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Research Article

Ardisia crenata subsp. *mukdahanensis*, a new subspecies of Primulaceae from Thailand

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Abstract

A new subspecies, *Ardisia crenata* Sims subsp. *mukdahanensis* Chatan & Promprom (Primulaceae), is described from Mukdahan Province, Thailand. This discovery was made during field studies conducted from 2021 to 2023, during which the authors collected and analysed specimens, comparing them with relevant taxonomic literature and herbarium collections. *A. crenata* subsp. *mukdahanensis* is distinct from its closest relative, *A. crenata* subsp. *crassinervosa* by a combination of morphological traits, such as moderately dense minute hairs on young shoots, abaxial side of young lamina and calyx, peduncles and pedicels; larger flowers (7.0–7.5 mm) that are pure white or pinkish; larger fruits (7–8 mm) and absence of glandular punctation in organs such as lamina, calyx, corolla, anther and fruit. This new subspecies grows in slightly dense dry evergreen forests or open areas near streams and is preliminarily assigned to the Data Deficient (DD) category according to IUCN guidelines.

Key words: Classification, diversity, Myrsinaceae, north-eastern Thailand, pollen, taxonomy

Introduction

Ardisia Swartz is a genus within the family Primulaceae, comprising approximately 500 to 735 species worldwide, with the majority found in Asia (Mao and Hu 2013; POWO 2024). Traditionally, *Ardisia* was classified within the Myrsinaceae by several taxonomists, including Larsen and Hu (1996, 2001) and Hu and Vidal (2004). In Thailand, the taxonomic study reported 72 species of *Ardisia* in the Flora of Thailand (Larsen and Hu 1996). Recent updates to the Flora of Thailand have included the description of a new subspecies of *A. crenata* Sims (Chatan and Promprom 2017b), the identification of new species, lectotypification and other taxonomic changes (Larsen and Hu 2001; Chatan and Promprom 2017a; Suparman et al. 2021).

During the flora exploration in Mukdahan Province, between 2021 and 2023, the authors discovered an undescribed taxon and brought it back to the laboratory at Mahasarakham University for further analysis. After carefully examining and comparing our findings with relevant taxonomic literature and herbarium collections from major herbaria in Thailand and Europe, we concluded that the



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Copyright: © Wilawan Promprom et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). undescribed taxon belongs to subgenus *Crispardisia*. This conclusion is based on the presence of nodules on sinuses on the crenate leaves. Additionally, the undescribed taxon is closely related to *A. crenata*, based on their crenate margins, marginal glands, flowering branches close to the apex of the stem or branch, mostly simple inflorescences and short calyx. Amongst the subspecies of *A. crenata*, it mostly resembles *A. crenata* subsp. *crassinervosa* (E. Walker) C.M.Hu & J.E.Vidal, as both share similar morphological characteristics, such as subcoriaceous and distinct-veined leaf blades, mostly sub-umbellate inflorescences and predominantly broadly ovate calyx lobes. These similarities suggest that the two subspecies are closely related, differing mainly in more specific morphological features. The following description is based on observations of both dried and fresh specimens, accompanied by illustrations of this newly-recognised taxon.

In the subgenus *Crispardisia*, pollen morphological characteristics could provide information for dividing sections and intra-sectional groups within *Ardisia* (Zhang et al. 2007). In this study, pollen morphology is also examined to provide additional insights into this subgenus.

Materials and methods

Field trips were conducted in Mukdahan Province between 2021 and 2023. Some mature plants of the undescribed taxon from these fields were planted in the third author's home garden in Kantharawichai District, Maha Sarakham Province, Thailand, for further morphological observation. We collected specimens including the type and studied the morphological characters of the living collection. We meticulously examined and compared our findings with relevant taxonomic literature including works by Sims (1817), Walker (1940), Chen and Pipoly (1996), Hu and Vidal (1996), Larsen and Hu (1996), Hu (1999), Larsen and Hu (2001), Hu and Vidal (2004), Zhang et al. (2007) and Chatan and Promprom (2017b).

The specimens were compared with herbarium collections from major herbaria in Thailand, including the Forest Herbarium, Department of National Parks, Wildlife and Plant Conservation (**BKF**) and the Bangkok Herbarium (**BK**). Additionally, images of other herbarium specimens of related species were examined from the databases of international collections, such as the Kew Herbarium (http://apps.kew.org/herbcat/gotoHomePage.do), the Muséum national d'Histoire naturelle (P) (https://science.mnhn.fr/all/search) and the JSTOR Global Plants database (http://plants.jstor.org/).

About 20 pollen grains of *A. crenata* subsp. *mukdahanensis* were examined by using Erdtman's method (Erdtman 1972). The pollen grains were dehydrated through a series of ethanol solutions at concentrations of 70%, 80%, 95% and 100%, with each step taking 5 minutes. After dehydration, the pollen was left to air-dry overnight at room temperature. The dried pollen was then mounted on to aluminium panels, which were attached to stubs using carbon tape. Then, the pollen grains were analysed using a scanning electron microscope (**SEM**) (Hitachi, TM-4000plus, Hitachi High-Tech, Tokyo, Japan) at the Laboratory Equipment Center in Mahasarakham University's Division of Research Facilitation and Dissemination. The analysis was conducted following Erdtman's pollen shape classification and terminology (Erdtman 1972).

Taxonomic treatment

Ardisia crenata Sims subsp. mukdahanensis Chatan & Promprom, sp. nov. urn:lsid:ipni.org:names:77349016-1 Figs 1-4

Type. THAILAND • Dong Luang District, Mukdahan Province, alt. 220–250 m, 16°46'23"N, 104°21'58"E, 10 November 2023 (fl.), *W. Chatan 2886* (holotype: BKF!; isotype: BK!).

Diagnosis. Ardisia crenata subsp. mukdahanensis is closely related to subsp. crassinervosa. However, the morphological distinctions of the new subspecies from the latter are as follows: moderately dense, minute hairs are present on the surfaces of young shoots, the abaxial side of the lamina (with very few or sparse hairs on older ones), peduncles, pedicels and the abaxial side of the calyx of the new subspecies, while they are absent in the latter. It has larger flowers (7.0–7.5 mm) that are typically pure white or pinkish. The fruits are mostly larger (7–8 mm in diameter) and glandular punctation is absent in the lamina, calyx, corolla, anther and fruit in the new subspecies, whereas they are present in the latter.

Description. Shrubs 40–100 cm high; branchlets slender, terete or angular, striate, generally each branch bearing more than 10 leaves. Leaves alternate, petioles 0.4-2.0 cm long; lamina subcoriaceous, oblanceolate or oblanceolate-oblong, 5-20 × 1.5-4 cm; base cuneate or attenuate; margin distinctly crenate and recurved, with large marginal glands on sinuses; adaxial surface glabrous or glabrescent, glandular dots absent; apices mostly obtuse, rarely acute; abaxial surface with very few minute hairs and sparsely hairs on the mid-rib, glandular dots absent; veins distinct; intramarginal veins present at 1.5-2.5 mm from the lamina edge at the middle between the marginal glands and those veins close to the margin by joining to the marginal glands. Inflorescences sub-umbellate or corymbiform, mostly simple or occasionally compound, terminal on branchlets; peduncles 0.4-0.5 cm long moderately dense minute hairs on the surface; bract oblong and V-shaped, 8-11 × 2.0-2.5 mm, primary rachis 2-6 mm long; pedicels 8-10 mm long, cylindrical, green, surface with moderate hairs. Calyx of 5-lobes, split almost to the base, pale green on both surfaces, distinctly imbricate at base; lobes broadly ovate, 3.0-3.5 × 2.5-3.0 mm, glandular-dots absent, apices acute or obtuse, margin entire and translucent, adaxially glabrous, abaxially covered with moderately dense minute hairs. Corolla of 5-lobes, connate at about 1 mm at the base, pure white or pinkish, sometimes pinkish only at base and centre, thick and succulent, lobes convolute in bud, broadly ovate, concavo-convex, $7.0-7.5 \times 4.5-5$ mm, glandular-dots absent on both surfaces, apex mucronate with curved mucro. Stamen 5; filament whitish, ca. 1 mm long; anther lanceolate, yellow, 5.0-5.5 × 1.8-2.1 mm, apex acute, glandular dots absent. Gynoecium length is longer than the stamen; ovary globose, 1.4-1.6 mm diameter, green, glabrous, 7 locules, 1 ovule in each locule, ovules in 1-series; styles about 4.5-5.0 mm long, irregularly curved and narrow to the apex, sparsely minute hairs on the lower half; stigma minute. *Fruits* young green, mature red, globose, 7–8 mm diameter, glandular dots absent. Seed globular, 4.0-4.5 mm diameter, brown.

Additional specimen examined. THAILAND • Dong Luang District, Mukdahan Province: Phu Pha Yol National Park, alt. 220–250 m, 16°46'42.3"N, 104°21'25.6"E, 1 September 2021 (fr.), *W. Chatan 2504* (paratype: BKF).



Figure 1. Ardisia crenata subsp. mukdahanensis A, B habit C inflorescence D infructescence (Image by Wannachai Chatan).

Distribution. Ardisia crenata subsp. mukdahanensis is an endemic to Thailand. So far, it has been only found in the type locality in Dong Luang District, Mukdahan Province. Its distribution is shown in Fig. 5.

Ecology. It mostly grows in slightly dense dry evergreen forests or open areas and usually grows near the stream. Sometimes it grows in dry-dipterocarp forests.

Phenology. Flowering in May to November and fruiting in June to February. **Vernacular name.** Takai Kao.

Etymology. The specific epithet *'mukdahanensis'* refers to its type locality, the Mukdahan Province, in the northeast of Thailand.

Provisional conservation status. Currently, *A. crenata* subsp. *mukdahanensis* is known only from its type locality. Comprehensive fieldwork is needed



Figure 2. Ardisia crenata subsp. mukdahanensis A leaf, adaxial side B leaf, abaxial side C intramarginal vein showing the distance from the margin D peduncle E flower bud F flower bud with corolla removed G dissected calyx, adaxial side H dissected calyx, abaxial side.

to conduct a thorough conservation assessment. Therefore, the species is classified as Data Deficient (DD) according to the Guidelines for using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee 2024).

Palynology. The pollen grains of *A. crenata* subsp. *mukdahanensis* are monads, semi-angular in polar shape, oblate-spheroidal in equatorial shape, small size, $11.50 \pm 1.30 \mu m$ in equatorial axis, $10.20 \pm 1.20 \mu m$ in polar, radially symmetrical, isopolar, tricolpate, separate apertures at the pollen pole, exine sculpturing foveolate-reticulate, perforate (Fig. 6).



Figure 3. Ardisia crenata subsp. mukdahanensis A dissected corolla B corolla-lobe, adaxial side C corolla-lobe, abaxial side D androecium, adaxial side E androecium, abaxial F androecium with opened anthers, adaxial G gynoecium H dissected ovary showing the ovules (X.S.).



Figure 4. Ardisia crenata subsp. mukdahanensis A fruits, lateral view B fruits, bottom view C fruit's surface showing its colour and lacks glandular punctation D–F seed, lateral, aerial and bottom views, respectively.

Notes. In the most recent update of classification, *A. crenata* was classified into three subspecies: *A. crenata* subsp. *crenata*, *A. crenata* subsp. *crassinervosa* and *A. crenata* subsp. *obtusifolia* (Chatan and Promprom 2017b). The discovery of *A. crenata* subsp. *mukdahanensis* has expanded this to four subspecies within *A. crenata*. *Ardisia crenata* subsp. *mukdahanensis* is most closely related to *A. crenata* subsp. *crassinervosa*, but it differs by having the following distinct characteristics: moderately dense, minute hairs present on the surfaces of young shoots, the abaxial side of the lamina (with very few or sparse hairs on older ones), peduncles, pedicels and the abaxial side of the calyx, whereas these hairs are absent in the latter. Additionally, *A. crenata* subsp. *mukdahanensis* typically has larger flowers (7.0–7.5 mm vs. 4–5 mm) that are pure white or pinkish (vs. pink or purplish), larger fruits (7–8 mm vs. ca. 5 mm in diameter) and lack glandular punctation in the lamina, calyx, corolla, anther and fruit, which are present in *A. crenata* subsp. *crassinervosa* (Figs 1–4). Details of the morphological differences are shown in Table 1.



Figure 5. Distribution of Ardisia crenata subsp. mukdahanensis at Dong Luang District, Mukdahan Province, Thailand.



Figure 6. Scanning electron microscopy (SEM) photomicrographs of pollen morphology of *Ardisia crenata* subsp. *muk-dahanensis* **A**, **B** show the pollen's morphology at different magnifications.

Several key characteristics can distinguish the new subspecies from the other subspecies. Compared to *A. crenata* subsp. *crenata*, the new subspecies has a subcoriaceous lamina (vs. chartaceous or subcoriaceous), a mostly obtuse lamina apex (vs. mostly acute or acuminate) and broadly ovate calyx-lobes (vs. ovate or ovate-oblong). In contrast to *A. crenata* subsp. *obtusifolia*, the new subspecies differs in having a subcoriaceous lamina (vs. highly coriaceous), an oblanceolate or oblanceolate-oblong leaf shape (vs. spathulate, narrowly elliptic or oblanceolate) and distinctly crenate and recurved on leaf margin (vs. sub-entire or shallowly crenate, undulate). In summary, the new subspecies is distinguished from *A. crenata* subsp. *obtusifolia* by its lamina texture, shape of apex and sepal and from *A. crenata* subsp. *obtusifolia* by its lamina texture, shape and margin (Figs 1, 2).

Zhang et al. (2007) examined the pollen grains of 23 species of *Ardisia* subgen. *Crispardisia* from China. The pollen grains of the studied taxa are subspheroidal to suboblate in shape and 3-colporate, forming syncolpate (except for *A. faberi*). Four pollen grain types were identified: type I (with foveolate-reticulate sculpture), type II (with finely reticulate sculpture), type III (with rugulate sculpture) and type IV (with finely granulate sculpture with spines). The pollen grains of *A. crenata* (based on the two samples of *A. crenata*, not identified at

Feature	A. crenata subsp. mukdahanensis	A. crenata subsp. crassinervosa	
Plant height	40-100 cm tall	100 cm tall	
Petiole length	0.4-2.0 cm long	up to 3 mm long	
Indumentum moderately dense, minute hairs present on the surfaces of young shoots, abaxial side of lamina, peduncles, pedicels and abaxial side of calyx-lobes		moderately dense, minute hairs lacking on the surfaces of young shoots, abaxial side of lamina, peduncles, pedicels and the abaxial side of the calyx-lobes	
Lamina	5–20 × 1.5–4.0 cm, subcoriaceous	4–10 × 1.5–4.0 cm, subcoriaceous or coriaceous	
Leaf apex	mostly obtuse, rarely acute	acute	
Lamina surface	without glandular punctations on both surfaces	with or without black punctations beneath	
Inflorescences	subumbellate or corymbiform, mostly simple or occasionally compound	subumbellate, simple	
Pedicels	8–10 mm long, cylindrical	ca. 10 mm long, somewhat flattened	
Flowers	pure white or pinkish, 7.0–7.5 mm long	pink to purplish, 4–5 mm long	
Calyx lobes	broadly ovate, 3.0–3.5 mm long, glandular dots absent broadly ovate or suborbicular, 2.5–3 mm long, glandul dots present or obscure		
Corolla lobes	glandular dots absent on both surfaces	glandular dots present abaxially	
Anthers	lanceolate, glandular dots absent	lanceolate, glandular dots present	
Fruits	7–8 mm diameter, without glandular dots	ca. 5 mm in diameter, with prominent glandular dots	

Table 1. Distinguishing features between Ardisia crenata subsp. mukdahanensis and A. crenata subsp. crassinervosa.

the infraspecific level) and one sample of *A. crassinervosa* E.Walker (subsp. *crassinervosa*) are classified as types I. Similar to these two studied taxa, the new subspecies has type I of pollen grain sculpturing. Additionally, the new subspecies are distinct amongst the most studied *Ardisia* taxa in terms of having tricolpate pollen with separate apertures at the pollen pole. Based on this pollen morphology, our collection is best recognised as a new subspecies of *A. crenata*, though studies on pollen morphology and other taxonomic characteristics are needed for further clarification of its taxonomic status.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Wannachai Chatan: Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Validation, Writing – original draft, Writing – review

& editing. Wilawan Promprom: Data curation, Formal Analysis, Funding acquisition, Investigation, Methodology, Writing – original draft. Phukphon Munglue: Data curation, Formal Analysis, Funding acquisition, Methodology, Validation.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Two new *Pleroma* species and an updated key: Melastomateae from the Serra da Canastra National Park, Minas Gerais, Brazil

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Abstract

Here we describe and illustrate *Pleroma canastrense* **sp. nov** and *Pleroma viscosa* **sp. nov.** two new species of the Melastomateae tribe from Serra da Canastra National Park, Minas Gerais, Brazil. We also provide an updated identification key for the members of the tribe that occur in this Protected Area. *Pleroma canastrense* **sp. nov.** has coriaceous leaves, broadly ovate to orbicular leaf blade, entire and adpressed-strigose margin, 11–17 basal acrodromous veins, and flowers with white petals. *Pleroma viscosa* **sp. nov.** has the younger branches, both side of the leaf blade, bracteoles, hypanthium, and sepals, densely covered by viscous trichomes, as well as prominent secondary veins on the abaxial surface of the blade. Both species have stamens with a short pedoconnective and an inconspicuous ventral appendage. In addition to the descriptions of new species, we present comments, geographic distribution data, conservation status and images of plants in the field. We recommend that *P. canastrense* and *P. viscosa* should be included as of 'Least Concern' (LC) in the IUCN Red List.

Resumo

Descrevemos e ilustramos aqui *Pleroma canastrense* **sp. nov** e *Pleroma viscosa* **sp. nov.**, duas novas espécies da tribo Melastomateae do Parque Nacional da Serra da Canastra, Minas Gerais, Brasil. Fornecemos também uma chave de identificação atualizada para os membros da tribo que ocorrem nesta área protegida. *Pleroma canastrense* **sp. nov.** apresenta folhas coriáceas, lâmina foliar amplamente oval a orbicular, margem inteira e estrigosa, 11–17 nervuras acródromas basais e flores com pétalas brancas. Enquanto *Pleroma viscosa* **sp. nov.** apresenta os ramos mais jovens, ambas as faces da lâmina foliar, bractéolas, hipanto e sépalas densamente cobertos com tricomas viscosos, além de nervuras secundárias proeminentes na face abaxial da lâmina. As duas espécies apresentam estames com pedoconectivo curto e apêndice ventral inconspícuo. Além das descrições das novas espécies, apresentamos comentários, dados de distribuição geográfica, estado de conservação e imagens das plantas no campo. Recomendamos que *P. canastrense* e *P. viscosa* sejam incluídas na categoria 'Pouco Preocupante' na Lista Vermelha da IUCN.

Key words: Campo rupestre, endemism, Melastomateae, pedoconnective, *Svitramia*, taxonomy

Palavras-chave: Campo rupestre, endemismo, Melastomateae, pedoconectivo, Svitramia, taxonomia



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Introduction

The Serra da Canastra National Park, located in southwestern Minas Gerais (IBAMA 2005), is considered the second-largest conservation unit in the state (Romero and Martins 2002; Machado and Romero 2014; Romero and Versiane 2014) and the sixth-largest area protected in Brazil (IBAMA 2005). The Park has a diverse flora with 101 families of Angiosperms and at least 17 endemism areas with 45 endemic species (see Romero and Nakajima 1999). However, these numbers must be higher since dozens of new species endemic to the region have been described in the last 30 years (e.g., Versieux and Wanderley 2008; Batista et al. 2010; Chautems et al. 2010; Feres 2010; Romero and Versiane 2014; Oliveira et al. 2016; Romero and Rocha 2017; Oliveira et al. 2019; Echternacht et al. 2021).

Among the most diverse families in this National Park, Melastomataceae Juss. stands out with 105 species in 21 genera (see Romero and Martins 2002; Silva and Romero 2008; Romero and Versiane 2014). The pantropical Melastomateae Bartl. tribe is represented in the National Park by 24 species distributed in *Pleroma* (18 spp.), *Chaetogastra* (3 spp.), and *Macairea, Pterolepis*, and *Tibouchina* (with one species each) (see Romero and Martins 2002; Silva and Romero 2008; Romero and Versiane 2014; Alves 2022; Silva 2023).

The phylogenetic study of the tropical specimens of Melastomateae recognized 17 genera (Michelangeli et al. 2013; Veranso-Libalah et al. 2022), and the most significant implication was the segregation of *Tibouchina* Aubl. This genus was previously considered the largest within the tribe, with 310 species (Guimarães et al. 2019). Then, *Tibouchina* was redefined into four monophyletic and easily distinguishable genera (Guimarães et al. 2019). The narrower circumscription of *Tibouchina* led to the reinstatement of *Pleroma* and *Chaetogastra* DC., along with the description of a new genus, *Andesanthus* P.J.F.Guim. & Michelang., with *Pleroma* also including *Itatiaia* Ule, *Microlepis* Schrad. ex Nees, and *Svitramia* Cham.

The six species previously recognized in *Svitramia* occur in the Serra da Canastra National Park: *S. pulchra* Cham. [=*Pleroma bandeirae* (Cham.) P.J.F.Guim. & Michelang.], *S. hatschbachii* Wurdack [=*P. gertii* (Wurdack) P.J.F.Guim. & Michelang.], *S. integerrimum* R.Romero & A.B.Martins [=*P. integerrimum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang.], *S. minor* R.Romero & A.B.Martins [=*P. minus* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang.], *S. petiolata* R.Romero & A.B.Martins [=*P. petiolatum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang.], *S. petiolata* R.Romero & A.B.Martins [=*P. petiolatum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang.], and S. *wurdackiana* R.Romero & A.B.Martins (=*P. wurdackianum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang.] (see Romero 2000; Romero and Martins 2003). Here, we describe two new species of *Pleroma*, initially referred to as *Svitramia* sp. nov. 1 and *Svitramia* sp. nov. 2 in the previous Melastomataceae checklist for Serra da Canastra National Park (see Romero and Martins 2002). We compare the new species with morphologically similar species and provide illustrative plates, field images, and an occurrence map of the new species. In addition, the identification key for the species of Melastomateae in the Serra da Canastra National Park is provided.

Methods

This study was based on the examination of *Chaetogastra*, *Pleroma*, *Pterolepis*, *Macairea*, and *Tibouchina* specimens from Serra da Canastra National Park deposited at the HUFU with duplicates at CESJ, HUEFS, K, NY, OUPR, P, R, RB, SP,

SPF, UB, UEC, UFG, VIC herbaria (Thiers 2024, continuously updated) and field observations. We also examined specimens with available images on Global Plants on Jstor (https://plants.jstor.org/), *species*Link (https://specieslink.net/), and Reflora Virtual Herbaria (http://reflora.jbrj.gov.br/reflora/herbarioVirtual). The vegetative and reproductive structures of the examined samples of the new species were measured in a stereoscopic microscope and with a digital caliper. Morphological terminology followed Radford (1986). The area of occupancy (AOO) was estimated using GeoCAT software (Bachman et al. 2011), and preliminary assessments of conservation status followed IUCN criteria (2001, 2022).

Results

Taxonomic treatment

Pleroma canastrense R.Romero, R.Pereira & P.J.F.Guim., sp. nov. urn:lsid:ipni.org:names:77349019-1 Figs 1-3

Type. BRAZIL • Minas Gerais. Parque Nacional da Serra da Canastra. São Roque de Minas: campo rupestre do morro próximo à sede administrativa do parque; 26 June 1994; fl. fr., *R. Romero & J.N. Nakajima 1039* (holotype HUFU!; isotypes: BHCB!, RB!, UEC!).

Diagnosis. The coriaceous leaf blade, broadly ovate to orbicular, entire and adpressed-margin, with 11–17 basal acrodromous veins, the stamens with a short pedoconnective and an inconspicuous ventral appendage together with the white petals, distinguish this species from another *Pleroma*.

Description. Subshrubs or shrubs, 0.6-1.8 m tall, decumbent. Stem terete to subterete, glabrous, or with setose trichomes in the basal portion. Younger branches quadrangular, flattened at the apex, with spherical glands, or glabrous, older branches terete, glabrous, internodes 2-5 cm long. Leaves sessile, decussate, horizontal, isomorphic in size at each node; blade 2.5-6.5 × 2-5 cm, discolorous (when fresh and dry), coriaceous, adaxial surface darker, broadly ovate to orbicular, obtuse to acute at the apex, rarely rounded, with a terminal trichome, 0.5-1 mm long, base cordate, semiamplexicaul, margin entire, adpressed-strigose, marginal trichomes 2-4 mm long, both surfaces glabrous, acrodromous veins 11-17, basal, principal vein lighter, conspicuously visible on both surfaces and secondary veins tenuous on the abaxial surface. Panicles of simple or compound dichasium, reduced or not, terminal; bracts two, 5-12.5 × 3-8.5 mm, caducous, leafy, sessile, coriaceous, largely ovate to orbicular, elliptic-lanceolate, obtuse to acute at the apex, base truncate, semiamplexicaul, margin strigose-ciliate, trichomes 0.3-1 mm long, both surfaces glabrous; bracteoles two, 3-7.5 × 2-6.7 mm, caducous, brownish, cucullate, membranaceous, both surfaces covered with spherical glands, margin glandular-ciliate, mainly at the apical portion. Flowers 5-merous; pedicel 1-2.5 mm long, glabrous; hypanthium 3-7 × 3-6 mm, green or glaucous, cylindrical, glabrous, furfuraceous; calyx tube 0.3 mm long; sepals 2-4 × 1.5-3 mm, green or glaucous, scarious, oblong, rounded at the apex, margin glandular-ciliate, furfuraceous; petals 8-14 × 9-12 mm, white, largely ovate, rounded or slightly retuse at the apex, base attenuate, margin entire, inconspicuously glandular-ciliate; androecium subisomorphic, stamens 10; filaments 4-7 mm long, white, filiform, glabrous or with sparse glandular trichomes in the basal portion; anthers 3-5 mm long, cream, oblong, straight, pore inclined ventrally, pedoconnective ca. 0.2 mm long, ventral appendage ca. 0.1 mm long, slightly bilobed, dorsal appendage ca. 0.1 mm long, lobed, glabrous; ovary 5-locular, half-inferior, free apical portion densely sericeous; style ca. 9 mm long, cream, filiform, slightly curved at the apex, glabrous, stigma truncate. *Fruits* loculicidal, capsules coated by persistent cupuliform hypanthium, $6-8.3 \times 5-6.8$ mm, brownish, oblong. *Seeds* ca. 0.5 × 0.3 mm, brown, numerous, cochleate, testa papillose.

Distribution and habitat. So far, we know *Pleroma canastrense* only from the Serra da Canastra National Park, where it is probably endemic (Fig. 3). The beautiful populations with white flowers occur exclusively in campo rupestre.

Conservation status. *Pleroma canastrense* has an area of occupancy (AOO) of 48 km². Although this species has a distribution restricted to Serra da Canastra, we indicate it preliminarily here as "Least Concern" (LC), according to the IUCN categories (2012, 2022). This assessment is because most individuals are in a conservation unit with complete federal protection, established almost 50 years ago, with no significant threats to the populations. Furthermore, we have not identified a continued decline in occupancy over the past 30 years (R. Romero, pers. obs.).

Phenology. *Pleroma canastrense* was collected in flower from April to August and in fruit from June to October.

Etymology. The specific epithet refers to the restricted occurrence of this species in the campo rupestre of Serra da Canastra, Minas Gerais state, Brazil. The name "Serra da Canastra" is due to the similarity presented by the immense plateau, which, when viewed from afar, resembles a canastra, a term of Greek origin used to name a type of rustic chest with a rectangular shape.

Discussion. *Pleroma canastrense* resembles *P. wurdackianum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., which also occurs in the Serra da Canastra National Park (Romero and Martins 2003). Both species share a subshrubby or shrubby habit, terete to subterete stem, glabrous and sometimes with setose trichomes on the basal portion, sessile leaves, discolorous leaf blade, cordate at the base, semiamplexicaul, and entire and adpressed-strigose margin with spiny trichomes. However, *P. wurdackianum* has pink petals (*vs.* white in *P. canastrense*), hypanthium and leaf blade with spherical glands (*vs.* glabrous). *Pleroma canastrense* is also similar to *P. integerrimum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., known only from Serra Preta in Delfinópolis (Romero and Martins 2003), since both have flowers with white petals. However, *P. integerrimum* differs in having a chartaceous and concolorous leaf blade (*vs.* coriaceous and discolorous in *P. canastrense*), glabrous at the margin (*vs.* adpressed-strigose).

Thirty years ago, John Julius Wurdack (1921–1998) wrote the following note on the sheet *Romero & Nakajima 1039* from HUFU herbarium: "*Svitramia* sp. *aff*. *S. hatschbachii* Wurdack (currently as *Pleroma gertii* P.J.F.Guim. & Michelang.), but leaf cilia shorter, blade relatively broader and scarcely puncticulate, calyx lobes shorter, corolla white and larger, anthers longer." *Pleroma canastrense* resembles *P. gertii*, the latter occurring preferentially in campo rupestre and more rarely in campo limpo and sujo in the south and southwest of Minas Gerais, i.e., a distribution that exceeds the limits of the Serra da Canastra National Park. However, *P. gertii* has elliptic, elliptic-lanceolate, or ovate to ovate-lanceolate leaf blade (*vs.* broadly ovate to orbicular in *P. canastrense*) with 7–9 basal acrodromous veins (*vs.* 11–17), and purple petals (*vs.* white).



Figure 1. *Pleroma canastrense* R.Romero, R.Pereira & P.J.F.Guim.: **A** flowering branch **B** adaxial leaf surface **C** detail of the leaf blade margin **D** flower **E** hypanthium and sepals **F** detail of the hypanthium surface **G** petal, abaxial view **H** petal margin detail **I** stamens, in lateral view **J** gynoecium **K** stigma detail **L** cross section of the ovary **M** fruit **N** seed (Illustration by Klei Souza based on the holotype (*R. Romero & J. N. Nakajima 1039*).

The specimen G.J. Shepherd et al. 7032 (UEC055432) deposited at UEC was first named as Svitramia alba by Angela Borges Martins (1945–) & João Semir (1937–2018) and this sheet annotated as holotype, but this name was never published by them.



Figure 2. *Pleroma canastrense* R.Romero, R.Pereira & P.J.F.Guim. **A** rocky outcrop at Serra da Canastra National Park, Minas Gerais, Brazil, the type locality of *Pleroma canastrense* **B** subshrub in campo rupestre near the road **C** flowering specimen showing the beautiful leaf architecture **D** flower **E** fruiting branch. Photos: Rosana Romero.

Additional specimens examined (paratypes). BRAZIL • Minas Gerais. Parque Nacional da Serra da Canastra. Capitólio: Reserva de Furnas; 20 February 1978; (fl), *G.J. Shepherd et al. 7032* (UEC055432-online image!) • Morro do Chapéu; 24 July 1993 (fl, fr); *R. Simão-Bianchini & S. Bianchini 413* (HUFU!, SP!) • Paraíso perdido, córrego Quebra-Anzol; 29 September 2005 (fr); *J.N. Nakajima 3737* (HUEFS!, HUFU!, VIC!) • estrada de Capitólio para Passos; 1 October 2005 (fl, fr); *R. Romero 7264* (HUFU!) • estrada para Pedreira Souza; 7 November 2005 (fl); *J.N. Nakajima et al. 4053* (HUFU!) • estrada atrás do Paraíso Perdido; 12 July 2006 (fr); *R. Romero et al. 7794* (HUFU!, RB!, SPF!, OUPR!, UEC!) • estrada para pedreira; 21 March 2007 (fr); *P.H.N. Bernardes et al. 45* (HUFU!, OUPR!, VIC!) •

morro atrás da pousada do Rio Turvo; 21 May 2007 (fl, fr); P.H.N. Bernardes et al. 140 (HUFU!, P!, UB!) • estrada para Cachoeira Feixo da Serra; 13 July 2007 (fl, fr); R. Romero et al. 7795 (HUFU!, NY!, SPF!, RB!, UB!, UEC!, UFG!) • Chapadão de Furnas; 18 May 2013 (fr); M.J.R. Rocha 985 (HUFU!, BHCB!) • Delfinópolis: estrada para a Babilônia; 24 May 1996 (fl, fr); R. Romero & J.N. Nakajima 3438 (HUFU!) • Cachoeirinhas; 27 February 2000 (fr); A.C.B. Silva 302 (HUFU!, SPF!, R!) • 2 May 2001 (fl, fr); A.C.B. Silva 881 (HUFU!, SPF!, R!) • s.d. (fl, fr); A.C.B. Silva 422 (HUFU!, SPF!, R!) • trilha Casinha Branca; 11 April 2002 (fl); R.A. Pacheco et al. 101 (HUFU!) • trilha do Zé Carlinho, subida para a Serra do Cemitério; 9 October 2002 (fr); J.N. Nakajima et al. 3193 (HUFU!, OUPR!, VIC!) • Paraíso Selvagem; 11 March 2003 (fl); R. Romero et al. 6707 (HUFU!) • trilha do S. Cannyon; 16 May 2003 (fl, fr); R. Romero et al. 6921 (HUFU!, UB!, UEC!) • estrada para Pedreira Souza; 30 September 2005; J.N. Nakajima et al. 3946 (HUFU!, K!, OUPR!, P!) • estrada para Pedreira Souza; 17 February 2006; R. Romero et al. 7704 (CESJ!, HUFU!, UFG!) • trilha Cachoeira Águas Claras; 23 June 2010 (fl); P.O. Rosa et al. 1306 (HUFU!, K!, P!, VIC!) • São Roque de Minas: Parque Nacional da Serra da Canastra; 20 August 1994 (fl, fr); R. Romero & J.N. Nakajima 1118 (HUFU!, SPF!, UFG!) • 15 October 1994 (fr); J.N. Nakajima et al. 452 (HUFU!, OUPR!, UB!) • estrada São Roque de Minas para Sacramento; 16 October 1994 (fr); R. Romero & J.N. Nakajima 1268 (HUFU!, VIC!) · Cachoeira Casca D'Anta; 17 October 1994 (fr); J.N. Nakajima & R. Romero 554 (HUFU!, UEC!) · córrego dos Passageiros; 11 May 1995 (fl); R. Romero et al. 2206 (CESJ!, HUFU!, NY!, OUPR!) • estrada para Cachoeira Casca D'Anta; 12 May 1995 (fl); J.N. Nakajima et al. 1026 (HUEFS!, HUFU!, K!, P!, RB!, SPF!, UEC!, VIC!) • Parque Nacional da Serra da Canastra; 15 July 1995 (fl, fr); R. Romero et al. 2384 (HUEFS!, HUFU!, OUPR!, RB!, SPF!, UEC!) • Cachoeira da Casca D'Anta; 17 July 1995 (fl, fr); R. Romero et al. 2505 (CESJ!, HUFU!, NY!, OUPR!) • caminho para a Cachoeira Casca D'Anta; 18 July 1995 (fl, fr); J.N. Nakajima et al. 1258 (HUEFS!, HUFU!, RB!, VIC!) • paredão da Cachoeira dos Rolinhos; 26 May 1996 (fl); J.N. Nakajima & R. Romero 1775 (HUFU!, P!, UB!, UFG!) · Chapadão do Diamante; 9 July 1996 (fl); J.N. Nakajima et al. 1929 (HUFU!, UEC!) • estrada para Cachoeira Casca D'Anta; 10 July 1996 (fl); J.N. Nakajima et al. 1939 (HUFU!, UB!, UFG!) • 10 July 1996 (fl, fr); J.N. Nakajima et al. 1947 (HUEFS!, HUFU!, K!, P!, US) • córrego dos Passageiros; 11 July 1996 (fl, fr); J.N. Nakajima et al. 2011 (CESJ!, HUFU!, K!, NY!, US) • próximo à sede administrativa; 11 July 1996 (fl, fr); J.N. Nakajima et al. 2043 (HUFU!, RB!, UEC!, VIC!) · Cachoeira Casca D'Anta; 10 August 1996 (fl); J.N. Nakajima et al. 1948 (CESJ!, HUEFS!, HUFU!, OUPR!) • trilha do paredão da Serra da Canastra; 17 April 1997 (fl); R. Romero et al. 4142 (HUFU!, SPF!, US!) • estrada para Fazenda do Fundão; 25 June 1997 (fl, fr); R. Romero et al. 4265 (HUFU!, NY!, OUPR!, UEC!) · Cachoeira dos Rolinhos; 29 June 1997 (fl, fr); R. Romero et al. 4369 (CESJ!, HUFU!, OUPR!) · Chapadão do Diamante; 29 June 1997 (fl); R. Romero et al. 4330 (HUFU!, UB!, UFG!) (fl, fr), R. Romero et al. 4336 (CESJ!, HUFU!, UFG!) • estrada para o sítio João Domingos; 20 August 1997 (fl); J.N. Nakajima et al. 2635 (CESJ!, HUFU!, UB!, UFG!) • estrada para o Vale dos Cândidos; 22 August 1997 (fr); J.N. Nakajima et al. 2708 (HUFU!, NY!, US!) (fr), J.N. Nakajima et al. 2696 (HUFU!, RB!, UB!, VIC!) • Guarita de São Rogue de Minas; 23 June 2001 (fl); R. Romero et al. 6140 (CESJ!, HUFU!, UFG!) • parte alta da Cachoeira Casca D'Anta; 14 May 2007 (fl); A.P.M. Santos & J.F. Silva 403 (HUEFS!, HUFU!) • morro próximo à sede administrativa; 23 July 2009; (fl), P.J.F. Guimarães et al. 402 (RB!) alto da Casca D'Anta; 29 May 2014 (fl); A.F.A. Versiane et al. 647 (HUFU!, NY!).



Figure 3. Geographical distribution of *Pleroma canastrense* and *Pleroma viscosa* in the Serra da Canastra National Park, Minas Gerais, Brazil [Adapted from Alves (2022)]. White line refers to the area of Serra da Canastra National Park.

Pleroma viscosa R.Romero, R.Pereira & P.J.F.Guim., sp. nov.

urn:lsid:ipni.org:names:77349020-1 Figs 3–5

Type. BRAZIL • Minas Gerais. Parque Nacional da Serra da Canastra. São Roque de Minas: campo rupestre próximo à sede administrativa; 16 April 1994 (fl); *R. Romero et al.* 845 (holotype: HUFU!; isotypes: BHCB!, RB!, UEC!, US!).

Diagnosis. The viscosity in the younger branches, leaf blade, bracteoles, hypanthium, and sepals, due to the spherical glands, the prominent secondary veins on the abaxial surface of the blade, and the stamen with a very short pedoconnective (ca. 0.2 mm long), are characteristics that differ from those of other *Pleroma* species.



Figure 4. *Pleroma viscosa* R.Romero, R.Pereira & P.J.F.Guim.: **A** flowering branch **B** adaxial leaf surface **C** detail of the abaxial surface and margin of the leaf blade **D** flower **E** detail of the hypanthium surface **F** hypanthium and sepals **G** petal, abaxial view **H** petal margin detail **I** stamen, in lateral view **J** gynoecium **K** stigma detail **L** cross section of the ovary **M** fruit **N** seed (Illustration by Klei Souza based on the holotype (*R. Romero et al. 845*).

Description. *Subshrubs* or *shrubs*, 0.5–1.7 m tall, erect. *Stem* subquadrangular to quadrangular, sparse to densely covered with spherical glands, glutinous. Younger branches subquadrangular to quadrangular, flattened at the apex, with spherical glands, glutinous, older branches subquadrangular, with spherical

glands, glutinous, internodes 2-5 cm long. Leaves sessile, decussate, horizontal, isomorphic in size at each node; blade 2-8 × 3-6 cm, discolorous (when fresh and dry), coriaceous, adaxial surface darker, ovate, ovate-oblong, elliptic-lanceolate to elliptic, obtuse or rounded at the apex, rarely acute, base rounded to subcordate, semiamplexicaul, margin entire, adpressed-strigose, marginal trichomes 1.5-2 mm long, both surfaces densely covered with brownish glands, glutinous, adaxial surface frequently glutinous, 5-7 acrodromous veins, basal, principal and secondary veins prominent on the abaxial surface. Panicles of simple or compound dichasium, reduced or not, terminal, densely covered with spherical glands, glutinous; bracts two, 2.5-9.5 × 4-8.5 mm, caducous, sessile, coriaceous, lanceolate or elliptic-lanceolate, obtuse or rounded at the apex, rarely acute, base truncate, semiamplexicaul, margin strigose-ciliate, trichomes 0.1-1.2 mm long, both surfaces densely covered with spherical, brownish glands, with glutinous aspect; bracteoles two, 4-5.5 × 3.5-4.3 mm, caducous, brownish, cucullate, membranaceous, both surfaces densely covered with spherical glands, with glutinous aspect, margin glandular-ciliate. Flowers 5-merous; pedicel 3.3-11 mm long, sparse to densely covered with spherical glands; hypanthium $3.3-5 \times 3.5-4.5$ mm, green or glaucous, cylindrical, with spherical glands; calyx tube 0.3 mm long, sepals 2-4.5 × 1.5-4 mm, green or glaucous, scarious, oblong, rounded at the apex, margin ciliate, rare sparse ciliate, with spherical glands and glutinous aspect; petals 11-17 × 11.5-16.5 mm, purple, obovate, rounded or slightly retuse at the apex, base attenuate, margin entire, glabrous or slightly ciliate; androecium subisomorphic, stamens 10; filaments 3.2-4.5 mm long, purple, filiform, glabrous, sometimes with sparse glandular trichomes; anthers 2.5-3.5 mm long, cream, oblong, slightly curved, pore inclined ventrally, pedoconnective ca. 0.2 mm long, ventral appendage ca. 0.1 mm long, slightly bilobed, dorsal appendage absent; ovary 5-locular, half-inferior, free apical portion densely sericeous; style ca. 8 mm long, cream, filiform, slightly curved at the apex, glabrous, stigma truncate. Fruits loculicidal, capsules coated by persistent cupuliform hypanthium, 6-8.5 × 5-6.8 mm, brownish, oblong. Seeds ca. 0.5 × 0.3 mm, brown, numerous, cochleate, testa papillose.

Distribution and habitat. Like *P. canastrense*, *P. viscosa* is only known from Serra da Canastra National Park, where it is probably endemic (Fig. 3). Its populations also occur in campo rupestre, often associated with rocky outcrops.

Conservation status. *Pleroma viscosa* has an area of occupancy (AOO) of 32 km². Like *P. canastrense*, *P. viscosa* populations are restricted to Serra da Canastra National Park. Therefore, we propose, for the same reasons, the preliminary category of "Least Concern" (LC) according to IUCN (2012, 2022). We also did not identify a continuous decline in occupancy of *P. viscosa* populations over the past 30 years (R. Romero, personal obs.).

Phenology. *Pleroma viscosa* was collected in flower from January to July and in fruit from April to October.

Etymology. The specific epithet refers to the viscous appearance of the plant due to the spherical glands of the younger branches, on both sides of the leaf blade, bracteoles, hypanthium, and sepals. The substance produced by the spherical glands often stains newspapers where they are dried (Romero 2000).

Discussion. *Pleroma viscosa* resembles *P. gertii* in having an erect stem, sessile leaves, coriaceous and discolorous leaf blade, with the adaxial surface darker than the abaxial surface. In addition, both species have a leaf blade ob-

Rosana Romero et al.: Two new species of Pleroma from Serra da Canastra



Figure 5. *Pleroma viscosa* R.Romero, R.Pereira & P.J.F.Guim., sp. nov. **A** flowering shrub in campo rupestre at Garagem de Pedras, Serra da Canastra National Park **B** adaxial leaf surface **C** abaxial leaf surface **D** flowering and fruiting branches **E** flower in frontal view. Photos: Rosana Romero.

tuse to rounded at the apex, rounded to subcordate at the base, semiamplexicaul, with entire and adpressed-strigose margin. However, in *P. viscosa*, the leaf blade is covered with brownish glands (vs. yellowish green in *P. gertii*), which give a glutinous appearance mainly on the adaxial surface (vs. non-glutinous). Furthermore, the secondary veins are prominent on the abaxial surface of the leaf blade (vs. inconspicuous in *P. gertii*).

Pleroma viscosa also resembles *Pleroma minus* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., also found in the Serra da Canastra National Park (see Romero and Martins 2003). Both species share coriaceous and discolorous leaf blade, entire and adpressed-strigose margin, both surfaces are covered with brownish spherical glands, and purple petals. However, *P. minor* can be distinguished by its glabrous or sparsely setose stem in the basal portion (*vs.* spherical glands in *P. viscosa*), ascending leaves (*vs.* horizontal), smaller leaf blade $0.8-4.5 \times 0.5-2.5$ cm (*vs.* $2-8 \times 3-6$ cm), pedicel ca. 2 mm long (*vs.* 3.3-11 mm long), petals rounded at the apex, and ciliate at the margin (*vs.* rounded or slightly retuse, glabrous or slightly ciliate). The specimen *W.A. Araújo 11528* (ESA066062) deposited at ESA herbarium was first identified by Henrique Lahmeyer Mello Barreto (1892–1962) as *Svitra-mia wilson-araujaei* but this name was never published.

Additional specimens examined (paratypes). Brazil · Minas Gerais Parque Nacional da Serra da Canastra. Araxá: Serra do Taquaral, divisas de Araxá e Sacramento; W.A. Araújo & H.L. Mello Barreto 11528; 25 May 1943 (ESA06606-image online!) · Delfinópolis: trilha Condomínio de Pedra; 23 June 2010 (fl); R. Romero et al. 8258 (HUFU!, RB!) · São Roque de Minas: 20 February 1994 (fl); R. Romero & J.N. Nakajima 625 (HUFU!, SPF!, UB!, UEC!) • 15 October 1994 (fr), J.N. Nakajima et al. 469 (HUFU!, UB!, UEC!) • estrada para Sacramento; 17 October 1994 (fr); J.N. Nakajima et al. 532 (CESJ!, HUFU!, UFG!) • 10 January1995 (fl); R. Romero et al. 1642 (HUFU!, UFG!) • 12 January 1995 (fl); R. Romero et al. 1779 (HUFU!, VIC!) • morro próximo à sede administrativa; 17 March 1995 (fl); R. Romero et al. 1899 (HUFU!, K!, NY!, OUPR!, P!, US!) • estrada do Chapadão Diamante; 18 March 1995 (fl, fr); J.N. Nakajima et al. 821 (CESJ!, HUFU!) • morro próximo à sede administrativa; 10 May 1995 (fl, fr); J.N. Nakajima et al. 998 (HUFU! RB!, SPF!, VIC!) • 15 July 1995 (fl); R. Romero et al. 2383 (HUFU!) • 11 January 1996 (fl, fr); R. Romero et al. 3250 (CESJ!, HUFU!, UFG!) · Cachoeira Casca D'Anta; 13 January 1996 (fl, fr); R. Romero et al. 3293 (HUFU!, K!, NY!, SPF!, UB!, UEC!) • morro após a nascente do Rio São Francisco; 20 March 1996 (fl); R. Romero & J.N. Nakajima 3351 (HUFU!, K!, P), R. Romero & J.N. Nakajima 3352 (HUEFS!, HUFU!, RB!, VIC!) • Serra Brava; 22 March 1996 (fl); R. Romero & J.N. Nakajima 3393 (CESJ!, HUFU!, UFG!) • morro próximo à sede administrativa; 24 March 1996 (fl, fr); J.N. Nakajima & R. Romero 1736 (HUFU!, K!, OUPR!, US!) · Chapadão do Diamante; 9 July 1996 (fl); J.N. Nakajima et al. 1904 (CESJ!, HUFU!, OUPR!, UFG!) • morro próximo à sede administrativa; 16 April 1997 (fl); R. Romero et al. 4063 (HUFU!, OUPR!, P) • Chapadão do Diamante; 18 April 1997 (fr); J.N. Nakajima et al. 2318 (HUFU!, RB!) • morro próximo à sede administrativa; 9 January 1998 (fl); R. Romero et al. 4832 (HUFU!, NY) · estrada a caminho da nascente do Rio São Francisco; 23 March 1999 (fl); S.I. Elias & G.S. Rolim 341 (HUFU!) • Garagem de Pedras; 21 June 2001 (fl, fr); R. Romero et al. 6136 (HUFU!, SPF!) • ca. de 2 km da sede; 23 June 2001 (fl); R. Romero et al. 6141 (HUFU!, UB!, UEC!) • III.2007 (fl, fr); C.M. Rodrigues 24 (HUEFS!, HUFU!) • morro próximo à sede administrativa; 23 July 2009, (fr); P.J.F. Guimarães et al. 400 (RB!).

The Melastomateae tribe from the Serra da Canastra National Park

Of the 24 species of Melastomateae cataloged for the Serra da Canastra National Park, nine are endemic to the Park and its surroundings: *Pleroma bergianum* (Cogn.) P.J.F.Guim. & Michelang., *P. canastrense* R.Romero, R.Pereira & P.J.F.Guim., *P. gertii* P.J.F.Guim. & Michelang., *P. integerrimum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., *P. minus* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., *P. petiolatum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang., *P. rubrobracteatum* (R.Romero & P.J.F.Guim.) P.J.F.Guim. & Michelang., *P. viscosa* R.Romero, R.Pereira & P.J.F.Guim., and *P. wurdackianum* (R.Romero & A.B.Martins) P.J.F.Guim. & Michelang. *Pleroma bandeirae* P.J.F.Guim. & Michelang. also occurs in the southern portion of Minas Gerais, in Lavras, Carrancas, São Tomé das Letras, Tiradentes, and São João Del Rey. Chaetogastra minor (Cogn.) P.J.F.Guim. & Michelang. occurs in São Paulo, Minas Gerais, and Rio de Janeiro (Goldenberg et al. 2024). The other species have a wide distribution in Brazil: Chaetogastra gracilis (Bonpl.) DC., C. herbacea (DC.) P.J.F.Guim. & Michelang., Macairea radula (Bonpl.) DC., Pleroma heteromallum (D.Don) D.Don, P. martiale (Cham.) Triana, P. stenocarpum (Schrank et Mart. ex DC.) Triana, P. candolleanum (Mart. ex DC.) Triana, P. estrellense (Raddi) P.J.F.Guim. & Michelang., P. fothergillii (Schrank et Mat. ex DC.) Triana, P. frigidulum (Schrank et Mart. ex DC.) Triana, P. oleifolium (DC.) R.Romero & Versiane, Pterolepis repanda (DC.) Triana, and Tibouchina aegopogon (Naudin) Cogn.

The species of the Melastomateae tribe from the Serra da Canastra National Park, Minas Gerais, Brazil can be identified by the key below.

Key to the species of the Melastomateae tribe from the Serra da Canastra National Park, Minas Gerais, Brazil

1	Branches, hypanthium, leaves, bracts, and sepals with indumentum lepi- dote Tibouchina aegopogon
-	Branches, hypanthium, leaves, bracts, and sepals with indumentum non-lepidote
2	Flowers 4-merous
_	Flowers 5-merous5
3	Herbs; hypanthium with penicellate emergences Pterolepis repanda
_	Subshrubs or shrubs; hypanthium without penicellate emergences4
4	Branches densely strigose; petals pink with a cream base Macairea radula
-	Branches densely glandulous; petals entirely purple
	Chaetogastra herbacea
5	Herbs or subshrubs, unbranched6
-	Shrubs or subshrubs branched and/or trees7
6	Herbs stoloniferous, $0.1-0.3$ m tall; leaf blade $0.1-2.4 \times 0.1-1.4$ cm
	Chaetogastra minor
-	Subshrubs non-stoloniferous, 0.4–0.8 m tall; leaf blade 2.5–9 \times 1.5–
	4 cm Chaetogastra gracilis
7	Pedoconnective with ventral appendage glandulous8
-	Pedoconnective with ventral appendage glabrous10
8	Hypanthium densely sericeous; petals purple with white base turning red-
	dishPleroma heteromallum
-	Hypanthium sericeous-stellate or setose; petals entirely purple9
9	Hypanthium sericeous-stellate; panicles 6–12 cm long
	Pleroma candolleanum
-	Hypanthium setose; panicles 1.5–5 cm long Pleroma fothergillii
10	Leaf blade and bracts dendritic-stellate or sericeous-glandular11
10 -	Leaf blade and bracts dendritic-stellate or sericeous-glandular
10 -	Leaf blade and bracts dendritic-stellate or sericeous-glandular
10 - 11	Leaf blade and bracts dendritic-stellate or sericeous-glandular
10 - 11	Leaf blade and bracts dendritic-stellate or sericeous-glandular
10 - 11 -	Leaf blade and bracts dendritic-stellate or sericeous-glandular

12	Filaments setose or glabrousPleroma martiale
-	Filaments glandular13
13	Subshrubs or shrubs; branches non-winged14
-	Trees; branches winged or sub-winged15
14	Scales between the sepals present; verticillate leaves Pleroma frigidulum
-	Scales between the sepals absent; decussate leaves16
15	Adaxial surface of the leaf blade strigose, abaxial surface sericeous;
	hypanthium sericeousPleroma stenocarpum
-	Adaxial surface of the leaf blade bullate-strigose, abaxial surface seri-
	ceous-stellate; hypanthium strigose-stellate Pleroma estrellense
16	Leaf with a long petiole 5–10 mm long Pleroma petiolatum
-	Leaf with a short petiole 1–5 mm long or sessile17
17	Style with trichomes at the base Pleroma bergianum
-	Style glabrous18
18	Leaf blade chartaceous, concolorous; margin glabrous
-	Leaf blade coriaceous, discolorous; margin entire, adpressed-strigose19
19	Leaf blade glabrous, except for the margin20
-	Leaf blade with indumentum21
20	Petals purple Pleroma wurdackianum
-	Petals white Pleroma canastrense
21	Both surfaces of the leaf blade with brownish glands22
-	Both surfaces of the leaf blade with yellowish-green glands23
22	Stem glabrous or sparsely setose; leaves ascending, blade $0.8-4.5 \times 0.5-$
	2.5 cm, leaf marginal trichome 0.8–1.5 mm longPleroma minus
-	Stem covered with spherical glands; leaves horizontal, blade 2-8 \times
	3–6 cm, leaf marginal trichome 1.5–2 mm long Pleroma viscosa
23	Branches and leaf blade with setose-adpressed trichomes; hypanthium
	sericeous Pleroma bandeirae
-	Branches glabrous or with spherical glands; leaf blade with spherical
	glands; hypanthium glabrous Pleroma gertii

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Resurrection of *Sorbus tapashana* (Rosaceae) based on molecular and morphological evidence

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Abstract

Sorbus tapashana (Rosaceae) from Taibai Shan, Qinling, China, has been treated as a synonym of *S. tianschanica*. Both species belong to a distinctive group characterized by white tomentose buds, relatively large flowers, and red fruits. However, these two species do not cluster together in the plastome-based phylogenetic analysis. Morphologically, *S. tapashana* differs from *S. tianschanica* by its persistent white tomentose on the peduncle, pedicels, rachis, both sides of the midrib on abaxial surface, its leaflets with 31–51 teeth on each side and much smaller corymbs and fruits. Therefore, *S. tapashana* is reinstated as a distinct species here.

Key words: Morphological data, plastome, Sorbus, synonym, taxonomy

Introduction

Sorbus L. sensu stricto (Maleae, Rosaceae) comprises approximately 90 species of trees and shrubs (Phipps et al. 1990; McAllister 2005). The genus is confined to the Northern Hemisphere, with its distribution spanning Europe, Asia, and northern North America (McAllister 2005). Morphologically, *Sorbus* s.s. can be distinguished from other genera in Maleae by its imparipinnate leaves and relatively small fruits with persistent sepals and styles. This genus exhibits high diversity in China, particularly in the southwestern mountainous regions (Lu and Spongberg 2003).

The monophyly of *Sorbus* s.s. has been confirmed by recent phylogenetic studies (Campbell et al. 2007; Liu et al. 2019, 2020, 2022, 2023a, 2023b; Jin et al. 2023, 2024). However, the circumscription of species within this genus remains unclear, particularly for those native to China (Lu and Spongberg 2003; McAllister 2005). For instance, there is debate regarding the taxonomic status of *Sorbus tapashana* C.K.Schneid. (Schneider 1906). This species has been recognized in numerous floristic and taxonomic works (Yü and Lu 1974; Gabrielian 1978; Phipps et al. 1990; Lu and Spongberg 2003) before being treated as a synonym of *S. tianschanica* Rupr. (Ruprecht 1869) by McAllister (2005). McAllister proposed that *S. tapashana* and *S. tianschanica* were conspecific, despite differences such as the denser white hairs on buds and leaflets of *S. tapashana*. However, based on our examinations of the protologues (Ruprecht 1869;



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Copyright: [©] Xin Chen et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). Schneider 1906), type specimens, and specimens collected from the type localities, we hypothesize that *S. tapashana* may be a distinct species.

In this study, we integrate phylogenetic inference with extensive morphological data to reevaluate the relationship between *Sorbus tapashana* and *S. tianschanica*. Our aims are to: (1) determine whether *S. tapashana* and *S. tianschanica* represent two distinct species, and (2) assess the phylogenetic relationships among *S. tapashana*, *S. tianschanica*, and other species within the genus *Sorbus* s.s.

Materials and methods

Taxon sampling

Leaf samples of *Sorbus tapashana* (China, Shaanxi, Taibai Shan, September 7, 2023, *Xin Chen 2255, 2257*) and *S. tianschanica* (Xinjiang, July 10, 2020, *Wenhao Fan 1761*) were collected from their type localities, Taibai Shan and Tianshan, respectively. Voucher specimens are deposited in the Herbarium of Nanjing Forestry University (**NF**).

DNA extraction, sequencing, and genome assembly

Whole genomic DNA was isolated from silica-gel dried leaves using a modified CTAB method (Doyle and Doyle 1987). Short-insert (150 bp) paired-end libraries were prepared for genome skimming using the Illumina HiSeq 4000 sequencing platform at Beijing Genomics Institute (BGI, Shenzhen, China). De novo assembly was performed using GetOrganelle v.1.7.5.3 (Jin et al. 2020) with *Torminalis glaberrima* (NC033975) as a reference. Genomes were annotated using the PGA program (Qu et al. 2019) with *S. tianschanica* (ON049666) as a reference. Annotation errors were manually verified and corrected using Geneious v.9.0.2 software (Kearse et al. 2012).

Phylogenetic analysis

The plastome dataset alignment for this study includes 41 individuals representing 37 *Sorbus* s.s. taxa. This dataset comprises three newly sequenced samples: two from *S. tapashana* and one from *S. tianschanica*, alongside 38 accessions sourced from GenBank (www.ncbi.nlm.nih.gov/genbank). *Photinia prionophylla* (Franch.) C.K.Schneid. was used as the outgroup for phylogenetic analyses. GenBank accession numbers utilized in this study are listed in Table 1.

The plastid genome dataset was aligned using MAFFT v.7.388 (Katoh and Standley 2013) within Geneious v.9.0.2, followed by manual adjustments. Phylogenetic relationships were inferred using both maximum likelihood (**ML**) and Bayesian inference (**BI**). ML analyses, employing the GTR+G nucleotide substitution model, were estimated with RAxML v.8.2.10, with 100 runs and 1,000 bootstrap (**BS**) Ronquist and Huelsenbeck 2003replicates (Stamatakis 2014). BI analyses were performed using MrBayes v.3.2.7 (Ronquist and Huelsenbeck 2003), running the Markov chain Monte Carlo (MCMC) for 2,000,000 generations with trees sampled every 1000 generations. The resulting trees from ML and BI analyses were visualized using FigTree v.1.4.3 (http://tree.bio.ed.ac.uk/ software/figtree).

Taxon	Genbank accession number	Taxon	Genbank accession number
Photinia prionophylla (Franch.) C.K.Schneid.	NC045355.1	Sorbus pohuashanensis (Hance) Hedl.	OP613257.1
Sorbus aestivalis Koehne	NC068530.1	Sorbus poteriifolia HandMazz.	OR915972.1
Sorbus albopilosa T.T.Yu & L.T.Lu	OR915913.1	Sorbus prattii Koehne	NC085635.1
Sorbus amabilis Cheng ex T.T.Yu & K.C.Kuan	MT357029.1	Sorbus randaiensis (Hayata) Koidz.	NC085665.1
Sorbus aucuparia L.	OR915953.1	Sorbus rehderiana Koehne	OR915914.1
Sorbus californica Greene	NC085651.1	Sorbus rufopilosa C.K.Schneid.	NC085638.1
Sorbus commixta Hedl.	MK920288.1	Sorbus sambucifolia (Cham. & Schltdl.) M.Roem.	NC085654.1
Sorbus decora (Sarg.) C.K.Schneid.	NC085652.1	Sorbus sargentiana Koehne	OR915977.1
Sorbus discolor (Maxim.) Maxim.	OR915986.1	Sorbus scalaris Koehne	NC085637.1
Sorbus dumosa House	NC085653.1	Sorbus scopulina Hough	NC085658.1
Sorbus helenae Koehne	NC068536.1	Sorbus setschwanensis (C.K.Schneid.) Koehne	NC046777.1
Sorbus himalaica Gabrieljan	NC085572.1	Sorbus sibirica (Hedl.) Prain	NC085576.1
Sorbus hupehensis var. hupehensis C.K.Schneid.	NC068721.1	Sorbus sitchensis var. grayi (Wenz.) C.L.Hitchc.	OR897861.1
Sorbus hupehensis var. paucijuga (D.K.Zang & P.C.Huang) L.T.Lu	MT916771.1	Sorbus tapashana C. K.Schneid.	PQ031218; PQ031219
Sorbus insignis (Hook.f.) Hedl.	NC051947.1	Sorbus tianschanica Rupr.	PQ031217
Sorbus kiukiangensis T.T.Yu	NC085636.1	Sorbus tianschanica Rupr.	MK920289.1
Sorbus kiukiangensis T.T.Yu	OR915919.1	Sorbus tianschanica Rupr.	ON049666.1
Sorbus macrantha Merr.	NC085631.1	Sorbus tianschanica Rupr.	OK375442.1
Sorbus microphylla (Wall. ex Hook. f.) Wenz.	NC085633.1	Sorbus ulleungensis Chin S.Chang	MG011706.1
Sorbus munda Koehne	NC062714.1	Sorbus unguiculata Koehne	MK814479.1
Sorbus oligodonta (Cardot) HandMazz.	NC085634.1	Sorbus wilsoniana C.K.Schneid.	OR915983.1

Table 1. Taxon name and GenBank accession numbers for all individuals included in this study.

Morphological analysis

Morphological characters were examined using our specimens and online images from various sources including herbaria A, HNWP, IBK, IBSC, IFP, KUN, LBG, NAS, NWTC, PE, and XBGH. These images were accessed through the Chinese Virtual Herbarium (http://www.cvh.ac.cn/), JSTOR Global Plants (https:// plants.jstor.org/), the Global Biodiversity Information Facility (GBIF; https:// www.gbif.org/), and the Plant Photo Bank of China (PPBC; http://ppbc.iplant. cn/). Measurements were taken from both actual specimens and those with scale bars in the images.

Results and discussion

Phylogenetic analyses

The phylogenetic trees inferred from ML and BI methods were topologically congruent, with only minor differences in support values. Consequently, only the ML tree is presented here, with support values from both ML and BI analyses indicated at each node (Fig. 1).

Our results strongly support the monophyly of *Sorbus* s.s., which is divided into two major clades (Fig. 1: I and II). Clade I includes 14 species and two varieties within *S.* subg. *Sorbus*, excluding *S. hupehensis* var. *paucijuga* (D.K.Zang & P.C.Huang) L.T.Lu. Clade II contains *S. tianschanica* and species from *S.* subg. *Albocarmesinae* McAll., with *S. tapashana* deeply nested within it. Notably, *S. tapashana* is distantly related to *S. tianschanica*.



Figure 1. Phylogenetic tree of *Sorbus* s.s. resulting from the maximum likelihood analysis and Bayesian inference of the plastome data set. Numbers below the branches indicate bootstrap values (\geq 70%) of the ML analyses and the posterior probability (\geq 0.95) of Bayesian analyses.

Our findings unequivocally demonstrate the existence of two distinct, well-resolved clades within the monophyletic *Sorbus* s.s., which broadly align with the two subgenera proposed by McAllister (2005). However, contrary to previous classifications that placed *S. tianschanica* within subg. *Sorbus* due to its uniformly red fruits, our data show that it is embedded in clade II along with species from subg. *Albocarmesinae*, consistent with other recent molecular studies (Li et al. 2017; Tang et al. 2022; Wang et al. 2024). While the plastome dataset analyses show

	Sorbus tapashana	Sorbus tianschanica	
Branchlets	brownish or grayish brown, terete, lenticellate		
Buds	white pubescent		
Leaves	9-18 cm in length	14–17 cm in length	
Petiole	1.5-4.1 cm long	1.5-4.3 cm long	
leaflets	(4-)5-7 pairs	(4–)6–7 pairs	
The number of teeth on each side of the leaflet	31-51	12-24	
Stipules	linear-lanceolate, 5–7 mm, caducous	linear-lanceolate, 7–11 mm, caducous	
Inflorescences	5–9 × 5–8 cm, with persistent white pubescent	6–10 × 7–12(–15) cm, sub-glabrous	
Flowers	1.5–2 cm in diameter	1.5-1.8(-2.0) cm in diameter	
Styles	usually 5, densely white tomentose basally	(3–)5, densely white tomentose basally	
Fruit	red, globose, 8–10 mm in diameter	scarlet, globose, 1–1.2 cm in diameter	
Phenology	flowering in June; fruiting in September	flowering in May and June, fruiting in September and October	
Distribution	Gansu, Shaanxi	Afghanistan, China (Gansu, Qinghai, and Xinjiang), Kazakhstan, Kirgizstan, Pakistan, Tadzhikistan, and Uzbekistan.	

Table 2. Comparison of morphological characters, phenologies, and distributions of Sorbus tapashana and S. tianschanica.

that *S. tapashana* and *S. tianschanica* are located in the same clade, they are isolated in different groups. *Sorbus tapashana* is more closely related to *S. aestivalis* Koehne, *S. macrantha* Merr., *S. helenae* Koehne, *S. microphylla* (Wall. ex Hook.f.) Wenz., and *S. prattii* Koehne than to *S. tianschanica*. Given that monophyly is a widely accepted as criterion for taxonomic classification (Chiarini et al. 2022; Böhnert et al. 2023), *S. tapashana* should be recognized as a distinct species.

Morphological analyses

Sorbus tapashana and S. tianschanica share several characters, including white tomentose winter buds, 5–7 pairs of leaflets, large flowers (1.5–2 cm in diameter), usually five and densely white tomentose styles, and red fruits (Table 2, Figs 2, 3). Consequently, both species were previously placed under ser. *Tianschanicae* Kom. ex T.T.Yü by Yü and Kuan (1963), Gabrielian (1978), and Phipps et al. (1990). Later, McAllister (2005) merged them as a single species. However, S. tapashana can be distinguished from S. tianschanica by several morphological characters (Table 2), e.g., more densely serrate leaflets (31–51 teeth per side compared to 12–24 teeth in S. tianschanica; Fig. 3: A2, B2), persistent white tomentose on the peduncle and pedicels (vs. sub-glabrous in S. tianschanica; Fig. 3: A3, B3), smaller inflorescences (5–9 × 5–8 cm compared to 6–10 × 7–12(–15) cm), and smaller fruits (8–10 mm vs. 10–12 mm in diameter; Fig. 3: A4, B4). Additionally, S. tapashana is restricted to Gansu and Shaanxi, China, whereas S. tianschanica has a much broader distribution area (Table 2).

Taxonomic treatment

Sorbus tapashana C.K.Schneid. in Bull. Herb. Boissier, sér. 2, 6: 313 (1906)

= Pyrus tapashana (C.K.Schneid.) M.F.Fay & Christenh. in Global Fl. 4: 123 (2018).

Type. CHINA • Shaanxi: the summit of Taibai Shan, 10–20 September 1897, *Giraldi* 5126 (lectotype, designated here: A[A00046062 (the upper left part)] image!).





Note. Sorbus tapashana was first described by Schneider (1906). It was later transferred to the genus *Pyrus* L. s.l. along with other species from *Sorbus* sensu lato by Christenhusz et al. (2018). However, *Pyrus* s.l. has proven to be overly inclusive and polyphyletic (Liu et al. 2019, 2022; Tang et al. 2022; Jin et al. 2024; Wang et al. 2024).

When Sorbus tapashana was described, Schneider (1906) cited three syntypes, Giraldi 5126, 5127, and 1082, deposited in the Berlin Herbarium (B). However, none of them could be located at B. In the herbarium of the Arnold Arboretum, Harvard University (A), duplicates of these gatherings are present. At A, we found the original materials of these gatherings on Plate no. 2296. The sheet, with barcode A00046062 (image available at: HUH - Databases -Specimen Search (harvard.edu)), bears a photo of specimen "Giraldi n. 5126" at B, and three fragments belonging to Giraldi 5126, 5127 and 1082 respectively (Fig. 1A). The photo of Giraldi 5126 is a fruit specimen, with scale bars and three labels on it. One of the three is the determination label of Schneider, with "Sorbus tapashana, an var. S. pohuashanensis?" on it, the same as those that had been stated in the protologue. Giraldi 5126 is a good candidate to serve as lectotype because: (1) there is a photo of complete specimen from herbarium B which bears Schneider's annotation; (2) the fragmentary material of Giraldi 5126 has a leaflet (clearly showing the white tomentose persistent along the mid-vein abaxially) and two fruits. Therefore, we designate Giraldi 5126 (the upper left part of A00046062) as the lectotype for the name.

In the protologue, it is implied that *Sorbus tapashana* may be a variety of *S. pohuashanensis* (Hance) Hedl. However, it is distinguished from the latter in having much larger flowers (1.5–2 cm in diameter), deciduous linear-lanceolate stipules (vs. relatively small flowers 5–8 mm in diameter, persistent



Figure 3. Comparison of morphological characters *Sorbus tapashana* C.K.Schneid. (A1–A4) and *S. tianschanica* Rupr. (B1–B4) 1 sterile branch showing leaves and buds (B2 were taken by Wenhao Fan) 2 leaflet margins 3 corymbs (A3 and B3 were taken by Renbin Zhu and Yongfu Xu, respectively) 4 fertile branch showing fruits (B4 were taken by Wenhao Fan).

broadly ovate or semi-orbicular stipules). Furthermore, *S. tapashana* is resolved in clade II while *S. pohuashanensis* in subclade I. Therefore, *S. tapashana* and *S. pohuashanensis* are separate species.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: XC. Data curation: WXH, MDD. Funding acquisition: XC. Investigation: XC. Methodology: XC. Software: WXH, HJL. Validation: BMT. Writing – original draft: XC. Writing – review and editing: XC.

Author ORCIDs

Data availability

All of the data that support the findings of this study are available in the main text.

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PhytoKeys

Research Article

Three new species of *Boesenbergia* (Zingiberaceae) from Sabah, Malaysia

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Abstract

Three new species of *Boesenbergia*, *B. bosuangii* **sp. nov.**, *B. ganaensis* **sp. nov.** and *B. gokusingii* **sp. nov.** were discovered in Sabah, Malaysia. *Boesenbergia bosuangii* is similar to *B. stenophylla* R.M.Sm. in the narrowly ovate lamina but differs in the shape of the bract and the calyx. *Boesenbergia ganaensis* is closely allied to *B. burttiana* R.M.Sm. but differs in the absence of a ligule, the longer petiole, the obtuse leaf base, the acute leaf apex, the bilobed calyx and the anther dehiscing by pores. Finally, *B. gokusingii* is similar to *B. variegata* R.M.Sm., by the single leafy shoot but differs in having an unequal, ovate lamina, a cordate leaf base, an acute leaf apex and the anther dehiscing by pores. The three new species are described and illustrated in detail. With the addition of these new species, there are in total 13 species with one variety in Sabah.

Key words: Biodiversity, Borneo, endemic, new species, wild gingers

Introduction

The genus *Boesenbergia* was initially classified in the tribe Hedychieae in the family Zingiberaceae (Burtt and Smith 1972). Considering molecular data, *Boesenbergia* was subsequently placed in the tribe Zingibereae, subfamily Zingiberoideae (Kress et al. 2002). Eight species from the genus *Haplochorema* and five species from the genus *Caulokaempferia* were added to the genus *Boesenbergia* (Mood et al. 2014; Mood et al. 2020) and there are currently 99 species of *Boesenbergia* (Lam et al. 2022).

The character, which distinguishes *Boesenbergia* from all other Zingiberoideae genera, is that the first flowers appear at the top of the inflorescence and flowering progresses towards the base (Poulsen and Searle 2005; Sakai and Nagamasu 2006, 2009; Mood et al. 2020). The flowers are usually white or pale yellow or orange with a spoon-shaped labellum ornamented with red and/or pink. The diagnostic characters of *Boesenbergia* in Sabah are the growth form (creeping or erect), number of leave per shoot (1 to many), anther dehiscence (slits or pores), length of petiole, and shape of the lamina, including base and apex (Lam 2023).



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Copyright: [©] Nyee Fan Lam et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). Borneo harbours approximately 38 species of *Boesenbergia* (Smith 1987; Ibrahim 1992; Sirirugsa 1992; Poulsen 1993; Larsen 1997; Cowley 1998, 2000; Larsen et al. 1999; Saensouk and Larsen 2001; Sakai and Nagamasu 2006, 2009; Lamb et al. 2013; Lam et al. 2022) of which only 10 species and one variety have been reported in Sabah (Lam et al. 2022). The distribution pattern of the species within Sabah is poorly known but they seem to be usually found in riverine, limestone, and near waterfalls in primary forests. Therefore, this study is focused on revealing the species diversity of *Boesenbergia* in Sabah.

Materials and methods

Field collections were made between August 2016 and August 2017 at Ranau and Kimanis Districts. The morphology of the new species was analyzed using living plants with reference to herbarium materials (E, K, KEP, KUL, SAN and SING). The procedures of the fieldwork and measurements were conducted based on Lam et al. (2022).

Information collected during fieldwork and herbaria was recorded in the Taxon Data Information Sheet (TDIS) form. The form consist of five sections, namely, taxon attributes, geographic range and demographic details on population (Chua et al. 2010). Ground points of collections were used in the IUCN Red List assessments (IUCN 2022). The assessments of Extent of occurrence (EOO) and Area of occupancy (AOO) and maps were plotted with GeoCAT (Bachman et al. 2011).

Key to the species of *Boesenbergia* in Borneo (modified from Sakai and Nagamasu 2009)

1	Creeping; leafy shoots normally single-leaved; inflorescence more or less sessile; anther dehiscing by slits 2
-	Erect; leafy shoots with one to many leaves; inflorescence sessile or long
2	Lamina more or less circular, obtuse or obscurely emarginate at apex
	B. orbiculata
-	Lamina elliptic or narrowly ovate, acute at apex3
3	Lamina plain green4
_	Lamina variegated5
4	Floral tube pubescent outside; flower not red at throat; labellum entire
	B. flavoalba
-	Floral tube glabrous outside; flower red at throat labellum bilobed
	B. flavorubra
5	Petiole 2-3 cm long; lamina 7-12 by 2.5-7 cm, dark green with a band of
	lighter green up the midrib, variegation sometimes extending to the main
	lateral veinsB. variegata
-	Petiole < 0.5 cm long; lamina shorter than 9 cm with width less than
	5.5 cm
6	Lamina 4-8 by 1.5-2 cm, mid-green with a broad silver band on either
	side of the midrib above, surface glabrous
_	Lamina 8.6 by 5.5 cm, upper surface undulating from green to dark green
	B. gokusingii

7	Fertile shoot single-leaved, rarely bladeless or 2- or 3-leaved8
-	Fertile shoot with two or more leaves12
8	Lamina 50 by 12 cm or largerB. grandifolia
_	Lamina much smaller, not exceeding 30 cm long9
9	Base of the lamina deeply cordateB. cordata
_	Base of the lamina ± attenutate 10
10	Petiole 17–34 cm longB. bruneiana
-	Petiole not exceeding 17 cm11
11	Lamina 7–12 cm wide; petiole robust ca. 5 mm thick; lamina with appressed hairs especially around midrib below
-	Lamina less than 7 cm wide; petiole slender, 2 mm or less thick; leaves
	glabrousB. ischonosiphon
12	Lamina large, much longer than 30 cm13
-	Lamina shorter than 30 cm, if longer narrower than 7 cm17
13	Leaf base thickened with outermost bracts forming a bucket or vase-like
	structure enclosing inflorescence sometimes together with sheaths of up-
	per leaves; petiole 42–50 cm longB. jangaruni
-	Leaf base or sheaths not thickened as above, long-attenuate forming a winged petiole less than 25 cm long 14
14	Anther dehiscing by subapical pores or slits15
_	Anther dehiscing by pores
15	Inflorescence densely pubescent; anther ca. 3 mm long, dehiscing by sub-
	apical pores
_	Inflorescence glabrous, anther ca. 10 mm long, dehiscing by longitudinal
	slits ca. 6 mm longB. armeniaca
16	Leaf sheath sparsely hairy or glabrous; bracts 5-8 cm; floral tube 8-10 cm;
	ovary glabrousB. grandis
-	Leaf sheath densely hairy; bracts 2-3.5 cm long; floral tube ca. 5.5 cm
	long; ovary densely hairy in upper half B. lysichitoides
17	Inflorescence long exserted from the leaf sheaths when fully grown, spin-
	dle-shaped; flowers red and white B. pulchella
-	Inflorescence never long exserted or spindle-shaped; flower colours vari-
	ous
18	Leaves linear; arrangement of blades strongly flabellate19
-	Leaves elliptic, narrowly ovate or rarely linear to narrowly ovate; arrange-
	ment of blades never flabellate20
19	Flower plain yellow; anther dehiscing by apical pores; bracts $3.5-6.5$ cm .
	B. flabellata
-	Flower white, yellow in the centre, pink at the base; anther dehiscing by
	slits; bracts < 3 cm B. burttiana
20	Leaves variegated21
-	Leaves plain green25
21	Leaves bullate, dark green around main veins and almost silvery on raised
	areaB. hutchinsonii
-	Leaves smooth with a silverish or light green central cloud22
22	Petiole never exceeding 3 cm, lamina narrowly obovate with attenuate base
_	Petiole usually much longer than 3 cm. lamina narrowly ovate to elliptic
	with cuneate base

23	Leaves with a silvery cloud; flowers yellow, labellum orange-spotted
_	low and reddish purple
24	Leaves 5–12 by 3–4 cm; flower orange, darker at base of labellum; anther
	dehiscing throughout its entire lengthB. aurantiaca
-	Leaves 18–23 by 4–6 cm flower white with some yellow and reddish pur-
	ple; anther dehiscing by apical pores, or anther dehiscent only in upper
	2/3 B. belalongensis
25	At least a few uppermost leaf sheaths thickened and forming a cup-
	shaped structure
-	Leaf sheath not thickened as above27
26	Innermost leaf sheaths enclosing inflorescence much shorter and wider
	than outer ones; leaves drying darkish brown
-	All leaves with more or less equal laminae; leaves green or grey-green
07	Anther debiasing by slits throughout their length
21	Anther dehiseing by sits throughout their length
28	Petiole < 8 cm
20	Petiole > 10 cm 20
29	Calvx unilaterally incised (split on one side) 30
_	Calvx tubular B. sugudensis
30	Lamina wider than 4 cm
_	Lamina less than 4 cm wide
31	Petiole up to 4 cm long; lamina longer than 10 cm
-	Petiole to 2 cm long; lamina 5.2-6.5 by 3.4-3.6 cm
32	Lamina 13–16 cm long B. apiculata
-	Lamina at least 11.5 by 5.5 cm B. ganaensis
33	Lamina narrowly ovate, more than 12 cm34
-	Lamina slightly ovate much shorter, up to 12 cm long, if longer, petiole
	much shorter than 7 cm35
34	Lamina 12–20 by 1.5–3 cm; petiole usually to 7–8 cm B. stenophylla
-	Lamina 19 by 3 cm; petiole usually at least 10.5 cm B. bosuangii
35	Leaf sheath and ligule hirsute
-	Leaf sheath and ligule almost glabrous
36	Flower yellow-orange
-	Flower white and yellow, occasionally red in throat

Taxonomy

Boesenbergia bosuangii N.F.Lam, sp. nov.

urn:lsid:ipni.org:names:77349804-1 Figs 1, 2

Diagnosis. The new species resembles *B. stenophylla* in having a narrowly ovate lamina, but differs in the shape of the bract (linear elliptic vs. cymbiform) and a tubular calyx (vs. tridentate) (Table 1).

Type. MALAYSIA. Borneo. Sabah. Cultivated at Kipandi Park, Moyog, 05°54.68'N, 116°06.27'E, 700 m elevation, 8 August 2016, *Lam Nyee Fan 356* (holotype BORH!, isotype SAN). Original material collected by Linus Gokusing (BS-23) at Marakau, Gana-gana, Ranau, Sabah, 06°12.24'N, 116°46.03'E, 480–500 m elevation, 3 August 2010.

Description. Terrestrial, evergreen, herb. Rhizome fibrous, subterranean, ca. 1 cm in diameter with 7 cm internodes, white to light brown, base ca. 0.6 cm in diameter, roots white, up to 18 cm long. Leafy shoots 29.5 cm tall, with 1-2 leaves, with 2-3 outer leafless sheaths, 6.0-6.5 × 0.7-1.1 cm, purple brownish, glabrous. *Ligule* ca. 0.55 cm long, caudate, brown, glabrous. Petiole 6–7.5 cm long, canaliculate, green, reddish at base. Lamina narrowly ovate, 17-17.4 × 2.5-2.75 cm, erect, dark green above, pale green beneath, glabrous, base attenuate, margin entire, apex acuminate, with acumen ca. 2 mm. Inflorescence ca. 2.8 cm, peduncle 1-2 cm, with up to 6 flowers arranged in a one-sided spiral, one flower open at a time. Fertile bracts linear elliptic, ca. 2.7 cm long, white, reddish at apex, pubescent, margin entire, apex attenuate. Bracteole elliptic, ca. 2 × 0.75 cm, translucent, pubescent, margin entire, apex acute. Flower white, born singly from each bract; calyx 1 cm long, tubular, 2-lobed, translucent, pubescent on both surfaces; corolla tube ca. 3.6 cm long, ca. 1.5 mm wide at base, lobes white, glabrous throughout, dorsal lobe ovate-oblong, ca. 1.1 × 0.5 cm, linear elliptic, concave, white, glabrous, apex acute, lateral lobes ovate, ca. 1.0 × 0.25 cm, oblong, glabrous, apex rounded; labellum, obovate, ca. 1.2 cm × 0.8 cm curved-backward, longer than corolla lobes, with yellow band from base in the centre spreading towards lip, faint red at base and dark red bands on both sides, glabrous; lateral staminodes white, reddish at base, linear, ca. 0.6 × 0.25 cm, glabrous; stamen white throughout, ca. 0.45 cm long, filament ca. 4 mm × 1 mm (widest at base), pubescent, anther ca. 0.5×0.3 cm, glabrous, anther crest ca. 0.5 × 2 mm, bilobed, pubescent, thecae oblong, ca. 0.3 × 0.1 cm, glabrous, dehiscing by pores; ovary ca. 4 × 1.5 mm, stigma cup-shaped, glabrous; epigynous glands, two, ca. 0.45 cm long, linear, apex truncate, white. Fruit not seen.

Distribution. Endemic to Borneo, Sabah.

Other specimens seen. MALAYSIA. Sabah. Telupid District, Taviu Forest Reserves, c. 200 m elevation, lowland forest, 17 May 2001, Sundaling D, SAN142970 (SING!, SAN!).

Etymology. The species is named after Dr. Steven Bosuang, owner of Kipandi Park. He is an entomologist doing conservation efforts on insects and plants of Sabah. His collaborations with local and overseas scientist produced many research papers and reports for the conservation of Sabah.

Ecology. Riverine area in mixed dipterocarp forest, 50–300 m elevation, flowering in August.

Conservation status. Vulnerable VU D1. *Boesenbergia bosuangii* is endemic to Sabah. This species is found at Ranau and Telupid Districts. Due to the small, restricted populations outside protected area and possible threats from development, landslides and flooding, this species is assessed as VU (Fig. 3).

Characters	B. bosuangii	B. stenophylla
Plant height	to 30 cm	To about 42 cm
Petiole	7.5 cm	10-18 cm
Leaf apex	Acuminate	Slightly acuminate
Bracts	2.7 cm, linear elliptic, pubescent	4 × 4.5 cm, cymbiform, glabrous
Calyx	2-lobed, pubescent	3-lobed, glabrous
Labellum	Yellow band from base in the centre spreading to- wards apex, faint red at base and dark red bands bordering the yellow band, obovate, 1.2 × 0.8 cm	White with yellow centre, flabelliform, 2.5 × 2 cm
Lateral corolla lobe	White, 1 × 0.25 cm	Pale yellow, 1.5 × 0.4 cm,

Table 1. Distinguishing morphological characters of B. bosuangii and B. stenophylla.



Figure 1. *Boesenbergia bosuangii* **A** habit **B** spike with one open flower **C** stamen, ventral view **D** flower **E** Bract, bracteole, calyx, epigynous gland, corolla lobes, staminodes, labellum, floral tube with stamen. (Photograph of Lam Nyee Fan 337; Photos: Lam Nyee Fan).



Figure 2. *Boesenbergia bosuangii* Lam N.F., sp. nov. **A** habit **B** bract **C** bracteole **D** calyx **E** epigynous glands, **F** spike with one open flower **G** flower **H** stamen, ventral view (Drawing by Lam Nyee Fan). Scale bars: 5 cm (**A**); 1 cm (**B**, **C**, **D**, **E**, **F**, **G**); 5 mm (**H**).



Figure 3. Distribution map of *Boesenbergia bosuangii*, $EOO = 0 \text{ km}^2$, $AOO = 8 \text{ km}^2$ (Bachman et al. 2011).

Boesenbergia ganaensis N.F.Lam, sp. nov.

urn:lsid:ipni.org:names:77349805-1 Figs 4, 5

Diagnosis. The new species resembles *B. burttiana* by having a narrowly ovate lamina and a similar plant height, but differs in having an obtuse leaf base, an acute leaf apex (vs. attenuate leaf base, slightly acuminate leaf apex), absence of ligule, a longer petiole (4 cm vs.1.8 cm) and the anther thecae dehiscing by pores (vs. slit) (Table 2).

Type. MALAYSIA. Borneo. Sabah. Cultivated at Kipandi Park, Moyog, 05°54.68'N, 116°06.27'E, 700 m elevation. 8 Aug 2016, *Lam Nyee Fan 348* (holo-type BORH!, isotype SAN). Original material collected from Ranau, Gana-gana, by Linus Gokusing (BS-15), 05°53.16'N, 116°39.30'E, 700 m elevation, 2 February 2013.

Description. Terrestrial, evergreen, herb. **Rhizome** fibrous, subterranean, base ca. 0.4 cm in diameter, light brown, roots white, ca. 4 cm long. **Leafy shoots** ca. 14 cm tall, with 2–4 sheaths, ca. 3.5×2.5 cm, glabrous, green, margins entire. **Ligule** absent. **Petiole** 2.8–4 cm long, grooved, green. Leafy shoots 1–2. **Lamina** elliptic, 10–11.5 × 4–5.5 cm, dark green above, green beneath, glabrous, margin entire; base obtuse, apex acute with acumen ca. 1 mm. **Inflorescence** ca. 2.7×0.4 cm, peduncle ca. 0.35 cm with up to 10 flowers arranged in a one-sided spiral, one flower open at a time. **Fertile bracts** narrowly ovate, ca. 2.4×0.5 cm, white, outer and inner surfaces glabrous, almost translucent, margin entire, apex acute. **Bracteole** elliptic, ca. 1.8×0.5 cm, white, outer and

Characters	B. ganaensis	B. burttiana
Ligule	Absent	0.55 cm, acuminate, reddish, glabrous
Petiole	4 cm, green, grooved	1.0–1.8 cm, green, without winged
Lamina	Upper surface dark green	Upper surface light green
Leaf size	11.5 × 5.5 cm	12-20 × 1.5-3 cm
Leaf base	Obtuse	Attenuate
Leaf apex	Acute	Slightly acuminate
Bracts	2.4 cm long, white, narrowly ovate, almost translucent-	4 cm long, cymbiform-
Labellum	Yellow band from base in the middle, spreading to almost entire surface near apex with lighter yellow laterally, red bands from 2/3 of the centre yellow band towards side, 1.1 × 0.8 cm	White, with yellow in the centre, pink at the base, 2.5 × 2 cm
Lateral corolla lobe	Glabrous, white, 1.2 × 0.2 cm, emarginated, white with link pink ad yellowish at base, light pink patches towards lip-	Slightly pubescent, pale yellow, 1.5 × 0.8 cm
Anther	reddish, pubescent	White, glabrous
Anther dehiscence	Pore	Slit
Stigma	Truncate	Rounded

Table 2. Distinguishing morphological characters of *B. ganaensis* and *B. burttiana*.



Figure 4. *Boesenbergia ganaensis* **A** habit **B** rhizome and roots **C** spike with one open flower **D** flower **E** bract, bracteole, calyx, corolla lobes, staminodes, labellum, floral tube with stamen **F** stamen, ventral view (Photos: Lam Nyee Fan).

inner surfaces glabrous, translucent, margin entire, apex acute. *Flower* white, born singly from each bract, calyx 0.7 cm long, tubular, white, glabrous, corolla tube white, glabrous, apex rounded, dorsal lobe elliptic, ca. 1.3×0.35 cm, concave, lateral lobes elliptic, ca. 1.2×0.2 cm, labellum bucket shaped, obovate (when flattened), ca. 1.1 cm $\times 0.8$ cm, yellow band from base in the middle, spreading to almost entire surface towards the apex with lighter yellow laterally with red bands from 2/3 of the centre yellow band towards side, lateral staminodes oblong, ca. 0.7×0.2 cm, white, apex acute, glabrous, stamen ca. 1.2 cm long; filament ca. 7×1 mm (widest at base), pubescent adaxially and abaxially, anther ca. 3.5 mm long, pubescent; anther crest trilobed, pubescent; thecae oblong, ca. 0.3×0.1 cm, white, glabrous, dehiscing by pores, stigma truncate apex, white, glabrous, epigynous glands 0.2-0.4 cm long, linear, apex pointed. *Fruit* not seen.

Distribution. Endemic in Borneo, Sabah; known only from the type locality at Kampung [village] Gana-gana, Ranau.

Etymology. The species epithet refers to the location where the species was collected.

Ecology. Granite area at 500–600 m elevation.

Conservation status. Vulnerable (VU D2). The species is endemic to Sabah and only found at Ranau, Sabah, Malaysia. There were only four populations found at the site of collection and it has not been found outside the type locality (Fig. 6).



Figure 5. *Boesenbergia ganaensis* Lam N.F., sp. nov. **A** habit, lateral view **B** bract **C** bracteole **D** calyx **E** epigynous glands **F** spike with one open flower **G** flower **H** stamen, ventral view (Drawing by Lam Nyee Fan). Scale bars: 5 cm (**A**); 1 cm (**B**, **C**, **D**, **E**, **F**, **G**); 1 mm (**H**).



Figure 6. Distribution map of *Boesenbergia ganaensis*, $EOO = 0 \text{ km}^2$, $AOO = 4 \text{ km}^2$ (Bachman et al. 2011).

Boesenbergia gokusingii N.F.Lam, sp. nov.

urn:lsid:ipni.org:names:77349806-1 Figs 7, 8

Diagnosis. The new species resembles *B. variegata* R.M.Sm. by having single-leaved shoots and a short petiole, but differs in having unequal ovate lamina (vs. elliptic), a cordate leaf base (vs. rounded or subcordate), an acute leaf apex (vs. subacute) and the anther thecae dehiscing by pores (vs. slits) (Table 3).

Type. MALAYSIA. Borneo. Sabah. Cultivated at Kipandi Park, Moyog, 05°54.68'N, 116°06.27'E, 700 m elevation. 8 Aug 2016, *Lam Nyee Fan 361* (holotype BORH!, isotype SAN). Original material collected from Tawau by Linus Gokusing (BS-21b), 05°11.93'N, 117°25.40'E, 500–600 m elevation, 1 Aug 2015.

Description. Terrestrial, evergreen, herb. Rhizome fibrous, subterranean, base ca. 0.4 cm in diameter, roots brown. Leafy shoots ca. 8.5 cm tall, with 1-2 sheaths, ca. 2 × 1.5 cm, glabrous, green, margins entire. Ligule 1 mm long, acute, light brown, glabrous. *Petiole* 2.8-3.5 cm long, grooved, green. Leafy shoots single. Lamina unequal ovate, 7.5-8.6 × 5-5.5 cm, upper surface undulating ranging from green to dark green, pale green beneath, glabrous, margin entire; base cordate, apex acute with acumen ca. 2 mm. Inflorescence ca. 2.5 × 0.5 cm, peduncle ca. 0.15 cm, with up to 8 flowers arranged in a one-sided spiral, one flower open at a time. Fertile bracts linear narrowly ovate, ca. 1.6 × 0.2 cm, green, pale red at apex, outer and inner surfaces glabrous, almost translucent, margin entire, apex acute. Bracteole linear elliptic, ca. 1.7 × 0.2 cm, white, outer and inner surfaces glabrous, almost translucent, margin entire, apex acute. *Flower* white, born singly from each bract, calyx 0.4 cm long, tubular, white, glabrous, corolla tube white, glabrous, dorsal lobe narrowly elliptic, ca. 0.7 × 0.2 cm, slightly concave, lateral lobes elliptic, ca. 0.7 × 0.1 cm, labellum obovate, ca. 0.7 cm × 0.4 cm, very light yellow at base, darker yellow spreading towards lip, curved forward, lateral staminodes elliptic, ca. 0.5 × 0.17 cm, white, apex acute, glabrous, stamen ca. 0.75 cm long; filament ca. 4 × 1 mm (widest at base), glabrous adaxially and abaxially, anther ca. 3.5 mm long, glabrous; anther crest rounded, glabrous; thecae oblong, ca. 0.1 × 0.05 cm, white, glabrous, dehiscing by pores, stigma cup-shaped, white, glabrous, epigynous glands 0.1 cm long, linear, apex pointed. Fruit not seen.

Distribution. Endemic in Borneo, Sabah; known from Tawau and Tambunan.

Etymology. The species is named after Mr. Linus Gokusing from Kipandi Park. He collected this species from Tawau in 2011. His passion for plants, such as orchids and gingers, has secured information useful to researchers, tourists and botany students.

Ecology. Mix dipterocarp forest at 500–600 m elevation.

Conservation status. Vulnerable (VU D2). The species has only been documented at Tawau and Tambunan, Sabah, Malaysia, where only 3–6 populations were found at each site (Fig. 9).

Characters	B. gokusingii	B. variegata
Ligule length	1 mm	2-3 mm
Lamina	Unequal ovate, upper surface undulating ranging from green to dark green	Elliptic, upper surface dark green with a lighter band along the midrib, sometimes variegated variegation extends to the lateral veins
Leaf size (cm)	8.6 × 5.5 cm	7–12 × 2.5–7 cm
Leaf base	Cordate	Rounded or subcordate
Leaf apex	Acute	Subacute
Bracts	1.6 cm long, linear to narrowly ovate, glabrous	0.6–0.8 cm long, ovate, acute, pubescent
Labellum	With light yellow at base, darker yellow spreading towards lip, obo- vate, curved-forward, 0.7 × 0.4 cm	Cream with a deep yellow spot in the centre and a deep red spot at the base, elliptic, 1.0×0.7 cm
Lateral corolla lobe	Glabrous, 0.7 cm long	Densely pubescent, 2 cm long
Anther dehis- cence	Pore	Slit

 Table 3. Distinguishing morphological characters of B. gokusingii and B. variegata.



Figure 7. *Boesenbergia gokusingii* **A** habit **B** rhizome and roots **C** spike with one open flower **D** flower **E** bract, bracteole, calyx, corolla lobes, staminodes, labellum, floral tube with stamen **F** stamen, ventral view (Photos: Lam Nyee Fan).







Figure 9. Distribution map of *Boesenbergia gokusingii*, $EOO = 0 \text{ km}^2$, $AOO = 8 \text{ km}^2$ (Bachman et al. 2011).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Supervision: HI, ADP, YYS. Writing - original draft: NFL. Writing - review and editing: NFL, ADP, RMZ.

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Data availability

The data underpinning the analysis reported in this paper are deposited at GBIF, the Global Biodiversity Information Facility, and are available at https://doi.org/10.15468/gm82es.

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PhytoKeys

Research Article

A new species of *Bonnetia* Mart. (Bonnetiaceae) from the Pantepui of South America

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Abstract

Bonnetia is the most representative genus of the Pantepui woody flora and is among the groups with the greatest endemism in the local flora. The genus has 28 currently recognized species in tropical America, 26 of them endemic to the Pantepui. Here we describe Bonnetia ayangannensis from the summit of Mount Ayanganna tepui in Guyana, providing a morphological description, illustrations, distribution maps, characterization of micromorphology under scanning electron microscopy and leaf venation, comments comparing the new species with closely related species, and a key for the identification of the species of Bonnetia occurring in Guyana. With its restricted distribution threat-ened by climate change, Bonnetia ayangannensis is assessed in the conservation threat category of Critically Endangered. Its description raises the number of endemic species of Bonnetia in the Pantepui to 27.

Key words: Amazonia, endemism, floristic inventory, Guayana Shield, herbarium, Malpighiales

Introduction

Bonnetia Mart. is the largest genus of the Bonnetiaceae, comprising 28 species of trees and shrubs distributed across tropical America, with 26 species endemic to the Pantepui region of the Guayana Shield in northern South America (Weitzman et al. 2007). Species of *Bonnetia* often dominate woody landscapes of the tepui summits and upper slopes (Maguire 1972; Huber 1988, 2005, 2006; Barbosa-Silva et al. 2020), and the genus provides an excellent model for understanding vascular plant diversity and endemism within the Pantepui region (Riina et al. 2019). The seven species of *Bonnetia* occurring in Brazil were the focus of a recent taxonomic study (Barbosa-Silva 2020), but additional taxonomic work is needed, especially on the species in other parts of the Pantepui region.

Floral morphology holds significant value in the circumscription of genera of Bonnetiaceae. Within the genus *Bonnetia*, however, leaf venation patterns, particularly branching patterns, which are highly diverse in the genus, have been more important in the group's taxonomy (Maguire 1972; Dickison and Weitzman 1996). Such characteristics have even been used to support generic



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Copyright: © Rafael G. Barbosa-Silva et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). segregates of *Bonnetia* (Maguire 1972; Steyermark 1984), but all these generic names are now treated as synonyms of *Bonnetia* (Barbosa-Silva 2020).

The most comprehensive advances in cataloging *Bonnetia* species diversity in the Pantepui resulted from several intensive floristic inventory programs in the region (see: Maguire 1972; Steyermark 1984; Barbosa-Silva et al. 2016; Kelloff et al. 2019). An example of these programs is the Smithsonian Institution's Biological Diversity of the Guiana Shield (**BDG**) Program, which began in 1983 as an initiative aimed at studying, documenting, and preserving the biological diversity of the Guayana Shield over 30 years. Here, we describe a new species of the genus based on collections gathered by the BDG (Kelloff et al. 2019). Its description marks the first addition of a new species to the genus (and the family Bonnetiaceae) in 37 years (Sastre 1987). It raises to 27 the number of species of *Bonnetia* endemic to the Pantepui region, and to six the number of species occurring in Guyana.

Materials and methods

All specimens of *Bonnetia* in the herbaria BM, COL, IAN, MG, MO, K, NY and US (acronyms follow Index Herbariorum, Thiers updated continuously) were examined. Specialized terminology for morphological structures follows Radford et al. (1974) and, for terms describing venation, Ellis et al. (2009). The description and illustration of reproductive structures was done from rehydrated material. Geographical data were sourced from specimen labels. The distribution map was generated using QGIS.org (2023). Assessment of the conservation status of the new species employed the categories and criteria of the IUCN Red List (IUCN 2012, 2024).

Samples of leaves, floral bracts, sepals and seeds from herbarium specimens deposited at NY were examined by Scanning Electron Microscopy (SEM), using a Hitachi model Su3500. Images were colored using Photoshop CS4 (Adobe). For the analysis of leaf venation, leaves were rendered transparent by soaking them in a 5% sodium hydroxide solution for two weeks at room temperature (Vasco et al. 2014). The transparent leaves were subsequently stained with 1% safranin and then immersed in ethanol to remove excess stain prior to imaging by an EPSON Perfection V750 PRO scanner.

Results

Taxonomic treatment

Bonnetia ayangannensis Barb.Silva, sp. nov.

urn:lsid:ipni.org:names:77349807-1

Type. GUYANA • Potaro-Siparuni, Mt Ayanganna, East slope, summit plateau; 5°23'18"N, 59°58'54"W; 1955m; fl.; 20 Mar 2014; *A. Radosavljevic et al. 247* (holotype: NY 04078880, isotype US 03457967) (Figs 1–4).

Description. Shrub or small tree up to 1.5 m tall. Branchlets often with remnants of inflorescences below the congested leaves. Leaves alternate, sessile or with a petiole c. 1 mm long, leaf blade $(1-)1.5-4 \times (0.5-)1-1.8$ cm, coriaceous, obtrullate, rarely rhombic or narrowly rhombic, base cuneate, apex slightly



Figure 1. Bonnetia ayangannensis **A** fertile branch, with details of the apex of a persistent inflorescence (at left) and the leaf abaxial surface and crenulate margin (at right) **B** immature inflorescence apex, showing bracts **C** flower bud **D** dimorphic sepals with glands, the detail showing the distal sepal margin **E** flower **F** stamens **G** closed capsule **H** transverse cut of the capsule **I** longitudinal cut of the capsule **J** seed (illustrated by: Bobbi Angell, from Radosavljevic et al. 247 and Clarke et al. 9524).

rounded to acuminate, margins crenulate, abaxial surface glabrous, with sparse black glands when dried, secondary veins scarcely visible, adaxial surface glabrous, rarely with black glands; venation pinnate with no naked basal veins, one basal vein, and no agrophic veins (Fig. 4), the major secondaries semicraspedodromous with irregular spacing, the secondary angle slightly increasing proximally, and with decurrent attachment to the midvein, the minor secondaries and interior secondaries absent, the intersecondaries parallel, spanning less than 50% of the length of the subjacent secondaries, the intercostal tertiary veins

irregularly reticulate, the epimedial tertiaries ramified with the admedial course parallel to the subjacent secondary and the exmedial course parallel to the intercostal tertiary, the exterior tertiaries terminating at the margin, the quaternary vein fabric irregularly reticulate, the quinternary vein fabric freely ramifying, areolation well developed, freely ending veinlets with two or more dendritic branches. Inflorescence axillary or occasionally terminal, once-paniculate, 2 cm long, with each branch bearing 3-4 flowers; bracts 2-3 × ca. 0.5 mm, oblanceolate to narrowly oblong, base truncate, rarely cuneate, apex rounded, margin ciliate; pedicels 2-3 mm long. Flowers 1.2-1.5 cm long, sepals 5, 2-4 × 1-2 mm, heteromorphic in size, oblong or ovate, apex rounded to acuminate, glabrous, margin ciliate, with sessile glands on the external surface; petals 5-6, 7-8 × 5-6 mm, broadly obtrullate, apex obcordate with asymmetric lobes, base cuneate, white with red margins; stamens 70-80, yellow, filaments 3 mm long, glabrous, anthers ca. 0.6 mm long; gynoecium ca. 5 × 2.5 mm, locules 3, carpels 3, green or yellow, stigma 3-branched in the upper fifth, the lobes reflexed. Capsules 7-8 × 3-3.5 mm, widely ovate to ovate. Seeds 1.5-2 mm long, linear.

Paratype. GUYANA • Potaro-Siparuni, Mt. Ayanganna, east face, edge of summit plateau; 5°23'18"N, 59°58'56"W; 2000 m elev.; fl., fr.; 24 June 2001; D. Clarke et al. 9524 (NY, US).

Notes. Bonnetia ayangannensis is morphologically most similar to *B. paniculata* Spruce ex Benth., but it differs from that species by the leaf blades (1-)1.5-4 cm long (vs. 6–18 cm in *B. paniculata*), the leaves with glandular punctuations on the abaxial surface (vs. glands absent), the bracts 2–3 mm long (vs. 6–7 mm), the sepals ciliate and glandular (vs. cilia and glands lacking) and 2–4 × 1–2 mm (vs. 10 mm × 6–7 mm). Bonnetia tepuiensis Kobuski & Steyerm. and *B. rubicunda* (Sastre) A.L. Weitzman & P.F. Stevens also occurs on the summit of Mount Ayanganna, however the new species can be differentiated by the leaves cuneate at base (vs. rounded in *B. tepuiensis*), the flowers pedicellate (vs. sessile), arranged in inflorescences (vs. solitary flowers) and by having leaf with venation pinnate and flowers with sepals and petals less than 8 mm long (vs. parallel leaf venation and sepals and petals more than 18 mm long in *B. rubicunda*). For better identification of the Bonnetia species of Guyana, see the identification key below.

The voucher Clarke et al. 9535 (NY 04067354) is a mixed specimen, consisting of three branches of *B. tepuiensis*, and a small branch to the right of *B. ayangannensis*.

Etymology. The epithet refers to the tepui Mount Ayanganna, where the new species was discovered.

Distribution and habitat. *Bonnetia ayangannensis* appears to be endemic to the summit area of Mount Ayanganna tepui, Potaro-Siparuni, in western Guyana. The species is known from only two collections gathered in close proximity from a single population on the eastern summit slope of Mount Ayanganna. The species occurs in scrub forest on sandstone, together with *B. tepuiensis, Clusia* spp. (Clusiaceae), and *Brocchinia* spp. (Bomeliaceae), among others, at elevations between 1900 and 2000 m.

Preliminary conservation status. We recommend that *Bonnetia ayangannensis* be assigned to the Critically Endangered category based on criterion B2ab(iv). The species is known from basically a single location (the two collection localities being separated by only c. 0.06 km), yielding an area of occupancy of 4 km², assuming the default settings in GeoCAT (Bachman et al. 2011;



Figure 2. SEM images of the *Bonnetia ayangannensis* **A** abaxial surface of the leaf showing the crenate margin, sometimes with deciduous spinulose projections (purple) **B** abaxial leaf surface with sessile glands (orange) and stomatal complexes (purple) at different levels **C** stomate immersed in a granular epidermis **D** bract **E** bract margin with shortstalked glands **F** sepals with sessile glands on the external surface **G** sepal margin with projections or short-stalked glands **H** seed (from Radosavljevic et al. 247 and Clarke et al. 9524).



Figure 3. Leaf venation of Bonnetia ayangannensis (from Radosavljevic et al. 247).

Bachman and Moat 2012). However, considering that the area above 1900 m elevation on Mount Ayanganna, where taller forest gives way to scrub forest, is only about 0.7 km², we suspect that the actual AOO is substantially less than 4 km². Moreover, it is likely that the population will undergo anthropogenic climate change-driven reduction, paralleling reduction in the extent of the summit scrub vegetation on Mount Ayanganna, the summit peak of which is only



Figure 4. A The map shows a topographic representation where warm colors indicate higher elevations, illustrating the geographical distribution of *Bonnetia ayangannensis* **B**, **C** view of Mount Ayanganna (photo by Adrian Warren/sasyimages.com).

2041 m elevation. This projection is based on modeling (Nogué et al. 2009) that suggests upward migration and potential habitat loss for many species with restricted tepui distributions. This, in turn, subjects these localities to threats according to the conditions of subcriterion b(iv). Other species occurring in the

eastern district of Pantepui, which are endemic to the summit of one or a few tepuis, are also threatened by rising temperatures, as is the case with *B. fasciculata* P.F.Stevens & A.L.Weitzman (Nogué et al. 2009) or are already listed on the IUCN Red List, such as *B. rubicunda* (Vulnerable) and *B. ptariensis* Steyerm. (Critically Endangered) (World Conservation Monitoring Centre 1998a, World Conservation Monitoring Centre 1998b).

Micromorphology. The leaves have a crenulate margin, sometimes bearing deciduous spinular projections (Fig. 2A). The abaxial leaf surface is rugose (i.e., not smooth and presenting different levels) and bears many sessile glands and stomata (Fig. 2B). At higher magnification, the surface takes on a warty-crustose appearance with granular projections (Fig. 2C). The margins of the bracts have short stalked glands with thin-walled elongate heads (Fig. 2D, E). The sepals have sessile glands on the external surface (Fig. 2F) and short stalked glands on the margins (Fig. 2F, G). The seeds bear longitudinal striations (Fig. 2H).

Key to the species of Bonnetia occurring in Guyana

1a	Petals and capsules < 1 cm long	
2a	Leaf blade rounded at base	.B. tepuiensis Kobuski & Steyerm.
2b	Leaf blade cuneate at base	
3a	Flowers arranged in inflorescences	B. ayangannensis Barb.Silva
3b	Flowers solitary	B. roraimae Oliv.
1b	Petals and capsules > 1 cm long	4
4a	Flowers arranged in inflorescences	B. paniculata Spruce ex Benth.
4b	Flowers solitary	5
5a	Leaf venation pinnate	B. sessilis Benth.
5b	Leaf venation parallelB. rubicunda (Sa	astre) A.L. Weitzman & P.F. Stevens

Discussion

Leaf characteristics hold significant taxonomic and historical value for the systematics of Bonnetiaceae. They provide support for the segregation of Bonnetiaceae as a distinct family (Dickison and Weitzman 1996) and have been used for the delimitation of genera now subsumed within *Bonnetia* (Maguire 1972). The micromorphological leaf features and leaf venation characters that we described for the new species may be of broader use in studies within the family, aiding in species delineation. For example, the warty-crustose leaf surface with a granular appearance that we observed in *B. ayangannensis* occurs in several other species of *Bonnetia*: *B. roraimae* Oliv., *B. steyermarkii* Kobuski, *B. wurdackii* Maguire (Dickison and Weitzman 1996). However, the spinulose projections on the leaf margin, which typically lack vascularization, are, as far as we know, shared only with *B. liesneri* Steyerm., although a similar structure is found in *B. ahogadoi* (Steyerm.) A.L. Weitzman & P.F. Stevens (Dickison and Weitzman 1996).

With respect to leaf venation, there is a fascinating array of branching patterns exhibited by different species of *Bonnetia*, ranging from pinnate to uniformly parallel (Maguire 1972; Dickison and Weitzman 1996). Our leaf clearing method showed that in *B. ayangannensis* the secondary veins are pinnate and the higher order veins, which in uncleared leaves are almost imperceptible, are irregularly reticulate, with the quaternary veins delimiting well defined areolae. Comprehensive phylogenetic sampling of *Bonnetia* is necessary to test whether species with pinnate (most species) and parallel veins (i.e., *B. fasciculata* A.L. Weitzman & P.F. Stevens, *B. maguireorum* Steyerm., *B. multinervia* (Maguire) Steyerm., and *B. rubicunda*) form distinct clades.

As is the case for *B. ayangannensis*, many plant species, including species of herbs, epiphytes, and trees, appear to be endemics of single mountains in the Pantepui region (Riina et al. 2019). The conservation of these species is of grave concern, in light of ongoing and projected impacts of climate change on the vegetation of the tepuis (Nogué et al. 2009; Vieira et al. 2024). These projections suggest reductions in the areas covered by unique summit vegetation types and upward migration of species. In many cases, these trends may result in the total loss of narrowly endemic species as current habitats become unsuitable for their occupation. With many species teetering on the brink of losing their climatic suitability, urgent conservation efforts are warranted to safeguard the biodiversity of these fragile ecosystems.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

All authors have contributed equally.

Author ORCIDs

Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Yersinochloa nianheana (Poaceae, Bambusoideae), a new species from southern Vietnam

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Abstract

Yersinochloa nianheana **sp. nov.** from Vietnam is described and illustrated. It is found in southern Vietnam, where it occurs at an elevation of 1400–1500 m in Voi Mountain, Duc Trong District, Lam Dong Province. This new species is distinguished from a similar species, *Yersinochloa dalatensis*, by culm nodes with a thick swollen patella, culm leaf blades erect, auricles conspicuous, margins bearing long hairs, palea dorsal view showing rachilla extension and rudimentary floret at the apex and lodicules purple gradually towards the top. Besides that, the species is distinguished from *Yersinochloa nghiana* by the leaf blades without being swollen at the base, the prophyllate bud 2-keeled, lodicules purple at ½ upper parts and unbifid at the base.

Key words: Bambusoideae, morphology, new taxon, pseudo-spikelet

Introduction

Yersinochloa H.N.Nguyen & V.T.Tran is a genus that was established by Hoang Nghia Nguyen and Van Tien Tran in 2016, based on *Yersinochloa dalatensis* H.N.Nguyen & V.T.Tran. It belongs to the subtribe *Bambusinae* J.S.Presl of the tribe Bambuseae (Poaceae, Bambusoideae) (Soreng et al. 2017). The genus consisting of two species are *Yersinochloa dalatensis* H.N.Nguyen & V.T.Tran and *Yersinochloa nghiana* V.T.Tran & T.V.Tran and is narrowly distributed in a degraded natural forest, in the south highlands of Vietnam (Nguyen and Tran 2016; Tran et al. 2023). *Yersinochloa* is distinguished from the other related genera of the subtribe *Bambusinae* by pseudo-spikelets with only one perfect floret, palea unkeeled and anther apices with tiny spines (Nguyen and Tran 2016).

During a bamboo survey in Voi Mountain, Duc Trong District, Lam Dong Province, southern Vietnam, in December 2023, the authors found several sparsely growing populations of climbing bamboo in a degraded natural forest of valleys, between 1400 and 1500 m a.s.l. Plants from these populations have only one perfect floret



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Copyright: © Nong Van Duy et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). Table 1. Morphological comparisons of *Yersinochloa nianheana* V.T.Tran, N.V.Duy. & T.V.Tran, sp. nov. with *Y. dalatensis* H.N.Nguyen & V.T.Tran and *Y. nghiana* V.T.Tran & T.V.Tran.

Chara	octers	Y. nianheana	Y. dalatensis	Y. nghiana
Internode		culm nodes with a thick swollen patella	culm nodes without a thick swollen patella	culm nodes with a thick swollen patella
Culm leaves	culm-leaves blade	erect, tardily deciduous, uninflated at the base	Reflexed	erect, tardily deciduous, swollen at the base
	auricles	conspicuous, dense bristles	absent or inconspicuous	conspicuous, entire
Rachilla		0.1 cm	0.1 cm	0.5 cm
Palea		acute at apex	bifid at apex	acute at apex
Lodicules		lanceolate, purple gradually towards the top, acute at apex	obovate, purple, acute at apex	obovate or oblong, purple, bifid at base

with no terminal vestigial flowers and the palea was unkeeled; the anther apex bore tiny spines. The form and structure of branches and inflorescences in the collected specimens are similar to *Yersinochloa*. However, the character states considered important at the species level for distinguishing clambering bamboo species are given in Table 1. As this combination of culm-leaf and inflorescence structure, along with the other features described here, is not found in any other bamboo species, we describe a new species from Vietnam, *Yersinochloa nianheana*.

Materials and methods

This study was based on plant material collected from Voi Mountain, Duc Trong District, Lam Dong Province, southern Vietnam. The plant specimens were deposited at VTN-Taynguyen Institute for Scientific Research, DLU and VNMN-Vietnam National Museum of Nature. Vegetative parts were measured in the field; fresh flowers were examined under a Meiji Techno EM-32 stereomicroscope and colour photographs were taken using a camera Canon 600D. Other similar species were used for critical comparison.

Taxonomic treatment

Yersinochloa nianheana V.T.Tran, N.V.Duy & T.V.Tran, sp. nov.

urn:lsid:ipni.org:names:77349808-1 Figs 1, 2

Diagnosis. Yersinochloa nianheana is morphologically most similar to Y. dalatensis and Y. nghiana, but Y. nianheana is distinguished from Y. dalatensis by culm nodes with a thick swollen patella (vs. without a thick swollen patella), culm-leaf blade erect (vs. reflexed) and auricles conspicuous (vs. absent). It also differs from Y. nghiana in culm-leaf blade flat at the base (vs. swollen at the base), palea with white cilia at the top (vs. glabrous), lodicules purple at $\frac{1}{2}$ upper parts, unbifid at the base (vs. purple, bifid at base) and prophyllate bud 2-keeled (vs. prophyllate bud 1-keeled) (Fig. 3).

Type. VIETNAM • Lam Dong Province, Duc Trong District, Voi Mountain, 1420 m a.s.l., 11°48'21.02"N, 108°24'46.12"E, 20 Sep 2023, *N.V. Duy, V.T. Tran VTN 1990* (holotype DLU!; isotype VNMN!).

Description. Culms and branches scrambling or hanging over nearby vegetation or trees, 5–8 m tall; internodes 50–70 cm long and 1.3–1.5 cm in diameter;



Figure 1. Yersinochloa nianheana V.T.Tran, N.V.Duy & T.V.Tran A habitat B clump C node D shoots E, F culm leaves G auricles H culm leaf I ligule J bud K leafy branch L, M section of a leafy branch N several branches with middle one dominant. Photos by Tran Thai Vinh from the type locality.



Figure 2. Yersinochloa nianheana V.T.Tran, N.V.Duy & T.V.Tran A, B, C inflorescence terminating at leafy branches D, E pseudo-spikelets F perfect florets G rachilla internode H prophyllate bud 2-keeled I glume J lemma K palea with rachilla extension L lodicules M stamens and pistil N anther apiece bearing tiny spines O young fruit P stigmas Q mature fruit. Photos by Tran Thai Vinh from the type locality.



Figure 3. Yersinochloa nianheana V.T.Tran, N.V.Duy & T.V.Tran, Y. dalatensis H.N.Nguyen & V.T.Tran and Yersinochloa nghiana V.T.Tran & T.V.Tran A1 bud A2 culm sheath A3 prophyll A4 lodicules B1 bud B2 culm sheath B3 prophyll B4 lodicules C1 bud C2 culm sheath C3 prophyll C4 lodicules. Photos by Tran Thai Vinh from the type locality.

white at the node when young, densely covered with adpressed white hairs; culm walls 0.4-0.5 mm thick; nodes with a thick swollen patella, hairy. Branches 5-7 with the middle one dominant and elongated. Culm leaves leathery purplish, sheaths with densely adpressed white hairs on the abaxial side; 25-27 cm long and 9-10 cm wide at the base, apex 6-7 cm wide; margins bearing dense whitebrown hairs; blades cordate, slightly constriction at the base, erect, early deciduous, purple-brown, 14-18 × 3-4 cm, abaxial surface with dense white hairs at the base; auricles conspicuous, $1.0-1.2 \times 0.1-0.2$ cm; margins bearing dense white bristles, ca. 0.8-1.0 cm long; ligule short, ca. 1 mm, entire. Leafy branches bearing 8-10 leaves, foliage leaf blades wedge-shaped, 35-38 × 6-8 cm, acute or cuneate-obovoid at base, glabrous; veins 11-13 pairs; sheaths with ciliate margins, auricles with dense bristles 4-6 mm long; inner ligule with a low rim, ca. 1 mm; pseudo-petiole ca. 7-9 mm length, arching over. Inflorescences terminating at leafy branches, indeterminate; pseudo-spikelets typically 1.8-2.2 cm long, each subtended by a prophyllate bud, 2-keeled, with ciliate margins and hairy on 2-keels; 0.8-1.0 × 1.0-1.2 mm, apex acute, mucronate, ca. 0.5 mm long and consisting of one glume, one perfect floret. Rachilla internode below fertile floret ca. 0.1 cm. Fertile floret 1.0-1.2 × 0.2-0.4 cm; lemma oblong-lanceolate, 0.8-1.0 × 0.2-0.4 cm, veins 9-10, apex acute with 0.1 mm long, margins bearing dense white cilia; palea unkeeled, dorsal view showing rachilla extension and a rudimentary floret at apex, 1.0-1.2 × 0.5-0.6 cm, with margins bearing dense white cilia at the top, acute at apex, base inrolled; lodicules 3, lanceolate, purple gradually towards the top, ca. 0.3-0.4 × 0.1-0.2 mm, acute at apex, top with hairs 0.5 mm long, ciliate margins at ¹/₂ upper parts. Stamens 6; filaments free, 0.7–0.8 cm; anther ca. 5 mm, purple, apices bearing tiny spines, ca. 0.5 mm. Ovary green, glabrous with a long style, style oblique 1.0-1.2 cm; stigmas 3, purple; caryopsis oblique, with a relatively thin pericarp, $0.6-0.7 \times 0.1-0.2$ cm, with a long style, ca. 0.9-1.1 cm.

Distribution and habitat. *Yersinochloa nianheana* grows in degraded natural forest in the valleys, between 1400 and 1500 m a.s.l., in Voi Mountain, Duc Trong District, Lam Dong Province.

Phenology. The plants were found flowering in December 2023. New shoots from June to August.

Local uses. *Yersinochloa nianheana* is of considerable importance to the local people. Its culms are used for making handicrafts and household tools.

Etymology. The new species is named in honour of Prof. Xia Nianhe, for his contributions to bamboo research.

Preliminary conservation status. *Yersinochloa nianheana* is only known from a single population in Voi Mountain, Duc Trong District, Lam Dong Province, Vietnam. This population has no more than 500 mature clumps, all growing in degraded natural forests in valleys. According to IUCN Red List Categories and Criteria (IUCN 2022), the species is classified as data deficient (DD) and needs more surveys.

Key to the species of Yersinochloa in Vietnam

Y. dalatensis	Leaf blade reflexed	1
2	Leaf blade erect	_
Y. nghiana	Leaf blade swollen at the base	2
Y. nianheana	Leaf blade flat at the base	-
Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Data availability

All of the data that support the findings of this study are available in the main text.

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PhytoKeys

Checklist

Annotated checklist of Rubus L. (Rosaceae) from South America

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Abstract

The diversity of *Rubus* in South America is much understudied and a taxonomic framework needs to be established as a basis for future revisionary and phylogenetic work. Our review identified 110 names based on South American specimens which were published since 1767. Each name was then classified according to its botanical description and type material. Additionally, where necessary, we suggest appropriate lecto-, neo-, or epitypes. A comprehensive list of synonyms is provided and representative herbarium specimens for each country are cited to tentatively document geographical range. In total, we accept 46 species of *Rubus* recorded across South America, propose 19 new synonyms, restore *R. organensis*, previously a synonym of *R. brasiliensis*, provide a replacement name for the latter, and include new country records of *R. azuayensis*, *R. laegaardii* and *R. rusbyi*. This checklist serves as an essential starting point for future monographic and evolutionary studies on *Rubus* in South America.

Key words: Amazonia, Andes, Rubeae, synonymy, taxonomy, typification

Introduction

Rubus L. is the most diverse genus in Rosaceae, with ca 900–1500 species distributed worldwide (Focke 1910, 1911b, 1914; Christenhusz and Byng 2016; Huang et al. 2023; POWO 2024). The genus is believed to have originated in North America and then colonized Eurasia, Central and South America during the Miocene, ultimately reaching Oceania through long-distance dispersal (Carter et al. 2019). However, its species-level taxonomy is challenging due to morphological diversity, hybridization, polyploidy and apomixis (Sochor et al. 2022). Recent molecular studies have helped to identify the major clades in *Rubus* and revise the infrageneric classification of the genus (Carter et al. 2019; Huang et al. 2023), but South American *Rubus*, particularly Andean species, are underrepresented in these studies.

South American species were until recently classified in three subgenera: *R*. subg. *Rubus*, *R*. subg. *Comaroposis* (Rich. ex Nestl.) Focke, and *R*. subg. *Orobatus* (Focke) Focke (Romoleroux 1996; Carter et al. 2019; Espinel-Ortiz and Romoleroux 2021), but according to Huang et al. (2023), all the South American species fall into *Rubus* subg. *Rubus*. Overall, the taxonomy and systematics of *Rubus* in South America on a larger scale is not well documented. Most of the



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Copyright: © David A. Espinel Ortiz et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). recent literature has focused on limited geographical areas (e.g., countries, departments, provinces or regions) when describing new species (Moreno-Medina et al. 2020; Espinel-Ortiz and Romoleroux 2021), reporting introduced or rediscovered taxa (Espinel-Ortiz and Romoleroux 2020; Espinel-Ortiz et al. 2023), and catalogs or revisions (Forzza et al. 2010; Romoleroux et al. 2014; IPNI 2024; POWO 2024; Tropicos.org 2024). Only two historical studies cover this taxon on a global scale: The first one is the multivolume monograph of *Rubus* by Focke (1910, 1911b, 1914), which was a reference for the genus diversity worldwide, but is outdated by now, not least due to the plethora of names published in the past 100 years. The second study is a recent compilation of *Rubus* taxa considered as distinct (Huang et al. 2023), which unfortunately omits recently described or rediscovered species and neither lists synonyms nor taxonomic types. Both studies represent important milestones towards a comprehensive taxonomic treatment of the genus, but are only of limited use for future work on the South American species.

There is no recent publication summarizing taxonomic diversity and nomenclature of *Rubus* in South America, especially with the recent additions, nor are many of the names effectively typified. The present study aims at a) clarifying the names of *Rubus* in South America, to identify types and tentatively assign synonyms, b) providing a clear starting point for future revisionary, monographic and phylogenetic work on the genus in South America. To this end, we compiled a critical taxonomic checklist of the genus in South America, which includes all the published names in *Rubus* based on South American specimens, their taxonomic identity and typification, as well as the species distribution ranges as currently understood.

Material and methods

We compiled the names of South American *Rubus* mentioned in the taxonomic literature (Macbride 1930; Fuks 1984; Romoleroux 1996; Romoleroux et al. 2014; IPNI 2024; POWO 2024; Tropicos.org 2024), tracing back each original publication with the help of the Biodiversity Heritage Library (https://www.biodiversitylibrary.org/). Across sources, we reviewed all the names where South America (e.g., *"America australis"*), or countries of South America were mentioned, either to search for type material and representative specimens for the distribution assessment.

We have personally checked the collections of *Rubus* of the following South American herbaria: CPUN, CUZ, HA, HUT, HUTI, LOJA, MA, Q, QAP, QCA, QCNE, QPLS, USM, and digitized material from: A, AAU, ASU, B, BM, BR, COL, CORD, E, F, FURB, G, GH, GOET, HAL, K, L, LD, LINN, M, MBM, MICH, MO, MPU, NY, P, PH, PRC, PUL, S, SPF, TEX, U, US, W, WU, Z. All the acronyms cited here followed those registered in Index Herbariorum (Thiers 2024).

Each species in this checklist has at least one cited specimen per country in South America, and notes on the typification and synonymy are provided where required. Herbarium acronyms are followed by a barcode, when available. Furthermore, some specimens (e.g., D. Espinel-Ortiz & H.G. Abad 281) were mounted on more than one herbarium sheet, and/or have additional dry or alcohol material, each one with its own herbarium barcode. For such specimens, we provide all the herbarium barcodes for each part when available. We have only included the herbarium specimens that we were able to revise; therefore, we do not provide information on their duplicates that we were unable to examine, unless they are considered as types, original or possible original material.

All the proposed nomenclatural actions in this checklist are based on the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018), hereafter referred to as ICN. We include designations (names not validly published) inside quotation marks in the synonymy where appropriate. Citations of types, original material, and possible original material include an exclamation mark if the material has been seen personally, [image!] when checked from digitalized material, or (n.v.) when not seen. Within the taxon citation, we cited all the syntypes if a lectotype is designated among the extant syntypes. Additionally, \equiv is used for homotypic synonyms and = for heterotypic synonyms. The specimens cited in the distribution section are organized geographically by country from North to South and West to East. In taxonomic notes, we include information about synonym; we also added "syn. nov." to each name treated here as a new synonym. A list of the accepted species, the compiled names/ designations and the type specimens are provided as supplementary material (See Suppl. material 1).

Checklist of the South American Rubus species

1. Rubus acanthophyllos Focke, Abh. Naturwiss. Vereins Bremen 4:161. 1874.

Rubus jelskii Fritsch in Szyszyl., Diss. Cl. Math.-Phys. Acad. Litt. Cracov. 29: 220. 1894.
 Type. PERU. Cajamarca: Cutervo, May 1879, *C. de Jelski 6* (lecto-type, designated by Romoleroux 1996, pg. 10: B-10-0278049 [image!]).

Type. VENEZUELA. Mérida: Sep 1846 (fl), *N. Funck & L.J. Schlim 1142* (holotype: LE-00018277 [image!]; isotype: P-00682371 [image!]).

Nomenclature notes. In the protologue, Focke (1874) cited a specimen at LE, which we recognize as the holotype of *R. acanthophyllos* according to Art. 9.1 of the ICN. Additionally, we found a duplicate kept at P, which we recognize as an isotype of *R. acanthophyllos*.

Taxonomic notes. The synonymy follows the revision of Romoleroux (1996).

Specimens examined. COLOMBIA. • **Boyacá:** Municipio Duitama, El Carmen, vía a Virolín, 3400–3500 m, 19 Nov 1994 (fl), *J. Betancur 5634* (COL-000057912). • **Unknown:** El Boquerón bei Bogotá, páramos, 3200–3700 m, Jul 1929 (fl), *C. Troll 3774* (B-10-0248179). **VENEZUELA.** • **Trujillo:** Parque Nacional Guaramacal, 09°16.700'N, 70°08.650'W, 2700–2800 m, Jan–Feb 1996 (fl), *B. Stergios & L. Zambrano* 17746 (US-00603198). **ECUADOR.** • **Loja:** Desvío a Fierro Urcu, aprox. 9 km desde la carretera E35, 03°42.842'S, 79°18.642'W, 3449 m, 14 Nov 2019 (fl, fr), *D. Espinel-Ortiz & E. Bastidas-León* 193 (QCA-244943, QCA-7010888). **PERU.** • **Cajamarca:** Hualgayoc, 06°45.680'S, 78°36.018'W, 3523 m, 27 May 2014 (fr), *J. Montoya, E. Linares & A. Galán* 3755 (USM-298275).

Distribution. *Rubus acanthophyllos* is recorded along the Andes of Venezuela, Colombia, southern Ecuador and Peru.

2. Rubus adenothallus Focke in Herzog, Meded. Rijks-Herb. 19: 56. 1913.

Type. BOLIVIA. Río Sanjana, near Calacheca, 3500 m, Jan 1911 (fl), *T. Herzog* 2399 (lectotype, designated by Romoleroux 1996, pg. 31: L-0019722 [image!], L-0019723 [image!]).

Specimens examined. ECUADOR. • AZUAY: Vía Cuenca-Loja, desvío en la carretera E35, entrada a la comunidad "Rañas", aprox. 37 km después de Cumbe, 03°15.213'S, 79°04.132'W, 3198 m, 13 Nov 2019 (fl, fr), *D. Espinel-Ortiz & E. Bastidas-León 187* (QCA-246116, QCA-7011142). **PERU. • Cusco:** Calca, Lares, 10 km antes del pueblo del Lares y cinco km más allá, 3200–3500 m, 30 Aug 1943 (fl, fr), *C. Vargas 3585* p.p. (CUZ-3991). • **San Martín:** Mariscal Cáceres, lado S de Río Chochos, Río Abiseo Parque Nacional, 3400 m, 07 Jun 1986 (fr), *K. Young 3717* (CPUN-4977). **BOLIVIA. • La Paz:** Inquisivi, "Aguas Calientes de Calachaca", 9 km NW of Choquetanga, 16°48.000'S, 67°19.000'W, 3400–3500 m, 09 Mar 1991 (fl), *M. Lewis 38259* (MO-1606899).

Distribution. *Rubus adenothallus* is recorded in the Andes of southern Ecuador, Peru and Bolivia.

3. Rubus adenotrichos Schltdl., Linnaea 13(2): 267. 1839.

= Rubus roseorum A.Berger, J. Wash. Acad. Sci. 16(6): 161. 1926. • Type. ECUADOR. [Pichincha]: Vicinity of Quito 26 Oct-01 Nov 1918 (fl, fr), J.N. Rose & G. Rose 23548 (holotype: US-00095484 [image!]; isotypes: GH-40522 [image!], NY-429652 [image!]).

Type. MEXICO. Jalapa, May 1829 (fl), *C.J.W. Schiede s.n.* (lectotype, designated here: HAL-60490 [image!]).

Nomenclature notes. There are some problems with the typification of *R. adenotrichos*, because the holotype was cited at different herbaria. Romoleroux (1996) cited a specimen from NY, while Tropicos.org (2024) cited specimens from G. However, neither matches the date cited in the protologue. Schlechtendal (1839) described *R. adenotrichos* from a specimen collected by Schiede in Jalapa in May. No herbarium is given in the protologue, but Schlechtendal was the director of the Botanical Garden of the Martin Luther University of Halle-Wittenberg (HAL) at the time of the description. Therefore, the original material examined by Schlechtendal is housed at HAL (Braun and Wittig 2003).

We located two specimens of *R. adenotrichos* collected by Schiede at HAL. HAL-60490 has a handwritten label which matches the protologue in locality, date of collection and flower color. The other specimen at HAL, as well as those at GOET, NY and P have only a handwritten label with the locality. It is clear that Schlechtendal used more than HAL-60490 for his description of *R. adenotrichos*. Thus, according to Art. 9.3, 9.11, and 9.12 of the ICN, lectotypification is required and we designate HAL-60490 as the lectotype of this name. Further specimens from Schiede are cited here as original material of *R. adenotrichos*. **Taxonomic notes.** The synonymy follows the revision of Romoleroux (1996). **Original material of** *Rubus adenotrichos* **Schltdl.: MEXICO.** Jalapa, *C.J.W. Schiede s.n.* (HAL-107628 [image!] two sheets).

Possible original material of *Rubus adenotrichos* **Schltdl.: Mexico.** Jalapa, *C.J.W. Schiede s.n.* (GOET-010090 [image!], NY-429609 [image!], P-00682372 [image!]).

Specimens examined. VENEZUELA. • **Trujillo:** Boconó, Parque Nacional Guarmacal, casa Vicuyal, 2100 m, 12 Apr 2003 (fl), *B. Stergios, L.J. Dorr, S.M. Niño & R. Caracas 20169* (US-00728400). **COLOMBIA.** • **Putumayo:** Valle de Sibundoy, 1.5 km S Sibundoy, 2200 m, 21 Sep 1963 (fl), *M.L. Bristol 1397* (COL-00197822). **ECUADOR.** • **Imbabura:** Cotacachi, vía a la laguna de Cuicocha, entrando por la carretera Cotacachi-Quiroga-Cuicocha, 00°17.563'N, 78°20.918'W, 3045 m, 03 Oct 2020 (fl), *D. Espinel-Ortiz, M.P. Ortiz, M.A. Espinel-Ortiz & C. Castillo 246* (QCA-246116, QCA-7011142). • **Pichincha:** Chillo Valley, Santa Rosa, 9600 ft, 26 Aug–02 Sep 1923 (fl), *H.E. Anthony & G.H.H. Tate 204* (US-03733224); Nono, Aug 1899 (fl), *A. Sodiro 408* (Q-3608). **PERU.** • **Huánuco:** Huánuco, San Pedro de Cani, 3088 m, 18 Jun 2017 (fl), *J.C. Tumbay 17* (USM-312932).

Distribution. *Rubus adenotrichos* is reported from Mexico through Central America to the Central Andes, along the Andean Cordillera of Venezuela, Colombia, Ecuador and central Peru.

4. *Rubus alutaceus* B.L.Moreno, Casierra & Albesiano, Revista Brasil. Fruticult. 42(2)-e542: 3. 2020.

Type. COLOMBIA. Boyacá: Municipality of Gachantivá, El Carmen Farm, 2504 m, 31 Mar 2017, *B. Moreno 2* (holotype: COL (n.v.)).

Notes. This species is known only from the holotype.

Distribution. *Rubus alutaceus* is only known from the type locality in the Cordillera Oriental of central Colombia.

5. Rubus azuayensis Romol., Fl. Ecuador 56: 9. 1996.

Type. ECUADOR. Azuay: The eastern Cordillera, 4–6 km, north of the village of Sevilla de Oro, 9000–1000 ft, 14 Aug 1945 (fl, fr), *W.H. Camp E-4693* (holotype: NY-39569 [image!]; isotypes: BM-000622366 [image!], US-00478811 [image!], US-01013533 [image!].

Specimens examined. ECUADOR. • Loja: Desvío a Fierro Urcu, aprox. 5.2 km desde la carretera E35, 03°41.871'S, 79°18.257'W, 3204 m, 21 Feb 2017 (fr), D. Espinel-Ortiz, E. Bastidas-León, K. Romoleroux & M. Hidalgo 101 (QCA-243563). PERU. • Cajamarca: Santa Cruz, Pulán, Cerro Campanario, alrededores de la Catarata La Cuda, 3100 m, 03 Jul 2004, G. Iberico Vela, L. Dávila & A. Chávez Santa Cruz 752 (CPUN-23094).

Distribution. *Rubus azuayensis* is known in southern Ecuador and northern Peru. We report here for the first time the presence of *R. azuayensis* in Peru.

6. Rubus bogotensis Kunth, Nov. Gen. Sp. [H.B.K.] 6[Quarto]: 220. 1823.

- = "Rubus bogotensis var. normalis Kuntze", Revis. Gen. Pl. 3[3]: 78. 1898, nom. inval.
- = Rubus adenomallus Sodiro ex Focke, Biblioth. Bot. 18, Heft 83: 52. 1914, syn. nov. • Type. Ecuador. [Pichincha]: "Crescit prope Nono" [grows near Nono], 1887 (fr), A. Sodiro 408 (lectotype, designated here: Q-3605!).

Type. COLOMBIA. Santa Fé de Bogotá, "1370 hex", Sep (fr), *A. von Humboldt* & *M.A. Bonpland s.n.* (lectotype, designated by Romoleroux 1996, pg. 36: P-00679380 [image!]).

Nomenclature notes. Romoleroux (1996) cited the lectotype of R. bogotensis in P, but we found two separate sheets at P that agreed with this typification. We cite here the barcode of the lectotype selected by Romoleroux, as only one specimen was used for the typification. The lectotype has a label from the "Herbier Humboldt & Bonpland" and a separate, handwritten label from Kunth with the species identification and locality. As it lacks a collection number, the second specimen at P without such labels is treated here as original material. Focke (1914) described R. adenomallus based on Sodiro 408, which was annotated "Rubus fulliginosus Sodiro" by the collector. We were unable to locate this specimen at B, but we found a collection at Q that matches the original description. Moreover, the specimen at Q has a previous handwritten annotation as "Rubus fulliginosus Sodiro", the same that is mentioned in the protologue. Therefore, according to Art. 9.3, 9.11 and 9.12 of the ICN, we designate it as the lectotype of R. adenomallus. Kuntze (1898) used "R. bogotensis var. normalis" when referring to the typical form of R. bogotensis automatically including its type. According to Art. 24.3 of the ICN, "R. bogotensis var. normalis" is an invalid name because its final epithet is different from the corresponding higher-ranked taxon.

Taxonomic notes. *Rubus adenomallus* is considered to be a new synonym of *R. bogotensis* because its type collection has the same trifoliolate leaves, glandular trichomes and fruits (few and big drupelets) as *R. bogotensis*.

Original material of *Rubus bogotensis* Kunth: Colombia. Santa Fé de Bogotá, A. von Humboldt & M.A. Bonpland s.n. (P-00162113 [image!]).

Specimens examined. VENEZUELA. • Trujillo: Trujillo, alrededores de Guirigay, 3200 m, Aug 1958 (fl), *L. Aristeguieta 3540* (US-00727722). COLOMBIA. • Cundimarca: Cordillera Oriental, páramo de Guasca, 2800–3300 m, 17 Feb 1951 (fl), *H. García-Barriga & R.E. Schultes 13504* (COL-000197256, US-03733321). ECUADOR. • Loja: San Lucas, desvío a Lomas de Oro, aprox. 5 km desde la carretera E35, 03°40.938'S, 79°14.897'W, 3212 m, 14 Nov 2019 (fl, fr), *D. Espinel-Ortiz & E. Bastidas-León 191* (QCA-246056, QCA-7011098 to QCA-7011100). PERU. • Junín: Tarma, Huasahuasi, carretera Cachiyazu-Cascas, 11°10.000'S, 75°35.617'W, 3852 m, 20 May 2021 (fl), *R. Vásquez, R. Rojas & E. Pinche 45877* (USM-330175). BOLIVIA. • La Paz: Inquisivi, "Jucumarini Trail", between Chichipata and Jucumarini, 16°58.000'S, 67°13.000'W, 3300–3400 m, 23 Feb 1990 (fr), *M. Lewis 37125* (US-03733297).

Distribution. *Rubus bogotensis* is recorded along the Andes of Venezuela, Colombia, Ecuador, Peru and Bolivia.

7. Rubus boliviensis Focke, Abh. Naturwiss. Vereins Bremen 4: 158. 1874.

- Rubus chagalensis Hieron., Bot. Jahrb. Syst. 20(3, Beibl. 49): 28. 1895. Type.
 ECUADOR. Azuay: Chagal, Western Andes of Cuenca, 2000–2600 m, Oct (fl), F.C. Lehman 4969 (lectotype, designated by Romoleroux 1996, pg. 46: F-V0068374F [image!]; isolectotype: K-000424913 [image!]).
- Rubus herzogii Focke in Herzog, Meded. Rijks-Herb. 19: 56. 1913, syn. nov.
 ≡ Rubus briareus subsp. herzogii (Focke) Focke, Biblioth. Bot. 18, Heft 83: 56. 1914.
 Type. BOLIVIA. Saimapata, 2000 m, Mar 1911 (fl), *T. Herzog 1663* (lectotype, designated here: L-0019779 [image!]).

Type. BOLIVIA. [La-Paz]: Larecaja "viciniis Soratam, ad rivum Challasuyo" [near Sorata, at the river Challasuyo], 2600 m, Aug 1857 (fl, fr), *G. Mandon 676* (lecto-type, designated by Romoleroux 1996, pg. 46: W-65297 [image!]; isoloectotype: K-000424914 [image!]).

Nomenclature notes. Romoleroux (1996) cited the holotype of *R. chagalensis* in F, but we found another sheet from this collection in K. While Hieronymus (1895) cited *Lehman 4969* in the protologue, he omitted the herbarium that held this specimen. According to Art. 9.3 of the ICN, as no clear holotype was selected and two sheets in different herbaria are extant, lectotypification is required. In this respect, Romoleroux (1996) effectively typified the name *R. chagalensis* at that time (Art. 7.11). We correct the type status to lectotype and add the corresponding barcode. Focke (Herzog 1913) described *R. herzogii* based on two specimens: *Herzog 1663* and *Buchtien s.n.* We located *Herzog 1663* in L, and according to Arts. 9.3, 9.11 and 9.12, we designate it as the lectotype of this name. We did not locate *Buchtien s.n.*, but instead we found *Buchtien 6176*, which has the same locality information as given in the protologue. We treat this specimen as possible original material of *R. herzogii*, because we lack evidence that Focke had access to it at the time of the description.

Taxonomic notes. We follow the revision of Romoleroux (1996), who recognized *R. chagalensis* as a synonym of *R. boliviensis*. Furthermore, we consider *R. herzogii* as a new synonym of *R. boliviensis* based on the same indumentum, especially in branches and leaves; as well as the stipules and fruits seen in the type collections.

Possible original material of *Rubus herzogii* **Focke: BOLIVIA.** Cotaña, 2500 m, Nov 1911 (fr), *O. Buchtien 6176* (US-00641886 [image!]).

Specimens examined. ECUADOR. · Loja: 12–20 km S de Yangana, 04°26.016'S, 79°08.933'W, 2320–2780 m, 14 Apr 1992 (fl), *K. Romoleroux & J.L. Luteyn 1362* (QCA-91807). **PERU. · Puno:** Sandía, entre Quinsa Cruz y Muruncunca, 1800 m, 05 Aug 1965 (fr), *C. Vargas 16361* (CUZ-5599). **BOLIVIA. · La Paz:** Sud Yungas, Hacienda "La Florida", 26 May 1920 (fr), *E.W.D. Holway & M.M. Holway 654* (US-00641862).

Distribution. *Rubus boliviensis* is recorded in the Andes of Ecuador, Peru and Bolivia.

8. Rubus bozae Vargas, Revista Univ. (Cuzco) 32(84): 261. 1943.

Type. PERU. Cusco: Calca, Lares, inmediaciones de Pampa Corral, 3600 m, 09 Feb 1943 (fl, fr), *C. Vargas 3212* (holotype: CUZ-3981!).

Notes. Rubus bozae is known only from the type collection.

Distribution. Rubus bozae is recorded in southern Peru.

9. Rubus briareus Focke, Repert. Spec. Nov. Regni Veg. 9: 235. 1911.

Type. BOLIVIA. La Paz: Nor Yungas, Unduavi, 3200 m, 12 Feb 1907 (fl, fr), *O. Buchtien 640* (lectotype, designated here: US-00097866 [image!]; isolectotype: NY-429632 [image!]).

Nomenclature notes. In the protologue, Focke (1911a) cited the gathering *Buchtien 640*, for which we found two specimens, one at NY and the other at US. The voucher at US has flowers and fruits, therefore we designate it as the lectotype of *R. briareus* (Art. 9.3, 9.11 and 9.12 of the ICN).

Additional specimens examined. BOLIVIA. • La Paz: Yungas, 1890 (fl), *M. Bang 684* (US-00641878); Sud Yungas, San Felipe, 19 May 1930 (fl), *E.W.D. Holway & M.M. Holway 617* (US-00641864). • Cochabamba: Cerros de Incachaca, 2000–3000 m, 04 Oct 1922 (fl), *J. Steinbach 6068* (US-03733821).

Distribution. Rubus briareus is recorded in central Bolivia.

10. Rubus bullatus Rusby, Bull. New York Bot. Gard. 4(14): 351. 1907.

≡ *Rubus betonicifolius* Focke, Biblioth. Bot. 72: 33. 1910, nom. illeg. superfl.

Type. BOLIVIA. *M. Bang* 2235 (lectotype, designated here: NY-429638 [image!]); isolectotypes: E-00010689 [image!], E-00296708 [image!], F-V0068373F [image!], GH-26798 [image!], GH- 26799 [image!], K-000424877 [image!], M-0214195 [image!], MICH-111130 [image!], MO-255141 [image!], NY-429635 [image!], NY-429636 [image!], NY-429637 [image!], PH-21481 [image!], PH-21482 [image!], PUL-380 [image!], US-00097868 [image!], US-00641884 [image!], TEX-371097 [image!]), WU-27792 [image!].

Nomenclature notes. Rusby (1907) and Focke (1910) described *R. bullatus* and *R. betonicifolius*, respectively, based on *Bang 2235* from different herbaria. Rusby worked at NY at the time of the description, so we designate the specimen NY-429638 as the lectotype (Art. 9.1, 9.3, 9.11 and 9.12 of the ICN) of *R. bullatus*. On the other hand, Focke (1910) described *R. betonicifolius* with two gatherings: *Bang 2235* and *Weberbauer 670*. The name *R. betonicifolius* was superfluous and, therefore, illegitimate when it was published as Focke included the only gathering cited by Rusby.

Specimens examined. PERU. • Cusco: Urubamba, Machu Picchu, Alccamayo, 13°09.033'S, 72°30.467'W, 2500–2840 m, 24 Feb 2003 (fl, fr), *L. Valenzuela, E. Succlli & I Huamantupa 1511* (CUZ-42697). • **Unknown:** Sandía, 06 Apr 1902 (fl, fr), *Weberbauer 670* (B-10-1172571).

Distribution. Rubus bullatus is recorded in southern Peru and northern Bolivia.

11. Rubus chloropetalus Vargas, Revista Univ. (Cuzco) 32(84): 262. 1943.

Type. PERU. Cusco: Calca, entre Quishuaraní y Lares, 3200–3500 m, 30 Aug 1943, *C. Vargas 3585* (holotype: CUZ-3991! p.p.; isotypes: CUZ!, USM-13834!).

Nomenclature notes. Vargas (1943) cited *Vargas 3583* as the type of *R. chloropetalus*, but this collection number is apparently a typographical error: *Vargas 3585* has the exact information (locality, altitude and date) given in the protologue, corresponds to the original description and is annotated as "typus". Therefore, according to Art. 9.2 of the ICN, we correct the collection number of the holotype. However, the holotype collection of *R. chloropetalus* has two different species mounted on the same sheet. The one referring to *R. chloropetalus* occupies most of the space and has broad leaves, while a small collection with smaller leaves, at the lower left of the sheet, is *R. adenothallus*.

Distribution. Rubus chloropetalus is recorded in southern Peru.

12. Rubus choachiensis A.Berger, J. Wash. Acad. Sci. 16(6): 160. 1926.

 Rubus gachetensis A.Berger, J. Wash. Acad. Sci. 16(6): 160. 1926, syn. nov.
 Type. Colombia. [Cundinamarca]: Camino de Gachetá, in forests, 2300 m, Jan 1920 (fl), Brother Ariste-Joseph A543 (holotype: US-00097911 [image!]).

Type. COLOMBIA. Cundinamarca: Páramo de Choachí, near Bogotá, 3700 m, 8 Aug 1922 (fl), *E.P. Killip & Brother Ariste-Joseph 11967* (holotype: US-00097876 [image!]).

Taxonomic notes. Berger (1926) described *R. choachiensis* and *R. gachetensis* based on two specimens from Cundimarca. We recognized both names as belonging to the same species, since their holotypes have the same indument, stipules, leaves and flowers. They differ only by a thicker branch in *R. choachiensis*, which was probably collected from a more developed individual.

Specimens examined. COLOMBIA. • Cundinamarca: Subachoque, páramo de El Tablazo, 3300 m, 13 Oct 2003 (fl, fr), *M. Hernández Schmidt, J.L. Fernández-Alonso, M.C. Vélez & C.A. Agudelo 1376* (COL-000048593).

Distribution. *Rubus choachiensis* is recorded in the Eastern Cordillera of central Colombia.

13. Rubus compactus Benth., Pl. Hartw. [Bentham]: 129. 1844.

Type. ECUADOR. [Loja]: "In montibus Saraguro" [mountain of Saraguro], *T. Hartweg 731* (lectotype, designated by Romoleroux 1996, pg. 24: K-000424927 [image!]; isolectotype: LD-1246155 [image!]).

Nomenclature notes. Hartweg's original collections ended up in different herbaria, so we correct here the typification of the South American names of *Rubus* published in Flora Hartwegiana (Bentham 1839). We located *Hartweg* 731 at K and LD, both corresponding to the information given in the protologue. Considering that Romoleroux (1996) cited the holotype of *R. compactus* at K, according to Art. 7.11 of the ICN, this was an effective typification at that time. Therefore, we here correct the type status to lectotype.

Specimens examined. ECUADOR. • AZUAY: Nabón, páramo de Chunazana, a 5.4 km desde carretera E35, 03°13.372'S, 79°07.050'W, 3170 m, 17 Aug 2023 (fl, fr), *D. Espinel-Ortiz & C. Restrepo 439* (QCA). **PERU. • Cusco:** Paucartambo, Cordillera de las tres Cruces, 3600 m, 10–11 Oct 1943 (fl), *C. Vargas 3632* (CUZ-5523).

Distribution. Rubus compactus is recorded in southern Ecuador and Peru.

14. Rubus conchyliatus Focke, Meded. Rijks-Herb. 19: 54. 1913.

≡ Rubus lechleri var. conchyliatus (Focke) Focke, Biblioth. Bot. 18, Heft 83: 21. 1914.

Type. BOLIVIA. Río Sanjana, 3400 m, *T. Herzog 2206a* (lectotype, designated here: L-0019750 [image!]).

Nomenclature notes. In the protologue, Focke (Herzog 1913) cited *Herzog 2206a* and omitted the specific herbarium. According to Art. 9.3, 9.11 and 9.12 of the ICN, we designate the specimen at L as the lectotype of *R. conchyliatus*.

Specimens examined. BOLIVIA. • La Paz: Sud Yungas, 19.8 km E of pass between Mururata and Illimani, 16°34.000'S, 67°45.000'W, 3500 m, 11 Dec 1983 (fl), *J.C. Salomon 11368* (U-1558220).

Distribution. Rubus conchyliatus is recorded in central Bolivia.

15. Rubus coriaceus Poir., Encycl. [J. Lamarck & al.] 6(1): 237. 1804.

- ≡ *Rubus roseus* var. *coriaceus* (Poir.) Ser., Prodr. [A. P. de Candolle] 2: 562. 1825.
- Rubus stuebelii Hieron., Bot. Jahrb. Syst. 21(3): 311. 1895. Type. COLOM-BIA. Excursión de Popayán al páramo de Huila, Mar 1869 (fl), A. Stübel 282f (lectotype, designated by Romoleroux 1996, pg. 12: B-10-0248190 [image!]).
 • Syntype. Colombia. Excursión al Volcán de Chiles, 4000–4500 m, Jan–Feb 1870 (fl), A. Stübel 461c (B-10-0248190 [image!]).
- "Rubus glabratus var. heterophyllos Sodiro ex Benoist", Bull. Soc. Bot. France
 90: 15. 1943 (as "heterophyllus"), nom. nud., syn. nov.

Type. PERU. J. Dombey s.n. (holotype: P-00678397 [image!]).

Nomenclature notes. Poiret (1804) cited all his new names of South American species of *Rubus* at the Jussieu Herbarium. We have located the holotype and isotype of *R. coriaceus* at P, but only the holotype has a label from the "Herbier D'Antoine Laurent de Jussieu". According to Art. 9.1 of the ICN, we accept this specimen as the holotype of *R. coriaceus*, but as it has no collection number, we cannot confirm any duplicates. Therefore, the other specimen at P is treated here as possible original material. Benoist (1943) cited *Rivet 314* as "*R. glabratus* var. *heterophyllos*", but omitted the description and diagnosis. Thus, "*R. glabratus* var. *heterophyllos*" was not validly published (Art. 38.1).

Taxonomic notes. The synonymy follows the revision of Romoleroux (1996), but we also recognize "*R. glabratus* var. *heterophyllos*" as a synonym of *R. coriaceus*. It is a designation whose cited specimen we identified as *R. coriaceus*.

Possible original material of *Rubus coriaceus* **Poir.: PERU.** *J. Dombey s.n.* (P-00162122 [image!]).

Specimens examined. COLOMBIA. • Caldas: Manizales, La Esperanza, Reserva Torre Cuatro, 05°03.867'N, 75°23.333'W, 3500–3750 m, 22 Feb 2000 (fl), *M. Alvear, D. García & D. Alvear 733* (COL-000197376). **ECUADOR. • Napo:** Límites de la Reserva Ecológica Cayambe-Coca, 00°20.000'S, 78°14.000'W, 3900 m, 18 Nov 1990 (fl, fr), *A.P. Yánez 73* (QCA-91900). • **Unknown:** Aug 1901 (fl), *A. Sodiro*

407 (QPLS-6755); El Pelado, Jan 1903 (fl), *M. Rivet 314* (P-03341383). **PERU.** • Lambayeque: Ferreñafe, Incahuasi, Sinchichual, above Tungula, 06°11.248'S, 79°18.618'W, 3368 m, 24 Nov 2014 (fl, fr), *M. Weigend, J. Chacón, E.F. Rodríguez, T. Henning, L.F. García, S.N. Miranda & D.F. Paredes 9690* (USM-286340).

Distribution. *Rubus coriaceus* is recorded along the Andes of Colombia, Ecuador, Peru and Bolivia (Romoleroux et al. 2014).

16. Rubus erythroclados Mart. ex Hook.f., Fl. Bras. (Martius) 14(2): 62. 1867.

Type. BRAZIL. Minas Gerais: "Habitat in sepibus prope Capaó ubi Tapazii inveniuntur" [habitat in the hedges near Capaó where the Tapazii are found], Feb (fl, fr), *C.F.P. von Martius 853* (lectotype, designated by Fuks 1984, pg. 13: M-0214178 [image!]). • **Syntypes. BRAZIL. Unknown:** "near Hamhó", Aug 1840 (fr), *G. Gardner 4546* (syntype: K-000424880 [image!]); Villa ricca, 1829 (fr), *J.P.E. Pohl s.n.* (syntype: M-0214179 [image!]).

Nomenclature notes. In the protologue, Hooker (1867) cited three specimens: *Martius, Pohl s.n.* and *Gardner 4546*. There are two lectotypifications of the name. Fuks (1984) stated that *Martius 853* (M) is the holotype of *R. erythroclados*, and according to Art. 7.11 of the ICN, this was an effective typification at that time. The other typification comes from Canero et al. (2016), who designated the same specimen as Fuks, as the lectotype of the name. Both authors referred to the same specimen, but the correct typification is that of Fuks. The other specimens are treated here as syntypes.

Specimens examined. BRAZIL. • Caldas: Manizales, La Esperanza, Reserva Torre Cuatro, 800 m, 14 Dec 1995 (fr), *R. Wasum 11570* (US-01351292). ARGENTINA. • Misiones: Gral. M. Belgrano, entre San Antonio y Bernardo de Yrigoyen, 30 Oct 1960 (fr), *L. Ariza Espinar 1180* (CORD-00098599). PARAGUAY. • Unknown: Curuguaty, Sep 1898–1899 (fl, fr), *E. Hassler 4597* (G-00640003 two sheets).

Distribution. *Rubus erythroclados* is recorded in Argentina, Paraguay and southern Brazil.

17. Rubus floribundus Kunth, Nov. Gen. Sp. [H.B.K.] 6[Quarto]: 219. 1823.

- = Rubus jamaicencis var. floribundus (Kunth) Kuntze, Revis. Gen. Pl. 1: 221. 1891.
 ≡ Rubus abundus Rydb., N. Amer. Fl. 22(5): 454. 1913, nom. illeg. superfl.
- = Rubus robustus C.Presl, Epimel. Bot.: 196. 1851. Type. PERU. "In vallibus cordillerum Peruviae" [in the valleys of the Peruvian cordillera], *T. Haenke s.n.* (lectotype, designated by Romoleroux 1996, pg. 45: PRC-450067 [image!]).
- Rubus floribundus var. nimbatus J.F.Macbr., Publ. Field Mus. Nat. Hist., Bot. Ser. 8: 118. 1930, syn. nov. = Rubus robustus var. nimbatus (J.F.Macbr.) J.F.Macbr., Publ. Field Mus. Nat. Hist., Bot. Ser. 13, pt. 2: 1101. 1938. Type. PERU. Huánaco: Huacachi, near Muña, ca 6500 ft, 20 May-01 Jun 1923 (fl, fr), J.F. Macbride 3894 (holotype: F-V0041909F [image!]).

Type. ECUADOR. [Loja]: "Crescit in andibus loxensium" [grows on Loja's Andes], "800–1800 hex", Aug (fl), *A. von Humboldt & M.A. Bonpland 3396* (lectotype,

designated by Romoleroux 1996, pg. 42: P-00679379 [image!]; isolectotype: P-00162116 [image!]).

Nomenclature notes. Romoleroux (1996) cited the lectotype of *R. floribundus* Kunth at P, but we located several additional sheets at P that agreed with the information provided in the protologue. The situation is similar to that of *R. bogotensis*, where the lectotype has a label from the "Herbier Humboldt & Bonpland". We cite the specimen P-00162116 as an isolectotype and specimen P-00162114 as possible original material because it lacks the collection number. The name *Rubus floribundus* Weihe has been incorrectly used in Colombia, Peru and Bolivia for several years. The basis of the problem began with Rydberg, who cited the publication of *R. floribundus* Weihe & Nees as dated by 1821 and treated this species name on the basis of erroneously presumed priority. He then used the name *R. abundus* to replace *R. floribundus* Kunth (Rydberg 1913). However, the correct publication date of *R. floribundus* Weihe is 1825, and on the basis of priority the legitimate name is *R. floribundus* Kunth, as cited by Romoleroux (1996).

Taxonomic notes. The synonymy follows the revision of Romoleroux (1996), but we also recognize *R*. *floribundus* var. *nimbatus* as a synonym of *R*. *floribundus* due to the lack of clear morphological characters to distinguish it from the type of *R*. *floribundus*.

Possible original material of *Rubus floribundus* **Kunth: ECUADOR. Loja:** "Andes" A. von Humboldt & M.A. Bonpland s.n. (P-00162114 [image!]).

Specimens examined. EcuADOR. • **Loja:** Carretera Yangana-Cerro Toledo, 04°20.000'S, 79°08.000'W, 1970–2450 m, 14 Nov 1990 (fl), *K. Romoleroux 1160B* (QCA-137902). **PERU.** • **Cajamarca:** Agua Tapada, 07°10.142'S, 78°31.768'W, 3072 m, 21 May 2013 (fr), *I. Sánchez, E. Lineares & A. Galán 3205* (CPUN-23561, USM-289503). **BOLIVIA.** • **Santa Cruz:** Caballero, 15–25 km al N de San Juan de Potrero, hacia Cerro Bravo, 17°48.000'S, 64°15.000'W, 2000–2500 m, 6 Jun 1992 (fl), *T. Killeen & I. Vargas 4067* (MO-1604562).

Distribution. *Rubus floribundus* is recorded along the Andes of southern Ecuador, Peru and Bolivia.

18. Rubus geoides Sm., Pl. Ic. Ined.: t. 19 (as "XIX"). 1789.

■ Dalibarda geoides (Sm.) Pers., Syn. Pl. [Persoon] 2(1): 53. 1807. = Rubus antarcticus Kuntze, Meth. Sp.-Beschr. Rubus 115. 1879, nom. illeg. superfl.

Type. CHILE. Magellan, P. Commerson s.n. (holotype: LINN-HS-902.95 [image!]).

Nomenclature notes. We traced back the collection LINN-HS-902.95, which corresponds to the drawing of *R. geoides* cited in the protologue. According to Art. 9.1 of the ICN, we recognize this specimen as the holotype of *R. geoides*. Kuntze (1879) proposed *R. antarcticus* to unite *R. geoides*, *R. radicans* and *R. gunnianus* in one species. Therefore, in the diagnosis and description of *R. antarcticus*, characters of these three taxa are mixed. However, *R. geoides*, *R. radicans* and *R. gunnianus* are separate, distinct species. *Rubus antarcticus* is therefore an illegitimate, superfluous name (ICN 52.1), since the oldest, legitimate name (*R. geoides*) should have been accepted in its place.

Taxonomic notes. We recognize *R. geoides* and *R. radicans* as separate species on the basis of the short pedicels (> 1.5 cm) and glabrous leaves of *R. geoides* compared to the long pedicels (> 2 cm) and pubescent leaves of *R. radicans*.

Specimens examined. ARGENTINA. • Chubut: Lago Futalaufquen, 27 Mar 1949 (fr), *T.M. Pedersen 313* (US-03733386). • **Tierra del Fuego:** Jan 1769 (fl), *J. Banks & D. Solander s.n.* (US-01299814); Estancia Harberton, 26 Nov 1967 (fr), *N. Goodall 1027* (US-03733384). **CHILE. • [Valparaíso]:** Archipiélago Juan Fernández, "Masafuera" [Isla Alejandro Selkirk], Las Torres, 1100 m, 28 Jan 1955 (fl) *I. Skottsberg & C. Skottsberg 158* (US-03733381); same locality as for preceding, 1150–1300 m, 14–25 Feb 1917 (fr), *I. Skottsberg & C. Skottsberg 404* (US-03733382); Archipiélago Juan Fernández, "Masafuera" [Isla Alejandro Selkirk], Los Inocentes, 1000–1200 m, 02 Dec 1965 (fl, fr), *O.T. Solbirg, H.E. Moore & J. Walker 3740* (US-03733380).

Distribution. *Rubus geoides* is recorded in southern Argentina and the Tierra del Fuego Archipelago in Argentina and Chile.

19. Rubus glabratus Kunth, Nov. Gen. Sp. [H.B.K.] 6[Quarto]: 221. 1823.

= Rubus ostrinus Focke, Biblioth. Bot. 18, Heft 83: 21. 1914, syn. nov. • Type. BOLIVIA. [La Paz]: Nord-Yungas, 4000 m, O. Buchtien 2857 (lectotype, designated here: US-00641902 [image!]).

Type. COLOMBIA. "Pasto, prope Guachucal" [near Guachucal], "1620 hex", Dec (fl), *A. von Humboldt & M.A. Bonpland 2187* (lectotype, designated by Romoleroux 1996, pg. 17: P-00679382 [image!]; isolectotypes: B-10-0248188 [image!], P-00162117 [image!], P-00162119 [image!]).

Nomenclature notes. The situation of the typification of *R. glabratus* is similar to that of *R. bogotensis* and *R. floribundus*. Romoleroux (1996) cited the lectotype at P, but we found several sheets corresponding to the information provided in the protologue. The lectotype of *R. glabratus* has a label from the "Herbier Humboldt & Bonpland". Focke (1914) cited the collection *Buchtien 2857* in the protologue of *R. ostrinus* and we designate the specimen at US as the lectotype of this name (Art. 9.3, 9.11 and 9.12 of the ICN).

Taxonomic notes. We recognize *R. ostrinus* as a new synonym of *R. glabratus* due to the absence of trichomes in branches and leaves, presence of small, trifoliolate leaves, asymmetrically ovate stipules, solitary flowers or small inflorescences with up to 5 flowers, and ovate sepals, with bi- or trifurcations towards the apex when mature present in both type collections.

Specimens examined. VENEZUELA. • Mérida: Sierra Nevada, Sep 1846 (fl), N. Funck & L.J. Schlim 1142 (P-03340873) • Trujillo: Boconó, Parque Nacional Guaramacal, 2200–2900 m, 15 Jun 2001 (fl), L.H. Dorr, S.M. Niño & R. Caracas 9024 (US-00662899). COLOMBIA. • Boyacá: Páramo de la Rusia, NW de Duitama, 3755 m, 12 Dec 1972 (fl), A.M. Cleef 7078 (U-1557324). • Cauca: Puracé, 3300 m, 19 Sep 2003 (fr), J.P.M. Martínez 141 (COL-000049524). ECUADOR. • Carchi: Tulcán-El Ángel road, ca 9 km SW of Pan American Highway, 00°48.000'N, 77°48.000'W, 3385 m, 04 Nov 1990 (fl), J.L. Luteyn, J. Ballington, M. Thompson, K. Romoleroux & R. Castillo 14030 (QCA-91984). • [Loja]: "Loxa", A. von Humboldt & M.A. Bonpland 2187 (P-000162118). PERU. • Cusco: Paucartambo, Acnajaco, subida a Quellhua Ccocha, Parque Nacional Manu, 3404 m, 01 Jul 1991 (fl, fr), A. Cano & S. Baldeón 4912 (USM-108815). BOLIVIA.
La Paz: Franz Tamayo, Parque Nacional Madidi, Munagamachay, entre Keara y Mojos, 14°41.567'S, 69°00.467'W, 3404 m, 24 Jun 2005, A. Fuentes, T. Miranda, J. Colque, R. Hurtado, I. Jímenez, E. Cuevas & R. Cuevas 8652A (QCA-91958).
Cochabamba: Chaparé, km 104 on raod from Cochabamba to Chaparé and Villa Tunaré, 3025 m, 17 Feb 1971 (fl, fr), J.G. Hawkes, J.P. Hjerting, P.J. Cribb & Z. Huamán 4441 (MO-1604544).

Distribution. *Rubus glabratus* is recorded along the Andes of Venezuela, Colombia, Ecuador, Peru and Bolivia.

20. Rubus glaucophyllus Vargas, Revista Univ. (Cuzco) 32(84): 263. 1943.

Type. PERU. Cusco: La Convención, alturas de Quillabamba, "El Dorado", 2900 m, 03 Aug 1943 (fl, fr), *C. Vargas 3502* (holotype: CUZ-4002!; isotype: CUZ-4003!).

Additional specimens examined. PERU. • Cusco: Paucartambo, Jamamayo, 1800 m, 04 May 1947 (fl), *C. Vargas 6488* (CUZ-5607!).

Distribution. Rubus glaucophyllus is known only from the type collection.

21. Rubus glaucus Benth., Pl. Hartw. [Bentham]: 173. 1845.

Type. Ecuador. [Pichincha]: "In declivitate montis Pichincha, et frequenter cultus sub nomine Mora de Castillo" [in slopes of Pichincha mountain, and frequently cultivated under the name "Mora de Castilla"], *T. Hartweg 973* (lectotype, designated by Romoleroux 1996, pg. 29: K-000424919 [image!]; isolectotype: LD-1036950 [image!]).

Nomenclature notes. The situation of the typification of *R. glaucus* is similar to that of *R. compactus*, where the original material was available at two herbaria. We located specimens from *Hartweg* 973 at K and LD, both of which correspond to the protologue information. Considering that Romoleroux (1996) cited the holotype in K, according to Art. 7.11 of the ICN, this was an effective typification at that time. Therefore, we here correct the designation to lectotype.

Specimens examined. COLOMBIA. • **Boyacá:** Paipa, Vereda La Pradera, 2650 m, 02 Dec 1978 (fl, fr), *S. Díaz 1445* (COL-000197464). **ECUADOR.** • **Carchi:** Tulcán-Maldonado road, 3–10 km of Tulcán, 00°50.000'N, 77°50.000'W, 2954–3077 m, 02 Nov 1990 (fl, fr), *J.L. Luteyn, J. Ballington, M. Thompson, K. Romoleroux & R. Castillo 104018* (QCA-92020, QCA-7000025).

Distribution. Romoleroux et al. (2014) cited *Rusby 471* (Bolivia) as *R. glaucus*, but we re-identified it as *R. ruizii*. No other collections of *R. glaucus* from Bolivia are known. The "Mora de Castilla", *R. glaucus*, is distributed from Mexico through Central America, finding its southern range limit in the Andes of Ecuador.

22. Rubus guyanensis Focke, Abh. Naturwiss. Vereins Bremen 4: 160. 1874.

"Rubus schomburgkii Klotzsch", Reis. Br.-Guiana [Ri. Schomburgk] 3: 1102. 1848, nom. nud. **Type. GUYANA.** Roraima, Nov 1842 (fl), *R. Schomburgk 1038* (lectotype, designated here: US-00468755 [image!]; isolectotype: NY-64737 [image!]).

Nomenclature notes. Focke (1874) published *R. guyanensis*, presumably based on the same specimen cited by Klotzch (Schomburgk et al. 1848) as "*R. schomburgkii*". Klotzch's name, despite being older, is invalid because it lacks a diagnosis or description (Art. 38.1 of the ICN) and does not refer to a description in an earlier publication (Art. 38.13). Furthermore, in the protologue, Focke (1874) cited the specimen from *R. Schomburgk* without indicating a specific herbarium. However, we found five specimens with the correct locality and collector, but with different collection numbers, that can be divided into three groups:

- 1) R. Schomburgk 1038 at US and NY;
- 2) R. Schomburgk 688 in P (two collections);
- 3) R. Schomburgk 688(1038) in K.

The collections in group 1 had a label from herbarium B (Ex Museo botanico Berolinense), the same collection year and locality as in the protologue, while those in groups 2 and 3 had only the same locality. Furthermore, the specimen in group 3 had two collection numbers. Considering that Focke was working at B at the time of the description, the original material must have been housed at B at some stage. We therefore designate the specimen at US as the lectotype, and the leaflet, flower fragment and photograph at NY is an isolectotype. The specimens in groups 2 and 3 are treated here as possible original material.

Possible original material of *Rubus guyanensis* **Focke: GUYANA.** Roraima, *R. Schomburgk* 688 (P-03372098 [image!], P-04114169 [image!]); same locality as for preceding, *R. Schomburgk* 688(1038) (K-000424881 [image!]).

Specimens examined. VENEZUELA. • **Trujillo:** Boconó, Parque Nacional Guaramacal, 1800–1900 m, Aug 2000 (fl), *B. Stergios & R. Caracas 18745* (US-00628291); same locality as for preceding, 09°15.233'N, 70°11.368'W, 2677–3100 m, 14 Jun 2001 (fr), *L.J. Dorr, S.M. Miño & R. Caracas 8974* (US-00662896). **COLOMBIA.** • **Huila:** Balsilla, on Río Balsillas, 2000–2300 m, 03–06 Aug 1917 (fl), *H.H. Rusby & F.W. Pennell 912* (US-03733450). **BRAZIL.** • **Roraima:** "am Abhang der Felsen" [on the rock precipice], 2200 m, Dec 1909 (fl), *E. Ule 8617* (L-1907464).

Distribution. *Rubus guyanensis* is recorded in Colombia, Venezuela, Guyana and northern Brazil.

23. Rubus imperialis Cham. & Schltdl., Linnaea 2(1): 13. 1827.

Type. BRAZIL. Santa Catarina: Apúna, Faxinalzinho, 27°10.817'S, 49°23.617'W, 793 m, 27 Sep 2018 (fl), *A. Kassner-Filho, D. Santos, G. Bollmann & L.F. Althoff 3519* (neotype, designated here: FURB-60544 [image!]).

Nomenclature notes. Schlechtendal and Chamisso (1827) cited five specimens in the protologue: "St. Catharina" and "Rio de Janeiro" collected by the authors, "prope Clemente ad Rio Paquaquer" collected by Beyrich, and "in provinciis Rio grande do Sul" and "Montevideo" collected by Sellow. However, we were unable to locate any of the syntypes. *Rubus imperialis* is a well-documented species from Brazil, thus we studied the material available and compared it with the description. We provisionally accept this species. As there is no extant original material, according to Art. 9.8 of the ICN, we designate *A. Kassner-Filho* 3519 as the neotype of *R. imperialis*.

Specimens examined. BRAZIL. • Paraná: Barras, 04 Jan 1974 (fr), *G. Hatschbach 33628* (MBM-034288). ARGENTINA. • Tucumán: En los matorrales de Tucumán, 8 Oct 1887 (fl), *L. 122* (P-03373467).

Distribution. Romoleroux et al. (2014) cited *Solomon 18420* (Bolivia) as *Rubus imperialis*, but this specimen was re-evaluated here as *R. boliviensis*. Therefore, *R. imperialis* is found only in Argentina and Brazil.

24. Rubus jamaicensis L., Syst. Nat., ed. 12. 2: 349. 1767.

- = "Rubus jamaicensis var. normalis Kuntze", Revis. Gen. Pl. 1: 221. 1891, nom. inval.
- = Rubus jamaicensis var. nudicaulis Kuntze, Revis. Gen. Pl. 1: 221. 1891, syn. nov. • Type. VENEZUELA. May 1874, O. Kuntze s.n. (lectotype, designated here: NY-429644 [image!]).

Type. (lectotype, designated by Adams in Cafferty and Jarvis 2002, pg. 543): [icon] "*Rubus foliis longioribus subtus molli lanugine obductis & incanis, flore & fructu minoribus*" in Sloane, Voy. Jamaica 2: t. 213, f. 1. 1725. • **Epitype. JAMAICA.** *H. Sloane s.n.* (epitype, designated here: BM-000594064 [image!]).

Nomenclature notes. Adams (Cafferty and Jarvis 2002) cited an illustration as the lectotype of *R. jamaicensis*. At the same time, he cited the specimen BM-000594064 as the "topotype". This collection was used for the illustration, so we select it as the epitype of this name. The original illustration is available at BM (BM-000594063).

Kuntze (1891) used "*R. jamaicensis* var. *normalis*" to distinguish the typical form of *R. jamaicensis* from three other varieties, thus including its type. According to Art. 24.3 of the ICN, "*R. jamaicensis* var. *normalis*" is an invalid name because its final epithet differs from that of the corresponding higher taxon. On the other hand, the other name *R. jamaicensis* var. *nudicaulis* is legitimate. We located three specimens at NY with handwritten annotation by Kuntze and designate specimen NY-429644 as the lectotype of this name. The other two specimens are treated here as original material.

Taxonomic notes. We consider *R. jamaicensis* var. *nudicaulis* to be a synonym of *R. jamaicensis*. It has the same curved, abundant prickles on the petioles, the same indument of petioles and leaves, especially the pannose abaxial surface of the leaf, and the same absence of or very few trichomes on the branches as in the epitype of *R. jamaicensis*.

Original material of *Rubus jamaicensis* var. *nudicaulis* Kuntze: VENEZUELA. May 1874, *O. Kuntze* s.n. (NY-990592 [image!], NY-990593 [image!]).

Specimens examined. GUYANA. • Cuyuni-Mazaruni: Mount Maingma, southern slopes of summit escarpment, Arabaru River, 05°12.277'N, 60°34.598'W, 1360 m, 11 Jun 2014 (fr), H.D. Clarke, C. Perry, E. Tripp, S. Stern & D. Gittens 11572 (US-00889792). VENEZUELA. • Miranda: Oripoto, 1400 m, 16 Jan 1954, Bro. Gines 4564 (US-03733828). COLOMBIA. • Norte de Santander: Northern slope of Mesa de los Santos, 1000–1500 m, 11–15 Dec 1926 (fr), E.P. Killip & A.C. Smith 15021 (US-03733613). **Distribution**. *Rubus jamaicensis* is reported from Jamaica, northern Guyana, northern Venezuela and northern Colombia.

25. Rubus killipii A.Berger, J. Wash. Acad. Sci. 16(6): 161. 1926.

Rubus pastasanus Diels, Notizbl. Bot. Gart. Berlin-Dahlem 15: 370. 1941.
 Type. ECUADOR. Pastaza: Río Pambay, a lado del paso lateral de Puyo, 01°28.089'S, 78°00.542'W, 955 m, 12 Aug 2023, D. Espinel-Ortiz & C. Restrepo 391 (neotype, designated here: QCA!; isoneotype: BONN! four sheets).

Type. COLOMBIA. Cauca: "La Gallera", Micay Valley, Cordillera Occidental, clearing near Río San Joaquin, 1100–1300 m, 29–30 Jun 1922, *E.P. Killip 7835* (holotype: US-1142423 [image!]; isotypes: GH-40520 [image!], NY-429646 [image!]).

Notes. Diels (1941) cited *H. Schultze-Rhonhof* 2969 as the holotype of *Rubus pastasanus*, which was in B (Renner 1993). It seems to have been destroyed during WWII, and no duplicates have been located (Romoleroux 1996). As no original material is extant, based on Art. 9.16 of the ICN, we designate collection *D. Espinel-Ortiz & C. Restrepo* 391 as the neotype of *R. pastasanus*. It was collected in Puyo (near Mera) at the same altitude and matches the original description.

Specimens examined. ECUADOR. • Tungurahua: Vía a Baños entre Río Negro y Mera, a 2 km de Río Negro en carretera E30, 01°25.194'S, 78°10.536'W, 1333 m, 12 Aug 2023, *D. Espinel-Ortiz y C. Restrepo 390* (QCA).

Distribution. Rubus killipii is found in southern Colombia and Ecuador.

26. Rubus laegaardii Romol., Fl. Ecuador 56: 15. 1996.

Type. ECUADOR. Morona Santiago: Near the pass on the road Sigsig-Gualaquiza, 3°09.000'S, 78°43.000'W, 3300 m, 29 May 2019, *S. Lægaard, L.G. Clark & P. Stern 103042* (holotype: AAU [image!] two sheets; isotype: QCA-92046!).

Specimens examined. ECUADOR. • Loja: Carretera Yangana-Zumba, desvío Cerro Toledo, 04°22.485'S, 79°06.677'W, 3080 m, 09 Feb 2002 (fl, fr), *K. Romoleroux, S. León-Yánez & V. Sandoya 4075* (QCA-92062, QCA-7000123). PERU. • Cajamarca: San Ignacio, abaconas, Santuario Nac, Tabaconas-Namballe, alrededores de las lagunas Coyona (Arrebiatadas), 05°13.525'S, 79°16.480'W, 3140–3180 m, 08 Apr 2003 (fl), S.M. Baldeón-Malpartida & L.A. Ocupa 5126 (USM-266692).

Distribution. *Rubus laegaardii* is known from the Andes of southern Ecuador and northern Peru. We report here for the first time the presence of *R. laegaardii* in Peru.

27. Rubus longistipularis Espinel-Ortiz & Romol., PhytoKeys 187: 143. 2021.

Type. ECUADOR. Pichincha: Nono-Tandayapa road, between km 116–117, 00°01.787'S, 78°38.567'W, 1950 m, 26 Jul 2021 (fl, fr), *D. Espinel-Ortiz & H.G. Abad 281* (holotype: QCA-243418!, QCA-7010714! to QCA-7010723!); isotypes: BONN! four sheets, HA-13781!, HUTI!, QAP!).

Specimens examined. ECUADOR. • Pichincha: Quito, Nanegalito, vía a San Tadeo, Área Protegida Privada Bellavista, 00°01.011'S, 78°40.867'W, 2255 m,

03 Dec 2021 (fr), *D. Espinel-Ortiz y H.G. Abad* 297 (QCA-244016) • same locality as for preceding, 00°01.938'S, 78°41.756'W, 2303 m, 03 Dec 2021 (fr), *D. Espinel-Ortiz y H.G. Abad* 299 (QCA-244018, QCA-7010803, QCA-7010804).

Distribution. *Rubus longistipularis* is reported from the Andes of northern and central Ecuador.

28. Rubus loxensis Benth., Pl. Hartw. [Bentham]: 128. 1843.

- Rubus extensus Fritsch in Szyszyl., Diss. Cl. Math.-Phys. Acad. Litt. Cracov.
 29: 221. 1894. Type. PERU. Chonta Cruz, Tambillo, *C. von Jelski 3* (lectotype, designated by Romoleroux 1996, pg. 7: B-10-0248186 [image!]).
- = Rubus extensus f. major Fritsch in Szyszyl., Diss. Cl. Math.-Phys. Acad. Litt. Cracov. 29: 221. 1894. • Type. PERU. Cutervo, C. von Jelski 4 (lectotype, designated by Romoleroux 1996, pg. 7: KRA (n.v.)).

Type. ECUADOR. [Loja]: "In montibus prope Loxa" [In mountain near Loja], *T. Hartweg 731* (lectotype, designated by Romoleroux 1996, pg. 7: K-000424878 [image!]; isolectotype: LD-1211845 [image!]).

Nomenclature notes. The situation of the typification of *R. loxensis* is similar to that of *R. compactus* and *R. glaucus*. Specimens from *Hartweg* 731 are available at K and LD, and a lectotype is required (Art. 9.3 of the ICN). Romoleroux (1996) effectively typified the species name at that time (Art. 7.11) when she cited the collection in K as the holotype. We correct the type status to lectotype.

Taxonomic notes. The synonymy follows the revision of Romoleroux (1996).
 Specimens examined. ECUADOR. • Loja: Yangana-Cerro Toledo, 04°23.000'S, 79°07.000'W, 2900 m, 30 Jan 1999 (fl, fr), *S. Lægaard 19518* (QCA-92058). PERU.
 Cajamarca: Jaén, Sallique, La Cocha, 05°40.967'S, 79°14.883'W, 2960 m, 21 Jun 1998 (fr), *J. Campos, C. Díaz, H. Tineo & P. Julca 5054* (USM-163652).

Distribution. *Rubus loxensis* is recorded in the Andes of southern Ecuador, Peru and Bolivia (Romoleroux et al. 2014).

29. Rubus mandonii Focke, Abh. Naturwiss. Vereins Bremen 4: 162. 1874.

Type. BOLIVIA. La Paz: Larecaja province, 2750–3200 m, Oct 1858–Apr 1859 (fl, fr), *G. Mandon 659* (lectotype, designated here: S-08-15139 [image!]; isolectotypes: BR-33828558 [image!], K-000424920 p.p. [image!], NY-435731 [image!], P-03372114 p.p. [image!], P-00682384 [image!]).

Nomenclature notes. Focke (1874) cited *Mandon 659* at LUB in the protologue of *R. mandonii*. However, we could not locate it, but found duplicates at BR, K, NY, P and S. According to Art. 9.3, 9.11, and 9.12 of the ICN, we designate the specimen from S as the lectotype, because it is the only one with 5-foliolate leaves corresponding to the original description. All the other specimens are treated as isolectotypes, except for specimen BR-33828558, which has a different locality and is treated here as possible original material.

Taxonomic notes. *Rubus mandonii* is similar to *R. nubigenus*, but differs by the glabrous or slightly pubescent branches, narrowly elliptic stipules, and

5-foliolate leaves of *R. mandonii* vs. the tomentose branches, broadly ovate to auriculate stipules and trifoliate leaves of *R. nubigenus*.

Specimens examined. BOLIVIA. • Cochabamba: Siberia, 3300 m, Jul 1955 (fl), *M. Cárdenas 5215* (L-1921409).

Distribution. Rubus mandonii is recorded in northern and central Bolivia.

30. Rubus maquipucunensis Espinel-Ortiz & Romol., PhytoKeys 187: 149. 2021.

Type. ECUADOR. Pichincha: cantón Quito, parroquia Nanegal, in front of the Ecological Reserve Maquipucuna entrance, 00°07.457'S, 78°37.744'W, 1278 m, 11 Feb 2021 (fl, fr), *D. Espinel-Ortiz, C. Restrepo & A. Sanguano 269* (holotype: QCA-243282!, QCA-7010670! to QCA-7010679!; isotypes: HA-13781!, HUTI!, LOJA!, Q!, QCNE!).

Specimens examined. ECUADOR. • Santo Domingo de los Tsáchilas: old road San Juan-Chiriboga, km 60–70, 00°17.000'S, 78°50.000'W, 1000–1500 m, 09 Jan 1993 (fl), *K. Romoleroux & A. Freire 1514* (QCA-92036, QCNE-77110).

Distribution. *Rubus maquipucunensis* is recorded in the western flank of the Andes of northern Ecuador.

31. Rubus megalococcus Focke, Abh. Naturwiss. Vereins Bremen 4: 157. 1874.

Rubus buchtienii Focke, Repert. Spec. Nov. Regni Veg. 9: 237. 1911, syn. nov.
 Type. BOLIVIA. La Paz: Nor Yungas, Unduavi, 3300 m, Nov 1910 (fl), O. Buchtien 641 (lectotype, designated here: NY-429634 [image!]).

Type. BOLIVIA. La Paz: Larecaja, "viciniis Sorata" [near Sorata], 3000–3200 m, 1859 (fl), *G. Mandon 662* (lectotype, designated by Romoleroux 1996, pg. 31: W (n.v.); isolectotypes: K-000424917 [image!], P-00682383 [image!], P-00682386 [image!]).

Nomenclature notes. Focke (1911a) cited *Buchtien 641* in the protologue of *R. buchtienii*, but did not specify a herbarium. We located a single specimen at NY and, according to Art. 9.3, 9.11, and 9.12 of the ICN, we designate it as the lectotype.

Taxonomic notes. We consider *R. buchtienii* to be a synonym of *R. megalococcus* because it has the same glabrous or puberulent indument in almost the whole plant, glabrous adaxial surface of the leaf with some trichomes near the veins, axillary inflorescences with up to 25 flowers and ovate-lanceolate sepals as *R. megalococcus*.

Specimens examined. ECUADOR. • **Loja:** Parque Nacional Yacuri, Jimbura, 04°42.950'S, 79°25.233'W, 3230–3450 m, 22 Apr 2015 (fr), *Á.J. Pérez, N. Zapata, W. Santillán & R. Jiménez 8681* (QCA-233883). **PERU.** • **Pasco:** Oxapampa, Huancabamba, zona de amortiguamiento del Parque Nacional Yanachaga Chemillén, 10°19.083'S, 75°36.467'W, 2567 m, 25 Jun 2008 (fr), *A. Monteagudo, A. Peña, J.L. Mateo & R. Rivera 16499* (USM-234511). **BOLIVIA.** • **La Paz:** Nor Yungas, Unduavi, 3300 m, Nov 1910 (fr), *O. Buchtien 173* (B-10-0278021, BR-13347901, E-00296709, GH-40519, K-000042918, M-0214192, NY-429633); Sud Yungas, 1.8 km W of Unduavi on road to La Paz, 16°18.000'S, 67°55.000'W, 3300 m, 21 Mar 1984 (fr), *J.C. Solomon, B. Stein & M. Uehling 11970* (US-3733542).

Distribution. *Rubus megalococcus* is recorded in the Andes of southern Ecuador, Peru and Bolivia.

32. Rubus mollifrons Focke, Repert. Spec. Nov. Regni Veg. 9: 236. 1911.

Туре. СоLOMBIA. Magdalena: Santa Marta, 1898–1901 (fl), *H.H. Smith 2512* (neotype, designated here: US-03733639 [image!]).

Nomenclature notes. The name *R. mollifrons* has not been used for several years, due to the absence of a type specimen. In the protologue, Focke (1911a) did not cite any collection, but mentioned that *R. mollifrons* resembles *R. floribundus* and is found in the Caribbean near South America, in Colombia and Venezuela. Fortunately, he published a photograph of the original material in his later monograph on the genus *Rubus* (Focke 1914), but we were unable to locate any extant material. We therefore used the photograph of *Karsten 21* to identify the species and select *Smith 5212* as the neotype of *R. mollifrons* (Art. 9.8 of the ICN).

Photograph of original material of *Rubus mollifrons* Focke: Colombia. 1846 (fl), *H. Karsten 21* (F [image!]).

Specimens examined. VENEZUELA. • Distrito Capital: Parque Nacional El Ávila, camino hacia "El Paraíso", 1100–1500 m, 29 Jul 1970 (fl), *R. Labbiente 74* (US-03733604); Galipan, Nov 1924 (fl), *A. Allart 168* (US-03733603); Las Flores, Sierra de El Ávila, 1600 m, 15 Dec 1938 (fl), *A.H.G. Alston 5509* (US-03733598).

Distribution. *Rubus mollifrons* is reported from northern Venezuela and northern Colombia near the Caribbean.

33. Rubus neobrasiliensis Espinel-Ortiz, Böhnert, Romol. & Weigend, nom. nov.

= "Rubus brasiliensis Mart.", Cat. Hort. Monac.: 173. 129. 1829, nom. nud.
 ≡ Rubus brasiliensis Mart. ex Hook.f., Fl. Bras. (Martius) 14(2): 62. 1867, nom. illeg. superfl.

Type. BRAZIL. Rio de Janeiro: *C.F.P. von Martius s.n.* (lectotype, designated by Fuks 1984, pg. 16: M-0214193 [image!]).

Nomenclature notes. There are some problems regarding the correct nomenclature of widely used *R. brasiliensis*. This name first appeared in the book "Hortus Regius Monacensis", where Martius used "*R. brasiliensis*", but omitted its respective diagnosis and description (Schrank and Martius 1829). According to the Art. 38.1 of the ICN, descriptive matter was necessary for the name to be validly published. We could not find any reference to an earlier description (Art. 38.13), and later publications written by or edited by Martius referred to page 173 of "Hortus Regius Monacensis" (Martius 1843; Hooker 1867). Therefore, according to Art. 38 of the ICN, *R. brasiliensis* was not validly published in 1829 and 1843.

The next time this name appeared in a revision, was by Hooker (1867) in Flora brasiliensis. Here, Hooker (1867) included a description of the species and cited two gatherings: *Martius s.n.* and *Pohl s.n.* According to Art. 38 of the ICN this was a valid publication of *R. brasiliensis*, but the species name was illegitimate. In the protologue, Hooker (1867) included *R. organensis* as a variety of *R. brasiliensis*. Therefore, the correct name of the species should have been *R. organensis*. However, we consider *R. organensis* and *R. brasiliensis* to be two different taxa, so a replacement name is needed for the latter. We decided on *R. neobrasiliensis* as a replacement name of *R. brasiliensis*. The corresponding

lectotype was effectively designated by Fuks (1984), when she treated *Martius s.n.* as the holotype (Art. 7.11).

Taxonomic notes. We follow the revision of Fuks (1984), but recognize *R. neo-brasiliensis* and *R. organensis* as two distinct taxa due to the following differences. *Rubus neobrasiliensis* is characterized by straight prickles covering the whole plant, absent or rarely present stipitate glands, broader stipules $(6-10 \times 1.5-1.8 \text{ mm})$ and densely villous-tomentose, thick leaves, especially on the abaxial surface near the veins compared to the curved prickles and stipitate glands covering the whole plant, narrower stipules $(9-10.5 \times 0.9-1.1 \text{ mm})$ and villous leaves, especially near the veins on the adaxial and abaxial surface of *R. organensis*.

Specimens examined. BRAZIL. • Bahia: Abaíra, distrito de Catolés, caminho para o Pico do Barbado, Mata da Furquilha, 14 Apr 1999 (fl, fr), *R.C. Forzza, A.M. Amorim, S.C., D.E. Sant'ana & C.B. Costa 1216* (NY-1874351). PARAGUAY. • Unknown: *E. Hassler 4689* (NY-656597).

Distribution. *Rubus neobrasiliensis* is recorded in southern Brazil and Paraguay.

34. Rubus novogranatensis Aspl., Bot. Not. 1939: 799. 1939.

Туре. СоLOMBIA. Cauca: Cordillera Central, Puracé, 3700 m, Feb 1938 (fl), *K. von Sneidern 1794* (holotype: S-R-8022 [image!]; isotypes: A-40521 [image!], B-10-0248184 [image!], NY-429647 [image!]).

Nomenclature notes. Asplund (1939) cited the types of *R. novogranatensis* and *R. sneidernii*, but did not specify a herbarium. In the introduction, however, he stated that Kjell von Sneidern's collections were deposited in S, where we located specimens corresponding to the information from the protologue. According to Art. 9.1 of the ICN, the specimens at S correspond to the holotypes of *R. novogranatensis* and *R. sneidernii*.

Specimens examined. COLOMBIA. • Valle del Cauca: Cordillera Central, Quebrada Las Vegas, 3400–3500 m, 23 Mar 1946 (fr), *J. Cuatrecasas 20353* (U-01557318, US-03733836).

Distribution. *Rubus novogranatensis* is reported from the Cordillera Central in Colombia.

35. Rubus nubigenus Kunth, Nov. Gen. Sp. [H.B.K.] 6[Quarto]: 220. 1823.

- = Rubus macrocarpus Benth., Pl. Hartw. [Bentham]: 129. 1844. Type. ECUADOR. Loja: "In jugo montium prope Loxa" [mountains near Loja], *T. Hartweg 731** (lectotype, designated by Romoleroux 1996, pg. 22: K-000424922 [image!]; isolectotype: LD-1246215 [image!]).
- = Rubus stipularis Benth., Pl. Hartw. [Bentham]: 173. 1845. Type. ECUADOR. Pichincha: "In decivitate montis Pichincha" [at the foot of Pichincha mountain], 11500 ft, *T. Hartweg 971* (lectotype, designated by Romoleroux 1996, pg. 22: K-000424924 [image!]; isolectotype: LD-1060102 [image!]).
- = Rubus lechleri Focke, Abh. Naturwiss. Vereins Bremen 4: 161. 1874, syn. nov.
 ≡ Rubus roseus var. lechleri (Focke) J.F.Macbr., Publ. Field Mus. Nat. Hist., Bot. Ser. 8: 118. 1930. • Type. PERU. Cajamarca: "In virgultis prope Agapta" [in

bushes near Agapta], Jun 1854, *W. Lechler 1997* (lectotype, designated here: K-000424925 [image!]; isolectotype: GOET-010123 [image!]).

- Rubus holtenii Kuntze, Revis. Gen. Pl. 3[3]: 78. 1898, syn. nov. Type. BOLIV-IA. 2500 m, 1–4 Apr 1892 (fr), O. Kuntze s.n. (lectotype, designated here: NY-429640 [image!]).
- = Rubus andicola Focke, Biblioth. Bot. 72: 36. 1910, syn. nov. Type. PERU. Junín: Tarma, Huacapistana, 2600–2700 m, 20 Jan 1903 (fl, fr), A. Weberbauer (lectotype, designated here: B-10-1172570 [image!]).
- Rubus sneidernii Aspl., Bot. Not. 1939: 799. 1939, syn. nov. Туре. Colombia. Cauca: "ad pag. El Tambo Munchique" [near El Tambo in Munchique], 2500 m, 26 Apr 1936 (fl), K. von Sneidern 648 (holotype: S-R-8024 [image!]; isotypes: B-10-0248183 [image!], NY-429656 [image!]).

Type. ECUADOR. Pichincha: Páramo de puntas, "1700 hex", Jan (fl, fr), *A. von Humboldt & M.A. Bonpland 3088* (lectotype, designated by Romoleroux 1996, pg. 21: P-00679381 [image!]; isolectotype: B-W-09899-010 [image!], P-00162120 [image!]).

Nomenclature notes. The situation of the typification of *R. nubigenus* is similar to that of *R. bogotensis*, *R. floribundus* and *R. glabratus*. We located three sheets at P that were treated as type material of *R. nubigenus*, but only two of them correspond to the typification of Romoleroux (1996) and the information on the protologue. We omit specimen P-00162121 from the type material, although it has the same collection number, because it was collected in Peru, while the type of *R. nubigenus* was collected in Ecuador. The lectotype of *R. nubigenus* has a label from the "Herbier Humboldt & Bonpland".

The situation of the typification of *R. macrocarpus* and *R. stipularis* is similar to that of *R. compactus*, *R. glaucus* and *R. loxensis*. We located the type material of these names at K and LD, so a lectotype is required for all of them (Art. 9.3 of the ICN). Romoleroux (1996) cited the holotypes of *R. macrocarpus* and *R. stipularis* at K, thus effectively typifying the names at that time (Art. 7.11); these type designations are here corrected to lectotypes.

We typify the other names cited here as synonyms of *R. nubigenus*, with the exception of *R. sneidernii*, whose holotype is at S (similar case as in *R. novo-granatensis*). We designate *Lechler* 1997 at K as the lectotype of *R. lechlerii*, and *Weberbauer* 2281 as the lectotype of *R. andicola*. We located duplicates of Kuntze's collections with his annotations in NY and US, and select specimen NY-429640 as the lectotype of *R. holtenii*, while the rest are treated here as original material.

Taxonomic notes. In addition to the previous synonyms for this name (Romoleroux 1996), we also consider *R. andicola*, *R. holtenii*, *R. lechleri* and *R. sneidernii* as synonyms of *R. nubigenus* and provide information on the typification of each name. The types of all these species have the same characters as the type of *R. nubigenus*: tomentose branches, orbicular stipules, trifoliolate leaves, abaxial leaf surface tomentose to deeply tomentose, ovate sepals, acute or acuminate apex, mostly bi- or trifurcate, and fruits with numerous, small drupelets.

Original material of *Rubus holtenii* **Kuntze: BOLIVIA. • Unknown:** Santa Rosa, 2500 m, 1892, *O. Kuntze s.n.* (US-00097920 [image!]); 2500 m, 1–4 Apr 1892, *O. Kuntze s.n.* (NY-429639 [image!], US-00097919 [image!]).

Specimens examined. COLOMBIA. • Magdalena: Sierra Nevada de Santa Marta, 10°55.000'N, 73°57.000'W, 2500–2650 m, 04 Aug 1972 (fl), *J.H. Kirkbride*, *J. Forero & E. Forero 1869* (US-03733525). ECUADOR. • Imbabura: Otavalo, vía a las lagunas de Mojanda, 00°09.267'N, 78°16.558'W, 3659 m, 24 Aug 2016, *D. Espinel-Ortiz, E. Bastidas & K. Romoleroux 12* (QCA-243403). • Chimborazo: Penipe, entrada oeste, sendero al Volcán Altar, 01°37.852'S, 78°29.810'W, 3524 m, 27 Nov 2019 (fl), *D. Espinel-Ortiz & C. Restrepo 197* (QCA-246102). PERU. • Cusco: Urubamba, Ollantaytambo, Garrapata, Pajonal, 13°04.950'S, 72°16.950'W, 3382 m, 25 Feb 2006 (fl, fr), *L. Valenzuela, J. Farfán, E. Suclli, I. Huamantupa & R. Ayerbe 6339* (CUZ, USM-231079). • Unknown: *A. von Humboldt & M.A. Bonpland 3088* (P-00162121). BOLIVIA. • Santa Cruz: Caballero. Laguna Brava, Cerro ponguillo, 17°47.892'N, 64°36.995'W, 2950–3085 m, 16 Apr 2003, *I.G. Vargas 6893* (QCA- 92202).

Distribution. *Rubus nubigenus* is reported from the Andes of Colombia, Ecuador, Peru and Bolivia.

36. Rubus organensis Gardn., London J. Bot. 2: 342. 1843.

Rubus brasiliensis var. organensis (Gardn.) Hook f., Fl. Bras. (Martius) 14(2):
 62. 1867.

Type. BRAZIL. Organ Mountains [Serra dos Órgãos], 1836 (fl, fr), *G. Gardner* 372 (lectotype, designated here: K-000424883 [image!]).

Nomenclature notes. The name *R. organensis* has not been typified, probably because it was consistently treated as a synonym of *R. brasiliensis* [= *R. neobrasiliensis*] from the middle of the 19th century until recently (see *R. neobrasiliensis* notes) (Hooker 1867; Fuks 1984). Gardner (1843) cited number 372 from his personal collection in the protologue, and we found two specimens at K with this number on the label. However, although they refer to the same species and have the same collection number, they are different gatherings, collected in different years. According to Art. 9.4 of the ICN, we recognize both collections as original material examined by Gardner, and according to Art. 9.3, 9.11 and 9.12, we designate specimen K-000424883 as the lectotype of *R. organensis*. The other collection is treated here as original material.

Original material of *Rubus organensis* **Gard.: BRAZIL.** Organ Mountains, 1838 (fl), G. *Gardner* 372 (K-000424882 [image!]).

Specimens examined. BRAZIL. • Paraná: Prudentopolis, Relogio, 14 Apr 1964 (fl), *G. Hatschbach 11167* (US-01351265). • **Santa Catarina:** Canoinhas, Ruderal, W of Canoinhas on the road to Porto União, 750 m, 17 Dec 1956 (fr), *L.B. Smith & P.R. Reitz 8595* (US-01351269); 12 km N of Abelardo Luz, 26°32.000'S, 52°20.000'W, 900–1000 m, 08 Dec 1964 (fr), *L.B. Smith & R.M. Klein 13862* (US-01351263); Caçador, Ruderal, W of Caçador on the road to Taquara Verde, 900–1000 m, 23 Dec 1956 (fr), *L.B. Smith & P.R. Reitz 9096* (US-01351268). • **Minas Gerais:** Chacha Valley road, ca 2 km from Agricultural gate, 675 m, 21 May 1930 (fr), *Y. Mexia 4730* (US-01351276).

Distribution. Rubus organensis is recorded in southern Brazil.

37. *Rubus paraguariensis* (Chodat & Hassl.) Basualdo & Zardini, Candollea 47 (Heft 2): 255. 1992.

= Rubus hassleri var. paraguariensis Chodat & Hassl., Bull. Herb. Boissier, ser. 2, 3: 799. 1903.

Type. PARAGUAY. San Pedro: "Jejui Guazu", Sep 1899, *E. Hassler 4618* (holo-type: G-00640009 [image!]).

Distribution. The species is found in Paraguay.

38. Rubus pendulus Rusby, Torreya 33 (2): 41. 1933.

Туре. Соloмвіа. Huila: Balsillas, at Balsillas river, 2000–2100 m, 03–05 Aug 1917, *H.H. Rusby & F.W. Pennell 719* (holotype: NY-429649 [image!]).

Specimens examined. VENEZUELA. • Táchira: Cabecera del Río Quinimarí, arriba de las Quebradas Las Copas, 2500–2630 m, 11 Jan 1968 (fl, fr), J.A. Steyermark, G.C.K. Dunsterville & E. Dunsterville 100727 (US-03733826, US-03733827). • Yaracuy: Sierra de Aroa, 9 km W of San Felipe, 10°21.000'N, 68°49.000'W, 900–1500 m, 5 Apr 1980 (fl), *R. Liesner & A. González 10061* (MBM-91017). COLOMBIA. • Huila: Neiva, Vereda La Plata, Finca La Colonia (Antigua Carolina), 2000 m, 31 Oct 1996 (fl), *F. Llanos & W.F. Gerardino 2797* (COL-000197900). ECUADOR. • Pichincha: Quito, Nanegalito, vía a San Tadeo, Área Protegida Privada Bellavista, 00°02.170'S, 78°42.067'W, 2297 m, 03 Dec 2021, *D. Espinel-Ortiz & H.G. Abad 300* (QCA-244065, QCA-7010819 to QCA-7010822). PERU. • Piura: Huancabamba, Rosario Alto, Cerro Pan de Azúcar, 04°55.900'S, 79°18.700'W, 2250 m, 03 Aug 1988 (fl, fr), *C. Díaz & H. Osores 3842* (USM-126985).

Distribution. *Rubus pendulus* is reported from the Andes of Venezuela, Colombia, Ecuador and Peru.

39. *Rubus peruvianus* Fritsch in Szyszyl., Diss. Cl. Math.-Phys. Acad. Litt. Cracov. 29: 220. 1894.

- Rubus helioscopus Focke, Bot. Jahrb. Syst. 54(1, Beibl. 117): 41. 1916, syn. nov.
 Type. PERU. Ayacucho: Prov. Huanta, "Weg von Tambo über Osno zum Flusse Apurimac" [road from Tambo, via Osno, to river Apurimac], 3100–3400 m, 31 May 1910 (fl), A. Weberbauer 5580 (holotype: B-10-0248187 [image!]).
- Rubus sparsiflorus Focke ex J.F.Macbr., Publ. Field Mus. Nat. Hist., Bot. Ser. 8: 117. 1930, syn. nov. • Type. PERU. Huánaco: 9000 ft, 08–22 Jul 1922 (fl, fr), J.F. Macbride & W. Featherstone 1674 (holotype: F-V0041932F [image!] p.p.; isotype: B-10-0248176 [image!]).
- Rubus bogotensis subsp. eglandulosus Killip, J. Wash. Acad. Sci. 24(1): 47. 1934, syn. nov. • Туре. СоLOMBIA. Santander: Eastern slope of Páramo de Santurbán, toward Mutiscua, 3600–3900 m, 20 Feb 1927 (fl), E.P. Killip & A.C. Smith 19595 (holotype: US-00097864 [image!]; isotypes: A-40516 [image!], GH-40517 [image!]).

Type. PERU. Cutervo, May 1879, *C. von Jelski 7* (lectotype, designated by Romoleroux 1996, pg. 34: KRA (n.v.)).

Nomenclature notes. The holotype of *Rubus sparsiflorus* is mounted together with a 5-foliolate leaf that belongs to a different species, which was not previously recognized and may have caused confusion with its identification.

Taxonomic notes. We recognize *R. helioscopus*, *R. sparsiflorus* and *R. bogotensis* subsp. *eglandulosus* as synonyms of *R. peruvianus*. The types of *R. helioscopus* and *R. sparsiflorus* have the same fruits with large and few drupelets as is typical of *R. peruvianus*. They also have the same villous indument without stipitate glands covering the whole plant. The type of *R. bogotensis* subsp. *eglandulosus* has no fruit, but the villous indument without stipitate glands, long and narrow stipule, trifoliate leaves, and ovate sepals are the same as in *R. peruvianus*.

Specimens examined. COLOMBIA. • Santander: Cordillera Oriental, páramo del Almorzadero, Peralonso, 3200 m, 19 Jul 1940 (fl), *J. Cuatrecasas & H. García-Barriga* 9926 (COL-000197246, US-03733276). ECUADOR. • Azuay: Vía Cuenca-Loja, a aprox. 500 m del desvío en la carretera E35, 03°14.208'S, 79°03.501'W, 3288 m, 13 Nov 2019, *D. Espinel-Ortiz & E. Bastidas-León 181* (QCA-246055). PERU. • Cajamarca: Hualgayoc, entre Quishuarani y Lares, 06°45.680'S, 78°36.018'W, 3523 m, 27 May 2014 (fl), *J. Montoya, E. Linares & A. Galán 3756* (USM-298276). BOLIVIA. • La Paz: Madidi, Apolobamba, Pelechuco-Río abajo, Santa Ana Ladera, 17°49.250'S, 69°04.017'W, 3547 m, 25 May 2009 (fl), *V. Torrez 572* (QCA-209074).

Distribution. *Rubus peruvianus* is reported from the Andes of Colombia, southern Ecuador, Peru and Bolivia.

40. Rubus radicans Cav., Icon. 5: 7. 1799.

= Comaropsis radicans (Cav.) Ser., Prodr. [A. P. de Candolle] 2: 555. 1825.

Type. CHILE. "Ex San Carlos de Chiloe" [from San Carlos de Chiloé, now Ancud city], Feb (fl); *L. Née 931* (lectotype, designated here: MA-01-00476192!).

Nomenclature notes. We recognize *R. radicans* as a distinct species (see *R. geoides* notes) and provide information on its typification. Cavanilles (1799) described *R. radicans* with collections from *L. Née*, before they were deposited at MA. Based on the common name "*Rubus frutilla*" mentioned in the protologue, we traced two specimens with different collection numbers: *Née 768* and *Née 931*, which have a handwritten annotation of "Rubus" and "frutilla", respectively. The lectotype has flowers and fruits, and a label with full details from the original publication. The other collection is treated as original material of the name.

Original material of *Rubus radicans* Cav.: Type. CHILE. "Ex San Carlos de Chiloe" [from San Carlos de Chiloé, now Ancud city], Feb (fl), *L. Née 768* (MA-01-00476191!).

Specimens examined. BOLIVIA. • **Cochabamba:** Chapare, Abro de Colomi, 13500 ft, 16 Mar 1939 (fl, fr), *E.K. Balls 6285* (US-00641905). **ARGENTINA.** • **Río Negro:** Puerto Blest, Nov 1926 (fl), *R.C. Shannon & E.S. Shannon 20* (US-03733386). **CHILE.** • **Los Lagos:** Puerto Montt, Nov 1925 (fl, fr), *F. Claude-Joseph 3294* (US-03733392). • **Los Ríos:** Valdivia, Panguipulli, 200 m, Oct 1926 (fl), *P.A. Hollermayer 1393* (US-03733566, US-03733379, Z-282091). • **Unknown:** Quitratúe, *F. Claude-Joseph 5870* (US-03733390); *R.A. Phillippi 799* (US-03733388). **Distribution.** *Rubus radicans* is reported from central Bolivia, southern Argentina and southern Chile.

41. Rubus roseus Poir., Encycl. [J. Lamarck & al.] 6(1): 245. 1804.

- = Rubus rosiflorus Hook., Icon. Pl. 1: t. 46 (XLVI). 1837 (as "rosaeflorus"), syn. nov. ≡ Rubus roseus var. rosiflorus (Hook.) Focke, Biblioth. Bot. 72: 36. 1910 (as "rosaeflorus"). • Type. ECUADOR. Pichincha: Woods on the western declivity of Pichincha, 9000 ft, W. Jameson 101 (holotype: K-000424926 [image!]).
- Rubus santarosensis Kuntze, Revis. Gen. Pl. 3[3]: 80. 1898, syn. nov. = Rubus roseus var. santarosensis (Ktze.) J.F.Macbr., Publ. Field Mus. Nat. Hist., Bot. Ser. 8: 118. 1930.
 Type. BOLIVIA. Santa Rosa, 3000 m, 01–04 Apr 1892 (fr), O. Kuntze s.n. (lectotype, designated here: NY-429655 [image!]).
- = Rubus Iloensis Benoist, Bull. Soc. Bot. France 81(2): 325. 1934. Type. ECUA-DOR. Pichincha: Palmira, 12 Feb 1931 (fl), R. Benoist 3842 (lectotype, designated by Romoleroux 1996, pg. 19: P-00162127 [image!], isolectotype: P-00162128 [image!]).
- = Rubus nubigenus var. subinermis Benoist, Bull. Soc. Bot. France 90: 15. 1943, syn. nov. • Type. ECUADOR. [Pichincha]: "Pentes orientales du Mojanda" [in western slopes of Mojanda], 03 Mar 1931 (fl), *R. Benoist 4000* (holotype: P-03145738 [image!]).

Type. PERU. J. Dombey s.n. (holotype: P-00678395 [image!]).

Nomenclature notes. The situation of the typification of *R. roseus* is similar to that of *R. coriaceus*, where Poiret (1804) cited a collection from the Jussieu Herbarium. We found one specimen with a label from the "Herbier D'Antoine Laurent de Jussieu" at P, and according to Art. 9.1 of the ICN, we recognize it as the holotype of *R. roseus*. This change immediately supersedes (Art. 9.19) the previous typification by Romoleroux (1996). We treated further specimens of *R. roseus* at P as possible original material.

We found original material of *R. santarosensis* at NY, similar to the case of *R. holtenii* (see notes on *R. nubigenus*). According to Art. 9.3, 9.11 and 9.12, we select collection NY-429655 as the lectotype of *R. santarosensis* because it has the locality information corresponding to the protologue. The other specimen is treated here as possible original material of the name.

Taxonomic notes. In addition to the previous synonyms for this name (Romoleroux 1996; Romoleroux et al. 2014), we also consider *R. nubigenus* var. *subinermis*, *R. rosiflorus*, and *R. santarosensis* as synonyms of *R. roseus*. The types of all these taxa have glabrous branches, stipules, petioles and leaves, broadly ovate to auriculate, reflexed stipules, trifoliolate leaves, ovate sepals, with long-acuminate apex, mostly bi- or trifurcate, and fruits with numerous, small drupelets like the type of *R. roseus*.

Possible original material of *Rubus roseus* **Poir.: PERU.** *J. Dombey s.n.* (P-00162129 [image!]).

Possible original material of *Rubus santarosensis* **Kuntze: BOLIVIA.** 3000 m, 01–04 Apr 1892 (fr), *O. Kuntze s.n.* (NY-429654 [image!]).

Specimens examined. VENEZUELA. • Táchira: Cabeceras del Río Quinimarí, entre el pie del peñasco de la Peña de Pata de Judío, 2500–2800 m, 12 Jan 1968 (fl), J.A. Steyermark, G.C.K. Dunsterville & E. Dunsterville 100819 (US-03733585, US-03733586). COLOMBIA. • Cauca: Cordillera Central, Páramo de Juntas, 3300 m, 13 Oct 1961 (fl, fr), J. Cuatrecasas & L. Willard 26437 (COL-000197689). ECUADOR. • Napo: Parque Nacional Llanganates, vía Salcedo-Tena, 00°59.450'S, 78°17.950'W, 3233 m, 22 Feb 2015 (fl, fr), Á.J. Pérez, N. Zapata & W. Santillán 8247 (QCA-234720). PERU. • Piura: Huancabamba, Carmen de la Frontera, quebrada Rosarios, 04°59.153'S, 79°22.815'W, 2300–2600 m, 22 May 2003 (fl, fr), S.M. Baldeón-Malpartida & F. Neyra-Jiménez 5406 (USM-273409). BOLIVIA. • La Paz: Murillo, valle de Río Zongo, 16°08.000'S, 68°07.000'W, 2750 m, 08 Jan 1988 (fl, fr), F. Grifo & J. Solomon 642 (QCA-92257). • Cochabamba: Ayopaya, Silapata, 2700 m, Dec 1935 (fr), M. Cárdenas 3377 (US-00641907).

Distribution. *Rubus roseus* is reported from the Andes of Venezuela, Colombia, Ecuador, Peru and Bolivia.

42. Rubus ruizii Focke, Abh. Naturwiss. Vereins Bremen 4: 162. 1874.

- *≡ Rubus nubigenus* var. *ruizii* (Focke) Focke, Biblioth. Bot. 72: 37. 1910.
- = Rubus weberbaueri Focke, Biblioth. Bot. 72: 38. 1910, syn. nov. Type. PERU. Huánuco: Huamalíes, "Berge südwestlich von Monzon" [mountains southwest of Monzon], 3200–3300 m, 12 Jun 1903 (fl, fr), A. Weberbauer 3362 (holotype: B-10-0248171 [image!]).

Type. PERU. H. Ruiz 19/65 (neotype, designated here: MA-01-00812077!).

Nomenclature notes. The holotype of *R. ruizii* at B was destroyed in WWII, but we found two specimens at MA, previously annotated by F. Bolle as *R. nubigenus* var. *ruizii*. The photograph of the holotype of *R. ruizii* at F allowed us to confirm the identity of the two specimens at MA as *R. ruizii*. We select specimen *Ruiz* 19/65 as the neotype of *R. ruizii* according to Art. 9.8 of the ICN.

Taxonomic notes. Although Focke (1874) described *R. ruizii*, he later considered it as a variety of *R. nubigenus* (Focke 1910). However, considering the neotype, it differs from *R. nubigenus* by: grayish-tomentose branches with abundant, short prickles; narrow leaves and leaflets; whitish-tomentose leaf abaxial surface; and unarmed sepals. These are characters of *R. weberbaueri* Focke, and it is clear that they refer to the same species. As *R. ruizii* is the oldest legitimate name available, it should be used for the taxon (Art. 11).

Photograph of original material of *Rubus ruizii* **Focke: PERU.** Pillao, *H. Ruiz* 206 (F [image!]).

Specimens examined. PERU. • San Martín: Mariscal Cáceres, Distrito Huicungo, valle de Allpamachay, Cueva del Oso en la intersección de Vacas Blancas y Allpamachay, 07°58.628'S, 77°21.323'W, 3518 m, 25 Jun 2010 (fl), *B. León 5609* (USM-243308). • Unknown: Tambo Real, *H. Ruiz 19/64* (MA-01-00812078). BOLIVIA. • La Paz: Nor Yungas, Unduavi, 3300 m, Nov 1910 (fl, fr), *O. Buchtien* 2858 (US-00641913). Yungas, 6000 ft, 1885 (fr), *H.H. Rusby 471* (NY-429650).

Distribution. *Rubus ruizii* is distributed in the Andes of southern Peru and Bolivia.

43. Rubus rusbyi Britton, Bull. Torrey Bot. Club 17(1): 10. 1890.

Type. BOLIVIA. La Paz: Unduavi, 10000 ft., Oct 1885 (fl), *H.H. Rusby 2508* (holo-type: NY-429653 [image!]).

Specimens examined. PERU. • **Pasco:** Oxapampa, Huancabamba, Parque Nacional Yanachaga-Chemillen, sector San Daniel, 10°25.767'S, 75°26.100'W, 3250–3450 m, 01 Mar 2008 (fl), *R. Vásquez, A. Monteagudo, A. Peña & J. Mateo 33855* (USM-235919). • **Cusco:** Paucartambo, Tres Cruces, Parque Nacional Manu, 3600–3700 m, 06 Mar 1991 (fl, fr), *A. Cano 4589* (USM-243308).

Distribution. *Rubus rusbyi* is known from the Andes of southern Peru and Bolivia. We report here the presence of *R. rusbyi* for the first time in Peru.

44. *Rubus schottii* Pohl ex Focke, Abh. Naturwiss. Vereins Bremen 4: 157. 1874.

Type. BRAZIL. Schott 5885 (lectotype, designated here: W-279047 [image!]; isolectotype: W-279046 [image!], W-279048 [image!]).

Nomenclature notes. Focke (1874) cited *Schott 5885* from two herbaria, thus a lectotype is required (Art. 9.3 of the ICN). Therefore, according to Art. 9.3, 9.11 and 9.12, we designate the collection W-279047 as the lectotype of *Rubus schottii* because it has fruits and shows the abaxial surface of a mature leaf.

Specimens examined. BRAZIL. • Minas Gerais: Caparaó, 24 Oct 1989 (fl), *R. Simao-Bianchini, J.R. Pirani, R. Mello-Silva & J.B. Fernandes 237* (SPF-68142).
• Espírito Santo: Conceição do Castelo, Alto Bananal, 120 m, 22 Aug 1987 (fl), *G. Hatschbach & A.C. Cervi 51315* (MBM-120266).

Distribution. Rubus schottii is reported from southern Brazil.

45. Rubus sellowii Cham. & Schltdl., Linnaea 2(1): 15. 1827.

Type. BRAZIL. Brasilia meridionalis, *Sellow s.n.* (lectotype, designated here: B-10-0248177 [image!]; isolectotype: HAL-98247 [image!]).

Nomenclature notes. *Rubus sellowii* requires a lectotype (Art. 9.3 of the ICN) because Schlechtendal and Chamisso (1827) cited two Sellow collections, from "Brasilia meridionalis" and "Montevideo" respectively. We located two specimens from "Brasilia meridionalis" in B and HAL. According to Art. 9.3, 9.11 and 9.12, we designate the specimen at B as the lectotype of *R. sellowii*, since it has the 5-foliolate leaf mentioned in the protologue.

Specimens examined. ARGENTINA. • Misiones: Posadas, Nov 1907 (fl), *E.L. Ekman 1867* (US-03733713). **PARAGUAY. • [Guairá]:** Villarrica, *P. Jörgensen 3860* (US-03733711). **BRAZIL. • Santa Catarina:** Itapiranga, 4 km W of Popí, 200– 350 m, 24 Feb 1957 (fl, fr), *L.B. Smith, R. Klein & J. Schnorrenberger 11766* (US-01351366).

Distribution. *Rubus sellowii* is reported in Argentina, Paraguay and southern Brazil.

46. Rubus urticifolius Poir., Encycl. [J. Lamarck & al.] 6(1): 246. 1804 (as "urticaefolius").

- ≡ Dyctisperma urticifolius (Poir.) Raf., Sylva Tellur.: 160. 1838. ≡ "Rubus urticifolius var. typicus Focke", Biblioth. Bot. 18, Heft 83: 56. 1914, nom. inval.
- = Rubus trichomallus Schltdl., Linnaea 13(2): 268. 1839. Type. MEXICO. Hacienda de la Laguna, Aug 1829 (fr), C.J.W. Schiede s.n. (lectotype, designated here: HAL-60486 [image!]).
- Rubus hassleri Chodat, Bull. Herb. Boissier 7, App. 1: 66. 1899. = Rubus urticifolius var. hassleri (Chodat) Focke, Biblioth. Bot. 18, Heft 83: 55. 1914.
 Type. PARAGUAY. Feb 1885–1895 (fl, fr), E. Hassler 1901 (lectotype, designated here: G-00640010 [image!] two sheets, isolectotypes: BM-000548793 [image!], P-682374 [image!]).

Type. PERU. J. Dombey s.n. (holotype: P-00678396 [image!]).

Nomenclature notes. The situation of the typification of *R. urticifolius* is similar to that of *R. coriaceus* and *R. coriaceus*, where Poiret (1804) cited a collection from the Jussieu Herbarium. Therefore, according to Art. 9.1 of the ICN, we recognize the only collection of *R. urticifolius* with a label from the "Herbier D'Antoine Laurent de Jussieu" at P as the holotype of *R. urticifolius*. We treat further specimens from P as possible original material, and provide information on the typification of previous synonyms of this name.

The original material of *R. trichomallus* is at HAL (Braun and Wittig 2003), with two sheets annotated with this name. We select HAL-60486 as the lecto-type of *R. trichomallus* (Art. 9.3, 9.11 and 9.12 of the ICN), while the other specimen is treated here as original material. Chodat (1899) did not cite any specimen in the protologue, but we traced back *Hassler 1901* which corresponds to the original description. We therefore designate the specimen at G as the lectotype of *R. hasslerii* (Art. 9.3, 9.11 and 9.12).

Taxonomic notes. The synonymy follows the revision of Fuks (1984).

Original material of *Rubus urticifolius* **Poir.: PERU.** *J. Dombey s.n.* (P-00162125 [image!]); Lima, *J. Dombey s.n.* (P-00162123 [image!], P-00162124 [image!], P-00162126 [image!]).

Original material of *Rubus trichomallus* **Scthltdl.: MEXICO.** Hacienda de la Laguna, Aug 1829 (fr), *C.J.W. Schiede* s.n. (HAL-107627 [image!]).

Specimens examined. VENEZUELA. • Bolívar: Río Anawaray-parú, vecindades del km 134 y campamento 134 al sur de El Dorado, 1300–1350 m, 25 Dec 1970 (fl, fr), *J.A. Steyermark, G.C.K. Dunsterville & E. Dunsterville* (US-03733792). COLOMBIA. • Valle del Cauca: Río Digua Valley, between La Elsa and Río Blanco, 900 m, 2–5 Apr 1939 (fl, fr), *E.P. Killip* (US-03733754). ECUADOR. • Pichincha: Quito, Nono, vía Nono-Tandayapa entre km 117–118, 00°01.967'S, 78°38.491'W, 1925 m, 26 Jul 2021 (fl, fr), *D. Espinel-Ortiz & H.G. Abad 279* (QCA-244015, QCA-7010801, QCA-7010802). PERU. • Cajamarca: San Ignacio, Huarango, El Convento, 05°13.000'S, 78°40.000'W, 1200–1600 m, 01 Jul 1996 (fl, fr), *J. Campos & E. Rodríguez 2836* (HUT-45736, USM-143879). ARGENTINA. • Misiones: Posadas, "La Granja", 14 Jan 1908, *E.L. Ekman 1873* (US-03733815). Paraguay. • Itapúa: Opposite Puerto Piray, 200 m, 23 Oct 1978 (fl, fr), *S.A. Renvoize 3215* (P-03340708, US-03733811). BRAZIL. • Bahía: Piatã, proximidades do riacho

Toborou, 13°09.550'S, 41°45.917'W, 1060 m, 04 Nov 1996 (fl, fr), *D.J.N. Hind*, *H.P. Bautista*, *M.M. da Silva & L.P. de Queiroz 4042* (US-01351270).

Distribution. *Rubus urticifolius* ranges from northern Central America across most of South America, from 200–2500 m asl.

Excluded names

a. Rubus adenomallus var. larecajanus Focke, Biblioth. Bot. 18, Heft 83: 52. 1914.

Type. BOLIVIA. [La-Paz]: Larecaja "viciniis Sorata, inter Laripata et monticulus Pancuasi" [near Sorata, between Laripata and small mountain Pancuasi], 2700–3100 m, Aug (fl, fr) 1859, *G. Mandon 658* (lectotype, designated here: K-000424915 [image!], isolectotype: BR-33828565 [image!]).

Notes. Focke (1914) cited two gatherings in the protologue: *Mandon 657* and *Mandon 658*. We found these specimens at K and BR. However, only *Mandon 658* matches the description based on the glands in the branches, while *Mandon 657* corresponds to *R. megalococcus*. Therefore, we designate *Mandon 658* at K as the lectotype of this name (Art. 9.3, 9.11 and 9.12 of the ICN).

It is possible that *R. adenomallus* var. *larecajanus* is related to *R. megalococcus*, *R. bogotensis* or *R. adenothallus*. *Mandon* 658 has abundant glands on the branches and leaves, which is a character of *R. bogotensis* and *R. adenothallus*. However, the shape and size of the leaves are similar to those of *R. adenothallus* and *R. megalococcus*, but the fruits with few, big drupelets are a character of *R. megalococcus* and *R. bogotensis*. Further studies are therefore required to clarify the identity of *R. adenomallus* var. *larecajanus*.

b. Rubus aenigmaticus Focke, Meded. Rijks-Herb. 19: 55. 1913.

Type. BOLIVIA. No collection was cited by Focke (Herzog 1913).

Notes. Focke (Herzog 1913) described this taxon as a possible hybrid of *R*. *brierus* and *R*. *buchtienii* [= R. *megalococcus*]. He did not cite any specific collection, just that it was collected by Buchtien. We could not locate any specimen annotated by Focke, thus its identity is currently unclear.

c. *Rubus eriocarpus* Liebm., Vidensk. Meddel. Naturhist. Foren. Kjøbenhavn 1852: 162. 1853.

= Rubus occidentalis subsp. eriocarpus (Liebm.) Focke, Abh. Naturwiss. Vereins Bremen 4: 147. 1875.

Type. Mexico. Puebla: Chinautla, 7000 ft, Jun (fl), *Liebmann s.n.* (syntype); Vulcanen Orizaba, 10000 ft, Sep (fl), *Liebmann s.n.* (syntype). **Oaxaca:** Cerro de Sempoaltepec, 8000–10000 ft, Jun (fr), *Liebmann s.n.* (syntype). **Unknown:** Jalapa, May, *Schiede s.n.* (syntype); Jalapa, Sep, *Lerma s.n.* (syntype); Mineral del Monte, *Ehrenberg s.n.* (syntype).

Notes. Tropicos.org (2024) treated *R. glaucus* as a synonym of *R. eriocarpus*, but we omitted the latter from the checklist as *R. glaucus* and *R. eriocarpus* may be different species (Carter et al. 2019; Huang et al. 2023; IPNI 2024; POWO 2024). The aim of this checklist was the South American species of *Rubus*, but *R. eriocarpus* was described from Mexico. Whether or not they are synonyms, the accepted name of the species in South America is *R. glaucus*. If *R. glaucus* and *R. eriocarpus* are synonyms, the name *R. glaucus* has priority over *R. eriocarpus* (Art. 11 of the ICN).

d. Rubus loxensis f. parvifolius Kuntze, Meth. Sp.-Beschr. Rubus: 117. 1879.

Type. Neu Granada, J. Goudot s.n. (holotype).

Notes. Kuntze (1879) cited a specimen collected by Goudot, previously identified as *R. loxensis*, at P. However, we were unable to locate any specimen annotated by Kuntze, or with this locality and identification. Based on the description, this name could be a synonym of *R. nubigenus* or *R. coriaceus*. The name needs to be typified to clarify its identity.

e. Rubus porphyromallos Focke, Repert. Spec. Nov. Regni Veg. 9: 235. 1911.

Type. "Andibus partis borealis America australis". No collection was cited by Focke (1911a).

Notes. Focke (1911a, 1911b) cited no collections for this name, just mentioned that it is similar to *R. bogotensis* and occurs in the North Andes of South America. We could not locate any specimens annotated by Focke, thus the identity of *R. porphyromallos* is currently unclear. It may refer to a specimen similar or related to *R. pendulus* (Espinel-Ortiz et al. 2023).

f. *Rubus schottii* var. *pohlianus* Focke, Abh. Naturwiss. Vereins Bremen 4: 158. 1874.

Type. BRAZIL. Matto Grosso: "In silva Matto grosso", Cap Goyaz, J.P.E. Pohl 1093 (holotype: W-279045 [image!]).

Notes. Focke (1874) cited *Pohl 1093* at W in the protologue, thus according to Art. 9.1 of the ICN, we recognize this specimen as the holotype of *R. schottii* var. *pohlianus*. We require further studies to clarify the identity of this name.

g. *Rubus urticifolius* var. *rosiflorus* Vargas, Revista Univ. (Cuzco) 32(84): 266. 1943 (as "rosaeflorus").

Type. PERU. Cusco: Convención, valle de Lucumayo, Amaibamba, 1900 m, 27 Jul 1943, *C. Vargas 3433* (hototype: CUZ-5585!; isotype: CUZ-5589!). **Notes.** We require further studies to clarify the identity of this name.

Conclusions

In this checklist, we recognized 46 species of *Rubus* from 110 names based on South American specimens published since 1767. Approximately 90% were published before 1990, when no holotype was required for a valid publication. As a result, 51 names required typification. Adams (Cafferty and Jarvis 2002), Fuks (1984) and Romoleroux (1996) typified 22 names, and we designated 22 lectotypes, 4 neotypes and 1 epitype. In addition, after careful examination, we proposed new synonyms explaining the reasoning behind each one and reported *R. azuayensis*, *R. laegaardii* and *R. rusbyi* for the first time from Peru. Some major changes introduced here were the restoration of *R. organensis* as a distinct species, the new name *R. neobrasiliensis* that replaced *R. brasiliensis* and the typification of *R. mollifrons* and *R. ruizii*. All in one, this annotated list will be the basis for future studies of *Rubus* in South America, especially monographic and evolutionary approaches, as well as catalogs or other disciplines that want to study *Rubus*.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Concept idea MW and DAEO; herbaria and literature revision DAEO and KR, first draft DAEO; editing and writing of the manuscript all authors; funding DAEO, MW.

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Data availability

All of the data that support the findings of this study are available in the main text or Supplementary Information.

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Supplementary material 1

Summary of accepted species of Rubus from South America, available names and their types

Authors: David A. Espinel Ortiz, Katya Romoleroux, Tim Böhnert, Maximilian Weigend Data type: xlsx

- Explanation note:Excel with three sheets summarizing the available names of *Rubus* from South America, their types and the valid species presented in the checklist. Each sheet is named after the information it contains. For example, the sheet "types" contains the hyperlinks to the respective online herbarium samples that are treated as types.
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Research Article

Schiedea waiahuluensis (Caryophyllaceae), an enigmatic new species from Kaua'i, Hawaiian Islands and the first species discovered by a drone collection system

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Abstract

During a survey by the National Tropical Botanical Garden drone team, an enigmatic *Schiedea* was observed in December 2021on steep, rocky cliff faces of the Waiahulu Valley in the Waimea Canyon of Kaua'i. Subsequently, another survey was conducted in March 2022 and, by use of a remotely controlled cutting device suspended below the drone, the first herbarium specimen was collected, as well as a seed collection of an undescribed cliff-dwelling species of *Schiedea*. Detailed study of the collections and plants grown at the University of California, Irvine greenhouse showed that it had enlarged, somewhat whitish sepals similar to those of cliff-dwelling *S. attenuata* (the sole species in sect. *Leucocalyx*), yet differed significantly from all other species in the genus. It also shares with *S. attenuata* a woody habit, hermaphroditic flowers, coloured nectar and styles 5 to 7 or 8. We describe it here as *S. waiahuluensis* given the only known localities are on the cliffs of this valley and place it in an enlarged sect. *Leucocalyx*. With the discovery of this new species, there are 36 species in this Hawaiian endemic genus.

Key words: Caryophyllaceae, conservation, drone exploration, Hawaiian Islands, Kaua'i, *Schiedea*

Introduction

Drone technology is advancing quickly and has become an effective tool for botanical surveys of cliff environments (Nyberg et al. 2023). Drone imagery with very high resolution has greatly increased our understanding of the distribution and abundance of many rare plant taxa. In Hawaii, researchers have been developing drone-based sampling systems capable of collecting plant material remotely. These platforms are being used to reach inaccessible areas to monitor the spread of forest pathogens (Perroy et al. 2022) and to conserve critically endangered plants (La Vigne et al. 2022).

While monitoring the walls of Waimea Canyon, Kaua'i for rare plant taxa and using a drone to photograph selected study sites, staff at the National Tropical

Botanical Garden (NTBG) documented an enigmatic *Schiedea* in December 2021. On first examination of our images, we speculated that the unique shrub could possibly represent the extinct Kaua'i species, *Schiedea amplexicaulis* H.Mann, last observed in 1855, or perhaps a new species. Subsequently, we returned in March 2022 and used a remotely controlled cutting device suspended below the drone to make the first herbarium specimen and seed collections of the *Schiedea*. On close examination of our herbarium specimen, it became immediately clear that we had discovered a new *Schiedea* species, bringing the total number of this Hawaiian endemic genus to 36 species (Wagner et al. 2022), with twelve species occurring on Kaua'i as single-island endemic taxa (Wagner et al. 2005). This discovery is likely the first time an undescribed species has been located and collected via drone, demonstrating the profound significance of unmanned aircraft systems in the conservation and prevention of plant extinctions.

Methods

For the survey portion of this work, we deployed a DJI Phantom 4 pro quadcopter drone. This is a consumer-grade platform that was chosen for its portability and high-resolution image sensor (20 megapixels). Still photographic images were collected approximately 5 m from the cliff surface to allow adequate resolution for the location and identification of small plants.

Photographs taken by the drone were reviewed and classified by species in Adobe Lightroom software. Image classification is a manual process that relies on visual acuity and expert field knowledge. The high-resolution imagery is examined for species identification and phenology, to track plant distribution and abundance and also to guide field operations. GPS location information is embedded into each image file which assists in locating access points and re-finding specific individual plants.

Once the collection target was selected, we deployed an Outreach Robotics Mamba, suspended under a DJI Matrice 300 drone. The Mamba is a robotic sampling manipulator designed to grab, cut and collect plant material in vertical cliff habitats using propellers to advance the device towards an adjacent cliff in a swinging motion, while keeping the carrying drone clear of obstacles.

Taxonomic treatment

Schiedea waiahuluensis W.L.Wagner, Weller, B.Nyberg, & A.K.Sakai, sp. nov. urn:lsid:ipni.org:names:77349836-1 Figs 1–6

Type. USA · Hawaiian Islands, Kaua'i: Cultivated at University of California, Irvine from seed collected at Waimea District, north-facing dry cliffs above Waiahulu, 767 m alt., 29 March 2022, *B. Nyberg et al. BN023* (PTBG), 12 April 2024, *S. G. Weller & A. K. Sakai 1172* (holotype: PTBG 1000097349!; isotypes: BISH!, G!, K!, MO!, UC1, US!).

Description. Erect to spreading shrub to 40 cm long; stems terete, green, glabrous in young plants, but becoming conspicuously viscid, glandular pubescent throughout as plants age, ascending, sprawling, becoming pendent



Figure 1. Schiedea waiahuluensis A habit, stem with leaves and inflorescence B branch of inflorescence, showing open flower with 6 sepals C hair types from petiole D flower, lateral view showing anthers at male stage E flower with 6 sepals and showing rarely dissected nectar shafts, face view F flower with 5 sepals, single petal, face view G flower with 5 sepals, female stage H fruit cut open to reveal seeds I dry fruit J seed. Drawn from living material from cultivated individual at University of California, Irvine (UCI) greenhouse (A, C, F, G, H, J), from photographs of cultivated material at UCI (B, D, I) and photograph taken by drone (E). Illustration by Alice Tangerini.



Figure 2. *Schiedea waiahuluensis* showing habit with stem, leaves, and inflorescence growing in wild on edge of rock wall. Drawn from photographs taken by drone in wild and of collected stems (20220607_PuuKaPele-3, IMG_5929, IMG_5939). Illustration by Alice Tangerini.

as they elongate in the wild, much branched, with side branches elongating to length of main axis and flowering at the same time as main axis. Leaves opposite, 4.5-7 (-11.9 in cultivation) cm long, 1.5-2.1 (-3.3 in cultivation) cm wide, thin, green, narrowly oblanceolate, mid-rib prominent and 2-5 conspicuous veins branching from the mid-vein near the base of the leaf, glandular pubescent on mature plants, margin entire, slightly thickened, apex acute, base gradually tapering, sessile. Inflorescence terminal, erect, with (4-)9-27(-45) flowers, pseudo-axillary or with a main axis 20.5-36.5 cm long; bracts green, densely glandular pubescent, the lowermost 13-29 mm long, 7-13 mm wide, those of the distal branches and flowers 5-12 mm long, 3-8 mm wide; pedicels spreading at anthesis, densely glandular pubescent (3-) 5-30 (-40) mm long at anthesis. Flowers hermaphroditic, strongly protandrous. Sepals (4-) 5-6, usually subequal in size, 4.5-11.9 mm in length and 2.5-5 mm in width, occasionally two narrower sepals positioned on opposite sides of the flower, green or whitish-green on adaxial face, occasionally with distinctive whitish margins, concave, ovate, orientated at ca. 90° angle to pedicel, adaxial side glabrous, abaxial side glandular pubescent, margins entire, scarious, apex apiculate. Nectary shaft tubular and notched at apex, rarely dissected in up to 3 parts, flap-like to tubular or partially tubular, 2.0-5.0 mm in length, recurved and appressed at the tip to the opposed sepal, small quantities of pale brown or rarely black nectar produced and, in the greenhouse, released on to subtending sepal as stigmas become receptive. Stamens 8-10(-12), 5.3-10 mm long; anthers ca.



Figure 3. *Schiedea waiahuluensis* habitat **A** Waiahulu branch of Waimea Canyon, drone photo, by Ben Nyberg **B** non-collected individual, drone photo by Ben Nyberg.

0.9 mm long, yellow, dehiscing after flower opens, but before stigmas become receptive. Styles 5-8(-11), 3.6-10.0 mm in length when receptive, stigmatic papillae on distal half of style. **Ovary** 1.5-3.0 mm in width, 1.0-2.0 mm in height. **Capsules** 2.6-3.2 mm long, subglobose, apparently tardily dehiscent. **Seeds** 13-82, viable following self-pollinations in greenhouse, black, 0.4-0.6 (-0.7) mm long, orbicular-reniform, compressed, the faces transversely rugose, the margins papillose. Chromosome number unknown.

Etymology. Specific epithet refers to the Waiahulu cliff region of Waimea Canyon, Kaua'i, the only known location where the new species is found.

Specimens examined. United States. Hawaiian Islands, Kaua'i: Waimea District, north-facing dry cliffs above Waiahulu, 767 m alt., 29 Mar 2022,



Figure 4. Collecting *Schiedea waiahuluensis* via drone **A** population accessed on rope, with drone in background *William AMW821*, photo by Adam Williams **B** collecting arm hanging from drone, photo by Ben Nyberg **C** drone collecting arm with specimen, *Nyberg BN023* photo by Ben Nyberg.

B. Nyberg et al. BN023 (PTBG) • Ridge below the Waimea Canyon Lookout, Waiahulu region of Waimea Canyon Complex, Pu'u Ka Pele Forest Reserve, 809 m alt., 12 Sep 2023, *Williams et al. AMW818–AMW825* (PTBG), *Wood et al. 19397* (PTBG) • NTBG Horticultural Center, 12 Jul 2024, K.R. Wood et al. 19557 (PTBG).

Distribution, habitat and threats. *Schiedea waiahuluensis* is endemic to the Hawaiian Islands where it is narrowly restricted to the western side of Kaua'i and occurs in open dry to mesic cliff habitat (1000–1500 mm rain/year) above Waiahulu Stream, which occurs in a small tributary of the greater Waimea Canyon located in the Pu'u Ka Pele Forest Reserve (Fig. 5). To date we have now established the distribution of *S. waiahuluensis* to extend ca. 5 km north to south along the basalt cliffs above Waiahulu Stream, with an estimated population of ca. 345 individuals ranging between 530–950 m elev. The majority of the plants are growing on vertical bare rock in minute cracks with small pockets of soil. Occasional observations include plants growing on rock shelves or under overhanging cliffs.

Although the native vegetation in Waimea Canyon has been seriously degraded by goats (*Capra hircus* L.) since their introduction in the late 1790s,



Figure 5. Map of Kaua'i, Hawaiian Islands, with rectangle indicating general distribution of *Schiedea waiahuluensis*.

there are still rich patches of endemic plant species found in the more inaccessible sections of the forest reserve, especially the vertical dry cliffs. Relictual native shrubs and trees associated in the region where S. waiahuluensis occurs include Nototrichium sandwicense (A.Gray) Hillebr. (Amaranthaceae); Peucedanum sandwicense Hillebr. (Apiaceae); Artemisia australis Less., Bidens sandvicensis Less. ssp. confusa Nagata & Ganders, Wollastonia fauriei (H.Lév.) Orchard, Wilkesia gymnoxiphium A.Gray (Asteraceae); Lobelia niihauensis H.St. John (Campanulaceae); Euphorbia celastroides Boiss. var. hanapepensis Sherff (Euphorbiaceae); Argemone glauca (Nutt. ex Prain) Pope (Papaveraceae); Dodonaea viscosa Jacq. (Sapindaceae); and Neraudia melastomifolia Gaudich. (Urticaceae). Two native grasses commonly found in this habitat include Eragrostis variabilis (Gaudich.) Steud. and Panicum lineale H.St.John (Poaceae), along with the fern Dorvopteris decora Brack. (Pteridaceae). Isodendrion pyrifolium A.Gray (Violaceae), a small federally endangered shrub previously unrecorded from Kaua'i, was also discovered growing with S. waiahuluensis (Nyberg et al. 2023) along with S. apokremnos H.St.John and S. spergulina A.Gray (Caryophyllaceae).

Although at least a portion of the sheer vertical cliff habitat of *Schiedea waiahuluensis* has apparently escaped degradation by feral goats, the former distribution of this species may have been more extensive prior to the introduction of goats. In addition to their immediate negative effects on native plant species, goats in this region aid in the dispersal of invasive non-native plant species, most notably *Pluchea carolinensis* (Jacq.) G.Don (Asteraceae); *Hyptis pectinata* (L.) Poit. (Lamiaceae); *Festuca bromoides* L. (Poaceae), *Pentapogon micranthus* (Cav.) P.M.Peterson, Romasch. & Soreng (Poaceae); *Grevillea robusta* A.Cunn. ex R.Br. (Proteaceae); and *Lantana camara* L. (Verbenaceae).

Preliminary conservation assessment. Critically Endangered - B1ab(i,ii,iii,v)



Figure 6. Schiedea waiahuluensis **A** drone collected specimen *Nyberg BN 023* with endemic Mirid on upper right bud **B** habit of plant in native habit *Williams AMW820*, photo by Ben Nyberg **C** seed *William AMW 821*, photo by seedsofhawaii.org **D** flower of drone collected specimen, *Nyberg BN 023*, photo by KR Wood.

Schiedea waiahuluensis was assessed for endangerment using the IUCN criteria. Its limited geographic range in Extent of Occurrence (EOO, 2.5 km²) along with its single location and inferred decline of habitat quality led to its classification as Critically Endangered (CR). Further surveys of adjacent cliff habitats are necessary to better understand the distribution and abundance of *S. waiahuluensis*. Establishment and replication of ex-situ collections is underway; additional collections from unrepresented sub-populations would add to better understanding of the genetic diversity of this species.

Discussion

The distinctive morphology of this remarkable new species places Schiedea waiahuluensis into sect. Leucocalyx W.L.Wagner & Weller, previously represented by a single cliff-dwelling species, S. attenuata W.L.Wagner, Weller & A.K.Sakai. Besides both being cliff-dwellers with a woody habit, they are also both hermaphroditic, with enlarged greenish-white sepals, coloured nectar and 5 to 7 or 8 styles. Schiedea attenuata occurs in Kalalau Valley, around 7 km to the north of S. waiahuluensis and is restricted to dry/mesic vertical cliffs. Morphological characters of these species and S. viscosa are compared in Table 1. The enlarged, somewhat whitish sepals of S. waiahuluensis (Fig. 6), glandular pubescence and coloured nectar are features also found in S. viscosa H.Mann and S. lychnoides Hillebr. (sect. Nothoschiedea H.Mann). Ongoing analyses (McDonnell et al., in prep.) of our study of the phylogenetics of the genus Schiedea using Hyb-Seq showed that addition of a single sample of S. waiahuluensis placed it as sister to S. attenuata. This clade was, in turn, sister to a clade consisting of sect. Nothoschiedea + sect. Alsinidendron. Additional samples of S. waiahuluensis that will be added to the analyses should help with further understanding of the phylogenetic placement of Schiedea waiahuluensis and other details of the diversification of the genus.

In contrast to the facultatively self-pollinating species in sect. *Nothoschiedea*, *S. waiahuluensis* appears to be outcrossing, based on strong protandry and production of ca. 16,000 pollen grains per flower, a value typical of outcrossing species (Weller et al. 1998). The large, spreading sepals of this species suggest biotic pollination, although field studies to test this possibility would be extremely challenging. *Schiedea waiahuluensis* is unique amongst *Schiedea* species for the discovery of a native, probably new species of *Engytatus* (Heteroptera, Miridae; Polhemus, pers. comm.) on several individuals surveyed on the cliffs of Waiahulu Canyon (Fig. 6A). These are the first observations of a potential native herbivore on a *Schiedea* species.

Character	S. waiahuluensis	S. attenuata	S. viscosa
Stem shape	Terete	Compressed-terete	Terete
Pubescence	Glabrous in young plant, becoming densely viscid, glandular pubescent	Glabrous to very sparsely puberulent with minute hairs	Moderately viscid glandular puberulent
Leaf length and width (cm)	4.5−7(−11.9) × 1.5−2.1 (−3.3) cm	5.3-7(-12) × 0.5-0.7(-1.1) cm	2.5−5 × 0.8−1.8 cm
Sepal number and aspect	(4–)5–6, usually subequal in size, slightly concave	5, equal, navicular towards apex	4–5, flat
Sepal length	6-12 mm	4–5 mm	6.5-12 mm
Nectary	Tubular and notched at apex, rarely dissected in up to 3 parts, flap-like to tubular or partially tubular	Tubular and notched at apex	Flap-like
Nectar colour	Brown or occasionally black	Clear	Black
Style number	5-8(-11)	5-6(-7)	5-7(-8)
Capsule length	2.6-3.2 mm	3.3-4.5 mm	8-12 mm

Table 1. Comparison of morphological characters of the subclade of species of *Schiedea* sect. *Leucocalyx* and *S. viscosa* (sect. *Nothoschiedea*).

Increasingly, drones are being used to assess and inventory cliff-dwelling plant taxa (Strumia et al. 2020; Reckling et al. 2021; Gao et al. 2024). The addition of drone-based sampling tools has the potential to transform plant conservation efforts in these hard-to-reach cliff environments (La Vigne et al. 2022). Hidden floristic diversity is likely to emerge as we embark on this new era of exploration and documentation of cliff ecosystems. The discovery of *S. waiahuluensis* after over 40 years of intense interest in this genus on Kaua'i indicates the potential for new discoveries using drone technology in studies of other endemic plant genera in the Hawaiian Islands.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Warren L. Wagner / lead author and coordination of other authors' contributions; Stephen G. Weller / co-author and oversaw greenhouse cultivation and gathering of measurements and descriptive data; Ann K. Sakai / co-author; Ben Nyberg / co-author, leader of drone team and field research; Kenneth R. Wood / co-author, drone team and field research member.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Gastrochilus balangshanensis (Orchidaceae, Aeridinae), a new subalpine epiphytic orchid from the Mountains of Southwest China

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Abstract

Gastrochilus balangshanensis, a new orchid species from the Balang Mountain, Sichuan Province, Southwest China, is described and illustrated. It morphologically resembles *G. affinis*, but differs in having shorter stems, a reniform epichile and a sub-hemispherical hypochile (spur), obtuse-rounded at the apex. The results of molecular phylogenetic analyses based on nuclear ribosome internal transcribed spacer (nrITS) and four chloroplast DNA markers (*matK*, *psbA*-*trnH*, *psbM*-*trnD* and *trnL*-F) from 50 *Gastrochilus* species indicate that *G. balangshanensis* is closely related to *G. heminii* and *G. bernhardtianus*, also endemic to the Hengduan Mountains. The novelty is a branch and trunk epiphyte in mixed coniferous forest.

Key words: Hengduan Mountains, new species, phylogeny, Sichuan, Vandeae

Introduction

Gastrochilus D.Don (Don 1825) is a vandoid genus of epiphytic orchids, within subtribe Aeridinae, consisting of 79 species, widely distributed in Tropical and Subtropical Asia (Tsi 1996; Tsi 1999; Liu et al. 2019; Govaerts et al. 2021; Zhou et al. 2021; Zhang et al. 2022; Ya et al. 2023; Zhang et al. 2024). It is characterized by the enlarged and saccate hypochile, forming a spur, and two subglobose pollinia borne on a slender stipe (Pridgeon et al. 2014; Liao et al. 2022). Recently, based on molecular and morphological data, a new infrageneric classification of *Gastrochilus* has been proposed by Zhang et al. (2024), dividing the genus into six sections, viz. *G.* sects. *Acinacifolii* Q.Liu & J.Y.Gao ex Jun Y.Zhang & H.He, *Brachycaules* Q.Liu & J.Y.Gao ex Jun Y.Zhang & H. He, *Caespitosi* Z.H.Tsi, *Gastrochilus, Microphylli* (Benth. & Hook.f.) Seidenf. and *Pseudodistichi* Jun Y.Zhang & H.He. More than 20 new species of *Gastrochilus* were described in the past five years, greatly enriching the diversity of this genus (Liu et al. 2019; Rao et al. 2019; Wu et al. 2019; Chen et al. 2022; Dey et al. 2022; Liao et al. 2022; Nguyen et al. 2022; Zhang et al. 2022; Lee et al. 2023; Liu et al. 2023; Ya et al. 2023; Zhang et al. 2024; Zhou et al. 2024).



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In April 2023, during a survey of orchid diversity in the subalpine forests of the Balang Mountain in Sichuan Province, Southwest China, some flowering specimens of *Gastrochilus* were collected. They were tentatively ascribed to the section *Microphylli*, which is characterized by the closely alternate leaves and a smooth-glabrous epichile (Zhang et al. 2024). After detailed morphological examination, the material could not be assigned to any recognized species of *G.* sect. *Microphylli*. Our phylogenetic analyses, combining the nuclear ribosome internal transcribed spacer (nrITS) with four plastid markers of 49 congeneric taxa, also support its recognition as a new species, which we describe here.

Materials and methods

Morphological analyses

Herbarium specimens and silica-gel dried leaves of the novelty were collected in the field in the Balang Mountain, Wenchuan County, Sichuan Province, Southwest China. The measurements and description of the novelty were based on four field-collected living plants and three dried herbarium specimens (*Jun-Yi Zhang & Yue-Hong Cheng ZJY185*; *Jun-Yi Zhang & Yue-Hong Cheng ZJY186*; *Jun-Yi Zhang & Yue-Hong Cheng ZJY204*). The taxonomic description follows the terminology used by Beentje (2016). Voucher specimens and additional silica-gel dried leaves are deposited in CDBI Herbarium (acronym following Thiers 2021, continuously updated). Additionally, we examined the scans of six specimens of three closely related taxa, including relevant type specimens (see taxonomic treatment for details), deposited at CDBI, K, PE and KUN.

DNA extraction, amplification and sequencing

The sequences of the 56 species included in the molecular phylogenetic analysis, originally published in Liu et al. (2019) and Zhang et al. (2024), were retrieved from GenBank, except those obtained from two individuals of the new species, which were newly generated in this study. Detailed information concerning the DNA markers, sampled taxa, voucher collections and GenBank accession numbers are listed in Appendix 1: Tables A1, A2. Total DNA was extracted exclusively from silica-gel dried leaves via a Plant DNA Isolation Kit (Cat.No.DE-06111). Based on the phylogenetic studies of *Gastrochilus* by Liu et al. (2019) and Zhang et al. (2024), we applied the same primers to amplify its nuclear ribosome internal transcribed spacer (nrITS) and four chloroplast DNA fragments (*mat*K, *psb*A–*trn*H, *psb*M–*trn*D, and *trn*L–F) through polymerase chain reaction (PCR). All DNA samples were sent to TSINGKE Biotech Co. Ltd (Chengdu, China) for sequencing. The final manually corrected sequences were then submitted to GenBank (Appendix 1: Table A2).

Phylogenetic analyses

All sequences were edited via Sequencher v4.1.4 (Gene Codes, Ann Arbor, Michigan, USA) and aligned via MAFFT v7.475 (Katoh and Standley 2013) with default parameters. We performed phylogenetic analyses based on the datasets of combined nuclear ribosome internal transcribed spacer (nrITS) and the

four chloroplast DNA fragments, after checking for congruence. A total of 56 taxa were included in the analysis of the combined datasets, with one species of Luisia Gaudich., one species of Saccolabium Blume, two species of Holcoglossum Schltr. and two species of Pomatocalpa Breda used as the outgroups based on Liu et al. (2019) and Zhang et al. (2024). The nucleotide substitution model for the data matrix was estimated using jModeltest v2.1.6 (Posada 2008) and the evolutionary best fit model (GTR+F+I+G4) was selected using the corrected Akaike Information Criterion (AICc). Maximum likelihood (ML) and Bayesian inference (BI) methods were employed for phylogenetic tree reconstruction. The ML analysis was performed using IQ-TREE v1.4.2 (Nguyen et al. 2014) with branch support estimated using 2,000 replicates. The BI analysis was conducted using MrBayes v3.2.7a (Ronquist and Huelsenbeck 2003) with two separate Markov chain Monte Carlo (MCMC) chains (20,000,000 generations and sampled every 1,000 generations). The first 25% of the trees were discarded as burn-in, and the remaining trees were used to generate a majority-rule consensus tree. The resulted phylogenetic trees were visualized using Chiplot (Xie et al. 2023).

Results

Phylogenetic reconstruction

The aligned nrITS matrix is 687 nucleotides long with 188 variable sites, and the combined four plastid markers matrix included 3,458 nucleotides in length with 185 variable sites, consists of 805 bp for *mat*K, 677 bp for *psb*A–*trn*H, 945 bp for *psb*M–*trn*D, and 1031 bp for *trn*L–F, respectively. The attributes of the five plastid markers are summarized in Appendix 1: Table A1. Both ML and BI analyses of the combined nrITS and four plastid markers matrix produced similar topologies (Fig. 1). The 50 taxa of *Gastrochilus* form a well-supported monophyletic group (BI/ML = 1/97, Fig. 1), which was subdivided into six well-supported section-specific clades (*G. sects. Gastrochilus, Pseudodistichi, Brachycaules, Acinacifolii, Microphylli*). The new species is resolved as distinct within section *G. sect. Microphylli*. The two accessions of *G. balangshanensis* were resolved as sisters to each other (BI/ML = 1/100, Fig. 1), clustering successively with *G. bernhardtianus* J.D.Ya & D.Z.Li and *G. heminii* M.Liao, B.Xu & Yue H.Cheng (Fig. 2; BI/ML = 0.98/88%).

Morphological comparison among *G. balangshanensis*, *G. heminii*, *G. bernhardtianus* and *G. affinis* is summarized in Table 1, further supporting the recognition of *Gastrochilus balangshanensis* sp. nov.

Taxonomic treatment

Gastrochilus balangshanensis Jun Y.Zhang, B.Xu & Yue H.Cheng, sp. nov. urn:lsid:ipni.org:names:77349954-1 Figs 2A, B, 3

Type. CHINA • Sichuan: Wenchuan, Balangshan, Yinchangou, mixed coniferous forest, on tree branches, elev. ca. 2,260 m, in flower, 19 April 2023, *Jun-Yi Zhang & Yue-Hong Cheng ZJY185* (holotype: CDBI!; isotype: KUN!).



Figure 1. Maximum Likelihood phylogenetic tree of *Gastrochilus*, including 50 taxa, based on the combined nrITS and four-plastid (*matK*, *psbA*-*trnH*, *psbM*-*trnD*, and *trnL*-F) marker dataset. Values before slash indicate Bayesian posterior probabilities and numbers after slash indicate ML bootstrap supports for major lineages. An asterisk (*) indicates that a node is not supported in the analysis. The two accessions of the inferred new species are highlighted in red, and colors of terminal nodes correspond to the six sections of *Gastrochilus* defined in Zhang et al. (2024).

Diagnosis. Gastrochilus balangshnensis is most similar to *G. affinis*, but can be distinguished by its shorter stem (1.5-3.5 vs. 3.0-12.0 cm), nearly elliptic leaves (vs. oblong-lanceolate to subspathulate), larger sepals ($5.6-6.4 \times 4.8-5.2$ vs. $3.0-5.0 \times 1.0-1.3$ mm) and petals ($5.0-5.8 \times 4.0-4.4$ vs. $3.0-4.0 \times 1.0-1.3$ mm), reniform epichile (vs. subtriangular) and sub-hemispherical hypochile, obtuse-rounded at the apex (vs. hypochile obconical, subacute to obtuse and shortly bifid at apex).

Description. Epiphytic herb, monopodial, pendent, 1.5-3.5 cm tall. Roots vermiform, 4.0-6.0 cm long, ca. 1.6 mm in diameter. Stem unbranched, 0.5-2.5 cm long, ca. 1.5 mm in diameter. Leaves closely alternate, nearly elliptic, 0.9-1.5 × 0.4-0.8 cm, apex acute and with 1-2 lobules, lobes setaceous, with purplish-red spots. Inflorescence a raceme with 1 or 2 flowers; peduncle curved upward and thickened, 5.0-8.0 mm long, proximally covered with one sheath; floral bracts ovate-lanceolate, 0.8-1.2 cm long, apex acute. Flowers spreading, ca. 1.0 × 1.4 cm, pedicel and ovary connate, 6.0-9.0 mm long, sepals and petals heterochromatic on both surfaces, yellow-green with purplish-red spots on the outer side, purplish-red with yellow-green margin on the inner side. Dorsal and lateral sepals similar and equal in size, elliptic, 5.6-6.4 × 4.8-5.2 mm, apex obtuse. Petals oblong, 5.0-5.8 × 4.0-4.4 mm, apex acute, base narrowed. Labellum with a reniform epichile, revolute, white with purplish-red spots, 10.0-12.0 × 5.5-6.5 mm, margin erose, smooth and glabrous above, central thickened purple-red mat with two inconspicuous ridges; hypochile sub-hemispherical, yellowish-green with purplish-red spots, 6.0-8.0 × 5.8-7.5 mm, dorsally compressed, obtuse-rounded at the apex. Column cylindrical, ca. 1.5 mm long; viscidium yellow, ca. 0.7 × 0.4 mm; stipe white, ca. 1.1 mm long; anther cap purplish-red, ca. 1.5 × 1.3 mm, rostellum bilobed, lobes acuminate at the apex; pollinia 2, ca. 0.5 × 0.4 mm, yellow, subglobular, porate; stigma deeply sunken, inverted V-shaped, ca. 0.7 mm long, yellow. Capsule ellipsoid, 12.0-15.0 × 8.0-10.0 mm, green with sparse purplish-red spots, prominently 6-ribbed.

Distribution and habitat. *Gastrochilus balangshanensis* is currently known only from Yinchanggou, Balang Mountain, Wenchuan County, Sichuan Province, Southwest China, part of the Hengduan Mountains (Fig. 4). It is epiphytic on

Character	G. balangshanensis	G. heminii	G. affinis	G. bernhardtianus
Stem length	1.5-3.5 cm	3.0-6.5 cm	3.0-12.0 cm	ca. 5.0 cm
Leaf shape	nearly elliptic	narrowly oblong or oblong-falcate	oblong-lanceolate to subspathulate	oblong-lanceolate
No. of flowers per inflorescence	1 or 2	1 or 2	1-4	1 or 2
Peduncle length	0.8-1.2 cm	0.4-0.7 cm	1.5-2.0 cm	ca. 0.3 cm
Dorsal sepal	elliptic, ca. 5.6–6.4 × 4.8–5.2 mm, apex obtuse	elliptic-oblong, ca. 2.4 × 1.5 mm, apex obtuse	elliptic-oblong, 3.0–5 .0 × 1.0– 1.3 mm, apex obtuse	elliptic, ca. 5.2 × 3.4 mm, apex obtuse
Lateral sepals	oblong, 5.0–5.8 × 4.0– 4.4 mm, apex obtuse	narrowly oblong, 2.6 × 1.3 mm, apex obtuse	elliptic-ovate, 3.5–4.0 × 0.7– 1.3 mm, apex obtuse	narrowly ovate, 5.5 × 2.8 mm, apex obtuse
Petals	oblong, 5.0–5.8 × 4.0–4.4 mm, apex obtuse	narrowly oblong, ca. 2.6 × 1.3 mm, apex obtuse	ovate-elliptic to elliptic, 3.0–4.0 × 1.0–1.3 mm, apex obtuse	narrowly oblong, ca. 5.2 × 2.7 mm, apex obtuse
Epichile (lip lamina)	reniform, 10.0–12.0 × 5.5– 6.5 mm, central thickened purple-red mat with two inconspicuous ridges	reniform, $4.2-6.5 \times 2.0-3.0$ mm, central thickened purple-red mat with irregular folds	subtriangular, ca. 8.0 × 4.5 mm, central thickened purple-red mat with 2 median ridges from base to apex	transversely oblong, ca. 8.0 × 2.8 mm, central thickened yellow- green mat with 2 conic calli near its base
Hypochile (lip spur)	sub-hemispherical, 6.0–8.0 × 5.8–7.5 mm, dorsally compressed, obtuse-rounded at the apex	subconical or helmet-shaped, ca. 2.0-2.4 × 1.6-2.0 mm, dorsally compressed, splits into two conical sacs at the apex	obconical, 3.0–4.0 × 2.0–3.0 mm, dorsally compressed, shortly bifid at the apex	subconical, ca. 5.1 × 3.8 mm, dorsally compressed splits into two conical sacs at the apex

Table 1. Morphological comparison of Gastrochilus balangshanensis with three related species of G. sect. Microphylli.



Figure 2. Habitat and habit of *Gastrochilus balangshanensis* in situ **A** habitat **B–D** flowering plants of *G. balangshanensis* growing on tree trunks or branches **E**, **F** fruiting plants of *G. balangshanensis*. Photograph credits: **A–E** Yue-Hong Cheng **F** Jun-Yi Zhang.

tree trunks or branches in subalpine mixed coniferous forest dominated by *Abies fargesii* var. *faxoniana* (Rehder & E.H.Wilson) T.S.Liu, at an elevational range between 2200–2300 m, co-occurring with two terrestrial orchids, *Goodyera recurva* Lindl. and *Calanthe arcuata* Rolfe.

Phenology. Flowering from March to April, during the dry season, fruiting from May to September.

Etymology. Its specific epithet refers to the Balang Mountain, type locality of this new orchid. A Chinese name, "ba lang shan peng ju lan" (巴朗山盆距兰), is suggested here.

Additional specimens examined. CHINA • Sichuan: Wenchuan, Balangshan, Yinchangou, mixed coniferous forest, on tree trunk, elev. ca. 2300 m, in flower, 19 April 2023, *Jun-Yi Zhang & Yue-Hong Cheng ZJY186* (CDBI!); *ibid. loc.*, mixed coniferous forest, on tree branch, elev. ca. 2315 m, in fruit, 22 July 2024, *Jun-Yi Zhang & Yue-Hong Cheng ZJY204* (CDBI!).



Figure 3. Gastrochilus balangshanensis A habit B leaf, abaxial view C raceme, front view D raceme, lateral view E flowers, front view F flowers, abaxial view G1 dorsal sepal G2, 3 petals G4, 5 lateral sepals G6 labellum H anther cap, ventral view I pollinarium with pollinia.

Examined specimens of Gastrochilus affinis. INDIA • Arunachal Pradesh: Lachong Valley, elev. ca. 2438 m, in flower, July 1897, *R. Pantling* 444 (lectotype K). CHINA • Xizang: Chayu, under forest, elev. ca. 2685 m, in flower, 24 August 2009, *Southeast Tibet Expedition Team SET-ET* 717 (PE); CHINA • Yunnan: Fugong, Jiakedi, east slope of Gaoligongshan, epiphytic on trunk, elev. ca. 2555 m, in flower, 16 May 2005, *X. H. Jin6984* (PE).

Examined specimens of Gastrochilus bernhardtianus. CHINA • Yunnan: Lijiang Prefecture, Yulong County, Yunshanping, elev. ca. 3308 m, in cold-temperate, evergreen conifer forest, in flower, 20 May 2020, *J.-D. Ya et al. 20CS19022* (holotype KUN).



Figure 4. Distribution map of Gastrochilus balangshanensis and four related species of G. sect. Microphylli.

Examined specimens of Gastrochilus heminii. CHINA • Sichuan: Wenchuan, Wolong, mixed coniferous forest, on tree trunk, elev. ca. 2640 m, in flower and fruit, 15 March 2022, *Min Liao & Yue-Hong Cheng ZJY143* (holotype CDBI!); Wenchuan County, Wolong, mixed coniferous forest, on tree trunk, elev. ca. 2640 m, in flower, 14 April 2022, *Min Liao, Jun-Yi Zhang & Yue-Hong Cheng ZJY167* (CDBI!).

Discussion

The Hengduan Mountains (HDM) is part of the Tibeto-Himalayan region (THR), which possesses an exceptionally diverse flora (~12,800 seed plant species are recognized, Sun et al. 2017). We have previously discovered some new species of *Gastrochilus* in Wenchuan County, such as *G. wolongensis* Jun Y.Zhang, B.Xu & Yue H.Cheng (Zhang et al. 2022), *G. heminii* M.Liao, B.Xu & Yue H.Cheng (Liao et al. 2022), *G. armeniacus* Jun Y.Zhang, B.Xu & Yue H.Cheng (Zhang et al. 2024) and *G. minjiangensis* Jun Y.Zhang, B.Xu & Yue H.Cheng (Zhang et al. 2024). The discovery of *Gastrochilus balangshanensis* reinforces the need for more in-depth botanical exploration in this region.

Based on a series of morphological characteristics, including leaf shape, leaf size and color markings, *Gastrochilus balangshanensis* is most similar to *G. bernhardtianus* and *G. heminii*. However, based on overall floral characters, namely color, *G. balangshanensis* is most similar to *G. affinis*. This is possibly explained by parallel evolution.

Our phylogenetic analysis retrieved *Gastrochilus balangshanensis* in a clade with *G. bernhardtianus* and *G. heminii*, both also endemic to the HDM. This supports the recognition of an overlooked center of endemism, possibly associated with rapid allopatric speciation in close mountain ranges within *G.* sect. *Microphylli*, which now numbers 11 species.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

JYZ, YHC, ML, SLJ, HQL, PYY, HH and BX discovered and identified the species. YHC, SLJ, HQL and PYY assisted in extensive field investigation and samples collection. JYZ and ML performed the experiments and analyzed the data. JYZ wrote the manuscript. ML, HH and BX revised the manuscript. All authors read and approved the final manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Appendix 1

Marker	Length (bp)	Variable sites (bp)	Primer Sequence (5'to3')	Origin
nrITS	687	188	GGAAGGAGAAGTCGTAACAAGG	Thiv et al. 1999
			CTTTTCCTCCGCTTATTGATATG	Thiv et al. 1999
psbA–trnH	677	37	GTTATGCATGAACGTAATGCTC	Sang et al. 1997
			CGCGCATGGTGGATTCACAAATC	Sang et al. 1997
matK	805	28	CGATCTATTCATTCAATATTTC	Sun et al. 1994
			TCTAGCACACGAAAGTCGA	Sun et al. 1994
psbM-trnD	945	65	GCGGTAGGAACTAGAATAAATAG	Zuo et al. 2011
			GGGATTGTAGTTCAATTGGT	Zuo et al. 2011
trnL-F	1031	55	CGAAATCGGTAGACGCTACG	Taberlet et al. 199
			ATITGAACTGGTGACACGAG	Taberlet et al. 199

 Table A1. Information on the DNA markers used in phylogenetic reconstruction of Gastrochilus.

Table A2. Voucher information and GenBank accession numbers of DNA sequences of *Gastrochilus* used in phylogenetic inference.

Таха	Voucher	Location	nrITS	matK	psbA-trnH	trnL-F	psbM-trnD
G. acaulis (Lindl.) Kuntze	-	-	KM583455	KM583465	_	-	-
G. acinacifolius Z.H.Tsi	Z. J. Liu 3316	CHINA	KJ733412	KJ733569	KJ733492	KJ733649	_
G. acinacifolius Z.H.Tsi	Q. Liu 62	CHINA: Hainan (Baomeiling)	MK357118	MK357138	MK357160	MK357208	MK357216
G. acinacifolius Z.H.Tsi	ZJY289	CHINA: Yunnan (Malipo)	OQ566796	0Q575562	OQ575590	OQ575530	OQ575619
G. acutifolius (Lindl.) Kuntze	Q. Liu 05	CHINA: Yunnan (Jingmai)	_	MK357140	MK357162	_	MK357230
G. acutifolius (Lindl.) Kuntze	JK-DEBCR- mat-31(JK)	_	MW475270	MW433889	_	-	-
G. affinis (King & Pantl.) Schltr.	Q. Liu 97	CHINA: Yunnan (Fugong)	_	MK357141	MK357163	-	MK357141
G. alatus X.H.Jin & S.C.Chen	Q. Liu 98	CHINA: Yunnan (Bingzhongluo)	_	_	_	-	MK357228
G. alatus X.H.Jin & S.C.Chen	ZJY297	CHINA: Yunnan	-	OQ575563	OQ575591	OQ575531	OQ575620
G. armeniacus Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY244	CHINA: Sichuan (Wenchuan)	OP348889	OP373113	OP373119	OP373128	OP373123
G. armeniacus Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY285	CHINA: Sichuan (Wenchuan)	OP348888	OP373114	OP373118	OP373127	OP373124
G. balangshanensis Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY317	CHINA: Sichuan (Wenchuan)	PP960151	PP944493	PP944495	PP944499	PP944497
G. balangshanensis Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY318	CHINA: Sichuan (Wenchuan)	PP960152	PP944494	PP944496	PP944500	PP944498
G. bellinus (Rolfe. F.) Kuntze	Q. Liu 52	CHINA: Yunnan (Lancang)	KY966597	KY966884	_	-	-
G. bellinus (Rolfe. F.) Kuntze	Q. Liu 53	CHINA: Yunnan (Mengsong)	MK357123	MK357142	MK357164	MK357202	MK357241
G. bellinus (Rolfe. F.) Kuntze	ZJY279	CHINA: Yunnan (Mengla)	OQ566799	0Q575564	0Q575592	0Q575534	OQ575621
G. bernhardtianus J.D.Ya & D.Z.Li	20CS19022	CHINA: Yunnan (Lijiang)	OR073404	20CS19022	20CS19022	20CS19022	20CS19022
G. bernhardtianus J.D.Ya & D.Z.Li	20CS19023	CHINA: Yunnan (Lijiang)	OR073405	20CS19023	20CS19023	20CS19023	20CS19023
G. <i>bigibbus</i> (Rchb. f. ex Hook. f.) Kuntze	Li 009	_	-	MN124439	MN124439	MN124439	MN124439
G. calceolaris D.Don	Z. J. Liu 3769	CHINA	KF545874	KF545885	KF545865	_	KF545896
G. calceolaris D.Don	Q. Liu 94	CHINA: Yunnan (Jingdong)	MK357126	MK357144	MK357169	MK357205	MK357233
G. calceolaris D.Don	ZJY281	CHINA: Yunnan (Malipo)	-	OQ575565	OQ575593	OQ575535	OQ575622
G. changjiangensis Q.Liu & M.Z.Huang	Q. Liu 45	CHINA: Hainan (Changjiang)	MK357124	-	MK357166	-	MK357236
G. ciliaris F.Maekawa	Q. Liu 88	CHINA: Nursery of Management Office of Yushan Scenic Area, Fuzhou	-	MK357148	MK357173	_	MK357225
G. ciliaris F.Maekawa	ZJY299	CHINA: Taiwan	-	OQ575566	0Q575594	-	OQ575623
G. dasypogon (Lindl.) Kuntze	Q. Liu 30	CHINA: Hainan (Baomeiling)	MK357129	MK357149	MK357181	MK357197	MK357219
G. deminutus J.M.H.Shaw	-	_	KY966600	KY966887	_	-	_
G. distichus (Lindl.) Kuntze	Z. J. Liu 4755	CHINA	KJ733414	KJ733571	KJ733494	KJ733651	-
G. distichus (Lindl.) Kuntze	ZJY309	CHINA: Yunnan (Malipo)	OQ566800	OQ575567	OQ575595	OQ575536	-
G. fargesii (Kraenzl.) Schltr.	20HT3548	CHINA: Chongqing	OR073405	S18942	S18942	S18942	S18942
G. formosanus (Hayata) Hayata	Z. J. Liu 4256	CHINA	KJ733416	KJ733573	KJ733495	KJ733653	_
G. formosanus (Hayata) Hayata Q. Liu 91 CHINA: Yunnan (Gongshan)		_	-	MK357174	-	MK357226	
G. formosanus (Hayata) Hayata	ZJY276	CHINA: Hubei (Enshi)	OQ566801	OQ575568	OQ575596	OQ575537	0Q575624
G. fuscopunctatus (Hayata) Hayata	Q. Liu 86	CHINA: Taiwan (Hualian)	_	MK357150	MK357171	MK357192	MK357231
G. fuscopunctatus (Hayata) Hayata*	_	_	_	KX871233	KX871233	KX871233	KX871233
G. gongshanensis Z.H.Tsi	ZJY295	CHINA: Yunnan (Malipo)	_	OQ575569	OQ575597	OQ575538	0Q575625
G. quangtungensis Z.H.Tsi	Z. J. Liu 4127	CHINA	KJ733417	KJ733574	KJ733496	KJ733654	_
G. quangtungensis Z.H.Tsi	ZJY293	CHINA: Yunnan	OQ566802	0Q575570	0Q575598	OQ575539	0Q575626
G. heminii M.Liao, B.Xu &	ZJY241	CHINA: Sichuan (Wenchuan)	ON286752	ON331126	ON331128	ON331130	ON331132
Yue.H.Cheng							
G. heminii M.Liao, B.Xu & Yue.H.Cheng	ZJY283	CHINA: Sichuan (Wenchuan)	ON286753	ON331127	ON331129	ON331131	ON331133
G. intermedius (Griff. ex Lindl.) Kuntze	Q. Liu 38	CHINA: Yunnan (Yinchang)	MK357121	MK357151	MK357172	MK357190	MK357213
G. japonicus (Makino) Schltr.	Q. Liu 87	CHINA: Taiwan (Pingdong)	KF545875	KF545886	KF545866	KF545897	-
G. japonicus (Makino) Schltr.	_	_	_	KX871236	KX871236	KX871236	KX871236
G. kadooriei Kumar et al.	ZJY268	CHINA: Yunnan (Malipo)	OQ566803	OQ575571	OQ575599	OQ575540	OQ575627
G. lihengiae J.D.Ya, H.Jiang & D.Z.Li	22CS21828	CHINA: Yunnan (Gongshan)	OR073408	S18742	S18742	S18742	S18742
G. lihengiae J.D.Ya, H.Jiang & D.Z.Li	23CS24145	CHINA: Yunnan (Gongshan)	OR073408	S18895	S18895	S18895	S18895

Таха	Voucher	Location	nrITS	matK	psbA-trnH	trnL-F	psbM-trnD
G. linearifolius Z.H.Tsi & Garay	Q. Liu 711	MYANMA: Hkakaborazi National Park	MK357133	MK357136	MK357187	MK357194	MK357229
G. linii Ormerod	Q. Liu 92	CHINA: Nursery of Management Office of Yushan Scenic Area, Fuzhou	-	MK357152	MK357176	MK357198	MK357224
G. malipoensis X.H.Jin & S.C.Chen	Q. Liu 71	CHINA: Yunnan (Nanwenghe)	-	MK357147	MK357177	MK357200	MK357235
G. malipoensis X.H.Jin & S.C.Chen	ZJY288	CHINA: Yunnan (Malipo)	OQ566804	OQ575572	OQ575600	0Q575541	OQ575628
G. matsuran (Makino) Schltr.	-	-	KT338700	-	-	-	-
<i>G. minjiangensis</i> Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY243	CHINA: Sichuan (Wenchuan)	OP348887	OP373112	0P373117	OP373126	0P373122
G. <i>minjiangensis</i> Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY284	CHINA: Sichuan (Wenchuan)	OQ566806	-	-	OQ575542	-
G. minutiflorus Aver.	Q. Liu 37	CHINA: Yunnan (Malipo)	-	MK357153	MK357179	-	MK357215
G. minutiflorus Aver.	ZJY287	CHINA: Yunnan (Malipo)	OQ566807	OQ575573	OQ575601	0Q575544	OQ575629
G. nanchuanensis Z.H.Tsi	ZJY296	CHINA: Chongqing (Nanchuan)	OQ566808	0Q575574	0Q575602	OQ575545	OQ575630
G. obliquus var. obliquus (Lindl.) Kuntze	Q. Liu 708	MYANMA: Hponkanrazi Wildlife Sanctuary	MK357131	MK357137	KJ733498	KJ733656	MK357211
G. obliquus var. obliquus (Lindl.) Kuntze	Q. Liu 44	CHINA: Yunnan (Yinchang)	MK357130	MK357154	MK357182	MK357195	MK357218
G. suavis Seidenf.	ZJY277	CHINA: Yunnan	OQ566809	OQ575575	OQ575603	OQ575546	OQ575631
G. suavis Seidenf.	ZJY282	CHINA: Yunnan (Maguan)	OQ566810	OQ575576	0Q575604	OQ575547	OQ575632
G. platycalcaratus (Rolfe) Schltr.	Q. Liu 19	CHINA: Yunnan (Yinchang)	MK357122	-	MK357175	-	MK357222
G. platycalcaratus (Rolfe) Schltr.	ZJY300	CHINA: Yunnan (Mengla)	OQ566811	-	OQ575605	OQ575548	OQ575633
G. prionophyllus H.Jiang, D.P.Ye & Q.Liu	ZJY291	CHINA: Yunnan	OQ566812	OQ575577	OQ575606	OQ575549	OQ575634
G. pseudodistichus (King & Pantl.) Schltr.	ZJY308	CHINA: Yunnan (Malipo)	OQ566813	OQ575578	OQ575607	OQ575550	OQ575635
G. pseudodistichus (King & Pantl.) Schltr.	ZJY290	CHINA: Yunnan (Maguan)	OQ566814	OQ575579	OQ575608	OQ575551	OQ575636
G. rantabunensis S.Chow ex T.P.Lin	Q. Liu 89	CHINA: Taiwan (Taipei)	-	MK357155	MK357184	MK357193	MK357223
G. rantabunensis S.Chow ex T.P.Lin	ZJY303	CHINA: Taiwan	OQ566815	OQ575580	OQ575609	OQ575552	OQ575637
G. raraensis Fukuy.	Z. J. Liu 4798	CHINA	KJ733420	KJ733577	KJ733499	KJ733657	_
G. setosus Aver. & Vuong	ZJY304	Vietnam	OQ566816	OQ575581	OQ575610	OQ575553	-
G. sinensis Z.H.Tsi	ZJY228	CHINA: Zhejiang (Hangzhou)	OM985813	OK042953	OK172399	OK172401	OQ575646
G. sinensis Z.H.Tsi	S1109	CHINA: Sichuan (Wenchuan)	OP348890	0P373115	0P373120	OP373129	0P373125
G. somai (Hayata) Hayata	Q. Liu 36	CHINA: Fujian (Pingnan)	MK357128	-	MK357180	-	MK357220
G. somai (Hayata) Hayata	Li 073	-	-	MN124436	MN124436	MN124436	MN124436
G. sororius Schltr.	-	-	ERR7622420	ERR7622420	ERR7622420	ERR76	522420
G. wenshanensis Q.Liu, D.P.Ye & X.H.Jin	ZJY292	CHINA: Yunnan (Maguan)	OQ566820	OQ575586	OQ575615	OQ575558	OQ575642
G. sumartranus J.J.Sm.	ZJY280	Vietnam	OQ566818	OQ575583	OQ575612	OQ575555	OQ575639
G. sumartranus J.J.Sm.	ZJY294	Vietnam	OQ566819	OQ575584	OQ575613	OQ575556	OQ575640
G. tianbaoensis Q.Liu & Y.H.Tan	ZJY275	CHINA: Yunnan (Malipo)	-	OQ575585	0Q575614	OQ575557	OQ575641
G. tianbaoensis Q.Liu & Y.H.Tan	Q. Liu 63	CHINA: Yunnan (Malipo)	MK357120	MK357157	MK357186	MK357207	MK357214
G. wolongensis Jun Y.Zhang, B.Xu & Yue H.Cheng	ZJY240	CHINA: Sichuan (Wenchuan)	OM985810	OK172400	OK172402	OK172404	OK172403
G. wolongensis Jun Y.Zhang, B.Xu & Yue H.Cheng	S1108	CHINA: Sichuan (Wenchuan)	OM985811	OM974209	OM974211	OM974210	OQ575647
G. xuanenensis Z.H.Tsi	ZJY298	CHINA: Guizhou	-	OQ575587	OQ575616	OQ575559	OQ575643
G. <i>yunlongensis</i> W.H.Rao, L.J.Chen & Z.J.Liu	ZJY301	CHINA: Yunnan	-	OQ575588	OQ575617	OQ575560	OQ575644
G. yunnanensis Schltr.	Q. Liu 60	CHINA: Yunnan (Mengsong)	MK165469	MK357158	MK357185	-	MK357212
G. yunnanensis Schltr.	ZJY278	CHINA: Yunnan	OQ566821	OQ575589	OQ575618	OQ575561	OQ575645
G. zhenyuanensis Q.Liu & D.P.Ye	Q. Liu 61	CHINA: Yunnan (Zhenyuan)	MK357127	MK357146	MK357168	MK357199	MK357237
Holcoglossum amesianum (Rchb. F.) Christenson	X.H. Jin 004/006	CHINA	HQ404389	JF763779	HQ404439	-	-
H. kimballianum (Rchb. F.) Garay	X.H. Jin 017	CHINA	HQ452901	JF763787	HQ404452	-	-
Luisia magniflora Z.H.Tsi et S.C.Chen	Z. J. Liu 3444	CHINA	KJ733426	KJ733583	KJ733505	-	-
Pomatocalpa diffusum Breda	TBG145837	INDONESIA	AB217576	AB217752	-	EF670432	_
P. spicatum Breda	Z. J. Liu 4589	CHINA	KJ733438	KJ733595	KJ733518	KJ733675	_
Saccolabium pusillum Blume	TBG144220	INDIA	AB217580	AB217756			

PhytoKeys

Research Article

Metagentiana jiangyouensis, a new species of Metagentiana (Gentianaceae) from Sichuan, China

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Abstract

Metagentiana jiangyouensis, a new species of Gentianaceae from Sichuan, China, is described and illustrated. This new species is similar to *Metagentiana villifera*, but differs by the fact that the plant is glabrous and has 1-4 flowering stems, well-developed basal vegetative rosettes, a pale purple corolla with dark purple spots on the tube and erose or denticulate, non-fringed plicae margins. It also somewhat resembles *M. rhodantha*, but can be easily distinguished by having shorter stems, entire leaf margins, smooth, shorter sepal lobes, spotted corolla tubes, non-fringed plicae and narrowly winged seeds.

Key words: Gentianaceae, Metagentiana, Morphology, taxonomy

Introduction

The genus *Metagentiana* T.N.Ho & S.W.Liu in Gentianaceae was separated from *Gentiana* L. by Ho et al. (2002) based on comprehensive morphological and cytological evidence, and fourteen species were listed in this genus. A recent molecular phylogenetic study of subtribe Gentianinae confirmed that *Metagentiana* was monophyletic when excluding two yellow-flowered species, notably *M. souliei* (Franch.) T.N.Ho, S.W.Liu & Shi L.Chen and *M. striata* (Maxim.) T.N.Ho, S.W.Liu & Shi L.Chen, which were transferred to the new genus *Sinogentiana* Adr.Favre & Y.M.Yuan (Favre et al. 2014). Both morphological and molecular evidence indicates that *Metagentiana* has a close relationship with *Sinogentiana*, *Tripterospermum* Blume and *Crawfurdia* Wall. (Ho et al. 2002; Favre et al. 2014). Currently, excluding the new species, *Metagentiana* contains twelve species: Nine of these are restricted to southwestern China; one is relatively widespread in northwestern and central China; one is distributed in eastern Myanmar, and one is endemic to Thailand.



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Copyright: [©] Hai-Feng Cao et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). Metagentiana can easily be distinguished from *Tripterospermum* and *Craw-furdia* by having ascending to erect, not twining or trailing, stems. It can be distinguished from *Gentiana* by the following features: stem leaves sessile, widely separated, leaf blades broadly ovate to ovate-triangular; flowers bracteate; calyx keeled or winged, plicae asymmetrical, very oblique; stamens unequal in length, apically recurved; style filiform, as long as or longer than the ovary; capsules cylindrical, wingless; seeds triquetrous with three winged edges, rarely wingless or areolate; seed coat minutely to coarsely reticulate (Ho et al. 2002).

Metagentiana and Sinogentiana are closely related, and their morphological characteristics are similar but flowers of Metagentiana are pink, purple or blue and the stem leaves are 0.3–1.5 cm long or up to 3 cm long in *M. rhodantha* (Franch.) T.N.Ho & S.W.Liu, whereas the corolla of Sinogentiana is consistently whitish or yellow and the stem leaves are 1–3 cm long. Most species in Metagentiana are annual herbs, except for *M. rhodantha* and *M. villifera* (H.W.Li ex T.N.Ho) T.N.Ho & S.W.Liu, which are perennials with extremely short rhizomes and basal rosettes (Favre et al. 2014).

One of the authors (Y. Zou) photographed an unknown species of Gentianaceae on 22 December 2018. After collection and observation of living material, we confirmed that this species belongs to the genus *Metagentiana* because of the large bracts at the bases of the flowers, the keeled and winged calyx-tube, the unequal stamens that are unilaterally curved downwards, and the filiform and long style. Literature study (Ho and Pringle 1995; Ho and Liu 2001; Struwe et al. 2002; Cao et al. 2019; Li et al. 2019; Yang et al. 2020; Favre et al. 2022; Chen et al. 2024) showed that this perennial species is closely similar to *M. villifera* and *M. rhodantha*. But its fewer branches and well-developed rosette leaves, shorter stems, entire leaf margins and smooth, shorter sepal lobes, as well as its corolla tube with dark purple spots and non-fringed plicae margins distinguish it from *M. villifera* and *M. rhodantha*. We confirm that this species is new to science based on its morphological characters and provide a detailed description below.

Materials and methods

The type specimens of the new species were collected from Qianyuan Mountain, Hanzeng Town, Jiangyou County, Mianyang City, Sichuan Province, and deposited in the herbaria of CSH, KUN, PE and SMCM (Shanghai Museum of TCM, Shanghai University of TCM). Measurements and description of morphological characters of the new species were based on dried specimens and living plants. Type specimens of *Metagentiana villifera* (holotype: CDBI 0172347!; isotype: SZ!, KUN!, PE!, SM!; topotype: SM!) and specimens of *M. rhodantha*, which is the most closely related to the new species, were consulted online (Chinese Virtual Herbarium, http://www.cvh.ac.cn/) firstly, and then examined from CDBI, KUN, SZ, PE and SM. The line drawings, the description and most of the photographs were based on the type specimens. The conservation status of the new species was evaluated according to the guidelines of the IUCN Red List Categories and Criteria (IUCN 2024).

Taxonomic treatment

Metagentiana jiangyouensis H.F.Cao, sp. nov.

urn:lsid:ipni.org:names:77349955-1 Figs 1, 2

Diagnosis. Metagentiana jiangyouensis is similar to *M. villifera* and *M. rhodan*tha, but differs from these species by the fact that the plant is completely glabrous and has green flowering stems 8-11 cm long with 6-9 pairs of leaves per stem, well-developed basal vegetative rosettes, glabrous stem leaves with entire margin, spatulate to lanceolate, 1.3-2(-3) mm long calyx lobes with glabrous margins, a pale purple corolla with dark purple spots on the tube, and erose or denticulate, but never fringed plicae margins.

Type. CHINA • Sichuan: Mianyang City, Jiangyou County, Hanzeng Town, Qianyuan Mountain, on the road to Yinguangdong, growing on a cliff; 31.847981°N, 104.608385°E; 1169 m a.s.l.; 5 January 2019; *Yuan Zou QYS01* (holotype: CSH!; isotype: KUN 1584155!, PE 02402078!, SMCM!).

Description. Perennial herbs, 8-11 cm tall, with a short rhizome, 5-20 mm long. Flowering branches 1-4, arising from basal rosette, stems green, glabrous, ascending to erect, slender, simple or branched in upper part, 0.5-1.0 mm in diameter when fresh and 0.4-0.6 mm in diameter when dried, each stem with 6-9 pairs of leaves. Basal rosette leaves well-developed and persistent at anthesis; petiole 4-10 mm long, leaf blade oblong-spatulate or elliptic, $10-30 \times 2.5-7$ mm, both surfaces glabrous, margin entire, apex acute, midvein distinct. Abbreviated vegetative shoots well-developed. Stem leaves widely spaced, shorter than internodes, sessile; blade ovate, elliptic, oblong to oblong-spatulate in basal cauline leaves, and ovate to broadly ovate in middle and upper cauline leaves, 7-12 × 3-7 mm, both surfaces glabrous, margin entire, base rounded, apex acute or obtuse, veins 1–3, base tapering into a short petiole, 0.5-2 mm long. Flowers terminal, solitary, sessile, floral bracts ovate, $7-10 \times 4-6$ mm, both surfaces glabrous, margin entire, base rounded, apex acute or obtuse, veins 1-3. Calyx tube broadly tubular to tubular-campanulate, glabrous outside, 6-7 mm long, membranous, with 5 prominent green veins but not winged; lobes spatulate to lanceolate, equal or unequal, $1.3-2(-3) \times 10^{-3}$ 0.4-0.8(-1.5) mm, base usually slightly shrunken, margin cartilaginous and smooth, apex acuminate, midvein outside prominent, sinus between lobes rounded. Corolla purple, with dark purple spots on corolla tube, 2.9-3.3 cm long, tube funnel-shaped; lobes ovate-triangular, $4.5-6 \times 4.5-6$ mm, margin entire, apex acute; plicae obliquely truncate or broadly ovate-triangular, 2-3 × 5-6 mm, margin erose or denticulate. Stamens inserted at basal part of corolla tube, unequal; filaments filiform, 10-18 mm long; anthers deep purple, narrowly ellipsoid, 1.2–1.5 × 0.4–0.8 mm. Ovary narrowly ellipsoid, 6–10 mm long; gynophore to 5 mm long, stout. Style filiform, 9-11 mm long; stigma lobes linear. Capsules ellipsoid, 10-15 mm long, gynophore 5-10 mm long at maturity. Seeds brown, triguetrous with three narrowly winged edges, $1.1-1.5 \times$ 0.6-0.85 mm, seedcoat coarsely reticulate.

Phenology. Flowering and fruiting from December to April.



Figure 1. *Metagentiana jiangyouensis* H.F. Cao **A** habit **B** longitudinally opened corolla **C** pistil **D** longitudinally opened calyx **E** middle or upper cauline leaf **F** seed **G**, **H** closed and open fruit. Drawn by H.F. Cao **A**–**E** *Yuan Zou QYS01* **F**–**H** *Hai-Feng Cao CAOHF033*.

Distribution and habitat. *Metagentiana jiangyouensis* is currently known only from its type locality in Hanzeng Town, Jiangyou County, Mianyang City, Sichuan, China. It grows on a cliff, at an elevation between 1160 and 1513 m.

Etymology. The specific epithet "jiangyouensis" refers to Jiangyou County, Mianyang City, Sichuan, China, the type locality of *Metagentiana jiangyouensis*.

Vernacular name. Chinese mandarin: jiang you xia rui long dan (江油狭蕊龙胆). Preliminary conservation status. *Metagentiana jiangyouensis* is currently known only from its type locality in Hanzeng Town, Jiangyou County, Mianyang City, Sichuan. Based on our field survey, the habitat of *M. jiangyouensis* has been frequently disturbed by anthropogenic activities and might be compromised by touristic development. Therefore, *M. jiangyouensis* should be considered as Vulnerable (VU D2) (IUCN 2024).

Additional specimens examined (paratypes). CHINA • Sichuan: Mianyang City, Jiangyou County, Hanzeng Town, Qianyuan Mountain, near the Yinguangdong, growing on a cliff or on mossy rocks, 31.849795°N, 104.611639°E, 1456 m, 5 January 2019, *Yuan Zou QYS02* (paratypes: CSH!) • Same locality, 31.849402°N, 104.612286°E, 1513 m, 23 March 2024, *Hai-Feng Cao CAOHF033* (CSH!, KUN!, PE!, SMCM!) • Same locality, 1160–1180 m, 4 March 2024, *Ang Liu & Chao-Ling Yang LAJY01* (CSFI, image!).



Figure 2. A, B habitat C habit D vegetative rosettes E seedling F stem G corolla, front view H calyx, side view I cauline leaves, adaxial view J fruits K opened fresh flower L seeds. Scale bars: 2 cm (C); 1 cm (D–G, J, K); 5 mm (H, I); 1 mm (L). A, B photographed by Y. Zou C–L photographed by H.F. Cao A–I, K Yuan Zou QYS01 J, L Hai-Feng Cao CAOHF033.

Discussion

Metagentiana jiangyouensis is morphologically similar to M. villifera and M. rhodantha by the perennial habit, the presence of basal rosettes and the similar leaves and flowers. In fact, these three are the only Chinese species of the genus with basal rosettes and can therefore easily be distinguished from all other Chinese species. M. jiangyouensis differs from the two closely related species of M. villifera and M. rhodantha by the fact that the whole plant is glabrous, the spatulate to lanceolate calyx lobes 1.3-2(-3) mm long, the corolla tube with dark purple spots and the non-fringed plicae margin. Basal rosettes and well-developed abbreviated vegetative shoots make M. jiangyouensis a distinctive species amongst other species of Metagentiana. Metagentiana villifera and M. rhodantha sometimes have basal rosette leaves or vegetative shoots, but they are usually not well-developed or the vegetative shoots would grow into longer stems at a later time in the development. The other species of Metagentiana are annuals or biennials without rosettes. M. jiangyouensis differs from M. rhodantha also by its seeds with a narrow wing along the edges, whereas seeds of M. rhodantha are broadly winged. Metagentiana jiangyouensis and M. villifera both grow on rock surfaces, but M. rhodantha grows in grasslands, alpine scrub, forests and on rock.

	M. jiangyouensis	M. villifera	M. rhodantha
Stems	8–11 cm long; green, 1–4 stems from base	20–30 cm long, purple, more than 4 stems from base	20–50 cm long, purple or green, 1–15 stems from base
Plant	glabrous	stems, leaves, and calyx densely pilose	glabrous or puberulent on petioles and leaf veins only
Basal leaves	well-developed rosette	rosette absent or present, usually poorly developed	rosette absent, if present, late growth as flowering stems
Stem leaves	glabrous, 7–12 × 4–7 mm, 6–9 pairs, margin entire	densely pilose, 5–10 × 3–9 mm, 17–21 pairs, margin entire	abaxially pubescent, 10−30 × 5−20 mm, 10−28 pairs, margin serrulate
Calyx lobes	spatulate to lanceolate, 1.3– 2(–3) mm long, margin glabrous	linear-lanceolate, 3–4 mm long, margin densely pilose	linear-lanceolate, 5–10 mm long, margin ciliolate
Corolla length	2.9-3.2 cm	3-4 cm	2.5-4.5 cm
Corolla tube	with dark purple spots	without spots	without spots
Corolla lobes	4.5–6 mm long, ovate	5–7 mm long, ovate-triangular	5–9 mm long, ovate to ovate-triangular
Plicae	margin erose or denticulate, 2–3 mm long	margin fringed, 5–6 mm long	margin fringed, 4–5 mm long
Anther	1.2-1.5 mm long	2.0-2.5 mm long	2.5-3 mm long
Seeds	1.1–1.5 mm in diam., narrowly winged		ca. 1 mm in diam., broadly winged
Altitude	1160-1513 m	ca. 800 m	500-1800 m
Fl. and Fr.	December to April	April to June	October to February
Distribution	NE Sichuan (Jiangyou)	SE Sichuan (Junlian)	Gansu, Guangxi, Henan, W Hubei, S Shaanxi, Shanxi, Sichuan, Chongqing, Guizhou, Yunnan, Hunan, Jiangxi.

Table 1. Comparison of key	characters between	Metagentiana	jiangyouensis, M	. villifera and M.	rhodantha.
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Metagentiana jiangyouensis is distributed in Jiangyou County, northeastern Sichuan, at an elevation between 1160 and 1513 m, whereas *M. villifera* is distributed in Junlian county, southeastern Sichuan, more than 420 km away from Jiangyou County, at an elevation of about 800 m; and *M. rhodantha* is widely distributed in southwest, northwest, central and south China, at an elevation between 500 and 1800 m. Furthermore, the flowering and fruiting phenophase of *M. jiangyouensis* is from December to April, while that of *M. villifera* is from April to June and that of *M. rhodantha* is from October to February. A comparison of the morphological characters of *M. jiangyouensis* and its related species is summarized in Table 1.

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The authors have declared that no competing interests exist.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Miconia garagoana - Melastomataceae: A new rheophytic species from the eastern Andes of Colombia

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Abstract

A new species, *Miconia garagoana*, from riparian environments of the northern Cordillera Oriental of Colombia, is described. This is the second species exclusive to rheophytic conditions that grows in the Andean forest in Colombia and is characterized by the presence of stellate-lepidote trichomes on young structures and inflorescences, terminal inflorescences, 4-merous (rarely 5-merous) flowers, oblong-subulate anthers with an apical pore and 2-locular ovary. The differences with other rheophytic species occurring in Colombia are noted and it is argued that it is related to other Andean species with bluish-green ripe fruits such as *M. squamulosa* and *M. symplocoidea*. This new species is so far known only from Colombia and its threat category is suggested as Critically Endangered" (CR).

Resumen

Se describe una nueva especie, *Miconia garagoana*, de ambientes riparios del norte de la Cordillera Oriental de Colombia. Esta es la segunda especie exclusiva de condición reofitica que crece en bosques andinos de Colombia y se caracteriza por la presencia de cubiertas de tricomas estrellado-lepidotos en las estructuras jóvenes e inflorescencias, inflorescencias terminales, flores 4-meras /raras veces 5-meras), anteras oblongo-subuladas con un poro apical y ovario 2-locular. Se establecen las diferencias con otras especies reofíticas presentes en Colombia y se argumenta que está relacionada con especies de andinas de frutos maduros color verde-azuloso como *M. squamulosa* y *M. symplocoidea*. Esta nueva especie hasta ahora se conoce sólo de Colombia y se sugiere su categoría de amenaza como En Peligro Crítico (CR).

Key words: Eastern Mountains, endemism, Miconieae, northern Andes, rheophytic plants, riparian environments

Palabras clave: Ambientes riparios, Cordillera Oriental, endemismo, Miconieae, norte de los Andes, plantas reofíticas

Introduction

The genus *Miconia* Ruiz & Pav. is one of the largest in the Melastomataceae family and among the largest exclusive to the Neotropical region (Goldenberg et al. 2008). Recently, phylogenetic analyses (Michelangeli et al. 2016, 2022) redefined this genus to include all Neotropical Melastomataceae species



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Copyright: [©] Humberto Mendoza-Cifuentes et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). characterized by fleshy fruits, small flowers, and multiflorous inflorescences. Previously, these species were grouped under the tribe Miconiae, which included 18–20 genera exclusively distributed in the Neotropics. The genus comprises an estimated 1900 species, with about 600 found in Colombia (Almeda et al. 2016; Mendoza Cifuentes et al. 2021; Michelangeli et al. 2022).

Miconia species grow in variety of environments at all altitudes, but are particularly rare along rivers and streams, especially in lowland areas of tropical rainforests. For example, *Miconia aplostachya* (Bonpl.) DC. and *M. riparia* Triana are found along blackwater rivers and streams in Amazonia and Antioquia department in Colombia, while *M. rheophytica* Posada-Herrera & Almeda is the only specie restricted to rocky margins of torrential rivers in the Andes of Colombia (Hoyos-Gómez and Bernal 2018; Posada-Herrera and Almeda 2018).

In order to document the floristic diversity of Sub-Andean forest remnants in Colombia, numerous expeditions have been carried out in the departments of Boyacá and Santander, with the discovery of a new species of *Miconia* from riparian environments. This manuscript describes this new species, exclusively associated with stream margins at elevations near 2000 meters above sea level. The habitat characteristics of the species are outlined, and an assessment of its extinction threat is provided.

Material and methods

This new species was discovered through a comprehensive review of collections housed in regional herbaria, coupled with field expeditions conducted in previously unexplored regions of the Eastern Cordillera in Colombia. Several collections were located in the herbaria UDBC and JBB. Measurements of vegetative parts were made in dry herbarium material using a digital caliper with a precision of 0.1 mm. Measurements of the floral parts and fruits were based on fresh flowers preserved in alcohol from the plants designated as types. Trichome types follow Wurdack (1986). Field photos were compiled and a map of the occurrence of this new taxon in Colombia was generated using Arc-GIS version 10.2.1. Preliminary conservation status was assessed by estimating the Area of Occupancy with GeoCat (http://geocat.kew.org/editor) and applying the IUCN Red List Category criteria (IUCN 2012, 2017).

Results

Taxonomic treatment

Miconia garagoana Humberto Mend., Ariza-Cortés & L.Carvajal, sp. nov. urn:lsid:ipni.org:names:77349957-1 Figs 1, 2

Diagnosis. Rheophytic shrubs with stellate-lepidote trichomes in distal branches and inflorescences; leaves linear-elliptic, 3-nerved or 3- slightly plinerved, length-to-width ratio is greater than 5.5:1; terminal inflorescences with 1-9(-14) flowers, flowers 4-merous (rarely 5-merous), anthers oblong-subulate with a ventrally oriented pore, ovary 2-locular, fruits bluish-green with large and relatively few sedes. Similar to *Miconia riparia* Triana but differs in the indumentum of



Figure 1. *Miconia garagoana* Humberto Mend., W.Ariza & L.Carvajal **A** flowering branch **B** leaf seen from the underside **C** flower in lateral view **D** longitudinal cut of the ovary-hypanthium **E** dorsal tooth of calyx **F** petals **G**, **H**, **I** stamens in different views **J** ripe friut. Illustration based on W. Ariza-Cortés et al. 4855 (UDBC).

stellate-lepidote trichomes (vs. indumentum of pinoid trichomes in *M. riparia*), flowers predominantly 4-merous (vs. 5-merous). Also similar to *Miconia rheophytica* Posada-Herrera & Almeda, but the latter has branches with dense indumentum of dendritic ferruginous trichomes, ciliate leaf margins, dichasial axillary inflorescences, 5-merous flowers and 3-locular ovary.

Type. COLOMBIA. • Boyacá: Municipio de Garagoa, vereda Ciénega Valvanera, Reserva Privada El Secreto, en borde de Quebrada; 2100 m elev.; 5°7'29"N, 73°16'42"W; 12 Apr 2016 (fl); *W. Ariza-Cortés et al. 4855* (holotype: UDBC!; isotypes: JBB!, COL! [Branches with inflorescences and fruits were deposited in the supplementary spirit collection -Anthoteca UDBC]).

Description. Shrub 30-250 cm tall, rheophytic; foliage dense; external bark smooth and whitish; primary branches sympodial, plagiotropic; young branches quadrangular, flattened and slightly channeled, older branches becoming oblong-terete and exfoliating in thin flakes; apical buds with dense indument of stellate-lepidote trichomes (type 38 of Wurdack 1986); internodes 0.9-3.5 cm long, 1.7-3.3 mm wide. Leaves decussate, isophyllous; petiole 5-17 mm long, slightly channeled adaxially, glabrous; blade 40-85 × 7-17 mm, linear-elliptic, apex and base acute, margin entire, revolute and denticulate toward apex, adaxial surface green, shiny (fresh material) and glabrous, in mature leaves yellow, abaxial surface clear pale green, with sparse stellate-lepidote trichomes especially along the middle vein; venation with one pair of secondary veins accompanying the middle vein, nerved or slightly plinerved to 1-3 mm, 22-34 pairs of tertiary veins lateral to the middle vein, 1-3 mm apart in the middle, central vein raised on both surfaces, tertiary veins blurred on the lower side. Inflorescence 2.5-5 cm long, paniculate, sparsely branched, terminal, sessile or with a peduncle 5-20 mm long, with a sparse to dense indument of stellate-lepidote trichomes (type 38); 1-9(-14) flowers, sessiles; central axis with 1-5 branching nodes; branch apices regularly with one flower; basal nodes with linear bracts 2-5 mm long, distal nodes with linear-subulate bracts 1.7-4.4 mm long; flower supported by two linear-triangular bracteoles 0.7-1 mm long. Flowers 4-merous, rarely 5-merous, diplostemonous. *Hypanthium* 2.3-2.4 × 1.7-2 mm, obconical, externally with dense indument of stellate-lepidote trichomes (type 39) ca. 0.09 mm diameter; internally glabrous and slightly ribbed; free thalamus of ovary ca. 0.9 mm long. Calyx lobed, externally with indument similar to the hypanthium; tube ca. 0.2 mm long; lobes 0.2-0.3 × 1.2-1.3 mm, wide triangular; dorsal teeth 0.55–0.6 mm long, triangular and exceeding the lobe length. Corolla patent; petals 2.9-3.2 × 1.4-1.7 mm, spatulate, apex rounded, white, glabrous. Stamens isomorphic, glabrous, white; filaments 3.3-3.7 mm long; anthers $1.8-2.1 \times 0.4 \times 0.6$ mm, oblong-subulate, with a ventrally oriented pore ca. 0.2 mm diameter; basal connective with two little ventral lobules 0.2-0.35 mm long. Ovary 1.6-1.7 mm long, 2-locular, basal part fused to the hypanthium ca. 1 mm long, apical part free of the hypanthium ca. 0.6 mm long, rounded, glabrous; style 5-6.1 mm long, cylindric; stigma 0.3-0.4 mm diameter, punctiform. Fruit 15–18 × 8–15 mm, pyriform, slightly ribbed, bluish-green when ripe, with 12-18 seeds. Seeds 1.3-2 × 1.2-1.5 mm, ovoid and angled, antiraphal portion symmetrical and ovate; testa smooth, shiny, light yellow.

Phenology. In Santander, flowering was recorded in November, while in Boyacá flowering was observed between February and July. Fruiting occurred between April and August. At least in the Boyacá locality, active flowering and fruiting events are presumed to occur for most of the year.

Habitat and distribution. *Miconia garagoana* is endemic to Colombia in the North of the Eastern Cordillera. This species has been recorded in the departments of Boyacá and Santander, within relatively undisturbed Andean forests at altitudes ranging from 2000 to 2200 meters above sea level (Fig. 3). It is a



Figure 2. *Miconia garagoana* Humberto Mend., W.Ariza & L.Carvajal **A**, **B** different views of flowering branch **C** leaf variation **D** branch with flowers and fruits **E** seeds. All photos by Lindon Carvajal and William Ariza.

rheophytic plant, which grows exclusively along the banks of streams and rivers, typically on slopes characterized by moderate to steep inclinations (Fig. 4). **Etymology.** The specific epithet refers to the municipality of Garagoa in the department of Boyacá, where the majority of individuals of the species have been observed.



Figure 3. Distribution of Miconia garagoana Humberto Mend., W.Ariza & L.Carvajal in northern South America.

Conservation status. *M. garagoana* is found in remnants of riparian vegetation along rivers and streams in Andean humid forests, typically within a matrix of pastures designated for livestock grazing (Fig. 4). Considering its limited area of occupancy AOO = 8 km², recorded only in two locations, it is proposed as Critically Endangered (CR), according to criteria B2a of IUCN (2012, 2017).

Specimens examined (Paratypes). COLOMBIA · Santander: Municipio de Gambita, Cueva de Choco, creciendo en borde de quebrada en el interior de la caverna; 2176 m elev.; 05°54'7.17"N, 72°20'22.73"W; 01 Nov 2018 (fl); H. Mendoza 21578 (JBB, UDBC).

Discussion

Miconia garagoana exhibits distinctive morphological characteristics. It is recognized by the rheophytic condition and its abundant branching, occasionally featuring plagiotropic main branches that incline under the influence of water currents. This species displays an indumentum of stellate-lepidote trichomes on its distal branches, inflorescences, and the underside of its leaves. The linear-elliptic leaf is a distinguishing feature commonly found in species inhabiting the banks of rivers and streams, representing an adaptation to withstand the constant impact of water currents (van Steenis 1987). Furthermore, other remarkable morphological traits of *Miconia garagoana* include terminal



Figure 4. *Miconia garagoana* Humberto Mend., W. Ariza & L. Carvajal **A** Andean forests in the area of origin **B** habitat **C**–**F** different views of growth habit. All photos by Lindon Carvajal and William Ariza.

inflorescences with few flowers (1-14), predominantly 4-merous flowers, oblong-subulate anthers featuring a ventrally oriented pore, and a 2-locular ovary. In addition, this species is characterized by its mature fruits, which feature an bluish-green color, and its large and relatively few seeds (less than 20).

The most vegetative similar species to *Miconia garagoana* is *M. riparia*, also present in Colombia, but the latter has dense rufous indumentum of pinoid trichomes on stems (vs. stellate-lepidotes in *M. garagoana*), and 5-merous flowers (vs. predominantly 4-merous) and dark purple or black fruits (vs. bluish-green). It is also similar to *Miconia rheophytica*, but the latter has branches with dense rufous indumentum of dendritic trichomes, ciliate leaf margins, dichasial axillary inflorescences, 5-merous flowers, yellow anthers, 3-locular ovary, globose to subglobose fruit with a bright indigo blue colour, and seeds ovoid with lateral and antiraphal symmetrical planes elliptic to elliptic-ovate (Posada-Herrera and Almeda 2018). Additionally, *Miconia riparia* and *M. rheophytica* grow below 1000 m, while *M. garagoana* grows around 2100 m elevation.

According to the number of petals, *M. garagoana* could be associated with the Ulmarioides complex (recently revised by Tiernan and Michelangeli (2018). However, all species of this complex always present 4-locular ovary and pink or fuchsia connective of the anther, so there is not full certainty.

Perhaps the species most closely related to *Miconia garagoana* are *M. squa-mulosa* (Sm.) Triana, and *M. symplocoidea* Triana, considering that they share the indumentum of stellate-lepidote thrichomes in vegetative parts and flowers, the shape of the stamens, and especially the bluish-green ripe fruits with angled ovoid seeds with smooth testa. *Miconia squamulosa* is part of section Cremanium, while *M. symplocoidea* is part of section Miconia (Goldenberg et al. 2013). However, these sections proposed by Cogniaux (1891) are considered artificial (Goldenberg et al. 2008).

The rheophytic condition is one of the distinctive characters of *Miconia garagoana*. Rheophyte is a term coined by van Steenis in 1987 to describe a biological group of flood-tolerant plants that are confined to the beds of swift-running streams and rivers in nature, growing there up to flood level, but not beyond the reach of regularly occurring flash floods (van Steenis 1987; Santana Costa et al. 2020).

In Melastomataceae, about 23 rheophytic species are reported, of which six, including the present novelty, correspond to the genus *Miconia* (Hoyos-Gómez and Bernal 2018; Posada-Herrera and Almeda 2018; Santana Costa et al. 2020). Among these species are *Miconia linearis* (Gleason) Michelang, *M. mulleola* Wurdack, *M. rheophytica*, *Miconia riparia* and *Miconia salicina* (Ser. ex DC.) Mabb. However, there are gaps in the information on the hábitat of the species, so it is not known with certainty how many, and which, species are restricted to this rheophytic condition. On the other hand, some of the species on record as being rheophytic are not exclusive to riparian environment, as is the case with *Miconia mulleola*. In order to guide conservation plans for riparian environments, the addition of this type of information would be very useful.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Cryptantha whippleae (Boraginaceae), a new serpentine-adapted species endemic to northern California, U.S.A.

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Abstract

Cryptantha whippleae D.A. York & M.G. Simpson (Boraginaceae) is described as new. This species is currently known to occur in serpentine barrens in the Shasta-Trinity National Forest of Siskiyou County, California, with one outlier population in possible serpentine of Lake County, California. The new species is most similar to Cryptantha grandiflora and to C. milobakeri, these three likely each others' closest relatives. All three have a relatively large corolla limb width and similar smooth, lance-ovate to ovate, marginally rounded, acuminate and abaxially transversely flattened nutlets. Cryptantha whippleae differs from C. grandiflora in having a short, as opposed to a tall, stem height; bifurcate as opposed to trifurcate primary axis cymules; and typically 2-3 nutlets per fruit, as opposed to usually one nutlet per fruit. Cryptantha whippleae differs from C. milobakeri also in having a short, versus tall, stem height; appressed-strigose and spreading-hispid stem vestiture, as opposed to strigose only or strigose and hirsute; calyx trichomes with two distinct vestiture types, these marginally appressed hirsute and medially hispid, as opposed to calyx trichomes of one type, dense, appressed to ascending, whitish sericeous; and 2-3 nutlets per fruit, as opposed to one nutlet per fruit. Cryptantha whippleae is relatively rare and joins seven other Cryptantha species that are found on serpentine, either obligately or facultatively. Current molecular phylogenetic studies support the mostly convergent evolution of serpentine adaptation in Cryptantha, but additional studies are needed.



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Copyright: © Michael G. Simpson & Dana A. York. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). **Key words:** Boraginaceae, California, conservation, *Cryptantha whippleae*, endemic, Klamath Mountains, serpentine, taxonomy

Introduction

Cryptantha is a genus of annual or (only in some South America taxa) perennial herbs of the family Boraginaceae, subtribe Amsinckiinae [sensu Chacón et al. (2016)]. *Cryptantha* s.l. has been found to be non-monophyletic in several molecular phylogenetic studies (Hasenstab-Lehman and Simpson 2012; Weigend et al. 2013; Simpson et al. 2017a; Mabry and Simpson 2018). Based on these studies, the genus was recircumscribed and split from the genera *Eremocarya*, *Greeneocharis*, *Johnstonella* and *Oreocarya* by Hasenstab-Lehman and Simpson (2012), these results being confirmed by Simpson et al. (2017a) and

Mabry and Simpson (2018). This updated classification has been consistently used, for example, in the *Jepson eFlora* [Jepson Flora Project 2024] of California vascular plants and in the treatments in the Flora Argentina project (Moroni et al. 2021; Moroni and Simpson 2022, 2023a, b, c). *Cryptantha* is currently recognised with 109 species and 124 minimum-ranked taxa, 63 of those species occurring in North America and 47 species in South America, with one taxon [*Cryptantha maritima* (Greene) Greene var. *pilosa* I.M.Johnst.] found on both continents (see Simpson et al. (2017b); Amsinckiinae Working Group (2024)).

Serpentine soils, specifically in northern California, are formed from ultramafic (meta-igneous) rocks that developed millions of years ago deep in the ocean floor. The soils are extremely high in heavy metals (i.e. nickel, iron and magnesium) and low in calcium and potassium. Serpentine soils are inhospitable to plants that have not evolved to tolerate the harsh conditions. Plants growing on serpentine outcrops tend to be slow-growing and isolated geographically and reproductively, thus evolving into new species (Kauffmann et al. 2022). Sawyer (2006) documented 200 neoendemic serpentine plants in north-western California. Serpentine-adapted species have a high rate of endemism (Harrison et al. 2004).

Seven species of *Cryptantha* have previously been identified as occurring on a serpentine substrate (Safford and Miller 2020; Table 1): *Cryptantha dissita* I.M.Johnst., *C. excavata* Brandegee, *C. flaccida* (Douglas ex Lehm.) Greene, *C. hispidula* Greene ex Brand, *C. intermedia* (A.Gray) Greene var. *intermedia*, *C. mariposae* I.M.Johnst. and *C. milobakeri* I.M.Johnst. Three of these species are listed in the *Inventory of Rare and Endangered Plants of California* as **1B.1**, **1B.2** or **1B.3** (CNPS Inventory 2024; see Table 1). Of these seven species, we believe that *C. intermedia* var. *intermedia* is likely not serpenticolous and is, in fact, listed by the authors as **WI/IN=**Weak Indicator/Indifferent. However, we add the taxon *C. clevelandii* Greene var. *clevelandii* to the list, as some San Luis Obispo County populations of that taxon occur on serpentine (personal observation by the first author).

A distinct form of *Cryptantha* was discovered in the Klamath Mountains, near Mt. Eddy of the Shasta-Trinity National Forest of California (see Figs 1–4) and several voucher specimens were collected. Additional specimens of this form were identified from previously deposited herbarium collections and these all were compared with morphologically similar taxa (Figs 4–6). From these studies, we found this form to be unique in the genus, warranting its recognition as a new species, based on a taxonomic (morphologic) concept (Cronquist 1978, 1988).

Methods

We collected additional specimens of the presumed new species in the Mt. Eddy region of Shasta-Trinity National Forest. An earlier collection was designated to be the type (holotype and isotypes) of the new species. In addition, we identified *Cryptantha* specimens that fit this new taxon from herbarium vouchers (listed as paratypes) from Cal Poly Humboldt (**HSC**), Pacific Union College Herbarium (**PUA**), California Botanic Garden (**RSA**), San Diego State University (**SDSU**) and University of California, Berkeley (**UC**); acronyms after Thiers (2024). These specimens were studied morphologically using a dissecting

microscope and a spreadsheet of morphological characters was made to generate a description of the new taxon. Fruits were examined from all specimens. Fruiting calyx length, nutlet number per fruit and nutlet size (length, depth and maximum width) were quantified. Mean nutlet length versus maximum width for all known specimens was graphed (Fig. 3) and evaluated in terms of qualitatively evaluating nutlet shape as ovate (with a length: width ratio = 1.5-2) versus lance-ovate (length: width ratio = 2-3), terminology after Simpson (2019). In order to illustrate their similarities and differences, fruiting calyces, nutlets and stems of the new species and of specimens of Cryptantha grandiflora Rydberg [C. intermedia (A. Gray) Greene var. grandiflora (Rydberg) Cronquist], C. milobakeri and six additional serpenticolous Cryptantha taxa were imaged using a Macropod Pro 3D camera system (Macroscopic Solutions, East Hartford, CT, USA) or an Infinity 2 camera on an Olympus SZ61 boom-mounted dissecting microscope (Figs 4, 6, 7). Representative herbarium specimens were also imaged for comparative purposes (Fig. 5). From collection label data of C. whippleae and from georeferenced specimen data available on the CCH2 (2024), we prepared distribution maps (Fig. 8A-C) for this new taxon and for Cryptantha species that occur on serpentine (minus C. clevelandii) and for the morphologically similar C. grandiflora. Maps (Fig. 8A, C) were prepared using the Berkeley Mapper tool (https://ucjeps.berkeley.edu/consortium/load_mapper_multi. html) or (Fig. 8B) using R v.4.3.1, occurrence points plotted on a custom Google Map (Kahle and Wickham 2013).

Results

Based on our studies of specimens of this new taxon and of morphologically similar *Cryptantha* species, we describe here a new species.

Taxonomic treatment

Cryptantha whippleae D.A.York & M.G.Simpson, sp. nov. urn:lsid:ipni.org:names:77350290-1

Note. Specimens cited indicate herbarium accession numbers, acronyms after Thiers (2024).

Type. UNITED STATES • California, Siskiyou County, Shasta-Trinity National Forest, The Eddys, ridge between China Mtn. and Mount Eddy, a few metres E of the county line, ca. 210 m N-NW of Parks Creek Trailhead. Annual with white (appendages yellow) flowers, rare, growing in serpentine soils on a S-facing, exposed, gravelly slope, serpentine soil, gravelly, associated taxa: *Danthonia unispicata, Eriogonum siskiyouense, Eriogonum umbellatum* var. *humistratum, Eriogonum umbellatum* var. *nelsoniorum, Eriophyllum lanatum, Festuca idahoensis, Penstemon roezlii* and *Pinus jeffreyi*. 41.34458, -122.53863, 2100 m (6888 feet) elevation. 18 June 2020, *D. York 3365 with Julie Kierstead, Ellen Uhler, Michael Uhler and Jennifer Whipple* (holotype: CAS1352444; isotype: HSC105848).

Diagnosis. Cryptantha whippleae is similar to C. grandiflora in having a relatively wide corolla limb [3–6 mm wide in C. whippleae; 4–8 mm wide in C. grandiflora] and in the size, shape and sculpturing of nutlets, differing in having a mostly shorter plant height [3–8(15) cm tall in *C. whippleae* versus 5–35 cm tall in *C. grandiflora*], in cymule branching [bifurcate or rarely solitary in *C. whippleae* versus trifurcate in *C. grandiflora*] and in having more nutlets per fruit [2–3 in *C. whippleae* versus (2) in *C. grandiflora*]. *Cryptantha whippleae* is similar to *C. milobakeri* in corolla limb width [3–6 mm wide in *C. whippleae*; 2–6 mm wide in *C. milobakeri*] and in the size, shape and sculpturing of nutlets, differing in having a shorter height [3–8(15) cm tall in *C. whippleae* versus 10–50 cm tall in *C. milobakeri*], in calyx vestiture [with two distinct trichome types in *C. whippleae* versus a single trichome type in *C. milobakeri*] and in having more nutlets per fruit [2–3 in *C. whippleae* versus 1(2) in *C. milobakeri*].

Description. (Figs 1-6). Plants annual, 3-8(15) cm tall, grey-green. Root a single taproot, not reddish. Stems erect, vegetative primary stem usually terminating in an inflorescence of bifurcate cymules (rarely of a solitary cymule), 0-2 lateral branches arising from base and/or middle region of primary stem, these usually terminating in a solitary cymule, stem surface both strigose, with trichomes antrorsely appressed, abruptly up-turned at base, ca. 0.5 mm long, and hispid, these trichomes spreading to inclined, ca. 1-1.5 mm long, ca. 0.05 mm wide proximally, mostly swollen at base, surfaces minutely scaberulous, all trichomes white, sharply tapered. Leaves alternate, those at plant base 4-7 in number, densely clustered, horizontal to ascending in upper cauline leaves, often brownish at anthesis, 4-10 mm × 1.5-3 mm at widest point, oblanceolate to obovate, those along aerial primary stem 0-4 in number, regularly spaced, ascending to appressed, green-grey, 7-15 mm × 1.5-3 mm at widest point, sessile, oblanceolate, oblance-ovate or narrowly oblong, base cuneate, apex obtuse to rounded, typically subtending lateral branches and base of cymule units, those above base often showing apparent evidence of herbivory; adaxial surface with mid-rib sunken, margins hispid, trichomes white, 1-2 mm long, ascending to appressed, trichome bases bulbous and prominently pustulate, pustules of 2 concentric rows of white to transparent, radially oblong cells; abaxial surface with strongly ridged mid-rib, hispid especially along mid-rib, trichomes similar to those of adaxial surface, but less prominently pustulate. Inflorescence with bifurcate (paired) cymules arising from the primary stem (cymules rarely solitary), a flower/fruit typically found at the junction of the cymules, with 1-2 additional solitary cymules branching from lower primary stem, cymules 20-65 mm long including basal axis, lowest flowers not touching at maturity, inflorescence bracts leaf-like, typically present at and slightly above cymule bases. Flowers with pedicels ca. 0.5 mm, hirsute and hispid, trichomes 0.5-1 mm, horizontal to ascending, subtending leaf-like flower bracts subtending only lowest 1-2 flowers, upper flowers lacking bracts. Calyx at anthesis 1.5-2 mm, in fruit 4-5.5 mm, ovoid, slightly constricted above middle, sepals distinct, lanceolate, erect, apices erect to recurved, abaxial mid-rib thickened, surface along sepal sides with trichomes straight, soft hirsute, inclined to ascending, 0.5-1.5 mm long, the raised mid-rib and sepal apex hispid, with trichomes horizontal to inclined, 1-1.5 mm long, ca. 0.5 mm wide near base, bulbous-based and often pustulate, trichome surface scaberulous, adaxial sepal surface glabrous basally, with appressed short trichomes apically. Corolla showy, white with yellow fornices, rotate, tube as long as calyx, limb 3-6 mm wide. Androecium of five stamens, attached at the same level ca. 2/3 along corolla tube between and below fornices; anthers ca. 0.5 mm long, ellipsoid,



Figure 1. Site of holotype of *Cryptantha whippleae*, a rocky, serpentine outcrop. Seen in this 18 June 2020 photograph, from left to right, are: Jennifer Whipple, Ellen Uhler, Michael Uhler and Dana York. Photo by Julie Kierstead.

dithecal, introrsely dehiscent, dorsifixed; filaments filiform, ca. 0.1 mm long. *Gynoecium* four-lobed, lobes ca. 0.4 mm long, widely ellipsoid to oblong, style gynobasic, ca. 0.8 mm long. *Nutlets* 2–3 per fruit, 1.6-2.6 mm × 0.8-1.4 mm wide at widest point, length: width ratio 1.6-2.6, homomorphic, lance-ovate to ovate, margins rounded, base broadly rounded to truncate, apex short-acuminate, extreme tip acute-rounded, abaxial surface transversely flattened, slightly curved longitudinally, spinal ridge absent, adaxial surface 2-planed convex, both surfaces smooth and shiny, brown to grey-brown, often dark brown mottled, attachment scar ventral groove in lateral view relatively straight, in face view, edges slightly raised, abutted apically, 2-forked at base, contiguous or delimiting small areole. *Gynobase* at maturity ca. 1/2 height of nutlets, style extending to ca. 3/4 height of mature nutlets. Abortive nutlets 1-2, tan to brown, lanceoloid to ellipsoid, position relative to inflorescence axis variable.

Distribution and habitat. *Cryptantha whippleae* is endemic to northern California, USA, ranging in elevation from ca. 800 to 2200 m. It occurs in open, rocky, serpentine substrate habitats (Figs 1, 2E). All but one of the known specimens occur in Siskiyou County. The sole Lake County specimen (*Nelson 5882*) is possibly on serpentine, but substrate type was not recorded on the label (see Discussion).

Phenology. Based on herbarium specimen records, *Cryptantha whippleae* flowers from late May to early August. Fruits typically mature within a few weeks after flowering.

Rarity and conservation status. *Cryptantha whippleae* is currently known from 15 collections in only 12 specific localities, all in northern California. Pending further surveys, we recommend that it be ranked as **1B** ("rare, threatened or endangered in California and elsewhere") using the California Native Plant Society Inventory Rankings (CNPS Inventory 2024).



Figure 2. Field shots of *Cryptantha whippleae* at holotype locality **A** upper part of plant. Note terminal bifurcate cymules at apex of primary stem; lateral cymules are solitary **B** close-up of a single cymule. Note hispid vestiture along sepal mid-ribs **C** ascendingly orientated stem leaf, abaxial surface showing hispid vestiture along raised mid-rib **D** close-up of corolla, showing yellow fornices and relatively large limb (this one ca. 5 mm wide) **E** several plants in the field at the type locality. Note small stature of plants and surrounding rocky, gravelly serpentine substrate **F** free nutlets (from various fruits), characteristically smooth and shiny, ovate to lance-ovate, abaxially transversely flattened, apically acuminate.



Figure 3. Graph of average length and width of nutlets of all known specimens of *Crypt*antha whippleae, showing variation in size. Straight line (slope = 2) shows the demarcation between an ovate shape (length: width ratio 1.5-2) and a lance-ovate shape (length: width ratio 2-3). Note that nutlets of *C. whippleae* span between the two shape categories; terminology after Simpson (2019).

Etymology. The epithet is named after Jennifer J. *Whipple*, an avid collector in the Mount Eddy/Scott Valley region and a retired Yellowstone National Park botanist. The epithet *whippleae* can be pronounced whíp-pul-ee as a commemorative, using the female genitive ending *-ae* and following Anglicised Latin (Stearn 1993).

Suggested common name. We suggest Whipple's Cryptantha as a common name.

Paratypes (arranged alphabetically by county, then by collector/collection number). UNITED STATES, California · Lake County: along Forest Service Rd. 17N16, 3.1 mi. E of Bear Creek Ranger Station, Chaparral, 39.326214, -122.786329, 1220 m elevation, 24 June 1980, T. W. Nelson & Jane Nelson 5882 (HSC202692!) • Siskiyou County: Dry hill near Yreka, 41.73234, -122.64111 [estimated from label locality data], 804 m elevation [estimated from label locality data], 27 May 1910, G. D. Butler 1416 (RSA0153874!, UC163852!) • Local landmark: Hayden Cabin. China Mt Quad, Mountain or Hillside Slopes, Slope Position: Upper Third, Vertical Slope Shape: Convex, Horizontal Slope Shape: Convex, Very Gravelly texture composed mainly of serpentine with a colluvial origin, 41.285611, -122.694556, 1737 m elevation, 2 July 1978, Clifton & Ground 1758 (PUA-CardNumber15387!) · Local landmark: Hayden Cabin. China Mt Quad, Mountain or Hillside Slopes, Slope Position: Upper Third, Vertical Slope Shape: Convex, Horizontal Slope Shape: Convex, Gravelly texture composed mainly of serpentine with a colluvial origin, 41.285611, -122.694556, 1737 m elevation, 2 July 1978, Clifton & Ground 1799 (PUA-CardNumber15438!) • Near Rock Fence Lake. China Mt Quad, close to the town of Callahan, Slope Position: Middle Third, Vertical Slope Shape: Smooth, Horizontal Slope Shape: Smooth, Gravelly texture composed mainly of serpentine with a colluvial origin, 41.336528, -122.609111, 2100 m elevation, 1 August 1978, G. J. Muth 6998 (PUA-CardNum-



Figure 4. Comparison of representative nutlets of **A** *Cryptantha whippleae* **B** *Cryptantha grandiflora* and **C** *Cryptantha milobakeri*. All are smooth and shiny, round-margined, apically acuminate, ranging from lance-ovate to ovate in shape, with a transversely flattened abaxial surface, a 2-planed adaxial surface, truncate to rounded base, rounded margins and contiguous ventral groove attachment scars, 2-forked at base delimiting a small to absent areole. Collector and accession numbers of specimens indicated.

ber14174!) • Local landmark: Cory Peak. China Mt Quad, Mountain or Hillside Slopes, Slope Position: Upper Third, Vertical Slope Shape: Smooth, Horizontal Slope Shape: Smooth, Very Gravelly texture composed mainly of serpentine with a colluvial origin, 41.333139, -122.603861, 2196 m elevation, 1 August 1978, G.



Figure 5. Herbarium specimen images of **A**, **B** *Cryptantha whippleae* **C** *Cryptantha grandiflora* and **D** *Cryptantha milobakeri*, all imaged at the same scale. Note relatively small stature of *C. whippleae*, which typically has bifurcate terminal cymules (**A**) as opposed to trifurcate terminal cymules in *C. grandiflora* (**C**); cymules of *C. milobakeri* (**D**) can be bifurcate or trifurcate. Collector and accession numbers of specimens indicated.

J. Muth 6960 (**PUA**-CardNumber14173!) • The Eddy's, ca. 30 metres northwest of Pacific Crest Trail, near Parks Creek Trailhead, along old, compacted road, Open, rocky alpine vegetation, tan, clay loam of rocky, gravelly, serpintine outcrop, annual herb, 6 cm tall, corolla white with yellow centre (fornices), limb



Figure 6. Comparison of stem vestiture (left) and fruits (right) of **A** *Cryptantha whippleae* **B** *Cryptantha grandiflora* and **C** *Cryptantha milobakeri*. Stems of *C. grandiflora* and *C. whippleae* are similarly both strigose and spreading hispid. Stems of *C. milobakeri* are mostly strigose, sometimes also with spreading, fine-hirsute trichomes. Fruiting calyces of *C. grandiflora* and *C. whippleae* are marginally appressed hirsute and coarse hispid along the mid-rib. Those of *C. milobakeri* characteristically have one type of trichomes, consisting of appressed to ascending, soft, whitish, hirsute trichomes. Accession numbers of specimens indicated.

4–5 mm broad, Not common. Ca. 40 individuals seen a few yards (metres) north on east side of road. Leaf material preserved in silica gel for genetic studies, 41.34464, -122.53864, 2099 m elevation, 28 June 2021, *M. G. Simpson & Lee M. Simpson 4760* (**SDSU**23504!) • Scott Valley, Weston Gulch, barren serpentine

ridge, 41.462668, -122.825083, 990 m elevation, 14 June 2015, J. J. Whipple 7131 (SDSU22884!) · Scott Valley, below Denny Point on hillside, Open serpentine north facing slope with scattered junipers, 41.4599, -122.828517, 990 m elevation, 31 May 2016, J. J. Whipple 7270 (SDSU23523!) · Slopes above Scott Valley below Denny Point, barren rabbitbrush steppe on serpentine, 41.462683, -122.825, 990 m elevation, 1 June 2019, J. J. Whipple 7639 (SDSU23524!) China Hill by Yreka, serpentine barren, 41.743683, -122.614983, 900 m elevation, 3 June 2019, J. J. Whipple 7645 (SDSU23525!) • Klamath National Forest, slope of Schneider Hill off of Masterson Road, 1.6 miles (2600 m) from Gazelle Callahan Road, Open serpentine barren, 41.32675, -122.726233, 1095 m elevation, 15 June 2019, J. J. Whipple 7650 (SDSU23527!) • Shasta-Trinity National Forest, The Eddys, ridge between China Mtn. and Mount Eddy a few metres E of the county line, ca. 210 m N-NW of Parks Creek Trailhead, growing in serpentine soils on a S-facing, exposed, gravelly slope, serpentine soil, gravelly, A rare annual with white (appendages yellow) flowers, 41.34458, -122.53863, 2100 m elevation, 5 July 2016, D. York 3293 (SDSU22761!) · Shasta-Trinity National Forest, The Eddys, ridge between China Mtn. and Mount Eddy a few metres E of the county line, ca. 210 m N-NW of Parks Creek Trailhead. A rare annual with white (appendages yellow) flowers, growing in serpentine soils on a S-facing, exposed, gravelly slope. 41.34461, -122.53862, 2100 m elevation, 10 July 2017, D. York 3322 (CAS1352445!, HSC105849!).

Key to the eight serpenticolous Cryptantha species

Key to the eight serpenticolous *Cryptantha* species, including *C. whippleae*, plus the non-serpenticolous, but presumed close relative *C. grandiflora*. Key modified from the *Jepson eFlora* (Simpson et al. 2021), only pertinent couplets included. (See Figs 4, 7 for comparison of nutlet morphology.)

1	Nutlet(s) all smooth2
_	Nutlets rough, variously papillate and tuberculate8
2	Calyx trichomes both straight and hooked-tipped; nutlets 1 C. flaccida
-	Calyx trichomes straight to curved, not hook-tipped; nutlets 1-43
3	Calyx abaxially with ± single trichome type, generally long, soft, appressed
	to ascending, whitish sericeous, mid-vein trichomes slightly longer, but
	not hispid; nutlets 1(2)C. milobakeri
-	Calyx abaxially with 2 trichome types, marginally appressed hirsute, medi-
	ally spreading, ascending or reflexed hispid; nutlets 1-44
4	Nutlets lance-ovate to ovate, abaxially transversely flattened5
-	Nutlets lance-ovate to lanceolate, abaxially convex6
5	Plants 5–35 cm tall; terminal cymules trifurcate; nutlets 1(2)
	C. grandiflora
-	Plants 3-8 cm tall; terminal cymules difurcate to rarely solitary; nutlets
	2–3 C. whippleae
6	Stems unbranched or few-branched near base; leaves crowded proximal-
	ly, subequal above; distal peduncle axis without bracts; nutlets $(1)2-4$
	C. dissita
-	Stems branched throughout; leaves reduced distally, not congested proxi-
	mally; distal peduncle axis typically with bracts; nutlets 1-27

Discussion

Where substrate data were recorded, all known specimens of *Cryptantha whippleae* are reported in open, rocky, serpentine, corresponding to a strict endemic ("**SE**") in the classification of Safford and Miller (2020). All but one of the collections of *Cryptantha whippleae* cited here are centred at or near Mt. Eddy in Siskiyou County, California, including the holotype/isotypes *York 3365* (see Fig. 8A, C). However, one collection was discovered that is disjunct in range: *Nelson 5882*, of Lake County, California (see map, Fig. 8A). We confidently identified this specimen as *Cryptantha whippleae*, as it fits all the morphological parameters of the species. The label information of the *Nelson 5882* specimen lists the sample as occurring on "chaparral," with no reference to the substrate type, although it possibly came from serpentine since Nelson collected plants nearby on the same day citing serpentine on the labels (CCH2 2024). Cardace et al. (2013) (fig. 1, p. 48) map out several serpentine outcrops in Lake County, California.

Cryptantha whippleae now adds an eighth, definitive serpenticolous species in the genus (Table 1). Of these eight taxa, phylogenetic relationships are known to date for only two: *Cryptantha flaccida* and *Cryptantha mariposae*, these belonging to two distantly related clades (Simpson et al. 2017a; Mabry and Simpson 2018). Relationships of the remaining serpentine-adapted *Cryptantha* are uncertain, but there is no indication from taxonomic studies (Johnston 1925, 1939) that any are each others' closest relative, except for *C. whippleae* being a likely close relative to the serpenticolous *C. milobakeri* and of the non-serpenticolous *C. grandiflora* (see below). Other than *C. milobakeri* and *C. whippleae*, our working hypothesis is that the serpenticolous *Cryptantha* taxa evolved adaptations to that rock substrate type independently.

Cryptantha whippleae joins 21 additional species (23 minimum-ranked taxa) of North American members of *Cryptantha* with obligately smooth-nutlets (Amsinckiinae Working Group 2024). The taxa of *Cryptantha* with smooth nutlets are generally more difficult to distinguish from one another than those with "rough" (tuberculate and/or papillate) nutlets given the absence of diagnostic sculpturing surface features. Of these, *C. grandiflora, C. milobakeri* and *C. whippleae* are most similar in nutlet morphology and all share a relatively wide corolla limb. These three species all have smooth and shiny, lance-ovate to ovate, short-acuminate, abaxially transversely flattened (gently curving longitudinally) and adaxially

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Figure 7. Comparison of nutlets of the eight *Cryptantha* species that occur on a serpentine substrate, in (left to right) dorsal, ventral and lateral views with herbarium accession numbers of samples listed. All nutlet images are shown to scale **A** *C*. *clevelandii* var. *clevelandii* **B** *C*. *dissita* **C** *C*. *excavata* **D** *C*. *flaccida* **E** *C*. *hispidula* **F** *C*. *mariposae* **G** *C*. *milobakeri* **H** *C*. *whippleae*. Accession numbers of specimens indicated.

2-planed convex nutlets, a spinal ridge absent, the attachment scar a narrow ventral groove, closed or delimiting a small, basal areole, that of *C. whippleae* often slightly larger (Fig. 4). We believe that these species likely belong to the same phylogenetic clade, but they have yet to be sequenced. [It should be noted that *Cryptantha torreyana* has nutlets similar to the above three (although relatively wider), but has a consistently small corolla limb width (1–2 mm);



Figure 8. Distribution maps **A** map showing the overall distribution of *C. whippleae*, of presumed close relatives *C. grandiflora* (red stars) and *C. milobakeri* (orange diamonds) and of other serpentine *Cryptantha* species in California (CA) and Oregon (OR) (minus *C. clevelandii* var. *c.*, which occurs further south); see legend for symbols. Note disjunct locality of *C. whippleae* in Lake County, California (*Nelson 5882*). California bioregions after Jepson Flora Project (eds.) (2024): CRH = Cascade Range Highlands; KR = Klamath Ranges; NCR = North Coast Ranges; SCR = South Coast Ranges; SNF = Sierra Nevada Foothills; SNH = Sierra Nevada Highlands **B** distribution map of *Cryptantha flaccida* (black dots), another serpentine taxon, albeit a weak indicator, sensu Safford and Miller (2020). This species is plotted separately because of its relatively widespread distribution in California (CA) and scattered in Idaho (ID), Oregon (OR), Washington (WA) and western Nevada (NV) **C** close-up of rectangle in "**A**", showing known sites of herbarium vouchers of *Cryptantha whippleae* (yellow triangles) in the Mt. Eddy region of Siskiyou County, California, labelled by collector/collection number (type at *York 3365*). Herbarium voucher sites of *Cryptantha milobakeri* (orange diamonds) in the same region are also shown. All maps from Google 2024, INEGI Data.

Morphological data are from Simpson and Kelley (2020), Simpson et al. (2021) and personal observations. Substrate rankings in bold are from rankings in Safford and Miller Table 1. Comparison of morphological features and rankings of known serpenticolous species of Cryptantha, plus C. grandiflora, a presumed close relative of C. whippleae. (2020): BE/SI = Broad Endemic/Strong Indicator; SE = Strong Endemic; SI = Strong Indicator; WI = Weak Indicator. Rarity rankings are from the CNPS Inventory (2024): 1B.1=Rare or Endangered, Seriously threatened in California; 1B.2 Rare or Endangered, Moderately threatened in California; 1B.3=Rare or Endangered, Not very threatened in California. *= Suggested rankings by the authors of this paper.

let Scupituring, Nutlet Length Extension	oth, lance-ovate, 1.5–2 mm 2/3–9/10	ly convex, margin rounded	ly convex, margin rounded vth, lanceolate to th, lanceolate to t, margin rounded	ly convex, margin rounded th, lanceolate to t, margin rounded t, margin rounded culate + papillate, t, margin rounded; t, margi	y convex, margin rounded th, lanceolate to ovate, abaxially 4, margin rounded cuate + papillate, t. margin rounded; t. margin rounded; t. margin rounded; t. margin rounded; t. margin rounded, t. margin rounded, t. margin r	y convex, margin rounded th, lanceolate to ovate, abaxially c, margin rounded aulate + papillate, c.margin rounded; c.margin rounded; c.margin rounded; c.e cavity-like th, lance-ovate, cel cavity-like th, lance-ovate to th, lance-ovate to th	y convex, margin rounded th, lanceolate to ovate, abaxially t, margin rounded aulate + papillate, t, margin rounded; t, margin rounded; t, margin rounded, t, margin rounded, t, margin rounded, t, margin rounded, t, nargin rounded, t, nargin rounded, t, nargin rounded, t, nargin rounded, t, nargin rounded, th, lance-ovate, th, lance-ovate to th, lance-ov	y convex, margin rounded th, lanceolate to ovate, abaxially (, margin rounded aulate + papillate,), margin rounded; ole cavity-like th, lance-ovate,), margin rounded, ole cavity-like th, lance-ovate, margin rounded (), and th in angin rounded th, lance-ovate to th, lance-ovate	y convex, margin rounded th, lanceolate to ovate, abaxially ¢, margin rounded ulate + papillate, cotte, abaxially ¢, margin rounded; ole cavity-like th, lance-ovate, th, lance-ovate, th, lance-ovate, th, lance-ovate, th, lance-ovate to th, l
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Stem Vestiture	Strigose or strigose and spreading-hispid	Spreading- hirsute only	Strigose or strigose and hirsute to hispid	Strigose only		Strigose and spreading-hispid	Strigose and spreading-hispid Strigose and spreading-hispid	Strigose and spreading-hispid Strigose and spreading-hispid Strigose and ascending to spreading-hispid	Strigose and spreading-hispid Strigose and spreading-hispid ascending to spreading-hispid strigose and spreading-hispid spreading-hispid hirsute to hispid
Height	10–50 cm	8–25 cm	5-30 cm	15-50 cm		5-35 cm	5–35 cm 10–50 cm	5–35 cm 10–50 cm 8–25 cm	5–35 cm 10–50 cm 8–25 cm 10–50 cm
Rankings	Mostly not serpentine (except San Luis Obispo Co), MI*	Serpentine, BE/SI, 1B.2	Rarely serpentine, WI , 1B.1	Rarely serpentine, WI		Not serpentine; rocky, clay, or volcanic soils	Not serpentine; rocky, clay, or volcanic soils Serpentine, SE	Not serpentine; rocky, clay, or volcanic soils Serpentine, SE Serpentine, SE, 1B.3	Not serpentine; rocky, clay, or volcanic soils Serpentine, SE SE, 1B.3 Serpentine, SI
Taxon	C. clevelandii var. clevelandii (in part)	C. dissita	C. excavata	C. flaccida	-	C. grandiflora	C. grandifiora C. hispidula	C. grandifiora C. hispidula C. mariposae	C. grandiflora C. hispidula C. mariposae C. milobakeri

its closest relative is the "rough" nutlet species *C. ambigua* (Simpson et al. 2017a; Mabry and Simpson 2018)] *Cryptantha whippleae* shows some variation in nutlet size and shape. Nutlets range from 1.6 to 2.6 mm long and 0.7 to 1.4 mm wide (at widest point). The shape ranges from lance-ovate to ovate, generally being near the boundary between these two (arbitrary) morphological terms (Fig. 3). As summarised in the Diagnosis, *Cryptantha whippleae* differs from *C. milobakeri* in plant height, stem and calyx vestiture and nutlet number. It differs from *C. grandiflora* in plant height, inflorescence cymule number and nutlet number (see Figs 4–6 and Table 1 for comparisons).

We note anecdotally the observation of apparent herbivory of the basal leaves of some *Cryptantha whippleae* specimens. Herbivory of *Cryptantha* species has been documented in South America (Villagrán et al. 2003; Echeverría et al. 2020), but requires further documentation in the North American continent.

In conclusion, we list *Cryptantha whippleae* as a serpentine endemic (Table 1), given that all are cited on collection labels to occur on that substrate, except for the *Nelson 5882* specimen, which we think could be. It is possible, with the publication of this paper, that other specimens of *Cryptantha whippleae* will show up in herbaria or from subsequent collections between the Shasta-Trinity region and the Lake County population. Surveys at and around the disjunct *Nelson 5882* specimen of Lake County will be valuable in order to confirm the occurrence of *C. whippleae* on a serpentine substrate. We also hope to obtain data on the interrelationships of populations from future molecular phylogenetic studies. The discovery of this new species highlights the need for additional taxonomic work on the flora of California, both from field collections and study of existing herbarium specimens.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

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Author contributions

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Data availability

All of the data that support the findings of this study are available in the main text.

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PhytoKeys

Research Article

Spiradiclis yanii (Rubiaceae), a new species from Guangxi, China

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Abstract

Spiradiclis yanii Y.Nong & L.Wu (Rubiaceae), a new species from Guangxi, China, is described and illustrated. This new species is most similar to *S. tomentosa*, but it can be easily distinguished by being densely multicellular villous, leaves narrow elliptic or oblanceolate, apex acute or shortly acuminate, stipules 2–4, linear or linear lanceolate, 4–8 mm, densely villous, corolla tube 3 mm, sparsely pubescent inside, flower homomorphism, lobes 3–5, stamens arising at the base of the tube, stigma 2-lobed, lobes ovoid, slightly swollen, 0.2 mm. The habitat of *Spiradiclis yanii* is extremely fragile. Therefore, this species deserves close attention and protection.

Key words: Longan, limestone, new species, sinkhole, taxonomy

Introduction

Spiradiclis Blume most closely resembles Ophiorrhiza L. and the two genera are in the same tribe Ophiorrhizeae, based on morphological characters (Verdcourt 1958; Darwin 1976; Lo 1999; Chen and Taylor 2011; Wu et al. 2019) and molecular evidence (Bremer 2009; Rydin et al. 2009; Wikström et al. 2013). Robbrecht (1988, 1993) accepted earlier conclusions that Spiradiclis is related to Ophiorrhiza; a more recent study, based on molecular data, suggests that the situation may be more complex and calls into question the separation of these genera (Rydin et al. 2009). Even so, the monophyly of the two genera is guestioned (Razafimandimbison and Rydin 2019). However, Spiradiclis is morphologically different from Ophiorrhiza by its linear-oblong or subglobose capsules with four valves (vs. obcordate and compressed capsules with two valves) when mature. Since the delimitation and relationship of the two genera still need further research, we prefer to accept the traditional concept of Spiradiclis here due to its unique capsule form. Subsequently, more than 20 new species of Spiradiclis have been discovered in the last decade (e.g. Wang 2016; Zhang et al. 2018; Pan et al. 2019; Tong et al. 2020; Cai et al. 2022).



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Copyright: [©] You Nong et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). During our field surveys in Longan County, Guangxi in March 2024, we found a special *Spiradiclis* population in flower and fruit that was morphologically similar to the species *S. tomentosa* D. Fang & D. H. Qin. However, this special population is distinctly different from *S. tomentosa*, based on being densely multicellular villous, leaves elliptic or oblanceolate, apex acute or shortly acuminate, mid-vein flat adaxially and convex abaxially, stipules 2–4, densely villous. Therefore, we proposed that this special population may represent a new species after we carried out more observations and examining many specimens of *Spiradiclis* from the Herbaria PE, IBK, GXMI and KUN and consulting relevant literature (Lo et al. 1983; Wang 2002; Wang et al. 2015; Wu et al. 2015, 2016, 2019; Pan et al. 2016; Liu et al. 2017; Zhang et al. 2018; Wen et al. 2019; Li et al. 2021; Song et al. 2022). Finally, we carried out one more field survey to confirm that the unusual plant is a species of *Spiradiclis* new to science and we describe it below.

Materials and methods

Morphology

The new species was described, based on field observations that were made in March 2024 and examination of herbarium specimens at GXMI. Other related *Spiradiclis* species were examined, based on online images from the Kew Herbarium Catalogue (http://apps.kew.org/herbcat/gotoHomePage.do) and JSTOR Global Plants (http://plants.jstor.org/) and PE, IBK and KUN. Morphological characters that distinguish it from all other species in the genus of *Spiradiclis* are used. We also observed living plants of the new species at flowering and fruiting time (March). We observed characters of stems, leaves, pedicels, flowers, receptacles, petals, stamens, gynoecium, carpels, size of flowers, size and shape of petals, number of stamens and the shape of gynoecium and fruit.

Descriptions were written from herbarium specimens. Measurements were made with a tape measure and calipers. The structure of the indumentum and its distribution were observed and described under a dissecting microscope at magnifications of more than 20×. Additional information on locality, habitat, ecology, plant form and fruits were collected in the field and taken from herbarium labels. The conservation threat assessment followed IUCN Categories and Criteria (IUCN 2022).

Results and discussion

Taxonomy

Spiradiclis yanii Y.Nong & L.Wu, sp. nov.

urn:lsid:ipni.org:names:77350291-1 Figs 1-4 Chinese name: yán shì luó xù cǎo (严氏螺序草)

Diagnosis. Spiradiclis yanii is most similar to S. tomentosa, but is different in being densely villous without knots (vs. densely grey-viscid multicellular tomentose); leaves narrow elliptic or oblanceolate (vs. oblanceolate, obovate or rarely elliptic); apex acute or shortly acuminate (vs. apex cuspidate to rounded); mid-vein flat adaxially and convex abaxially (vs. mid-rib and lateral veins nearly



Figure 1. Habitat of Spiradiclis yanii Y.Nong & L.Wu on cliffs at the bottom of the sinkhole. Photographed by YN.

flat on both sides); stipules 2–4, linear or linear lanceolate, 4–8 mm, densely villous (vs. stipules persistent, triangular, 8–22 mm, tomentose); corolla tube 3 mm, sparsely pubescent inside (vs. tube 6–8 mm, glabrous inside); lobes 3–5 (vs. lobes 5); stamens arising at the base of the tube (vs. located at the throat of the corolla); stigma 2-lobed, lobes ovoid, slightly swollen, 0.2 mm (vs. stigma deeply bifid with linear lobes, 1–1.5 mm). At first glance, it also looks similar to *S. villosa* X. X. Chen & W. L. Sha, but differs by its leaves narrow elliptic or oblanceolate, 5–10 × 2–2.5 cm, densely villous adaxially and abaxially (vs. leaves oblong-elliptic or obovate-elliptic, $10-25 \times 3-8$ cm, adaxially dark brown pubescent, abaxially densely brown villous), petiole 0.5–1 cm (vs. petiole 3.5–7 cm), stipules 2–4, linear or linear lanceolate, 4–8 mm, densely villous (vs. stipules 2-lobed, densely dark brown villous, lobes laciniate, 15–30 mm). More detailed morphological differences amongst the three species are shown in Table 1.

You Nong et al.: Spiradiclis yanii (Rubiaceae), a new species from Guangxi, China



Figure 2. Line drawing of *Spiradiclis yanii* Y.Nong & L.Wu **A** flowering branch **B** flower **C** ovary and stigma **D** filaments of stamens and perianth **E** capsule **F** seeds **G** stipules (Drawn by Xin-cheng Qu).

Morphological traits	S. yanii	S. tomentosa	S. villosa
Plant height	5–25 cm	3-23 cm	30-50 cm
Stems	densely multicellular villous	densely grey-viscid multicellular tomentose	densely dark brown villous
Leaves	elliptic or oblanceolate, 5-10 × 2-3 cm	oblanceolate, obovate or rarely elliptic, 3.5–14 × 1.5–5 cm	oblong-elliptic or obovate-elliptic, 10-25 × 3-8 cm
Pedicel	0.5-1 cm	0.5-4.5 cm	3.5-7 cm
Stipules	2–4, linear or linear lanceolate, 4–8 mm, densely villous	persistent, triangular, 8–22 mm, tomentose	2-lobed, lobes laciniate, 15–30 mm. densely dark brown villous
Corolla tube	3 mm, sparsely pubescent inside	6–8 mm, glabrous inside	Inflorescences and flowers not seen
Stamens	arising at the base of the tube, not protruding	arising at the throat of the corolla, slightly protruding	_
Style and stigma	style 2–3 mm, lobes ovoid, slightly swollen, 0.2 mm	style 6–7 mm, stigma is deeply bifurcated, lobes linear, 1–1.5 mm	_
Capsule	obovate, ca. 1 mm	subglobose, ca. 2 mm	ovoid, ca. 2 mm

Table 1. Main morphological differences amongst Spiradiclis yanii, S. tomentosa and S. villosa.

Holotype. CHINA • Guangxi: Longan, 23°03'03"N, 107°22'20"E, alt. 327 m, on the cliff at the bottom of a sinkhole, 7 March 2024, *Y Nong NY2024030701* (GXMI) (holotype: GXMI!; isotypes: IBK!).

Description. Perennial herbs, erect, 5–25 cm tall, stems cylindrical, 1–2 branches, densely multicellular villous when young, but grabrous when old-;Leaves opposite, leaf blade drying membranous, narrow elliptic or oblanceolate,



Figure 3. Spiradiclis yanii Y.Nong & L.Wu A, B plant (flowering and fruiting) C inflorescence (lateral view) D inflorescence (front view, corolla lobes 3–5) E flower (front view) F stamens, ovary and stigma G infructescence (lateral view) H calyx and bracts I capsule J seeds K leaf (adaxially view) L leaf (abaxially view) M, N stipules (Photographed by Ke-Jian Yan & You Nong, edited by You Nong).

 $5-10 \times 2-2.5$ cm, densely multicellular villous adaxially and abaxially, base cuneate or acute, apex acuminate or shortly acuminate,petiole 0.5–1 cm, densely villous;Mid-vein flat adaxially and convex abaxially,secondary veins 9–14 pairs; Stipules 2–4, linear or linear lanceolate, 4–8 mm, densely villous. Inflorescence terminal, paniculiform, peduncles 6–15 cm,densely villous,pedicels 3–6 mm,bracts linear, 3–7 mm; Hypanthium portion turbinate, 4 mm, calyx lobes 5, linear or narrow lanceolate, 1.5–2 mm; Flower homomorphism,corolla white, lobes 3–5, ovate, 2–3 mm, outside sparsely pubescent, glabrous inside, tube 3 mm, sparsely pubescent inside; Stamens 5, arising at the base of the tube, not protruding, glabrous, filaments 2 mm, anthers oblong, 0.5 mm; top of the ovary 4-lobed, sparsely pubescent; Ovary 2-loculed, with many ovules, style 2–3 mm, glabrous, stigma 2-lobed, lobes ovoid, slightly swollen, 0.2 mm;

Figure 4. Digital images of type specimens A Spiradiclis yanii B S. tomentosa C S. villosa.

Figure 5. The distribution of Spiradiclis yanii (red circle) in Guangxi, China.

Capsule obovate, ca. 1 mm in diam., valves 4, persistent calyx lobes 2–4 mm; Seeds numerous, small and angular.

Phenology. Flowering and fruiting in February to March.

Etymology. The new species is named after Mr. Ke-Jian Yan, who worked in Guangxi Institute of Chinese Medicine & Pharmaceutical Science and made many contributions to GXMI, especially in Rubiaceae and Lamiaceae.

Distribution and habit. Known only from the southeast of Guangxi, China. It has been mainly found on cliffs at the bottom of a sinkhole at elevations of 320 m.

IUCN red list category. Data available for the new species are still insufficient to assess its conservation status. According to the IUCN Criteria (IUCN 2022), it is considered Data Deficient (DD) until more information becomes available. Although *S. yanii* currently has relatively good growth, further collection and monitoring are necessary to allow more conclusive estimations about the rarity and vulnerability of the species. Therefore, special attention should be given to the conservation of the new species of *Spiradiclis*.

Additional specimen. Longan • Southeast Guangxi: limestone hills, 7 November 2011, J.C. Yang&Y.B. Liao TK028 (IBK!); Longan, 14 March 2024 Y Nong NY2024031401 (GXMI!).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Data curation: YN. Funding acquisition: YN, CGX. Investigation: YN, CGX, YGW. Methodology: YN, LQL, YGW. Project administration: YN, ZYZ. Supervision: BF, LW. Visualisation: YN, LQL. Writing-original draft: YN. Writing-review and editing: YN

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Data availability

All of the data that support the findings of this study are available in the main text.

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PhytoKeys

Research Article

Pothos deleonii (Araceae, Potheae, Pothoideae), a new species from Bukidnon, Mindanao, Philippines

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Abstract

A new species of *Pothos* is described and illustrated. This species is very similar to *Pothos philippinensis* (sheathing and leaf morphology) but differs by the inflorescence and flowers. It is closely related also to *P. kingii* by the deep purple inflorescence, but differs in having longer peduncle, broadly ovate-concave to cucullate spathe (which is deep wine-red when fresh to purplish-black when senescing), and the spadix that is 7/10th the entire length of the spathe.

Key words: Allopothos, Araceae, aroid diversity, critically endangered, endemic, *Pothos philippinensis*

Introduction

Pothos L. (Araceae Juss., Pothoideae, Potheae ; Mayo et al. 1997; Cusimano et al. 2011; Chartier et al. 2014; Haigh et al. 2022) is a genus comprising 65 species (WCPV 2024) distributed in subtropical to tropical regions from Madagascar to Oceania, China to Australia with Borneo as the center of diversity (Boyce 2000; Boyce and Hay 2001; Wong and Boyce 2019). Morphologically, it includes forest-dwelling hemiepiphytes (Zots 2013; Zots 2020; Zots et al. 2021a, 2021b) with bisexual flowers (Linnaeus 1753). Recently, a number of new species were recorded in Asia (Nguyen et al. 2017; Wong and Boyce 2019; Rajkumar et al. 2020; Wong et al. 2020) and the latest is the new combination, *P. venustus* (Wall. ex C.DC.) A.Hay & P.C.Boyce in Malesia (Hay and Boyce 2022).

In the Philippines, a total of eight species [*P. cylindricus* C. Presl, *P. dolichophyllus* Merr., *P. inaequilaterus* (C. Presl) Engl., *P. insignis* Engl., *P. luzonensis* (C. Presl) Schott, *P. ovatifolius* Engl., *P. philippinensis* Engl., and *P. scandens* L.] have been recorded (Boyce and Hay 2001) of which four are endemic (Pelser et al. 2011). Two species (*P. insignis* and *P. ovatifolius*) are confined in Borneo, Sulawesi, Sumatera, Malay Peninsula, and Philippines, while *P. scandens* is widely distributed in Asia and other South-East Asian regions. The last complete revision of *Pothos* including the Philippine species was published by Boyce and Hay (2001). Subsequently, no additional species of *Pothos* from the Philippines has been published.



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During bird expeditions in 2019 by Dr. Miguel De Leon, he observed a species of aroid with very striking inflorescence in one of the Robert S. Kennedy Bird Conservancy conservation sites in Bukidnon. The plant was collected because of its unique and regal inflorescence. Last February of 2024, this new species was again observed and photographed *in situ*. The original collection and fresh material were sent for further examination by the authors. Morphologically, the observed plants are distinct and do not match with any described species of *Pothos*. As a consequence, we here propose to describe a new species for science.

Material and methods

The voucher specimens were collected from the type locality last February 18, 2024 with Gratuitous Permit R-102024-22. Specimens were processed using the methods of Bridson and Forman (1999) and deposited at the herbaria **PNH**, and **CMUH** (acronyms according to Thiers 2024, continuously updated). Detailed photographs and a description were taken from fresh materials in the field using a digital camera. Taxonomic identification was based on morphological vegetative and reproductive characters following the aforementioned literature.

Taxonomic treatment

Pothos deleonii M.P.Medecilo-Guiang & D.Cabactulan, sp. nov.

urn:lsid:ipni.org:names:77350292-1 Figs 1, 2

Type. PHILIPPINES • Bukidnon Province, Manolo Fortich date: February 18, 2024, MPMG1005 (holotype PNH! PNH259023); isotypes CMUH!)

Diagnosis. This new species is morphologically similar to *Pothos philippinensis* based on vegetative characters but differs by the purplish peduncle, dark wine red to purplish black spathe and pendulous peduncle and acuminate to caudate (vs. acuminate to apiculate) leaf apex. *P. deleonii* is closest to *R. kingii* and *P. atropurpurascens* M. Hotta by having a purple cylindrical spadix but differs from 2 later species by having a much longer, purplish green to dark purple peduncle, 16–18 cm long (vs 5 cm long in *P. kingii* and 8 cm in *P. atropurpurascens*) broadly ovate spathe, subsessile spadix and 7/10 the entire length of the spathe, bigger diameter of flowers (2 mm) and flower orientation.

Description. Plant growth glabrous, root climbing, fibrous liana. **Stem** moderate slender, slightly woody, terete, green, internodes 2 cm long by 7 mm in diameter in juvenile stage and 7 cm long by 3 mm in diameter upon maturity, younger shoots arising above from the base of the half of the entire length of older stem. **Roots** present along stem when juvenile, fewer to absent towards the terminal shoots with inflorescence. **Leaves** spreading, long petiolate, petiole slender angular, 45 degree angled towards the stem, 6–15 cm long by 4–12 mm in diameter, petioles deeply canaliculate with petiolar sheath prominently distinct, erect extending to pulvinus and imbricate to the stem, base decurrent, apex prominently geniculate, petiolar sheath apically ligulate in young growth, ligule and sheath margins later scarious-disintegrating, 7–14 cm long by 0.6–2.5 mm wide, 7/8 of the entire length of the petiole. **Lamina** oblong-lanceolate, occasionally falcate, asymmetrical, coriaceous, margins entire, flat-



Figure 1. *Pothos deleonii* M.P Medecilo-Guiang and D. Cabactulan **A** habit with flowering branch **B** leaf apex **C** leaf base **D** venation pattern **E** inflorescence **F** detail of spadix.

tened, shallowly sinuate to slightly conduplicate, 15.5–26.3 cm long by 4–6 cm wide, apex acuminate to caudate and thickened, base acute to obtuse, slightly cordate in juvenile stage, adaxially slightly glossy, dark green and abaxially pale green. Venation closely pinnate, brochidodromous, midrib pale green, adaxially flattened and abaxially rounded raised, primary lateral veins arising running at the base of midrib towards the intra-marginal veins, secondary veins arising at each primary lateral vein, close-spaced disorganized reticulated towards



Figure 2. Line drawing of *Pothos deleonii* **A** whole plant **B** leaf phyllotaxy **C** venation pattern **D** Inflorescence **E** detail of spadix: Scale bars: 10 mm (**B**); 15 mm (**D**); 5 mm (**E**).

the intra-marginal vein, 2 intra-marginal veins on both sides of the leaf, arising from the base of midrib towards the apex, disorganized reticulated, primary intra-margins 6.5–9.0 mm wide, secondary intra-margins 0.8–1.0 mm wide, venation adaxially less prominent to absent when fresh and slightly present

when dry, abaxially prominent visible in both fresh and dry state, intra-marginal veins raised abaxially when dry, outer intramarginal vein remaining very close and parallel to margin. Inflorescence solitary, elongated, deflexed, pendent, and arising from each terminal of matured stem, positive geotropic. Peduncle long terete, stout, deflexed, base purplish-green, dark purple towards the base of the spathe, 16-18 cm long by 2-3 mm in diameter. Spathe broadly ovate, concave to cucullate, apex acuminate, curved, base cordate and slightly decurrent on the peduncle, dark wine red when fresh and purplish black when near wilting, 9.2-10.0 cm long and 4.5-5.5 cm wide, softly-leathery when fresh and papery when dried, prominently 9-nerved, veins dirty white when fresh and dark purplish black when dried, less prominent acrodomous venation. Spadix long cylindrical, stout, subsessile, dark purplish, 6.4-6.9 cm long by 3.5-4.0 mm in diameter, 7/10 the entire length of the spathe, flower c. 2.7 mm, tepals 1 mm by 0.70 mm, oblong-cymbiform, dark purplish-black, apex fornicate, triangular, truncate, minutely 3-4-lobed, flower compressed angular-ellipsoid, black purplish, stylar region truncate, centrally depressed, 1.5 mm in diameter, stigma prominently punctiform, stamens, 0.3 mm long by 0.1 mm wide, filaments strap-shaped, thecae c. 0.2 mm in diameter, creamy yellow, ovary 1.0-1.6 mm high by 0.25–0.70 mm in diameter, fertile zone 5.2–5.8 cm long, appendix 8-11 mm long. Infructescence not observed.

Ecology and habitat. Known only in a highly restricted area in two sites in degraded secondary, open-canopy dipterocarp forest in a 500-hectare avian conservation site located at the northern foothills of Mt. Kitanglad, 1,150 and 1,270 m a s l. The plant grows from the ground or at the base of trees (*Shorea* sp.) and trunk of *Alsophila* sp., 12–20 cm dbh; adherent to host plants from the ground to 4–6 meters, at which plants become branched and grow freely, either pendent or supported by vines or branches of adjacent trees. No specific association with plants other than host plants can be gleaned. But the habitat is favorable to other aroids like *Alocasia sanderiana*, *A. zebrina*, and *Rhaphidophora* sp.

Distribution. Philippines. BUKIDNON: Manolo Fortich, (exact location withheld as a conservation measure).

Vernacular. None recorded.

Etymology. The specific epithet honors Dr. Miguel David De Leon, a vitreoretinal surgeon and wildlife conservationist, who first photographed the species *in situ*, and supports the conservation of wild flora, particularly orchids and hoyas, and fauna, specifically raptors, in Mindanao.

Uses. No known usage in traditional medicine; potentially valuable in horticulture.

Conservation status. Extensive survey in the 500-hectare area revealed only 12 mature individuals. Because the plants are located in an avian conservation site and constantly monitored by the Robert S. Kennedy Bird Conservancy, there are currently no threats. However, due to its small population and highly restricted extent of occurrence (less than 2 hectares), this species is considered as Critically Endangered based on the criteria of IUCN (2024).

Notes. *P. deleonii* belongs to subgenus *Allopothos* under the *Pothos barberianus* group and it is closely related to the Philippine endemic *P. philippinensis* and two Malaysian species: *P. kingii* and *P. atropurpurascens* but differs in the size, shape, color and orientation of other floral segments (Table 1).

	Pothos deleonii	P. philippinensis	P. kingii	P. atropurpurascens
Leaves				
Color	dark green	drying dull greenish brown	bright to mid-green	midgreen
midrib	pale green	slightly paler green	slightly paler green	pale yellow
blade shape	adaxially flattened and adaxially raised	ovate to oblong elliptic or narrowly lanceolate	prominently raised	slightly raised
base	oblong lanceolate, occasionally falcate	rounded, rarely truncate or cordate	ovate to elliptic or lanceolate	ovate-elliptic to narrowly oblong elliptic or oblanceolate
apex	acute to obtuse, slightly cordate	acute to long attenuate	acute to rounded	acute to obtuse
primary lateral	acuminate to caudate	apiculate	acute or attenuate	rounded and abruptly cuspidate, minutely apiculate
veins	arising at 85–90°	arising at c. 45°	45-65°	65-80°
Peduncle	deflexed ca. 90° at base	nodding to deflexed	reflexing held inverted	reflexed c. 90° at base
Spathe shape	broadly ovate concave to cucullate	triangular, subcucullate	ovate, deeply cucullate	ovate, deeply cucullate
apex	acuminate	long-acuminate	acute	acute to attenuate
color	dark wine red to dark purple	pale green	deep purple inside and out	white stained purple
Spadix	subsessile	sessile but basally decurrent on spathe	sessile	sessile
color	dark purple	paler green	deep purple-brown	deep purple gray
Flowers	ca. 2.7 mm	c. 1.3 mm	1 mm	1.2 mm

Table 1. Morphological comparison of P. deleonii, P. philippinensis, P. kingii and P. atropurpurescens.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Conceptualization: MMPM-G, DC; Collection: MMMG; Data Collection: MMPM-G, DC; Formal analysis: MMPM-G, DC; Funding acquisition: MMPM-G.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Research Article

Vincetoxicum nakaianum (Asclepiadoideae, Apocynaceae), a new species from Japan for Cynanchum magnificum Nakai, nomen nudum

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Abstract

Vincetoxicum Wolf is the third largest genus in Asclepiadoideae, and 23 species are distributed in Japan. We discovered that an erect herb species, distributed in the eastern part of the Honshu island, was invalidly named *Vincetoxicum magnificum* (Nakai) Kitag. based on *Cynanchum magnificum* Nakai, nomen nudum. Therefore, we presently name this species *Vincetoxicum nakaianum* K.Mochizuki & Ohi-Toma, and we give a detailed description in this study. Additionally, we provide photographs that demonstrate its ecology and diagnostic characteristics.

Key words: Asclepiadoideae, Cynanchum magnificum, Japan, Vincetoxicum magnificum

Introduction

Within the Apocynaceae, the subfamily Asclepiadoideae comprises approximately 3,000 species in 183 genera distributed worldwide (Endress et al. 2018). These plants are characterized by the presence of pollinia, one pollinium per locule, and gynostegia with a highly modified stamen and pistil. The pollinia and stigmata are normally spatially isolated, which suggests that the members of this group strongly rely on animals for pollination (Ollerton and Liede 1997). Because their floral structure physiologically limits access by pollinators, many asclepiads possess specialized pollination systems involving specific animals (Mochizuki et al. 2017; Shuttleworth et al. 2017). The highly specialized pollination systems and the easy assessment of pollinators (determined by the presence of pollinia on the pollinator body) make Asclepiadoideae a good model for studies of pollination (Ollerton and Liede 1997; Ollerton et al. 2019).

Vincetoxicum Wolf (tribe Asclepiadeae) is the third largest genus in Asclepiadoideae, comprising ca. 260 species that geographically extend from the tropics of Africa, Asia, and Oceania to temperate regions from Eurasia (Liede-Schumann et al. 2016; Endress et al. 2018; Liede-Schumann and Meve 2018; POWO 2024). In total, 23 *Vincetoxicum* species are known from Japan, including 16 endemic species (Yamashiro 2017). A recent molecular phylogeny



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Copyright: [©] Ko Mochizuki et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). subdivided Japanese *Vincetoxicum* into four groups: a "Far Eastern" clade comprising 11 species endemic to Japan and four wider-ranging species, a single species that was sister to the "Far Eastern clade", a "subtropical" clade comprising two species, and a "*Vincetoxicum* s. str." clade comprising five species (Liede-Schumann et al. 2016).

Vincetoxicum magnificum (Nakai) Kitag. (Japanese common name: tachi-gashiwa), a perennial herb species endemic to Japan, is closely related to Vincetoxicum macrophyllum Siebold. & Zucc. (Japanese common name: tsukushi-gashiwa) and Vincetoxicum macrophyllum var. nikoense Maxim. (= Cynanchum nikoense (Maxim.) Makino; Japanese common name: tsuru-gashiwa), which belong to the basal lineage of the "Vincetoxicum s.str." clade (Liede-Schumann et al. 2016). These three taxa have been recognized in several publications thus far, including the recent flora of Japan (Yamazaki 1993; Yamashiro 2017). Recently, the first author introduced V. magnificum in Curtis's Botanical Magazine (Mochizuki et al. 2024); however, we subsequently noticed that the name was not validly published according to the International Code of Nomenclature (ICN, Shenzhen Code; Turland et al. 2018). This species was first published by Nakai (1937) as Cynanchum magnificum Nakai, in association with a taxonomic study of related species V. macrophyllum (as Cynanchum grandifolium Hemsl.) and V. macrophyllum var. nikoense (as Cynanchum nikoense (Maxim.) Makino). In that publication, the name Cynanchum magnificum Nakai was proposed for the "tachi-gashiwa" populations distributed in the Kanto region of Honshu, Japan; however, no Latin description, diagnosis, or even an indirect reference to any former description was provided. Therefore, the name Cynanchum magnificum Nakai is a nomen nudum (ICN Art. 38.1 and 39.1). Later, based on this nomen nudum, Kitagawa (1959) published Vincetoxicum magnificum (Nakai) Kitag.; therefore, this combination was not validly published (ICN Art. 6.10 and 41.5). In addition, the name cannot be considered as a species novum, "Vincetoxicum magnificum Kitag.", because it was not accompanied by a description, diagnosis, or a reference to a previously and effectively published Latin description or diagnosis (ICN Art. 38.1 and 39.1).

In this study, the Japanese species "tachi-gashiwa" is validly described as *Vinc-etoxicum nakaianum* K.Mochizuki & Ohi-Toma (ICN Art. 6.9, 38.1, and 39.1), with a detailed description and photographs of living plants. In this case, our proposed name is not "nomen novum" but "species nova" because the names *C. magnificum* and *V. magnificum* have never been validly published (ICN Art. 6.11).

Material and methods

To provide a detailed description of *Vincetoxicum nakaianum*, we inspected approximately 50 herbarium specimens in TI for the measurement of vegetative traits, follicles, and seeds. We examined 20 flowers collected from the field (Nikko Botanical Garden, the University of Tokyo) for the measurement of floral traits and dissected 10 flowers to examine staminal traits. The measurement was conducted using ImageJ ver. 1.48 software (Schneider et al. 2012).

We consulted herbarium specimens to establish the distribution information at TI, TUS, KPM, and CBM, as well as digitized specimen images of TNS, ICM, FKSE, BDCJ, and NAC. We examined ca. 160 specimens in total excluding misidentified sheets. The conservation status of *Vincetoxicum nakaianum* ("tachi-gashiwa") was calculated following the IUCN Red List categories and criteria v3.1 (IUCN 2012) and IUCN guidelines (IUCN 2019). The Extent of Occurrence (EOO) and Area of Occupancy (AOO) were calculated using the GeoCAT software (Bachman et al. 2011). Further, to complement our calculation, we consulted the red data book published by the Ministry of the Environment of Japan (https://www.env.go.jp/content/900515981.pdf), which is based on the IUCN criterion.

Taxonomic treatment

Vincetoxicum nakaianum K.Mochizuki & Ohi-Toma, sp. nov.

urn:lsid:ipni.org:names:77350303-1 Figs 1-3

Cynanchum nikoense (Maxim.) Makino pro parte, Somoku-Dzusetsu, ed. 3.
1: 299 (1907), in nota excl. basionym; Makino, Bot. Mag. (Tokyo) 22: 169 (1908), excl. basionym et synonym; Makino & Nemoto, Fl. Jap.: 329 (1925), quoad descr. tantum; Makino, III. Fl. Jap.: 241, f. 460 (1925); Makino, III. Fl. Nippon: 207, f. 619 (1940).

Type. JAPAN, Pref. Tochigi • Nikko city, Nikko Botanical Garden, naturally distributed, 36°44'59.9"N, 139°35'15.1"E, alt. 640 m, 22 May 2021, fl., *K. Mochizuki KMH0484* (holotype: TI[00239769]).

Diagnosis. Vincetoxicum nakaianum is morphologically similar to V. macrophyllum but is distinguished by an erect stem terminated by an inflorescence, and larger, greenish to brownish flowers, 10–15 mm in diam. (vs. flowers dark purple and 4–5 mm in diam.) with a glabrous corolla (vs. villous).

Description. Perennial herb 30-60 cm in height. Roots fibrous fascicled. Rhizome short, erect. Stems erect, weakly pubescent, not branched, 4-6 mm in diam., terminated by an inflorescence. Leaves opposite, 1-4 pairs crowded near the shoot apex; petiole 1-4 cm long; blade broadly ovate to rhombic, 3-8 cm long, 2-6 cm wide when flowering, 8-20 cm long, 5-13 cm wide when fruiting. Inflorescence terminal and sometimes axillary, densely umbellately cymose; flowers 10-30, 5-merous, 10-15 mm in diam., weakly pubescent, greenish; peduncle 5-20 mm long, unbranched; pedicels glabrous, 5-15 mm long, ca. 0.5 mm in diam., greenish; calyx rotate, weakly pubescent on abaxial surface, 4-6 mm in diam., deeply lobed, lobes lanceolate, ca. 2 mm long, ca. 0.7 mm wide, apex obtuse to acute; corolla rotate, 10-15 mm in diam., dull brownish to dull greenish, deeply lobed, lobes oblong, apex obtuse to orbicular, 6-9 mm long, 2-3 mm wide, both surfaces glabrous, apex obtuse to orbicular; gynostegial corona fleshy, 1.5-2 mm long, 1.5-2 mm in diam., lobes 0.75-1 mm long, ca. 1 mm wide, apex obtuse to orbicular and medially angustate. Gynostegium 1-1.5 mm in diam., slightly below level of corona; stylehead flattened, 0.5-1 mm in diam. Stamen 0.6-0.8 mm long, 0.4-0.5 mm wide; anther wings 0.2–0.25 mm long; connective appendage membranous, ovate, 0.1-0.17 mm long, 0.3-0.4 mm wide. **Pollinarium: corpusculum** narrowly oblong, ca. 0.12 mm long; caudicles oblong, ca. 0.04 mm long, sub-basally connected to corpusculum at a 120° angle; pollinium ellipsoid, ca. 0.08 mm long, ca. 0.05 mm wide, subapically attached to caudicle. Follicles usually two per



Figure 1. Vincetoxicum nakaianum K.Mochizuki & Ohi-Toma A habitat and flowering stems of a single individual B young inflorescence and coetaneous leaves C mature inflorescence D flower E top view of gynostegium F shoots of previous year (black triangles) and current year (white triangles) G young follicles H seed. Scale bars: 3 cm (A); 1 cm (B, C, F–H); 2 mm (D); 0.5 mm (E).

flower, erect, divaricate at a 70° – 100° angle, 7–15 cm long, narrow-lanceolate, gradually attenuate to apex. **Seeds** brown, slightly winged, narrowly ovate, 10–15 mm long, 2–3.5 mm wide; **coma** 2–5 cm long, silver.

Japanese common name. Tachi-gashiwa. Makino (1890) was the first to mention the common name "tachi-gashiwa" as a misidentification for *Vince-toxicum macrophyllum* Siebold & Zucc.

Phenology. Flowering from late March to May; fruiting from June to February. **Distribution and habitat.** Japan. Alt. ca. 100–850 m. Central to northern Honshu: Prefs. Aomori, Iwate, Miyagi, Fukushima, Gunma, Tochigi, Ibaraki, To-kyo, Kanagawa, Shizuoka, Yamanashi, Nagano, and Aichi (see Additional specimens examined) (Fig. 4). Grows in understories of Japanese ceder plantation forests and deciduous forests dominated by *Fagus japonica* Maxim., *Abies firma* Siebold & Zucc., *Quercus* L., *Acer* L., and *Carpinus* L.

Etymology. The species epithet honors Prof. Takenoshin Nakai (1882–1952), who conferred the name *Cynanchum magnificum* for "tachi-gashiwa".

Conservation status. Least Concern (LC). *Vincetoxicum nakaianum* is known from many populations throughout the central to northern Honshu island of Japan. Based on the specimen records, the extent of occurrence (EOO) is calculated to be ca. 79.000 km² and the area of occupancy (AOO) is 240 km². However, we should note that this result may be underestimated since the sampling does not cover all the known populations. This species is not listed in the Red Data Book of Japan published by the Ministry of the Environment (Ministry of the Environment 2020). Given that the natural habitat area has not been fragmented or reduced, it is assessed here as Least Concern according to the IUCN criterion (IUCN 2012, 2019).

Nomenclatural notes. The following not validly published "names" correspond with *Vincetoxicum nakaianum* K.Mochizuki & Ohi-Toma.

Cynanchum magnificum Nakai, J. Jap. Bot. 8(2): 69 (1937), in textu, nomen nudum. No Latin description, diagnosis, or even an indirect reference to any former description was provided. Therefore, the name *Cynanchum magnificum* Nakai is a nomen nudum (ICN Art. 38.1 and 39.1, Turland et al. 2018)

= Vincetoxicum magnificum (Nakai) Kitag., J. Jap. Bot. 34(12): 364 (1959), nomen invalidum.

Notes. *Vincetoxicum nakaianum* is unique in its early flowering habit from late March to May, while the leaves are unfolding, often with the inflorescence blooming before the leaves are fully developed (Fig. 1B). The leaves enlarge from flowering to fruiting, reaching ca. 20 cm long. This flowering habit is rare in the genus *Vincetoxicum*.

Its flowers open in the morning and persist for 2–3 days. The flowers emit a faint odor during daytime, and tiny insects are often observed flying around the inflorescence. Variations in flower color are frequently observed within large populations, ranging from entirely brown to green. In the Nikko area of Tochigi Prefecture on Honshu, this species often co-occurs with *V. macrophyllum* var. *nikoense*; however, their flowering seasons do not overlap, and *V. macrophyllum* var. *nikoense* flowers from June to September.

Although Nakai (1937) cited no specimens, we discovered one specimen (*T. Nakai, s.n.*, TI[00267868]) for which "Cynanchum grandifolium Hemsley" and "Flores viridescentes" were written on the original label by Nakai; the former was lined out and corrected to "Cynanchum magnificum Nakai, sp. nov.", also by Nakai.



Figure 2. Gynostegium and pollinarium (enlarged) A oblique view of gynostegium B pollinarium C abaxial side of a stamen covered with the corona D adaxial side of a stamen E side view of a stamen. Scale bars: 0.5 mm (A, C–E); 0.1 mm (B).

Additional specimens examined. JAPAN, Pref. Aomori: • Hashikami-cho, Mt. Hashikami-dake, 25 Jun. 1946, fr., J. Koikawa s.n. (TI[00267869]). Pref. Iwate: • Ninohe-gun, Fukuoka-machi, 30 Jun. 1967, wilted fl. and young fr., H. Hara s.n. (TI[00267870]) • Iwaizumi-cho, Egawa, 25 Aug. 1973, fr., M. Takahashi s.n. (TI[00267871]) • Shimohei-gun, Iwaizumi-machi, 22 Jun. 2000, fr., K. Yonekura 5634 (TUS[251310]) • Kesen-gun, Sumita-cho, 31 May 2001, fr., Y. Tazawa s.n. (TUS[267156]). Pref. Miyagi: • Kurihara-shi, Kurikoma, Monzi, Mt. Kurikoma-yama, 24 Jul. 1978, fr., W. Takahashi 19728 (TUS[465015]) • Kurokawa-gun, Ohmori-yama, 16 May, 1915, fl., Ogura s.n. (TI[00267874]) • Akiu, Uenohara, 6 May 1962, fl., H. Ohashi 2872, (TI[00267872]) • Oshika-gun, Kinkazan, 23 Jun. 1963, sterile, M. Takahashi s.n. (TI[00267873]) • Oshika-gun, Onagawa-cho, Mt. Dairokuten-yama, 5 Aug. 1973, fr., Y. Sasaki 1409-1 (TUS[321031]) • Iwanuma-shi, Miiroyoshi, 5 Oct. 1993, fr., T. Mori 8659-c (TUS[418789]) • Katta-gun, Zao-machi, 18 Jul. 1986, fr., T. Mori 1607 (TUS[418790]) · Kakuda-shi, Oda, 21 May 1992, fl., T. Mori 8222-b (TUS[418791]). Pref. Fukushima: • Fukushima-shi, Matsukawamachi-mizuhara, 14 May 2002, fl., T. Kurosawa 20505



Figure 3. Holotype of Vincetoxicum nakaianum K.Mochizuki & Ohi-Toma. (K.Mochizuki KMH0484, TI [00239769]).



Figure 4. Distribution map of *Vincetoxicum nakaianum* K.Mochizuki & Ohi-Toma. Dots indicate the geographic locations of the specimens examined, including the holotype. Prefectures with records based on herbarium specimens are indicated in orange.

(FKSE[14339]) • Adachi-gun, Ohtama-mura, 8 May 2001, fl., *M. Sato s.n.*(FKSE[94390]) • Sohma-gun, Odaka-machi, 4 May 1969, fl., *N. Sakurai s.n.*(FKSE[33860]) • Futaba-gun, Kashimadaira, 28 Jul. 1962, sterile, *H. Sase, s.n.* (FKSE[6199]) • Tamura-gun, Takine-machi, 30 May 1971, fl., *H. Sase 170-28* (FKSE[6196]) • Iwaki-shi, Tabitomachi, 14 May 2014, fl., *S. Nemoto 1183* (FKSE[82848]) • Ishikawa-gun, Furudono-machi, Okaze, 24 May 2020, fl., *S. Nemoto et al. 5795* (TI[00267875]) • Nishishirakawa-gun, Koseki-mura, date unknown, fl., *N. Imai s.n.* (TNS[31085]). Pref. Gunma: • Yamada-gun, Ume-da-mura, 10 May 1936, fl., *H. Koidzumi 106893* (TNS[904856]) • Kiryu-shi, Narukamiyama, May 1957, fl., *Y. Asai, s.n.* (TI[00267877]) • Kanra-gun, Shimonita-machi, Kuriyama, 18 Sept. 1954, fr., *T. Wakana WT5856* (CBM[BS5856])
• Kanra-gun, Shimonita-machi, Mt. Arafune-yama, Oct. 1954, sterile., *T. Yamazaki, s.n.* (TI[00270877]) • Kanra-gun, Shimonita-machi, Mt. Myogi-san,

28 May 1954, fl., K. Sato s.n. (TI[00270883]). Pref. Tochigi: • Nasushiobara-shi, Ooami, 4 Jun. 2005, fl., M. Tsuchiya 11243 (CBM[BS303509]) • Nikko-shi, Yamakubo, 22 Sept. 2021, fr., K. Mochizuki KMH0457 (TI[00239771]) · Nasu-gun, Bato-machi, Mt. Torinoko-san, 26 Sept. 1954, fr., S. Suzuki s.n. (TUS[243360]) · Kawachi-gun, Kamikawachi-mura, 10 May 1964, fl., C. Okawa s.n. (TNS[410216]) • Haga-gun, Mashiko-machi, Mt. Amemaki-yama, 18 May 1952, wilted fl., S. Suzuki s.n. (TUS[243359]). Pref. Ibaraki: • Kitaibaraki-shi, 3 May 1958, fl., M. Suzuki s.n. (TNS[137568]) • Kitaibaraki-shi, Sekimoto-cho, Ogawa, 19 Sept. 2001, sterile, A. Tamura s.n. (KPM[0217161]). Pref. Saitama: • Iruma-gun, Agano-mura, 17 Oct. 1934, sterlile, S. Okuyama s.n. (TNS[663437]) · Chichibu, Buko-san, 24 May, 1953, fl., S. Kurosawa s.n. (TI[00267876]) · Hannno-shi, Agano, Mt. Nenoo-gongen, 15 Jun. 1974, sterile, M. Togashi s.n. (TI[00271481]). Pref. Tokyo: • Mt. Kariyose, 8 May 1930, fl., T.Nakai s.n. (TI[00267868]), "Cynanchum magnificum Nakai, sp. nov.," in sched. • Usuigun, Usui-machi, 7 Sept. 1952, fr., I. Yokota 14 (TNS[115037]) · Hachioji-shi, Mt. Jinba, 13 May 1951, fl., S. Okuyama 9782 (TNS[101552]) • Nishitama-gun, Itsukaichi-machi, 18 Oct. 1970, sterile, M. Harimoto s.n. (TNS[754776]) • Omeshi, May 1955, fl., T. Satow 8146 (TNS[123870]) • Minamitama-gun, Asakawa-machi, Mt. Takao, 3 May 1921, fl., T. Ito s.n. (TNS[396248], TNS[61439]). Pref. Kanagawa: • Tsukui-gun, Tsukui-machi, Mt. Yakeyama, 20 Jul. 1980, fl., S. Kigawa s.n. (KPM[1000451]) • Aikou-gun, Kiyokawa-mura, 26 Jun. 1981, fr., H. Takahashi s.n. (KPM[1000449]) • Minamiashigara-shi, Saijoji, 4 Sept. 1983, fl., A. Yoshikawa s.n. (KPM[1000453]) • Isehara-shi, Mt. Ohyama, 2 May 2003, fl., M. Morikawa s.n. (KPM[0123462]) • Hadano-shi, Hane, 7 May 2015, fl., C. Akiko CKD-2-46 (KPM[0182259]) • ibid., 18 Jun. 2015, fr., C. Akiko CKD-2-166 (KPM[0181449]) • Naka-gun, Isehara-machi, 5 May 1966, fl., F. Kazami s.n. (TNS[170266]). Pref. Shizuoka: · Gotenba-shi, Higashi-tanaka, 13 Oct. 2021, sterile, K. Mochizuki KMH0460 (TI[00267878]) • Haibara-gun, Honkawane-cho, Ooma, 19 Jul. 1977, fr., F. Konta et al. SK301 (TNS[940477]) • Fujinomiya-shi, Fumoto, 30 Aug. 1977, sterile, F. Konta & T. Masuzawa 2159 (TNS[940473]) • Fujinomiya-shi, Awakura, 8 May 1998, fl., F. Konta 18501 (TNS[665002]) • Fujinomiya-shi, Saori, 4 May 1985, fl., T. Sato 7597 (TNS[940476]). Pref. Yamanashi: • Minamikomagun, Minobu-cho, 15 Jul. 1951 sterile, S. Nakagomi s.n., (BDCJ[2361]). Pref. Nagano: • Kitasaku-gun, Karuizawa-machi, 21 Jul. 1936, fr., K. Shirai s.n. (TNS[65102]) · lida-shi, Minamishinano-mura, Tayorigashima, 29 May 2010, fl., K. Hiruma s.n. (ICM[HE009442]) • Minamishinano-mura, Tayorigashima, 31 May 2020, M. Ozeki MOCL200531-10 (NAC[214171]) • Minamishinano-mura, Toyamakawa, 21 Jul. 1936, sterile, R. Fujiwara 381353-22, (NAC[65102]). Pref. Aichi: • Nishikamo-gun, Obara-mura, Apr. 1954, fl., 16 Oct. 1960, fr., K. Inami s.n. (CBM[BS72659], CBM[BS194212]).

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

KM and NS conceived of the project, KM and T.O-T conceptualized the study, KM collected data, KM prepared the figures, KM and T.O-T created the draft, KM, SN, JM, and T.O-T edit the manuscript.

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Data availability

All of the data that support the findings of this study are available in the main text.

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PhytoKeys

Research Article

Hemipilia zhuxiensis (Orchideae, Orchidaceae), a new species from Hubei Province, China

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Abstract

Hemipilia zhuxiensis (Orchidaceae), is a new species discovered in the Shibali Long Canyon National Nature Reserve, Zhuxi County, Hubei Province, China. It is morphologically similar to *Hemipilia henryi* and *Hemipilia crassicalcarata*, but differs in having an oblong, simple labellum with a slightly involute margin, an upcurved apex, and a spur shorter than the ovary. Molecular phylogenetic analyses, using nuclear (nrITS) and plastid (combined *matK*, *psaB*, *psbA-trnH*, *rbcL* and *trnL-F*) DNA sequences, confirm that *H. zhuxiensis* is closely related to *Hemipilia henryi* and *Hemipilia crassicalcarata*, supporting its recognition as a new species in the *H.* section *Hemipilia* as defined by Tang et al. (2015).

Key words: Morphology, phylogeny, subtribe Orchidinae, Zhuxi County

Introduction

The genus Hemipilia Lindley sensu stricto (subtribe Orchidinae, Orchidaceae) comprises c. 13 species (Chase et al. 2015). Hemipilia s.s. is characterized by distinct morphological features, such as protruding and tongue-like rostellum, separate stigma and rostellum, basal and single leaves (Luo and Chen 2000; Chen et al. 2009). Nevertheless, the phylogenetic relationships between Hemipilia and other genera within the subtribe Orchidinae remain controversial (Jin et al. 2014, 2017; Tang et al. 2015). The monophyletic Hemipilia s.s. is clustered with Ponerorchis brevicalcarata (Finet 1901: 420) von Soó (1966: 353) and Hemipiliopsis purpureopunctata (Lang in Lang and Ji 1978: 127) Luo and Chen (2003: 450) in a strongly supported clade (Luo 1999; Bateman et al. 2003; Jin et al. 2014). Tang et al. (2015) further proposed a broad circumscription of Hemipilia sensu latissimo, lumping Neottianthe Schltr., Ponerorchis, Tsaiorchis Tang & Wang and Hemipiliopsis into a single monophyletic genus. Most recently, Jin et al. (2017) updated the phylogeny with samples from the subtribe Orchidinae and recognized Hemipilia, Ponerorchis, and Tsaiorchis as distinct genera. Therefore, the circumscription of Hemipilia still requires refinement with additional data.



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Copyright: © Cai-quan Shen et al. This is an open access article distributed under terms of the Creative Commons Attribution License (Attribution 4.0 International – CC BY 4.0). In recent years, many new species of *Hemipilia* have been discovered (Tang et al. 2016; Wang et al. 2022; Yang et al. 2022). During our 2020 field investigation in the Wuling Mountains of Hubei Province, we found numerous small, purple-flowered *Hemipilia* species. However, the literature shows no such characteristics in any of *Hemipilia* species studied before. The oblong and simple labellum with a slightly involute margin and a shorter spur distinguishes it from all the known species of *Hemipilia*. Morphological and phylogenetic analyses suggest that *H. zhuxiensis* is closely related to *H. henryi* and *H. crassicalcarata*. Consequently, we describe it as a new species in *H.* sect. *Hemipilia* as defined by Tang et al. (2015).

Materials and methods

Morphological observations

The morphological characterization and description of the new species are based on the comprehensive examination of both living plants and the herbarium specimens. The voucher specimens of *Hemipilia zhuxiensis* and *Hemipilia henryi*, collected from Zhuxi County in Hubei Province, have been deposited in the Herbarium of Wuhan Botanical Garden, CAS (HIB). The list of all herbarium specimens examined for this study is provided in Appendix 1.

Phylogenetic reconstruction

Molecular analysis was performed using 89 samples (including 2 newly sequenced) and 6 DNA sequence makers (nrITS, *matK*, *psaB*, *psbA-trnH*, *rbcL*, *trnL-F*) to explore the phylogenetic placement of the new species within Orchidinae following the phylogenetic study of Jin et al. (2017) and Yang et al. (2022). Three species (*Corycium ingeanum*, *Corycium nigrescens*, and *Ceratandra grandiflora*) were considered as outgroups following Yang et al. (2022).

DNA of *Hemipilia zhuxiensis* and *Hemipilia henryi* was extracted from silica-dried leaf fragments using the modified 2×CTAB procedure of Doyle and Doyle (1987). All sequences were obtained from the genome skimming data. DNA extraction, library preparation, and sequencing were performed at Major-Bio Company (Shanghai, China). The nrDNA regions (18S-ITS1-5.8S-ITS2-26S) and complete chloroplast genome were assembled using GetOrganelle v1.7.4 with default parameters (Jin et al. 2020). Chloroplast genome annotation was performed with Geseq (Tillich et al. 2017). Annotation results were checked, adjusted and used to extract DNA sequence makers accordingly (nrITS, *matK*, *psaB*, *psbA-trnH*, *rbcL*, *trnL-F*) in Geneious 11.0.4 (Kearse et al. 2012). The final nrITS and plastome sequences of *Hemipilia zhuxiensis* and *Hemipilia henryi* have been submitted to GenBank, and their accession numbers are provided in Table 1.

Phylogenetic analyses were conducted using Maximum likelihood (ML) and Bayesian Inference (BI). All DNA sequence markers were aligned individually using MAFFT (Katoh and Standley 2013). Subsequently, the aligned sequences were manually adjusted and modified using trimAI (Capella-Gutiérrez et al. 2009). The concatenation of five plastid DNA sequences and the construction of a phylogenetic tree were eventually completed using PhyloSuite (Zhang et al. 2020). **Table 1.** GenBank accession numbers of taxa included in phylogenetic reconstruction. Sequences generated in this study are marked with asterisks (*). Missing data are indicated with "–".

Species	ITS	matK	psaB	psbA_trnH	rbcL	trnL_F
Hemipilia zhuxiensis	PP988699	PP999314	PP999314	PP999314	PP999314	PP999314
Hemipilia henryi	PP988698	PP999315	PP999315	PP999315	PP999315	PP999315
Hemipilia alpestris	KJ460093	KJ452849	MF944593	MF944800	KJ451547	MF945360
Hemipilia amplexifolia	KM651222	KM651386	-	KM651467	_	KM651546
Hemipilia basifoliata	KM651223	KM651387	_	KM651468	_	KM651547
Hemipilia capitata	KM651224	KM651388	_	KM651469	_	KM651548
Hemipilia cf. faberi	KM651226	KM651395	_	KM651471	_	KM651550
Hemipilia faberi	KM651230	KM651389	_	KM651475	_	KM651554
Hemipilia farreri	KJ460047	KJ452803	MF944558	MF944765	KJ451501	MF945325
Hemipilia gonggashanica	KM651233	KM651394	_	KM651478	_	KM651557
Hemipilia gracilis	KJ460036	JN696435	MF944434	MF944644	JN696420	MF945203
Hemipilia hemipilioides	KM651238	KM651400	_	KM651483	_	KM651562
Hemipilia keiskei	KM651239	KM651401	_	_	_	KM651563
Hemipilia keiskeoides	KM651240	KM651402	MF944552	KM651484	_	KM651564
Hemipilia kinoshitai	KM651241	KM651403	-	KM651485	_	KM651565
Hemipilia lepida	KM651242	KM651404	_	KM651486	_	KM651566
Hemipilia monantha	KJ460037	JN696436	MF944443	MF944653	JN696421	MF945212
Hemipilia physoceras	KM651246	KM651408	_	KM651490	-	KM651570
Hemipilia parceflora	KJ460052	KJ452808	MF944562	MF944769	KJ451506	MF945329
Hemipilia physoceras	KM651247	KM651409	_	KM651492	_	KM651572
Hemipilia thailandica	KM651256	KM651419	_	KM651501	_	KM651581
Hemipilia trifurcata	KJ460055	KJ452811	MF944565	MF944772	KJ451509	MF945332
, Hemipilia wenshanensis	KM651258	KM651422	_	KM651504	_	KM651584
Anacamptis laxiflora	AM711747	KF997312	_	AM711707	KF997401	_
Anacamptis pyramidalis	AY364870	JN894348	_	_	JN891189	KU931755
Benthamia perularioides	MT500652	MT533554	_	_	MT506429	MT507741
Brachycorythis henryi	MF944262	MF945438	MF944465	MF944675	MF944873	MF945234
Brachycorythis obcordata	MF944263	MF945500	MF944533	MF944742	MF944936	MF945301
Ceratandra grandiflora	EU687530	EU687535	_	_	_	EU687540
Chamorchis alpina	_	FR832740	_	_	FN870786	_
Corycium ingeanum	EU301446	EU301499	_	_	_	EU301552
Corycium nigrescens	EU301461	EU301514	_	_	_	EU301567
Dactvlorhiza fuchsii	MF944265	MF945400	MF944423	MF944633	MF944836	MF945192
Dactvlorhiza viridis	JN696446	KJ452797	MF944555	MF944762	KJ451495	MF945322
Galearis roborowskvi	KM651265	KM651429	_	KM651511	_	KM651591
Galearis spathulata	KJ460094	KJ452850	MF944594	MF944801	KJ451548	MF945361
Galearis tschiliensis	KJ460057	KJ452813	MF944566	MF944773	KJ451511	MF945333
Galearis wardii	MF944274	MF945417	MF944442	MF944652	MF944853	MF945211
Hemipilia calophylla	K.J460095	K.J452852	MF944596	MF944803	KJ451550	MF945363
Hemipilia cordifolia	MF944329	MF945454	MF944481	MF944691	MF944888	MF945250
Heminilia crassicalcarata	KM651270	KM651434	_	_	_	KM651596
Hemipilia cruciata	MF944330	MF945462	MF944490	MF944700	MF944896	MF945259
Heminilia flabellata	KM651271	K. 1452806	-	-	K.J451504	KM651507
Heminilia forrestii	K 1/600/0	K 1/52000	ME0//550	ME0//766	K 1/151502	MEQ/5006
	KJ400049	KJ432803	IVIF 944009	IVIF944700	NJ401003	IVIE 940320
пенирина уанеата	K1103499	K1103490	-	_	-	K1103300

Species	ITS	matK	psaB	psbA_trnH	rbcL	trnL_F
Hemipilia kwangsiensis	KM651272	KJ452851	MF944595	MF944802	KJ451549	MF945362
Hemipilia yajiangensis	OM009240	OM009241	OM009241	OM009241	OM009241	OM009241
Hemipilia avisoides	OP597820	OP595696				OP595697
Hemipilia purpureopunctata	KJ460051	KJ452807	MF944561	MF944768	KJ451505	MF945328
Herminium esquirolii	KR350147	KR350183	KR350222	KR350277	KR350328	KR350367
Himantoglossum hircinum	AY351385	KF997261	_	_	KF997440	_
Neolindleya camtschatica	KT338754	KF262003	_	KF262121	KF296612	_
Neotinea maculata	AM711744	_	_	AM711706	FN870882	KU931823
Hemipilia compacta	JN696455	KJ452796	MF944554	MF944761	KJ451494	MF945321
Hemipilia cucullata	JN696456	KJ452792	MF944550	KM651522	KJ451490	MF945317
Hemipilia fujisanensis	KM651280	KM651444	_	KM651524	_	KM651606
Hemipilia cucullata	JN696454	KJ452791	MF944549	MF944756	KJ451489	MF945316
Ophrys apifera	AJ539529	AJ543953	AY381047	AM711642	AF074202	AJ409432
Ophrys insectifera	MF944348	MF945396	MF944525	MF944734	MF944928	MF945293
Orchis anthropophora	AY364869	_	_	_	KF997307	EU294186
Orchis mascula	AY351379	JN895683	_	HG800547	MK925129	KU931823
Orchis militaris	AY014548	KF997352	-	-	KF997273	AY014586
Orchis purpurea	AY364882	_	-	_	KF997502	-
Platanthera bakeriana	KJ460061	KJ452817	MF944569	MF944776	KJ451515	MF945336
Hemipilia basifoliata	MF944399	MF945455	MF944482	MF944692	MF944889	MF945251
Hemipilia brevicalcarata	KJ460041	KJ452793	MF944551	MF944758	KJ451491	MF945318
Hemipilia camptoceras	MF944400	MF945409	MF944433	MF944643	MF944845	MF945202
Hemipilia cf. hui	KM651296	KM651462	-	KM651539	_	KM651621
Hemipilia chidori	KM651286	KM651450	-	KM651531	_	KM651613
Hemipilia chusua	MF944401	MF945460	MF944488	MF944698	MF944894	MF945257
Hemipilia cucullata	MF944402	MF945451	MF944477	MF944687	MF944885	MF945246
Hemipilia graminifolia	KM651292	KM651456	-	KM651538	_	KM651620
Hemipilia kiraishiensis	MF944403	MF945445	MF944472	-	MF944879	MF945241
Hemipilia hui	MF944398	MF945425	MF944451	MF944661	MF944861	MF945220
Hemipilia chusua	MF944404	MF945475	MF944504	MF944713	MF944908	MF945273
Hemipilia oblonga	MF944405	MF945472	MF944501	MF944710	MF944906	MF945270
Hemipilia omeishanica	KM651299	KM651464	-	KM651542	-	KM651624
Hemipilia compacta	MF944406	MF945458	MF944485	MF944695	MF944892	MF945254
Hemipilia sichuanica	KJ460059	KJ452815	MF944567	MF944774	KJ451513	MF945334
Hemipilia simplex	MF944407	MF945427	MF944453	MF944663	MF944863	MF945222
Hemipilia graminifolia var. suzukiana	KM651300	KM651459	-	KM651543	-	KM651625
Hemipilia tetraloba	MF944411	MF945440	MF944467	MF944677	MF944875	MF945236
Hemipilia tibetica	MF944412	MF945449	MF944476	MF944685	MF944883	MF945245
Pseudorchis albida	KU974068	_	-	-	KF997412	GQ245349
Pseudorchis straminea	DQ022894	_	-	-	FN870908	_
Schizochilus flexuosus	MT500598	FR832831	-	-	FN870929	MT507689
Hemipilia pinguicula	MF944417	MF945495	MF944528	MF944737	MF944931	MF945296
Sirindhornia pulchella	KJ460045	KJ452801	MF944557	MF944764	KJ451499	MF945324
Steveniella satyrioides	AM711746	FR832840	-	-	_	KU931833
Traunsteinera globosa	KT318279	_	-	HG800585	HG417055	_
"–" indicates lacking data.						

Nuclear and plastid data were analyzed separately following Tang et al. (2015). The best-fit DNA substitution model was estimated for nrITS using ModelFinder (Kalyaanamoorthy et al. 2017) and for the concatenated 5 plastid DNA sequences using PartitionFinder2 (Lanfear et al. 2016). The ML phylogenetic tree was obtained using IQ-TREE with ultrafast bootstrap support of 1000 replicates (Nguyen et al. 2015). The BI tree was constructed using MrBayes version 3.2.6 (Ronquist et al. 2012) with the Markov Chain Monte Carlo (MCMC) method and sampled every 1000 generations of a total of 2 million. Once the average standard deviation of split frequencies fell below 0.01, the first 25% of generated trees were discarded as a burn-in process, and the runs were considered to have reached a stable state. The phylogenetic trees were edited and visually optimized using TreeGraph2 (Stover and Muller 2010).

Results

Morphological comparison

In *Hemipilia* sect. *Hemipilia*, many species exhibit morphological similarity, characterized by relatively small purplish-red flowers, tongue-like rostellum, and ovate leaves with purple spots. We have selected *H. henryi and H. crassical-carata* for morphological comparison with *H. zhuxiensis*, as they share general attributes, and also have the closest phylogenetic relationship. Morphological comparisons of *H. zhuxiensis*, such as leaf and flower characteristics, with the similar taxa *H. henryi and H. crassicalcarata*, are provided in Table 2. Morphological data are summarized from the literature (Chen et al. 2009) and recent observations of herbarium specimens (see Appendix 1).

Characters	H. zhuxiensis	H. henryi	H. crassicalcarata
Numbers of leaves	1	1	1
Leaf shape	Ovate	ovate	ovate to ovate-cordate
Leaf color (adaxial)	green with purple spots	green with purple spots	uniformly green
Inflorescence length	14-23 cm	17-30 cm	13-30 cm
pedicel plus ovary long	13-21 mm	16-24 mm	12-18 mm
Petal shape	obliquely ovate	obliquely rhombic-ovate	oblong-ovate, oblique
Labellum shape	oblong, margin slightly involute, apex upcurved	broadly obovate-cuneate	suboblong, margin irregularly crenate, apex truncate
Labellum size	10 × 3−5 mm	12 × 10 mm	13 × 9−10 mm
Labellum margin	Simple	3-lobed	simple
Spur shape	short and infundibuliform, apex hooked	straight and horizontal or slightly curved downward	straight and horizontal or sometimes slightly curved downward
Spur shape	narrowly conic	narrowly conic, gradually attenuate	cylindric, uniformly thick (not attenuate)
Spur length	4–6 mm, significantly shorter than ovary	14–18 mm, slightly shorter than ovary	10–12 mm, slightly shorter than ovary

Table 2. Morphological comparison of H. zhuxiensis, H. henryi, H. crassicalcarata.

Phylogenetic reconstruction

The phylogenetic relationship reconstructed based on nrITS and combined plastid datasets in this study, show minor differences (Figs 1, 2). Phylogenetic analyses based on nrITS data demonstrated that *H. zhuxiensis* does not cluster well with *H. crassicalcarata* and *H. henryi* into a clade. However, the plastid tree demonstrated that *H. zhuxiensis* is clustered with *H. crassicalcarata* and *H. henryi* into a clade. However, the plastid tree demonstrated that *H. zhuxiensis* is clustered with *H. crassicalcarata* and *H. henryi* into a clade with strong support (94.6/100/1, 83.6/100/1). These results indicate that *H. zhuxiensis* possibly has a close phylogenetic relationship with *H. crassicalcarata* and *H. henryi*, and analysis of data from nrITS and plastid trees consistently support *H. zhuxiensis* as a member of *H.* sect. *Hemipilia*.



Figure 1. Phylogenetic placement of *H. zhuxiensis* (bold representation) using the maximum likelihood (ML) method based on nrITS. The maximum likelihood SH-aLRT supports and UFBoot supports (SH-aLRT_{ML} /UFboot_{ML}) are displayed above the branches, and Bayesian posterior probabilities (PP_{BI}) are displayed below the branches. Only SH-aLRT >= 80% and UFboot >= 95%, PP \ge 0.95 are considered as strong supports.



Figure 2. Phylogenetic placement of *H. zhuxiensis* (bold representation) using the maximum likelihood (ML) method based on the combined plastid DNA (*matK*, *psaB*, *psbA-trnH*, *rbcL*, *trnL-F*). The maximum likelihood SH-aLRT supports and UFBoot supports (SH-aLRT_{ML} /UFboot_{ML}) are displayed above the branches, and Bayesian posterior probabilities (PP_{BI}) are displayed below the branches. Only SH-aLRT >= 80% and UFboot >= 95%, PP ≥ 0.95 are considered as strong supports.

Taxonomic treatment

Hemipilia zhuxiensis Hong Liu, sp. nov. urn:lsid:ipni.org:names:77350375-1 Figs 3–5

Type. CHINA. • Hubei: Zhuxi County, Shibali Long Canyon National Nature Reserve; 733 m; 18 June 2020; *HSN13099* (holotype: HSN). To protect this species, the exact latitude and longitude are not published.



Figure 3. *Hemipilia zhuxiensis* A habit B flower (front view) C flower (top view) D flower (side view) E labellum and column F spur G dorsal sepal H lateral sepals I petals. Drawn by Ta-Li Cai.

Diagnosis. Though apparently similar to *H. henryi* Rolfe and *H. crassical-carata* S.S.Chien, *H. zhuxiensis* shows certain differences in having ovate, purple-spotted leaf; $10 \times 3-5$ mm, oblong, simple labellum; slightly involute labellum margin; upcurved labellum apex; and a significantly shorter spur compared with the ovary (Table 2).



Figure 4. *Hemipilia zhuxiensis* **A** habit **B** flower and spur (side view) **C** morphological contrast of *H. zhuxiensis* (left) and *H. henryi* (right) **D** flowering whole plant **E** column and labellum **F** tubers and roots **G** leaves (adaxial and abaxial view).

Description. Terrestrial herbs, 17-25 cm tall. Tubers ellipsoid, 4-11 × 3-5 mm. Stem slender with 1 tubular cataphyll at the base, 1- or rarely 2-leaved. Leaf solitary, ovate, 6-12 × 5-8 cm, apex subacute, base cordate or contracted into amplexicaul sheath, adaxially green with purple spots, rarely uniformly green, abaxially pale green. Inflorescence terminal, 14-23 cm long with 1-2 sterile bracts; laxly 4-9-flowered; floral bracts lanceolate, to ca. 11 mm, apex acuminate or long acuminate. Flowers purplish red; pedicel and ovary straight or slightly arcuate, 13-21 mm long. Dorsal sepal ovate-elliptic, 6-9 × 3-7 mm, apex obtuse, 1-veined; lateral sepals broadly ovate, oblique, spreading, $7-10 \times 5-8$ mm, 1-veined, apex obtuse. Petals obliquely ovate, $6-7 \times 4-5$ mm, 1-veined, apex obtuse, purplish red. Labellum oblong, $10 \times 3-5$ mm, purplish red, adaxially finely papillate, simple; margin slightly involute, irregularly crenate; apex upcurved, obtuse to emarginate; spur short and infundibuliform, slightly curved downwards, narrowly conic, 4–6 mm long, entrance 2–2.5 mm wide. Column ca. 3 mm long; rostellum tongue-like, purple, ca. 2 mm, apex rounded.

Distribution and habitat. *H. zhuxiensis* is currently known to have two populations in Shibali Long Canyon National Nature Reserve, Zhuxi county, Hubei Province, China. The two populations are about 500 meters apart along the rock wall of the canyon. The new species grows on the rock wall together with *H. henryi*. The canyon is an arid valley, and many shrubs and mosses grow on the rock walls on both sides.

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Figure 5. Photograph of the herbarium specimens of H. zhuxiensis Hong Liu (left) and H. henryi Rolfe (right).

Preliminary conservation assessment. Only two populations comprising approximately 10 mature individuals were found in Shibali Long Canyon National Nature Reserve, Zhuxi County, Hubei Province, China. The two populations are about 500 meters apart and growing on the rock wall alongside *H. henryi*. The habitat of *H. zhuxiensis* could be easily disturbed by development as it is close to roads and villages. Due to the limited population size and restricted distribution of *Hemipilia zhuxiensis*, the new species should be preliminarily classified as Critically Endangered (CR B2ab;C2a(i);D) according to the guidelines of the International Union for Conservation of Nature (IUCN) Red List Categories and Criteria (IUCN Standards and Petitions Committee 2022).

Etymology. The specific epithet refers to the name of the type locality in Zhuxi County.

Vernacular name. The Chinese name is "竹溪舌喙兰".

Phenology. Flowering in June.

Discussion

Molecular and morphological evidence demonstrates that *Hemipilia zhuxiensis* is a member of *Hemipilia* sect. *Hemipilia* (Tang et al. 2015). Morphologically, *H. zhuxiensis* is very similar to *H. henryi* and *H. crassicalcarata*, and it is sympatric with *H. henryi*. Therefore, we cannot exclude the possibility that *H. zhuxiensis* is a teratological form of *H. henryi*. However, it is clearly distinguishable by its distinctive labellum and spur. In addition, *H. zhuxiensis* has the earliest anthesis (June) compared to *H. henryi* (August) and *H. crassicalcarata* (July).

The phylogenetic trees based on nuclear and plastid DNA sequences show slight differences, but both datasets undoubtedly place the new species within the sect. Hemipilia according to Tang et al. (2015). The ITS-based phylogenetic tree shows that H. zhuxiensis cannot cluster well with H. crassicalcarata and H. henryi into a clade, likely due to the short ITS sequence and limited informative sites. In contrast, the plastid-based phylogenetic tree strongly supports the clustering of H. zhuxiensis with H. henryi, and further reveals a well-supported clade comprising these two species and H. crassicalcarata. These results indicate that H. zhuxiensis is closely related to H. henryi and H. crassicalcarata. In contrast with previous studies, while our study expands and reconstructs the phylogenetic tree, it also fails to resolve the weak support for several clades, such as H. sect. Ponerorchis (Tang et al. 2015), which may be one of the reasons why the affinities of the Hemipilia s. I. are still controversial (Tang et al. 2015; Jin et al. 2017; Yang et al. 2022). In addition, the plastid tree constructed in this study shows slight differences from that of Yang et al. (2022), particularly in the clade comprising H. yajiangensis and H. galeata, which may be attributed to the differences in the partitioning model employed. H. sect. Hemipilia is a stable clade in phylogenetic analyses, and the discovery of H. zhuxiensis would prove to be significant in understanding phylogenetic relationships within Hemipilia. Moreover, H. zhuxiensis also provides morphological characteristics for defining the taxonomic boundary of H. sect. Hemipilia.

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Additional information

Conflict of interest

The authors have declared that no competing interests exist.

Ethical statement

No ethical statement was reported.

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Author contributions

Data curation: GHL, CS. Formal analysis: CS. Funding acquisition: HL. Investigation: DQL, GHL, LSY, XTC. Methodology: DQL. Project administration: HL, RQ. Writing - original draft: CS, GHL. Writing - review and editing: CS, HL.

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Data availability

All of the data that support the findings of this study are available in the main text.

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Appendix 1

Table A1. The information of all the herbarium specimens examined in this study. "*" represents self-collected specimens,

 "-" represents information loss.

The information of all the herbarium specimens							
Herbarium	Scientific Name	Collection Locality	Year				
HIB 0256186	Hemipilia zhuxiensis*	China, Hubei	2020				
HIB 0256188	Hemipilia henryi*	China, Hubei	2020				
PE 01517112	Hemipilia henryi	China, Hubei	1977				
PE 01517111	Hemipilia henryi	China, Hubei	1977				
PE 01517109	Hemipilia henryi	China, Hubei	1938				
PE 01056970	Hemipilia henryi	China, Hubei	1976				
PE 01056968	Hemipilia henryi	China, Hubei	1976				
PE 01056969	Hemipilia henryi	China, Hubei	1976				
PE 01056967	Hemipilia henryi	China, Hubei	1976				
PE 00340918	Hemipilia henryi	China, Sichuan	1931				
PE 00340917	Hemipilia henryi	China, Sichuan	1931				
PE 00340916	Hemipilia henryi	China, Sichuan	1931				
PE 00340915	Hemipilia henryi	China, Sichuan	1931				
PE 00340913	Hemipilia henryi	China, Sichuan	1934				
PE 00340914	Hemipilia henryi	China, Sichuan	1931				
PE 00340912	Hemipilia henryi	China, Sichuan	1934				
PE 00340911	Hemipilia henryi	China, Sichuan	1934				
PE 00340910	Hemipilia henryi	China, Sichuan	1976				
PE 00340909	Hemipilia henryi	China, Chongqing	1958				
PE 00340908	Hemipilia henryi	China, Chongqing	1964				
IBSC 0636166	Hemipilia henryi	China, Hubei	1985				
IBSC 0636169	Hemipilia henryi	China, Guangxi	1939				
IBSC 0636168	Hemipilia henryi	China, Guangxi	1937				
IBSC 0636165	Hemipilia henryi	China, Sichuan	1979				
IBSC 0636167	Hemipilia henryi	China, Hubei	1985				
KUN 1393999	Hemipilia henryi	China, Hubei	2011				
KUN 0023146	Hemipilia henryi	China, Sichuan	1930				
KUN 0023147	Hemipilia henryi	China, Sichuan	1934				
WUK 0350417	Hemipilia henryi	China, Sichuan	1959				
WUK 0138378	Hemipilia henryi	China, Sichuan	1959				
WUK 0239782	Hemipilia henryi	China, Sichuan	1964				
WUK 0330459	Hemipilia henryi	China, Sichuan	1934				
NAS NAS00558549	Hemipilia henryi	China, Sichuan	1957				
NAS NAS00560681	Hemipilia henryi	China, Hubei	1978				
SZ 00039926	Hemipilia henryi	China, Sichuan	1964				
SZ 00039927	Hemipilia henryi	China, Sichuan	1954				
CDBI CDBI0171211	Hemipilia henryi	China, Sichuan	1976				
CDBI CDBI0171210	Hemipilia henryi	China, Sichuan	1976				
CDBI CDBI0180069	Hemipilia henryi	China, Sichuan	2003				
N 050025209	Hemipilia henryi	China, Hubei	1922				
The information of all the herbarium specimens							
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Herbarium	Scientific Name	Collection Locality	Year				
SYS SYS00028750	Hemipilia henryi	China, Hubei	-				
IMC IMC0012888	Hemipilia henryi	China, Guizhou	2003				
IMC IMC0012889	Hemipilia henryi	China, Chongqing	2004				
HUH GH00100247	Hemipilia henryi	China	-				
NY 00008940	Hemipilia henryi	China	-				
NY 00579391	Hemipilia henryi	China	1901				
P P00369342	Hemipilia henryi	China	-				
P P00259950	Hemipilia henryi	China	_				
NAS NAS00633540	Hemipilia henryi	China, Hubei	2019				
PE 02023829	Hemipilia crassicalcarata	China, Henan	2009				
PE 01681710	Hemipilia crassicalcarata	China, Sichuan	1998				
PE 01527207	Hemipilia crassicalcarata	China, Sichuan	1998				
PE 01517113	Hemipilia crassicalcarata	China, Shaanxi	1959				
PE 00340868	Hemipilia crassicalcarata	China, Sichuan	1930				
PE 00340867	Hemipilia crassicalcarata	China, Sichuan	1984				
PE 00340866	Hemipilia crassicalcarata	China, Hubei	1956				
PE 00340865	Hemipilia crassicalcarata	China, Shaanxi	1952				
PE 00340864	Hemipilia crassicalcarata	China, Shaanxi	1959				
PE 00340862	Hemipilia crassicalcarata	China, Shanxi	1959				
PE 00027177	Hemipilia crassicalcarata	China, Sichuan	1928				
PE 00340863	Hemipilia crassicalcarata	China, Henan	1992				
IBSC 0636150	Hemipilia crassicalcarata	China, Hubei	1986				
WUK 0059599	Hemipilia crassicalcarata	China, Shaanxi	1952				
WUK 0327685	Hemipilia crassicalcarata	China, Shanxi	1959				
HNWP 8224	Hemipilia crassicalcarata	China, Shanxi	1959				
SZ 00039897	Hemipilia crassicalcarata	China, Shaanxi	1959				
BNU 009588	Hemipilia crassicalcarata	China, Shanxi	2014				
HENU 0450489	Hemipilia crassicalcarata	China, Henan	1978				
HENU 0450490	Hemipilia crassicalcarata	China, Henan	1978				
HENU 0450491	Hemipilia crassicalcarata	China, Henan	1978				
HENU 0450492	Hemipilia crassicalcarata	China, Henan	1978				
HENU 0450493	Hemipilia crassicalcarata	China, Henan	1978				
GNUG GNUG0006147	Hemipilia crassicalcarata	China, Guizhou	1993				
CDCM CDCM0003656	Hemipilia crassicalcarata	China, Sichuan	1978				
E E00162723	Hemipilia crassicalcarata	China, Sichuan	2003				
"*" repersents self-collected sp	pecimen, "–" repersents information los	S.					



Research Article

Nomenclature and systematics of two *Cocconeis* species (Bacillariophyta) from Lake Baikal: *Cocconeis baicalensis* and *Cocconeis skvortzowii*

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Abstract

The study provides nomenclatural history, morphological characteristics and taxonomy of *Cocconeis baicalensis* and *C. skvortzowii* described by B.V. Skvortzov from Lake Baikal. The lecto- and epitypification of the names are made, based on the K.I. Meyer and A.P. Skabichevsky materials, ensuring compliance with current nomenclatural standards. The morphological traits of these species were thoroughly examined using light microscopy (LM) and scanning electron microscopy (SEM), leading to refined diagnoses and the clarification of previously confused synonymy.

Key words: Baikal, *Cocconeis*, diatom, epitype, lectotypification, nomenclatural history, taxonomy

Introduction

Lake Baikal is the world's deepest lake and diatoms are an integral part of its recent ecosystem. Monoraphid diatoms, including the genus *Cocconeis* Ehrenb., are poorly studied in Lake Baikal (Kulikovskiy et al. 2012, 2016a). Nine taxa of the genus *Cocconeis*, including 3 endemic ones, *C. placentula* var. *baicalensis*, *C. placentula* var. *baikalensis* and *C. nanoburyatica*, are known for the lake (Skvortzow and Meyer 1928; Skvortzow 1937; Gololobova 2012; Kulikovskiy et al. 2016a). Nomenclatural and taxonomic history of two of them, *C. placentula* var. *baicalensis* and *C. placentula* var. *baikalensis*, described by B.V. Skvortsov and currently reduced to synonyms for *C. skvortzovii* Sheshukova-Poretskaya, is confusing. The "disappearance" of one of the names from the taxonomic content of the genus, as well as different spelling of epithets, as Gololobova (2012) already had pointed out, and the citation of their authors in AlgaeBase (Guiry and Guiry 2024), made us feel the need to understand this issue.

This paper aims to typify the names of two *Cocconeis* taxa and to study their taxonomy and morphology based on typical specimens. All available published data were analyzed to outline their nomenclatural history. Based on original drawings, LM and SEM illustrations, lectotypes and epitypes are designated, as well as emended diagnoses are presented. Since the text of the new



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Nomenclatural history

The variety Cocconeis placentula Ehrenberg var. baicalensis B.V. Skvortzov et K.I. Meyer was described based on the materials of Meyer from Baikal Lake (Skvortzow and Meyer 1928). Since the authors of the name were not cited in the protologue, then, according to the ICN, its authorship is to be ascribed to the authors of the publication (Turland et al. 2018, Art. 46.3, Note 5), i.e. to both Skvortzov and Meyer. Nevertheless, Meyer in a subsequent study, cited the authorship of this name "Cocconeis placentula Ehr. var. baicalensis Skvortz." (Meyer 1930, 341), and reported that the treatment of the Baikal diatoms collected by Meyer was made by Skvortzov alone (Meyer 1930, 183, 327). Later on, Skabichevsky (Skabichevsky 1974) on the basis of these notes by Meyer (1930) as well as the Meyer's personal communication, concluded that Skvortzov should be cited as the only author of the diatom names published in Skvortzow and Meyer (1928). This view was adopted by Kociolek and Stoermer (1988, 96) and Williams and Reid (2001, 94). However, if we follow the laws of nomenclature, "In determining the correct author citation, only internal evidence in the publication... where the name was validly published is to be accepted" (Turland et al. 2018, Art. 46.8). On this ground, we consider both Skvortzov and Meyer as the authors of C. placentula var. baicalensis (Skvortzow and Meyer 1928).

Later, Skvortzov (1946) published a new combination at the rank of species with a full and direct reference to the basionym (Skvortzow and Meyer 1928), but with a changed letter in the epithet: "Cocconeis baikalensis (Skv. et Mey.) Skv." (Skvortzov 1946, 19), which subsequently contributed to further confusion (see below). The species description was greatly changed and emended, especially regarding the density of striae, the range of which was increased and did not include data from the protologue, and new figures were also provided. We assume an erroneous measurement in Skvortzow and Meyer (1928) and we are clearly sure that these epithets refer to the same taxon (see below).

In 1937, Skvortzov described another variety from Baikal under almost the same name as in Skvortzow and Meyer (1928), *Cocconeis placentula* var. *baikalensis* Skvortzov, based on other material and with different from *C. placentula* var. *baicalensis* illustration and description in protologue (Skvortzow 1937). Giving homonymic names to two different taxa was not the only case in Skvortzov's scientific activity. In total, there are 58 «double» and even «triple» names in his 57 publications (M.A. Gololobova, pers. comm.). The epithets of the discussed varieties, as differing in one letter, are not full homonyms, but are so similar that they are likely to be confused (Turland et al. 2018, Art. 53.2, 53.3, Ex. 11). By analogy with Ex. 11, the epithets *baicalensis* and *baikalensis* should be treated as homonymous, with the later name being illegitimate.

To resolve the homonymy, a replacement name instead of the later homonym was published, cited as *"Cocconeis placentula* Ehr. ... var. *Skvortzowii* (Skv.) Skabitsch." (Sheshukova 1950, 85–86), with an incorrect statement of the status of the name, since parenthetical author citation suggests a name with a basionym (see Turland et al. 2018, Art. 49.1 and Art. 49.1, Note 1). The authorship of the combination was ascribed to Skabichevsky, which differs from authorship of the publication. The only reference to the replaced synonym is provided by the mention to "C. placentula var. baicalensis Skv.", without any reference to publication (Sheshukova 1950, 86). Since there is no explicit statement of Skabichevsky's contribution to the publication (see the discussion below), as provided by Art. 46.2 (Turland et al. 2018), the authorship of the name should be ascribed to Sheshukova, the author of the Chapter "Subordo Monoraphineae" in Sheshukova (1950), and cited as "Skabitsch. ex Sheshukova" or simply "Sheshukova" (Turland et al. 2018, Art. 46.5, Ex. 31). An indirect reference to a replaced synonym is sufficient for valid publication of a replacement name before 1 January 1953 (Turland et al. 2018, Art. 41.3). Despite the spelling of the replaced epithet with a "c", the description and the images of the variety clearly indicate to C. placentula var. baikalensis Skvortzov (Skvortzow 1937). It remains unclear why the other variety, C. placentula var. baicalensis B.V. Skvortzov et K. I. Meyer 1928, was not mentioned in Sheshukova (1950). According to Skabichevsky (1977), this was due to a vague description and a very schematic drawing in the protologue provided by Skvortzow and Meyer (1928, 11; Pl. 1, fig. 25).

Sheshukova (1951, 193) considered morphological peculiarities of *C. placentula* var. *skvortzowii* essential enough to raise it to the rank of species, and published the new combination: *Cocconeis skvortzowii* "(Skv.) Sheshukova" (ascribing the authorship of the basionym to Skvortzov) with references to *C. placentula* var. *baicalensis* "Skv." and *C. placentula* var. *skvortzowii* "(Skv.) Skabitsch." (Sheshukova 1951, 193). Again, any mention of *C. placentula* var. *baicalensis* B.V. Skvortzov et K.I. Meyer 1928 was missing there.

Skabitschewsky (1952), who most probably had overlooked both Sheshukova's (1950, 1951) publications, also published a replacement name for *C. placentula* var. *baikalensis* Skvortzov 1937, namely "Cocconeis placentula var. *sibirica*" (Skabitschewsky 1952). Due to the existence of an earlier replacement name (Sheshukova 1950) the Skabichevsky's combination is nomenclaturally superfluous (Turland et al. 2018, Art. 52.1).

In his subsequent work, Skabichevsky (1977) raised the rank of both varieties of *C. placentula* to subspecific, and published corresponding combinations, with *C. placentula* subsp. *sibirica* Skabichevskij being legitimate if treated as a replacement name rather than combination.

No specimens or localities are cited in the protologue of *Cocconeis placentula* var. *baicalensis* B.V. Skvortzov et K.I. Meyer (Skvortzow and Meyer 1928, 11) [=*Cocconeis baicalensis* (B.V. Skvortzov et K.I. Meyer) Skvortzov]. In the publication (Skvortzow and Meyer 1928), there is only the list of 36 gatherings, but without exact places of finding of particular taxa (Skvortzow and Meyer 1928, 2). The names of taxa were associated with collection sites by Meyer, who listed 8 localities of *C. placentula* var. *baicalensis* (MEYER 1930, 341) corresponding to nine gatherings (Skvortzow and Meyer 1928, 2). Opposite, material of Skvortzow (1937), including *C. placentula* var. *baikalensis* Skv., was obtained from a little bottom sample collected by Prof. K.I. Meyer at the depth of 33 meters near the Olhon Gate of Baikal Lake July 29, 1916 (Williams and Reid 2001, 297). Such difficult nomenclature history of Skvortzov's taxa of the genus *Cocconeis* led to mistakes, including in databases that were popular among diatomologists such as Algabase and DiatomBase. That was considered and described in Yurchak et al. (2023).

The nomenclatural history outlined above clearly demonstrates that there are 8 validly published names, both legitimate and illegitimate, referring to 2 independently described taxa (originally in the rank of varieties) and, accordingly, 2 groups of homotypic synonyms.

Thus, based on the significantly different valve morphology, we accept two independent *Cocconeis* species in the genus from Baikal, the basionyms of which are homonyms, but have different years of description and types.

Materials and methods

In the work, some materials of K.I. Meyer and A.P. Skabichevsky were investigated, including those described in the protologues of the *Cocconeis baicalensis* and *C. skvortzowii* (Table 1).

Sample preparation for light and scanning electron microscopy included the dissolution of samples with diatoms in concentrated hydrogen peroxide. The samples were treated with 10% hydrochloric acid to remove carbonates and were then rinsed several times with deionized water every 12 hours. Afterwards the samples were boiled in concentrated hydrogen peroxide (~37%) to mineralize the organic matter. They were washed again with deionized water four times at 12-hour intervals. After decantation and filling with deionized water up 25 to 100 ml, the suspension has been spread onto cover slips and left to dry at room temperature.

Permanent diatom preparations were mounted in Naphrax[®]. LM observations were performed by means of a Nikon Eclipse E600 equipped with a Plan-apochromatic oil immersion objective (×100/n.a. 1.4) and Nikon DS-5M digital camera, a Zeiss AxioScope A1 microscope equipped with a Plan-apochromatic oil immersion objective (×100/n.a. 1.4, DIC) and a Zeiss Axio Imager A2 equipped with a EC Plan-Neofluar oil immersion objective (×100/1.30, DIC) and Axiocam 506 color digital camera. Valve ultrastructure was examined using a Hitachi S4500 and JSM-35C field emission scanning electron microscopes with an accelerate voltage 10–35 kV. The LM Zeiss Axio Imager.A2 and SEM JSM-35C microscopes are an equipment of The Core Facilities Center "Cell and Molecular Technologies in Plant Science" at the Komarov Botanical Institute RAS (Saint Petersburg, Russia).

The specimens and slides are deposited in LE (Komarov Botanical Institute of RAS, Saint Petersburg, Russia), diatom collection SZCZ (University of Szczecin, Szczecin, Poland), and the collection of M.S. Kulikovskiy (Herbarium of the K.A. Timiryazev Institute of Plant Physiology of RAS, Moscow, Russia).

The measurements of length and width of valves, density of striae and areolae were carried out using the program ImageJ. We calibrated scale bars in the program according to the lines of pictures for correct measurements. We measured the length of 10 striae/areolae in the middle between (1) an axial area and a valve face border, (2) a center and apex of valve. Then we recounted their density in 10 μ m by using arithmetical proportion. If there were not 10 striae/ areolae on valve, we used a smaller number.

Slide/Specimen	Data of sampling	Location in Baikal	Legit	Original label	Deposition, slide number
Specimen authenticum	n.d.	n.d.	K.I. Meyer	Baikal. 9.8. zavar	Diatom collection LE
Specimen authenticum	26 May 1921	n.d.	K.I. Meyer	N 96. Vemetlenskiy zal., 26/V 21	Diatom collection LE
Specimen authenticum	n.d.	n.d.	K.I. Meyer	N 2. Baikal 25.	Diatom collection LE
Specimen authenticum	11 June 1925	West Baikal, railway station Marituy	K.I. Meyer	N 5. Baikal 25 g. Maritui	Diatom collection LE A0002317
Specimen authenticum	n.d.	n.d.	K.I. Meyer	N 9. Baikal 25	Diatom collection LE
Specimen authenticum	n.d.	Marituy	K.I. Meyer	N 10. Baikal 25, Maritui	Diatom collection LE
Specimen authenticum	n.d.	Marituy	K.I. Meyer	N 13. Baikal 25 g. Maritui	Diatom collection LE
Specimen authenticum	n.d.	Cape Polovinny, near Marituy	K.I. Meyer	N 18. Baikal 25 g. B. "Polovinni"	Diatom collection LE
Specimen authenticum	n.d.	Cape Polovinny, near Marituy	K.I. Meyer	N 19. Baikal 25 g. B. "Polovinni"	Diatom collection LE
Specimen authenticum	n.d.	Proval Bay, Village Dubinino	K.I. Meyer	N 38. Baikal 25, Proval u m. Prorzy	Diatom collection LE
Specimen authenticum	n.d.	River Selenga	K.I. Meyer	N 53. Baikal 25, r. Selenga	Diatom collection LE A0004246
Specimen authenticum	n.d.	River Selenga	K.I. Meyer	N 61. Baikal 25, Selenga	Diatom collection LE A0004247
Specimen authenticum	n.d.	River Selenga	K.I. Meyer	N 69. Baikal 25 g. r. Selenga	Diatom collection LE A0004248
Specimen authenticum	n.d.	River Selenga	K.I. Meyer	N 70. Baikal 25 g. Selenga	Diatom collection LE A0004249
Specimen authenticum	n.d.	River Selenga	K.I. Meyer	N 71. Baikal 25 g. Selenga	Diatom collection LE A0004250
Specimen authenticum	n.d.	Left from River Angara	K.I. Meyer	N 88. Baikal 25 g. M. Tolsty	Diatom collection LE
Specimen authenticum	14 July 1925	Village Oymur	K.I. Meyer	N 125. Baikal 25 g. laguna Oimur, 14-VII-25	Diatom collection LE
Specimen authenticum	n.d.	n.d.	K.I. Meyer	N 154. Baikal 25, Istyakskiy sor	Diatom collection LE
Specimen authenticum	19 July 1925	n.d.	K.I. Meyer	N 159. Baikal 25, Proval, 19- VII-25	Diatom collection LE
Specimen authenticum	n.d.	City Babushkin	K.I. Meyer	N 216. Baikal 25, Mysovka	Diatom collection LE
Specimen authenticum	4 August 1925	n.d.	K.I. Meyer	N 232. Baikal 25, Istyakskiy sor, 4-VIII-25	Diatom collection LE
Specimen authenticum	n.d.	Cape Kotelnikovskiy	K.I. Meyer	N 302. Baikal 26 g. Koteln. mys, Khimeinovy ist.	Diatom collection LE A0004251
Specimen authenticum	27 June 1926	Cape Kotelnikovskiy	K.I. Meyer	N 303. Baikal, "Kotelnikovi" istochnik, 27/VI 26	Diatom collection LE A0004252
Specimen authenticum	30 June 1926	Cape Kotelnikovskiy	K.I. Meyer	N 318, "Kotelnikovi Maiak", Aegagrophila, 30/VI-26	Diatom collection LE, A0004242, A0004243
Specimen authenticum	n.d.	Boguchanskaya Gulf	K.I. Meyer	N 336. Baikal 26, "Bogutchanskaia" guba	Diatom collection LE, A0004244, A0004245
Specimen authenticum	n.d.	Between Khargino and Buguldeyka	K.I. Meyer	N 524. Baikal, m. Mar, m. Krasny [Yar]	Diatom collection LE
Specimen authenticum	2 June 1927	Village Onguren	K.I. Meyer	N 632. Baikal, Onguren, 2-VI-27	Diatom collection LE
Specimen authenticum	20 June 1928	Between Murino and Vydrino	K.I. Meyer	N 654. g. Tan', 20/VI 28	Diatom collection LE
Specimen	21 June 1928	n.d.	K.I. Meyer	N 661. Mezhdu Utulikom i Teler, 21/VI 28	Diatom collection LE

Table 1. List of specimens and slides.

Slide/Specimen	Slide/Specimen Data of sampling		Legit	Original label	Deposition, slide number
Specimen authenticum	29 June 1928	Opposite Island Olkhon	K.I. Meyer	N 695-96. o. Listvennichny, 29/ VI 28	Diatom collection LE
Specimen authenticum	4 July 1928	Cape Buchenkova	K.I. Meyer	Baikal, g. Buchenkova, 4-VII-28	Diatom collection LE
Specimen authenticum	11 July 1928	Island Bolshoy Ushkaniy	K.I. Meyer	N 751. Baikal, B. Ushkaniy o., 11-VII-28	Diatom collection LE
Specimen authenticum	19 July 1928	Nord-East Baikal, near Mountain Turkukit	K.I. Meyer	N 820. Baikal, u r. Shengangda, s gl. 8 m, 19-VII-28	Diatom collection LE
Specimen authenticum	31 July 1928	n.d.	K.I. Meyer	N 904. Baikal, t. m. Kosy, 31- VII-28	Diatom collection LE
Specimen authenticum	n.d.	Nord-West Baikal, Cape Elokhin	K.I. Meyer	N 909. Baikal 28, m. Elokhin	Diatom collection LE A0002318
Specimen authenticum	n.d.	n.d.	K.I. Meyer	Radzimovski	Diatom collection LE
Slide authenticum	23 June 1925	East Baikal, Cape Ostrovki	K.I. Meyer	N 6 (= 7, = 53 [under label]), r. Selenga, Ostrovki, 23 VI 1925	Diatom collection LE A0002284
Slide authenticum	26 June 1925	Selenga River delta, channel Motumga	K.I. Meyer	N 4 (= 4, = B?), r. Selenga, prot. Motumga, 26 VI 1925	Diatom collection LE A0002285
Slide authenticum	30 June 1925	Selenga River delta, near Village Merkutov	K.I. Meyer	N 1 (= 2), r. Selenga, Merkushevo, 30 VI 1925	Diatom collection LE A0002286
Slide authenticum	30 June 1925	Village Merkutov	K.I. Meyer	N 2 (= 7c), r. Selenga, Merkusheva, 30 VI 1925	Diatom collection LE A0002287
Slide authenticum	30 June 1925	Village Merkutov	K.I. Meyer	N 3 (= 7?), r. Selenga, Merkushevo, 30 VI 1925	Diatom collection LE A0002288
Slide authenticum	1 July 1925	Village Merkutov	K.I. Meyer	N 5 (= 73), r. Selenga, d. Merkushevo, 1 VII 1925	Diatom collection LE A0002289
Slide authenticum	n.d.	Village Kultuk	V.P. Sukachev	Oz. Baikal, u Kultuk', Chara	Diatom collection LE A0002290
Slide	20 July 1965	Island Bolshoy Ushkaniy	A.P. Skabichevsky	SZCZ BL18566, SZCZ BL18567, SZCZ BL18568, SZCZ BL18569, SZCZ BL18570, SZCZ BL18571, SZCZ BL18572, SZCZ BL18573, SZCZ BL18574, SZCZ BL18575, SZCZ BL18676	Collection of Maxim Kulikovskiy
Specimen	20 July 1965	Island Bolshoy Ushkaniy, sand, 42 m depth	A.P. Skabichevsky	SZCZ BL15645	Diatom collection SZCZ
Specimen	20 July 1965	Island Bolshoy Ushkaniy, epiphithic assemblage on macroalgae thallus, 8 m depth	A.P. Skabichevsky	SZCZ BL15646	Diatom collection SZCZ
Specimen	20 July 1965	Island Bolshoy Ushkaniy, epilithon assemblage on macroalgae thallus, 4 m depth	A.P. Skabichevsky	SZCZ BL15647	Diatom collection SZCZ
Specimen	20 July 1965	Island Bolshoy Ushkaniy, sand, 42 m depth	A.P. Skabichevsky	SZCZ BL15650	Diatom collection SZCZ
Specimen	20 July 1965	Island Bolshoy Ushkaniy, sand, south shore, 14 m depth	A.P. Skabichevsky	SZCZ BL15657	Diatom collection SZCZ

Terminology

LM	light microscopy.
RV	raphe valve.
RVVC	raphe valve valvocopula.
SEM	scanning electron microscopy.
SV (RLV)	sternum (rapheless) valve.
Leg.	Legit (latine), collected.

The common terminology follows Romero and Rivera (1996) and Gogorev et al. (2018, 2024).

Results

We propose here three terms that are needed to define and distinguish "unusual" morphological structures found in some taxa of the genus *Cocconeis* (contra mantle) or more widely represented in diatoms, but not found in the terminology used.

Contra mantle – the mantle (or its part) of the raphe valve in some *Cocconeis* species is not directed towards the adjacent rapheless valve, but in the opposite direction.

Ghost areolae – small depressions located in striae or irregularly and visible in LM as usual/normal areolae.

Ghost raphe – a rudimentary raphe on rapheless valve of some monoraphid diatoms filled in with silica during valve morphogenesis and distinguishable in mature valve: in SEM **GR** is externally presented as a small groove, less often as two grooves corresponding to two branches of the raphe; in LM **GR** often looks like a normal raphe, so a rapheless valve can be confused with a raphe valve.

Below we provide complete taxonomical citations of two species with nomenclatural remarks and indications of mistakes and inaccuracies committed in the referred publications (Tables 2, 3, Figs 1, 2).

Cocconeis baicalensis (B.V. Skvortzov & K.I. Meyer) B.V. Skvortzov 1946 in Zapiski Kharbinskogo Obshchestva Estestvoispytatelei i Etnografov, 2. Botany: 19, pl. 3, fig. 24; pl. 5, figs 9–11 (as "baikalensis" (Skv. et Mey.) Skv.) emend. Gogorev & Yurchak

- Cocconeis placentula Ehrenberg var. baicalensis Skvortzov & K.I. Meyer 1928 in Proceedings of the Sungaree River Biological Station 1, 5: 11, pl. 1. fig. 25, earlier homonym of *C. placentula* var. baikalensis Skvortzov 1937. Basionym.
- Cocconeis placentula Ehrenberg subsp. baicalensis (Skvortzov & K.I. Meyer)
 Skabichevskij 1977 in Prirodnye kompleksy nizshikh rastenii Zapadnoi Sibiri:
 127, fig. 2, 6–8 (with authorship of the basionym "Skv."). Synonym.

Type materials. *Lectotype* • (designated here): Baikal, Cape Kotelnikovskiy, No. 318, 30 June 1926 [N 318, "Kotelnikovi Maiak", *Aegagrophila*, 30/VI-26], leg. K.I. Meyer, permanent slide No. 318a, LE A0004242.

Isolectotype • Baikal, Cape Kotelnikovskiy, No. 318, 30 June 1926 [N 318, "Kotelnikovi Maiak", *Aegagrophila*, 30/VI-26], leg. K.I. Meyer, permanent slide No. 318b, LE A0004243.

Epitype • (designated here): figures here represented by Fig. 9C (Baikal, specimen BL15645, leg. A.P. Skabichevsky, 20 July 1965).

Type locality. Russia, Lake Baikal, Barguzin Bay, Bay Pestchannaya, Boguchanskaya Gulf, Cape Elokhin, Cape Kotelnikovskiy, Island Bolshoy Ushkaniy, Maloe More, Marituy, Selenga River, Village Guelga.

Description. LM (n = 56) (Figs 3–7). Valves broadly elliptical, 11.2–29.2 μ m in length (mean 19.4), 8.6–21.5 in breadth (mean 14.6). RV with straight raphe, SV with straight or slightly curved axial area. On RV 20–28 striae in 10 μ m (mean 23.4) and 18.5–27.5 areolae in 10 μ m of stria (mean 24.5), on SV 22–28 striae in 10 μ m (mean 24.3) and 13.0–19.5 areolae in 10 μ m of stria (mean 16.6). Length to breadth ratio 1.2–1.5:1 (mean 1.3:1).

		Val	ve meası		
in the source	Distribution source (specimens)	Length (µm)	Width (µm)	Striae in 10 µm	Reference
Cocconeis placentula Ehrenb. var. baicalensis	Baikal (thematic monograph on Baikal), no data on distribution or samples	25.5	22.1	14 (RV)	Skvortzow and Meyer (1928, p. 11, Pl. 1, fig. 25)
Cocconeis placentula Ehr. var. baicalensis Skvortz.	 Baikal expedition of the USSR Academy of Sciences, 1916, 1925–1929: r. Selenga, okolo Merkusheva (No. 15–16, Selenga River, near the village–Merkutov, 30 VI 1925), bukhta Peschanaya (No. 20, Pestchannaia [Peschanaya] Bay, from <i>Aegagrophila pulvinata</i>, 25 VII 1925), Kotel'nikovskiy mayak (No. 21, 27, "Kotelnikovi Maiak" [lighthouse], near shore, from <i>Ulotrix</i>, at depth 10–15 m, 30 VI 1926), p. Guyel'ga (No. 22, Guelga village, from <i>Ulotrix</i>, 2 VII 1926), Boguchanskaya guba (No. 23, 29–30, "Bogutchanskaia" gulf, near "Tonki" cape, at depth 5–7 m, 5 VII 1926), Maloye more (Kharansa Island, 1927), m. Elokhin, Barguzinskiy zal. (guba Buchenkova, 1928 g.) [Cape Elokhin, Barguzin Bay (Buchenkova Bay, 1928)] 	25.1	22.1	14 (RV)	Meyer (1930, 341)
Cocconeis baikalensis (Skv. et Mey) Skv.	Hab. Siberia, in lacum Baikal	14- 30.6	14-23	22-24 (SV), 18-20 (RV)	Skvortzov (1946, 19, table 3, fig. 24; table 5, figs 9–11)
Cocconeis placentula Ehr. subsp. <i>baicalensis</i> (Skv.) Skabitsch.	Lake Baikal, eastern shore in the area of Davsha Bay and Cape Pongonye (Tolsty), from <i>Chaetomorpha curta</i> , depth 30–50 m. Material from the Expedition of the Limnological Institute, June 1965	10-23	10-19	25-27 (SV), 23-25 (RV)	Skabichevsky (1977, 127, fig. 2, 6–8)

Table 2. Synonyms and traits of Cocconeis baicalensis (= var. baicalensis Skvortzow et Meyer 1928) in published sources.

Table 3. Synonyms and traits of *Cocconeis skvortzowii* (≡ var. *baikalensis* Skvortzow, 1937) in published sources.

		Val	ve measu	rements			
as in the source	Distribution source (specimens)	Length (µm)	ngth Width Striae in μm) (μm) 10 μm		Comments	Reference	
Cocconeis placentula (Ehr.) var. baikalensis	p. 297: little bottom sample collected by Prof. K.I. Meyer at the depth of 33 meters near the Olhon Gate of Baikal Lake July 29, 1916	12-24	6.8–14	18 (SV), 30 (RV)	description and drawings of the taxon do not correspond to the "first" epithet	Skvortzow (1937, 310, Pl. 5, figs 5(?), 7, 8)	
Cocconeis placentula Ehr. var. Skvortzowii (Skv.) Skabitsch.	Baikal Lake	12-24	7-14	18 (SV), 30 (RV)	n.d.	Sheshukova (1950, 86, table 30, figs 10a, b)	
Cocconeis Skvortzowii (Skv.) Sheshukova	Baikal Lake	14-36	8-22	15-20 (SV)	emended description and all drawings correspond to protologue (Skvortzow 1937)	Sheshukova (1951, 193, fig. 104, a–c)	
Cocconeis placentula var. sibirica	n.d.	n.d.	n.d.	n.d.	n.d.	Skabitschewsky (1951, 36)	
Cocconeis placentula Ehr. subsp. <i>sibirica</i> (Skv.) Skabitsch.	Baikal Lake, eastern shore in the area of Davsha Bay and Cape Pongonye (Tolsty), from <i>Chaetomorpha curta</i> , depth 30–50 m. Material from the Expedition of the Limnological Institute, June 1965	11-32	7–15	13-15 (SV), 20 (RV)	Based on Skvortzov's description in Skvortzow (1937), author incorrectly provided data on striae density of RV and SV (confused with each other)	Skabichevsky (1977, 127, figs 2, 9–11)	

n.d. - no data.

SEM (n = 74). Valves from subcircular to broadly elliptical, with broadly rounded apices, $11.5-36.7 \mu m$ in length (mean 19.1-21.3), 8.7-27.1 in breadth (mean 15.2-17.2). Length to breadth ratio 1.0-1.4:1 (mean 1.2-1.3:1). RV and SV very different on structure.

RV (n = 28). Valves concave, with straight raphe and narrow-linear axial area. Striae uniseriate, 21-32 in 10 μ m (mean 24.6), weakly radial in valve middle, more radial towards valve apices, interrupted by submarginal hyaline strips and



Figure 1. Reproduction of original drawings of *Cocconeis baicalensis* **A** protologue, Skvortzow and Meyer (1928), pl. 1, fig. 25 **B–E** Skvortzov (1946), table 5, figs 9–11, table 3, fig. 24 **F–H** Skabichevsky (1977), fig. 2, 6–8 **A–D**, **F**, **H** raphe valve **E**, **G** sternum valve. Scale bar: 10 µm.



Figure 2. Reproduction of original drawings of *Cocconeis skvortzowii* **A**–**C** protologue, Skvortzow (1937), pl. 5, figs 7, 8, 5 **D**, **E** Sheshukova (1950), 86, table 30, fig. 10a, b, reproduction from Skvortzow (1937) **F**–**H** Sheshukova (1951), 193, fig. 104, a–c **I–K** Skabichevsky (1977), 127, figs 2, 9, 11, 10 **A**, **D**, **F**, **I** raphe valve **B**, **C E G**, **H**, **J**, **K** sternum valve. Scale bar: 10 μm.

not reached valve margin. Areolae 20–31 in 10 μ m of stria (mean 24.8), absent at valve apices. Valve mantle reversed (contra mantle): valve face flat, mantle (or part of it) elevated and opposite directed to the adjacent SV, these two parts (flat and raised) separated from each other by narrow submarginal hyaline strips, 0.3–0.8 μ m in breadth. Wider marginal ridge, 0.8–2.0 μ m in breadth, at mantle or along valve edge.

RV, external view (Figs 8A-F, 11A-D, 13A, B, 15A, C, D). Central area small, round or rectangular. Raphe straight, proximal (central) endings drop-shaped,



Figure 3. *Cocconeis baicalensis*. LM. Lectotype. Slide No. 318a, Kotelnikovskiy Mayak, LE A0004242 **A–K** raphe valve **L–AA** sternum valve. Scale bar: 10 μm.

slightly extending into central area; distal endings more extending and frequently T-shaped. Areolae round or unevenly rounded, small along raphe, increasing towards valve edge.

RV, internal view (Figs 9A–D, 11E, F, 13C, 15B). Central area round, axial and central areas slightly convex. Proximal raphe endings directed opposite; distal ones straight or directed opposite from each other and from proximal endings, i.e. raphe branches S-shaped. Hyaline area (submarginal hyaline strips) in form of ridge. Areolae round, equal in size, and occluded (not always) by hymen.



Figure 4. Cocconeis baicalensis. Raphe valve. LM. Slides No. BL18566-BL18675, Island Bolshoy Ushkaniy. Scale bar: 10 µm.

RVVC (Fig. 13D). Valvocopula connected conically to RV, closed or opened, up to 3 μ m in breadth, with uneven edge bears and elongated weakly curved fimbriae, 0.9–1.8 μ m high, 13–18 in 10 μ m, some fimbriae with dichotomously branched tips.

SV (n = 45). Valves convex, increasing of convexity closer to valve edge. Central area and hyaline rings absent. Striae uniseriate, 17–28 in 10 μ m (mean 25). Areolae round to unevenly rounded, sometimes elongated, 11–23 in 10 μ m of stria (mean 18.7).

SV, external view (Figs 12A–D, 14A, B, 15E). Axial area narrowly linear or absent. Middle part of valve (not mantle) often with small granules arranged in order or randomly.



Figure 5. *Cocconeis baicalensis*. Sternum valve. LM. Slides No. BL18566– BL18675, Island Bolshoy Ushkaniy. Scale bar: 10 µm.

SV, internal view (Figs 10A–D, 12E, F, 14C, D, 15F). Axial area narrowly linear to narrowly lanceolate, usually slightly raised as rib.

SVVC. Valvocopula closed, 1.3–1.7 µm in breadth.

There are no data on copulae, except valvocopulae.

Comments. Our data differ from the data of Skvortzov and Skabichevsky in the following (Table 4): the valve length corresponds to Skvortzov's description (Skvortzov 1946). The upper range of valve width and the stria density on both valves are increased. The protologue data of 14 striae in 10 μ m were not observed and are likely erroneous. Literature data on the areola density in striae most likely refer to a SV, according to our data it is somewhat higher than it is in the literature; while the areola density on the RV is significantly higher than on the SV.

Cocconeis baicalensis, in contrast to *C. placentula* Ehrenberg, has (1) broadly elliptical valves, (2) the lanceolate submarginal hyaline strip on the RV, (3) the stria density is higher on the RV and lower on the SV, (4) striae located along the valve edge are interrupted on/near the apices by the submarginal hyaline strips, (5) rounded areolae on the SV, (6) the sternum on the SV is clear on the internal surface.

We choose SEM photograph Fig. 9C, as the epitype of *C. baicalensis*, to show the morphological features of the RV in the internal view, which are poorly represented in the type material, namely its 3D-shape, density and arrangement of striae, shape and size of hyaline areas. Additionally, figures 8A, 10A and 12C show the same traits of the RV in the external view and SV in the external and internal view.

The validating description of *Cocconeis placentula* var. *baikalensis* (Williams and Reid 2001, 310) (≡*Cocconeis skvortzowii*) is "based on a little bottom sample collected by Prof. K.I. Meyer at the depth of 33 meters near the Olhon Gate



Figure 6. *Cocconeis baicalensis*. LM. Slide No. 336a, Boguchanskaya Gulf. LE A0004244 **A–D** raphe valve **E–I** sternum valve. Scale bar: 10 µm.



Figure 7. Cocconeis baicalensis. LM. Slide No. 5, Marituy, LE A0002317 A, D sternum valve with valvocopula B, C, E, F raphe valve G valvocopula of raphe valve H sternum valve. Scale bar: 10 μm.

of Baikal Lake July 29, 1916" (Williams and Reid 2001, 297). No specimen of this gathering has been found in LE. In its absence, the only element of the original material are the illustrations in the protologue (Williams and Reid 2001, pl. 5, figs 5, 7, 8), two of which we are designating as the lectotype.

Since the drawings (Williams and Reid 2001, pl. 5, figs 7, 8) do not demonstrate the morphological details, but only the valve outlines and a wide axial area on both valves, we are designating the epitype, namely SEM photograph



Figure 8. *Cocconeis baicalensis*. Raphe valve, external view. SEM. Specimen No. BL15645, Island Bolshoy Ushkaniy. Scale bar: 5 µm.

Fig. 18C of Skabichevsky's material from the Island Bolchoy Ushkaniy. The epitype illustration clearly shows the morphological features of the RV and SV in the external and internal view, namely shape, density and arrangement of striae, shape and size of areolae.



Figure 9. *Cocconeis baicalensis* **A–D** raphe valve, internal view **B** valve with valvocopula. SEM. Specimen No. BL15645, Island Bolshoy Ushkaniy. Scale bar: 5 µm.

Cocconeis skvortzowii (Sheshukova) Sheshukova 1951 in Proshkina-Lavrenko (ed.) Opredelitel presnovodnykh vodoroslei SSSR 4: 193, figs 104 a-c (with indirect reference; with authorship of basionym "Skv.") emend. Gogorev & Yurchak

- *Cocconeis placentula* Ehrenberg var. *skvortzowii* Skabichevskij ex Sheshukova 1950 in Proshkina-Lavrenko (ed.) *Diatomovyi analiz* 3: 86, pl. 30, figs 10 a, b (with indirect reference; as combination with authorship "(Skv.) Skabitsch."). Basionym.
- Cocconeis placentula Ehrenberg var. baikalensis Skvortzov 1937 in Philippine Journal of Science, C 62(3): 310, pl. 5, figs 5, 7, 8, illegitimate name, later homonym of C. placentula var. baicalensis Skvortzov & K.I. Meyer 1928. Replaced synonym.

≡ Cocconeis placentula Ehrenberg var. sibirica Skabichevskij 1952 in Botanicheskie materialy otdela sporovykh rasteniy Botanicheskogo instituta imeni V.L. Komarova 8: 36 (as combination with authorship of basionym "Skv."), illegitimate superfluous name. ≡ Cocconeis placentula Ehrenberg subsp. sibirica Skabichevskij 1977 in Prirodnye kompleksy nizshikh rastenii Zapadnoi Sibiri: 127, fig. 2, 9–11 (as combination with authorship of basionym "Skv."). Synonyms.

Type materials. *Lectotype* • (designated here): Skvortzov, 1937, Philippine Journal of Science, Section C 62(3): 310, Pl. 5, figs 7, 8.

Epitype • (designated here): figures here represented by Fig. 18C (Baikal, specimen BL15645, leg. A.P. Skabichevsky, 20 July 1965).

Type locality. Russia, Siberia, Lake Baikal, Olhon Gate, Boguchanskaya Gulf, Cape Elokhin, Cape Kotelnikovskiy.

Description. LM (n = 17) (Fig. 16A–Q). Valves lanceolate-elliptical, 8.9– 16.1 μ m in length (mean 12.7), 5.6–9.0 μ m in breadth (mean 7.1). Length to breadth ratio 1.5–2.0:1 (mean 1.8:1). RV with straight raphe, SV with broad lanceolate axial area. On RV 20–24 striae in 10 μ m (mean 22), on SV – 18–23 in 10 μ m (mean 21.4). Often SV with "ghost raphe", so such valves similar to RV in view. Valvocopula closed or open, with sparsely spaced fimbriae.

SEM (n = 17). Valves from elliptical to linear-elliptical, $11.6-27.0 \mu m$ in length (mean 14.7-16.7), 6.3-17.7 in breadth (mean 9.1-10.5). Length to breadth ratio 1.3-1.9:1 (mean 1.6:1).

RV (n = 9). Valves concave, with slightly convex middle part. Axial area narrowly linear or indistinguishable. Striae uniseriate, 21-24 in $10 \mu m$ (mean 22.7). Areolae rounded or unevenly rounded, 22-33 in $10 \mu m$ of stria (mean 29.1), absent at valve apices. Valve mantle (contra mantle) slightly reversed.

RV, external view (Figs 17A–C, 19A–C). Central area absent. Raphe straight, proximal endings slightly widened, distal endings more widened. Striae weakly radial, sometimes interrupted by clear or weakly defined narrow submarginal hyaline strips. Areolae increased in size and more densely located toward valve edge. Marginal ridge wider, $0.4-1.0 \mu m$ in breadth, and more distinct than submarginal hyaline strips.

RV, internal view (Fig. 19D). Central area small, round. Proximal raphe endings directed opposite, distal endings form small helictoglossae. Areolae equal in size.

RVVC. Valvocopula closed, up to 1.3 μ m in breadth, with straight or weakly curved fimbriae, up to 1.3–1.6 μ m high, 7–8 in 10 μ m.

SV (n = 8). Valves convex, with concave middle part. Axial area usually wide, lanceolate, rarely narrowly or broadly lanceolate, with often ghost raphe. Central area absent. Striae uniseriate, 13–20 in 10 μ m (mean 17.6), consisted of 2–4 elongated areolae.

SV, external view (Figs 17D, E, 18A, B). Openings of areolae slit-like, usually located in depression. Axial area often with ghost areolae (small depressions) located in "striae" or randomly.

SV, internal view (Figs 17F, 18C, D). At edge, striae consisted of 1–2 rounded or elongated areolae, divided into 1–2 parts by thin or thickened baffle. Areolae rounded or irregularly rounded near axial area, in 2–3 (up to 5) curving apical rows (distance between areolae in stria different). Adjacent "postmacroareolae" delimited by small ribs and sometimes extended up to axial area.

There are no data on copulae, except valvocopulae.

	Valve	Valve		Striae number in 10 µm		Areolae		
Species	length (µm)	breadth (µm)	Ratio	RV	sv	number in 10 µm	Distribution	References
Cocconeis skvortzowii	8.9-27.0	5.6-17.7	1.3-2.0:1	20-24	13-23	22-33 (RV)	Lake Baikal	Our data
C. placentula var. skvortzowii	11-36	6.8-22.0	1.6- 1.8(2.1):1*	20-30	13-20	11-13 (SV)	Lake Baikal	Skvortzow 1937; Skabichevsky 1977
C. placentula var. skvortzowii	12-24	7-14	1.7:1*	~30	18	n.d.	Lake Baikal	Sheshukova 1950
C. skvortzowii	14-36	8-22	1.6-1.8:1*	15-20	15-20	11-13	Lake Baikal	Sheshukova 1951
C. disculus	20-25	11-16	1.6-1.8:1*	22	7-9	n.d.	Europe	Sheshukova 1950, 1951
(Schumann) Cleve	10-25	7-16	1.4-1.6:1*	20-22	6-10	18-22 (RV)	Cosmopolitan, Germany	Krammer and Lange-Bertalot 1991; Hofmann et al. 2011; Kulikovskiy et al. 2016b; Lange-Bertalot et al. 2017
C. diminuta Pant.	8.5	6	1.4:1*	35	24	n.d.	Lake Baikal	Skvortzow 1937
C. disculus var. diminuta (Pant.) Scheshukova	7-15	5-9	1.4–1.7:1*	~32	13	n.d.	European Russia, Mongolia	Sheshukova 1950, 1951
C. neodiminuta Krammer	7–18	5-9	1.4-2:1*	24-32	11–14 (2–4 areolae per stria)	25-32 (RV)	Germany, Hungary, Switzerland, Ireland	Krammer and Lange-Bertalot 1991; Kulikovskiy et al. 2016b
	9.6-19.4	6.5-8.0	1.5-2.4:1*	ca. 25	n.d.	n.d.	Poland	Wojtal 2009
	8-18	6-9	1.3-2:1*	24-32	11-14	25-32 (RV)	Germany, Hungary, Ireland	Romero and Van de Vijver 2011
	13-17	7-10	1.7-2:1*	30	13-15	n.d.	Brazil	Costa et al. 2020
C. placentula var. euglypta (Ehrenb.)	10-46	n.d.	n.d.	n.d.	19-22	n.d.	Cosmopolitan	Krammer and Lange-Bertalot 1991
Grunow	11.0-41.2	7.4-26.6	1.5:1*	ca. 20	20-22	n.d.	Poland	Wojtal 2009
C. euglypta Ehrenb. (epitype)	15.9-29.5	9.8-17.7	1.5-1.8:1	17-22	18.5-24 / 20-24	n.d.	Baltic Sea	Romero and Jahn 2013
	15-30	9-18	1.7:1*	17-22	18-24	n.d.	Cosmopolitan	Kulikovskiy et al. 2016b
	15-45	9-28	1.5-1.8:1	17-22	18-24	n.d.	n.d	Lange-Bertalot et al. 2017
	13.4-29.5	8.3-16.6	1.6-1.8:1*	19-24	22-24	n.d.	Brazil	Costa et al. 2020
C. placentula var.	30	18	1.7:1*	n.d.	24	n.d.	Lake Baikal	Skvortzow 1937
lineata (Ehrenb.) Van Heurck	40-70	30-40	1.3-1.8:1*	n.d.	n.d.	n.d.	Russia, Europe	Sheshukova 1951
	10-80	n.d.	n.d.	n.d.	16-23	n.d.	Cosmopolitan	Krammer and Lange-Bertalot 1991
	14.0-25.2	10.5-14.0	1.3-1.8:1*	22.0-23.5	20-22	n.d.	Poland	Wojtal 2009
	11-42	7-28	1.5-1.6:1*	15-24(30)	n.d.	n.d.	North Russia	Genkal and Vekhov 2007
C. lineata Ehrenb. (epitype)	18.6-22.7	6.4-13.1	1.6-2.4:1	20-28	(7)10-15 / 12-20	16-24(26) (SV)	Faroer Islands, Denmark	Romero and Jahn 2013
C. lineata	18-23	6-14	1.6-3:1*	20-28	10-15	16-24 (SV)	Cosmopolitan	Kulikovskiy et al. 2016b
	16-80	6-35	1.6-2.4:1	20-28	10-15	16-24 (SV)	Europe	Lange-Bertalot et al. 2017
	12.7-19.6	7.9-10.9	1.6-1.8:1	21-22	25-32	n.d.	Brazil	Costa et al. 2020
	19.1-22.8	9.4-12.6	1.6-2.2	18-24	22-28	25-28 (RV), 12- 18 (SV)	Korea	Jahn et al. 2017
C. placentula var. pseudolineata Geitler	7.5-38.0	n.d.	n.d.	n.d.	13-20(22)	n.d.	n.d.	Krammer and Lange-Bertalot 1991
	7.5-38.0	n.d.	n.d.	16-20(22)	20-23	n.d.	n.d.	Romero and Van de Vijver 2011
C. pseudolineata (Geitler) Lange-Bert.	7.5-38.0	6-18	1.3-2.1:1*	20-23	13-18(20)	16-20(22) (SV)	Europe	Hofmann et al. 2011; Lange- Bertalot et al. 2017
	12.5-23.0	8-18	1.3-1.6:1*	23-24	13-15	n.d.	Poland	Wojtal 2009
	16-32	8-14	2-2.3:1*	23-26	12-22	23-28 (RV)	n.d.	Werum and Lange-Bertalot 2004

Table 4. Comparison of morphological features of Cocconeis skvortzowii and related species.

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Species	Valve	Valve breadth (µm)	Ratio	Striae number in 10 µm		Areolae		
	length (µm)			RV	sv	number in 10 µm	Distribution	References
C. pseudothumensis Reichardt	11.5-13.5	8.2-9.5	1.4:1*	35-40	10-20	10-20 (RV)	Europe, France, Germany, Switzerland	Reichardt 1982; Romero and Van de Vijver 2011
	11.5-13.5	8.2-9.5	1.4:1*	35-40	10-12	n.d.	France, Europe	Krammer and Lange-Bertalot 1991; Hofmann et al. 2011; Lange-Bertalot et al. 2017
	9-15	6.5-11.0	1.4:1*	35-40	10-14	n.d.	Holarctic	Kulikovskiy et al. 2016b
C. thumensis Ant. Mayer	Up to 10	5-6	n.d.	15-16	15-16	n.d.	North European Russia, Europe	Sheshukova 1950, 1951
C. neothumensis Krammer	6.5-13.0	4.0-8.3	1.6:1*	28-36	16-25	34-37 (RV)	Cosmopolitan, Germany	Krammer and Lange-Bertalot 1991; Hofmann et al. 2011; Kulikovskiy et al. 2016b; Lange-Bertalot et al. 2017
	11.2-12.2	7.0-7.4	1.6:1*	23	26	n.d.	Brazil	Costa et al. 2020
	8.0-10.6	4.4-8.0	1.3-1.8:1*	25-30	28	n.d.	North Russia	Genkal and Vekhov 2007

* - our calculations on illustrations; n.d. - no data.



Figure 10. Cocconeis baicalensis A–D sternum valve, internal view A, B valve with valvocopula D lowest valve (arrowhead). SEM. Specimen No. BL15646, Island Bolshoy Ushkaniy. Scale bars: 5 µm.



Figure 11. *Cocconeis baicalensis*. Raphe valve (**A**–**D**) external view (**E**, **F**) internal view. SEM. Specimen No. 318, Kotelnikovskiy Mayak. Scale bars: 2 μm (**A**); 5 μm (**B**, **D**–**F**); 1 μm (**C**).



Figure 12. *Cocconeis baicalensis*. Sternum valve (**A**–**D**) external view (**E**, **F**) internal view. SEM. Specimen No. 318, Kotelnikovskiy Mayak. Scale bars: 5 µm (**A**, **C**, **E**); 2 µm (**B**, **D**, **F**).



Figure 13. *Cocconeis baicalensis* **A**–**C** raphe valve **A**, **B** external view **C** internal view **D** valvocopula (VCRV). SEM. Specimen No. 5, Marituy. Scale bars: 5 µm (**A**–**C**); 2 µm (**D**).



Figure 14. *Cocconeis baicalensis* **A**–**D** sternum valve **A**, **B** external view **C** internal view **D** valve with valvocopula. SEM. Specimen No. 5, Marituy. Scale bars: 5 μm (**A**, **C**, **D**); 2 μm (**C**).

Comments. Our data differ from the data of Skvortsov and Skabichevsky (Table 4) in the following: the range of valve length and width has been increased, namely, the minimal size of the studied valves is less than those noted in the literature; the stria density on the RV corresponds to the previous data,



Figure 15. Cocconeis baicalensis A, B raphe valve A external view B internal view C frustule D part of frustule, external RV and internal SV view E, F sternum valve E external view F internal view. SEM. Specimen No. 336, Boguchanskaya Gulf. Scale bars: $5 \mu m (A-C, E)$; $1 \mu m (D)$; $2 \mu m (F)$.



Figure 16. *Cocconeis skvortzowii* **A–C** raphe valve **D–Q** sternum valve **D–O**, **Q** valve with ghost raphe. LM. Slides No. BL18566– BL18675, Island Bolshoy Ushkaniy. Scale bar: 10 µm.

but density on the SV has been increased. Data in the literature available on areola density in stria most likely refer to a SV; our data obtained are significantly higher and refer to a RV.

Valves shown in Figs 17D, E, 18A, B are somewhat similar to *Cocconeis margaritata* Riaux-Gobin & Al-Handal and *Cocconeis* spp. (Riaux-Gobin et al. 2010) according to the areolae pattern on external surface of the SV, namely, the openings of areolae are slit-like and located in a depression.

A comparison of *Cocconeis skvortzowii* with related species (Table 4) showed that the species is externally similar to small valves of *C. pseudothumensis* (including the ratio of valve length to breadth), but differs greatly in the stria density on the RV. The same results can be seen for *C. neothumensis* as well as the *C. diminuta / C. neodiminuta* complex.

The comparative analysis shows similarity/overlapping in stria density of *Cocconeis skvortzowii* with *C. lineata* and *C. pseudolineata*. But two last species have the larger size of valve compared to *C. skvortzowii*, and, accordingly, a larger length-to-breadth ratio. Data on the stria density on the SV in *C. lineata* are quite contradictory from different references, which most likely indicates a complex of several species. If we take into account only data on the epitype of *C. lineata*, then their stria density is lower than that of *C. skvortzowii*.

Two species, *Cocconeis disculus* and *C. euglypta*, differ from *C. skvortzowii* in both valve shape and SV structure, namely, in the number of apical rows of areolae.

A direct reference to the location of *Cocconeis placentula* Ehrenb. var. *baicalensis* is absent in Skvortzow and Meyer (1928): "The list is published without reference to the place where a certain species had been found". However, the locations of 36 samples are given in their publication, of which later Meyer (1930, 341) indicated 8 typical locations for this variety (Table 1).

The three permanent slides with the date given in the protologue, and one more with a later date are deposited in the LE diatom collection. Slides No. 15 and 16 (according to the numbering of Skvortzow and Meyer 1928, 2) are labelled as the village of Merkusheva ("village Merkutov"), on the label of third one it is given "d. Merkushevo [Merkusheva]." The exact location (with coordinates)



Figure 17. *Cocconeis skvortzowii* **A**–**C** raphe valve, external view **C** Lower valve (arrowhead) **D**–**F** sternum valve **D**, **E** external view **F** internal view. SEM **A**, **C** specimen No. BL15646, Island Bolshoy Ushkaniy **B**, **D**–**F** specimen No. BL15645, Island Bolshoy Ushkaniy. Scale bars: 3 μm (**A**, **B**, **D**); 5 μm (**C**); 6 μm (**E**); 8 μm (**F**).



Figure 18. *Cocconeis skvortzowii* **A**–**F** sternum valve **A**, **B** external view **B** sternum with ghost raphe and ghost areolae **C**, **D** internal view. SEM. Specimen No. BL15645, Island Bolshoy Ushkaniy. Scale bars: 4 μm (**A**, **B**, **D**); 5 μm (**C**).

was established using a 1912 map (http://www.etomesto.ru/map-chita_zabaykalskaya-oblast-1912). Reliable and abundant findings of *Cocconeis baicalensis* were not identified when studying these slides in LM.

Also, in the Diatom collection LE there is authentic material collected by K.I. Meyer in 1921–1928 (35 samples, Table 1), including 9 samples (data June 30 1926, or no data), the locations of which are indicated in Skvortzow and Meyer (1928) and Meyer (1930). The last ones are used to make permanent slides stored in LE, in two of them (LE A0004242–LE A0004245) clear and numerous valves of *Cocconeis baicalensis* were found.

Skabichevsky's material (Table 1) was studied in LM and SEM to clarify the morphology and taxonomy of *Cocconeis baicalensis*, since many morphological characters and elements of the valve are not satisfactory when studied in LM. We choose SEM photograph Fig. 9C, as the epitype of *C. baicalensis*, which clearly show the morphological features of the RV in the internal view, namely its 3D-shape, density and arrangement of striae, shape and size of hyaline areas, poorly represented in the type material. Additionally, figs 8A, 10A, 12C show the same of the RV in the external view and SV in the external and internal view.



Figure 19. *Cocconeis skvortzowii* **A**–**D** raphe valve **A**–**C** external view **D** valve with valvocopula, internal view. SEM **A**, **B** specimen No. 336, Boguchanskaya Gulf **C** specimen No. 318, Kotelnikovskiy Mayak **D** Cape Elokhin. Scale bars: 2 μm (**A**–**C**); 5 μm (**D**).

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Conflict of interest

The authors have declared that no competing interests exist.

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Rinat Gogorev: sample analysis, draft, writing. Maria Yurchak: sample analysis, draft, writing. Irina Sokolova: writing, editing. Anton Glushchenko: sample analysis, editing. Maxim Kulikovskiy: sampling, sample analysis, editing.

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Data availability

All of the data that support the findings of this study are available in the main text.

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