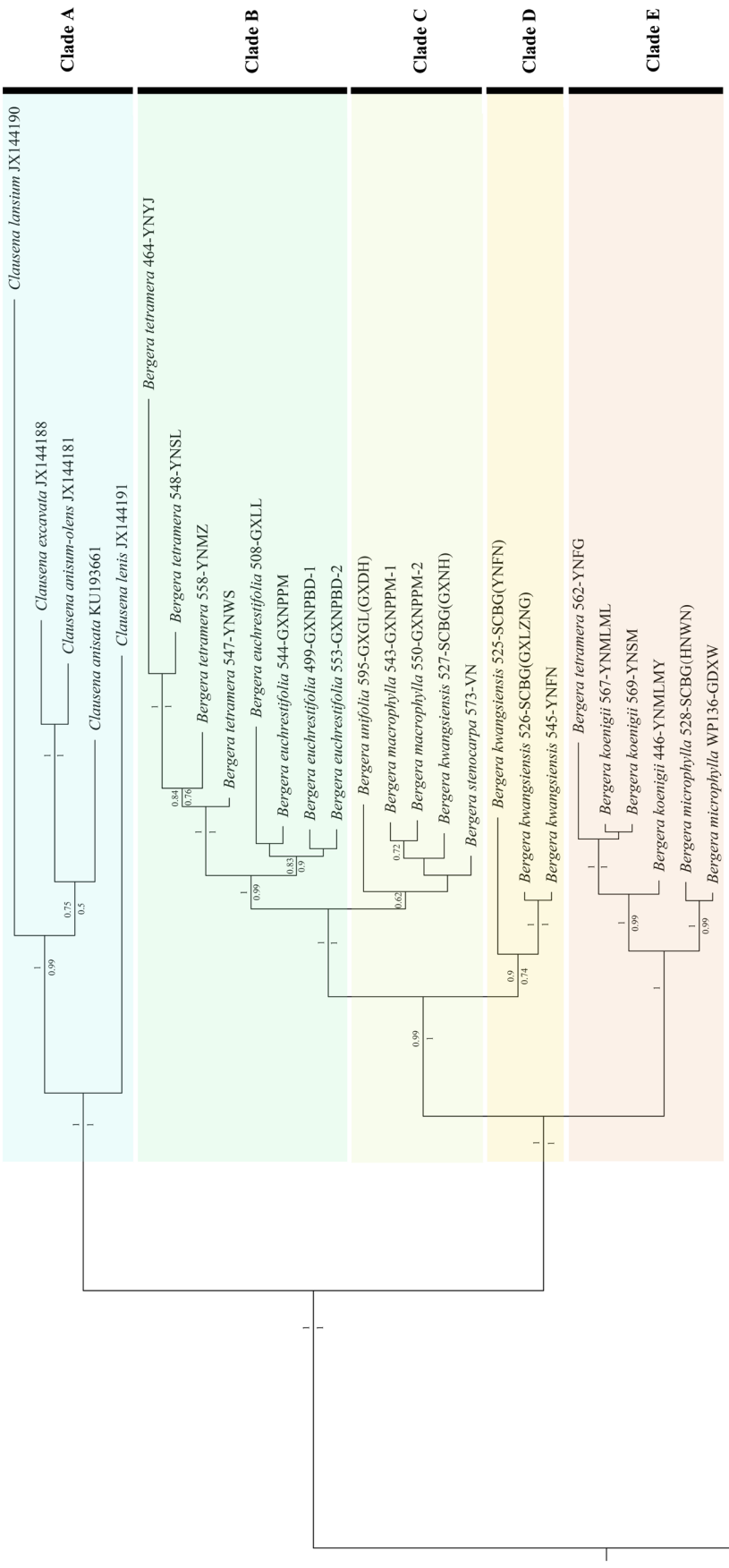

Fig. 1. Bayesian tree, based on nuclear ITS data of representatives of *Bergera* J.Koenig ex L. and *Clausena* Burm.f., *Murraya elongata* DC. ex Hook.f. and *Merrillia caloxylon* Swingle. Branch lengths are proportional to the number of nucleotide changes (indicated above branches with Bayesian posterior probabilities, PP); bootstrap support (BS) values for maximum likelihood (ML) are given below the branches.

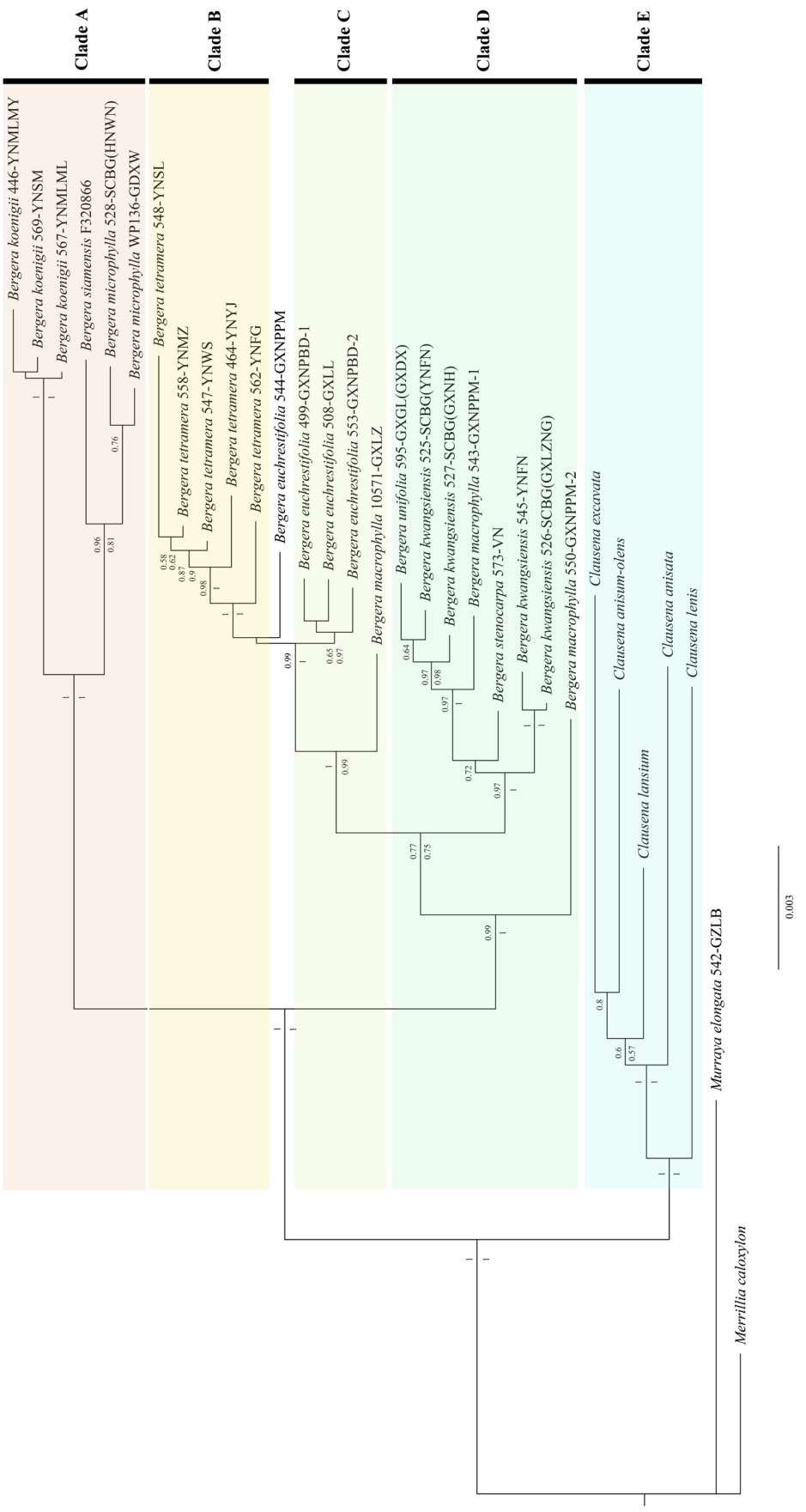

Fig. 2. Bayesian tree, inferred from cpDNA markers of representatives of *Bergera* J.Koenig ex L., *Clausena* Burm.f., *Murraya elongata* DC. ex Hook.f. and *Merrillia caloxylon* Swingle. Branch lengths are proportional to the number of nucleotide changes (indicated above branches with Bayesian posterior probabilities, PP); bootstrap support (BS) values for maximum likelihood (ML) are given below the branches.

Key to the species of *Bergera*

1. Evergreen; leave rachis not winged 2
– Deciduous; leave rachis obviously winged .....*B. alternifolia* (Kurz) F.J.Mou comb. nov.

2. Pinnately compound leaves, with at least 3 leaflets 3
– Unifoliolate leaves 11

3. Leaves with more leaflets, 11–31-foliolate 4
– Leaves with less leaflets, 3–11-foliolate 6

4. Leaflet blades 5–20 mm wide, apex mucronate to acuminate 5
– Leaflet blades 3–6 mm wide, apex rounded to obtuse .....
.....*B. microphylla* (Merr. & Chun) F.J.Mou comb. nov.

5. Leaflet blades glabrous adaxially; berries globose, somewhat apiculate .....*B. koenigii* L.
– Leaflet blades curly pubescent adaxially; berries somewhat 4-grooved, apex depressed .....
..... *B. siamensis* (Craib) F.J.Mou comb. nov.

6. Leaflet blades densely pubescent abaxially .....*B. kwangsiensis* (C.C.Huang) F.J.Mou comb. nov.
– Leaflet blades glabrous adaxially and abaxially 7

7. Leaflets bigger, more than 7 cm long 8
– Leaflets smaller, less than 7 cm long 9

8. Inflorescences terminal, glabrous .....*B. macrophylla* (C.C.Huang) F.J.Mou comb. nov.
– Inflorescences terminal and axillary, covered with very short hairs .....
.....*B. glabra* (Guillemin) F.J.Mou comb. nov.

9. Leaflet blades lanceolate, 0.8–2.0 cm wide, tertiary veins inconspicuous adaxially .....
.....*B. tetramera* (C.C.Huang) F.J.Mou comb. nov.
– Leaflet blades ovate to elliptic or rarely lanceolate or obovate, 2–4 cm wide, tertiary veins slightly prominent adaxially 10

10. Calyx lobes acute pointed, without hair on margin; stigmas obscure .....
.....*B. euchrestifolia* (Hayata) F.J.Mou comb. nov.
– Calyx lobes rounded, ciliate on margin; stigmas capitate .....
..... *B. crenulata* (Turcz.) F.J.Mou comb. nov.

11. Leaflets coriaceous, 4–15 × 3–6 cm; inflorescences terminal .....
.....*B. stenocarpa* (Drake) F.J.Mou comb. nov.
– Leaflets subcoriaceous, 4.0–12.5 × 3–5 cm; inflorescences terminal and axillary .....
.....*B. unifolia* C.L.Deng & F.J.Mou

Bergera alternifolia (Kurz) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314667-1
Fig. 3

Limonia alternifolia Kurz, *Bengal Journal of the Asiatic Society of Bengal* 42 (2): 64 (Kurz 1873). – *L. alternans* Wall. ex Voigt, *Hortus Suburbanus Calcuttensis* 139 (Voigt 1845), nom. inval. – *L. alternans* Wall. ex Hook., *The Flora of British India 1 (pt. 3)*: 508 (Hooker 1875), nom. illeg. – *L. alternans* Wall. ex Kurz, *Forest flora of British Burma 1*: 192 (Kurz 1877). – *Murraya alternans* (Kurz) Swingle, *Journal of the Washington Academy of Sciences* 28 (12): 532 (Swingle 1938).

– **Type**: MYANMAR • Pegu; 24–26 Feb. 1871; *S. Kurz 2010*; holotype: CAL[CAL0000213357] image!; isotypes: CAL[CAL0000213351, CAL0000213352, CAL0000213353, CAL0000213354, CAL0000213355, CAL0000213356, CAL0000213358, CAL0000213359] images!. **Designated here**.

Etymology

The specific epithet refers to the leaves with alternate leaflets.

Description

Shrubs or small trees, 0.6–1.2 m tall; slender, simple or sparingly branched; deciduous. Twigs are slender, glabrous, with numerous shallow, longitudinal furrows and low ridges. Leaves are odd-pinnate, 11–15-foliolate, 10–25 cm long, and completely glabrous; rachis obviously winged; leaflets alternate, nearly sessile, oblong-lanceolate to lanceolate, 2.5–5.0 cm long, terminal much larger, somewhat unequal-sided toward the cuneately narrowed base, slightly attenuate to a blunt tip, and margins slightly crenate above the middle. Cymes are axillary, appearing with the new leave, small, short-peduncled, glabrous. Flower buds are small, oblong or elliptical, 3–5 × 2–3 mm; flowers short-pedicellate, 5-merous; calyxes nearly flat, 5-lobed, lobes triangular, glabrous, 1.0–1.5 mm long, 1.5–2.0 mm wide, and with numerous oil glands; petals white, 5, upright, linear, 5–7 mm long, tapering to a point, and with many oil glands in the upper half. Stamens are free; filaments 10, slightly swollen above, sparingly short-pilose, anthers small, oblong, 1.2–1.3 mm long. Disks are annular, as broad as ovary or broader, 1.8–2 mm wide, 0.5–0.6 mm high. Pistils are glabrous, 4.5–5.5 mm long; ovaries borne on a long, slender, nearly cylindrical stipe, 0.8–1.0 mm long and 0.4–0.5 mm wide, and arising from flat top of the disk (said to elongate after flowering); ovaries obovoid, 1.8–2.0 mm high, 1.1–1.2 mm wide, and bluntly rounded or obcordate at top because of 2 large oil glands; locules 2, each with 2 ovules, and spendulous; styles slender, curved, subclavate, 2.2–2.6 mm long, 0.2–0.5 mm wide; stigmas thickened, at tip not clearly delimited. Fruits are ovoid, glabrous, short-stalked, ca 4 mm long. This species is described based merely on Swingle & Reece (1967) and some images of plants cultivated in Myanmar.

Phenology

Flowering in May, while fruiting from July to August.

Distribution and habitat

Myanmar: Pegu, Tenasserim (Mergui), Irrawaddy (Hinthada, Pathein, Bago); Yomah, the deltaic areas of Myanmar, not un-frequent in the upper mixed and occasionally in the moist forests of the Pegu Yoma, sporadical, but usually gregarious.

Remarks

The species is unique in the genus *Bergera* and differs from all other species in this genus by deciduous leaves, narrowly winged rachis, pubescent filaments, and the ovary borne on a slender, nearly cylindrical stipe, which looks like the gynophores found in *Clausena* (Swingle & Reece 1967). A very strong smell comes out from the leaves of this species and is very similar to *B. koenigii*. It is thought that the fresh juice of this species' leaves can neutralize the toxic action of snake venoms from cobra or viper (Aye *et al.* 2001; Min *et al.* 2004, 2007).

Bergera crenulata (Turcz.) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314668-1
Fig. 4

Glycosmis crenulata Turcz., *Bulletin de la Société impériale des aturaliste de Moscou* 31: 250 (Turczaninow 1858). – *Clausena crenulata* (Turcz.) F.Muell., *Contributions to Phytography of New Hebrides and Loyalty Islands, from Mr. F.A. Campbell's collections*: 7 (Müller 1873). – *Chalcas crenulata* (Turcz.) Tanaka, *Bulletin de la Société botanique de France, Paris* 75 (4): 710 (Tanaka 1928). – *Murraya*

Fig. 3. *Bergera alternifolia* (Kurz) F.J.Mou comb. nov. **A**. Holotype, *S. Kurz 2010*, CAL0000213357 (Botanical Survey of India, CAL). **B.** Cultivated plant. **C**. Leaves of cultivated plant. **D**. Flowers. Photos taken by Yoshiaki Takaya and Hla Myoe Min in Myanmar.

crenulata (Turcz.) Oliv., *Journal of the Proceedings of the Linnean Society* 5 (2): 29 (Oliver 1861). – **Type**: SINGAPORE (PHILIPPINES?) • *Th. Lobb 469*; holotype: KW[KW001000633] image!.

Micromelum coriaceum Seem., *Flora Vitiensis* 1: 32 (Seemann 1865). – **Type**: NEW CALEDONIA • Isle of Pines; 1774; *Capt. J. Cook s.n.;* holotype: BM[BM001015581] image!.

Clausena worcesteri Merr., *The Philippine Journal of Science* 5 (3): 180 (Merrill 1910). – **Type**: PHILIPPINES • Luzon, Cagayan, Apiao, near Tauit; 1 Aug. 1909; *D.C. Worcester Bur. Sci. 10743*; holotype: US[US00101712] image!; isotype: B[B100296007] image!.

Micromelum globosum Elmer ex Tanaka, *Bulletin de la Société botanique de France* 75 (4): 710 (Tanaka 1928), in synonymy.

Micromelum sorsogonense Elmer ex Tanaka, *Journal of the Society of Tropical Agriculture* 1: 30 (Tanaka 1929), in synonymy.

Murraya sorsogonensis Elmer ex Tanaka, *Transactions of the Natural History Society of Formosa* 22: 423 (Tanaka 1932), in synonymy.

Clausena smyrelliana P.I.Forst., *Austrobaileya* 5 (4): 716 (Forster 2000), **syn**. **nov**. – **Type**: AUSTRALIA • Queensland, Wide Bay pastoral district, Sawmill road, Dundowran-Craignish, Oceanpark Estate; 25°16′40″ S, 152°44′50″ E; 15 m a.s.l.; 8 Nov. 1999; *P.I. Forster PIF25182*; holotype: BRI[BRI-AQ0642676] 2 sheets, images!; isotypes: A n.v., K[K000717902] image!, L[L.4166717] image!, MEL[MEL2290585] image!, A[A009937355] image!.

Etymology

The specific epithet refers to the leaves with crenulate margins.

Material examined

AUSTRALIA • Queensland; 8 Nov. 1999; *P.I. Forster PIF25182*; BRI image!, K image!, MEL image!, A image!.

CHINA • Taiwan, Taitung, Lanyü; 14 Aug. 1962; *C.E. Chang 3203*; TAI image!, L image! • 12 Jul. 1970; *M.T. Kao 7668*; TAI image!.

INDONESIA• Sulawesi, Menado; Mar. 1895; *S.H. Koorders 18776 b*; L image!.

LAOS • Mar. 1932; *E. Poilane 20505*; P image!.

NEW CALEDONIA • *G. Petit 189*; P image! • 1774; *C.J. Cook s.n.*; BM image! • Nouméa; Jun. 1871; *B. Balansa 3055*; P image! • Oct. 1906; *I. Franc 557*; P image! • Mar. 1914; *I. Franc 1543 a*; P image! • Oct. 1923; *C.T. White 2136*; P image! • Nouméa, Ile des Pins; Nov. 1966; *A. Nothis 307*; P image! • Magenta; Jan. 1956; *H.S. MacKee 3784*; P image! • Bosquets des environs de Nouméa; Oct. 1868; *B. Balansa 560*; P image! • Dec. 1868; *B. Balansa 763*; P image! • Nouméa, dans les bosquets près du littoral; Jun. 1869; *B. Balansa 1786*; P image! • Lifou, Képénéhé; Oct. 1925; *A.U. Däniker 2233*; P image! • 1927; *C. Bergeret 40*; P image! • Plateau de Lifou; Jan. 1966; *M. Schmid 1072*; P image! • Ouvéa, St Gabriel; Sep. 1925; *A.U. Däniker 2153*; P image! • Kanala; *E. Deplanche 8*, *9*, *10*, *11*; P image! • 1861; *E. Deplanche 437*; P image! • Anse Vata; Oct. 1902; *A.J. Le Rat 29 bis*; P image! • Nov. 1902; *A.J. Le Rat 70*; P image! • Calédonie et Ile des Pins; *J. Pancher 714*, *5501*; P image! • Maré, Netsche; Nov. 1911; *K.F. Sarasin 497*; P image! • Balade; *E. Vieillard 286*, *311*; P image!.

PAPUA NEW GUINEA • New Guinea; Jan. 1862; *M. Pancher s.n.*; L image! • Jan. 1969; *H. Streimann & A. Kairo NGF 39173*; L image! • Milne Bay, Modewa, Modewa Bay; Dec. 1956; *L.J. Brass 28878*; US image! • Magenta, low rocky headland; Jan. 1965; *H.S. MacKee 3784*; L image! • Central District, Port Moresby Sub-district, near Vanapa River; Mar. 1972; *J.S. Womersley NGF 43911*; L image!.

PHILIPPINES • Nov. 1929; *G. Edano78547*; SYS! • May 1930; *M. Ramos 80390*; SYS!. – **Mindoro** • May 1953; *H.C. Conklin PNH 17589*; L image! • Pinamalayan; Jun. 1922; *M. Ramos BS 41027*; L image! – **Luzon** • 1855; *H. Cuming 1355*; L image!, G image!, C image!, MO image! • Jun. 1917; *A.D.E. Elmer17779*; L image! • Benguet; May 1914; *E.D. Merrill 1797*; L image! • Laguna, Mt. Maquiling; Aug. 1914; *A. Villamil, Forestry Bureau 21989*; US image! • Los Baños (Mt. Maquiling); Jun. 1917; *A.D.E. Elmer17945*; K image! • *A.D.E. Elmer18084*; L image!, K image! • *A.D.E. Elmer18322*; L image!, K image!, US image! • Central Luzon; *A. Loher 1353*; US image!.

SOLOMON ISLANDS • Maisua; Jan. 1933; *J.H.L. Waterhouse 848 B*; L image! • Rennell, North Lavangu Village; May 1969; *I.H. Gafui et al. BSIP 14946*; L image!.

VANUATU • Erromango, Dillon Bay; Jun. 1928; *S.F. Kajewski 374*; US image! • Aneityum Island, Anelgauhat Bay, the New Hebrides; Feb. 19219; *S.F. Kajewski 789*; US image!.

VIETNAM • Apr. 1922; *E. Poilane 2944*; P image!.

Description

Small trees, 4 m high. Branchlets and leaves are glabrous; stems bark blackish brown, glabrous. Leaves are pinnate, 20–30 cm long, 5–11-foliolate, leaflets alternate; leaflet blades thick chartaceous, ovate-elliptic, 5–10 × 2.0–4.5 cm, strongly inequilateral, base obtuse and oblique, apex acuminate, margin more or less crenulate, semi-coriaceous, shining above, black after drying; midrib prominent, glabrous, venation inconspicuous, oil gland conspicuous, dense, oil gland on leaf margin with no hairy; petiolules ca 4–9 mm long, glabrous. Cymes are terminal, pubescent, 7–10 cm, many-flowered; pedicels 5–6 mm long. Flower buds are long oblong; calyxes cupulate, puberulent, 5-lobed, broad and rounded, and often imbricate and

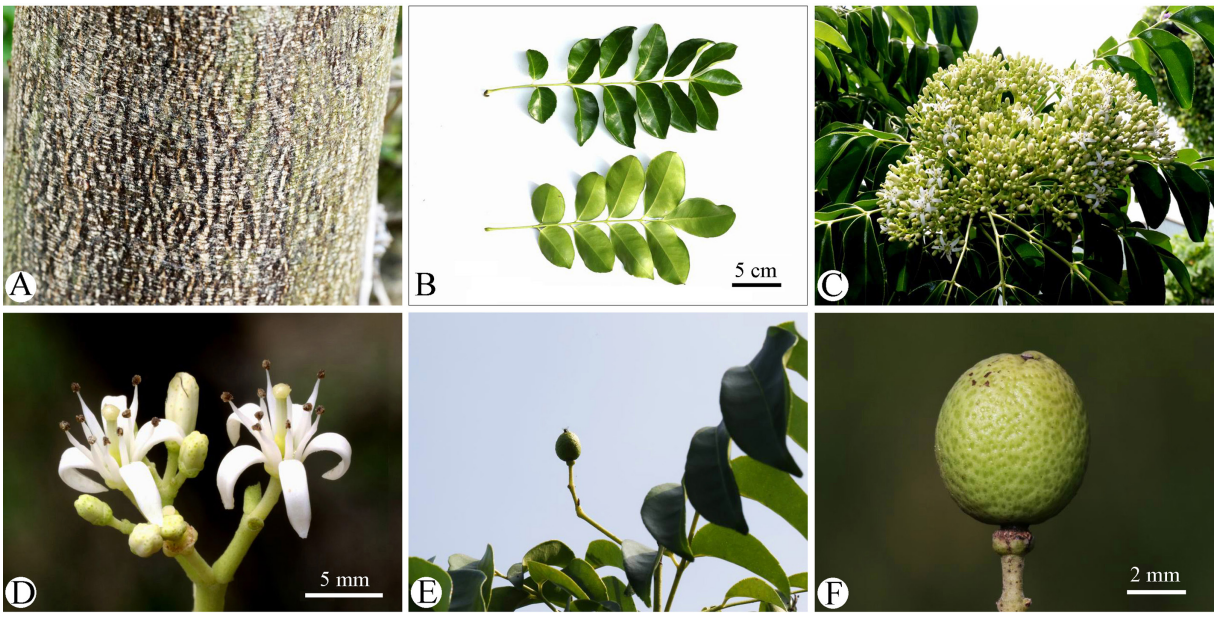

Fig. 4. *Bergera crenulata* (Turcz.) F.J.Mou comb. nov. **A**. Stem. **B**. Leaves. **C**. Inflorescence. **D**. Flowers. **E–F**. Fruit. Photos taken by Chuang His in Taiwan, China.

ciliate on margin; peduncle slender, tomentose; petals 5, oblong, glabrous, 6–7 mm long, 1.5–2.0 mm broad, striated, with obscure black dots, revolute after open. Stamens are glabrous, 10, 5 longer alternating with 5 shorter, the longer filaments 5 mm long, very sharp pointed at the apex; anthers globose. Pistils are nearly as long as the filaments; ovaries glabrous, cylindric, ca 1.5 mm long; styles stout, cylindric, with hairs upper, and basal portion often persistent in fruits; stigmas globose. Berries are broadly ovoid to subglobose and minutely apiculate, yellow when mature, 6–7 mm long, densely covered with oil glands.

Phenology

Flowering between May and July, while fruiting from August to January next year.

Distribution and habitat

China (Taiwan), Philippines (Luzon, Leyte), Indonesia (Java, Sulawesi), New Caledonia, New Guinea Vanuatu, SW Pacific Islands, northeastern Australia (Queensland), Solomon Islands, Vietnam and Laos..

Remarks

The species *Bergera crenulata* is allied to *B. koenigii*, but has fewer, thicker, and larger leaflets, attached to a glabrous instead of a pubescent rachis. The fruit is subglobose and minutely apiculate, whereas in *B. koenigii* it is short-ellipsoid and apiculate. Meanwhile, *B. crenulata* is often confused with *Clausena anisum-olens* Merr. and *Micromelum minutum* var. *curranii* (Elmer) Tanaka in the field, but it has longer flower buds and longer pistils, which are never found in *Clausena* or *Micromelum*.

In Vanuatu, the fruits are considered edible. The whole plant is also used in folk medicine (Mota Lava, Banks Islands, and north of Vanuatu). In New Caledonia, maceration of the plant is used against migraines and headaches (Lifou Island). The crushed leaves have a very pleasant and characteristic smell; the vernacular name in Lifou means ‘scent like honey’. The flowers are worn by traditional dancers to leave a pleasant smell in Anatom, the southernmost island of Vanuatu, and in the past the leaves were used for the confection of scented costumes for men in Maré Island, New Caledonia. On Ouvéa Island (New Caledonia), a mixture of *Murraya crenulata* bark and grated coconut is used as a shampoo (Hnawia *et al.* 2007).

Bergera euchrestifolia (Hayata) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314669-1
Fig. 5

Murraya euchrestifolia Hayata, *Icones Plantarum Formosanarum* 6: 11 (Hayata 1916). – *Clausena euchrestifolia* (Hayata) Kaneh., *Formosa Trees*: 97 (Kanehira 1917). – *Chalcas euchrestifolia* (Hayata) Tanaka, *Journal of the Society of Tropical Agriculture* 1: 32 (Tanaka 1929). – **Type**: CHINA • Taiwan (Formosa), Nantou (Nantocho Bikei); 15 Jan. 1914; *T. Ito s.n.*; holotype: TI[TI00011285] image!.

Etymology

The specific epithet refers to the glabrous leaves.

Material examined

CHINA • Sichuan Province, Junlian; 19 Jun. 1977; *Anonymous 60*; SM image! • Xingwen; 2 Sep. 1977; *Xingwen Expedition 77-626*; SM image! • Hunan Province, Xinning, cultivated; 19 Jun. 1986; *General Expedition 393*; PE image! • 29 Aug. 1986; cultivated; *Collection group 1032*; PE image! • Guangxi Province, Yülin; 12 May 1959; *Y.K. Li 403794*; IBK! • 13 Dec. 1959; *S.Q. Zhong A63016*; IBK! • Tianyang; 15 May 1964; *Z.Z. Chen 54073*; IBK! • 14 Nov. 2016; *Tianyang Collection 4510211611140008LY*; GXMG! • Longzhou; 21 Oct. 1959; *D.A. Huang 61775*; IBK! • Longlin; 4 Jun. 1977; *Longlin Expedition 3-0965*;

GXMI! • 15 Apr. 1979; *M.F. Qin & S.Q. Lin 02123*; IBK! • 8 Nov. 1980; *J.Y. Liang & M.F. Qin K0321*; IBK! • 22 Sep. 1983; *J.Y. Liang K1272*; IBK! • Yacha; 1985; *Z.R. Xu DH4240*; IBSC! • 26 Jun. 2017; *F.J. Mou 508*; SWFC! • Xincheng; 10 Nov. 1979; *S.Q. Lin 00337*; IBK! • 5 May 1983; *C.Z. Gao & G.M. Lan 61260*; GXMI! • 4 Sep. 1984; *C.Z. Gao & G.M. Lan 61284*; GXMI! • Rongxian; 20 Oct. 1975; *Rongxian Expidition 75*; GXMI! • *S.Y. Tian & Y.M. Li 75*; GXMI! • Bobai; 20 Apr. 1979; *Bobai Medical Research Institute 18803*; GXMI! • Jingxi; 3 May 2008; *W.B. Xu & Y.X. Zhu B0629*; IBK! • 29 May 2009; *W.B. Xu et al. 09605*; IBK! • 25 Sep. 2010; *Y.S. Huang et al. LYJX0731*; IBK! • 7 Jun. 2011; *Y.S. Huang & D.X. Nong Y0687*; IBK! • 15 Apr. 2012; *Y.S. Huang Y1236*; IBK! • Dizhou; 19 Oct. 2011; *L.Y. Yü et al. YLYJX323*; GXMG! • 11 Dec. 2012; *D.X. Nong et al. 451025121211022LY*; GXMG! • Guwen; 22 Oct. 2011; *D.C. Nong et al. YLYJX371*; GXMG! • Napo; 24 Jun. 2010; *Y.F. Huang & Y.D. Peng HYF0456*; GXMG! • 31 May 2011; *Y.F. Huang & Y.F. Huang HYF0994*; GXMG! • 8 May 2014; *Z.Z. Lan et al. 451025140508007LY*; GXMG! • Anning; *Y.D. Peng 451025141011019LY*; GXMG! • Pingmeng; 25 May 2015; *D.X. Nong et al. 451026150525015LY*, *451026150525032LY*; GXMG! • 30 Sep. 2016; *F.J. Mou 544*; SWFC! • Baidu; 18 May 1977; *Z.S. Lin 3-50823*; GXMI! • 22 Jun. 2015; *F.J. Mou 499*; SWFC! • 26 Dec. 2016; *F.J. Mou 553*; SWFC! • Liujiang; 20 Jun. 2010; *W.B. Xu & Y.S. Huang 10863*; IBK! • Guoba; 21 Nov. 1935; *X.P. Gao 56101*; IBK!, IBSC! • 3 Jun. 2006; Baisheng; *H.N. Qin et al. 603030*; IBK! • 19 Aug. 2009; *W.B. Xu et al. 091192*; IBK! • Yaohuangshan; 9 Dec. 2017; *F.J. Mou 632*; SWFC! • Longhe; 18 Aug. 2010; *Y.F. Huang & Y.F. Huang HYF0707*; GXMG! • *Y.F. Huang & G.M. Luo 79835*; GXMI! • Huanjiang; 15 Nov. 2007; *F. Ye & T. Ding 0108016*; IBK! • Xianan; 29 Apr. 2013; *Huanjiang General Expedition 451226130429001LY*; IBK!, GXMG! • 30 Apr. 2013; *Huanjiang General Expedition 451226130430022LY*; IBK!, GXMG! • Chuanshan; 29 May 2013; *Huanjiang General Expedition 451226130529015LY*; IBK!, GXMG! • Long'an; 23 Oct. 1981; *X.H. Lu 11603*; GXMG! • 19 Sep. 1990; *C.C. Huang & D.R. Liang 00951*; GXMI! • 3 Sep. 2011; *J.C. Yang LH0584*; IBK! • Longhushan; 13 Jul. 2014; *Long'an General Expedition 50123140713014LY*; GXMG! • Dingjiashan; 3 Sep. 2011; *J.C. Yang et al. LH0590*; IBK! • Xinguang; 15 Sep. 2011; *J.C. Yang et al. LH0911*; IBK! • Jiaxiufeng; 2 Jul. 2012; *J.C. Yang & Y.B. Liao LH2415*; IBK! • Debao, Ma'ai; 12 May 2016; *Debao General Expedition 451024160512012LY*; GXMG! • Lingyun; 12 Dec. 2012; *Lingyun General Expedition 451027121212004*; GXMI!, GXMG! • 29 Apr. 2013; *Lingyun Expedition 451027130429062*; GXMG!, GXMI! • 6 Jun. 2013; *Lingyun Expedition 451027130606006*; GXMG!, GXMI! • Sicheng; 7 Jun. 2013; *Lingyun Expedition 451027130607004*; 12 Aug. 2013; *451027130812020*; GXMG!, GXMI! • Luocheng; 28 Apr. 2013; *Luocheng General Expedition 451225130428027LY*; GXMG! • Tianlin, Langping; 30 Nov. 2013; *Tianlin General Expedition 451029121130043*; GXMI! • Fusui; 25 Apr. 2015; *D.X. Ning & Y.S. Huang 451421150425042LY*; GXMG! • Changping; 11 Sep. 2015; *D.X. Nong et al. 451421150911079LY*; GXMG! • Shanwei; 27 May 2016; *D.X. Nong et al. 451421160527015LY*; GXMG! • Quli; 9 Sep. 2015; *D.X. Nong et al. 451421150909028LY*; GXMG! • Fangcheng; 26 Dec. 1943; *S.Q Chen 4193*; IBSC! • Guangdong Province, Zhuhai; 5 Nov. 1973; *Yue73 3022*; IBSC! • Taiwan; Oct. 1929; *S. Saito 7670*; L image! • May 1934; *J.L. Gressitt 98*; U image! • Nantou (Nantocho Bikei); 15 Jan. 1914; *T. Ito s.n.*; TI image! • Wushe; 18 Jan. 1924; *S. Sasaki s.n.*; TAI image! • Fenhuangku; Dec. 1978; *H.N. Yang 1641*; L image!, TAI image! • 2 Dec. 1995; *K.C. Yang 4603*; HAST image! • Hsinyi; Jan. 1993; *M.H. Chen et al. 5*; L image!, HAST image! • Shuili; 13 Nov. 1994; *C.I. Peng 16044*; HAST image! • 20 Sep. 1995; *L.H. Wu et al. 80*; PE image!, HAST image! • Ren'ai; 24 Dec. 1995; *S.M. Liu 311*; HAST image! • 31 Jan. 1996; *C.H. Chen 1573*; HAST image! • 10 Nov. 2011; *K.F. Chung 1937*; HAST image! • Liukuei; Dec. 1961; *J.M. Chao 670*; L image! • Pingdong; 7 Nov. 1916; *E. Matuds s.n.*; TAI image! • Gaoxiong; 18 Dec. 1961; *J.M. Chao 670*; TAI image! • *T.C. Huang et al. 13892*; TAI image! • 29 Jan. 1989; *J.C. Wang 5255*; HAST image! • 22 Jan. 1991; *J.C. Wang 6508*; HAST image! • Sanmin; 13 May 2000; *S.C. Liu 430*; HAST image! • Maolin; 7 May 1995; *J.C. Wang 9591*; HAST image! • 29 Jun. 1995; *J.C. Wang 9678*; HAST image! • Taoyuan; May 1994; *C.M. Wang W 801*; L, HAST image! • 19 May 1992; *C.C. Wang 1015*; HAST image! • Puxin; 1 Jan. 1965; *M.T. Kao 3130*; TAI image! • Hualian, Zhuoxi; 26 Sep. 1995; *L.Y. Lin 9*; HAST image! • 27 Sep. 1995; *L.Y. Lin 36*; HAST image! • 9 Aug. 2008; *P.F. Lu 16683*; HAST image! • Taidong, Hongye; 26 Feb. 1987; *M.T. Kao 10413*;

TAI image! • Yanping; 17 May 1995; *S.C. Hsiao1228*; HAST image! • Jinfeng; 3 Nov. 2002; *S.C. Liu 891*; HAST image! • Miaoli; 15 Nov. 2002; *C.H. Yu 394*; HAST image! • Dahu; *Y. Simada 2540 A*; HAST image! • Jiayi; 8 Dec. 1988; *K.C. Yang 3537*; TAI image! • 3 Jul. 1991; *J. C. Wang 7004*; HAST image! • Taizhong; 17 Oct. 2013; *K. F. Chung 2123*; HAST image!.

MYANMAR • Pegu; *S. Kurz 1021*; E image!.

PHILIPPINES • Luzon; Dec. 1915; *A.D.E. Elmer 14806*; L image! • Batangas; Aug. 1917; M. *Ramos 1919*; L image!.

Description

Shrubs or trees, 1.5–7 m. Branchlets slender, glabrous to slightly pubescent; oil glands swell after drying. Leaves are 5–9-foliolate; rachis fine, puberulent; leaflets ovate to elliptic or rarely lanceolate or obovate, 5–8 × 2–4 cm, nearly glabrous, shiny above even after drying, the lower surface of the midrib is slightly puberulent, margin entire, apex mucronate to acuminate; petiolules ca 3 mm long. Cymes are terminal, many-flowered; flower buds small, ca 4 × 1.4 mm, black dotting few on the upper half. Flowers are 4- or 5-merous; sepals pale yellowish-green, ovate, 0.6–1.5 mm; petals bovate-elliptic, 3–5 mm long, ca 2 mm broad. Stamens are 8 or 10, one shorter after the other, longer ones ca 4.5 mm, nearly as long as the petals when fully expanded; filaments linear, flat, gradually narrowed and acutely pointed; anthers small, roundish, slightly cordate, ca 2–3 mm in diam. Ovaries are pale yellowish-green, oval, constricted at the base toward the broad end; styles cylindric, terete, and often slightly curved; stigmas obscure, altogether ca 3.5 mm long. Berries are red to dark red, globose, 1.0–1.5 cm in diam., smooth, rather sparingly large pellucid-dotted, 1- or 2-seeded. Seeds are glabrous and crimson-red when mature.

Phenology

Flowering between July and August, while fruiting from November to December.

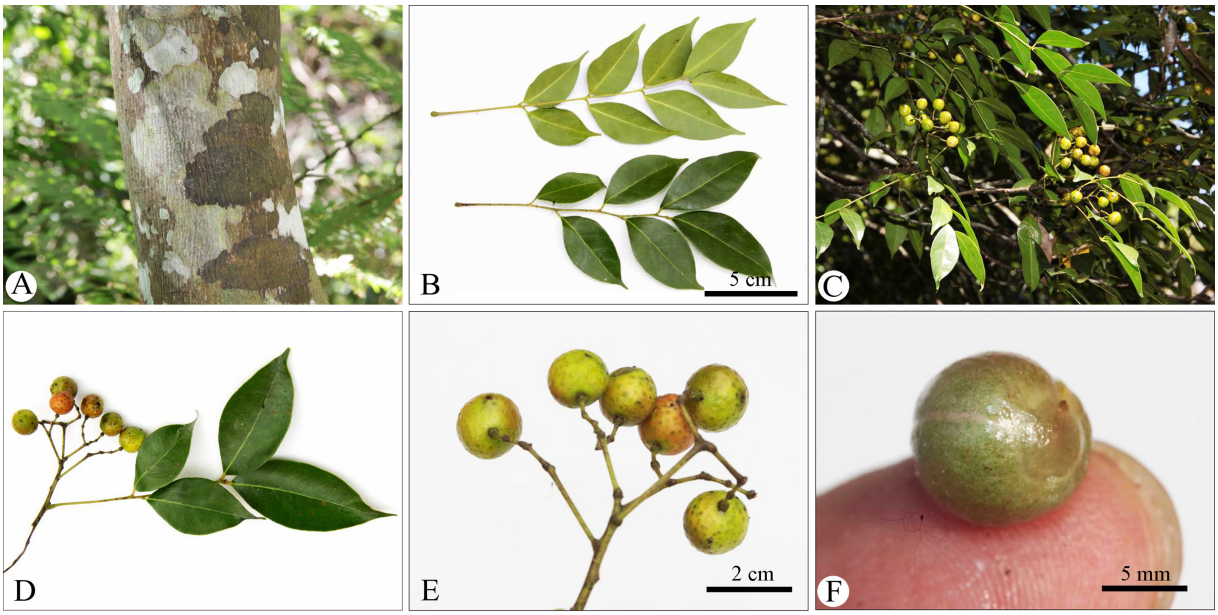

Fig. 5. *Bergera euchrestifolia* (Hayata) F.J.Mou comb. nov. **A**. Stem. **B**. Leaves. **C–E**. Fruits. **F**. Seed. Photos taken by Chuang His in Taiwan, China.

Distribution and habitat

China: Guangxi (Jingxi, Baise, Debao, Napo, Longlin, Huanjiang, Lingyun, Luocheng, Liujiang, Xincheng, Rongxian, Tianyang, Longzhou, Yulin, and Fangcheng), Guizhou (Anlong, Xingyi, Wangmo, Libo Renhuai, Xishui, Luodian, Zhenfeng, and Xingren), Sichuan (Xinglian and Junlian), Guangdong (Ruyang, Fengkai, and Nan'ao), Hainan (Changjiang), Taiwan (Taoyuan, Nantou, Hualian, Pingdong, Taidong, Jiayi, and Gaoxiong). The species grows in open and well drained forests and thickets, along streams, about alt. 500–1400 m.

Remarks

This plant most closely resembles *Bergera crenulata* and *B. tetramera* in appearance, but the calyx lobes are acutely triangular, and the leaflets are not so oblique, lacking crenulation. In this respect, it approaches *B. koenigii* more closely, although the number of leaflets is fewer and the leaflets are larger and glabrous. It differs from both species in having a smaller flower, an obscure stigma, and a slightly constricted ovary.

Bergera glabra (Guillemin) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314670-1
Fig. 6

Micromelum glabrum Guillemin, *Notulae systematicae* (Paris) 1: 216 (Guillemin 1910). – *Chalcas glabra* (Guillemin) Tanaka, *Bulletin de la Société botanique de France* 75 (4): 711 (Tanaka 1928). – *Murraya glabra* (Guillemin) Swingle, *Journal of the Washington Academy of Sciences* 28 (12): 532 (Swingle 1938). – **Type**: VIETNAM • Tonkin, Kien-khé; *H. Bon 2977*; lectotype: P[MNHN-P-P05186001] image!; isolectotype: P[MNHN-P-P05186003, MNHN-P-P05186004] image!. Designated by Tanaka (1928).

Etymology

The specific epithet refers to the glabrous leaves.

Material examined

VIETNAM • 14 Jun. 1920; *M.E. Poilane 1590*; P image! • 31 May 1924; *M.E. Poilane 10685*, *10689*; P image! • 2 Jul. 1924; *M.E. Poilane 11099*; P image! • Đà Nẵng, Liên Chiêu près Tourane; 17 Aug. 1923; *M.E. Poilane 7596*, *7602*; P images! • Quảng Trị, Col d'Ailao pro; 2 Aug. 1933; *M.E. Poilane 22820*; P image!.

Description

Shrub or small tree, 2–7 m high. Branches, rachis, petiole and petals are especially fragrant, dispersed with very prominent oil glands, becoming black dots when drying. Compound leaves are 12–46 cm long; rachis (petiole) rather thin, ca 28 cm long; leaflets 3–11, alternate, thick chartaceous, glabrous, obovate or oblong-lanceolate, 5–17 × 2–9 cm, inequilateral, pointed at the base, abruptly acuminate at the tip, undulate and very slightly denticulate, with oil glands; lateral veins, 6–9 pairs, prominent on lower surface; petiolules cylindric, glabrous, 3–4 mm long; petiole cylindric, glabrous. Cymes are terminal or axillary a near the top, shorter than the leaves, corymbiferous, large, with many small white flowers, and covered with very short pubescence; pedicels longer than flowers, with 2 small bracts at the base or lower third. Flower buds are long, 6.0 × 2.5 cm, 4-angled, white, fragrant; calyxes 4-connate, indistinct; sepals very shortly, ciliate with a big oil gland; petals 4, 4–6 mm long, 1.5 mm wide, glabrous, and lanceolate. Stamens are alternate with long and short, 8, and 4 mm long; filaments dilated and pubescent upper part; anthers attached by the back, oval, with a few hairs, becoming black then; disk extremely short. Ovaries are cylindric, warty, glabrous, distinctly constricted at ca ⅓ from the apex; styles longer than

ovary, elongated, with prominent dots; stigmas globose, yellow, scabrous, and ca 3 mm long. Berries are subglobose, diameter 7–9 mm, rough, with glands, red when ripe, and containing 1–2 seeds. This species is described based merely on Swingle & Reece (1967) and some images of specimens and plants in Vietnam.

Phenology

Flowering between April and June, while fruiting from July to October.

Distribution and habitat

Vietnam: Tonkin, Annam; Lang Son, Quang Ninh, Ninh Binh, Hoa Binh, Thanh Hoa, Vinh Phuc, Quang Tri, Hai Phong (Cat Ba, the National Park Cat Ba); Nature Reserve Hang Kia-Pa Co (Peace); Ha Nam, Hoa Binh, Quang Tri, Da Nang. It is common among limestone rocks, often grows wild in clumps and drought-resistant.

Remarks

The leaves and leaflets of this species are the longest and widest in the genus *Bergera*. All parts of the plant, especially the leaves and fruits, are strongly aromatic and dispersed with very prominent oil glands becoming black dots when drying.

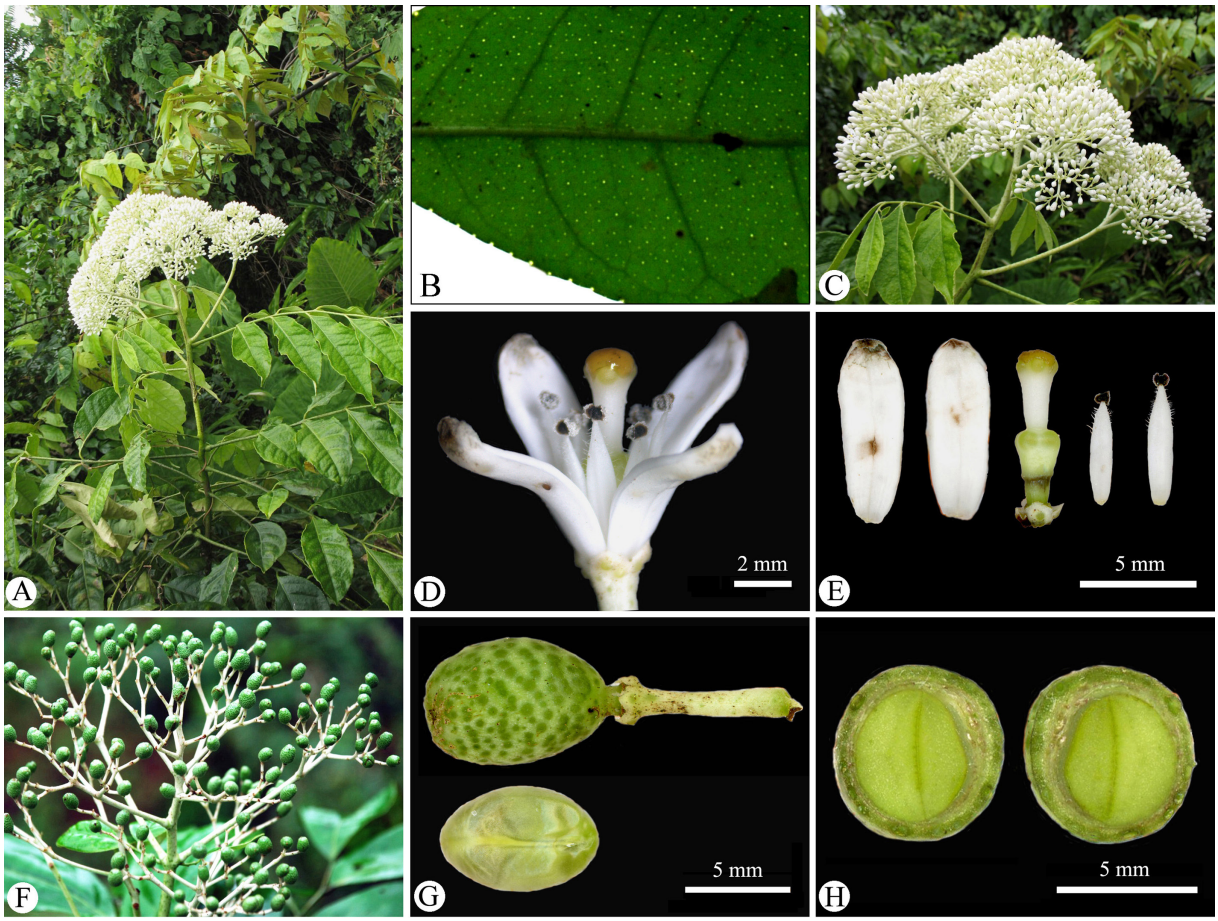

Fig. 6. *Bergera glabra* (Guillemin) F.J.Mou comb. nov. **A**. Plant. **B**. Leaf. **C**. Inflorescence. **D**. Flower. **E**. Flower parts. **F**. Infructescence. **G**. Fruit. **H**. Seeds. Photos taken by Tran The Bach and Dr Truong in Vietnam.

Bergera koenigii L.
Fig. 7

Bergera koenigii L., *Mantissa Plantarum Vol. 2*: 563 (Linnaeus 1771). – *Murraya koenigii* (L.) Spreng., *Systema Vegetabilium* 2: 315 (Sprengel 1825). – *Chalcas koenigii* (L.) Kurz, *Journal of the Asiatic Society of Bengal* 44 (2): 132 (Kurz 1875). – **Type**: INDIA • Eastern; *J.G. Koenig s.n.*; lectotype: LINN[No. 548.1] image!. Designated by Coode (1979).

Murraya foetidissima Teijsm. & Binn., *Natuurkundig Tijdschrift voor Nederlandsch Indië* 27: 41 (Teijsmann & Binnendijk 1864). – **Type**: INDONESIA • Java, Bantam; *Anonymous s.n.;* holotype: L[L.2127420] image!.

Etymology

The species is named after Johann Gerhard Koenig, who collected the type specimen.

Material examined

BANGLADESH • Sylhet; *W. Gomez Cat. no. 6370G*; K image!.

CHINA • Yunnan Province; *Kunming Work Station of Institute of Botany 1082*; PE image! • *P.Y. Mao 5669*; KUN! • *B.Y. Qiu 56094*, *56848*, *56882*; KUN! • 18 Aug. 1959; *S.J. Pei 9385*; KUN! • Lüchun; 31 May 1974; *Lüchun Expedition 1268*, *1280*, *1300*, *1301*; KUN! • *Lüchun Expedition 1300*; IBSC! • Mengla; 11 Dec. 1959; *S.J. Pei 10893*; KUN! • Mar. 1964; *Y.H. Li 005231*; IBK!, KUN!, IBSC! • 18 Apr. 1994; *H.P. He H98041802-1*; KUN! • Mengyuan; 14 Mar. 1959; *Y.H. Li 1004*; HITBC!, KUN! • 22 Apr. 1964; *Y.H. Li 4884*; IBK!, IBSC!, HITBC!, KUN! • 17 May 1982; *Expedition 32503*; HITBC! • Yiwu; 19 May 1982; *S.Q. Tong & A.M. Li 82813*; HITBC!, KUN! • 23 Apr. 1998; *D.D. Tao et al. 9831*; KUN! • 26 Jan. 2015; *F.J. Mou 446*; SWFC! • Menglun; 22 Mar. 1959; *Y.H. Li 945*; HITBC!, KUN! • 19 May 1959; *Y.H. Li 1323*; HITBC! • 22 Apr. 1960; *Y.H. Li 1859*; HITBC!, KUN!, IBSC! • 3 May 1961; *Y.H. Li 3071*; HITBC!, KUN! • 27 Jun. 1977; *Biological department of Yunnan University 1246*; YUKU! • 13 May 1986; *X.F. Gao 134*; KUN! • 2007; *F.J. Mou 47*; IBSC! • 2008; *F.J. Mou 175*, *191*; IBSC! • 10 Apr. 2017; *F.J. Mou 567*; SWFC! • Jinghong; 9 May 1953; *L.Z. Shen 112*; KUN! • Menghan (Ganlanba); *D.L. Li 2085*; SWFC! • 3 May 1955; *G.M. Feng 20050*; IBSC!, KUN!, LBG image! • 15 Apr. 1957; *China-Soviet Expedition 9311*; KUN!, IBSC!, PE image! • 8 May 1959; *Anonymous L01750*; KUN! • Mengyang; 5 Jul. 1986; *R.S. Guo 00737*; IMDY! • Simao; 11 May 2012; *Simao General Expedition 5308020255*; IMDY! • Liushun; 11 Apr. 2017; *F.J. Mou 569*; SWFC! • Ning'er, Xiaoheijiang; 3 Mar. 1990; *G.D. Tao 41526*; HITBC! • Shiping; 8 May 2013; *C. Liu et al. 13CS635*; KUN! • Yuangyang, Nansha; 11 Nov. 1973; *D.D. Tao 1332*; KUN! • Yuanjiang; 21 Apr. 1984; *S.G. Wu 84006*; KUN! • 4 Jul. 1988; *Y. Tang 1031*; KUN! • 4 Jun. 2012; *Yuanjiang General Expedition 5304280505*; IMDY! • Wutaishan; 5 May 1984; *G.D. Tao 37887*; HITBC! • Dashuiping; 17 Mar. 2011; *Q.R. Liu 2011-0317-007*, *2011-0317-020*; BNU image! • Xinping; 9 May 1990; *Yüxi Expedition 2622*; KUN! • Eshan, Huanian; 5 Jul. 1954; *P.Y. Mao 4390*; KUN!, IBSC! • Shuangbai; *C.J. Wang 60*; SWFC! • Jinggu; 30 Apr. 1955; *China-Soviet Expedition 6235*; IBSC!, PE image! • Zhenkang (Chen-Kang Hsien); Mar. 1936; *C.W. Wang 72124*; KUN!, IBSC!, NAS image! • Yongde, Daxueshan; 22 Apr. 2003; *E.D. Liu 290*, *302*; KUN! • 5 Jul. 2005; *E.D. Liu et al. 997*; KUN! • Fengqing (Shunning); 22 Jun. 1938; *T.T. Yü 16414*; KUN!, PE image! • Baoshan; 19 May1955; *China-Soviet Expedition 05669*; PE image! • Longyang, Lujiang; *Yaozhi Team 6*; KUN! • Jianshui (Kien-shuei Hsien); 22 Apr. 1933; *H. T. Tsai 53247*; KUN!, PE image! • Mangshi; 31 Mar. 1985; *Spice Plant Expedition 85-41*; KUN! • Hainan Province; *G.A. Fu 5341*; IBSC! • Sanya; 26 Jul. 1932; *S.K. Lau 319*; IBSC!, SYS!, LBG image!, NAS image!, PE image!, N image!, AU image! • 9 Jul. 1933; *K.Z. Hou 12180*; IBK! • *K.Z. Hou 70990*; IBSC! • 12 Mar. 1956; *The General investigation 901*; IBSC! • Wanning; 28 May 1988; *Z.X. Li et al 4721*; IBSC! • Macao, cultivated; 30 Nov. 2003; *H.G. Ye and F.W. Xing 9320*; IBSC!.

INDIA • *J.G. Koenig s.n.*; LINN[548.2] image!, possible isolectoype of *B. koenigii* according to Mabberley (2016) • Jan. 1881; *G. King s.n.*; L image! • Coromandel; *J.G. König s.n.*; BM image! • Assam; *F. Jenkins s.n.*; L image! • 1893; *King's collector G. s.n.*; L image! • Lakhipur; Apr. 1950; *T.R. Chand 3120*; L image! • Phulbari, Garo Hills; Apr. 1950; *T.R. Chand 3102*; L image! • Uttar Pradesh, Gorakhpur, Doma; Feb. 1968; *G. Panigrahi 10684*; L image! • Bengal; *J.D. Hooker s.n.*; L image! • Jan. 1861; *W. Griffith 5303*; L image! • Tiruchi, Thuraiyur taluk Pacchaimalaise, Kannimar shola; Jul. 1979; *K.M.Matthew 24099*; L image! • Uttar Pradesh, Allahabad; Mar. 1964; *G. Panigrahi & O.P. Misra 2776*; U image! • Kumaon; *R. Blinkworth Cat. no. 6370G*; K image! • Gingee; Sep. 1826; *s. coll. Cat. no. 6370D*; K image! • *s. coll. Cat. no. 6370A*; K image! • *s. coll. Cat. no. 6370B*; K image! • *s. coll. Cat. no. 6370C*; K image! • *s. coll. Cat. no. 6370E*; K image! • *s. coll. Cat. no. 6370G*; K image!.

INDONESIA – **Java** • *F.W. Junghuhn s.n.*; L image! • *F.A.C. Waitz s.n.*; L image! • Jun. 1904; *C.A. Backer 71*; L image! • Oct. 1929; *C.A. Backer 37232*; L image! • Archipel. Ind. Java Res. Batavia Tandjong Priok; *R.C. Bakhuizen van den Brink Jr 2365*; U image! • Kalkheuvels ten westen van Grissee by Sitinggi; Oct. 1940; *J.H. Coert 4014*; L image! • Insula, N. Sumatra, Medan; Apr. 1931; *J.A. Lörzing 16342*; L image! • Batavia, kust O. van Pasar Ikan; Feb. 1948; *P. van der Meer & G. den Hoed 2078*; L image!.

LAOS • Pac Bac pres de L. Prabaug; *E. Poilane 2050*; L image! • Xayaboury, Ban Na La; Jun. 2001; *K. Kone 248*; L image!.

MALAYSIA • Along Kuah roadside; Feb. 1983; *K. Khairuddin KEP FRI 31831*; L image!.

MYANMAR • 8 Aug. 1898; *J.H. Lace 1816*; E image! • 20 Mar. 1914; *C.G. Rogers 203*; E image!.

PALAU • Koror, Lizzette, Ngiraibai; *D.O. Otobed P-10196*; US image!.

PHILIPPINES – **Luzon** • Laguna, San Antonio; Jun. 1912; *M. Ramos BS 15059*; L image! • Sorsogon, Irosin (Mt. Bulusan); Aug. 1961; *A.D.E. Elmer 16972*; L image!.

SRI LANKA • Kandy District, Central Province; Jul. 1972; *F.N. Hepper & G. de Silva 4705*; L image! • Matale, Nikawatuna off Dambulla; Oct. 1974; *D.B. Sumithraarachchi 530*; L image! • Anuradhapura, Ritigala Strict Natural Reserve; Jan. 1973; *A.H.M. Jayasuriya 1048*; L image!.

TANZANIA • Pwani-Bagamoyo; *C. Posthouwer & S. Abihudi 222*; WAG image!.

THAILAND • *D.D. Soejarto et al. 5834*; L image! • Nov. 1928; *N. Put 2123*; L image! • Aug. 2010; *J.F. Maxwell 1016*; P image! • Prachuap Khiri Khan, Amphoe Pran Buri; *D.J. Middleton et al. 1139*; L image! • Prachuap Kiri Khan, Amphoe Pran Buri; *M.F. Newman et al. 1133*; L image! • Lampang, Mae Ta; Jan. 2012; *J.F. Maxwell 12-8*; L image!, P image! • Kanchanaburi, Muang, Chong Sadao; Aug. 2010; *J.F. Maxwell 10-16*; L image!.

USA • Hawaii, Kaua'i, Koloa, Lawai Valley, National Tropical Botanical Garden; *D.H. Lorence 6603*; US image! • Florida; 23 May 1935; *J.L. Fennell 4090*; ECON image! • Homestead; 11 Oct. 1944; *G. Aveue et al. 162*; NY image!.

VIETNAM • Ninh Thuận, Ca-Na; Jan. 1923; *E. Poilane 9267*; P image!.

Description

Shrubs or trees, up to 6 m. Branches are glabrous or slightly puberulous. Leaves are 17–31-foliolate, unpaired-pinnate; rachis usually more or less pubescent, rarely quite glabrous; petiolule short, puberulous; leaflet blades oblong-lanceolate or ovate, 2–5 × 0.5–2.0 cm, almost falcate, oblique at base, margin entire

or crenulate, glabrous, midrib often puberulous. Inflorescences are terminal, many flowered. Flowers are small, white, 5-merous, and ellipsoid in the bud; sepals ovate, less than 1 mm; petals white, oblanceolate to oblong, 5–7 mm long. Stamens are alternately shorter, 10. Ovaries are 2-celled, styles short and thick; stigmas capitate. Fruits are blueish black when mature, ovoid to oblong, 1.0–1.5 cm; 1- or 2-seeded. Seed coats are membranous.

Phenology

Flowering between March and April, while fruiting from July to August.

Distribution and habitat

Pakistan, India, Sri Lanka, Bhutan, Nepal, Thailand, Myanmar, Vietnam, Cambodia, Laos, China (Hainan, Guangdong, and Yunnan Provinces), Tanzania, Bangladesh, Indonesia, and Malaysia. It is cultivated in USA. It grows in moist forests between alt. 500–1600 m.

Remarks

The natural distribution is somewhat uncertain in that it is widely cultivated and naturalized as the indispensable 'curry leaf' in the Indian subcontinent. Curry leaves are highly aromatic when rubbed or bruised. The species can be distinguished by the more numerous, more pubescent and small leaflets, and more compact corymbose terminal inflorescence and the pistil is much shorter than the stamens.

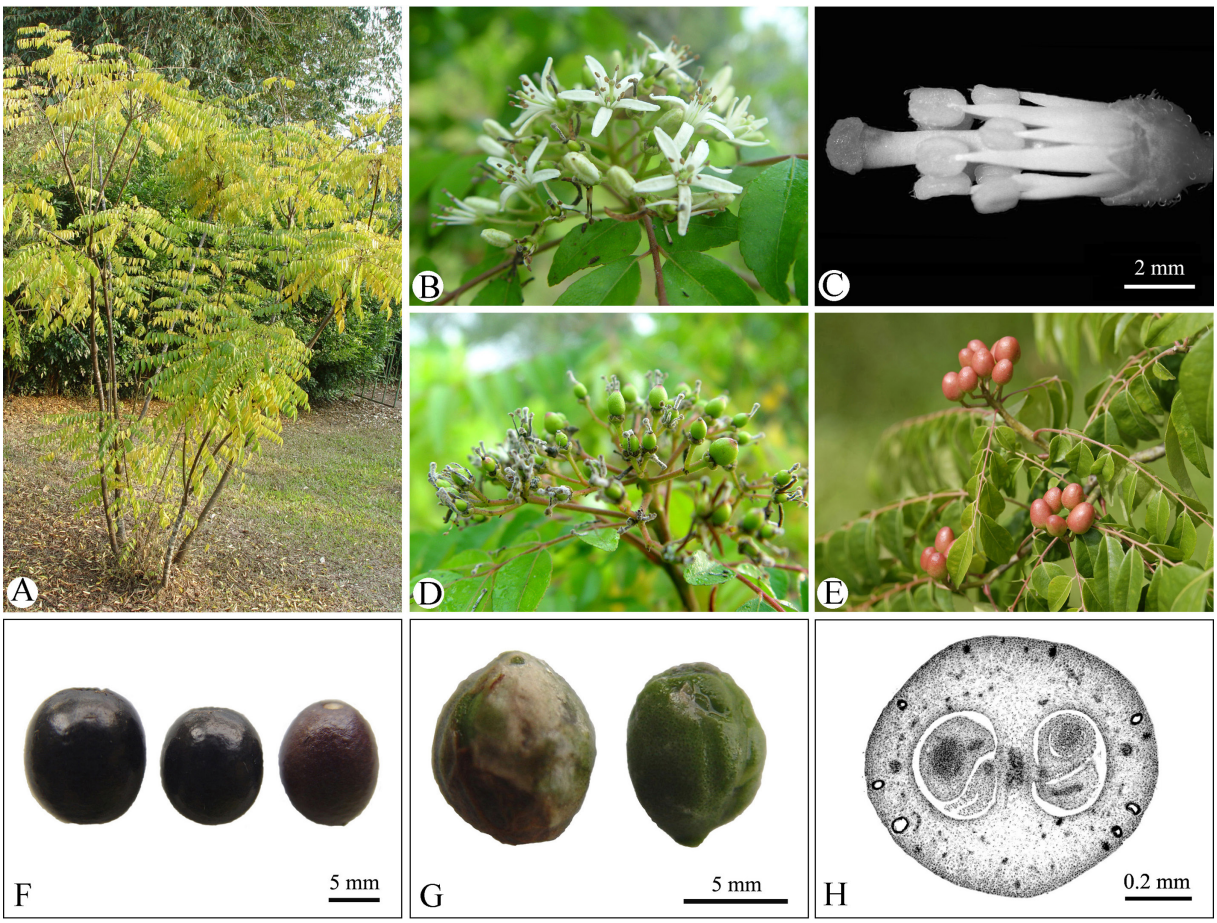

Fig. 7. *Bergera koenigii* L. **A**. Plants. **B**. Inflorescence. **C**. Pistil and stamens. **D–E**. Infructescence. **F**. Fruits. **G**. Seeds. **H**. Ovary crossection. Photos taken by Feng-Juan Mou in China.

Bergera kwangsiensis (C.C.Huang) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314675-1
Fig. 8

Clausena kwangsiensis C.C.Huang, *Acta Phytotaxonomica Sinica* 8 (1): 90 (Huang 1959). – *Murraya kwangsiensis* (C.C.Huang) C.C.Huang, *Acta Phytotaxonomica Sinica* 16 (2): 85 (Huang 1978). – **Type**: CHINA • Guangxi, Baise, Baiguoshan; alt. 830 m; *R.C. Ching 7667*; holotype: PE[00022500] image!; isotype: NAS[NAS00404843] image!.

Etymology

The specific epithet is derived from the type locality, Guangxi in China.

Material examined

CHINA • Guangxib Province; 5 Sep. 1928; *R.C. Ching 7667*; NAS image! • 1958; *Nanning Institute of traditional Chinese Medicine 11744*; GXMG! • 1960; *Nanning Institute of traditional Chinese Medicine 11758*; GXMG! • 1964; *Y.X. Gan 68238*; GXMG! • 8 Jun. 1983; *J.Y. Luo & J.X. Ling 76250*; GXMI! •17 Dec. 1985; *L. Ou & A.N. Mo 000748*; GXMI! • 25 Sep. 1990; *D. Fang & L. Zeng 169*; GXMI! • Shanglin, Mushan; 9 Jun. 2014; *J.B. Teng et al. 450125140609023LY*; GXMG! • Long'an, Chengxiang; 19 Jan. 2013; *Long'an General Expedition 450123130119033LY*; IBK! • 9 Nov. 2013; *Long'an General Expedition 450123130119033LY*; GXMG! • 25 Jun. 2014; *Long'an General Expedition 450123140625098LY*; IBK!, GXMG! • Nanwei; 3 Dec. 2012; *Long'an General Expedition 450123121203008LY*; IBK!, GXMG! • Dujie; 6 Nov. 2013; *Long'an General Expedition 450123130116012LY*; IBK!, GXMG! • 27 Jun. 2014; *Long'an General Expedition 450123140627072LY*; IBK!, GXMG! • Pinshan, Longhushan; 24 Jul. 2013; *Long'an General Expedition 450123130724004LY*; IBK! • Longhushan; 13 Oct. 1981; *Expedition 11321*; GXMG! • 11 May 2008; *Guangxi Expedition of Chinese Plant Combination 0162*; IBK! • Xinguang; 12 Nov. 2011; *J.C. Yang & Y.B. Liao LH1316*; IBK! • Yali; 22 Nov. 2011; *J.C. Yang & Y.B. Liao LH1765*; IBK! • Wuming; 23 Jun. 1955; *Guangxi Team 528*; PE image! • 16 Dec. 1991; *B.S. Huang 22767*; GXMI! • Tengxiang; Jun. 1970; *S.Q. He s.n.*; IBK! • Taiping; 29 Jan. 1975; *J.J. Wang 6578*; GXMI! • 21 Jul. 1985; *Q. Li 166*; SYS! • 14 Nov. 1985; *Q. Li 173*; SYS! • Chengxiang; 12 Decembr 2013; *J.B. Teng et al. 450122131212004LY*; GXMG! • Ningwu; 14 Jul. 2010; *K.J. Yan 22707*; GXMI! • 19 Nov. 2014; *J.B. Teng et al. 450122141119007LY*; GXMG! • Yongning; 26 Jul. 1958; *S.Q. Zhong A62018*; KUN!, IBK! • 16 Sep. 1964; *J.Q. Ge & Y. Wang 17638*; GXMI! • Dingtun; 20 Jul. 1985; *Q. Li 167*; SYS! • Chongzuo, Heping; 13 Nov. 1997; *D.R. Liang & B.S. Huang 02570*; GXMI! • Ningming; 14 Dec. 1977; *G.D. Guo 15489*; HITBC! • Nongrui; 29 Apr. 1980; *Nonggang Comprehensive Expedition 11881*; IBK! • 26 Jul. 2011; *Y.S. Huang & Y.B. Liao NM1369*; IBK! • 30 May 2013; *B.Y. Huang et al. 451422130530024LY*; GXMG! • Tuolong; 8 Dec. 2012; *H.Z. Lü et al. 451422121208075LY*; GXMG! • Tingliang; 2 Nov. 2013; *H.Z. Lü et al. 451422131102031LY*; GXMG! • Chengzhong; 26 Dec. 2012; *B.Y. Huang et al. 451422141226027LY*; GXMG! • 4 Nov. 2013; *H.Z. Lü et al. 451422131104016LY*; GXMG! • Longzhou, Jinlong; 3 Jul. 1960; *C.J. Liang 21533*; GXMI! • Shangjin; 31 Oct. 1979; *Nonggang Comprehensive Expedition 20565*; GXMI! • 17 Aug. 1989; *K.J. Yan & W.Y. Rao 76364*; GXMI! • Nonggang, Nonghu; 24 Sep. 1979; *Nonggang Comprehensive Expedition 10310*; IBK! • Shida; 5 Oct. 1979; *Nonggang Comprehensive Expedition 10790*; IBK! • Pingxiang, Xiashi; 21 Dec. 1959; *X.F. Deng 10670*; IBK! • Xiangshui; 8 Jun. 1979; *Investigation team of Longzhou Medical Institute 0024*; GXMI! • 14 Jun. 1979; *Investigation team of Longzhou Medical Institute 0264*; GXMI! • 30 Dec. 1986; *Y.P. Tao 80172*; GXMI! • Daxin, Taiping, Anmin; 21 Jun. 1977; *Y.Z. Zhang Da-127*; GXMI! • Longlin; 15 Apr. 1979; *S.Q. Lin & M.F. Qin 2132*; IBK! • Youjiang, Banshui; 18 Jul. 2014; *Youjiang General Expedition 451002140718024LY*; GXMG! • Jinxi, Kuiwei, Dezhou; 11 Oct. 2013; *X.Y. Huang et al. 451025131011014LY*; GXMG! • Napo Dingye; 20 Jun. 2010; *Y.F. Huang & J. Huang HYF0165*; GXMG! • Yunnan Province, Funing, Bo'ai; 21 Oct. 1958; *H.T. Tsai 8813*; KUN! • Guichao; 4 Mar. 2007; *F.J. Mou 75*, *77*; IBSC! • Guichao; 20 Jul. 2007; *F.J. Mou 140*; IBSC! • 19 Sep. 2016; *F.J. Mou 528*;

SWFC! • Wenshan, Xishan; 14 Oct. 1958; *H.T. Tsai* 8444; KUN! • Mengla, Menglun, cultivated; 3 Feb. 2007; *F.J. Mou 41*, *42*; IBSC!.

Description

Shrub, 1–2 m tall. Leaves are 3–11-foliolate, 3–10 × 2.5–6.5 cm; rachises and petiolules covered with soft hairs; leaflet blades alternate, ovate-oblong, coriaceous, dispersively oil-glandular, dark green and shining adaxially and yellowish green abaxially, lower surface covered densely with white soft hairs abaxially, apex obtuse to rounded, margin crenulate; petiolules 2–3 mm. Inflorescences are terminal. Flowers are 5-merous, ellipsoid in bud; sepals broadly ovate, ca 1 mm; petals ca 4 mm, dispersing oil glands. Stamens are 10; filaments flat and widening down; filaments and anthers ciliate. Ovaries are oblong, as long as styles; stigmas not prominent. Fruits are globose, ca 1 cm in diam., and red when ripe.

Phenology

Flowering between June and July, while fruiting from October to November.

Distribution and habitat

China: Guangxi (Longzhou, Ningming, Wuming, Yongning, Fushui, and Baise), Yunnan (Wenshan and Funing); Vietnam: Quỳ Chau. Growing in the shrub or forestry of limestone areas, alt. 100–800 (1400) m.

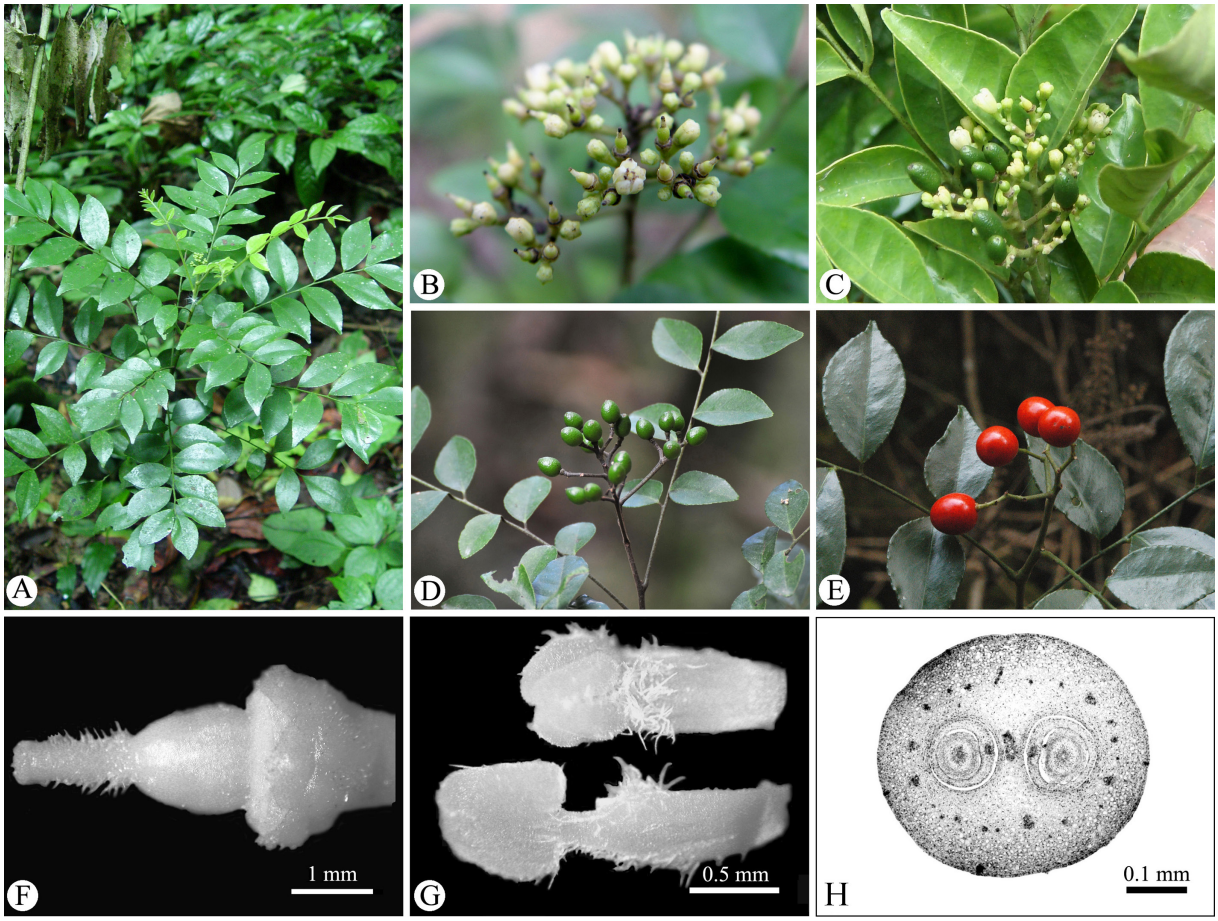

Fig. 8. *Bergera kwangsiensis* (C.C.Huang) F.J.Mou comb. nov. **A.** Plant. **B**. Inflorescence. **C**. Flowers and young fruits. **D–E**. Infructescence. **F**. Pistil. **G**. Stamens. **H**. Ovary crossection. Photos taken by Feng-Juan Mou in China.

Remarks

The leaves and fruits of this species have a strong, pleasant scent.

Bergera macrophylla (C.C.Huang) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314671-1
Fig. 9

Murraya kwangsiensis (C.C.Huang) C.C.Huang var. *macrophylla* C.C.Huang, *Acta Phytotaxonomica Sinica* 16 (2): 85 (Huang 1978). – *Murraya macrophylla* (C.C.Huang) F.J.Mou, *Guihaia* 40 (2): 272 (Mou *et al.* 2020). – **Type**: CHINA • Guangxi, Daxin, Xialei, Bitun; *Z.J. Li 3198*; holotype: IBK[IBK00191042] image! • Longzhou, Kejia, Longshan; *X.F. Deng 10571*; syntype: IBK[IBK00191043] image! • Longzhou, Jinlong, Banbi; *H.Q. Li 40099*; syntype: IBK[IBK00191044] image!.

Etymology

The specific epithet refers to the large leaves.

Material examined

CHINA • Guangxi Province; *P.X. Tan 57677*; GXMI! • Napo, Pingmeng; 26 Sep. 2016; *F.J. Mou 543*, *544*; SWFC! • 25 Nov. 2016; *F.J. Mou 550*; SWFC! • 8 Dec. 2017; *F.J. Mou 624*, *625*; SWFC! • Baidu, Nonghua; 19 Oct. 1977; *D. Fang 3-15482*; GXMI! • 17 Oct. 1990; *D. Fang et al. 0885*; GXMI! • Nongbu; 22 Jul. 2013; *D.X. Nong et al. 451026130722029LY*; GXMG!, GXMI! • 27 Nov. 2013; *X.Y. Huang et al. 51026131127023LY*; GXMG! • Nonglong; 15 Oct. 2014; *B.Y. Huang et al. 451026141015067LY*; GXMG! • Jingxi, Tunpan; 14 Oct. 2014; *Y.D. Peng et al. 451025141014005LY*; GXMG! • Longzhou, Kejia, Longshan; 30 Oct. 1959; *X.F. Deng 10571*; IBK! • Jinlong, Banbi; Oct. 1958; *H.Q. Li 40099*; IBK! • Daxin; 20 Nov. 1956; *Z.J. Li 3198*; IBK! • Xialei; 7 Dec. 2017; *F.J. Mou 618*, *619*; SWFC!.

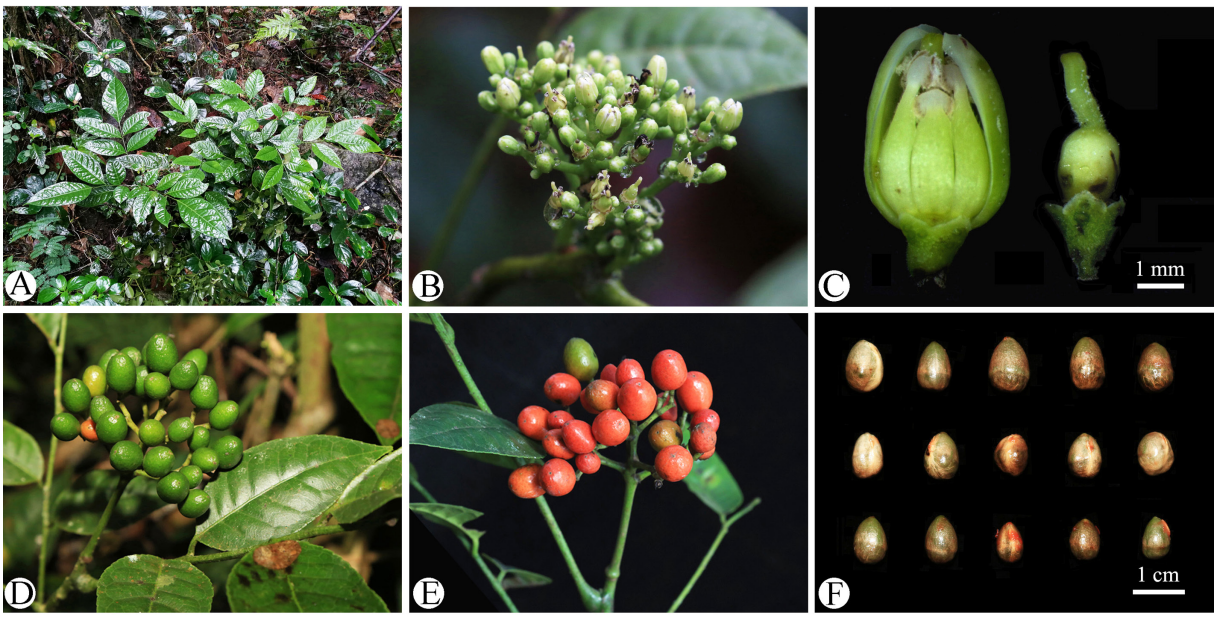

Fig. 9. *Bergera macrophylla* (C.C.Huang) F.J.Mou comb. nov. **A.** Plants. **B**. Inflorescence. **C**. Flower and pistil. **D–E**. Infructescence. **F**. Seeds. Photos taken by Feng-Juan Mou in China.

Description

Shrub, high up to 2 m. Compound leaves are 12–46 cm long; rachis rather thin, ca 28 cm long; leaflets 3–9, alternate; chartaceous, leaflets blades 7–18 × 4–10 cm, glabrous, inequilateral, pointed at the base, abruptly acuminate at the tip, very slightly denticulate, with few oil glands; lateral veins, 6–9 pairs, prominent on lower surface; petiolules cylindric, glabrous, 3–4 mm long; petiole cylindric, glabrous. Cymes are terminal, with a few small white flowers, much shorter than the leaves; pedicels longer than flowers, with 2 small bracts at the base or lower third. Flower buds are long, 6 × 2.5 cm, yellow-green, fragrant; calyxes 4-connate, indistinct, very shortly ciliate sepal with a big oil gland; petals 5, lanceolate, 4–6 mm long, 1.5 mm wide, glabrous, a few oil glands. Stamens are 10, 4 mm long; filaments dilated and pubescent upper; anthers attached by the back, oval, with a few hairs. Disks are extremely short. Ovaries are cylindric, warty, glabrous, and distinctly constricted at ca ⅓ from the apex; styles longer than ovaries, with elongated styles, and pubescent lower; stigmas inconspicuous. Berries are oval, diameter 5–10 mm, glabrous, with glands, and red when ripe, containing 1-2 seeds.

Phenology

Flowering between June and July, while fruiting from August to December.

Distribution and habitat

China, SW Guangxi (Longzhou, Daxin, Jingxi, and Napo); Vietnam. Growing in forestry of limestone hill or valley forests between alt. 550 and 1400 m.

Remarks

The species *Bergera macrophylla* shares few similarities of flowers with *B. kwangsiensis*, but both are so different in many morphological characteristics (Mou *et al.* 2020). However, the taxon is more similar to *B. glabra* from Vietnam in leaf morphological characteristics, and different having fewer oil glands in the mesophyll, smaller cymes, fewer flowers and fruits.

Bergera microphylla (Merr. & Chun) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314676-1
Fig. 10

Clausena microphylla Merr. & Chun, *Sunyatsenia* 2: 251, fig. 27 (Merrill & Chun 1935). – *Murraya microphylla* (Merr. & Chun) Swingle, *Journal of the Washington Academy of Sciences* 32 (1): 26 (Swingle 1942). – **Type**: CHINA • Hainan, Xincun (Sun Chue); 21 Jul. 1932; *N.K. Chun & C.L. Tso 43323*; lectotype: IBSC[0409335]!; isolectotypes: IBSC[0409328, 0001859, 0409330]!, IBK[IBK00108120]!, SYS[SYS00095204]!, K[K000736100] image!, P[MNHN-P-P06638005] image!, B[B100296006] image!, A[A00044115] image!, US[US00101714] image!, NY[NY00399952] image!. **Designated here**.

Etymology

The specific epithet refers to the small leaflets.

Material examined

CHINA • Hainan Province, Lingshui; 21 Jul. 1932; *N.K. Chun & C.L. Tso 43323*; IBCS!, IBK!, SYS!, K image!, P image!, B image!, A image!, US image!, NY image! • 16 Oct. 1935; *K.Z. Hou 73825*; IBSC! • 11 May 1983; Nanwanling; *G.A. Fu 3570*; IBSC! • 11 Sep. 1986; *Q. Li 265*; SYS! • Dongfang (Gan'en); 20 Aug. 1936; *X.Q. Liu 27726*; IBK!, IBSC!, PE image! • Changjiang; 25 Apr. 1975; *G.A. Fu 0502*; IBSC!, SZ image! • Ledong, Jianfengling; 11 May 1964; *H.S. Lin 269*; IBSC! • Sanya; 24 Jun. 1933;

K.Z. Hou 70882; IBSC!, PE image!, NAS image!, SZ image! • 4 Jul. 1933; *X.R. Liang 61885*; IBK!, IBSC!, KUN!, PE image! • *Z. Huang 32740*; IBK!, IBSC! • 30 Aug. 1933; *Z. Huang 33795*; IBK!, IBSC! • Jul. 1964; *P.Y. Huang 386*; SYS! • 17 Oct. 1984; *Q. Li 156*; SYS! • 8 Sep. 1986; *Q. Li 248*; SYS! • 1 Aug. 1987; *Q. Li 248*; SYS! • Wanning; 8 Apr. 1984; *Z.X. Li et al. 1786*; IBSC! • 28 May 1988; *Z.X. Li et al. 4690*; IBSC! • 2008; *F.J. Mou 163*; IBSC! • 19 Sep. 2016; *F.J. Mou 528*; SWFC! • Guangdong Province, Xuwen; *D. Liang et al. WP136*; IBSC!.

Description

Shrubs or small trees, up to 6 m. Branches are glabrous; branchlets with a dispersed white pubescence. Leaves 11–21-foliolate; petiolules extremely short; petiole and rachis with scattered white pubescence of short curved hairs; leaflet blades suborbicular to ovate to elliptic, 3–20 × 3–6 mm, glabrous, base usually inequilateral, margin crenate, and apex rounded to obtuse. Inflorescences are terminal, 10–30-flowered. Flower buds are 4–5 × 2.5 mm; flowers 5-merous, white, and fragrant; sepals ovate-elliptic, ca 1 mm, persistent in fruits; petals in bud 4–5 mm scattered with large and very dark oil glands. Stamens are as long as the pistil, with linear subulate filaments. Disks are very short. Pistils 4 mm long; ovaries 1.2–1.5 mm long, 0.9–1 mm wide, 1- or 2-loculed, and with 1 or 2 large oil glands at the top of the locule; styles 3 × 0.4–0.5 mm; stigmas subcapitate, 0.7–0.9 mm diam. with a few small oil glands. Fruits are ellipsoid to ovoid-ellipsoid, up to 1 cm.

Phenology

Flowering between April and May, while fruiting from July to October.

Distribution and habitat

China: Hainan (Sanya, Lingshui, Wanning, Changjiang, Ledong, and Dongfang). Growing in thickets on the sand near beach.

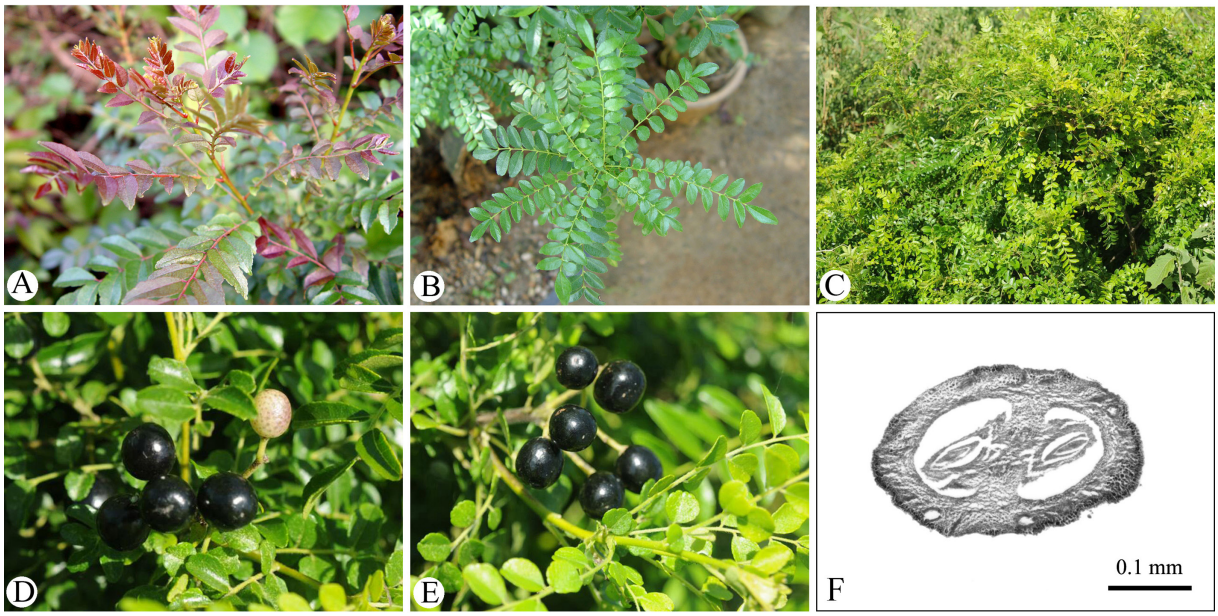

Fig. 10. *Bergera microphylla* (Merr. & Chun) F.J.Mou comb. nov. **A–C**. Plants. **D–E**. Infructescence. **F**. Ovary crossection. Photos taken by Feng-Juan Mou and Dan Liang in China.

Remarks

This species is very close to *B. koenigii* on some flower and fruit morphological traits, but with much smaller leaflets.

Bergera siamensis (Craib) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314672-1
Fig. 11

Murraya siamensis Craib, *Bulletin of Miscellaneous Information* 8: 340 (Craib 1926). – *Chalcas siamensis* (Craib) Tanaka, *Bulletin de la Société botanique de France* 75 (4): 710 (Tanaka 1928). – **Type**: THAILAND • Lampang, Mê Kat; alt. 250 m; 24 Apr. 1923; *Winit 849*; lectotype: K[K000382432] image!; isolectotype: BKF [SN055887] image!. Designated by Tanaka (1928).

Etymology

The specific epithet is derived from the type locality, Thailand (namely Siam).

Material examined

THAILAND • Nov. 1928; *Put Nai 2123*; TCD image!, L image! • Nov. 1929; *Put Nai 2440*; TCD image! • Lampang, Me Kart; 24 Apr. 1923; *Winit 849*; K image!, BKF image! • Saraburi, Pukae Botanical Garden, cultivated; 30 Mar. 1987; *D.D. Soejarto et al. 5834*; L image!.

Description

Small tree, up to 8 m tall. Trunk with fuscous or blackish bark having high ridges or deeply cracked; year-old twigs puberulous, then fuscous, with small lenticels; young twigs, rachis, petiolule, pedicel and sepal covered with short and curly pubescence. Leaves 15–30 cm long; leaflets 17–25, alternate or rarely subopposite, inequilateral, apex obtuse, subacuminate, 2–7 cm long, 1–2.7 cm broad, chartaceous, clearly dotted on the upper surface, above curly pubescent, very soon more or less glabrescent below, chiefly pubescent at the midrib, margin subentire or more or less obscurely crenulate; petiolule ca 2 mm long. Inflorescences are terminal, subcorymbose, small, 15 cm long, and with 10–15 flowers. Flower buds are small, oblong-ovoid, ca 5 mm long, without glandular dots; flowers greenish-white, aromatic; pedicels short, and ca 3–4 mm long; calyxes 5-lobed, ovate, lanceolate or deltoid, obtuse, 1.25 mm long, with long soft hairs, and persistent; petals 5, linear-oblanceolate, incurving-apiculate, 6.5 mm long, 1.75 mm wide, glabrous, thickened at the middle, and imbricate. Stamens are 10, alternate ones longer, filaments 4–5 mm long, narrowed toward the apex, the lower half slightly broader but scarcely complanate, anthers ca 1 mm long, and papillate. Disks are fleshy, glabrous, and slightly shorter than calyx. Ovaries are slightly oblong, cylindric, notched, glabrous, and shortly stipitate; styles cylindric, 3–5 mm long, articulated at the base, and glabrous; stigmas capitate. Fruits are black, large, up to 2 cm diam., somewhat 4-angled, with shallow depressions between slightly protuberant locules after drying. The species is described based merely on Swingle & Reece (1967) and some images of specimens images.

Phenology

Flowering between March and April, while fruiting from May to August

Distribution and habitat

The species is only found in Thailand (Lampang) in forestry between alt. 50 and 250 m.

Fig. 11. Branches, leaves, flowers and fruits of *Bergera siamensis* (Craib) F.J.Mou comb. nov. **A**. *Winit 849*, K000382432 (holotype: the Kew Herbarium, K). **B**. SN055887 (isotype: Bangkok Forest Herbarium, BKF). **C**. *D.D. Soejarto et al. 5834*, L.2127107 (National Herbarium Nederland, Leiden University branch, L). **D**. *Put Nai 2440*, TCD0013457 (Trinity College Dublin Herbarium, TCD).

Remarks

Although a few researchers reduced *Bergera siamensis* (syn. *Murraya siamensis*) to a synonym of *Bergera koenigii* (Esser 2021; Govaerts *et al.* 2021), it is an independent species based on both phylogenetic relationship and morphology. Although this species *Bergera siamensis* is closely allied with *B. koenigii* based on some morphological characteristics, the dots on the petals are nearly indistinct, filaments are less subulate, petals much narrower, and fruit much larger and 4-grooved; the pubescence of the plant is more pronounced than *B. koenigii*, and sometimes the whole plant is covered with white curved hairs. Many volatile oil glands were seen in its leaves (Inpuron *et al.* 2013). It has a specific volatile smell and the crushed leaves are aromatic. In Thai folkloric medicine, it has been used for the treatment of blurred vision (eye sores), snake-poison and tuberculosis (Likhitwitayawuid *et al.* 1999).

Bergera stenocarpa (Drake) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314673-1
Fig. 12

Atalantia stenocarpa Drake, *Journal de Botanique* 6: 277 (Drake del Castillo 1892). – *Glycosmis stenocarpa* (Drake) Guillemin, *Notulae Systematicae (Paris)* 2: 158 (Guillemin 1911). – *Chalcas stenocarpa* (Drake) Tanaka, *Bulletin de la Société botanique de France* 75 (4): 711 (Tanaka 1928). – *Murraya stenocarpa* (Drake) Tanaka, *Blumea* 2 (2): 102 (Tanaka 1936), in obs. – *Murraya stenocarpa* (Drake) Swingle, *Journal of the Washington Academy of Sciences* 28 (12): 532 (Swingle 1938). – **Type**: VIETNAM • Tonkin; 1885; *B. Balansa 1110*; lectotype: P[MNHN-P-02441044] image!. **Designated here**.

Glycosmis bonii Guillemin, *Notulae Systematicae (Paris)* 1: 214 (Guillemin 1910). – **Type**: VIETNAM (INDO-CHINE) • Tonkin, Bac-bat; 15 Sep. 1881; *H.F. Bon 798*; holotype: P[P02441050] image!.

Etymology

The specific epithet refers to the narrow fruits.

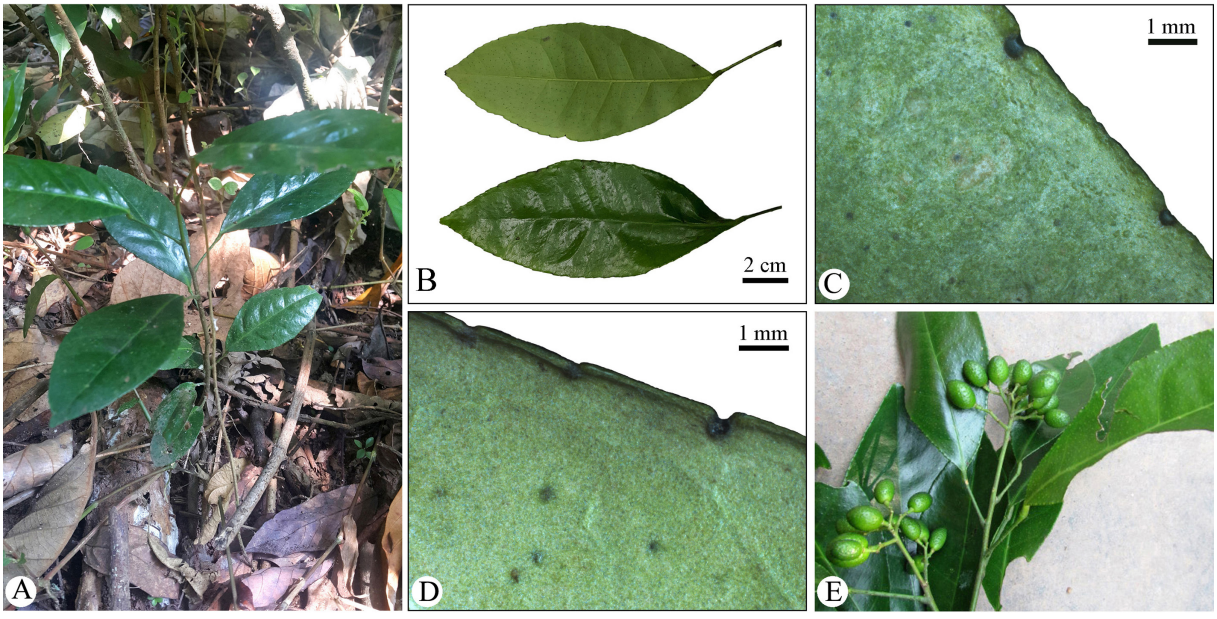

Fig. 12. *Bergera stenocarpa* (Drake) F.J.Mou comb. nov. **A**. Plant. B. Leaves. **C–D**. Dorsal side of leaf. **E**. Infructescence. Photos taken by Nguyen Manh Cuong in Vietnam and Feng-Juan Mou.

Material examined

VIETNAM • Tonkin; 1885; *B. Balansa 1111*, *1112*, *1113*; P images! • Lang Son; 4 Apr. 1965; *China-Vietnam Expedition 1305*; IBSC!, HITBC!, PE image! • Tonkin occidental; Sep. 1881; *H.F. Bon 798*; P image! • Hai Duong, Hoang Hoa Tham; 2016; *F.J. Mou 573*; SWFC!.

Description

Small shrub, up to 1.0–1.5 m high. Branches are grayish brown, short pilose. Leaves unifoliate, rarely 2-foliolate; petiole 3–4 cm, with a swelling at the base of the leaf blade; leaflet blades 8–15 × 3–6 cm, subcoriaceous, shining, elliptical or oblong-lanceolate, acute at the base, narrowed at the apex, rounded to obtuse or retuse to subemarginate, and margin evident teeth or serrate; secondary veins 10–12 pairs, pilose at veins in both sides, midvein slightly ridged; oil glands easily visible principally on the margins and in the angles of the teeth; petiolule of leaflet 5 mm, pilose. Cymes are axillary, 2 cm, (2- or) several flowered; pedicel pilose. Flowers are small; calyxes 5-lobed, short, triangular, and 0.5 mm long; petals 5, white, glabrous, oblong, 3-4 mm, and with pellucid dots on the surface. Stamens are 10, filaments free, 5 long and 5 short, dilated at the base and abruptly pointed at the tip, and pilose. Ovaries are subglobose, glabrous, borne on a low disk, 2-ovuled, and each with 1 ovule. Berries are fleshy, oblong, 15 mm long, 1 cm in diam., shortly attenuated at the tip, and with many evident oil glands; reddish or orange when mature. The species is described based merely on Swingle & Reece (1967) and some images of specimens and plants in Vietnam.

Phenology

Flowering between September to December, while fruiting from March to April (next year).

Distribution and habitat

Vietnam: North Vietnam (Tonkin), Hai Phong (Cat Ba National Park), Lang Son (Thanh Muoi), Ha Noi (Bat Bat). Distributed on limestone mountains.

Remarks

This species is characterized by the unifoliate leaves, which is familiar to other species *Bergera unifolia*.

Bergera tetramera (C.C.Huang) F.J.Mou, comb. nov.
urn:lsid:ipni.org:names:77314674-1
Fig. 13

Murraya tetramera C.C.Huang, *Acta Phytotaxonomica Sinica* 8 (1): 102, pl. 13 (Huang 1959). – **Type**: CHINA • Yunnan, Mangshi (Luxi); *H.T. Tsai 57277*; lectotype: PE[00022518] image!; isolectotypes: PE[00022517] image!, IBSC[0409247]!, NAS[NAS00071351] image!. **Designated here**.

Etymology

The specific epithet refers to the 4-merous flowers.

Material examined

CHINA • Yunnan Province; 1933; *H.T. Tsai 57277*; NAS image!, PE image!, A image! • *H.T. Tsai 57287*; KUN!, SWFC!, NAS image!, PE image!, A image! • *H.T. Tsai 57525*; KUN!, PE image!, A image! • *H.T. Tsai 57453*; KUN! • 20 Oct. 1933; *H.T. Tsai 56249*; KUN!, NAS image! • 23 May 1940; *C.W. Wang 89515*; KUN!, IBSC!, PE image! • Yanshan; 26 Oct. 1932; *H.T. Tsai 51453*; NAS image!, PE image! • 19 Sep. 1939; *C.W. Wang 83565*; KUN!, IBSC!, PE image! • *83595*; KUN!, IBSC!, WUK image!, PE image! • 24 Oct. 1939; *C.W. Wang 83520*; KUN!, WUK image!, PE image! • 30 Oct. 1939;

C.W. Wang 83555; KUN!, PE image! • Bayao; 6 Nov. 1939; *Q.W. Wang 84818*; KUN!, PE image! • Xinghua; 5 Nov. 1958; *H. T. Tsai 589112*; KUN! • 18 Jun. 1964; *S.Z. Wang 775*; KUN! • 2 Oct. 2016; *F.J. Mou 547*; SWFC! • Malipo; 20 Feb. 1940; *C.W. Wang 86992*; KUN!, PE image! • Tingting; 23 Sep. 1947; *K.M. Feng 11965*; KUN!; PE image!, A image! • 22 Nov. 1947; *K.M. Feng 13555*; KUN! A image! • Tungting; 18 Nov. 1947; *K.M. Feng 13367*; KUN! A image! • Xichou, Yaobang; 27 Dec. 1939; *C.W. Wang 86068*, *86094*; KUN!, PE image! • Fadou; 16 Nov. 1960; *Q. A. Wu 90*; KUN! • 3 Jun. 1964; *S.Z. Wang 650*; KUN! • 14 Dec. 1964; *Q.A. Wu 10013*, *Z.W. Lin 685*; KUN! • 8 Oct. 2011; *Q.R. Liu & S.Y. Meng 2011-10-122*; BNU image! • Nanchang; 10 May 1959; *Q.A. Wu 5093*; KUN! • Mengla, Yiwu; 9 Sep. 1959; *S.J. Pei 10092*; KUN! • Mengyuan; 21 Jun. 1973; *P.Z. Zhu 8650*; HITBC!; IBSC! • 31 May 1982; *Expedition 32673*; HITBC! • 9 Dec. 1982; *Expedition 34392*; HITBC! • Jinghong, Jinuo; 1 Jun. 1961; *Y.H. Li 3309*; HITBC! • 7 Dec. 1961; *Y.H. Li 3716*; HITBC! • 31 Jul. 1977; *G.D. Tao 15722*; HITBC!, PE image! • Menghai; 20 Apr. 1959; *Z.D. Wang 57991*; KUN! • Jianshui; 16 Mar. 1941; *S.E. Liu 018293*; PE image! • Ning'er, Dehua; 28 Jan. 1991; *G.D. Tao 44127*; HITBC! • Mengzi; *A. Henry 9651 D*; L image!, LE image! • *A. Henry 9651*; LE image! • 27 Nov. 2016; *F.J. Mou 558*; SWFC! • Mile, Xi'er, Nuozu; 29 May 1990; *Investigation group of plant resources in Mile County 400*; KUN! • Shilin, Naigu; 30 Oct. 2016; *F.J. Mou 548*; SWFC! • Eshan, Chahe; Jan. 1979; *Yüxi Plant Expedition s.n.*; KUN! • 17 Dec. 2012; *J. Cai et al. 12CS5744*; KUN! • Yimen; 6 Agu. 2018; *F.J. Mou 640-2*; SWFC! • Lanping; 19 Sep. 1964; *S.G. Wu 8980*; KUN! • 5 Nov. 2006; *T. Zhang et al. SCSB-B-000208*; KUN! • Weixi; 6 May 1960; *Anonymous 8658*; KUN! • Fugong, Pihe; 30 May 1978; *Bijiang Expedition 0252*; KUN! • Fugong, Pihe; 2 Feb. 2017; *F.J. Mou 562*; SWFC! • Guizhou Province, Anlong; 20 May 1960; *Z.S. Zhang & Y.T. Zhang 3703*; IBK! • 20 May 1960; *Guizhou Expedition 3730*; IBSC! • 12 Mar. 2009; *F.J. Mou 233*; IBSC! • Longshan; 9 Jun. 1960*; Z.S. Zhang 3183*; IBSC!, HGAS image! • 12 Jun. 1960; *Guizhou Expedition* 4346; IBSC! • 23 Jun. 1960; *Guizhou Expedition* 5758; IBSC! • Pingle; 23 Apr. 2014; *C.Y. Deng 522328140423700 LY*; GZTM image! • Xishui; 10 Apr. 2003; *C.W. Wu 1153*; PE image! • 9 May 2003; *1192*; PE image! • Renhuai; 16 Apr. 2003; *X.L. Wang & M.T. An 2130*; PE image! • 14 May 2003; *X.L. Wang 2166*; PE image! • Xingyi; 7 Aug. 1959; *Anshun Expedition 867*; KUN! • *869*; HGAS image! • 26 Jul. 1960; *Guizhou Expedition 6547*; IBK!, IBSC!, NAS image! • Xingren; 4 Dec. 1980; *C.Z. Dang 80526*; HGAS image! • Libo; 8 May 1981; *M.Z. Yang 810258*; HGAS image! • Wangmo;

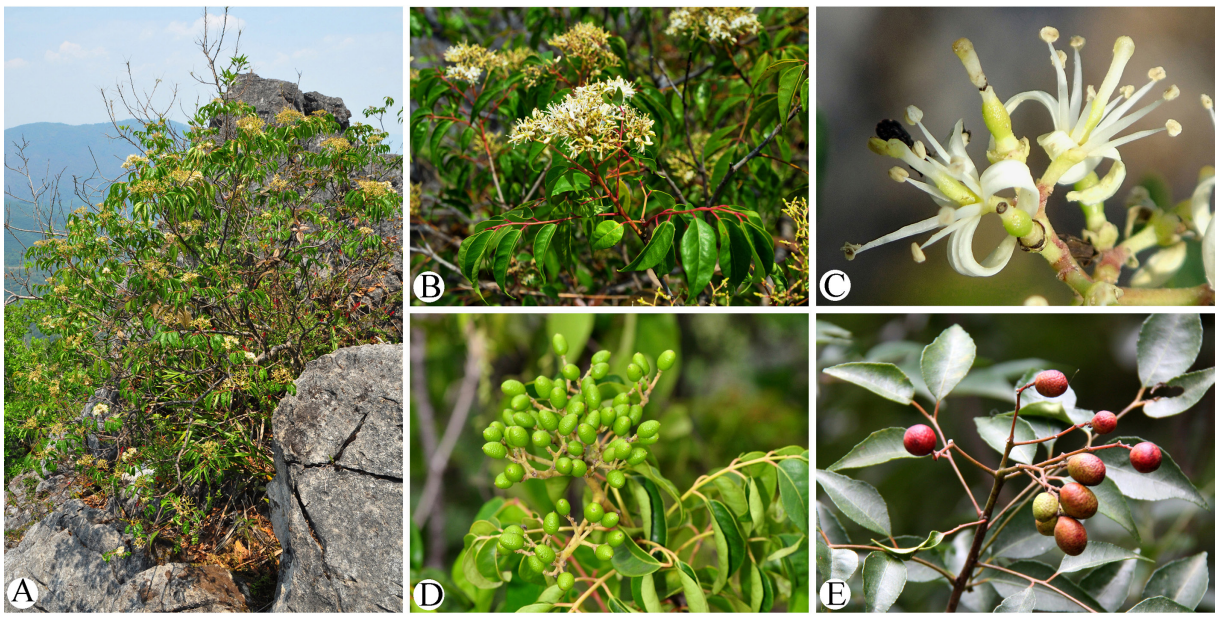

Fig. 13. *Bergera tetramera* (C.C.Huang) F.J.Mou comb. nov. **A**. Plants. **B**. Inflorescence. **C**. Flowers. **D–E**. Infructescence. Photos taken by Jian Huang and Feng-Juan Mou in China.

23 Apr. 1960; *Guizhou Expedition 1221*; IBSC! • 8 Nov. 1986; *Longtan Expedition 00751*; IBK! • Zhenfeng; 8 Oct. 1982; *D.J. Liu 622*; HGAS image! • 23 Oct. 1982; *D.J. Liu 847*, *848*; HGAS image! • Huishui, Heping; 16 Oct. 2010; *F.L. Zou ZouFL0155*; KUN!.

Description

Small trees, 3–7 m high. Branches, leaves pedicel and peduncle covered sparsely with hairs, becoming glabrous later; strongly fragrant. Leaves are 5–11-foliolate; leaflet blades narrowly lanceolate, 2–5 × 0.8–2.0 cm, usually yellow-green, becoming dark brownish-black and oil glands slightly swelling when dry, slightly asymmetrical or symmetrical at the base, and apex acuminate; petiolules 2–4 mm, reddish usually. Inflorescences are terminal cymes. Flowers are white; 4-merous; sepals ovate, less than 1 mm, connate at base; petals white, oblong, 4–5 mm, and revolute when open. Stamens are 8, alternate with long and short, filaments ca 4 mm long and slim. Ovaries are ellipsoid, ca 1 mm; styles ca 2 mm long. Fruits are reddish, globose, 1.0–1.2 cm in diam., with many oil glands, brown after drying, 1–3-seeded. Seed coats are membranous and smooth.

Phenology

Flowering between March and April, while fruiting from July to August.

Distribution and habitat

China: W Guangxi (Baise and Debao), SW Guizhou (Anlong), Yunnan (Yanshan, Funing, Wenshan, Xichou, Malipo, Jinghong, Mengla, Menghai, Ninger, Menglian, Eshan, Yuanyang, Yuanjiang, Mengzi, Jianshui, Mile, Weixi, Lanping, Fugong, and Mangshi). Often growing at the sunny top of limestone hills.

Remarks

Morphologically, this species is relative to *B. euchrestifolia*, but the plants are characterized with heavier smell and flowers are 4-merous stably. Two species have different distributions.

Bergera unifolia C.L.Deng & F.J.Mou
Fig. 14

Bergera unifolia C.L.Deng & F.J.Mou, *Annales Botanici Fennici* 58 (4–6): 363 (Deng *et al.* 2021). – **Type**: CHINA • Guangxi, Guilin (transplanted from Duyang, Dahua); alt. ca 540 m; 18 Aug. 2017; *F.J. Mou 595*; holotype: SWFC!; isotype: SWFC!.

Etymology

The specific epithet refers to the unifoliate leaves.

Material examined

CHINA • Guangxi, Dahua; 18 Aug. 2017; *C.L. Deng et al. 1*, *2*, *3*; preserved in Guangxi Academy of Specialty Crops, China.

Description

Shrub, up to 1 m high. Spineless, glabrous; oil glands prominent and easily visible principally on the young branches, rachis, and petiolule, as well as along the margins and in the mesophyll. Young branches are green, becoming grey-brown when old. Leaves are unifoliolate; rachis ca 2.5–5.5 cm long and swelling at the base; petiolule more swollen than rachis and 4–5 mm long; leaflets subcoriaceous, shining above and hairy underneath, and elliptical or oblong-lanceolate; leaf blades 7–12 cm long, 3–6 cm wide, acute cuneiform at the base, narrowed attenuate and slightly emarginate at the tip, and obtuse or subemarginate,

serrate; with 10–15 pairs of lateral veins and clearly distinct from the veinlets and elevated above the surface below. Cymes are both axillary and terminal and up to 50-flowered. Flower buds are small, 2.5–3.5 × 2.0 mm; calyxes 5-lobed, short, ovate, acute, and 0.8–1.3 × 0.5–0.9 mm; petals oblong, 2.5–3.5 × 0.5–1.0 mm wide; pellucid dots on the surface of the petals and calyx lobes. Stamen filaments are free, 10, alternately unequal in length, ciliate, 2.5 mm and 3 mm long, respectively, dilated at the base and abruptly pointed at the tip; anthers not large, pubescent. Pistils are 1.8–2.5 mm long; ovaries are oblong, yellow, substipitate, and glandular, borne on a low disc, with 2 ovules, each with 1 ovule; styles cylindrical, pubescent, and white. Fruits are fleshy, red, oval, and up to 15 mm long.

Phenology

Flowering between May and June, while fruiting from July to August.

Distribution and habitat

The species is only endemic to Dahua (Guangxi Province, China). It grows in limestone hills at alt. 500 m.

Remarks

This species is similar to *B. stenocarpa* with unifoliate leaves, but is distinguished easily from the latter by having smaller and thinner leaflets. The leaflets of this taxon are also close to *B. kwangsiensis* due to the hairs under the leaflets, oil glands and smell (Deng *et al.* 2021).

Discussion

Our phylogenetic analyses inferred from ITS and cpDNA data reveals that *Bergera koenigii*, *B. siamensis* and *B. microphylla* form a clade, which is in accordance with morphological data. Based on flower and fruit characteristics, *Bergera microphylla* is very close to *B. koenigii*, but has much smaller leaflets. Our molecular data also support these morphological affinities between *B. microphylla* and *B. koenigii*. Most organs and sometimes the whole plant of *B. siamensis* are densely covered with the white curved hairs.

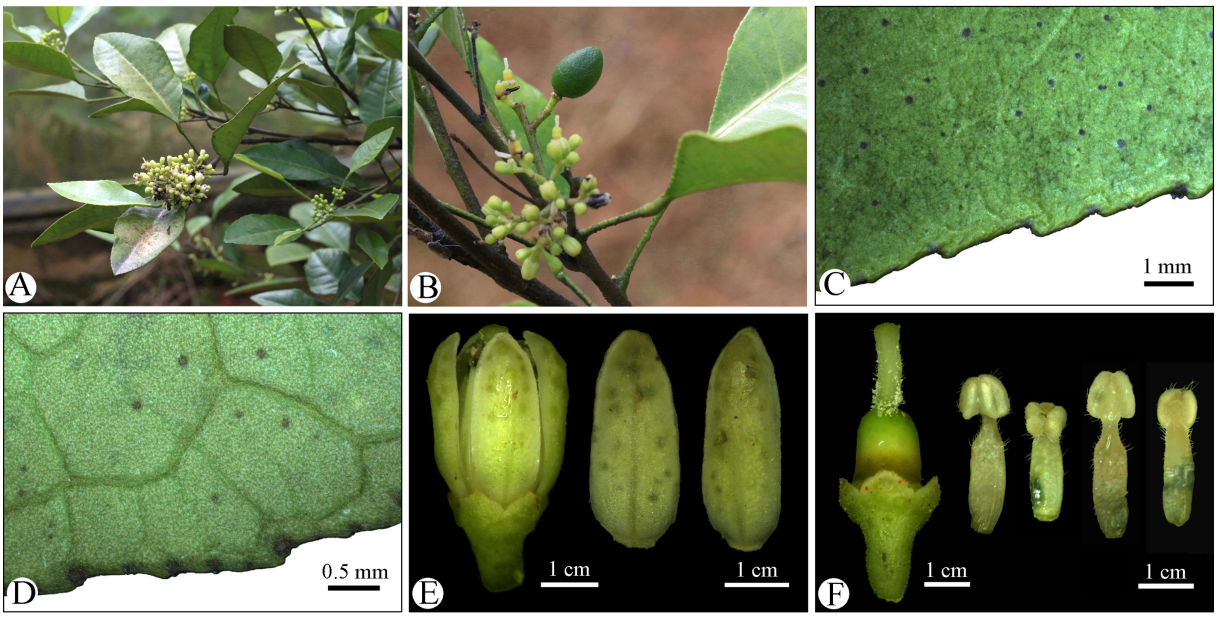

Fig. 14. *Bergera unifolia* C.L.Deng & F.J.Mou. **A**. Inflorescence. **B**. Fruit. **C–D**. Dorsal side of leaf. **E**. Flower. **F**. Flower parts. Photos taken by Feng-Juan Mou in China.

It is different from other relative two species (*B. koenigii* and *B. microphylla*), of which only young branches are pubescent.

The molecular phylogenetic and morphological data indicates that *B. macrophylla* should be regarded as a distinct species, rather than a variety of *B. kwangsiensis* (Mou *et al.* 2020), and has a close relationship with *B. stenocarpa* and *B. unifolia* (Deng *et al.* 2021). Two species *B. stenocarpa* and *B. unifolia* have the unifoliate leaves, but both species are distributed in separated areas, Vietnam and China, respectively.

The species *B. tetramera*, *B. euchrestifolia* and *B. crenulata* are morphologically similar but distributed in different regions. However, the plants of *B. tetramera* are characterized by stronger aroma, and flowers are always tetramerous while *B. crenulata* has thicker and bigger leaflets and cymes with more flowers.

In a previous study by But *et al.* (1986), the species *B. alternifolia* (syn. *B. alternans*) was included in *Murraya* sect. *Murraya*, but lacking more information of morphological or biochemical data. However, strong aroma from the leaves and flowers is very similar to that from *B. koenigii* (formerly placed in *Murraya* sect. *Bergera*); meanwhile, the leaves and branches of *B. alternifolia* get slightly brown after drying in a shady and well-ventilated area. Although a new dihydrofuranocoumarin was found in *B. alternifolia* (Aye *et al.* 2001; Min *et al.* 2004, 2007), it is a special species in *Bergera*, based on morphological data, and needs further studies.

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References

Appelhans M.S., Bayly M.J., Heslewood M.M., Groppo M., Verboom G.A., Forster P.I., Kallunki J.A. & Duretto M.F. 2021. A new subfamily classification of the *Citrus* family (Rutaceae) based on six nuclear and plastid markers. *Taxon* 70 (5): 1035–1061. https://doi.org/10.1002/tax.12543

Aye M., Min H.M. & Htun S. 2001. Isolation and structural elucidation of an unknown compound from *Murraya alternans* (Kurz) Swingle. *Proceedings of the Myanmar Academy of Arts and Science* 2: 193–200.

Bayer R.J., Mabberley D.J., Morton C., Miller C.H., Sharma I.K., Sharma I.K., Pfeil B.E., Rich S., Hitchcock R. & Sykes S. 2009. A molecular phylogeny of the orange subfamily (Rutaceae: Aurantioideae) using nine cpDNA sequences. *American Journal of Botany* 96 (3): 668–685. https://doi.org/10.3732/ajb.0800341

But P.P.-H., Kong Y.-C., Ng K.-H, Chang H.-T., Li Q., Yu S.-X. & Waterman P.G. 1986. A chemotaxonomic study of *Murraya* (Rutaceae) in China. *Acta Phytotaxonomica Sinica* 24 (3): 186–192. [In Chinese.] http://www.jse.ac.cn/CN/Y1986/V24/I3/186

Coode M.J.E. 1979. Rutacées. *In*: Bosser J., Ferguson I.-K. & Soopramanien C. (eds) *Flore des Mascareignes* 65: 25. Sugar Industry Research Institute, Mauritius.

Craib W.G. 1926. Contributions to the Flora of Siam: Additamentum XIX. *Bulletin of Miscellaneous Information (Royal Botanic Gardens, Kew)* 8: 337–363. https://doi.org/10.2307/4118199

Deng C.-L., Chen C.-W., Wu X.-X., Cuong N.-M. & Mou F.-J. 2021. *Bergera unifolia* (Rutaceae), a new species from Guangxi (China) based on morphological and molecular data. *Annales Botanici Fennici* 58 (4–6): 363–376. https://doi.org/10.5735/085.058.0423

Doyle J.J. & Doyle J.L. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissues. *Phytochemical Bulletin* 19 (1): 11–15.

Drake del Castillo E. 1892. Contribution à l'étude de la Flore du Tonkin. *Journal de Botanique* 6: 271–278.

Esser H.-J. 2021. Taxonomic notes on the Rutaceae of Thailand. *Thai Forest Bulletin (Botany)* 49 (1): 27–31. https://doi.org/10.20531/tfb.2021.49.1.02

Farris J.S., Källersjö M., Kluge A.G. & Bult C. 1995. Testing significance of incongruence. *Cladistics* 10 (3): 315–319. https://doi.org/10.1111/j.1096-0031.1994.tb00181.x

Forster P.I. 2000. *Clausena smyrelliana* (Rutaceae: Aurantioideae), a new and critically endangered species from south-east Queensland. *Austrobaileya* 5 (4): 715–720.

Govaerts R., Nic Lughadha E., Black N., Turner R. & Paton A. 2021. The World Checklist of Vascular Plants, a continuously updated resource for exploring global plant diversity. *Scientific Data* 8: 215. https://doi.org/10.1038/s41597-021-00997-6

Guerra M., Dos Santos K.G.B., Barros E., Silva A.E. & Ehrendorfer F. 2000. Heterochromatin banding patterns in Rutaceae-Aurantioideae – a case of parallel chromosomal evolution. *American Journal of Botany* 87 (5): 735–747. https://doi.org/10.2307/2656860

Guillemin A. 1910. Espèces ou localités nouvelles pour les Rutacéeae d'Extrême-Orient. *Notulae systematicae (Paris)* 1: 207–224.

Guillemin A. 1911. A propos de l'*Atalantia stenocarpa* Drake. *Notulae Systematicae (Paris)* 2: 157–158.

Guindon S., Dufayard J.F., Lefort V., Anisimova M., Hordijk W. & Gascuel O. 2010. New algorithms and methods to estimate maximum-likelihood phylogenies: assessing the performance of PhyML 3.0. *Systematic Biology* 59 (3): 307–21. https://doi.org/10.1093/sysbio/syq010

Hayata B. 1916. Contributions to the Flora of Formosa IV. *Icones Plantarum Formosanarum nec non et Contributiones ad Floram Formosanam* 6: 11.

Hnawia E., Cabalion P., Raunicher I., Waikedre J., Patissou J., Buchbauer G. & Menut C. 2007. The leaf essential oil of *Murraya crenulata* (Turcz.) Oliver from New Caledonia. *Flavour and Fragrance Journal* 22 (1): 32–34. https://doi.org/10.1002/ffj.1745

Hooker J.D. 1875. *The Flora of British India 1 (pt. 3)*. L. Reeve, London.

Huang C.-C. 1959. Preliminary study on Chinese Rutaceae (3). *Acta Phytopathologica Sinica* 8 (1): 69–124. [In Chinese.] Available from http://www.jse.ac.cn/CN/Y1959/V8/I1/69 [accessed 10 Jan. 2023].

Huang C.-C. 1978. Materials of Chinese Rutaceae. *Acta Phytopathologica Sinica* 16 (2): 81–85. [In Chinese.] Available from http://www.jse.ac.cn/CN/Y1978/V16/I2/81 [accessed 10 Jan. 2023].

Huang C.-C. 1997. Rutaceae. *In*: Delectis Florae Reipublicae Popularis Sinicae Agendae Academiae Sinicae Edita (ed.) *Flora Reipublicae Popularis Sinicae, Tomus 43 (2)*: 139–150. Science Press, Beijing. [In Chinese.]

Inpuron S., Musikachat L., Boonmark W., Suchaitanavanit S. & Eakwaropas P. 2013. Antioxidant activities of *Vernonia cinerea* and *Murraya siamensis*. Proceedings of the 1st Academic Science and Technology Conference ASTC2013, Science and Technology for Better Life.

Kanehira R. 1917. *Formosan Trees Indigenous to the Island*. Department of Forestry, Government Research Institute, Formosa [Taiwan].

Kinoshita T. 2014. A new taxonomic system of the genus *Murraya* (Rutaceae) based on integration of morphology-based taxonomy and chemotaxonomy; and a philological survey on *M. exotica* in view of the relationship between Okinawa and China. *Yakugaku Zasshi Journal of the Pharmaceutical Society of Japan* 134 (12): 1265–1286. [In Japanese.] https://doi.org/10.1248/yakushi.14-00200

Kong Y.-C., Cheng K.-F., Ng K.H., But P.P.-H., Li Q., S.-X. Yu, Chang H.-T., Cambie R.C., Kinoshita T., Kan W.-S. & Waterman P.G. 1986. A chemotaxonomic division of *Murraya* based on the distribution of the alkaloids yuehchukene and girinimbine. *Biochemical Systematics and Ecology* 14 (5): 491–497. https://doi.org/10.1016/0305-1978(86)90008-6

Kong Y.-C., But P.P.-H., Ng K.-H., Li Q., Cheng K.-F., Chang K.-L., Wonga K.M., Gray A.I. & Waterman P.G. 1988a. The biochemical systematics of *Merrillia* in relation to *Murraya*, the Clauseneae and the Aurantioideae. *Biochemical Systematics and Ecology* 16 (1): 47–50. https://doi.org/10.1016/0305-1978(88)90116-0

Kong Y.-C., But P.P.-H., Ng K.-H., Li Q., Cheng K.-F. & Waterman P.G. 1988b. *Micromelum*: a key genus in the chemosystematics of the Clauseneae. *Biochemical Systematics and Ecology* 16 (5): 485–489. https://doi.org/10.1016/0305-1978(88)90049-X

Kumar S., Stecher G. & Tamura K. 2016. MEGA7: molecular evolutionary genetics analysis version 7.0 for bigger datasets. *Molecular Biology and Evolution* 33 (7): 1870–1874. https://doi.org/10.1093/molbev/msw054

Kubitzki K. 2011. *The Families and Genera of Vascular Plants, Vol. 10*. Springer, London. https://doi.org/10.1007/978-3-642-14397-7

Kurz S. 1873. New Burmese plants. *The Journal of the Asiatic Society of Bengal* 42 (2): 59–110.

Kurz W.S. 1875. Contributions towards a knowledge of the Burmese Flora. *Journal of the Asiatic Society of Bengal* 44 (3): 49–288.

Kurz S. 1877. *Forest Flora of British Burma 1*. Office of the superintendent of government printing, Calcutta. https://doi.org/10.5962/bhl.title.52413

Lefort V., Longueville J.-E. & Gascuel O. 2017. SMS: Smart model selection in PhyML. *Molecular Biology and Evolution* 34 (9): 2422–2424. https://doi.org/10.1093/molbev/msx149

Li Q., Zhu L.-F., But P.P.-H., Kong Y.-C., Chang H.-T. & Waterman P.G. 1988. Monoterpene and sesquiterpene rich oils from the leaves of *Murraya* species: chemotaxonomic significance. *Biochemical Systematics and Ecology* 16 (5): 491–494. https://doi.org/ 10.1016/0305-1978(88)90050-6

Likhitwitayawuid K., Dej-adisai S., Jongbunprasert V. & Krungkrai J. 1999. Antimalarials from *Stephania venosa*, *Prismatomeris sessiliflora*, *Diospyros Montana* and *Murraya siamensis*. *Planta Medica* 65 (8): 754–756. https://doi.org/10.1055/s-2006-960858

Linnaeus C. 1767. *Mantissa Plantarum. Generum Editionis VI et Specierum Editionis II, Vol. 1*. Impensis Direct. Laurentii Salvii, Holmiae [Stockholm]. https://doi.org/10.5962/bhl.title.69083

Linnaeus C. 1771. *Mantissa Plantarum. Altera Generum Editionis VI et Specierum Editionis II, Vol. 2*. Impensis Direct. Laurentii Salvii, Holmiae [Stockholm]. https://doi.org/10.5962/bhl.title.69083

Mabberley D.J. 2016. The typification of *Murraya*, *M. exotica*, and *M. paniculata* (Rutaceae): Its significance for the world citrus industry. *Taxon* 65 (2): 366–371. https://doi.org/10.12705/652.15

Mabberley D.J. 2017. (2558) Proposal to conserve Murraya, nom. cons., against the additional name Chalcas (Rutaceae). *Taxon* 66 (5): 1229–1230. https://doi.org/10.12705/665.25

Manen J.F., Natali A. & Ehrendorfer F. 1994. Phylogeny of Rubiaceae-Rubieae inferred from the sequence of a cpDNA intergene region. *Plant Systematics and Evolution* 190 (3–4): 195–211. https://doi.org/10.1007/BF00986193

Merrill E.D. 1910. New or noteworthy Philippine plants, VIII. *The Philippine Journal of Science, Section C, Botany* 5 (3): 167–257.

Merrill E.D. & Chun W.Y. 1935. Hainan flora. *Sunyatsenia* 2: 251–253.

Min H.M. & Aye M. 2004. Structure elucidation of a new coumarin type compound, alternamin, isolated from the plant (*Murraya alternans* (Kurz) Swingle) having the antidote activity on snake venoms. *The Journal of the Myanmar Academy of Arts and Science* 2 (5): 67–79.

Min H.M., Aye M., Taniguchi T., Miura N., Monde K., Ohzawa K., Nikai T., Niwa M. & Takaya Y. 2007. A structure and an absolute configuration of (+)-alternamin, a new coumarin from *Murraya alternans* having antidote activity against snake venom. *Tetrahedron Letters* 48 (35): 6155–6158. https://doi.org/10.1016/j.tetlet.2007.06.156

Morton C.M. 2009. Phylogenetic relationships of the Aurantioideae (Rutaceae) based on the nuclear ribosomal DNA ITS region and three noncoding chloroplast DNA regions, *atp*B-*rbc*L spacer, rps16, and *trn*L-*trn*F. *Organisms Diversity & Evolution* 9 (1): 52–68. https://doi.org/10.1016/j.ode.2008.11.001

Mou F.-J. & Zhang D.-X. 2009. Pollen morphology supports the reinstatement of *Bergera* L. (Rutaceae). *Nordic Journal of Botany* 27 (4): 298–304. https://doi.org/10.1111/j.1756-1051.2009.00369.x

Mou F.-J., Tu T.-Y., Chen Y.-Z. & Zhang D.-X. 2018. Phylogenetic relationship of Clauseneae (Rutaceae) inferred from plastid and nuclear DNA data and taxonomic implication for some major taxa. *Nordic Journal of Botany* 36 (3): njb-01552. https://doi.org/10.1111/njb.01552

Mou F.-J., Hu X., Ma S.-Z. & Li Y.-G. 2020. *Murraya macrophylla*, a name at new rank and new combination of Rutaceae and its supplements of biological characters. *Guihaia* 40 (2): 272–276. https://doi.org/10.11931/guihaia.gxzw201811001

Mou F.-J., Peng Y., Li Y.-G. & Hu X. 2021. Taxonomic revision of *Murraya* J.Koenig (Rutaceae) based on the molecular phylogeny and morphological characters. *Taiwania* 66 (3): 387–397. https://doi.org/10.6165/tai.2021.66.387

Müller F. 1873. *Contributions to Phytography of New Hebrides and Loyalty Islands, from Mr. F.A. Campbell's collections*. G. Mercer, Geelong.

Oliver D. 1861. The natural order Aurantiaceae, with a synopsis of the Indian species. *Journal of the Proceedings of the Linnean Society (Supplement)* 5 (2): 1–44. https://doi.org/10.1111/j.1095-8339.1861.tb01274.x

Penjor T., Yamamoto M., Uehara M., Ide M., Matsumoto N., Matsumoto R. & Nagano Y. 2013. Phylogenetic relationships of *Citrus* and its relatives based on *mat*K gene sequences. *PLoS one* 8 (4): e62574. https://doi.org/10.1371/journal.pone.0062574

Reverdatto S.V., Andreeva A.V., Buryakova A.A., Chakhmakhcheva O.G. & Efimov V.A. 1989. Nucleotide sequence of the 5.2 kbp barley chloroplast DNA fragment, containing *psb*B-*psb*H-*pet*B-*pet*D gene cluster. *Nucleic Acids Research* 17 (7): 2859–2860. https://doi.org/10.1093/nar/17.7.2859

Ronquist F., Huelsenbeck J.P. 2003. MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics*, 19 (12): 1572–1574. https://doi.org/10.1093/bioinformatics/btg180

Rumpf G.E. 1747. *Herbarium Amboinense Vol. 5*. Uytwerf, Amsterdam.

Samuel R. Ehrendorfer F., Chase M.W. & Greger H. 2001. Phylogenetic analyses of Aurantioideae (Rutaceae) based on non-coding plastid DNA sequences and phytochemical features. *Plant Biology* 3 (1): 77–87. https://doi.org/10.1055/s-2001-11747

Sang T., Crawford M.J. & Stuessy T.F. 1997. Chloroplast DNA phylogeny, reticulate evolution, and biogeography of *Paeonia* (Paeoniaceae). *American Journal of Botany* 84: 1120–1136. https://doi.org/10.2307/2446155.

Seemann B.C. 1865. *Flora Vitiensis* 1: 32. L. Reeve, London.

Sprengel C. 1825. *Systema Vegetabilium (Ed. 16) Vol. 2*. Sumtibus Librariae Dieterichianae, Gottingae [Göttingen].

Swingle W.T. 1938. A new taxonomic arrangement of the orange subfamily, Aurantioideae. *Journal of the Washington Academy of Sciences* 28 (12): 530–533.

Swingle W.T. 1942. Three new varieties and two new combinations in Citrus and related genera of the orange subfamily. J*ournal of the Washington Academy of Sciences* 32 (1): 24–26.

Swingle W.T. & Reece P.C. 1967. The botany of *Citrus* and its wild relatives of the orange subfamily. *In*: Reuther W., Webber H.J. & Batchelor L.D. (eds) *The Citrus Industry, Revised 2nd Ed., Vol. 1, History, World Distribution, Botany, and Varieties*: 196–242. University of California, Berkeley.

Taberlet P., Gielley L., Pautou G. & Bouvet J. 1991. Universal primers for amplification of three non-coding regions of chloroplast DNA. *Plant Molecular Biology* 17 (5): 1105–1109. https://doi.org/10.1007/BF00037152

Tanaka T. 1928. Revisio Aurantiacearum I. *Bulletin de la Société botanique de France* 75 (4): 708–715. https://doi.org/10.1080/00378941.1928.10837094

Tanaka T. 1929. *Chalcas*, a Linnean genus which includes many new types of Asiatic plants. *Japanese Society for Tropical Agriculture* l: 23–44.

Tanaka T. 1932. Philippine Rutaceae-Aurantioideae (Revisio Aurantiacearum VII). *Transactions of the Natural History Society of Formosa* 22: 418–433.

Tanaka T. 1936. The taxonomy and nomenclature of Rutaceae-Aurantioideae. *Blumea: Biodiversity, Evolution and Biogeographyof Plants* 2 (2): 101–110.

Teijsmann J.E. & Binnendijk B. 1864. Plantae novae V. minus cognitae in horto Bogorienst cultae, augtoribug. *Natuurkundig tijdschrift voor Nederlandsch Indië* 27: 15–58.

Thiers B. continuously updated. *Index Herbariorum: A Global Directory of Public Herbaria and Associated Staff. New York Botanical Garden's Virtual Herbarium*. Available from https://sweetgum.nybg.org/science/ih/ [accessed 20. Jan. 2023].

Tian X.N. 2014. *A phylogeographic Study of Bombax ceiba Linn. in Dry-hot Valleys of Southwest*. Master thesis, Southwest Forestry University, Kunming.

Turczaninow N. 1858. Animadversions in secundam partem herbarii Turczaninowiani, Nunc Universitatis Caesareae Charkowiensis. *Bulletin de la Société Impériale des Naturalistes de Moscou* 31: 185–250.

Voigt J.O. 1845. *Hortus Suburbanus Calcuttensis*. Bishop's College Press, Calcutta.

White T.J., Bruns T., Lee S. & Taylor J.W. 1990. Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. *In*: Innis M.A., Gelfand D.H., Sninsky J.J. & White T.J. (eds) *PCR Protocols: a Guide to Methods and Applications*: 315–322. Academic Press Inc., New York. https://doi.org/10.1016/B978-0-12-372180-8.50042-1

Zhang D.X., Hartley T.G. & Mabberley D.J. 2008. Rutaceae. *In*: Wu Z.Y., Raven P.H. & Hong D.Y. (eds) *Flora of China, Vol. 11*: 83–85. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis.

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