

Petrocosmea duyunensis (Gesneriaceae), a new species from Guizhou, China

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Abstract

Plants belonging to the genus *Petrocosmea* are rare and small herbs difficult to find in the wild. In the present study, a new species, *Petrocosmea duyunensis*, from Guizhou, China, is described. The species is most similar to *P. leiandra* and differs from it by a distinctly recurved abaxial corolla lip, free anthers and included pistil. Detailed morphological comparisons are given. One population with about 100 mature individuals was found at the type locality. This new taxon was assessed as “Data Deficient” (DD) according to the IUCN standards.

Keywords

Didymocarpoideae, flora of China, morphology, taxonomy

Introduction

The genus *Petrocosmea* Oliv. belongs to the family Gesneriaceae, subfamily Didymocarpoideae (Weber et al. 2013). According to an earlier revision of the genus by Wang (1985), 27 species and four varieties were recognised and classified into

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three sections, *viz.*, sect. *Anisochilus* Hemsl., sect. *Deinanthera* W.T.Wang, and sect. *Petrocosmea*. In 2015, the first phylogenetic analyses of the genus were presented, 33 species and three varieties were classified into five sections, *viz.*, sect. *Petrocosmea* Oliv., sect. *Anisochilus* Hemsl., sect. *Minor* Zhi J. Qiu, sect. *Barbata* Zhi J. Qiu, and sect. *Deinanthera* W.T. Wang (Qiu and Liu 2015; Qiu et al. 2015). Presently, the genus comprises 56 species with three varieties (GRC 2021). Its native range is from the eastern Himalayas to central China and Indo-China (POWO 2021). The distribution of most of *Petrocosmea* species is restricted to relatively small geographical areas (Wang et al. 1998; Wei and Wen 2009). South and southwestern China are the centres of gesneriad diversity (Xu et al. 2017). Guizhou is a province that lies in the southwest of China. To date, 14 taxa of *Petrocosmea* have been recorded in Guizhou, and the type localities of eight taxa were in Guizhou (Wang 1984; Gou et al. 2010; Han et al. 2017, 2019).

In November 2020, during field work in Duyun county, Guizhou province, we collected some living plants belonging to the genus *Petrocosmea*. In April 2021, when the plants flowered in the greenhouse of the Guizhou Botanical Garden, they had distinctly recurved abaxial corolla lips and included pistil. In the same month, we visited the type locality again and collected flowering specimens. The plants were classified as belonging to sect. *Minor*, which mostly possesses a highly fused upper lip and forms a carinate-plicate shape on the upper lip. They were most similar to *P. leiandra* (W.T.Wang) Z. J. Qiu in the shape of leaf blades and corolla limb, and anther dehiscence. After thorough comparisons, we concluded that the plants represented a new species.

Methods

Morphological observations of flowering plants were performed in the field and in the greenhouse. All morphological characteristics were observed under a dissecting microscope (Olympus SZ61, Tokyo, Japan), and descriptions were made following the terminology used in Wang et al. (1998). The relevant literature was consulted, including Xu et al. (2011), Qiu et al. (2012), Zhang et al. (2013), Han et al. (2018), Wen (2019), Jiang et al. (2020), Qiu et al. (2020), Huang and Xin (2021), in addition to those mentioned in the introduction. The images of type specimens available in virtual herbaria and databases, including RBGE (<https://data.rbge.org.uk/search/herbarium/>), Kew Herbarium Catalogue (<http://apps.kew.org/herbcat/navigator.do>), MNHN (<https://www.mnhn.fr/en>), PE (<https://pe.ibcas.ac.cn/index.html>), and iPlant (<http://www.iplant.cn/>) were also examined. In order to obtain comparable morphological data for living plants, flowering plants belonging to the new taxon and similar species were collected from their type localities. The type specimens of the new taxon were collected by Sheng-Hu Tang in the field.

Taxonomic treatment

Petrocosmea duyunensis Sheng H. Tang, sp. nov.

urn:lsid:ipni.org:names:77219124-1

Figure 1

Type. CHINA Guizhou Province, Duyun County, Doupeng Mountain, 26.37 N, 107.37 E, about 1047 m a.s.l., 23 April 2021, *Sheng-hu Tang 2021001* (Holotype: IBK!; Isotype: CSH!)

Diagnosis. *Petrocosmea duyunensis* is most similar to *P. leiandra* in the shape of leaf blades and corolla limb, and in the indumentum of peduncles, calyx, and ovary. However, it differs from the latter in the following characteristics: apex of abaxial lip lobes of corolla acute and reflexed (*vs.* round and not reflexed), filaments densely glandular puberulent (*vs.* glabrous or sparsely pilose), pistil 4.7–5.8 mm long, included (*vs.* ca. 9 mm long, exerted), ovary ovoid (*vs.* narrowly ovoid), style distinctly curved, sparsely glandular puberulent, and 2.7–3.7 mm long (*vs.* slightly curved, glabrous, and ca. 7 mm long).

Description. Perennial herbs; rhizomes short, 7–8 mm in length. Leaves 10–30, basal, crowded, with long petioles up to 5 cm, petioles densely glandular pilose and sparsely villous; leaf blades papery when dry, their outer blades ovate or suborbicular, 1.6–2.8 × 1.6–2.6 cm, the blade apex obtuse or rounded, base cordate, sometimes oblique, margin crenate, adaxial blade surface densely glandular pilose, abaxial blade surface densely pilose and sparsely glandular pilose, lateral veins adaxially impressed, abaxially conspicuous, 4–6 on either side of the midrib. Cymes 2–7, 1–3 flowers per cyme; peduncles 1.8–4.0 cm long, densely glandular pilose and sparsely villous; bracts 2, opposite, linear, 2–2.2 × 0.7–0.8 mm, sparsely puberulent outside, glabrous inside. Pedicels 1.0–2.5 cm long, densely glandular pilose and sparsely villous. Calyx zygomorphic, 5 lobes apex acuminate, densely pilose and sparsely glandular pilose outside, glabrous inside; adaxial calyx lobes 3.9–4.2 mm in length, 3-lobed to below the middle, lobes narrowly triangular, 2.2–2.6 × 1.0–1.4 mm; abaxial calyx lobes 2-lobed near the base, lobes oblong-triangular, 3.9–4.3 × 1.4–1.5 mm. Corolla blue-purple, 10.7–12.5 mm, glandular pubescent outside, glabrous inside; tube 4.6–5.4 mm, two yellow spots inside the tube beneath the anthers, throat violet, two white spots in the throat; adaxial corolla lip distinctly short, 1.0–2.0 mm in length, indistinctly 2-lobed, lobes 0.5–1.2 × 2.6–2.8 mm, reflexed slightly; abaxial corolla lip 6.8–8.1 mm, 3-lobed, lobes 2.6–3.0 × 4.6–7.1 mm, broadly ovate, with acute and reflexed apex. Stamens 2, free, adnate to the corolla tube at the base, included; filaments 1.5–2.0 mm in length, 0.5–0.7 mm in diameter, densely glandular puberulent, slightly curved near the middle; anthers ovate, 1.5–1.6 × 1.0–1.1 mm, dorsifixed; thecae parallel, dehiscing longitudinally. Staminodes 3, inconspicuous, adnate to the corolla tube at the base, glabrous. Pistil 4.7–5.8 mm long, included; ovary densely glandular pilose, ovoid, ca.

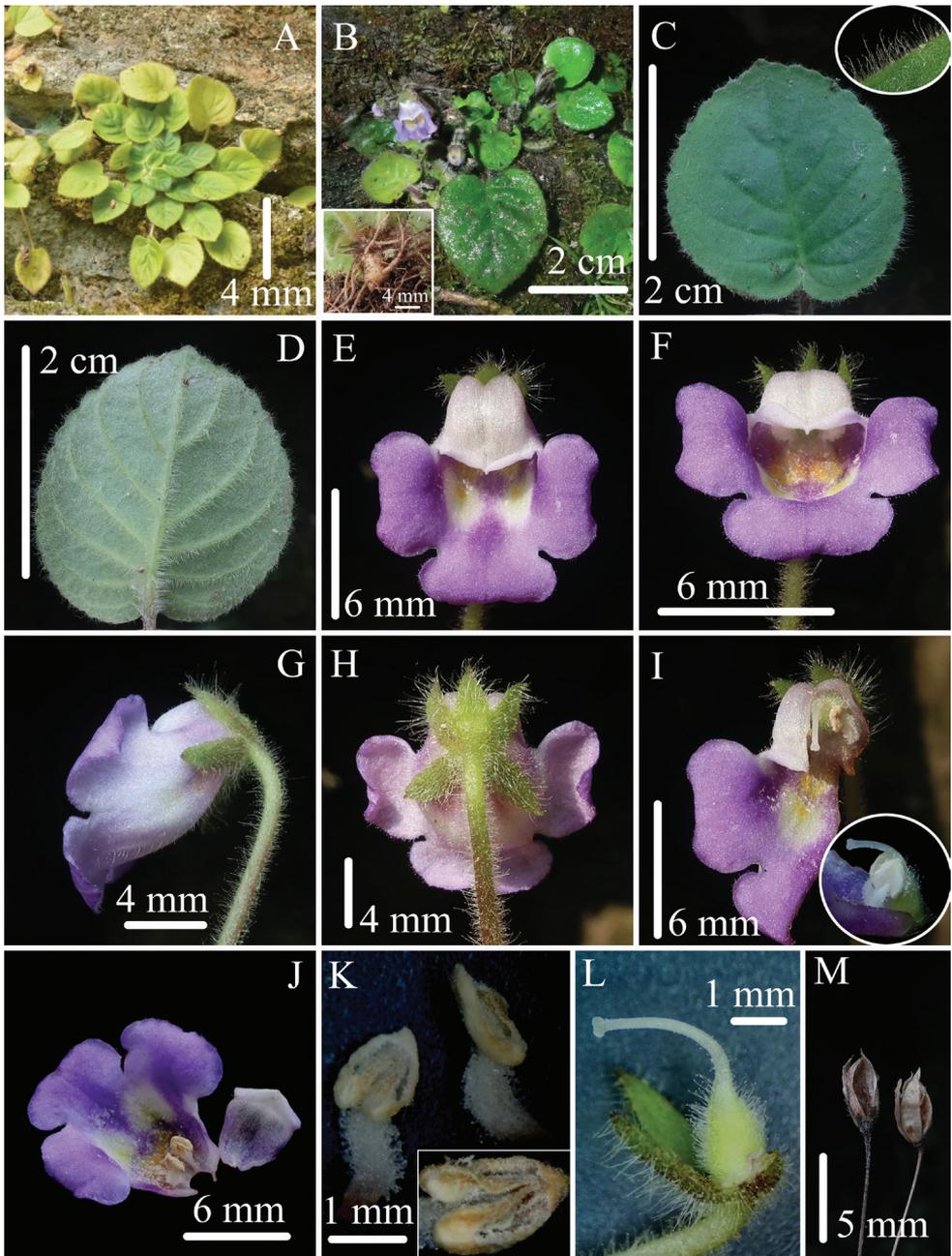


Figure 1. *Petrocosmea duyunensis* Sheng H.Tang sp. nov. **A** habitat **B** flowering plant, rhizome and fibrous roots (inset) **C** adaxial surface of leaf blade and indumentum (inset) **D** abaxial surface of leaf blade **E, F** flowers in front view **G** flower in side view **H** flower in back view **I, J** dissected corolla, stamens and pistil with corolla removed (inset) **K** stamens and anther (inset) **L** pistil with abaxial calyx lobes, and adaxial lobes removed **M** capsules of previous year. (Photographed by Sheng-Hu Tang).

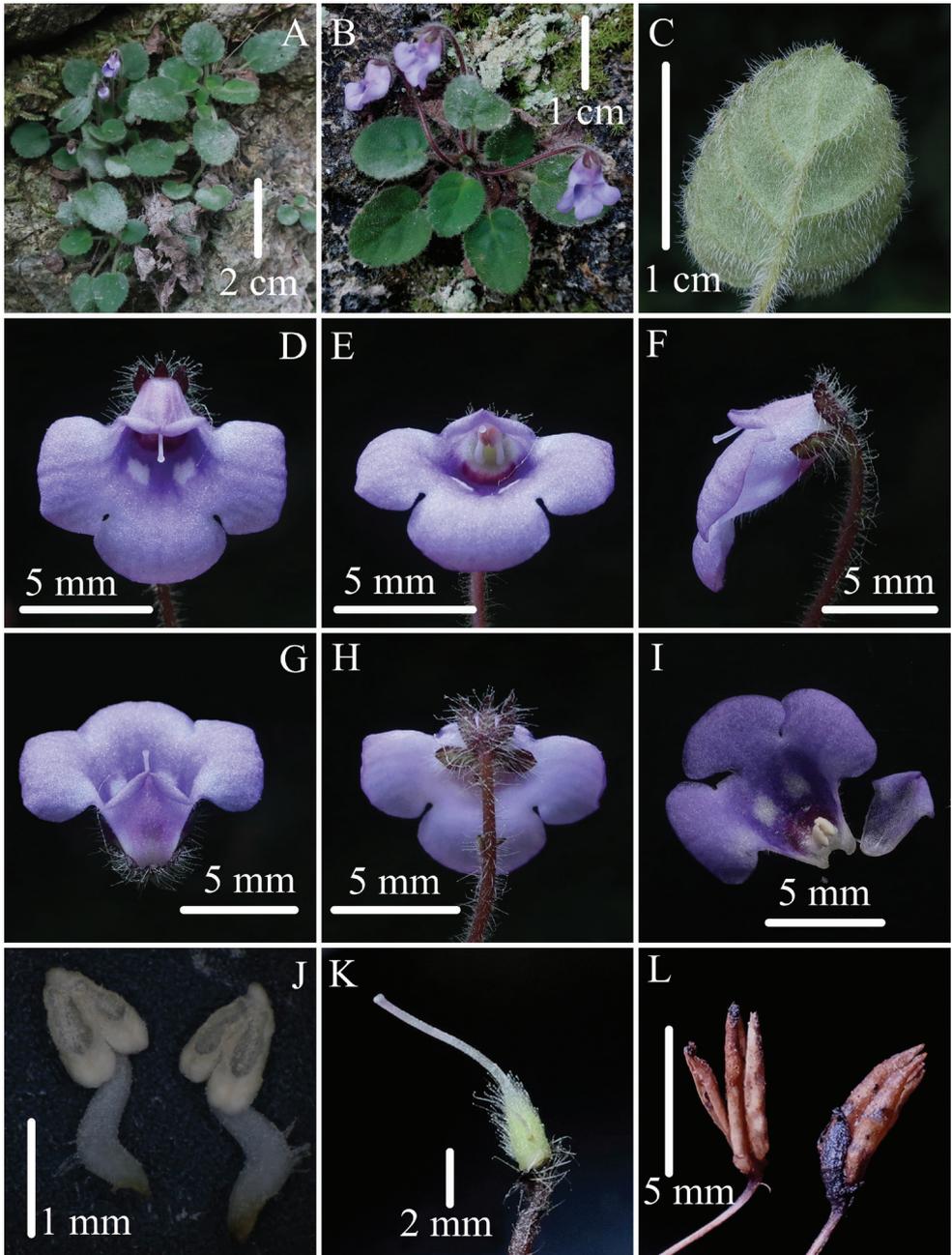


Figure 2. *Petrocosmea leiandra* (W.T.Wang) Z. J. Qiu **A** habitat **B** flowering plant **C** abaxial surface of leaf blade **D, E** flower in front view **F** flower in side view **G** flower in top view **H** flower in back view **I** dissected corolla **J** stamens **K** pistil with calyx removed **L** capsules of previous year. (Photographed by Sheng-Hu Tang).

Table 1. Detailed comparison between *Petrocosmea duyunensis* and *P. leiandra*.

Character / species	<i>P. duyunensis</i>	<i>P. leiandra</i>
Apex of abaxial corolla lip lobes	acute and reflexed	round and not reflexed
Stamen filament indumentum	densely glandular puberulent	glabrous or sparsely pilose
Anthers	free	coherent at apex
Pistil length	4.7–5.8 mm	ca. 9 mm
Pistil position	included in the corolla	exserted from the corolla
Ovary shape	ovoid	narrowly ovoid
Style indumentum	sparsely glandular puberulent	glabrous
Style length	2.7–3.7 mm	ca. 7 mm
Style shape	with a bent approaching 90°	slightly curved

2.0 mm long, 1.2–1.6 mm in diameter; style 2.7–3.7 mm long, 0.2 mm in diameter, sparsely glandular puberulent below the middle, curved above the base at an angle approaching 90°; stigma capitate, 0.3 mm in diameter. Capsule 4.8–6.2 mm long, 1.9–2.0 mm in diameter, ovoid, dehiscent loculicidally to base, valves 2.

Phenology. Flowering from April to May, fruiting in the wild is unknown, only capsules of the previous year were observed.

Etymology. The new taxon is named after the type locality, Duyun county, China.

Vernacular name. The Chinese name is “Dū Yún Shí Hú Dié” (都匀石蝴蝶).

Distribution and habitat. To date, only a single population has been found in Doupeng mountain, Duyun county, Guizhou province, China. The plants were found growing on a moist shady cliff in a valley at an altitude of ca. 1047 m.a.s.l. The main companion species were *Sloanea hemsleyana* (Ito) Rehd. et Wils., *Corylopsis multiflora* Hance, *Pittosporum glabratum* Lindl., and *Oreocharis elegantissima* (H.Lév. & Vaniot) Mich.Möller & W.H. Chen.

Conservation status and IUCN Red List category. One population with about 100 mature individuals was found at the type locality. The habitat is in a nature reserve protected by the local government. It is highly likely that more populations are present in the area. Before further investigations, this species should be assessed as “Data Deficient” (DD) according to the IUCN standards (IUCN 2019).

Notes. Although *Petrocosmea duyunensis* has a short adaxial corolla lip, the pistil is still included in the corolla. This is because the style is relatively short and distinctly curved. The plant possesses two free anthers. These characteristics differ from those of other *Petrocosmea* species. Morphologically, the species is similar to *P. leiandra* (Fig. 2), and detailed morphological comparisons are shown in Table 1.

Acknowledgments

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References

- Gou GQ, Wang XY, Xiong YX (2010) *Petrocosmea xanthomaculata* G. Q. Gou et X. Y. Wang, a new species of the genus *Petrocosmea* Oliv. Bulletin of Botanical Research 30(4): 394–396.
- GRC (2021) The RBGE Gesneriaceae Resource Centre. <https://padme.rbge.org.uk/grc/> [accessed 09.07.2021]
- Han MQ, Lü TF, Liu Y (2017) *Petrocosmea viridis*, a new species of *Petrocosmea* (Gesneriaceae) from Guizhou, China and supplementary and revised description of *P. minor*. Nordic Journal of Botany 36(3): e01566. <https://doi.org/10.1111/njb.01566>
- Han MQ, Yuan Q, Lü TF, Jiang H, Liu Y (2018) *Petrocosmea chrysotricha* sp. nov. (*Petrocosmea*, Gesneriaceae), a species previously mistaken for *P. begoniifolia* on marlstone cliffs in Yunnan, China. Nordic Journal of Botany 2018(4): e01664. <https://doi.org/10.1111/njb.01664>
- Han MQ, Yuan Q, Lü TF, Zhang LB, Liu Y (2019) *Petrocosmea qiruniae* (Gesneriaceae), a new species from Guizhou, China with supplementary data and revised description of *P. leian-dra*. Kew Bulletin 74(2): 1–5. <https://doi.org/10.1007/s12225-019-9811-8>
- Huang ZJ, Xin ZB (2021) *Petrocosmea adenophora* (Gesneriaceae), a new species from Yunnan, China. Nordic Journal of Botany 2021(3): e02944. <https://doi.org/10.1111/njb.02944>
- IUCN (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. <http://www.iucnredlist.org/documents/RedListGuidelines.pdf> [accessed 24.04.2021]
- Jiang H, Han MQ, Dong Z, Han ZD, Liu Y (2020) Two new species of *Petrocosmea* (Gesneriaceae) from Yunnan, China. Nordic Journal of Botany 2020(12): e02847. <https://doi.org/10.1111/njb.02847>
- POWO (2021) Plants of the World Online. <http://powo.science.kew.org/> [accessed 09.07.2021]
- Qiu ZJ, Liu ZY (2015) Plants of *Petrocosmea* in China. Science Publishing House, Beijing.
- Qiu ZJ, Wang XL, Liu ZY, Yang JF, Zhang SZ (2012) Cytological and phylogenetic study of *Petrocosmea hexiensis* (Gesneriaceae), a new species from Chongqing, China. Phytotaxa 74(1): 30–38. <https://doi.org/10.11646/phytotaxa.74.1.2>
- Qiu ZJ, Lu YX, Li CQ, Dong Y, Smith JF, Wang YZ (2015) Origin and evolution of *Petrocosmea* (Gesneriaceae) inferred from both DNA sequence and novel findings in morphology with a test of morphology-based hypotheses. BMC Plant Biology 15(1): e167. <https://doi.org/10.1186/s12870-015-0540-3>
- Qiu ZJ, Zhang J, Baskaran XR, Hu J, Li ZY, Liu ZY (2020) *Petrocosmea nanchuanensis* (Gesneriaceae), a new species from Chongqing, China. PhytoKeys 157: 137–144. <https://doi.org/10.3897/phytokeys.157.33625>
- Wang WT (1984) Notulae de Gesneriaceae Sinensibus (V). Bulletin of Botanical Research 4: 9–35.
- Wang WT (1985) The second revision of the genus *Petrocosmea* (Gesneriaceae). Yunnan Zhi Wu Yan Jiu 7(1): 49–68.
- Wang WT, Pan KY, Li ZY, Weitzman AL, Skog LE (1998) *Petrocosmea*. In: Wu ZY, Raven PH (Eds) Flora of China (Vol. 18) (Gesneriaceae). Science Press, Beijing, and Missouri Botanical Garden Press, St. Louis, 302–308.
- Weber A, Clark JL, Möller M (2013) A new formal classification of Gesneriaceae. Selbyana 31(2): 68–94.

- Wei YG, Wen F (2009) *Petrocosmea xingyiensis* (Gesneriaceae), a new species from Guizhou, China. *Novon* 19(2): 261–262. <https://doi.org/10.3417/2007090>
- Wen F (2019) *Petrocosmea weiyigangii* (Gesneriaceae), a new species from a limestone cave in southern China. *Gardens' Bulletin* (Singapore) 71(1): 175–183. [https://doi.org/10.26492/gbs71\(1\).2019-11](https://doi.org/10.26492/gbs71(1).2019-11)
- Xu WB, Pan B, Liu Y (2011) *Petrocosmea huanjiangensis*, a new species of Gesneriaceae from limestone areas in Guangxi, China. *Novon* 21(3): 385–387. <https://doi.org/10.3417/2009101>
- Xu WB, Guo J, Pan B, Zhang Q, Liu Y (2017) Diversity and distribution of Gesneriaceae in China. *Guihaia* 37(10): 1219–1226. <https://doi.org/10.11931/guihaia.gxzw201707004>
- Zhang Q, Pan B, Meng T, Li GF, Xu WB, Li ZM (2013) *Petrocosmea funingensis* (Gesneriaceae): A new species from southeastern Yunnan, China. *Phytotaxa* 77(1): 5–8. <https://doi.org/10.11646/phytotaxa.77.1.2>

Hanguana deflexa (Hanguanaceae), a new forest species from Sarawak, Borneo

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Abstract

Hanguana deflexa **sp. nov.** (Hanguanaceae) from Lawas district, Sarawak, Malaysia (northern Borneo) is described and illustrated, bringing the total number of species in Borneo to eight. The new species differs from all other recognized *Hanguana* species by a combination of flat leaf blade, deflexed infructescences, one-seeded dull red fruits with centrally positioned stigma and globose seed with wedge-shaped ostiole. Revised key for Bornean *Hanguana* species is presented.

Keywords

Commelinales, Malaysia, rainforest, taxonomy

Introduction

The flora of Borneo is one of the richest in the World (Kier et al. 2005). At the same time, it is among the most threatened, especially due to forest logging, conversion of forest to cropland and large-scale infrastructure projects (Wilcove et al. 2013; Alamgir et al. 2019). Knowledge regarding the taxonomy and diversity of many plant groups is far from perfect and some species probably become extinct before they are even discovered. An illustrative example of such groups are the monocot herbs (so called

macroherbs; Siti Nurfaizilah et al. 2011). While the diversity of some families is well to moderately well explored (e.g. Araceae and Zingiberaceae; Smith 1985, 1986, 1987, 1988, 1989; Boyce and Julia 2006; Boyce and Wong 2015, 2019, and to some extent also Lowiaceae and Taccaceae; Poulsen and Leong-Škorničková 2017; Syaquina et al. 2019; Wong and Chua 2019; Leong-Škorničková et al. 2021), the diversity of others remains poorly understood (e.g. Hypoxidaceae, Hanguanaceae). The herbarium taxonomy of these groups suffers from the scarcity of well-preserved herbarium specimens documenting the full set of morphological characters (i.e. flowers and fruits) and high superficial similarity of their vegetative parts (e.g. Boyce and Julia 2006; Siti Nurfaizilah et al. 2011; Leong-Škorničková and Niissalo 2017). Consequently, the existing flora accounts usually contain very broad species circumscription, e.g. Flora Malesiana accounts for *Curculigo* (Geerinck 1993), *Hanguana* (Backer 1951) and *Tacca* (Drenth 1976).

Hanguana Blume, the sole genus of the family Hanguanaceae, is distributed from Sri Lanka and Myanmar to northern Australia (POWO 2019). Currently, 21 species are recognized of which *Hanguana anthelminthica* (Blume ex Schult. and Schult.f.) Masam. covers the whole distribution range of the genus, while the vast majority of all other species have very narrow ranges (Leong-Škorničková and Niissalo 2017; Randi et al. 2021). The species are dioecious. However, males are only rarely observed and for numerous species, male plants remain unknown. As many female plants produce viable seeds in the absence of males the discovery of polyploidy and apomixis in some species (Niissalo et al. 2020) is not surprising. Consequently, only female individuals in the mature fruiting stage are usually used for description of new taxa. Morphological traits for species delimitation were first reviewed by Siti Nurfaizilah et al. (2011) and later expanded by Leong-Škorničková and Boyce (2015). The presence of stolons, indumentum presence and type, shape of staminodial scales, stigma morphology and position, inflorescence/infructescence architecture, colour of the ripe fruit, and morphology and number of seeds per fruit are considered as the most important (Siti Nurfaizilah et al. 2011; Leong-Škorničková and Boyce 2015). On the infrageneric level, the most phylogenetically informative traits seem to be the presence of stolons and especially the seed shape (Niissalo et al. 2020). Both so far known stoloniferous species (*H. anthelminthica* and *H. nitens* Siti Nurfaizilah, Mohd Fahmi, Sofiman Othman & P.C.Boyce) share shallowly cupuliform seeds and diverged early from the other non-stoloniferous, forest species. The forest species can be further divided into two monophyletic groups, one consisting of robust species with bowl shaped seeds (the so-called large forest species) and the second consisting of small-sized species with almost globose, internally deeply excavated seeds with a wedge-shaped ostiole resembling the popular video game main character called pac-man (the so-called small forest species; Niissalo et al. 2020).

During our field work near Long Tuyu village in Lawas district of Sarawak (northern Borneo) we discovered a small species of *Hanguana* with “pac-man” looking seeds which does not correspond to any described species so far. It is therefore described and illustrated below as *Hanguana deflexa*.

Material and methods

This study is based on the material collected in January 2020 in northern Sarawak (Borneo, Malaysia). Morphological characters were studied using hand lens (30–60× magnification) and stereo microscope and documented by macro photography. Collected specimens were thoroughly compared with protologues and types of all *Hanguana* species, with particular focus on species reported from Borneo and species with similar inflorescence and seed morphology. Additionally, herbarium material of *Hanguana* deposited in E, K, KEP, L, P, SAN and SING was studied (herbarium codes according to Thiers 2020). Herbarium vouchers for this study are deposited in SAR and OL. The descriptions follows the style and level of details outlined in Leong-Škorničková and Boyce (2015), while the general terminology is based on Beentje (2016). The preliminary conservation assessments are based on the most recent version of the guidelines of IUCN Standards and Petitions Subcommittee (2019).

We sequenced the tissue of the type collection using ddRADseq with the methods described in full in Niissalo et al. (2020). We mapped the sequences to the consensus sequence published therein, and conducted a phylogenetic reconstruction using 1000 bootstrap replicates with random seed of 1, *Cyrtostachys renda* as an outgroup, and default settings in RAxML 7.2.8 (Stamatakis 2006). As a test of ploidy levels, we used Smudgeplot v. 0.2.3dev (Ranallo-Benavidez et al. 2020), modified for ddRADseq data as described in Niissalo et al. (2020).

Taxonomic treatment

Hanguana deflexa Hroneš & Dančák, sp. nov.

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Figures 1, 2

Diagnosis. Similar to *Hanguana loi* Mohd Fahmi, Sofiman Othman & P.C.Boyce but differs in flat leaf blade (vs corrugated), pseudopetioles 0.8–2.1 cm wide (vs to 0.6 cm wide), rachis of infructescence up to 10 cm long (vs ca 58 cm long), ripe fruit ca 1 cm in diam. (vs ca 0.5 cm in diam.), and unbranched partial infructescences (vs branched).

Type. Malaysia, Sarawak, Lawas district, Long Tuyo village, on slopes in primary rainforest above left bank of Tuyo river, ca 2.3 km ESE of village, 4°27.75833'N, 115°29.86000'E, ca 610 m a.s.l., 22 Jan 2020; M. Hroneš & M. Dančák 422020 (holotype SAR, isotype OL).

Description. Herbaceous, dioecious mesophyte to ca 1.5 m tall. Stem terete, to 2.5 cm in diam., basally semi-ascending to erect, fully covered by leaf sheaths when young, with age becoming leafless and covered by fibrous remnants of leaf sheaths, terminally with crown of up to 10 leaves; stolons absent. Leaves 70–110 cm long, spreading then arching, bases imbricate with hyaline margins (young leaves), turning brown and erose-marcescent with age; pseudopetiole 13–70 cm long, 0.8–2.1 cm

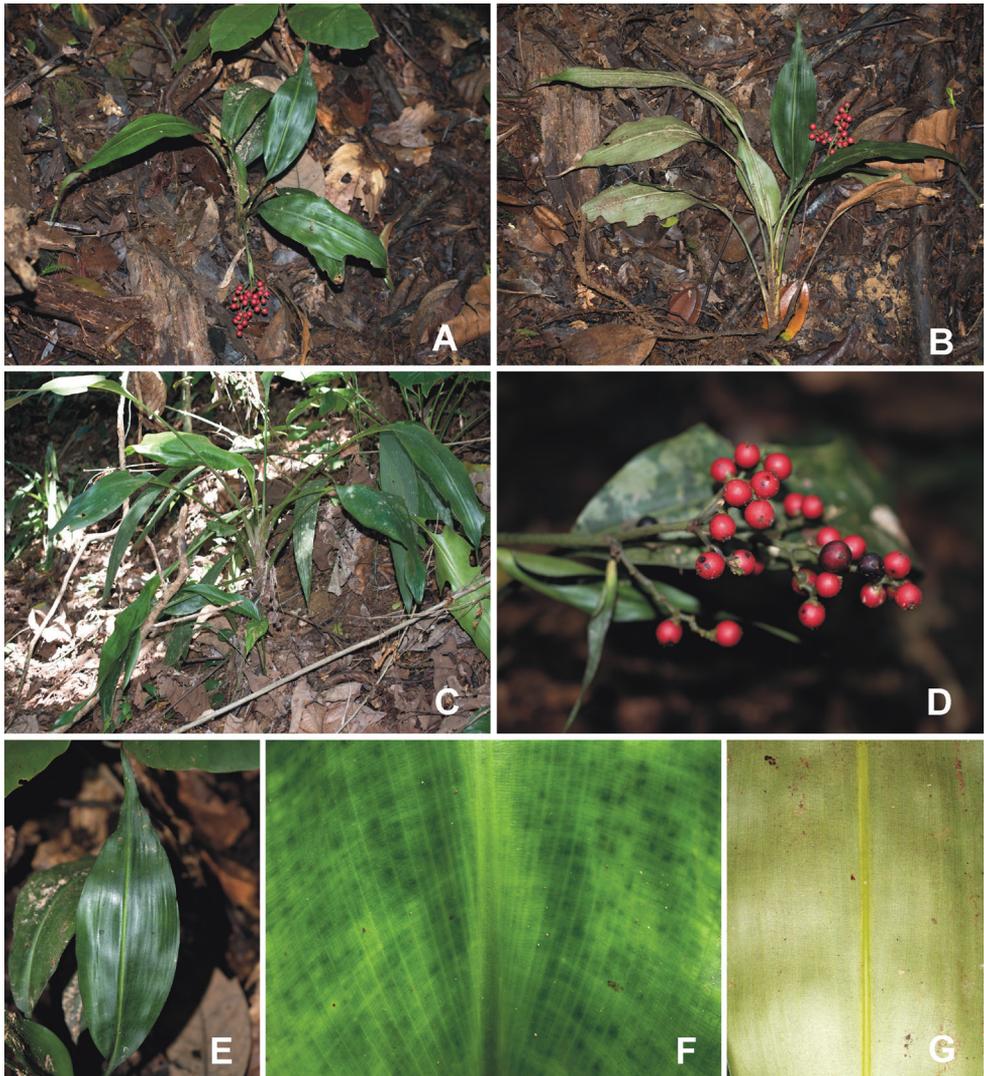


Figure 1. *Hanguana deflexa* Hroneš & Dančák **A–C** habit in-situ **D** structure of infructescence **E** lamina **F** adaxial and **G** abaxial surface of lamina. Photographed by M. Hroneš (all except **C** from Hroneš & Dančák 422020, **C** from Hroneš & Dančák 452020).

wide, accounting for 1/3–1/2 of entire leaf length, roundly channelled with sharp margins, basally greyish-white floccose; leaf blade 40–70 × 8–20 cm, narrowly elliptic to elliptic, base attenuate, tip long narrowly attenuate with apicule to 5 mm, leathery, flat, adaxially mid to dark green (in close-up with darker green blotches and transverse veins resulting in checker-like variegation), greyish-white floccose when young, falling off in older leaves, abaxially light green, prominently floccose in young leaves, falling off with age; midrib weakly impressed, pale green adaxially, round-raised, lighter green, almost glabrous and shiny abaxially. Male inflorescences not seen, female inflorescence

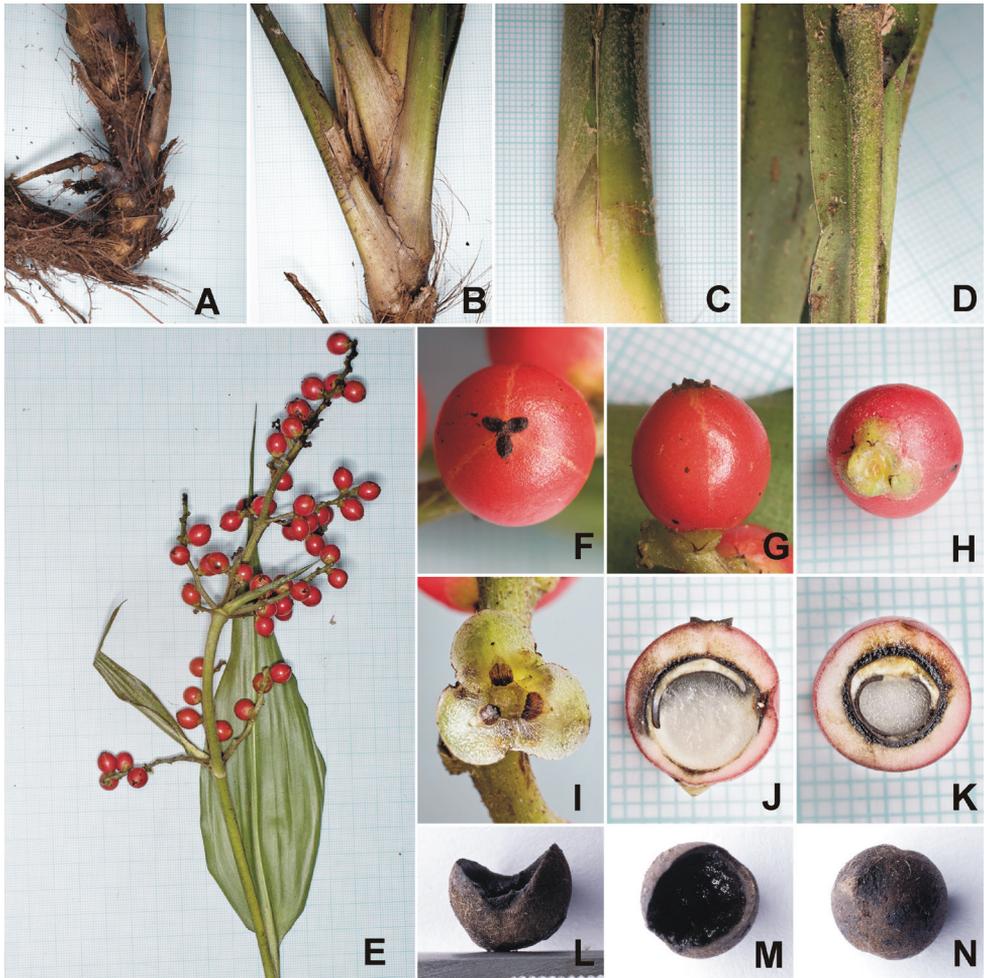


Figure 2. *Hanguana deflexa* Hroneš & Dančák **A** rhizome with fibre remnants of leaf sheaths **B** stem covered by leaf sheaths **C** flocuose indumentum on abaxial side of pseudopetiole **D** peduncle with pale brown-grey flocuose indumentum **E** structure of infructescence with sterile and fertile bracts **F** top view of fruit showing detail of stigma **G** side view of fruit **H** basal part of fruit with tepals **I** detail of inner tepals, staminodes and staminodial scales **J** longitudinal section of fruit **K** cross-section of fruit **L** side view of seed **M** top view of seed **N** bottom view of seed. The smallest grid (where applicable): 1×1 mm. Photographed by M. Hroneš (**A, B, D, G–O** from Hroneš & Dančák 422020, **C, E, F** from Hroneš & Dančák 452020).

not seen. Infructescence deflexed, procumbent to suberect, comprising of up to 5 partial, whorled, alternate-secund, spiciform infructescences ascending at 70°–80° angle, plus a terminal spike; peduncle and rachis together up to 35 cm tall, pale green when fresh, densely pale brown-grey flocculose, visible portion of peduncle up to 25 cm long; sterile bract one per peduncle, foliaceous, persistent, narrowly ovate to narrowly elliptic with a basal claw, up to ca 14–24 (incl. 2 cm long claw) × ca 3–5 cm; bracts subtending lower partial infructescences similar to sterile bracts, diminishing in size

and becoming narrowly triangular distally along the infructescence, the bract supporting the most basal partial infructescence ca 7×1 cm (incl. ca 1.5 cm long claw), fully reduced in uppermost partial infructescences; all bracts densely pale brown-grey flocculose; partial infructescences each comprising up to 4 branches at basal levels (gradually less with up to single branch towards the apex of the infructescence), branches arising simultaneously from the axil of the subtending bract, ca 2–3 mm in diam., usually unbranched, up to 5 cm long, with up to ca 10 fruits each. Female flowers scattered, solitary, sessile, all with an associated minute bracteole; perianth composed of 6 tepals in two whorls tightly clasping ovary/fruit in fresh material, all tepals with prominent bulbous thickening at base (more prominent in outer whorl), light green, margin ca 0.5–1 mm wide, hyaline translucent white (turning brown with age); outer tepals broadly ovate, ca 0.5–1 mm long, ca 1.5–2 mm broad, connate at base (only 0.2 mm), sparsely hairy; inner tepals almost orbicular, ca 3–3.5 mm long, 2.5–3 mm broad, basally imbricate but free, sparsely hairy; staminodes 6, in two whorls, pale green, triangular to narrowly triangular, outer staminodes ca 0.5–1 mm long, ca 0.3 mm broad at base, inner staminodes longer, ca 1.5–2 mm long, ca 0.5 mm at base, each basally sheathed with orbicular to broadly ovate, apically pointed to shallowly bilobed scale, ca 1–1.4 mm long, and 0.8–1.2 mm broad, apex and margins semitranslucent (when fresh) to light brown (when dry), gradually darker brown towards the base. Stigma 3-lobed, ca 2.5–3 mm in diam., each lobe ca 1.2–1.5 mm long (fruiting material), ovate to elliptic with slightly pointed apex curved upwards, lobes connate basally with somewhat raised centre, dark brown at fruiting stage, positioned terminally in ripe fruit. Ripe fruit globose, 8–12 mm in diam., dull purplish red, finally turning black; pulp 0.5–2 mm thick, pinkish-white to pinkish-yellow, fairly hard. Seed one per fruit, ca $5\text{--}6 \times 4$ mm, dark brown, $\frac{3}{4}$ globose to ellipsoid, deeply excavated, ostiole wedge-shaped accounting for ca $\frac{1}{4}$ of the seeds, without any discernible appendage on the rim, cavity filled with placental tissue.

Etymology. The specific epithet is derived from Latin adjective *deflexus* (i.e. bend, deflexed) and referring to the position of infructescence, a rare character in hitherto described *Hanguana* species.

Distribution and habitat. The species is known only from two localities in primary rainforest southeast of the village of Long Tuyu in Lawas district (northern Sarawak). Both populations occur on moderately steep slopes in altitudes around 600 m a.s.l.

Conservation status. The species is so far known only from two small populations ca 1.4 km apart, each consisting of up to 10 adult individuals. Both populations, considered to be a single location (sensu IUCN Standards and Petitions Subcommittee 2019), are located in the forest with no legal protection and therefore threatened by potential logging. Although it is very likely, that *H. deflexa* occurs in suitable habitats in surrounding areas, it is also clear that the species is not widespread, since no other herbarium collections exist in any of the major herbaria we have examined. Based on the IUCN criteria (IUCN Standards and Petitions Subcommittee 2019), this species shall be provisionally treated as Critically Endangered (CR B2ab(iii); D) until more information is available for easing off this status.

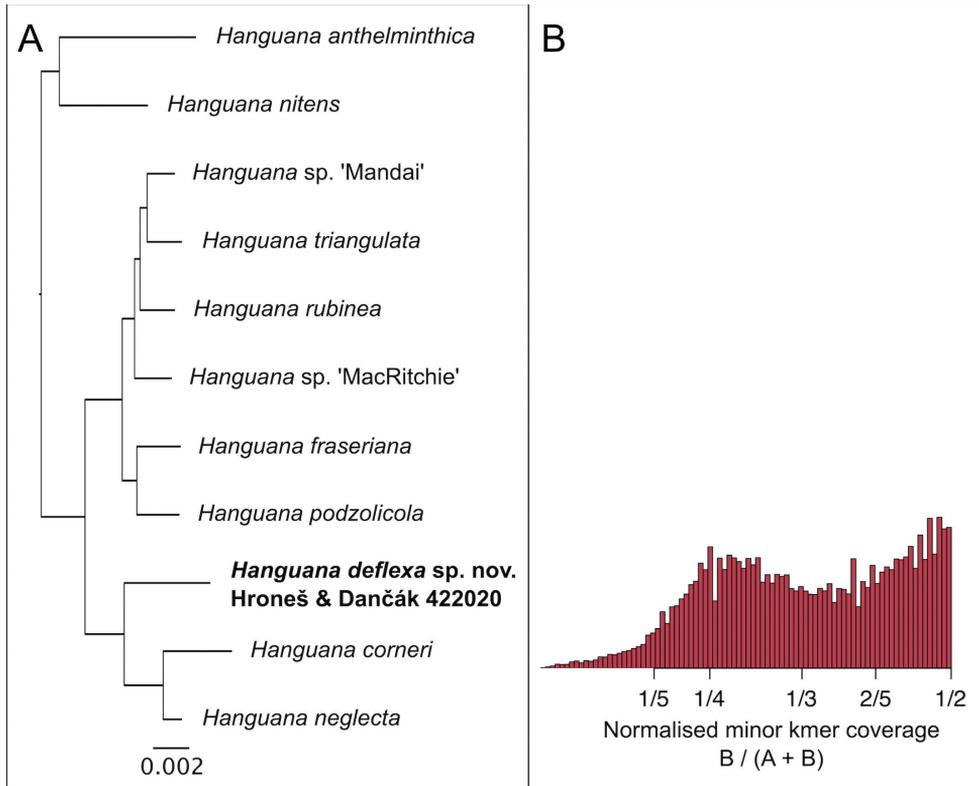


Figure 3. Genomic analyses of *Hanguana deflexa* Hroneš & Dančák, using ddRADseq **A** maximum likelihood phylogenetic reconstruction using RAxML 7.2.8 (Stamatakis 2006). Sequences were added to a data matrix first published in Niissalo et al. (2020). Outgroups are not shown **B** allele balance, supporting tetraploid status of the species, measured using Smudgeplot v. 0.2.3dev (Ranallo-Benavidez et al. 2020), using kmer length of 21, minimum kmer coverage of 20 and maximum kmer coverage of 10,000.

Taxonomic remarks. Based on the seed morphology, *Hanguana deflexa* belongs to the small forest species clade of *Hanguana* (Niissalo et al. 2020) and therefore it is probably related to *H. corneri* Škorničk. & P.C.Boyce and *H. neglecta* Škorničk. & Niissalo (Niissalo et al. 2014; Leong-Škorničková and Boyce 2015). However, it differs from both species by its deflexed (vs erect) infructescence. It further differs from *H. corneri* by leaf blade abaxially light green (vs purple red) and from *H. neglecta* by fruits ripening purplish red (vs fruits ripening black). The close relationship of *H. deflexa* to *H. neglecta* and *H. corneri* is confirmed in our phylogenetic reconstruction (Fig. 3); however, no other Bornean taxa are yet included in the matrix. The allele balance of *H. deflexa* has a distinctive peak at 25%, suggesting that the species is tetraploid, and, like another tetraploid species, *H. anthelminthica*, it may be capable of sexual reproduction (Niissalo et al. 2020).

The deflexed infructescence is a very rare trait among known *Hanguana* species. Except of *H. bakoensis* Siti Nurfazilah, Sofiman Othman & P.C.Boyce and *H. nana*

Randi & Škorničk., all *Hanguana* species have erect infructescences. The protologue illustration of *H. loi* Mohd Fahmi, Sofiman Othman & P.C.Boyce depicts a plant with deflexed infructescence, however, it is described as erect in the main text (Mohd Fahmi et al. 2012). Larger individuals of *H. deflexa* may superficially remind *H. loi* by somewhat arching pseudopetioles and leaf blades (Fig. 1C) and red ripe fruits but both species differ in lamina architecture, width of pseudopetioles, size of ripe fruits and infructescence arrangement as already outlined in the diagnosis. Another similar species, *H. nana*, shares with *H. deflexa* small overall size and red coloured fruits in somewhat sparse, deflexed infructescences but differs by stem evenly covered by leaves and bowl-shaped seeds (Randi et al. 2021).

Hanguana deflexa is already the sixth described species of *Hanguana* known to occur in Sarawak (Mohd Fahmi et al. 2012). Most species are known only from the south-western part of Sarawak, the only exception is *Hanguana major* Airy Shaw known from one locality in Lawas district in northern Sarawak. Our field observations suggest that the diversity of *Hanguana* in central and north-eastern parts of Sarawak is much greater and at least ten species occur in this area. However, these species cannot be described at present due to lack of complete photographic evidence and herbarium material of fruiting females necessary for their description.

Additional specimen studied (paratype). Malaysia, Sarawak, Lawas district, Long Tuyu village, on slopes in primary rainforest above right bank of unnamed left-bank tributary of Tuyu river, ca 2 km SE of village, 4°27.37333'N, 115°29.22667'E, ca 620 m a.s.l., 23 Jan 2020; M. Hroneš & M. Dančák 452020 (OL).

Key to *Hanguana* (Hanguanaceae) in Borneo

Adapted from Mohd Fahmi et al. (2012)

- 1a Colonial helophytes with massive, foliaceous stolons; seeds shallowly cupuliform. Plants of open habitats (banks of large rivers, margins of freshwater bodies) ***H. anthelminthica***
- 1b Clump-forming mesophytes lacking stolons; seeds bowl-shaped or globose with wedge-shaped ostiole. Plants of closed-canopy forests (lowland to montane rainforests, kerangas) **2**
- 2a Leaf blade corrugated ***H. loi***
- 2b Leaf blade flat to wavy, not corrugated **3**
- 3a Leaf blade linear-lanceolate to very narrowly elliptic; all parts of the plant (sub) glabrous, without floccose indumentum; fruits weakly 3-lobed, ripening medium pink to magenta ***H. bakoensis***
- 3b Leaf blade broadly lanceolate, oblanceolate to elliptic, abaxially floccose, at least in juveniles; fruits variable but never 3-lobed, ripening pale yellow, red or black **4**
- 4a Flowering plants small, up to 30 cm tall **5**
- 4b Flowering plants usually 40–150 cm tall **6**

- 5a Stem evenly covered by leaves; lamina elliptic; infructescence deflexed *H. nana*
 5b Stem apically with terminal crown of leaves; lamina broadly lanceolate; infructescence erect *H. bogneri*
 6a Lamina 40–70 cm long; infructescence deflexed; ripe fruits red *H. deflexa*
 6b Lamina 60–100 cm long; infructescence erect; ripe fruits pale yellow or black ..7
 7a Lamina oblanceolate to narrowly elliptic, with midrib round-raised abaxially; fruit lageniform, ripening black; stigma terminal, prominently stipitate *H. major*
 7b Lamina elliptic, with midrib weakly impressed; fruit globose, ripening pale yellow; stigma distinctly oblique, sessile..... *H. karimatae*

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References

- Alamgir M, Campbell MJ, Sloan S, Suhardiman A, Supriatna J, Laurance WF (2019) High-risk infrastructure projects pose imminent threats to forests in Indonesian Borneo. *Scientific Reports* 9(1): e140. <https://doi.org/10.1038/s41598-018-36594-8>
- Backer CA (1951) *Hanguana*. *Flora Malesiana ser. I* 4: 248–250.
- Beentje H (2016) *The Kew plant glossary, an illustrated dictionary of plant terms* (2nd edition). Kew Publishing, Royal Botanic Gardens Kew.
- Boyce PC, Julia S (2006) A review of entire-leaved *Tacca* (Dioscoreaceae) in Sarawak, Borneo. *Gardens' Bulletin (Singapore)* 58: 25–540.
- Boyce PC, Wong SY (2015) Compendium Genera Aracearum Malesianum. *Aroideana* 38: 40–177.
- Boyce PC, Wong SY (2019) Borneo and its disproportionately large rheophytic aroid flora. *The Gardens' Bulletin Singapore* 71(Suppl. 2): 497–524. [https://doi.org/10.26492/gbs71\(suppl.2\).2019-24](https://doi.org/10.26492/gbs71(suppl.2).2019-24)
- Drenth E (1976) *Taccaceae*. *Flora Malesiana ser. I* 7: 806–819.
- Geerinck DJL (1993) *Amaryllidaceae* (including *Hypoxidaceae*). *Flora Malesiana ser. I* 11: 353–373.
- Kier G, Mutke J, Dinerstein E, Ricketts TH, Küper W, Kreft H, Barthlott W (2005) Global patterns of plant diversity and floristic knowledge. *Journal of Biogeography* 32(7): 1107–1116. <https://doi.org/10.1111/j.1365-2699.2005.01272.x>

- Leong-Škorničková J, Boyce PC (2015) *Hanguana* in Singapore demystified: An overview with descriptions of three new species and a new record. *Gardens' Bulletin (Singapore)* 67(01): 1–28. <https://doi.org/10.3850/S2382581215000010>
- Leong-Škorničková J, Niissalo MA (2017) Identity and typification of *Hanguana malayana* and *H. anthelminthica* and notes on other early names in Hanguanaceae. *Plant Systematics and Evolution* 303(9): 1213–1223. <https://doi.org/10.1007/s00606-017-1432-9>
- Leong-Škorničková J, Lamb A, Linton J, Gokusing L (2021) Six new *Orchidantha* species (Lowiaceae) from Borneo. *The Gardens' Bulletin Singapore* 73(1): 179–202. [https://doi.org/10.26492/gbs73\(1\).2021-08](https://doi.org/10.26492/gbs73(1).2021-08)
- Mohd Fahmi AB, Ahmad Sofiman O, Boyce PC (2012) Studies on *Hanguana* (Commelinales: Hanguanaceae) for Sunda IV: *Hanguana major* clarified, a new species from Sarawak, Malaysian Borneo, and description of male reproductive organs in *H. bakoensis*. *Kew Bulletin* 67(2): 205–211. <https://doi.org/10.1007/s12225-012-9358-4>
- Niissalo M, Wijedasa L, Boyce PC, Leong-Škorničková J (2014) *Hanguana neglecta* (Hanguanaceae): A new plant species from a heavily collected and visited reserve in Singapore. *Phytotaxa* 188(1): 14–20. <https://doi.org/10.11646/phytotaxa.188.1.2>
- Niissalo MA, Leong-Škorničková J, Šída O, Khew GS (2020) Population genomics reveal apomixis in a novel system: uniclonal female populations dominate the tropical forest herb family, Hanguanaceae (Commelinales). *AoB PLANTS* 12: plaa053. <https://doi.org/10.1093/aobpla/plaa053>
- Poulsen AD, Leong-Škorničková J (2017) Two new *Orchidantha* species (Lowiaceae) from Borneo. *Blumea* 62(2): 157–162. <https://doi.org/10.3767/blumea.2017.62.02.08>
- POWO (2019) Plants of the World Online. Royal Botanic Gardens, Kew. [accessed 1 February 2021] <http://www.plantsoftheworldonline.org/>
- Ranallo-Benavidez TR, Jaron KS, Schatz MC (2020) GenomeScope 2.0 and Smudgeplot for reference-free profiling of polyploid genomes. *Nature Communications* 11(1): e1432. <https://doi.org/10.1038/s41467-020-14998-3>
- Randi A, Wijedasa LS, Boyce PC, Leong-Škorničková J (2021) Two new species of *Hanguana* (Hanguanaceae) from Kalimantan, Indonesia. *Blumea* 66(1): 101–105. <https://doi.org/10.3767/blumea.2021.66.01.07>
- Siti Nurfazilah AR, Ahmad Sofiman O, Boyce PC (2011) Studies on *Hanguana* (Commelinales-Hanguanaceae) for Sunda I: *Hanguana bakoensis*, a new forest species from Sarawak, Malaysian Borneo, and notes on critical morphologies for elucidating *Hanguana* taxonomy. *Acta Phytotaxonomica et Geobotanica* 61: 139–143.
- Smith RM (1985) A review of Bornean Zingiberaceae: I. (Alpineae p.p.). *Notes from the Royal Botanic Garden Edinburgh* 42: 261–314.
- Smith RM (1986) A review of Bornean Zingiberaceae: II. (Alpineae, concluded). *Notes from the Royal Botanic Garden Edinburgh* 43: 439–466.
- Smith RM (1987) A review of Bornean Zingiberaceae: III (Hedychieae). *Notes from the Royal Botanic Garden Edinburgh* 44: 203–232.
- Smith RM (1988) A review of Bornean Zingiberaceae: IV (Globbeae). *Notes from the Royal Botanic Garden Edinburgh* 45: 1–19.

- Smith RM (1989) A review of Bornean Zingiberaceae: V (Zingiber). Notes from the Royal Botanic Garden Edinburgh 45: 409–423.
- Stamatakis A (2006) RAxML-VI-HPC: Maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. Bioinformatics (England) 22(21): 2688–2690. <https://doi.org/10.1093/bioinformatics/btl446>
- Standards IUCN, Petitions Subcommittee (2019) Guidelines for Using the IUCN Red List Categories and Criteria, ver. 14. [accessed 8 March 2021] <http://www.iucnredlist.org/documents/RedListGuidelines.pdf>
- Syauqina MY, Meekiong K, Aimi-Syazana S (2019) *Orchidantha sarawakensis* sp. nov. (Zingiberales: Lowiaceae), a new species endemic to East Malaysia, Borneo. Journal of Tropical Forest Science 31(3): 371–376. <https://doi.org/10.26525/jtfs2019.31.3.371>
- Thiers B (2020) Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's virtual herbarium. [accessed 1 February 2021] <http://sweetgum.nybg.org/ih/>
- Wilcove DS, Giam X, Edwards DP, Fisher B, Koh LP (2013) Navjot's nightmare revisited: Logging, agriculture, and biodiversity in Southeast Asia. Trends in Ecology & Evolution 28(9): 531–540. <https://doi.org/10.1016/j.tree.2013.04.005>
- Wong SY, Chua KS (2019) Phylogeny of *Tacca* (Taccaceae) and traits in reproductive structures with description of a new Bornean species. Biodiversitas (Surakarta) 20(11): 3096–3118. <https://doi.org/10.13057/biodiv/d201102>

Pseudostellaria wuyishanensis, a new species of Caryophyllaceae from Fujian, China

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Abstract

Pseudostellaria wuyishanensis, a new species from the Wuyishan National Park, Fujian, China, is described and illustrated. Morphologically, *Pseudostellaria wuyishanensis* resembles *P. heterantha*. However, the new species can be distinguished by presence of stolons, 1 line of hairs on the stem, smaller leaf blades, shorter pedicels, and ovary with 2 styles.

Keywords

Caryophyllaceae, Fujian, *Pseudostellaria*, Wuyishan National Park

Introduction

Pseudostellaria Pax is a small genus that belongs to the tribe Alsineae in Caryophyllaceae (Bittrich 1993; Tang et al. 1996). This genus can be easily distinguished from other genera in Caryophyllaceae from the presence of the flesh root tuber. In addition, the vast majority

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of species in the genus have cleistogamous flower and chasmogamous flowers that have petals with two sections (Zeng et al. 2016). Some recent molecular studies show that this group is non-monophyletic which includes a new described genus *Hartmaniella* and 2 species *Stellaria americana* (Porter & B.L.Rob.) Standl. and *Arenaria przewalskii* Maxim. nested within *Pseudostellaria* (Greenberg and Donoghue 2011; Zhang et al. 2017). Russian botanist Turczaninow (1842) first used *Krascheninikovia* Turcz. ex Fenzl for this genus, but this name was in fact a previous synonym for *Eurotia* Adans and did not comply with the international nomenclature regulations. *Pseudostellaria* was established by Pax in 1934 as the new name, which has been used until now (Schischkin and Komarov 1936; Ohwi 1937; Mizushima 1965). Currently, the genus is represented by ca.22 accepted species that are widely distributed all over the world, with 20 species in eastern and northern Asia, 1 species in Europe, and 1 species in North America. (Zeng et al. 2016; Zhang et al. 2017).

Since the turn of the 21st century, 3 new species of *Pseudostellaria* have been established in China. Jin and Ding (2003) described *P. zhejiangensis* X.F Jin & B.Y Ding from the Zhejiang province based on its decumbent creeping stems, obtuse petals, and compressed seeds with a narrow wing. Lian (2009) described *P. polymorpha* W. Z. Di & Y. Ren based on the regular variation in its floral morphology from stem apex to base. Xia et al. (2011) described *P. tianmushansis* Xia et al. based on its several tubers in a row, obovate with a bi-lobed apex petal and tubercles awned seeds. 12 species of *Pseudostellaria* have been recorded in China out of which 5 species are endemic.

During an investigation of wild plants in Fujian Province, southeastern China, that took place in May 2019 and October 2020, an unknown species of *Pseudostellaria* was collected from the deciduous broad-leaved forest in Wuyishan National Park. We found that it resembles *P. heterantha* Pax but has stolons, 1 line of hairs in the stem, smaller leaves, and shorter pedicels. Therefore, we established it as a new species.

Material and methods

All general morphological data were obtained by observation of specimens during field-works and AU, FJIDC, IBSC, KUN, LE herbaria. Terminologies used in the present study follows the *Flora of China* (Lu and Rabeler 2001) and additional consultation of online databases, including Chinese Field Herbarium and Plant Photo Bank of China.

Taxonomy

***Pseudostellaria wuyishanensis* X. Luo & Q.Y. Yang, sp. nov.**

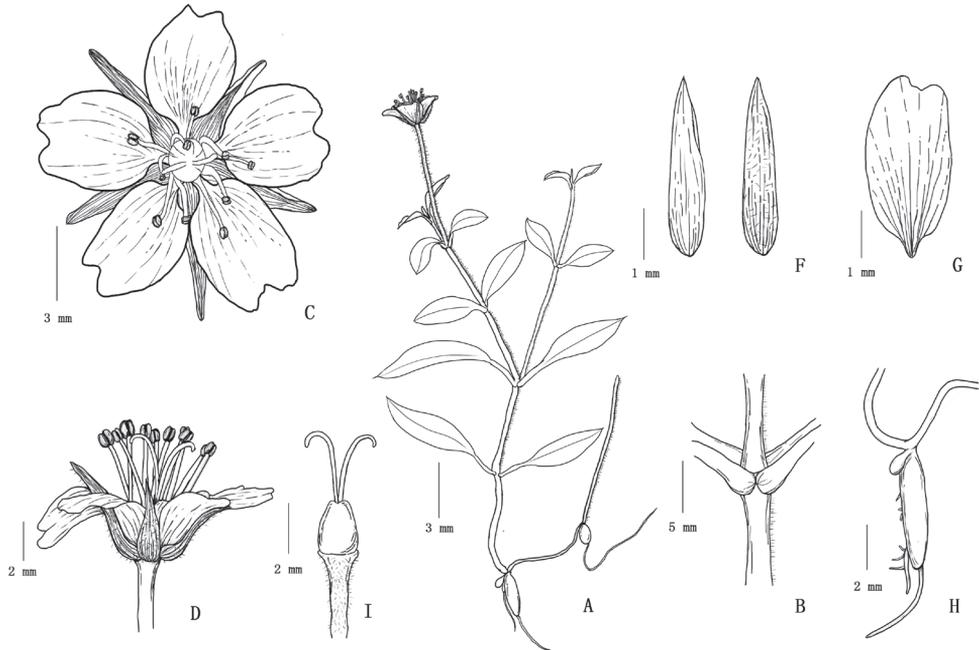
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Figs 1, 2

Type. China. Fujian: Wuyishan National Park, on rocks along a stream, ca.1700 m a.s.l, 1 May 2019, Xiao Luo et Qiyi Yang20190501 (**holotype:** FAFU!; **isotype:** FAFU!)

Table 1. Morphological comparison of *Pseudostellaria wuyishanensis*, *P. heterantha*.

Characters	<i>P. wuyishanensis</i>	<i>P. heterantha</i>
Stem	has stolons, branched at apex, 6–7 cm tall, with 1 line of hairs	no stolon, branched at base, 8–15 cm tall, with 2 lines of hairs
Leaf blade	1–1.6 × 0.5–0.7 cm	2–2.5 × 0.8–1.2 cm
Pedicel	ca. 2 cm long	3–3.5 cm long
Sepal	abaxially pilose, margin glabrous	abaxially pilose, margin ciliate
Ovary	2 styles	2 or 3 styles
Distribution	Fujian (Southeastern China)	Northern and Southwestern China

**Figure 1.** *Pseudostellaria wuyishanensis* sp. nov. **A** plant **B** stem with one line of hair **C** flower **D** flower in side view **E** calyx **F** petal **G** tuber **H** gynoecium of chasmogamous flower.

Diagnosis. *Pseudostellaria wuyishanensis* can be distinguished from *P. heterantha* by several morphological features and distribution (Table 1). *P. wuyishanensis* has stolons (vs. no stolon in *P. heterantha*), 1–1.6 × 0.5–0.7 cm (vs. 2–2.5 × 0.8–1.2 cm in *P. heterantha*) leaf blade, ca. 2 cm long (vs. 3–3.5 cm long in *P. heterantha*) pedicel and is 6–7 cm tall with 1 line of hairs (vs. 8–15 cm tall with 2 lines of hairs in *P. heterantha*). *P. wuyishanensis* only distribute in Wuyishan National Park, Southeastern China (vs. Northern and Southwestern China in *P. heterantha*)

Description. Plants perennial. Root tubers green, fusiform, 0.4–0.6 × 0.2–0.3 cm. Stem erect, 6–7 cm tall, slender, unbranched at base, apex false dichotomous branched, stoloniferous, with 1 line of hairs. Leaves opposite, entire, 1–1.6 × 0.5–0.7 cm; proximal middle leaves oblanceolate, base attenuate into a petiole, apex acute; distal leaves ovate, shortly petiolate, membranous, both surfaces glabrous, the adaxial green, the

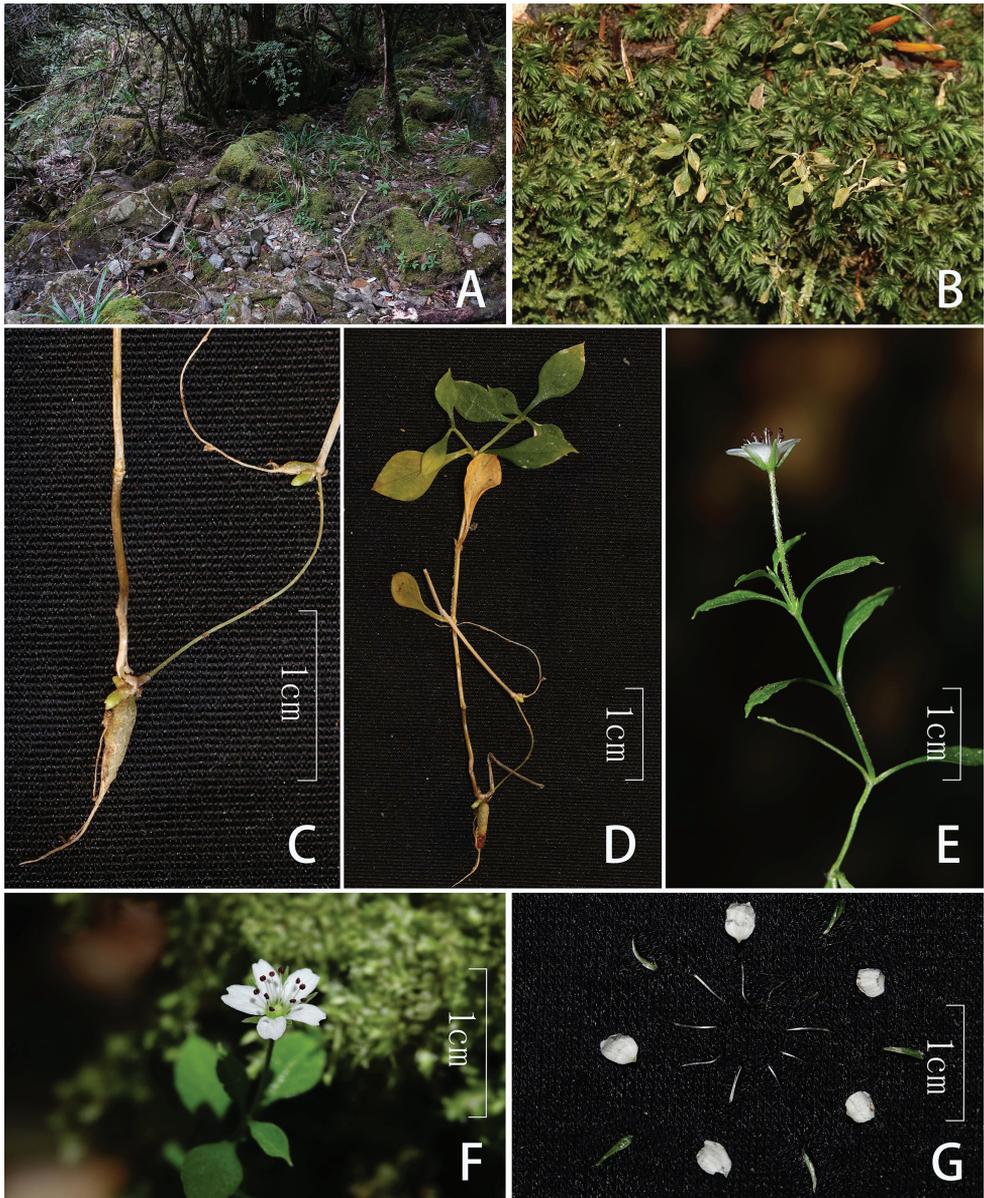


Figure 2. *Pseudostellaria wuyishanensis* X. Luo, Q.Y. Yang **A** habitat **B** habit **C** tuber **D** plant **E** flowering plant **F** flower **G** all parts of flower.

abaxial viridescent, apex acute, usually with mucro ca.0.5 mm, sparsely ciliate at base, pinnately veined, lateral veins 3–4 pairs, inconspicuous. Chasmogamic flowers terminal or axillary, solitary; pedicel erect, ca. 2 cm long, pilose; sepals 5, green, lanceolate, ca. 3 mm, abaxially slightly pilose, margin membranous, glabrous; petal 5, oblong, slightly longer than sepals, ca. 4 mm, apically emarginate, base with a short claw;

stamens 10, shorter than petals, ca. 4 mm; filament glabrous; anthers purple-red, reniform; ovary coniform, ca. 2×0.9 mm, with 2 thin styles to 3 mm, revolute, longer than the ovary, ovules numerous. Cleistogamous flowers and fruits not seen.

Distribution and habitat. The new species is endemic to the Wuyishan National Park, Fujian Province. The plant grows in the deciduous broad-leaved forest at 2000 m in elevation. The dominant species of the community include *Pinus taiwanensis* Hayata (Pinaceae), *Lithocarpus harlandii* (Hance) Rehder (Fagaceae), *Buxus sinica* var. *parvifolia* M. Cheng (Buxaceae), *Veratrum schindleri* Loes (Melanthiaceae), and *Dichocarpum franchetii* (Finet&Gagnepain) W.T. Wang & Hsiao (Ranunculaceae).

Phenology. Flowers were observed in June.

Conservation status. There is only one known location and fewer than 50 individuals of *P. wuyishanensis* found during our fieldworks in the Wuyishan National Park in both 2019 and 2020. But the investigation has not been through enough to fully understand the species natural distribution. According to IUCN Red List criteria (2012), this new species should be assessed as Data Deficient (DD; criteria B1ab(i-v) + 2ab(i-v)).

Etymology. The specific epithet ‘*wuyishanensis*’ refers to Wuyishan National Park, the locality of the type collection.

Discussion

The new species morphologically resembles *P. heterantha* in the leaf shape, terminal chasmogamous flowers with pilose pedicel, and white emarginate petal. The two taxa differ in that the stem of *P. wuyishanensis* is shorter, conspicuously stoloniferous, apex false dichotomous branched, and only has 1 line of hairs, while that of *P. heterantha* is longer, solitary, branched at base, and has 2 line of hairs; the leaf blades of *P. wuyishanensis* is smaller and the pedicel is shorter.(Table 1).

Ohwi (1937) regarded *P. maximowicziana* (Franch. & Sav.) Pax and *P. himalaica* (Franchet) Pax as the synonym of *P. heterantha*. The view was also approved by Mizushima (1965) and Lu (1998). However, some research results published in recent years do not support such a view (Chen et al. 2014; Zeng et al. 2016; Zhang et al. 2017). Zeng et al. (2016) suggested taking *P. maximowicziana*, *P. himalaica*, and *P. heterantha* as independent species respectively. None of the 3 species were collected in Fujian province or the surrounding area.

We only found two *Pseudostellaria* sp. specimens, IBSC 0149273 and IBSC 0149274 (Fig. 3) were collected in the Wuyishan National Park. Former researchers have identified them as *P. rupestris* (Turczaninow) Pax or *P. heterophylla* (Zeng et al. 2016). Morphologically, we found that the arrangement, shape and hairs of the leaves of these specimens were completely different from those two species, and the morphology of each part was consistent with *P. wuyishanensis*. In addition, the distribution location of *P. rupestris* was far away from the collection site. Considering all the factors, we believe that these specimens are in fact *P. wuyishanensis*.

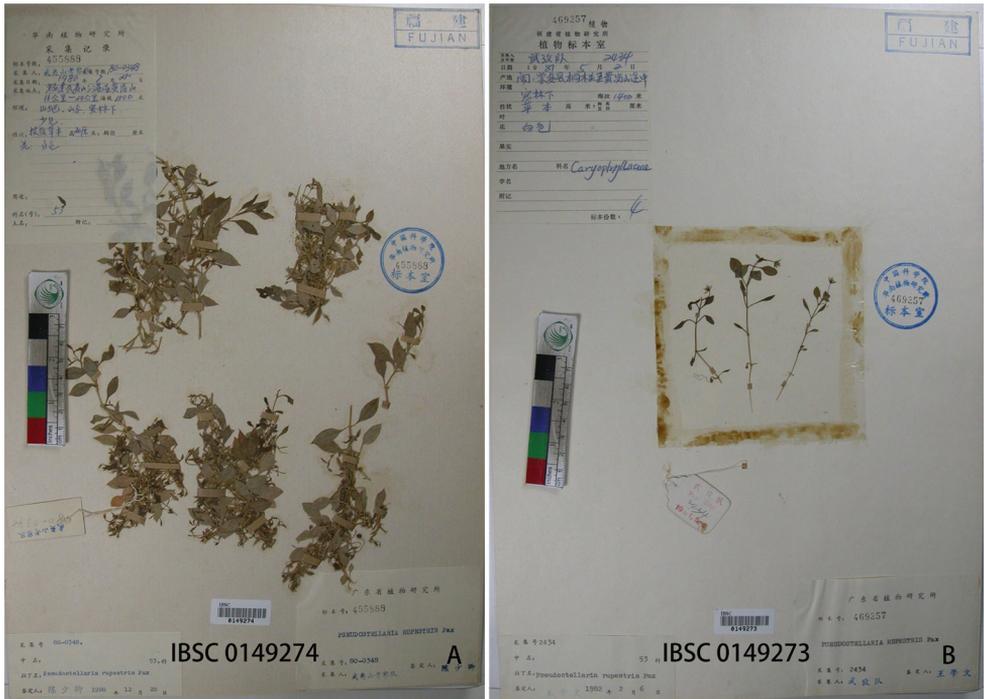


Figure 3. Specimens of *Pseudostellaria wuyishanensis* collected in 1980s.

Key to the Chinese species of *Pseudostellaria*

- 1 Seeds with persistent anchor-shaped barb *Pseudostellaria rupestris*
- Seeds with awned tubercles 2
- 2 Stems with apical 2 pairs of leaves larger, approximate, decussate
..... *P. heterophylla*
- Stems not as above 3
- 3 Chasmogamic flowers with petals apex 2-lobed 4
- Chasmogamic flowers with petals apex entire, sometimes emarginate 7
- 4 Root tubers several in a row 5
- Root tubers solitary 6
- 5 All leaves linear or lanceolate-linear, sessile *P. sylvatica*
- All leaves narrow elliptic-lanceolate, with short petiole *P. tianmushanensis*
- 6 Chasmogamic flowers with sepals 4, petals 4, stamens 8 *P. helanshanensis*
- Chasmogamic flowers with sepals 5, petals 5, stamens 10 *P. japonica*
- 7 Chasmogamic flowers with sepals glabrous *P. tibetica*
- Chasmogamic flowers with sepals abaxially pubescent 8
- 8 Stem repent 9
- Stem erect 10

- 9 Leaves pubescent in both side; seeds flat, with narrow wings.....*P. zhejiangensis*
*P. zhejiangensis*
 – Leaves ciliate; seeds reniform or subglobose *P. davidii*
 10 Stem pubescent; Leaves both surfaces pubescent *P. himalaica*
 – Stems with 1 or 2 line of hairs; base of the leaves sparsely ciliate 11
 11 Stem has stolons, with 1 line of hairs; pedicel short, ca. 2 cm.....
 *P. wuyishanensis* (sp. nov.)
 – Stem has 2 line of hairs; pedicel longer than 3 cm..... 12
 12 Petals spatulate or obovate *P. maximowicziana*
 – Petals oblong-oblancheolate *P. heterantha*

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References

- Bittrich V (1993) Caryophyllaceae. In: Kubitzki K, Rohwer JG, Bittrich V (Eds) The families and genera of vascular plants. Springer, Berlin, 206–236. https://doi.org/10.1007/978-3-662-02899-5_21
- Chen XB, Meng SY, Zhang XF, Han YB, Liu QR (2014) Numerical Taxonomic Analysis of *Stellaria* and *Pseudostellaria* (Caryophyllaceae). *Zhiwu Xuebao* 49(4): 432–439. <https://doi.org/10.3724/SP.J.1259.2014.00432>
- Greenberg AK, Donoghue MJ (2011) Molecular systematics and character evolution in Caryophyllaceae. *Taxon* 60(6): 1637–1652. <https://doi.org/10.1002/tax.606009>
- IUCN (2012) IUCN Red List Categories and Criteria, Version 3.1. 2nd edn., IUCN, Gland.
- Jin XF, Ding BY (2003) A new species of *Pseudostellaria* (Caryophyllaceae) from Zhejiang. *Yunnan Zhi Wu Yan Jiu* 25(6): 639–640.
- Lian YS (2009) A new species of *Pseudostellaria* (Caryophyllaceae) from Gansu, China. *Novon* 19(2): 191–193. <https://doi.org/10.3417/2004104>
- Lu DQ (1998) Some revisions and supplements on Caryophyllaceae from China. *Bulletin of Botanical Research* (1): 1–3.
- Lu DQ, Rabeler RK (2001) *Pseudostellaria*. In: Wu ZY, PH Raven, Hong DY (Eds) *Flora of China*. St. Louis: Science Press, Missouri Botanical Garden Press, Beijing, 7–10.
- Mizushima M (1965) Critical studies on Japanese plants, II: The genus *Pseudostellaria* Pax in Japan. *Bulletin of the Botanical Survey of India* 7: 62–72.
- Ohwi J (1937) The Revision of the genus *Pseudostellaria*. *Shokubutsu Kenkyu Zasshi* 9: 95–105.

- Schischkin BK, Komarov VL (1936) Flora of the USSR, vol. 6. Akademiya Nauk SSSR, Moskva-Leningrad, 326–330.
- Tang CL, Ke P, Lu DQ, Zhou LH, Wu ZY (1996) Caryophyllaceae. In: Tang CL (Ed.) Flora of China. St. Louis: Science Press, Missouri Botanical Garden Press, Beijing, 47–448.
- Turczaninow NS (1842) Krascheninnikowia. Bulletin de la Société Impériale des Naturalistes de Moscou 15: 609.
- Xia GH, Liu CH, Xie WY, Li GY (2011) *Pseudostellaria tianmushanensis* sp. nov. (Caryophyllaceae) from Zhejiang, China. Nordic Journal of Botany 29(2): 204–207. <https://doi.org/10.1111/j.1756-1051.2010.00933.x>
- Zeng XQ, Zhang ML, Lei Y (2016) Classification outline and geographical distribution of *Pseudostellaria* Pax in the world. Journal of Plant Resources and Environment 25: 92–99.
- Zhang ML, Zeng XQ, Li C, Sanderson SC, Byalt VV, Lei Y (2017) Molecular phylogenetic analysis and character evolution in *Pseudostellaria* (Caryophyllaceae) and description of a new genus, *Hartmaniella*, in North America. Botanical Journal of the Linnean Society 184(4): 444–456. <https://doi.org/10.1093/botlinnean/box036>

Nomenclatural revision of *Cryptantha* (Boraginaceae s. str.) names linked to South American taxa

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Abstract

During the preparation of the treatment of the genus *Cryptantha* Lehmann ex G. Don for South America, numerous names were identified as needing typification to stabilize their nomenclature. As a result, lectotypes are designated for 11 names and second-step lectotypes for 20 names. Furthermore, supporting information about the type material of the basionyms of four *Cryptantha* names already typified by Johnston (*Eritrichium talquinum* Phil., *Eritrichium dimorphum* Phil., *Eritrichium carrizalense* Phil., and *Eritrichium subamplexicaule* Phil.) is provided.

Keywords

Boraginaceae, Johnston, nomenclature, Philippi, typification

Introduction

Boraginaceae (sensu Weigend et al. 2014; Luebert et al. 2016; Hasenstab-Lehman 2017) are widely distributed, mainly in tropical, subtropical and temperate regions, with a high number of poorly studied taxa in the Americas. These lands are among the most diverse ecoregions in the world and, in line with this, their plant diversity has been a challenge, especially for taxonomically complex and diverse genera such as *Cryptantha* Lehmann ex G. Don. This genus and close relatives, commonly known in English as

“popcorn flowers”, are notable for their simplified morphology, complex taxonomy and nomenclature, and partially resolved phylogeny (Mabry and Simpson 2018). Members of *Cryptantha* are strigose and/or hispid, annual or perennial herbs, with simple to highly branched, generally ascending to erect (rarely decumbent) stems and simple, basal to cauline, generally linear, lanceolate, or oblanceolate leaves (Johnston 1925; Payson 1927; Higgins 1971; Simpson and Hasenstab-Lehman 2009; Kelley et al. 2012).

As in the case of several other South American genera (e.g., O’Leary et al. 2007, 2010; Moroni et al. 2016; O’Leary et al. 2016), *Cryptantha* has a distinctive amphitropical distribution restricted to the non-tropical regions of western North America and western South America (Guilliams et al. 2017; Simpson et al. 2017). In these last lands, approximately 46 *Cryptantha* species distributed through Argentina, Bolivia, Chile and Peru (Johnston 1927; Zuloaga et al. 2008; Amsinckinae Working Group 2021) are generally accepted (Amsinckinae Working Group 2021), with a remainder of ca. 35 *Cryptantha* names considered synonymous with other *Cryptantha* taxa. At this point it is worth noting that, of the South American taxa of *Cryptantha*, the following have more recently undergone taxonomic changes: 1) *Cryptantha albida* (Kunth) I.M. Johnst. (which also occurs in North America), *C. diplotricha* (Phil.) Reiche, and *C. parviflora* (Phil.) Reiche have been transferred to the genus *Johnstonella* (Hasenstab-Lehman and Simpson 2012; Simpson et al. 2019); 2) *Cryptantha circumscissa* (Hook. & Arn.) I.M. Johnst. has been transferred to the genus *Greeneocharis* (Hasenstab-Lehman and Simpson 2012); and 3) *Cryptantha pegazzinii* I.M. Johnst. is a synonym of *Amsinckia calycina* (Moris) Chater (Chater 1971).

Almost all of the currently accepted South American taxa of *Cryptantha* were treated by Johnston (1927), who provided a treatment based on his studies of Boraginaceae (see also Johnston 1925, 1935). After Johnston’s (1927) contribution, restricted taxonomic revisions of *Cryptantha* have been provided in regional floristic works for Argentina [covering Buenos Aires (Dawson 1965), Entre Ríos (Pérez Moreau 1979), Jujuy (Pérez-Moreau and Cabrera 1983), Patagonia (Correa 1999), and San Juan (Pérez-Moreau and Crespo 2018)]. Besides, floristic treatments and catalogues of *Cryptantha* have also been published for Argentina (Zuloaga and Morrone 1999), Bolivia (Miller et al. 2014), Chile (Rodríguez et al. 2018), and Peru (Macbride 1960; Brako and Zarucchi 1993), and for the Americas (Ulloa Ulloa et al. 2017) and the Southern Cone of the Americas (Zuloaga et al. 2008; Zuloaga et al. 2019).

Despite the taxonomic effort of the works mentioned above, the treatments proposed lack clarifications on nomenclatural subjects concerning the taxa studied, all of which constitute a non-trivial prerequisite to any comprehensive revisionary work. In light of this, the nomenclature of “one of the largest and most perplexing genera of the Boraginaceae” (Johnston 1927) still remains at the preliminary stage. Consequently, during the revision of *Cryptantha* for South America (Moroni, in prep.), a relatively large number of names were identified as needing typification or nomenclatural clarifications. Thus, the objective of this article is to make progress in producing a well-founded nomenclatural treatment for the genus in South America.

Materials and methods

In order to resolve typifications, the protologues of the treated taxa were studied and key literature (e.g., Johnston 1927; Pérez-Moreau 1976) was consulted to identify possible prior typifications. Type specimens and original material from the herbaria *CORD*, *E*, *F*, *G*, *GH*, *HAL*, *K*, *MA*, *P*, *S*, *SGO*, and *US* (herbarium acronyms after Thiers 2021+) were analyzed from images on the JSTOR Global Plants database (ITHAKA 2021) or by personal communication with herbarium curators. To proceed with the typifications, the rules of the ICN (Turland et al. 2018) and suggestions proposed by McNeill (2014) were followed. In selecting lectotypes, whenever choosing between syntypes (Art. 9.6 of the ICN), the one that shows the best quality of preservation of the important diagnostic features of the taxon was selected to preserve the current application of the names involved.

Concerning the names described by the Prussian botanist R. A. Philippi, who greatly contributed to the taxonomic knowledge of *Cryptantha* in South America (Philippi 1857, 1860, 1864, 1873, 1891, 1895), a clarification of the material he used to describe numerous taxa might help to overcome some future difficulties. A relevant type collection of Philippi's names is well-known to be currently lodged at *SGO* (Stafleu and Cowan 1983). However, duplicates annotated and thus presumably studied by him can be traced in several other herbaria such as *CORD*, *GH*, and *HAL*, or previously lodged at *B* and then destroyed by the fire caused by the Allied bombing in 1943 (Hiepko 1987; R. Vogt, curator at *B*, pers. comm.). In this context, it is not at all clear in which instances there is a holotype for his names, unless the author made clear in the protologue that only a single specimen of the gathering existed. Thereby, if Philippi did not specify a single specimen and syntypes are (or were) available, it is possible to designate a lectotype (Art. 40.2 of the ICN, Turland et al. 2018).

Typifications

Lectotypes are here selected for 11 names, whereas 20 names already typified by Johnston (1927) or Pérez-Moreau (1976) were found to require second-step lectotypifications (Art. 9.17 of the ICN; Turland et al. 2018) because more than one specimen exists at the herbarium cited by them. It is worth noting that several names typified by Johnston are in need of second-step lectotypification given that the material held at *SGO* was unmounted and part of it was in storage by the time he visited the herbarium (Muñoz Pizarro 1960; Taylor and Muñoz-Schick 1994). On the other hand, supporting information related to the names *Eritrichium talquinum* Phil., *Eritrichium dimorphum* Phil., *Eritrichium carrizalense* Phil., and *Eritrichium subamplexicaule* Phil. is provided.

Type designations are organized into a single treatment arranged by accepted species, with a full accounting of homotypic synonyms, followed by the heterotypic synonyms (and their homotypic synonyms) in need of typification, and a discussion of the

typification/s involved. Concerning numerous specimens currently found at GH, they mainly consist of fragments removed by Johnston from sheets at P and SGO; *Amsinckia patagonica* Speg. and *Cryptantha argentea* I.M. Johnst. constitute the only exception in which the material lodged at GH consist of whole specimens.

1. *Cryptantha alfalfalis* (Phil.) I.M. Johnst., Contr. Gray Herb. 78: 61. 1927.

- ≡ *Eritrichium alfalfalis* Phil., Anales Univ. Chile 90: 525. 1895. Type: CHILE. [Región Metropolitana de Santiago:] Río Colorado, Jan. 1888, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 61: SGO; second-step lectotype, designated here: SGO [SGO000004033 digital image!]; isolectotypes: SGO [SGO000004034 digital image!], GH [GH00096302 digital image!]).
- = *Eritrichium rigidum* Phil., Anales Univ. Chile 90: 529. 1895. *Cryptantha rigida* (Phil.) Reiche, Fl. Chile 5: 224. 1907. Type: CHILE. [Región Metropolitana de Santiago:] Río Colorado, Jan. 1888, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 61: SGO; second-step lectotype, designated here: SGO [SGO000004131 digital image!]; isolectotypes: GH [GH00096574 digital image!], SGO [SGO000004132 digital image!]).

Notes. Rudolph A. Philippi's (1895) description of *Eritrichium alfalfalis* was based on a collection he made in the valley of the Colorado River in Chile. Johnston (1927) discussed this name and its original material, stating that the "type" was lodged at SGO, although two sheets annotated in Philippi's hand as "*Eritrichium alfalfalis*" are actually lodged there. The material found at SGO is in agreement with the locality and the diagnosis cited in the protologue. Thus, according to the Art. 9.17 (Turland et al. 2018), the choice of Johnston (1927) is here interpreted as a first-step lectotypification. From among the material available for typification purposes, the sheet SGO000004033 is here selected as a second-step lectotype of the name.

The protologue of *Eritrichium rigidum* (Philippi, 1895) includes a direct reference to a collection made by R. A. Philippi in the valley of the Colorado River in Chile. Johnston (1927) referred to the original material of this name, stating that the "type" was lodged at SGO. However, two sheets annotated by Philippi as "*Eritrichium rigidum*" were found there in agreement with the protologue. Thus, Johnston's statement is here interpreted as a first-step lectotypification. In this context, the sheet SGO000004131 is here selected as a second-step lectotype of the name

2. *Cryptantha alyssoides* (A. DC.) Reiche, Anales Univ. Chile 121: 824. 1907.

- ≡ *Eritrichium alyssoides* A. DC., Prodr. [A. P. de Candolle] 10: 131. 1846. *Krynitzkia alyssoides* (A. DC.) A. Gray, Proc. Am. Acad. 20: 280. 1885. Type: CHILE. Región del Libertador General Bernardo O'Higgins: Talcaleguén, 1833, *C. Gay s.n.* (holotype: G [G00204936 digital image!]).

- = *Eritrichium gilliesii* Phil., Anales Univ. Chile 43: 517. 1873. *Cryptantha gilliesii* (Phil.) Reiche, Fl. Chile 5: 229. 1907. Type: CHILE. Región Metropolitana de Santiago: Valle del Yeso, Jan. 1866, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 65: SGO; second-step lectotype, designated here: SGO [SGO000004084 digital image!]; isolectotype: SGO [SGO000004085 digital image!]).
- = *Eritrichium talquinum* Phil., Anales Univ. Chile 90: 517. 1895. *Cryptantha talquina* (Phil.) Brand, Pflanzenr. (Engler) [Heft 97] 4, Fam. 252: 32. 1931. Type: CHILE. Región del Maule: Talca, Feb. 1879, *F. Philippi s.n.* (lectotype, designated by Johnston 1927, pg. 65: SGO [SGO000004140 digital image!]; isolectotypes: CORD [CORD00003778 digital image!], GH [GH00096580 digital image!]).

Notes. In describing *Eritrichium gilliesii*, Rudolph A. Philippi (1873) cited a collection he made in Valle del Yeso, Chile. Two specimens of the gathering referred to by Philippi are found at SGO; these duplicates all bear original labels annotated by him with the identification of “*E. gilliesii*” and agree with the diagnosis cited in the protologue. Johnston (1927) clearly indicated a sheet housed at SGO as the “type”, although more than one specimen is actually lodged there. Thus, Johnston’s choice is here interpreted as a first-step lectotypification. In order to narrow this designation, the sheet SGO000004084 is here selected as a second-step lectotype.

The original material of *Eritrichium talquinum*, as referred to by Rudolph A. Philippi (1895) in the protologue of the species, was collected by Friedrich Philippi in Talca, Chile. There are two sheets of apparent original material, which agree with the diagnosis and cited locality, at CORD and SGO. Both specimens were presumably studied by R. A. Philippi since they were annotated, in his hand, as “*Eritrichium talquinum*”. Johnston (1927) noted the specimen at SGO as the “type”, although the author of the name had not indicated any collection as such at the time he published the species. Thus, given that only one element at SGO satisfies the information given by Johnston, his statement is here interpreted as a lectotype designation.

3. *Cryptantha aprica* (Phil.) Reiche, Anales Univ. Chile 121: 814. 1907.

- ≡ *Eritrichium apricum* Phil., Linnaea 33: 190. 1864. Type: Chile. Región de Valparaíso: Catemu, Sep. 1860, *R.A. Philippi s.n.* (lectotype, designated here: SGO [SGO000004035 digital image!]).
- = *Eritrichium bridgesii* Phil., Anales Univ. Chile 90: 515. 1895. *Cryptantha bridgesii* (Phil.) Brand, Pflanzenr. (Engler) [Heft 97] 4, Fam. 252: 30. 1931. Type: CHILE. Región Metropolitana de Santiago: Lampa, Nov. 1864, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 70: SGO; second-step lectotype, designated here: SGO [SGO000004044 digital image!]; isolectotypes: GH [GH00096364 digital image!], SGO [SGO000004043 digital image!]).

Notes. The protologue of *Eritrichium apricum* (Philippi 1864) includes a direct reference to various collections made by R. A. Philippi in Aconcagua province and Catemu,

Chile. Four syntypes annotated in Philippi's hand as "*Eritrichium apricum*" and in agreement with the diagnosis cited in the protologue are found at GH, S, and SGO. The material held at GH and SGO consists of three specimens collected in Catemu in 1860; one from among them (SGO000004035), however, has a more precise reference to the place of collection (i.e., Cajón del Boldo). On the other hand, the sheet found at S (S12–25271) comes from a collection made in Aconcagua province, Chile, without reference to the date of collection. In this context, the sheet SGO000004035 is here chosen as the lectotype.

In describing *Eritrichium bridgesii*, Rudolph A. Philippi (1895) cited a collection he made in Lampa, Chile. Three specimens linked to the type collection are found at GH and SGO. The material kept at SGO bears original labels annotated by R. A. Philippi with the identification of "*Eritrichium bridgesii*" and agree with the diagnosis as referred to in the protologue. Johnston (1927) clearly indicated by direct citation that the type is housed at SGO with no further reference. In this context, Johnston's (1927) statement must thus be considered as a first-step typification since two duplicates of the gathering made by R. A. Philippi were found at SGO. In order to narrow this broad designation, the sheet SGO000004044 is here selected as a second-step lectotype (Art. 9.17 of the ICN; Turland et al. 2018).

4. *Cryptantha argentea* I.M. Johnst., *Contr. Gray Herb.* 78: 42. 1927.

Type. CHILE. Región de Antofagasta: Antofagasta, about head of high fog-bathed sea-cliffs near Aguada Grande, 16–18 Dec. 1925, *I.M. Johnston 5814* (lectotype, designated here: GH [GH00011520 digital image!]; isolectotypes: E [E00026029 digital image!], GH [GH00011519 digital image!], K [K000573751 digital image!], US [US00111035 digital image!]).

Note. In the protologue of *Cryptantha argentea*, Johnston (1927) cited a collection he made near Aguada Grande, Chile, and explicitly stated that the type was lodged at GH. Two duplicates of the gathering *Johnston 5814* are found there in agreement with the protologue as referred to by Johnston (1927). Thus, Johnston's (1927) statement is insufficiently precise since it cannot be ascertained to which of the two specimens at GH he was referring. In this context, the sheet GH00011520 is selected as lectotype of the name.

5. *Cryptantha capituliflora* (Clos) Reiche, *Anales Univ. Chile* 121: 822. 1907.

≡ *Eritrichium capituliflorum* Clos, *Fl. Chil.* 4(4): 467. 1849. *Cynoglossospermum capituliflorum* (Clos) Kuntze, *Revis. Gen. Pl.* 3[3]: 204. 1898. Type: CHILE. Región de Coquimbo: "Sur les collines des environs de Los Patos", s.d., *C. Gay 533* (lectotype,

designated here: P [P00606749 digital image!]; isolectotypes: GH [GH00096371 digital image!], P [P00606750 digital image!]).

Note. Clos' (1849) description of *Eritrichium capituliflorum* includes a direct reference to a collection made by Claude Gay in Coquimbo, Chile. Two duplicates of the collection involved are found at P in agreement with the diagnosis and cited locality as referred to by Clos in the protologue. In this context, the duplicate P00606749 is here selected as lectotype of the name.

6. *Cryptantha chaetocalyx* (Phil.) I.M. Johnst., *Contr. Gray Herb.* 78: 43. 1927.

- ≡ *Eritrichium chaetocalyx* Phil., *Fl. Atacam.* 39. 1860. Type: CHILE. Región de Atacama: Caldera, Pan de Azúcar, Dec. 1853, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 43: SGO; second-step lectotype, designated here: SGO [SGO000004073 digital image!]; isolectotypes: GH [GH00096375 digital image!], SGO [SGO000004050 digital image!]).
- = *Eritrichium divaricatum* Phil., *Anales Univ. Chile* 90: 534. 1895. *Cryptantha divaricata* (Phil.) Reiche, *Anales Univ. Nac. Tec. Altiplano* 121: 827. 1907. Type: CHILE. Región de Atacama: Caldera, Sep. 1885, *F. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 43: SGO; second-step lectotype, designated here: SGO [SGO000004070 digital image!]; isolectotypes: GH [GH00096373 digital image!], SGO [SGO000004071 digital image!]).
- = *Eritrichium pustulosum* Phil., *Anales Univ. Chile* 90: 537. 1895. Type: CHILE. Región de Atacama: Caldera, Sep. 1879, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 43: SGO; second-step lectotype, designated here: SGO [SGO000004125 digital image!]; isolectotypes: GH [GH00096374 digital image!], SGO [SGO000004126 digital image!], SGO [SGO000004127 digital image!]).

Notes. In describing *Eritrichium chaetocalyx*, Rudolph A. Philippi (1860) cited a gathering he made near Pan de Azúcar, Chile. Two duplicates of the type collection in agreement with the protologue and annotated by him as “*Eritrichium chaetocalyx*” were located at SGO. Johnston (1927) discussed this name and its original material, referring to a sheet lodged at SGO as the “type” of the name. In this context, Johnston’s (1927) statement must thus be considered as a first-step typification. Thus, in order to narrow this designation, the sheet SGO000004073 is here selected as a second-step lectotype.

In the protologue of *Eritrichium divaricatum*, Rudolph A. Philippi (1895) cited as type material a collection made by F. Philippi in Caldera, Chile. Johnston (1927) referred to a specimen kept at SGO as the “type” of the name, although two sheets annotated, in R. A. Philippi’s hand, as “*Eritrichium divaricatum*” are found there. This situation determines that Johnston’s (1927) statement must be considered as a first-

step lectotypification. In this context, the duplicate SGO000004070 is here selected as a second-step lectotype (Art. 9.17 of the ICN; Turland et al. 2018).

Rudolph A. Philippi (1895) described *Eritrichium pustulosum* based on a specimen he collected in Caldera, Chile. According to Johnston (1927), the type material of the name is lodged at SGO. However, three sheets linked to *E. pustulosum*, in agreement with the protologue, were located at SGO, which can certainly be considered as original material. In this context, Johnston's (1927) statement must be considered as a first-step lectotypification. In order to narrow this earlier designation, the sheet SGO000004125 is here selected as a second-step lectotype.

7. *Cryptantha cynoglossoides* (Phil.) I.M. Johnst., *Contr. Gray Herb.* 78: 67. 1927.

- ≡ *Eritrichium cynoglossoides* Phil., *Linnaea* 29: 16. 1858. Type: CHILE. Región de Coquimbo: Arqueros, Oct. 1836, *C. Gay s.n.* (holotype: SGO [SGO000004057 digital image!]).
- = *Eritrichium uspallatense* Phil., *Anales Univ. Chile* 90: 521. 1895. Type: ARGENTINA. Mendoza: Baños del Inca, Jan. 1886, *A. Borchers s.n.* (first-step lectotype, designated by Johnston 1927, pg. 68: SGO; second-step lectotype, designated here: SGO [SGO000004144 digital image!]; GH [GH00096583 digital image!]; SGO [SGO000004145 digital image!]).

Note. In the protologue of *Eritrichium uspallatense*, Rudolph A. Philippi (1895) indicated that his diagnosis was based on material collected by Augusto Borchers in Baños del Inca, Mendoza, Argentina. Johnston (1927) extensively revised the type collection linked to this name and stated by direct citation that the type is housed at SGO. However, two duplicates were found there in agreement with the protologue. Consequently, Johnston's (1927) statement must be considered as a first-step typification. In order to narrow his designation, the specimen SGO000004144 is here selected as a second-step lectotype (Art. 9.17 of the ICN, Turland et al. 2018).

8. *Cryptantha dichita* (Phil.) I.M. Johnst., *Contr. Gray Herb.* 78: 35. 1927.

- ≡ *Eritrichium dichita* Phil., *Anales Univ. Chile* 90: 516. 1895. Type: CHILE. [Unknown region:] Desierto de Atacama, 1877, *A. Villanueva s.n.* (first-step lectotype, designated by Johnston 1927, pg. 35: SGO; second-step lectotype, designated here: SGO [SGO000004062 image!; isolectotypes: GH [GH00096381 digital image!], SGO [SGO000004063 digital image!]).

Note. In describing *Eritrichium dichita*, Rudolph A. Philippi (1895) cited eight specimens received from Augusto Villanueva from the Atacama Desert, Chile. However, only two

specimens are currently lodged at SGO, where R. A. Philippi worked (Staffleu and Cowan 1983). Both specimens are annotated, in Philippi's hand, as "*Eritrichium dichita*" and in agreement with the diagnosis found in the protologue. Johnston (1927) referred to a sheet housed at SGO as the "type" of the species name, although Philippi did not indicate any material as such at the time he published the species. Thus, Johnston's (1927) statement must be considered as a first-step lectotypification. In order to narrow this broad designation, the specimen SGO000004062 is here selected as a second-step lectotype.

9. *Cryptantha diffusa* (Phil.) I.M. Johnst., *Contr. Gray Herb.* 78: 52. 1927.

- ≡ *Eritrichium diffusum* Phil., *Linnaea* 33: 191. 1864. Type: CHILE. Región de Coquimbo: "Huanta, Baños del Toro", 1860–1861, *H. Volckmann s.n.* (first-step lectotype, designated by Johnston 1927, pg. 53: SGO; second-step lectotype, designated here, SGO [bc] SGO000004064 image!; isolectotype, SGO [bc] SGO000004065 image!).
- = *Eritrichium micranthum* Phil., *Fl. Atac.* 38. 1860. Type: CHILE. [Región de Antofagasta:] Sandón, Feb. 1854, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 53: SGO; second-step lectotype, designated here: SGO [SGO000004107 digital image!]; isolectotype: SGO [SGO000004106 digital image!]).
- = *Cryptantha famatinae* Brand, *Repert. Spec. Nov. Regni Veg.* 20: 317. 1924. Type: ARGENTINA. La Rioja: La Incrucijada [sic], Sierra Famatina, 1879, *G.H.E.W. Hieronymus & G. Niederlein* 466 (lectotype, designated here: CORD [CORD00003765 digital image!]; isolectotype: GH [GH00096383 digital image!]).

Notes. The protologue of *Eritrichium diffusum* (Philippi 1864) includes a direct reference to a collection made by Herman Volckmann in Coquimbo, Chile. Johnston (1927) referred to a specimen lodged at SGO as the "type" of the name, while Pérez-Moreau (1976) later stated "Chile. Coquimbo: Huanta, Baños del Toro, 1860–61, Volckmann (tipo de *E. diffusum*, SGO)". Despite the statements of these authors, in the general collection at SGO two sheets were found in agreement with the protologue. The specimens match the diagnosis as coined by Philippi. In this framework, the earliest statement made by Johnston (1927) is here interpreted as a first-step lectotypification. In order to narrow this broad designation, the sheet SGO000004064 is here selected as a second-step lectotype.

Rudolph A. Philippi (1860) described *Eritrichium micranthum* based on a collection he made in Sandón, Chile, with no further reference. According to Johnston (1927), the type element of this species is housed at SGO. Johnston's (1927) statement is here interpreted as a first-step lectotype designation since two sheets in agreement with the protologue and annotated by Philippi as "*Eritrichium micranthum*" were found at SGO. The specimens involved match the protologue and, thus, the designation of Johnston (1927) is here narrowed by selecting the sheet SGO000004107 as a second step-lectotype.

In the protologue of *Cryptantha famatinae*, Brand (1924) cited a collection made by Georg H. E. W. Hieronymus and Gustav Niederlein in the province of La Rioja, Argentina. No original collections could be traced at B, where Brand worked (Staffeu and Cowan 1976), but duplicates of Hieronymus and Niederlein's collection were located at CORD and GH. These sheets agree with the diagnosis and cited locality found in the protologue. Thus, the sheet CORD00003765 is here selected as lectotype of the name.

10. *Cryptantha dimorpha* (Phil.) Greene, *Pittonia* 1(3): 112. 1887.

≡ *Eritrichium dimorphum* Phil., *Linnaea* 29: 16. 1857. Type: CHILE. Región Metropolitana de Santiago: Cordillera de Santiago, Feb. 1857, *R.A. Philippi s.n.* (lectotype, designated by Johnston 1927, pg. 67: SGO [SGO000004066 digital image!]; isolectotypes: CORD [CORD00003771 digital image!], GH [GH00096384 digital image!], S [S no. 12–25247 digital image!]).

Note. Rudolph A. Philippi (1857) based the diagnosis of *Eritrichium dimorphum* on a collection he made in Santiago, Chile, without explicit further reference to any locality. Johnston (1927), in his revision of *Cryptantha* in South America, referred to a specimen lodged at SGO as the “type” of the name. However, an additional duplicate annotated, in Philippi's hand, as “*Eritrichium dimorphum*”, is found at CORD. Both specimens are in agreement with the diagnosis as referred to by Philippi (1857). Therefore, the element cited by Johnston and his statement must be considered as an effective lectotypification of the name.

11. *Cryptantha filaginea* Reiche, *Anales Univ. Chile* 121: 829. 1907.

≡ *Eritrichium filagineum* Phil., *Anales Univ. Chile* 90: 536. 1895. Type: CHILE. Región de Atacama: Monte Amargo, Sep. 1885, *F. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 47: SGO; second-step lectotype, designated here: SGO [SGO000004075 digital image!]; isolectotypes: GH [GH00096386 digital image!], SGO [SGO000004074 digital image!]).

Note. The protologue of *Eritrichium filagineum* (Philippi, 1895) includes a direct reference to a collection made by F. Philippi between Caldera and Copiapó, Chile. Two duplicates of a collection in agreement with the protologue and annotated, in R. A. Philippi's hand, as “*Eritrichium filagineum*” were found at SGO. According to Johnston (1927), the type element of this species is housed at SGO, and therefore his statement is here interpreted as a first-step lectotype designation. In this context, the duplicate SGO000004075 is here selected as a second-step lectotype of the name.

12. *Cryptantha globulifera* (Clos) Reiche, *Anales Univ. Chile* 121: 827. 1907.

- ≡ *Eritrichium globuliferum* Clos, *Fl. Chil.* 4(4): 464. 1849. Type: CHILE. Región de Coquimbo: Coquimbo, 1836, *C. Gay* 47 (first-step lectotype, designated by Pérez-Moreau 1976, pg. 175: P; second-step lectotype, designated here: P [P00606762 digital image!]; isolectotypes: GH [GH00096393 digital image!], P [P00606763 digital image!]).
- = *Eritrichium glareosum* Phil., *Linnaea* 33: 189. 1864. *Cryptantha glareosa* Greene, *Pittonia* 1(3): 111. 1887. Type: CHILE. Región de Valparaíso: “In alveo fluminis Aconcagua prope San Felipe”, Sep. 1860, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 52: SGO; second-step lectotype, designated here: SGO [SGO000004086 digital image!]; isolectotypes: GH [GH00096392 digital image!], SGO [SGO000004087 digital image!]).
- = *Eritrichium carrizalense* Phil., *Anales Univ. Chile* 90: 526. 1895. *Cryptantha carrizalensis* (Phil.) Reiche, *Fl. Chile* 5: 224. 1907. Type: CHILE. Región de Atacama: Yerba Buena, 1885, *R. Godoy de Collao s.n.* (lectotype, designated by Johnston 1927, pg. 52: SGO [SGO000004049 digital image!]; isolectotype: GH [GH00096372 digital image!]).
- = *Eritrichium sphaerophorum* Phil., *Anales Univ. Chile* 90: 539. 1895. Type: CHILE. Región de Atacama: Caldera, Sep. 1879, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 52: SGO; second-step lectotype, designated here: SGO [SGO000004137 digital image!]; isolectotypes: GH [GH00096576 digital image!]; SGO [SGO000004136 digital image!]).

Notes. Clos' (1849) described *Eritrichium globuliferum* based on two syntypes from Chile. The first collection was made by C. Gay (no. 47) in Coquimbo, while the other one was also made by him (*s.n.*) in Copiapó. Pérez-Moreau (1976) discussed this name and its original material, stating “CHILE. Coquimbo, común en dunas de la costa, La Serena, C. Gay 47, IX-1836 (tipo de *E. globuliferum*, P)”. However, Pérez-Moreau's statement is insufficiently precise since it cannot be ascertained to which of the two specimens at P he was referring. Thus, his choice is here interpreted as a first-step lectotypification. In order to narrow this designation, the specimen P00606762 is here selected as a second-step lectotype.

In describing *Eritrichium glareosum*, Rudolph A. Philippi (1864) cited a collection made in “alveo fluminis Aconcagua”, Chile. Two specimens of this collection in agreement with the protologue are found at SGO. These duplicates all bear original labels annotated by Philippi with the identification of “*E. glareosum*” and agree with the diagnosis cited in the protologue. Johnston (1927) referred to a sheet lodged at SGO as the “type” of *E. glareosum* and, thus, his statement is here interpreted as a first-step lectotype designation. In order to narrow this earlier designation, the specimen SGO000004086 is here selected as a second-step lectotype.

Rudolph A. Philippi (1895) described *Eritrichium carrizalense* based on a Rosario Godoy de Callao collection made in Yerba Buena, Chile. A duplicate of this material, annotated in Philippi's hand as “*Eritrichium carrizalense*”, was lodged at B and now destroyed but a photograph from Macbride's Berlin negatives (neg. 17371) is avail-

able at F with a copy at GH. Furthermore, there is a duplicate at herbarium SGO and fragments of the syntype at B lodged at GH. Johnston (1927) referred to the original material of this name, stating that the “type” was lodged at SGO; in the protologue of the species, however, there is no indication of any particular specimen as such. Thus, Johnston’s (1927) statement is here interpreted as a lectotype designation.

The protologue of *Eritrichium sphaerophorum* (Philippi 1895) includes a direct reference to a collection made by Rudolph A. Philippi near Caldera, Chile, in 1879. Johnston (1927) clearly indicated a sheet housed at SGO as the “type”, although an additional element, also annotated in Philippi’s hand as “*Eritrichium sphaerophorum*” was located there in agreement with the protologue. In this context, Johnston’s (1927) choice is here interpreted as a first-step lectotypification. In order to narrow this designation, the specimen SGO000004137 is selected as a second-step lectotype.

13. *Cryptantha glomerulifera* (Phil.) I.M. Johnst., Contr. Gray Herb. 78: 55. 1927.

≡ *Eritrichium glomeruliferum* Phil., Anales Univ. Chile 90: 521. 1895. Type: CHILE. Región de Coquimbo: Las Mollacas, Cordillera de Illapel, 1888, *F. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 56: SGO; second-step lectotype, designated here: SGO [SGO000004088 digital image!]; isolectotypes: GH [GH00096394 digital image!], SGO [SGO000004089 digital image!]).

Note. The protologue of *Eritrichium glomeruliferum* (Philippi 1895) includes a direct reference to a collection made by F. Philippi in Las Mollacas, Chile. Two specimens in agreement with the protologue as referred to by R. A. Philippi are found at SGO. Johnston (1927) referred to a specimen kept at SGO as the “type” of the species name, while Pérez-Moreau (1976) later discussed this name and its original material, stating “Chile. Coquimbo, Las Mollacas, Cordillera de Illapel, s/c, 1–1888 (tipo de *E. glomeruliferum*, SGO)”. However, the statements made by the authors are insufficiently precise since it cannot be ascertained to which of the specimens at SGO they were referring. Thus, the earliest choice of Johnston is here interpreted as a first-step lectotypification. In order to narrow this designation, the specimen SGO000004088 is here selected as a second-step lectotype.

14. *Cryptantha granulosa* (Ruiz & Pav.) I.M. Johnst., Contr. Gray Herb. 68: 54. 1923.

≡ *Myosotis granulosa* Ruiz & Pav., Fl. Peruv. 2: 5. 1799. Type: PERU. Lima: “In Chancay collibus”, s.d., *H. Ruiz & J.A. Pavón s.n.* (lectotype, designated here: MA [MA814804 digital image!]).

Note. According to the protologue of *Myosotis granulosa*, Ruiz López & Pavón (1799) based the description of this species on two syntypes they had collected during their

stay in the Americas. The first collection was made in Lima, Peru, while the other one consists of a collection from Chancay, Peru. Two specimens linked to this name were located at MA in full agreement with the diagnosis and localities cited in the protologue. From among the material available for typification purposes, the specimen MA814804 from Chancay is preferred over the material from Lima (MA814805) since it bears an original label annotated, in Pavón's hand, as "Myosotis granulosa". Therefore, it is here selected as the lectotype of the name.

15. *Cryptantha kingii* (Phil.) Reiche, Anales Univ. Chile 121: 815. 1907.

≡ *Eritrichium kingii* Phil., Anales Univ. Chile 90: 516. 1895. Type: CHILE. Región de Atacama: "Prope Carrizal Bajo", s.d., *G. King s.n.* (Type not found).
 = *Eritrichium virens* Phil., Anales Univ. Chile 90: 519. 1895. *Cryptantha virens* (Phil.) Reiche, Anales Univ. Chile 121: 826. 1907. Type: CHILE. Región de Atacama: Bandurrias, 1885, *G. Geisse s.n.* (first-step lectotype, designated by Johnston 1927, pg. 72: SGO; second-step lectotype, designated here: SGO [SGO000004149 digital image!]; isolectotype: SGO [SGO000004150 digital image!]).

Note. Rudolph A. Philippi (1895) based the diagnosis of *Eritrichium virens* on a collection made by Guillermo Geisse in Copiapó, on the road to Chañarillo, Chile. Johnston (1927), in his revision of South American *Cryptantha*, referred to a specimen lodged at SGO as the "type" of the name. However, two duplicates studied by Philippi were located at SGO in agreement with the protologue. Thus, Johnston's choice is here interpreted as a first-step lectotypification. In order to narrow this designation, the specimen SGO000004149 is here selected as a second-step lectotype.

16. *Cryptantha longifolia* (Phil.) Reiche, Anales Univ. Chile 121: 823. 1907.

≡ *Eritrichium longifolium* Phil., Anales Univ. Chile 90: 522. 1895. Type: CHILE. Región del Biobío: La Polcura, Jan. 1888, *R.A. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 57: SGO; second-step lectotype, designated here: SGO [SGO000004102 digital image!]; isolectotypes: GH [GH00096556 digital image!], SGO [SGO000004103 digital image!]).

Note. Rudolph A. Philippi (1895) based the diagnosis of *Eritrichium longifolium* on a collection he made in La Polcura, Chile. Johnston (1927) referred to a specimen lodged at SGO as the "type" of the name. However, two duplicates studied and annotated as "*Eritrichium longifolium*" by Philippi were located there in agreement with the protologue. Thus, Johnston's (1927) choice is here interpreted as a first-step lectotypification. In order to narrow this broad designation, the specimen SGO000004102 is here selected as a second-step lectotype.

17. *Cryptantha patagonica* (Speg.) I.M. Johnst., Contr. Gray Herb. 68: 54. 1923.

≡ *Amsinckia patagonica* Speg., Nov. Add. Fl. Patag. 39. 1902. Type: ARGENTINA. [Unknown province:] “Hab. in aridis secus Río S. Cruz”, Feb. 1882, *C. Spegazzini s.n.* (lectotype, designated here: GH [GH00096569 digital image!]).

= *Eritrichium parvulum* Phil., Anales Univ. Chile 90: 535. 1895. *Cryptantha parvula* (Phil.) Brand, Pflanzenr. (Engler) [Heft 97] 4, Fam. 252: 50. 1931. Type: CHILE. Región de Atacama: Caldera, Sep. 1885, *F. Philippi s.n.* (lectotype, designated here: SGO [SGO000004116 digital image!]; isolectotypes: CORD [CORD00003777 digital image!], GH [GH00096568 digital image!], SGO [SGO000004115 digital image!]).

Notes. In describing *Amsinckia patagonica*, Spegazzini (1902) cited a syntype from Patagonia, Argentina. The gathering consists of a collection he made in Río Santa Cruz, Argentina, in 1882. No specimen corresponding to the material cited in the protologue was located at LP, where Spegazzini worked (Staffeu and Cowan 1986). However, a duplicate of the syntype in agreement with the protologue is kept at GH. This material matches the diagnosis coined by Spegazzini, and, thus, it is here chosen as the lectotype of the name. Rudolph A. Philippi (1895) based the description of *Eritrichium parvulum* on three collections made by F. Philippi on a trip to the Atacama Region, Chile, in 1885. The first gathering consists of a collection from Caldera, while the other two were made in Piedra Colgada and Chañarcillo. Four duplicates of the syntype collected in Caldera are kept at CORD, GH, and SGO. Among the other syntypes, a duplicate of each collection is housed at SGO. All specimens are in agreement with the localities and the diagnosis cited in the protologue. The syntype from Caldera is preferred as it shows the best quality of preservation of the important diagnostic features of the taxon. Thus, a duplicate from this collection is here chosen as lectotype of the name.

18. *Cryptantha spathulata* (Phil.) Reiche, Anales Univ. Chile 121: 823. 1907.

≡ *Eritrichium spathulatum* Phil., Anales Univ. Chile 90: 517. 1895. Type: CHILE. [Región del Libertador General Bernardo O’Higgins:] Colchagua de Popeta, 1881, *F. Philippi s.n.* (first-step lectotype, designated by Johnston 1927, pg. 58: SGO; second-step lectotype, designated here: SGO [SGO000004135 digital image!]; isolectotypes: GH [GH00096577 digital image!], SGO [SGO000004134 digital image!]).

Note. In describing *Eritrichium spathulatum*, Rudolph A. Philippi (1895) cited a collection made by F. Philippi in Colchagua de Popeta, Chile. Two duplicates of this gathering in agreement with the protologue and annotated as “*Eritrichium spathulatum*” by Philippi are found at SGO. Johnston (1927) referred to the “type” as lodged at SGO and, therefore, his statement must be considered as a first-step lectotypification. In order to narrow this broad designation, the specimen SGO000004135 is here selected as a second-step lectotype.

19. *Cryptantha subamplexicaulis* (Phil.) Reiche, Anales Univ. Chile 121: 826. 1907.

≡ *Eritrichium subamplexicaule* Phil., Fl. Atacam. 39. 1860. Type: CHILE. Región de Antofagasta: Paposo, Dec. 1853, *R.A. Philippi s.n.* (lectotype, designated by Johnston 1927, pg. 41: SGO [SGO000004139 digital image!]; isolectotypes: GH [GH00096579 digital image!], HAL [HAL0115278 digital image!]).

Note. In the protologue of *Eritrichium subamplexicule*, Rudolph A. Philippi (1860) cited a collection he made near Paposo, Chile. There are two sheets of apparent original material, which agree with the diagnosis and cited locality, at HAL and SGO. Both specimens were presumably studied by Philippi since they were annotated, in his hand, as “*Eritrichium subamplexicaule*”. The material at SGO was referred to as the “type” of the species name by Johnston (1927). Therefore, the element cited by him must be considered as an effective lectotypification.

20. *Cryptantha volckmannii* (Phil.) I.M. Johnst., Contr. Gray Herb. 78: 66. 1927.

≡ *Eritrichium volckmannii* Phil., Anales Univ. Chile 18: 54. 1861. Type: CHILE. Región de Coquimbo: Huanta, 1860, *H. Volckmann s.n.* (holotype: SGO [SGO000004151 digital image!]).

= *Eritrichium chrysanthum* Phil., Linnaea 33: 191. 1864. *Cryptantha chrysantha* (Phil.) Reiche, Anales Univ. Chile 121: 815. 1907. Type: CHILE. Región de Coquimbo: Cordillera de Illapel, Aug. 1861, *H. Volckmann s.n.* (first-step lectotype, designated by Johnston 1927, pg. 66: SGO; second-step lectotype, designated here: SGO [SGO000004051 digital image!]; isolectotypes: GH [GH00096376 digital image!], SGO [SGO000004052 digital image!]).

Note. Rudolph A. Philippi’s description of *Eritrichium chrysanthum* (Philippi 1864) was based on material collected by H. Volckmann near Illapel, Chile. Johnston (1927) indicated a specimen housed at SGO as the “type”. However, two sheets linked to *E. chrysanthum* were located at SGO and, therefore, his statement must be considered as a first-step lectotypification. In order to narrow this broad designation, the specimen SGO000004051 is here selected as a second-step lectotype.

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References

- Amsinckiinae Working Group (2021) Systematics of Amsinckiinae (Boraginaceae): The popcorn flowers. <https://plants.sdsu.edu/amsinckiinae> [accessed on 15.04.2021]
- Brako L, Zarucchi JL (1993) Catálogo de las angiospermas y gimnospermas del Perú. Monographs in Systematic Botany from the Missouri Botanical Garden 45.
- Brand A (1924) Decas specierum novarum quinta. Repertorium Specierum Novarum Regni Vegetabilis 20(6–21): 317–320. <https://doi.org/10.1002/fedr.19240200617>
- Brand A (1931) Borraginaceae. Borraginoidea-Cryptanthae. Das Pflanzenreich 4(252): 1–236.
- Chater AO (1971) Flora Europaea: Notulae Systematicae ad Floram Europaeam spectantes: No. 11. In: Heywood VH (Ed.) Short Notes: Boraginaceae. (192) *Amsinckia* Lehm. Botanical Journal of the Linnean Society 64: 353–381. <https://doi.org/10.1111/j.1095-8339.1971.tb02152.x>
- Clos D (1849) Eritrichium. Flora Chilena 4(4): 462–472.
- Correa MN (1999) Flora Patagónica: Dicotiledóneas Metaclamídeas. Colección Científica del Instituto Nacional de Tecnología Agropecuaria 8(6): 116–145.
- Dawson G (1965) Boraginaceae. In: Cabrera AL (Ed.) Flora de la Provincia de Buenos Aires, Vol. 4(5). Instituto Nacional de Tecnología Agropecuaria, Buenos Aires, 100–121.
- Guilliams MC, Hasenstab-Lehman K, Mabry M, Simpson MG (2017) Memoirs of a frequent flier: Phylogenomics reveals 18 long-distance dispersals between North America and South America in the popcorn flowers (Amsinckiinae, Boraginaceae). American Journal of Botany 104(11): 1717–1728. <https://doi.org/10.3732/ajb.1700369>
- Hasenstab-Lehman KE (2017) Phylogenetics of the Borage Family: Delimiting Boraginales and Assessing Closest Relatives. Aliso: A Journal of Systematic and Evolutionary Botany 35: 41–49. <https://doi.org/10.5642/aliso.20173501.04>
- Hasenstab-Lehman KE, Simpson MG (2012) Cat's eyes and popcorn flowers: Phylogenetic systematics of the genus *Cryptantha* s.l. (Boraginaceae). Systematic Botany 37(3): 738–757. <https://doi.org/10.1600/036364412X648706>
- Hiepkö P (1987) The collections of the Botanical Museum Berlin-Dahlem (B) and their history. Englera 7: 219–252.
- Higgins LC (1971) A revision of *Cryptantha* subgenus *Oreocarya*. Brigham Young University Science Bulletin Biological Series 8: 1–62.
- ITHAKA (2021) JSTOR Global Plants. <https://plants.jstor.org> [accessed 4.04.2021]
- Johnston IM (1925) Studies in the Boraginaceae IV. The North American species of *Cryptantha*. Contributions from the Gray Herbarium of Harvard University 74: 1–114.
- Johnston IM (1927) Studies in the Boraginaceae VI. A revision of the South American Boraginoidea. Contributions from the Gray Herbarium of Harvard University 78: 1–118.
- Johnston IM (1935) Studies in the Boraginaceae XI. New or otherwise noteworthy species. Journal of the Arnold Arboretum 16: 173–205.
- Kelley RB, Simpson MG, Hasenstab-Lehman KE (2012) *Amsinckia*, *Cryptantha*, *Harpagonella*, *Pectocarya*, *Plagiobothrys*. In: Jepson Flora Project (Eds) 2021. Jepson eFlora. <https://ucjeps.berkeley.edu/eflora> [accessed 15.04.2021]
- Luebert F, Cecchi L, Frohlich MW, Gottschling M, Guilliams CM, Hilger HH, Hasenstab-Lehman KE, Miller JS, Mittelbach M, Nazaire M, Nepi M, Nocentini D, Ober D, Olm-

- stead RG, Selvi F, Simpson MG, Sutorý K, Valdés B, Walden GK, Weigend M (2016) Familial classification of Boraginales. *Taxon* 65(3): 502–522. <https://doi.org/10.12705/653.5>
- Mabry EM, Simpson MG (2018) Evaluating the monophyly and biogeography of *Cryptantha* (Boraginaceae). *Systematic Botany* 43(1): 53–76. <https://doi.org/10.1600/036364418X696978>
- Macbride JF (1960) Flora of Peru. Botanical Series Field Museum of Natural History 13: 601–605. <https://doi.org/10.5962/bhl.title.147682>
- McNeill J (2014) Holotype specimens and type citations: General issues. *Taxon* 63(5): 1112–1113. <https://doi.org/10.12705/635.7>
- Miller JS, Nee M, Maldonado C (2014) Boraginaceae. In: Jørgensen PM, Nee MG, Beck SG (Eds) Catálogo de las plantas vasculares de Bolivia. Monographs in Systematic Botany from the Missouri Botanical Garden 127(1–2): 1–1744. <http://legacy.tropicos.org/Project/BC>
- Moroni P, O’Leary N, Filloy J (2016) Species delimitation in the *Aloysia gratissima* complex (Verbenaceae) following the phylogenetic species concept. *Botanical Journal of the Linnean Society* 180(2): 193–212. <https://doi.org/10.1111/boj.12369>
- Muñoz Pizarro C (1960) Las especies de plantas descritas por R. A. Philippi en el siglo XIX. Estudio crítico en la identificación de sus tipos nomenclaturales. Editorial Universitaria, S. A., Santiago de Chile.
- O’Leary N, Múlgura ME, Morrone O (2007) Revisión taxonómica de las especies del género *Verbena* (Verbenaceae): Serie Pachystachyae. *Annals of the Missouri Botanical Garden* 94(3): 571–621. [https://doi.org/10.3417/0026-6493\(2007\)94\[571:RTDLED\]2.0.CO;2](https://doi.org/10.3417/0026-6493(2007)94[571:RTDLED]2.0.CO;2)
- O’Leary N, Múlgura ME, Morrone O (2010) Revisión Taxonómica de las especies del género *Verbena* (Verbenaceae). II: Serie Verbena. *Annals of the Missouri Botanical Garden* 97(3): 365–424. <https://doi.org/10.3417/2007070>
- O’Leary N, Lu-Irving P, Moroni P, Siedo S (2016) Taxonomic revision of *Aloysia* (Verbenaceae, Lantaneae) in South America. *Annals of the Missouri Botanical Garden* 101(3): 568–609. <https://doi.org/10.3417/2013015>
- Payson EB (1927) A monograph of the section *Oreocarya* of *Cryptantha*. *Annals of the Missouri Botanical Garden* 14(3): 211–358. <https://doi.org/10.2307/2394051>
- Pérez-Moreau RL (1976) Revisión del género *Cryptantha* en la Argentina (Boraginaceae). *Darwiniana* 20(1/2): 155–188.
- Pérez-Moreau RL (1979) Boraginaceae. In: Burkart A (Ed.) Flora Ilustrada de Entre Ríos 6(5). INTA, Buenos Aires, 209–229.
- Pérez-Moreau RL, Cabrera AL (1983) Boraginaceae. In: Cabrera AL (Ed.) Flora de la Provincia de Jujuy. INTA, Buenos Aires, 274–291.
- Pérez-Moreau RL, Crespo S (2018) Boraginaceae. In: Kiesling R (Ed.) Flora de San Juan, República Argentina. INTA, Buenos Aires, 49–72.
- Philippi RA (1857) Plantarum novarum Chilensium: centuria quarta, quinta, sexta. *Linnaea* 29(1): 1–47, 48–95, 96–110.
- Philippi RA (1860) Florula Atacamensis seu enumeratio plantarum, quas in itinere per desertum Atacamense. Sumptibus E. Anton. <https://doi.org/10.5962/bhl.title.162865>
- Philippi RA (1864) Plantarum novarum Chilensium. *Linnaea* 33: 1–308.
- Philippi RA (1873) Descripción de las plantas nuevas incorporadas últimamente en el herbario chileno. *Anales de la Universidad de Chile* 43: 479–583.

- Philippi RA (1891) *Catalogus Praevius Plantarum in Itinere ad Tarapaca a Friderico Philippi Lectarum*. Anales del Museo Nacional de Chile, Santiago de Chile II: 1–94.
- Philippi RA (1895) Plantas nuevas chilenas de las familias que corresponden al tomo IV de la obra de Gay: (continuación). Anales de la Universidad de Chile 90: 511–566. <https://doi.org/10.5354/0717-8883.2012.20872>
- Rodríguez RC, Marticorena DA, Baeza C, Cavieres L, Finot VL, Fuentes N, Kiessling A, Michoc M, Pauchard A, Ruiz E, Sanchez P, Marticorena A (2018) Catálogo de las plantas vasculares de Chile. Gayana. Botánica 75(1): 1–430. <https://doi.org/10.4067/S0717-66432018000100001>
- Ruiz López H, Pavón JA (1799) *Flora peruviana et chilensis 2*. Gabrielis de Sancha, Madrid.
- Simpson MG, Hasenstab-Lehman KE (2009) *Cryptantha* of Southern California. *Crossosoma* 35: 1–59.
- Simpson MG, Williams CM, Hasenstab-Lehman KE, Mabry ME, Ripma L (2017) Phylogeny of the popcorn flowers: Use of genome skimming to evaluate monophyly and interrelationships in subtribe Amsinckiinae (Boraginaceae). *Taxon* 66(6): 1406–1420. <https://doi.org/10.12705/666.8>
- Simpson MG, Mabry ME, Hasenstab-Lehman KE (2019) Transfer of four species of *Cryptantha* to the genus *Johnstonella* (Boraginaceae). *Phytotaxa* 425: 279–289. <https://doi.org/10.11646/phytotaxa.425.5.3>
- Spegazzini CL (1902) *Nova addenda ad Flora Patagonicam*. Anales del Museo Buenos Aires 7: 135–308.
- Stafleu FA, Cowan RS (1976) *Taxonomic Literature Vol. 1, a Selective Guide to Botanical Publications and Collections with Dates, Commentaries and Types*, ed. 2. Bohn, Scheltema & Holkema, Utrecht. <https://doi.org/10.5962/bhl.title.48631>
- Stafleu FA, Cowan RS (1983) *Taxonomic Literature Vol. 4, a Selective Guide to Botanical Publications and Collections with Dates, Commentaries and Types*, ed. 2. Bohn, Scheltema & Holkema, Utrecht.
- Stafleu FA, Cowan RS (1986) *Taxonomic Literature Vol. 6, a Selective Guide to Botanical Publications and Collections with Dates, Commentaries and Types*, ed. 2. Bohn, Scheltema & Holkema, Utrecht.
- Taylor CM, Muñoz-Schick M (1994) The Botanical Works of Philippi, Father and Son, in Chile. *Annals of the Missouri Botanical Garden* 81(4): 743–748. <https://doi.org/10.2307/2399918>
- Thiers B (2021) *Index Herbariorum: A global directory of public herbaria and associated staff*. New York Botanical Garden's Virtual Herbarium. <http://sycamore.nybg.org/science/ih>. [accessed on 15.04.2021]
- Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber WH, Li DZ, Marhold K, May TW, McNeill J, Monro AM, Prad J, Price MJ, Smith GF [Eds] (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabile* 159. Koeltz Botanical Books, Glashütten. <https://doi.org/10.12705/Code.2018>

- Ulloa Ulloa C, Acevedo-Rodríguez P, Beck SG, Belgrano MJ, Bernal R, Berry PE, Brako L, Celis M, Davidse G, Forzza RC, Gradstein SR, Hokche O, León B, León-Yáñez S, Magill RE, Neill DA, Nee M, Raven PH, Stimmel H, Strong MT, Villaseñor JL, Zarucchi JL, Zuloaga FO, Jørgensen PM (2017) An integrated assessment of vascular plants species of the Americas. *Science* 358: 1614–1617. [f. 1–4] <https://doi.org/10.1126/science.aao0398>
- Weigend M, Luebert F, Gottschling M, Couvreur TLP, Hilger HH, Miller JS (2014) From capsules to nutlets – Phylogenetic relationships in the Boraginales. *Cladistics* 30(5): 508–518. <https://doi.org/10.1111/cla.12061>
- Zuloaga FO, Morrone O [Eds] (1999) *Catálogo de las Plantas Vasculares de la Argentina: Dicotyledoneae*. Monographs in Systematic Botany from the Missouri Botanical Garden 74: 1–1246.
- Zuloaga FO, Morrone O, Belgrano MJ (2008) *Catálogo de las plantas vasculares del Cono Sur (Argentina, Sur de Brasil, Chile, Paraguay y Uruguay)*. Monographs in Systematic Botany from the Missouri Botanical Garden 107: 1–3348. <http://www2.darwin.edu.ar/Proyectos/FloraArgentina/fa.htm>
- Zuloaga FO, Belgrano M, Zanotti C (2019) Actualización del Catálogo de las Plantas Vasculares del Cono Sur. *Darwiniana* 7(2): 208–278. <https://doi.org/10.14522/darwiniana.2019.72.861>

Clarifying the nomenclatural history of *Tovomitopsis*, a Brazilian endemic genus of Clusiaceae

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Abstract

Tovomitopsis Planch. & Triana is a Brazilian Atlantic Forest endemic genus composed of two species: *T. paniculata* (Spreng.) Planch. & Triana and *T. saldanhae* Engl. An investigation was conducted to clarify the nomenclatural history of *Tovomitopsis*. We report the results of this investigation, provide an updated description of the genus, and propose lectotypes for *T. paniculata* and its synonyms: *Tovomita foliosa* C.Presl and *Tovomita paniculata* Cambess. We also propose lectotypes for *T. saldanhae* and for the new synonym *Clusia angustifolia* Engl.

Keywords

Atlantic Forest, lectotype, Malpighiales, Neotropics, South America

Introduction

Tovomitopsis Planch. & Triana is a Brazilian endemic genus currently composed of two species: *T. paniculata* (Spreng.) Planch. & Triana and *T. saldanhae* Engl. Both species occur in preserved remnants of Atlantic Forest in southeastern Brazil (Marinho 2021). *Tovomitopsis* was proposed in 1860 (Planchon and Triana 1860) as a replacement name

for the illegitimate *Bertolonia* Spreng. (non *Bertolonia* Raddi 1820) and to accommodate presumably tetramerous flowered species. Together with *Chrysochlamys* Poepp. and *Tovomita* Aubl., these three genera were known by Planchon and Triana (1860: 225) as *Les Tovomitées*, being differentiated from each other especially by the arrangement of sepals on the floral bud: in *Chrysochlamys* and *Tovomitopsis* the outer sepals are smaller, exposing the inner sepals in bud, while in *Tovomita* the outer sepals are larger, covering the inner sepals and petals. Moreover, Planchon and Triana (1860) indicated that aril anatomy could be useful to differentiate, or at least, better circumscribe *Les Tovomitées*, but surprisingly this topic has not yet been further investigated.

Although some recent studies still indicate floral merosity as relevant to distinguish *Tovomitopsis* from *Chrysochlamys* (e.g. Hammel 2010), the latter includes species with four or five petals (e.g. Hammel 1999; Martínez y Pérez et al. 2015), and a clear morphological distinction between these two genera is yet missing. Taxonomic treatments and checklists carried out in Mexico (Martínez y Pérez et al. 2015), Central America (e.g. Hammel 1999), northern South America (Kearns 1998), where *Chrysochlamys* is distributed, and the Brazilian Atlantic Forest (Oliveira-Filho 2006) considered these two genera as congeneric.

Molecular phylogenetic evidence shows *Tovomitopsis* in a polytomy with *Dystovomita* and the rest of Clusiaceae, and thus not very closely related to *Chrysochlamys* despite their gross morphological similarity (Marinho et al. 2019). Pollen morphology and aril anatomy (Planchon and Triana 1860; Hammel 1999; Stevens 2007; Marinho et al. 2019) have been suggested as promising to distinguish these two genera, but were so far gathered from only a few species of *Chrysochlamys*. The presence of resin glands in the anther dorsal region of *Tovomitopsis* could be a synapomorphy of the genus, and the absence of a pistillode in staminate flowers of *Chrysochlamys* could be also relevant to distinguish these genera (Bittrich and Marinho pers. com.).

Tovomitopsis consists of dioecious small trees or shrubs with prop roots and yellowish viscous exudate. The opposite leaves are petiolate, entire, chartaceous or coriaceous, with numerous closely arranged veins. The flowers have two pairs of sepals, the outer ones being smaller than the inner ones, and two pairs of whitish petals. Staminate flowers have yellow subclavate resiniferous stamens and a pistillode; pistillate flowers have staminodes similar to the stamens and a green-yellowish pistil with expanded stigmas. The fruits are green fleshy capsules that expose seeds with an orange vascularized aril when ripe (Bittrich 2003; Stevens 2007).

Although *Tovomitopsis* includes only two species, the genus has a long taxonomic history (see Hammel 1999), with several species floating among the three genera of *Les Tovomitées* (sensu Planchon and Triana 1860). The type species of the genus, *Tovomitopsis paniculata*, was described two hundred years ago, but a few nomenclatural issues remain to be addressed. Here, we clarify the nomenclatural history of *Tovomitopsis*, provide an updated description for the genus, and propose lectotypes for *T. paniculata* and its synonyms: *Tovomita foliosa* C.Presl and *Tovomita paniculata* Cambess. We also propose lectotypes for *T. saldanhae* and its new synonym, *Clusia angustifolia* Engl.

Material and methods

This study is based on the analysis of the protologues of *Tovomitopsis* names and some of its synonyms, on visits to historical collections in Europe (B, K, M, P, W) and the Americas (A, GH, NY, R, RB; herbaria acronyms according to Thiers 2021), and by analyzing specimens from virtual herbaria. Data on collectors and botanists were accessed in the Taxonomic Literature II website (Staffeu and Cowan 1976–1988). All nomenclatural decisions follow the International Code of Nomenclature for algae, fungi, and plants (Turland et al. 2018).

Nomenclature and discussion

Tovomitopsis was proposed by Planchon and Triana (1860) as a replacement name for *Bertolonia* Spreng. [with just one species, *B. paniculata*, which was initially attributed to Chenopodiaceae (as “Chenopodieae”), a later homonym of *Bertolonia* Raddi (Melastomataceae)]. Along with the newly transferred *T. paniculata* they described five additional new species, all six of which they felt could be distinguished from *Chrysochlamys* and *Tovomita*. *Bertolonia paniculata* Spreng. was based on a pistillate specimen according to the illustration provided by the author (see Fig. 1, 1–4b). Sprengel (1821) did not mention either location, number or collector name for this collection.

In the “Flora Brasiliae Meridionalis”, edited by Auguste de Saint-Hilaire et al., Jacques Cambessèdes (1828) used the same epithet “paniculata” when he published the new species *Tovomita paniculata* Cambess. This binomial is sometimes mistakenly interpreted as a new combination for *Bertolonia paniculata* Spreng. However, Cambessèdes is clearly indicated as the author of the Guttiferae monograph at the end of the treatment, and the † sign was used to indicate a new species throughout “Flora Brasiliae Meridionalis”. The complete description of *Tovomita paniculata* that Cambessèdes (1828) provided included stamens, pollen grains and gynoecium, indicating that he studied both staminate and pistillate specimens. The protologue contains the following statement: “*in sylvis primaevis propè vicum Aguassu, haud longè ab urbe Rio de Janeiro. Florebat Februario*”, and an illustration of a branch with many flowers, a feature found only in staminate specimens, while the illustration details show a pistillate flower and the detail of an ovary, as well as stamens with well-formed anthers (see Fig. 2). Cambessèdes (1828) did not indicate a type collection, but one specimen housed at P that was collected by Saint-Hilaire is probably the original material. The specimen P00093861 bears a label indicating the same location as in the protologue.

Presl (1834) proposed *Tovomita foliosa* C.Presl, as a new species and provided a detailed description and an illustration, but again without indication of the material he used. The author cited only “*Habitat in Brasilia ad Rio de Janeiro*”. Although he described the species as a *Tovomita*, the pair of outer sepals not covering the inner sepals and other floral parts allow us to recognize a *Tovomitopsis paniculata* specimen in the



Figure 1. Lectotype (1–4b) of *Bertolonia paniculata* Spreng. (\equiv *Tovomitopsis paniculata* (Spreng.) Planch. & Triana) published by Sprengel (1821) in “Neue Entdeckungen im ganzen Umfang der Pflanzenkunde II”.

illustration. In 1860, Planchon and Triana described *Tovomitopsis* and included, in addition to *Tovomitopsis paniculata* (Spreng.) Planch. & Triana (\equiv *Bertolonia paniculata* Spreng.), five new species (currently placed in *Chrysochlamys*), and justified this decision based, in part, on the number of floral parts: while *Tovomitopsis* was circumscribed to include tetramerous flowers, *Chrysochlamys* retained the species with pentamerous flowers. In that work, the authors indicated two specimens for *T. paniculata*: “Brésil, Rio-de-Janeiro (Aug. de Saint-Hilaire; Sellow)”.

In the “Flora brasiliensis”, Engler (1888) provided a description and an illustration of *Tovomitopsis paniculata* citing eight collections, all of which were collected in Rio de Janeiro state: 1 – *Habitat in Brasiliae prov. Rio de Janeiro: Sello in herb. reg. Berol.*; 2 and 3 – *Glaziou n. 7429, 12466*; 4 – *in silvis primaevae pr. Aguasta: St-Hilaire*; 5 – *in silvis umbrosis Capivary: Riedel n. 1318 in herb. Petrop.*; 6 – *in Serra de Friburgo: Saldanha n. 7044*; 7 – *in Serra de Tingua: Saldanha n. 5313*; 8 – *in Serra dos Orgãos: Riedel – Flor. Febr.* The author also described two new species in the genus: *Tovomitopsis spruceana* Engl., based on specimens from the Peruvian Amazon, and *Tovomitopsis saldanhae* Engl., based on specimens from Rio de Janeiro state.

The material used in the original description of *Tovomitopsis paniculata* was not mentioned or indicated by either Planchon and Triana or Engler, but the protologue and subsequent publications provided two important clues to find the type: i) both the description of the pistil and the illustration point to a pistillate specimen; ii) several points indicate that the type was collected in Rio de Janeiro state. For the locality of his *Tovomita paniculata*, Cambessède (1828) mentioned the village of *Aguassu*, which we believe to be Nova Iguaçu (before spelled as *Iguassú*), today a municipality in the metropolitan region of Rio de Janeiro city. Planchon and Triana (1860) cited Rio de Janeiro as the only locality of *Tovomitopsis paniculata*, and also all specimens cited by Engler (1888) came from the state of Rio de Janeiro. Both Planchon and Triana (1860) and Engler (1888) cited specimens collected by Friedrich Sellow and Auguste de Saint-Hilaire as the basis for their respective descriptions. Sellow collected in the state of Rio de Janeiro between 1814 and 1821 (Staffeu and Cowan 1976–1988) and most of his specimens were deposited in B, but there are additional specimens originally from the Müller-Sprengel herbarium which were purchased by B in 1890 (Staffeu and Cowan 1976–1988). We speculate that Kurt Sprengel, the German botanist who first described *Tovomitopsis paniculata* (as *Bertolonia paniculata*), likely studied one or more specimens collected by Sellow rather than the ones collected by Saint-Hilaire.

During a visit to European herbaria in 2016, a search at B was made for specimens assigned to the names *Bertolonia paniculata*, *Tovomita paniculata*, and *Tovomitopsis paniculata*, but none were found. Likewise, there are no Macbride negatives of such specimens in the Chicago Field Museum. Two relevant Sellow specimens were located in K (K001231050, image seen in Reflora Virtual Herbarium 2021), with the ♂ symbol indicating that it is a staminate specimen, and US (01882513) herbaria, both with floral buds; however, it is uncertain that these



Figure 2. Illustration of *Tovomita paniculata* Cambess. published by Cambessèdes (1828) in “Flora Brasiliae Meridionalis”.

specimens are duplicates of a presumed type specimen housed in B. Therefore, we selected the illustration provided by Sprengel (1821) as the lectotype of *Tovomitopsis paniculata*, as this is the only unambiguous original material known to us. We also choose the illustration provided by Presl (1834) as the lectotype of *Tovomita foliosa*; and followed Planchon and Triana (1860) and Engler (1888) by considering *T. paniculata* Cambess. as an heterotypic synonym of *Tovomitopsis paniculata*, rather than a new combination.

***Tovomitopsis paniculata* (Spreng.) Planch. & Triana, Ann. Sci. Nat. Bot., Sér. 4, 14: 262. 1860.**

- ≡ *Bertolonia paniculata* Spreng., Neue Entdeck. Pflanzenk. II: 110, t. I. 1820 (“1821”).
- = *Tovomita paniculata* Cambess., Fl. Bras. Merid. (quarto ed.) 1(8): 315, pl. 64. 1828.
Type. lectotype (designated here), [BRAZIL: Rio de Janeiro] in sylvis primaevae propè vicum Aguassu, haud longè ab urbe Rio de Janeiro. Florebat Februario [1816–1821, *A. De Saint-Hilaire s/n*] (P! P00093861; isolectotypes: MPU 2-sheets MPU014277, MPU014278). (Fig. 3)
- = *Tovomita foliosa* C.Presl, Symb. Bot. (Presl) ii(7). 20. tab. 66. 1834 (1833). Type. lectotype (designated here), illustration in Presl (1834: Tab. 66). (Fig. 4)

Type. lectotype (designated here), illustration in Sprengel (1821: Tab. I). (Fig. 1, 1–4b)

Notes about *Tovomitopsis saldanhae*

Tovomitopsis saldanhae was described by Engler (1888) based on specimens from the Serra dos Órgãos (Rio de Janeiro state) as “*Habitat in Brasiliae provincia Rio de Janeiro, in Serra dos Orgãos ad Theresopolim: J. de Saldanha n. 6777, 6780, 6781, Glaziou n. 13576 in herb. Eichler*”. His description and the illustration point to the use of both staminate and pistillate specimens. In the same contribution, Engler also described *Clusia angustifolia* Engl. based on *Saldanha 7335*, which was collected in the same locality of *T. saldanhae*. The specimen (pistillate) clearly matches with specimens of *T. saldanhae*, especially the oblanceolate leaves with dark dots below, four petals and two series of resiniferous staminodes with subapical antherodes. As the specimen of *Clusia angustifolia* deposited in B was destroyed during World War II in 1943, we select a duplicate at R as the lectotype.

Tovomitopsis saldanhae was later transferred to *Chrysochlamys* as *C. saldanhae* (Engl.) Oliveira-Filho, but Oliveira-Filho (2006) did not mention or indicate a type. *Chrysochlamys saldanhae* is now a synonym of *T. saldanhae* (Marinho 2021). Among the *T. saldanhae* syntypes, we chose *A. Glaziou 13576* (P01901232, Fig. 5), which is the best preserved specimen housed at P, as the lectotype.



Figure 3. Lectotype of *Tovomita paniculata* Cambess. (P00093861) housed at P.



Figure 4. Lectotype of *Tovomita foliosa* C.Presl (= *Tovomitopsis paniculata* (Spreng.) Planch. & Triana) published by Presl (1834) in "Symbolae botanicae, sive, Descriptiones et icones plantarum novarum aut minus cognitarum".

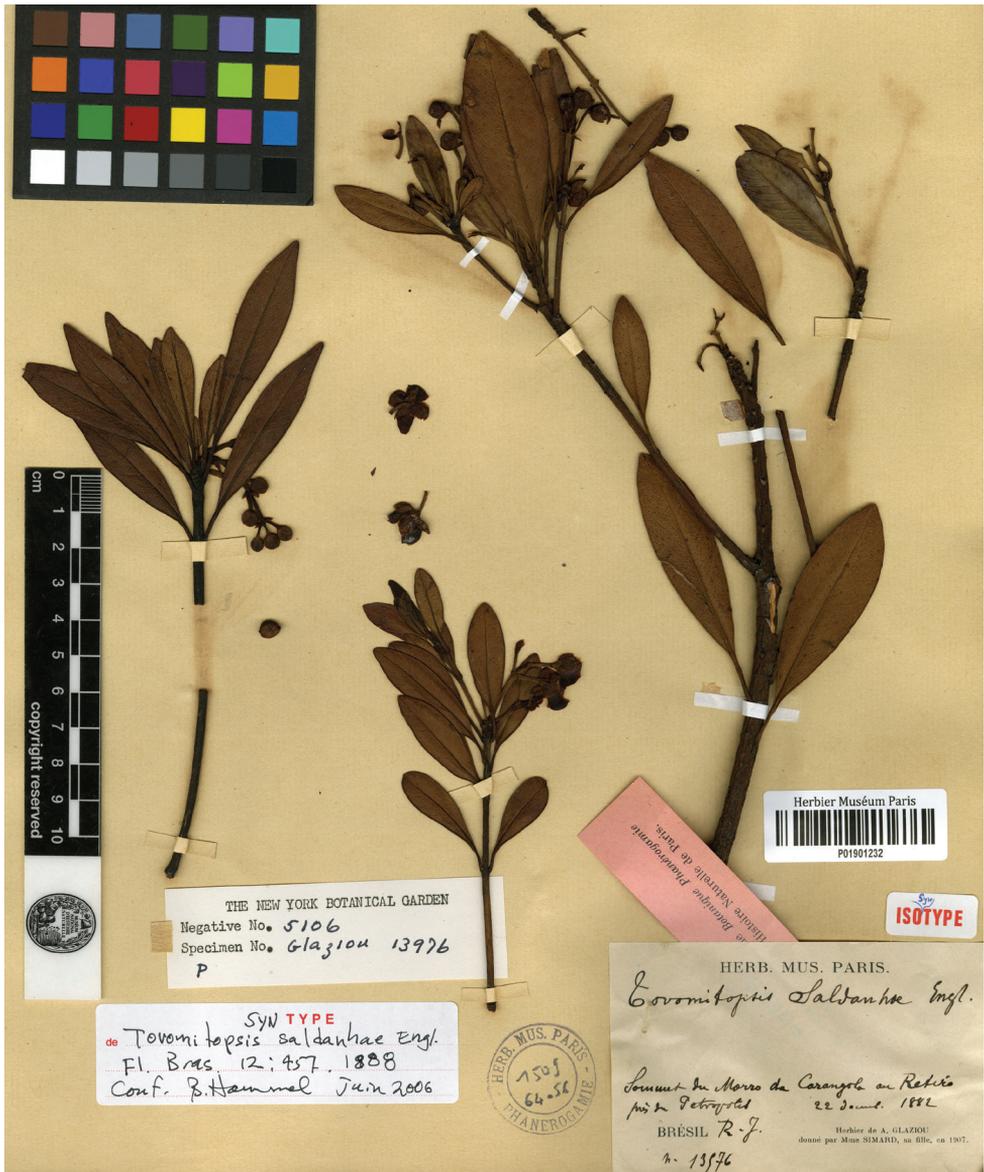


Figure 5. Lectotype of *Tovomitopsis saldanhae* Engl. (P01901232) housed at P.

***Tovomitopsis saldanhae* Engl., Fl. Bras. (Martius) 12(1): 457. 1888.**

≡ *Chrysochlamys saldanhae* (Engl.) Oliveira-Filho, Cat. Árvores Nativas Minas Gerais: 93. 2006.

= *Clusia angustifolia* Engl., Fl. Bras. (Martius) 12(1): 420. 1888, syn. nov. Type. lectotype (designated here), [BRAZIL: Rio de Janeiro] *habitat in Brasiliae provincia Rio de Janeiro, in Serra dos Orgãos* [21–31 March 1883], J. Saldanha da Gama 7335 (R! excl. branch with long internodes in the center and leaves without dark dots below). (Fig. 6)



Figure 6. Lectotype of *Clusia angustifolia* Engl. housed at R. The long branch in the center belongs to a different species not yet identified. Photographed by V. Bittrich.

Type. lectotype (designated here), [BRAZIL: Rio de Janeiro, Petrópolis], *Sommet du Morro da Carangola an Retiro, près de Petropolis*, [22 December 1882], *A. Glaziou 13576* (P! P01901232; isolectotypes: BR BR0000008675873, F F0360328F, P! P01901230, P! P01901231, R R000007580).

Note. Saldanha's collection numbers listed in a close numerical sequence may well belong to the same gathering (R. Forzza pers. com.). However, it is not possible for us to authenticate the preceding.

Regarding the other species of *Tovomitopsis* described by Engler (1888), Vesque (1893) transferred *Tovomitopsis spruceana* to *Clusia* (as *C. trochiformis* Vesque) and inadvertently proposed the lectotype by citing *Spruce 4569* at the Boissier herbarium (now housed at G) as the type, but unfortunately this specimen was not found.

Emended description of *Tovomitopsis*

***Tovomitopsis* Planch. & Triana, Ann. Sci. Nat., Bot., sér. 4, 14: 261. 1860.**

≡ *Bertolonia* Spreng., Neue Entdeck. Pflanzenk. 2: 110. 1820 ('1821'), non Raddi (1820)

Type. *Tovomitopsis paniculata* (Spreng.) Planch & Triana. (*Bertolonia paniculata* Spreng.)

Description. Small dioecious trees or shrubs with prop roots; axillary shoots with internodes regularly spaced from each other, grouped at the branch apex; exudates yellowish viscous on the branches and leaves. Leaves simple, opposite, decussate, petiolate; leaf blades chartaceous or coriaceous, light green *in vivo*, greenish to grayish *in sicco*, margin entire; venation simple brochidodromous, midvein prominent abaxially, flat adaxially; secondary veins slightly arcuate or straight, prominent abaxially, flat adaxially, forming angles between 40°–65° with the midvein; major secondary spacing generally regular; intersecondary veins parallel to major secondary veins, one per intercostals area; intramarginal secondary veins sometimes present. Inflorescences terminal, cymose, widely lax or congested, a single dichasium or a closed thyse (the staminate more floriferous than the pistillate); bracteoles 2, triangular. Buds green, spheroid, apex rounded; sepals 2 pairs, green, decussate, base truncate, margin entire, apex rounded, outer pair smaller than inner pair and not enclosing the bud; petals 4, whitish, base truncate, margin entire, apex rounded. Staminate flowers with ca. 25 resiniferous stamens, filaments dorsiventrally compressed, yellow, sometimes the outer ones smaller than the inner ones, anthers lateral, yellow, thecae with longitudinal dehiscence, resiniferous glands present at the dorsal side of the anthers, pistillode inconspicuous. Pollen with general format in polar view subtriangular; isopolar, tricolporate, and with long ectocolpi; reticulate, and the semitectum not solid, but composed of twisted bacula. Pistillate flowers with staminodes similar to stamens; ovary 4-locular, 1 ovule per locule, styles 4, very short, distinct and persistent; stigmas 4, capitate, free from each other, persistent. Capsule pendant or straight on the branch, with 4 valves, epicarp smooth,

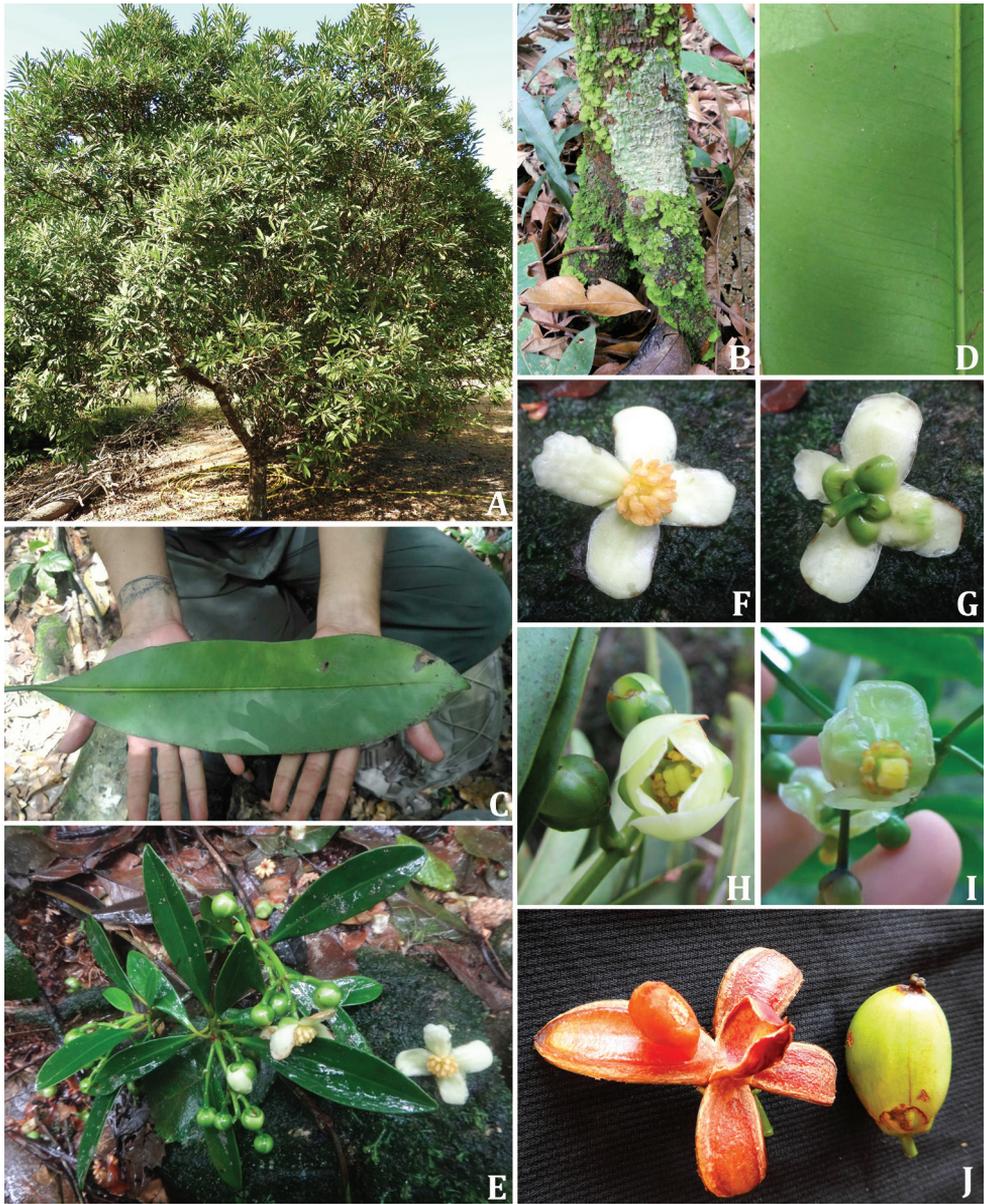


Figure 7. General morphology of *Tovomitopsis*. **A** habit **B** prop roots; **C** leaf undersurface **D** detail of leaf showing the veins **E** branch with leaves and staminate flowers **F, G** staminate flower **H** pistillate flower in the beginning of anthesis **I** pistillate flower in anthesis **J** open (left) and closed fruit (right). **A–D, I, J** *T. paniculata* **E–H** *T. saldanhae*. Photos **A** and **J** Marcelo Mig **B** Lucas Marinho **C, D** Ana Cláudia Alencar **E–G** Rodrigo Penati **H** Luciano Pedrosa **I** Rodrigo Castro.

green, mesocarp light red to purplish red. Seeds 1 per locule, each enclosed by a vascularized orange aril. Fig. 7.

Tovomitopsis and *Chrysochlamys* relationship

The phylogenetic relationship between *Tovomitopsis* and *Chrysochlamys* remained unknown until DNA sequence data became available for most genera of Clusiaceae. Taxonomic errors of attributing new Central American species to *Tovomitopsis* instead of *Chrysochlamys* (Maguire 1977) were likely due to characterizing the latter as having cauliflorous inflorescences, a condition only observed in *Dystovomita* (Engl.) D'Arcy among Clusiaceae. Moreover, Maguire (1977) almost certainly did not look at the type species of *Chrysochlamys*, i. e. *C. multiflora* Poepp., and it is doubtful that he analyzed species of *Tovomitopsis* from southeastern Brazil, including the type *T. paniculata*. A few years later, D'Arcy (1980) synonymized *Chrysochlamys* under *Tovomitopsis*, even though the latter is more recent (Hammel 1999).

Recent phylogenetic analyses of Clusiaceae demonstrated that *Chrysochlamys* is not sister to *Tovomitopsis*, but to *Clusia* (Gustafsson et al. 2007; Ruhfel et al. 2011; Marinho et al. 2019), and that floral resin evolved more than once in Clusiaceae and, possibly, even in *Clusia* (Gustafsson et al. 2007; Ruhfel et al. 2011). However, few species of *Chrysochlamys* were sampled in these studies, and phylogenetic relationships in this genus remain uncertain. Moreover, in two species of *Chrysochlamys* with resiniferous androecia (*C. tenuifolia* Cuatrec. and *C. chrisharonii* Vásquez & R. Rojas), male plants produce resin in a “capitulum” in the center of the flowers, where stamens are basally inserted (Hammel 1999; Vásquez Martínez and Rojas González 2009), while this structure is absent in flowers of *Tovomitopsis*. Further phylogenetic studies are needed to investigate if these *Chrysochlamys* species with the uncommon androecial morphology really belong to the genus if would be better placed elsewhere.

Final remarks

We present a brief contribution to the nomenclature of *Tovomitopsis*, a small endemic genus of Clusiaceae from the Brazilian Atlantic Forest. Except for the gross similarity with *Chrysochlamys*, the recognition of the genus is easy if associated with geographic distribution, as *Chrysochlamys* only occurs in Mexico, Central America and northern South America. Even so, further information on the geographic distribution and morphological limits between *T. paniculata* and *T. saldanhae* is needed. These two species are usually distinguished based on leaf size, shape and texture, but these features vary considerably both along an altitudinal gradient and from the coast to more inland sites. The presence and quantity of tiny blackish resinous glands on the abaxial surface of the leaves also should be considered and further investigated to distinguish species. An integrated taxonomic approach involving population genetics, geometric morphometrics of leaf outlines and classical taxonomy could shed light on species delimitations in *Tovomitopsis*.

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References

- Bittrich V (2003) Clusiaceae. In: Wanderley MGL, Shepherd GJ, Melhem TS, Giulietti AM, Kirizawa M (Eds) *Flora Fanerogâmica do Estado de São Paulo*, vol. 3. Fapesp, RiMa, São Paulo, 45–62.
- Cambessèdes J (1828) XV. Guttiferae. In: Saint-Hilaire A, Cambessèdes J, de Jussieu A (Eds) *Flora Brasiliae Meridionalis*, vol. 1(8). A. Belin, Paris, 314–319.
- D’Arcy WG (1980) *Flora of Panama*, family 123 – Guttiferae. *Annals of the Missouri Botanical Garden* 67(4): 969–1043. <https://doi.org/10.2307/2398964>
- Engler A (1888) Guttiferae (Clusiaceae). In: Martius CFP, Eichler AW, Urban I (Eds) *Flora Brasiliensis*, vol. 12. Frid. Fleischer, Leipzig, 441–455.
- Gustafsson MHG, Winter K, Bittrich V (2007) Diversity, phylogeny and classification of *Clusia*. In: Luttge U (Ed.) *Clusia: A woody Neotropical genus of remarkable plasticity and diversity*. Springer, New York, 95–116. https://doi.org/10.1007/978-3-540-37243-1_7
- Hammel BE (1999) Synopsis of *Chrysochlamys* (Clusiaceae: Clusioideae: Clusiaceae) in Mesoamerica. *Novon* 9(3): 360–374. <https://doi.org/10.2307/3391734>
- Hammel BE (2010) Clusiaceae. In: Hammel BE, Grayum MH, Herrera C, Zamora N (Eds) *Manual de Plantas de Costa Rica, Dicotiledóneas (Clusiaceae-Gunneraceae)*, vol. V. Missouri Botanical Garden Press, St. Louis, 1–54.
- Kearns DM (1998) *Chrysochlamys*. In: Steyermark JA, Berry PE, Holst BK (Eds) *Flora of the Venezuelan Guayana*, vol. 4. Missouri Botanical Garden Press, St. Louis, 215–217.
- Maguire B (1977) Notes on the Clusiaceae – Chiefly of Panama I. *Phytologia* 36: 391–407. <https://doi.org/10.5962/bhl.part.21688>
- Marinho LC (2021) *Tovomitopsis*. *Flora do Brasil 2020*. Jardim Botânico do Rio de Janeiro. <http://reflora.jbrj.gov.br/reflora/floradobrasil/FB6889> [accessed 19.03.2021]
- Marinho LC, Cai L, Duan X, Ruhfel BR, Fiaschi P, Amorim AM, van den Berg C, Davis CC (2019) Plastomes resolve generic limits within tribe *Clusiaceae* (Clusiaceae) and reveal the new genus *Arawakia*. *Molecular Phylogenetics and Evolution* 134: 142–151. <https://doi.org/10.1016/j.ympev.2019.02.005>

- Martínez y Pérez JL, Castillo-Campos G, Morejón FN (2015) Flora de Veracruz, Clusiaceae. Fascículo 165. Instituto de Ecología A. C., Xalapa.
- Oliveira-Filho AT (2006) Catálogo das árvores nativas de Minas Gerais: mapeamento e inventário da flora nativa e dos reflorestamentos de Minas Gerais. UFLA, Lavras.
- Planchon JE, Triana J (1860) Mémoire sur la famille des Guttifères. Ann. Sci. Nat., Bot., sér. 4, vol. 14. Victor Masson et Fils, Paris.
- Presl CB (1834) Symbolae botanicae, sive, Descriptiones et icones plantarum novarum aut minus cognitarum, vol. II(7). Sumptibus Friderich Tempsky, Praga.
- Raddi G (1820) Quaranta piante nuove del Brasile. Memoria di Matematica e Fisica della Società Italiana Del Scienze residente in Modena 18: 382–414.
- Reflora Virtual Herbarium (2021) <http://reflora.jbrj.gov.br/reflora/herbarioVirtual/> [accessed 03.08.2021]
- Ruhfel BR, Bittrich V, Bove CP, Gustafsson MHG, Philbrick CT, Rutishauser R, Xi Z, Davis CC (2011) Phylogeny of the clusoid clade (Malpighiales): Evidence from the plastid and mitochondrial genomes. American Journal of Botany 98(2): 306–325. <https://doi.org/10.3732/ajb.1000354>
- Sprengel K (1821) Neue Entdeckungen im ganzen Umfang der Pflanzenkunde II. Friedrich Fleischer, Leipzig.
- Stafleu FA, Cowan RS (1976–1988) Taxonomic literature: a selective guide to botanical publications and collections with dates, commentaries and types, vol. 1–7. Bohn, Scheltema & Holkema, Utrecht. <https://doi.org/10.5962/bhl.title.48631>
- Stevens PF (2007) Clusiaceae-Guttiferae. In: Kubitzki K (Ed.) The families and genera of vascular plants. Flowering plants. Eudicots: Berberidopsidales, Buxales, Crossosomatales, Fabales p.p., Geraniales, Gunnerales, Myrtales p.p., Proteales, Saxifragales, Vitales, Zygophyllales, Clusiaceae alliance, Passifloraceae alliance, Dilleniaceae, Huaceae, Picramniaceae, Sabiaceae. Springer-Verlag, Berlin, 48–66. https://doi.org/10.1007/978-3-540-32219-1_10
- Thiers B (2021) Index herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's virtual herbarium. <http://sweetgum.nybg.org/science/ih/> [accessed 28.11.2020]
- Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, et al. (Eds.) (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code). Regnum Veg. 159. <https://doi.org/10.12705/Code.2018>
- Vásquez Martínez R, Rojas González RP (2009) Una nueva especie de *Chrysochlamys* (Clusiaceae: Clusioideae: Clusieae) del Perú. Arnaldoa 16: 23–28.
- Vesque J (1893) Monographiae Phanerogamarum. In: De Candolle A, De Candolle C (Eds) vol. 8. Sumptibus G. Masson, Paris.

Proposal to recognise the tribes Adinobotryeae and Glycyrrhizeae (Leguminosae subfamily Papilionoideae) based on chloroplast phylogenomic evidence

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Abstract

Within the legume family, the taxonomic status of tribe Glycyrrhizeae and of the genus *Adinobotrys* has been re-assessed. Based on genome skimming data, we conducted phylogenomic analyses of the inverted repeat-lacking clade within subfamily Papilionoideae. The results support the sister relationship between Glycyrrhizeae and *Adinobotrys*. Glycyrrhizeae is resurrected based on *Glycyrrhiza* and *Glycyrrhizopsis*, and a new tribe, Adinobotryeae, is proposed to accommodate *Adinobotrys*.

Keywords

Adinobotrys, Fabaceae, genome skimming, *Glycyrrhiza*, IRLC legumes, the GAW clade, Wisterieae

Introduction

Within subfamily Papilionoideae of Leguminosae, a series of molecular phylogenetic studies have supported a monophyletic group that lost one copy of the 25-kilobase inverted repeat (IR) in the plastid genome, known as the “IR-lacking clade” or IRLC (Lavin et al. 1990; Sanderson and Liston 1995; Sanderson and Wojciechowski 1996; Doyle et al. 2000; Wojciechowski 2003). The IRLC harbours many economically important plants, for example, alfalfa, beans, clovers, lentils, peas, vetches, chickpeas and liquorice (Lewis et al. 2005). Recently, phylogeneticists have revealed an early branching clade, the Glycyrrhizaceae-*Adinobotrys*-Wisterieae clade [i.e. the GAW clade named by Duan et al. (2021)], as sister to the remaining IRLC taxa (LPWG 2013, 2017; Duan et al. 2020, 2021; Xia et al. 2021).

Within the GAW clade, the temperate herbaceous genera *Glycyrrhiza* L., with *Meristotropis* Fisch. & C.A.Mey. being treated within *Glycyrrhiza*, and *Glycyrrhizopsis* Boiss. are sister taxa (Duan et al. 2020, 2021; also see Fig. 1). Tribe Glycyrrhizeae was proposed by Rydberg (1917) to accommodate *Glycyrrhiza*, which was degraded as subtribe Glycyrrhizinae of tribe Galegeae by Rydberg (1923) and was then slightly emended by Polhill (1981) with *Glycyrrhizopsis* species treated as a synonym of *Glycyrrhiza*. Although Glycyrrhizeae was not widely accepted by taxonomists, the taxonomic position of Glycyrrhizinae is also questionable. Galegeae is a polyphyletic and morphologically diverse tribe (Sanderson and Liston 1995; Lock and Schrire 2005; Duan et al. 2015), and our prior phylogenetic studies have shown that Glycyrrhizinae is only distantly related to core Galegeae (Duan et al. 2015, 2021). In consequence, the taxonomic rank of Glycyrrhizeae/Glycyrrhizinae needs to be reconsidered.

Apart from Glycyrrhizeae, the remaining taxa of the GAW clade included some woody genera, formerly placed in tribe Millettieae s.l., which were subsequently assigned into two clades: the liana (rarely climbing shrubs) tribe Wisterieae and the tree genus *Adinobotrys* Dunn (Compton et al. 2019; Duan et al. 2021; also see Fig. 1). Previous phylogenetic results excluded *Adinobotrys* from Wisterieae or Millettieae (Hu et al. 2000; Duan et al. 2021), but further taxonomic study is required to re-assess the placement of this genus.

In the present study, we used the genome skimming method (Straub et al. 2012; Zhang et al. 2015) to obtain 75 chloroplast (cp) coding sequences (CDSs), and constructed a phylogenomic framework of the GAW clade to test the taxonomic position and status of genus *Adinobotrys* and tribe Glycyrrhizeae. Our study provides a taxonomic foundation for future evolutionary, systematic and biogeographical studies of the IRLC legumes.

Material and methods

Taxon sampling

Sampling for molecular phylogenetic analyses included the genus *Adinobotrys* (one species sampled), both of the genera of tribe Glycyrrhizeae (eight species sampled) and 14 of the 15 genera (*Serawaia* J.Compton & Schrire not included) within tribe Wisterieae (26 spp. sampled) (Compton et al. 2019; Compton and Schrire 2020; Duan et al.

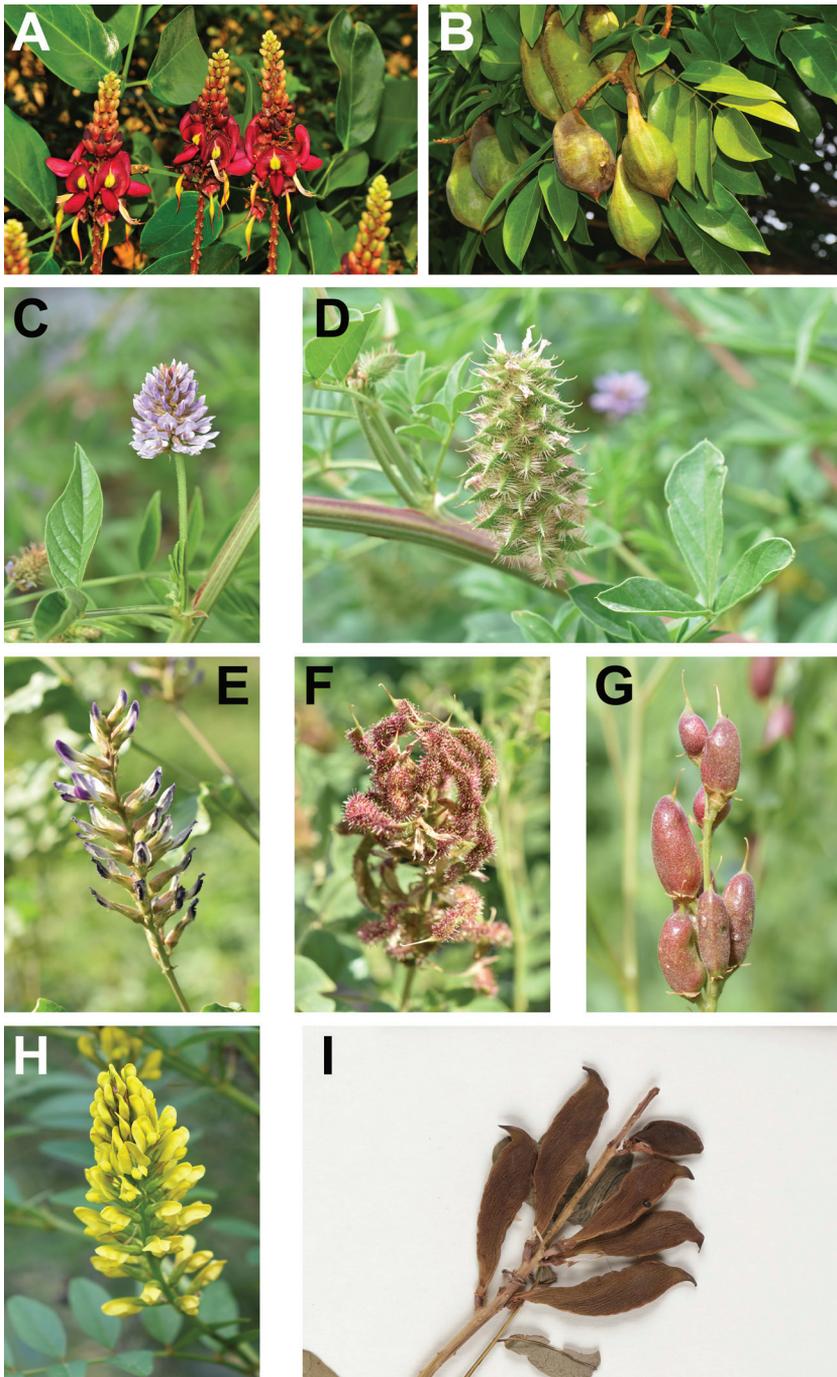


Figure 1. Representative plants of Adinobotryeae and Glycyrrhizeae. Inflorescences (**A**) and fruits (**B**) of *Adinobotrys atropurpureus*; inflorescence (**C**) and infructescence (**D**) of *Glycyrrhiza pallidiflora*; inflorescence (**E**) and infructescence (**F**) of *Glycyrrhiza uralensis*; fruits (**G**) of *Glycyrrhiza inflata*; inflorescence (**H**) and part of dried infructescence [**I**; photographed on herbarium specimen: A. Eustace 31 (E!)] of *Glycyrrhizopsis flavescens*.

2020, 2021). Following Wojciechowski et al. (2004) and Duan et al. (2021), ten other genera of the IRLC (10 spp.) and three genera of Robinioids were selected as outgroups. Most samples for the study were obtained from fresh field collections or from preserved herbarium specimens (see Table S1 in the supplementary file for details), except that DNA samples of *Austrocallerya megasperma* (F.Muell.) J.Compton & Schrire, *Whitfordiodendron nieuwenhuisii* (J.J.Sm.) Dunn, *Wisteria brachybotrys* Siebold & Zucc. and *Wisteria floribunda* (Willd.) DC. were accessed from the DNA and Tissue Bank, Royal Botanic Gardens, Kew (<https://dnabank.science.kew.org>), and the chloroplast genome of *Lotus japonicus* (Regel) K.Larsen was downloaded from GenBank.

DNA Extraction, Genome Assembly, Annotation and Alignment

We extracted the total genomic DNA following a modified CTAB protocol (Doyle and Doyle 1987). Yield and integrity (size distribution) of genomic DNA extracts were quantified by fluorometric quantification on a Qubit (Invitrogen, Carlsbad, California, USA) using a dsDNA HS kit, as well as by visual assessment on 1% agarose gels. Subsequently, we used all samples to build blunt-end DNA libraries using the NEBNext Ultra II DNA library Prep kit for Illumina (New England Bio-labs) following the protocol of the manufacturer. We pooled the final indexed libraries in equimolar ratios and sequenced them in a single lane of an Illumina XTen sequencing system (Illumina Inc.).

From the raw reads, we filtered out adaptors and low-quality reads in Trimmomatic v.0.33 (Bolger et al. 2014). We checked the quality of the remaining reads using FastQC (www.bioinformatics.babraham.ac.uk/projects/fastqc/) and performed *de novo* assembly in SPAdes 3.11 (Bankevich et al. 2012) with the k-mer of 75, 85, 95 and 105. A customised python script was employed (Jin et al. 2018) with its default parameters to apply BLAST and a built-in library to connect verified contigs into plastomes in SPAdes. We annotated the assembly of the resulting complete cp genomes using the Dual Organellar GenoMe Annotator (DOGMA) (Wyman et al. 2004) with *Glycyrrhiza glabra* L. [GenBank Accession #: NC_024038; Sabir et al. (2014)] as a reference (see Suppl. material 1 for details of the annotated cp genomes). Start and stop codons and intron/exon boundaries for protein-coding genes were checked manually. As our samples covered a vast phylogenetic range of clades within the IRLC legumes, the character of the cp genomes, such as genomic structure and gene order, varied dramatically (Sabir et al. 2014; Sveinsson and Cronk 2016). To avoid introducing potential error from the various genomic characters, we extracted 75 protein coding sequences (CDSs; as in Kang et al. 2018, except for *rps12*) from the annotated genomes and concatenated them with Geneious (Kearse et al. 2012) (see Table S2 in the supplementary file for details of the CDSs).

Phylogenetic Analyses

We aligned the cp CDS sequences independently with MAFFT v.7 (Katoh and Standley 2013). The alignment was partitioned (Thode et al. 2020) and the best nucleotide

substitution models for each CDS were inferred using PartitionFinder 2 (Lanfear et al. 2016) under the default settings (for the best models see Suppl. material 2). Accordingly, we carried out separate phylogenetic analyses using Bayesian Inference (BI; Rannala and Yang 1996; Mau et al. 1999) implemented in the programme MrBayes 3.2.5 (Ronquist and Huelsenbeck 2003; Ronquist et al. 2012) by applying default prior settings. Each BI was performed by applying two independent runs of the Markov Chain Monte Carlo (MCMC) for 10 million generations with sampling every 1,000 generations. We discarded the first 2,500 trees as burn-in and summarised the remaining posterior topologies as a maximum clade credibility (MCC) tree. The analysis stationarities were verified with Tracer v.1.6 (<http://tree.bio.ed.ac.uk/software/tracer>) by ensuring that all ESS values exceeded 200 and the convergence was confirmed between independent runs. In addition to BI, we also performed Maximum Likelihood (ML) analyses for cp CDSs, respectively, using IQ-TREE v.1.6 (Nguyen et al. 2015) with the following settings: rapid bootstrap analysis with 1,000 replicates, followed by a search for best-scoring ML tree starting with a random seed.

Results

All the sequenced plastomes were successfully assembled into complete circular configurations. The sizes of the cp genomes ranged from 122,310 to 156,702 bp and the GC contents were between 33.7% and 35.9% (see Suppl. material 1 for details). The alignment length of concatenated cp CDSs for the analyses in MrBayes and IQ-TREE was 72,106 bp. Our ML results were congruent in topology with the corresponding BI trees, and the support values of the former (as “LBS” hereafter) were thus labelled on the corresponding branches of the latter (as “PP” hereafter). Phylogenetic reconstructions (Fig. 2) supported the monophyly of the IRLC (PP = 1, LBS = 100%), and the GAW clade (PP = 1, LBS = 71%) was sister to the rest of the IRLC taxa (PP = 1, LBS = 100%). Within the GAW clade, *Adinobotrys* and the well-supported Glycyrrhizeae (PP = 1, LBS = 100%) formed a clade (PP = 1, LBS = 80%), which was sister to tribe Wisterieae (PP = 1, LBS = 100%).

Discussion

Within the GAW clade, some tropical/subtropical (rarely temperate) woody liana/tree species, formerly belonging to Millettieae s.l., clustered with the temperate herbaceous *Glycyrrhiza-Glycyrrhizopsis* clade (Compton et al. 2019; Duan et al. 2020, 2021; also see Fig. 2). Recently, Compton et al. (2019) and Duan et al. (2021) assigned the above-mentioned liana/tree group into two non-sister clades: genus *Adinobotrys* and tribe Wisterieae (14 genera), corroborated by our cp CDSs trees (Fig. 2). Herein, we propose a monogeneric tribe Adinobotryeae based on *Adinobotrys*, and resurrect the tribe Glycyrrhizeae corresponding to the *Glycyrrhiza-Glycyrrhizopsis* clade (see Taxonomic Treatment) for the following reasons:

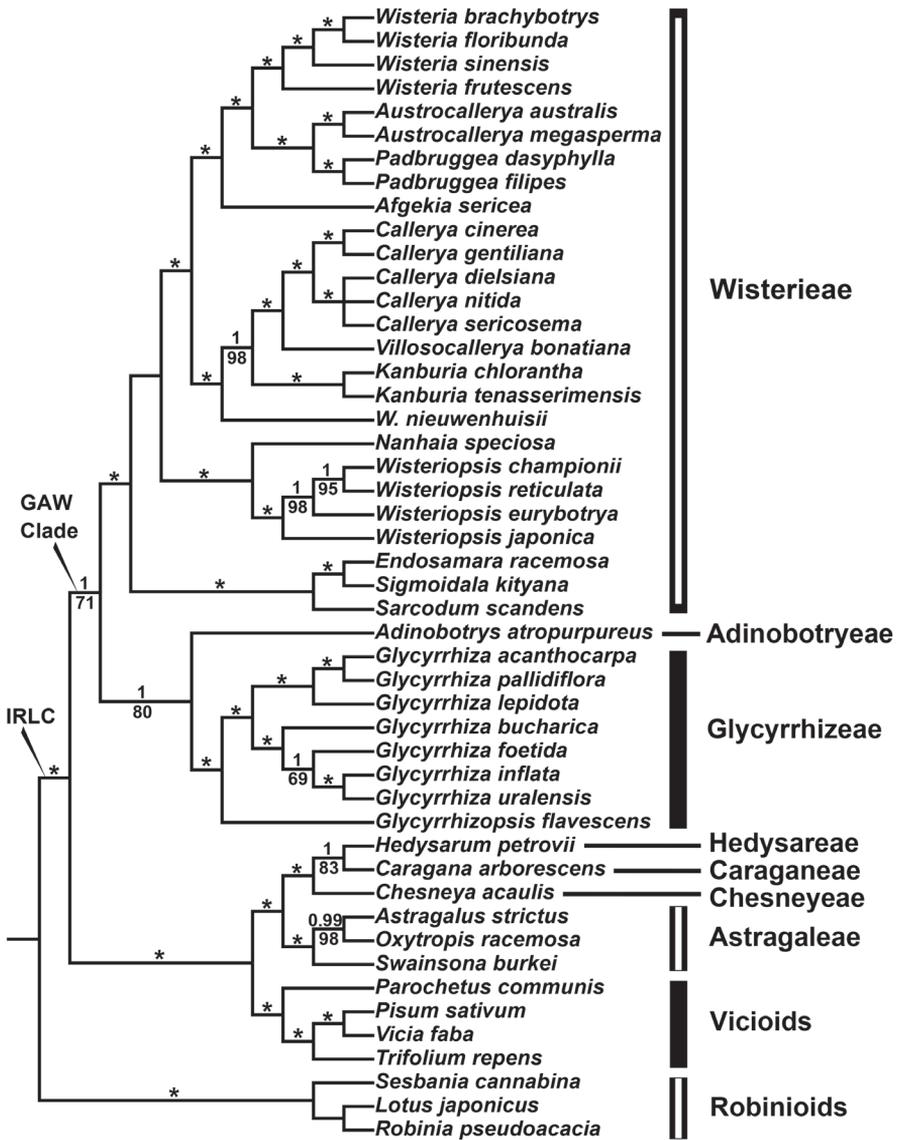


Figure 2. Bayesian maximum clade credibility tree of the GAW clade and related groups based on chloroplast CDSs. Bayesian posterior probabilities are given above branches, Maximum Likelihood bootstrap values below branches. Asterisks indicate PP = 1 and LBS = 100%. *W. nieuwenhuisii* indicates *Whitfordiodendron nieuwenhuisii*.

A. Our phylogenomic analyses (Fig. 2) validated that *Adinobotrys* does not belong to Wisterieae; and the *Glycyrrhiza-Glycyrrhizopsis* clade is phylogenetically distant from both of the core groups of Galegeae [i.e. the *Erophaca-Astragalean* clade; see Lock and Schrire (2005)] and the type genus (i.e. *Galega* L.) (also see Wojciechowski et al. 2004; Duan et al. 2015, 2021; Compton et al. 2019). It is thus reasonable to divide the

GAW clade into three independent groups to ensure monophyly of *Adinobotrys* and the *Glycyrrhiza-Glycyrrhizopsis* clade with respect to tribe Wisterieae.

B. Our recent analyses indicated that a chloroplast capture event may have occurred in the GAW clade, and the common ancestors of the *Adinobotrys* and Wisterieae were hypothesised to be the putative paternal and maternal parents of *Glycyrrhiza-Glycyrrhizopsis* clade, respectively (Duan et al. 2021). Since Wisterieae was already known as a well-defined tribe in the GAW clade, its counterpart groups (*Adinobotrys* and the *Glycyrrhiza-Glycyrrhizopsis* clade) should also be recognised at the tribal rank. Such an evolutionary event-linked taxonomy was also noted in previous studies (e.g. Degtjareva et al. 2012).

C. As far as morphological differentiation is concerned, Glycyrrhizeae, containing the widely distributed *Glycyrrhiza* and the Anatolian endemic *Glycyrrhizopsis* Boiss. (Meng 2005; Duan et al. 2020; see Fig. 1C–I), is easily distinguished from Wisterieae and *Adinobotrys* by its herbaceous habit and temperate distribution. *Adinobotrys*, which has often been treated as part of *Callerya* Endl. within Wisterieae (Polhill 1981; Schot 1994; Schrire 2005), has a unique evergreen tree habit in contrast to the predominantly liana habit of Wisterieae (Fig. 1A, B; also see Compton et al. 2019; Compton and Schrire 2020).

Despite the tribal revision above, taxonomic questions still remain. Since Glycyrrhizeae, and Astragaleae sensu Duan et al. (2021), corresponding to the aforementioned *Erophaca-Astragalean* clade, were removed from tribe Galegeae, the remaining genus *Galega* was found to be nested within the Vicioid clade (Steele and Wojciechowski 2003; Wojciechowski et al. 2004; Duan et al. 2021). Therefore, tribe Galegeae needs further taxonomic consideration before either being merged into a larger tribe corresponding to the Vicioid clade, or re-instated in its earlier, narrower sense, i.e. as the monogeneric tribe circumscribed by Hutchinson (1964). In addition, the recent work of Compton and Schrire (2020) expanded the genus *Adinobotrys* sensu Compton et al. (2019) to contain four species, although its infra-generic relationships need to be studied in more detail.

Taxonomic treatment

Adinobotryeae L.Duan, J.Compton & Schrire, tr. nov.

urn:lsid:ipni.org:names:77219547-1

Fig. 1A, B

Type. *Adinobotrys* Dunn, Bull. Misc. Inform. 1911: 194. 1911.

Diagnosis and note. Compared to the tribe Wisterieae, the monogeneric Adinobotryeae comprises four species of evergreen trees (vs. lianas in tribe Wisterieae). The species are: *A. atropurpureus* (Wall.) Dunn, *A. katinganensis* (Adema) J.Compton & Schrire, *A. sarawakensis* (Adema) J.Compton & Schrire and *A. vastus* (Kosterm.) J.Compton & Schrire. See the detailed description of *Adinobotrys* in Compton et al. (2019: 49) and a diagnostic key to the species and full list of synonymy in Compton and Schrire (2020).

Description. Evergreen trees, up to 20 m in height. Stipules triangular, persistent. Stipels absent. Leaves 5–9 (–11) foliolate; rachis 11–33 cm long; leaflets 5–21 × 2–11 cm, coriaceous, ovate, elliptic to obovate, glabrous, apex acuminate, base obtuse

to cordate. Inflorescence a terminal panicle 10–40 cm long; bracts 2–4 mm long, ovate; peduncle sparsely hairy to tomentose. Flowers 14–20 mm long; bracteoles at base of calyx tube, persistent, ovate; pedicels densely pubescent. Calyx narrowly campanulate, oblique, green, puberulent, five lobes acute to obtuse. Standard 11–20 × 13–20 mm, broadly ovate, apex acute, outer surface glabrous, inner surface pink to reddish-purple, rarely white, nectar guide yellow, with callosities; wings 12–19 × 5–8 mm, glabrous; keel ± equal to wings in length, glabrous, apex acute to rounded. Stamens diadelphous, vexillary filament free from other nine, all curved upwards at apex. Ovary hairy; style glabrous. Pods 7–25 × 3–6 cm, dehiscent, inflated or compressed, irregularly ovate to oblong or narrowly elliptic, surface glabrous, rugose, subseptate. Seeds 1–4 per pod, ovoid to oblong or flattened-orbicular, 15–38 mm long.

Distribution and habitat. Evergreen forests in Brunei, Cambodia, India, Indonesia (Java, Kalimantan and Sumatra), Laos, Malaysia (Peninsula and Sabah), Myanmar, Thailand and Vietnam, below 1200 m in altitude.

Glycyrrhizae Rydb., Fl. Rocky Mts. 454. 1917.

Fig. 1C–I

≡ Glycyrrhizinae Rydb., N. Amer. Fl. 24(3): 156. 1923.

Type. *Glycyrrhiza* L., Sp. Pl. 2: 741. 1753.

Distribution and habitat. Mediterranean, warm temperate and continental temperate grasslands, shrublands, deserts and forest edges in the Old World [from the western Mediterranean region (Iberian peninsula in Europe and Algeria in North Africa), through the Russian Far East, Mongolia and northern China (plus Sichuan and Yunnan of southwestern China) to Australia (*Glycyrrhiza acanthocarpa* J.M.Black), including the States of Queensland, New South Wales, Victoria, South Australia and Western Australia] and the New World [in western temperate Canada and the United States (*G. lepidota* Pursh) and in the temperate region of Argentina and Chile (around 40°S; *G. astragalina* Gillies)].

Note. The tribe includes two genera, *Glycyrrhiza* and *Glycyrrhizopsis*, with the latter confined in S. Anatolia. The root of *Glycyrrhiza* is widely used as medicine and in the food industry (see Duan et al. 2020).

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References

- Bankevich A, Nurk S, Antipov D, Gurevich AA, Dvorkin M, Kulikov AS, Lesin VM, Nikolenko SI, Pham S, Prjibelski AD, Pyshkin AV, Sirotkin AV, Vyahhi N, Tesler G, Alekseyev MA, Pevzner PA (2012) SPAdes: A new genome assembly algorithm and its applications to single-cell sequencing. *Journal of Computational Biology* 19(5): 455–477. <https://doi.org/10.1089/cmb.2012.0021>
- Bolger AM, Lohse M, Usadel B (2014) Trimmomatic: A flexible trimmer for Illumina sequence data. *Bioinformatics (Oxford, England)* 30(15): 2114–2120. <https://doi.org/10.1093/bioinformatics/btu170>
- Compton JA, Schrire BD (2020) A reappraisal of *Adinobotrys* Dunn (Fabaceae) with two new combinations. *PhytoKeys* 165: 63–67. <https://doi.org/10.3897/phytokeys.165.58477>
- Compton JA, Schrire BD, Könyves K, Forest F, Malakasi P, Mattapha S, Sirichamorn Y (2019) The *Callerya* group redefined and tribe Wisterieae (Fabaceae) emended based on morphology and data from nuclear and chloroplast DNA sequences. *PhytoKeys* 125: 1–112. <https://doi.org/10.3897/phytokeys.125.34877>
- Degtjareva GV, Valiejo-Roman CM, Samigullin TH, Guara-Requena M, Sokoloff DD (2012) Phylogenetics of *Anthyllis* (Leguminosae: Papilionoideae: Loteae): Partial incongruence between nuclear and plastid markers, a long branch problem and implications for morphological evolution. *Molecular Phylogenetics and Evolution* 62(2): 693–707. <https://doi.org/10.1016/j.ympev.2011.11.010>
- Doyle JJ, Doyle JL (1987) A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin* 19: 11–15.
- Doyle JJ, Chappill JA, Bailey DC, Kajita T (2000) Towards a comprehensive phylogeny of legumes: evidence from *rbcL* sequences and non-molecular data. In: Herendeen PS, Bruneau A (Eds) *Advances in Legume Systematics*, part 9. Royal Botanic Gardens, Kew, 1–20.
- Duan L, Wen J, Yang X, Liu PL, Arslan E, Ertuğrul K, Chang ZY (2015) Phylogeny of *Hedysarum* and tribe Hedysareae (Leguminosae: Papilionoideae) inferred from sequence data of ITS, *matK*, *trnL-F* and *psbA-trnH*. *Taxon* 64(1): 49–64. <https://doi.org/10.12705/641.26>
- Duan L, Harris AJ, Su C, Zhang Z-R, Arslan E, Ertuğrul K, Lóc P-K, Hayashi H, Wen J, Chen HF (2020) Chloroplast phylogenomics reveals the intercontinental biogeographic history of the liquorice genus (Leguminosae: *Glycyrrhiza*). *Frontiers of Plant Science* 11: e793. <https://doi.org/10.3389/fpls.2020.00793>
- Duan L, Li SJ, Su C, Sirichamorn Y, Han LN, Ye W, Lóc PK, Wen J, Compton JA, Schrire B, Nie ZL, Chen H-F (2021) Phylogenomic framework of the IRLC legumes (Leguminosae subfamily Papilionoideae) and intercontinental biogeography of tribe Wisterieae. *Molecular Phylogenetics and Evolution* 163: 107235. <https://doi.org/10.1016/j.ympev.2021.107235>
- Hu J-M, Lavin M, Wojciechowski MF, Sanderson MJ (2000) Phylogenetic systematics of the tribe Millettieae (Leguminosae) based on chloroplast *trnK/matK* sequences and its implications for evolutionary patterns in Papilionoideae. *American Journal of Botany* 87(3): 418–430. <https://doi.org/10.2307/2656638>

- Hutchinson J (1964) The genera of flowering plants, vol. 1. Clarendon Press, Oxford.
- Jin J-J, Yu W-B, Yang J-B, Song Y, Yi T-S, Li D-Z (2018) GetOrganelle: A simple and fast pipeline for *de novo* assembly of a complete circular chloroplast genome using genome skimming data. bioRxiv 256479. <https://doi.org/10.1101/256479>
- Kang S-H, Lee J-H, Lee H-O, Ahn B-O, Won S-Y, Sohn S-H, Kim J-S (2018) Complete chloroplast genome and 45S nrDNA sequences of the medicinal plant species *Glycyrrhiza glabra* and *Glycyrrhiza uralensis*. *Genes & Genetic Systems* 93(3): 83–89. <https://doi.org/10.1266/ggs.17-00002>
- Katoh K, Standley DM (2013) MAFFT multiple sequence alignment soft-ware version 7: Improvements in performance and usability. *Molecular Biology and Evolution* 30(4): 772–780. <https://doi.org/10.1093/molbev/mst010>
- Kearse M, Moir R, Wilson A, Stones-Havas S, Cheung M, Sturrock S, Buxton S, Cooper A, Markowitz S, Duran C, Thierer T, Ashton B, Meintjes P, Drummond A (2012) Geneious Basic: An integrated and extendable desktop software platform for the organization and analysis of sequence data. *Bioinformatics (Oxford, England)* 28(12): 1647–1649. <https://doi.org/10.1093/bioinformatics/bts199>
- Lanfear R, Frandsen PB, Wright AM, Senfeld T, Calcott B (2016) PartitionFinder 2: New methods for selecting partitioned models of evolution for molecular and morphological phylogenetic analyses. *Molecular Biology and Evolution* 34: 772–773. <https://doi.org/10.1093/molbev/msw260>
- Lavin M, Doyle JJ, Palmer JD (1990) Evolutionary significance of the loss of the chloroplast-DNA inverted repeat in the Leguminosae subfamily Papilionoideae. *Evolution; International Journal of Organic Evolution* 44: 390–402. <https://doi.org/10.1111/j.1558-5646.1990.tb05207.x>
- Lewis G, Schrire B, Mackinder B, Lock M (2005) Legumes of the World. Royal Botanic Gardens, Kew.
- Lock JM, Schrire BD (2005) Galegeae. In: Lewis G, Schrire B, Mackinder B, Lock M (Eds) Legumes of the World. Royal Botanic Gardens, Kew, 475–487.
- LPWG [The Legume Phylogeny Working Group] (2013) Legume phylogeny and classification in the 21st century: Progress, prospects and lessons for other species-rich clades. *Taxon* 62(2): 217–248. <https://doi.org/10.12705/622.8>
- LPWG [The Legume Phylogeny Working Group] (2017) A new subfamily classification of the Leguminosae based on a taxonomically comprehensive phylogeny. *Taxon* 66(1): 44–77. <https://doi.org/10.12705/661.3>
- Mau B, Newton MA, Larget B (1999) Bayesian phylogenetic inference via Markov chain Monte Carlo methods. *Biometrics* 55(1): 1–12. <https://doi.org/10.1111/j.0006-341X.1999.00001.x>
- Meng L (2005) Systematics of *Glycyrrhiza* L. (Fabaceae) - with a special reference to its relationship to *Glycyrrhizopsis* Boiss. & Bal. Ph.D. Thesis, Institute of Botany, Chinese Academy of Sciences, China.
- Nguyen LT, Schmidt HA, von Haeseler A, Minh BQ (2015) IQ-TREE: A fast and effective stochastic algorithm for estimating maximum-likelihood phylogenies. *Molecular Biology and Evolution* 32(1): 268–274. <https://doi.org/10.1093/molbev/msu300>

- Polhill RM (1981) Carmichaelieae, Cicereae, Galegeae, Hedysareae, Trifolieae and Viciae. In: Polhill RM, Raven PH (Eds) *Advances in Legume Systematics, part 1*. Royal Botanic Garden, Kew, 245–260, 357–363.
- Rannala B, Yang Z (1996) Probability distribution of molecular evolutionary trees: A new method of phylogenetic inference. *Journal of Molecular Evolution* 43(3): 304–311. <https://doi.org/10.1007/BF02338839>
- Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics (Oxford, England)* 19(12): 1572–1574. <https://doi.org/10.1093/bioinformatics/btg180>
- Ronquist F, Teslenko M, van der Mark P, Ayres DL, Darling A, Höhna S, Larget B, Liu L, Suchard MA, Huelsenbeck JP (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology* 61(3): 539–542. <https://doi.org/10.1093/sysbio/sys029>
- Rydberg PA (1917) Glycyrrhizeae. *Flora of the Rocky Mountains and adjacent plains: Colorado, Utah, Wyoming, Idaho, Montana, Saskatchewan, Alberta, and neighboring parts of Nebraska, South Dakota, North Dakota, and British Columbia*. New York Botanical Garden, New York, 454.
- Rydberg PA (1923) Glycyrrhizinae. *North American Flora*, 24(3). New York Botanical Garden, New York, 156 pp.
- Sabir J, Schwarz E, Ellison N, Zhang J, Baeshen NA, Mutwakil M, Jansen R, Ruhlman T (2014) Evolutionary and biotechnology implications of plastid genome variation in the inverted-repeat-lacking clade of legumes. *Plant Biotechnology Journal* 12(6): 743–754. <https://doi.org/10.1111/pbi.12179>
- Sanderson MJ, Liston A (1995) Molecular phylogenetic systematics of Galegeae, with special reference to *Astragalus*. In: Crisp MD, Doyle JJ (Eds) *Advances in Legume Systematics, part 7, Phylogeny*. Royal Botanic Gardens, Kew, 331–350.
- Sanderson MJ, Wojciechowski MF (1996) Diversification rates in a temperate legume clade: Are there “so many species” of *Astragalus* (Fabaceae)? *American Journal of Botany* 83(11): 1488–1502. <https://doi.org/10.1002/j.1537-2197.1996.tb13942.x>
- Schot AM (1994) A Revision of *Callerya* Endl. (including *Padbruggea* and *Whitfordiodendron*) (Papilionaceae: Millettieae). *Blumea* 39: 1–40.
- Schrire BD (2005) Millettieae. In: Lewis G, Schrire B, Mackinder B, Lock M (Eds) *Legumes of the World*. Royal Botanic Gardens, Kew, 367–387.
- Steele KP, Wojciechowski MF (2003) Phylogenetic analyses of tribes Trifolieae and Viciae, based on sequences of the plastid gene *matK* (Papilionoideae: Leguminosae). In: Klitgaard B, Bruneau A (Eds) *Advances in Legume Systematics, part 10, Higher Level Systematics*. Royal Botanic Gardens, Kew, 355–370.
- Straub SC, Parks M, Weitemier K, Fishbein M, Cronn RC, Liston A (2012) Navigating the tip of the genomic iceberg: Next-generation sequencing for plant systematics. *American Journal of Botany* 99(2): 349–364. <https://doi.org/10.3732/ajb.1100335>
- Sveinsson S, Cronk Q (2016) Conserved gene clusters in the scrambled plastomes of IRLC legumes (Fabaceae: Trifolieae and Fabeae). *bioRxiv* 040188. <https://doi.org/10.1101/040188>

- Thode VA, Lohmann LG, Sanmartín I (2020) Evaluating character partitioning and molecular models in plastid phylogenomics at low taxonomic levels: A case study using *Amphilophium* (Bignoniaceae, Bignoniaceae). *Journal of Systematics and Evolution* 58(6): 1071–1089. <https://doi.org/10.1111/jse.12579>
- Wojciechowski MF (2003) Reconstructing the phylogeny of legumes (Leguminosae): An early 21st century perspective. In: Klitgaard BB, Bruneau A (Eds) *Advances in Legume Systematics*, part 10, Higher Level Systematics. Royal Botanic Gardens, Kew, 5–35.
- Wojciechowski MF, Lavin M, Sanderson MJ (2004) A phylogeny of legumes (Leguminosae) based on analyses of the plastid *matK* gene resolves many well-supported subclades within the family. *American Journal of Botany* 91(11): 1846–1862. <https://doi.org/10.3732/ajb.91.11.1846>
- Wyman SK, Jansen RK, Boore JL (2004) Automatic annotation of organellar genomes with DOGMA. *Bioinformatics (Oxford, England)* 20(17): 3252–3255. <https://doi.org/10.1093/bioinformatics/bth352>
- Xia MQ, Liao RY, Zhou JT, Lin HY, Li JH, Li P, Fu CX, Qiu YX (2021) Phylogenomics and biogeography of *Wisteria*: Implications on plastome evolution among inverted repeat-lacking clade (IRLC) legumes. *Journal of Systematics and Evolution*. [early view] <https://doi.org/10.1111/jse.12733>
- Zhang N, Wen J, Zimmer EA (2015) Congruent deep relationships in the grape family (Vitaceae) based on sequences of chloroplast genomes and mitochondrial genes via genome skimming. *PLoS ONE* 10(12): e0144701. <https://doi.org/10.1371/journal.pone.0144701>

Supplementary material I

Voucher information, characters of chloroplast (cp) genomes and GenBank BioSample accession of genome skimming raw reads in this study

Authors: Lei Duan, Li-Na Han, Yotsawate Sirichamorn, Jun Wen, James A. Compton, Shuang-Wen Deng, Emine Arslan, Kuddisi Ertuğrul, Brian Schrire, Hong-Feng Chen
Data type: XLSX. file

Explanation note: Voucher information, characters of chloroplast (cp) genomes and GenBank BioSample accession of genome skimming raw reads in this study.

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Link: <https://doi.org/10.3897/phytokeys.181.71259.suppl1>

Supplementary material 2

Chloroplast protein coding sequences (cp CDSs) and their corresponding substitution models generated from PartitionFinder 2

Authors: Lei Duan, Li-Na Han, Yotsawate Sirichamorn, Jun Wen, James A. Compton, Shuang-Wen Deng, Emine Arslan, Kuddisi Ertuğrul, Brian Schrire, Hong-Feng Chen
Data type: XLSX. file

Explanation note: Chloroplast protein coding sequences (cp CDSs) and their corresponding substitution models generated from PartitionFinder 2.

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Validation of *Hosta alata* (Asparagaceae) as a new species and its phylogenetic affinity

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Abstract

Molecular phylogenetic studies of *Hosta pulchella* (Asparagaceae) and its relatives, which are native to Japan, have been conducted and resulted in a highly resolved phylogeny. Specifically, the relationship of *H. pulchella* to *H. alata* Hatusima, **nom. nud.** is investigated. These data include genome-wide SNPs obtained through conducting multiplexed ISSR genotyping by sequencing (MIG-seq). Based on these phylogenetic results, morphological observations, distribution, and differences in flowering periods of *H. alata* collections sympatric with *H. pulchella*, we find the two species closely related, but distinct. As such, we formally describe *Hosta alata* **sp. nov.** from the Oita Prefecture of Kyushu island, southwestern Japan.

Keywords

Flowering season, MIG-seq, next generation sequencing, reproductive isolation, threatened species

Introduction

The genus *Hosta* Tratt. (Asparagaceae) is a group of 22 to 25 species endemic to East Asia and Russia (Jones 1989). The genus presents with remarkable diversity and fifteen species are endemic/native in Japan (Fujita 1976; Tamura and Fujita

2013, Tamura 2015), four in China (Chen and Boufford 2000), six in Korea (Lee et al. 2019), and one in Russia (Chen and Boufford 2000). *Hosta* are widely cultivated by gardeners in temperate areas for their attractive flowers and foliage, and continue to garner considerable interest from botanists (Jones 1989; Schmid 1991; Lee et al. 2019). Although several studies have been conducted thus far, the classification of *Hosta* remains difficult (Lee et al. 2019). Whereas Schmid (1991) enumerated 43 species in his revision of the genus, Lee et al. (2019) cited a more conservative estimate than that reported by Jones (1989) as 22 to 25 species. Recently, Lee et al. (2019) determined the sequences of the whole cpDNA genome for six Korean species and elucidated their phylogenetic relationships. Molecular phylogenetic studies are necessary for the *Hosta* species that occur in Japan, where the highest diversity has been reported (Fujita 1976; Tamura and Fujita 2013; Tamura 2015).

Here, we examined the molecular phylogeny and taxonomy of *Hosta* on Kyushu island, Japan, by focusing on a species group that contains an undescribed species, *Hosta alata* Hatusima, nom. nud. According to Arakane (2001), flowering plants of this undescribed species were discovered on Mt. Sobo on August 23, 2000, where *H. pulchella* N. Fujita is endemic. Independently, Dr. S. Hatusima examined a specimen of this species collected from Mt. Karasu-dake, 10 km NE of Mt. Sobo, and concluding that it was an undescribed species, informed Mr. Arakane of this discovery. Upon examination of the specimen, Mr. Arakane considered the *Hosta* specimen collected from Mt. Sobo to be identical to the undescribed species reported by Dr. Hatusima. Mr. Arakane then sent the Mt. Sobo specimen to Dr. Hatusima. In a letter sent to Mr. Arakane, Dr. Hatusima provided the name, *H. alata* Hatusima, nom. nud., but never formally published the species. Arakane (2001) documented the morphological characteristics of this undescribed species in Japanese, with photographs and sketched illustrations. Arakane (2001) also documented that *H. alata* blooms in late August, but *H. pulchella* blooms in July. *Hosta alata* is listed in the Red Data Book of the Oita Prefecture (Anonymous 2011); however, the name has never been validly published.

To elucidate the identity of *Hosta alata*, we visited the above-mentioned two localities, Mt. Sobo and Mt. Karasu-dake, and collected voucher specimens and silica-gel dried samples of all located *Hosta* spp. for DNA isolation. Additionally, we collected as many related species as possible during field surveys on Kyushu. From these samples, we reconstructed a phylogeny to determine their relationships. We performed multiplexed ISSR genotyping by sequencing (MIG-seq; Suyama and Matsuki 2015), which is a method for efficient reconstruction of phylogenetic relationships among closely related species (Binh et al. 2018; Strijk et al. 2020; Zhang et al. 2020). Here, we examine whether *H. alata* is a genetically distinct species from other species including *H. pulchella*. The results of our analyses support the novelty of *H. alata* and we validate the name proposed by Dr. Hatusima. Last, we discuss the implications of our findings and suggest the need to conduct further studies to elucidate the classification of *Hosta*.

Materials and methods

Field surveys

We visited two known localities of *Hosta alata* reported by Arakane (2001): Mt. Karasu-dake on September 24, 2020, and Mt. Sobo on September 26, 2020. Mt. Karasu-dake (683 m above sea level) is located at the end of the ridge extending north-east from Mt. Sobo (1756 m above sea level), and there is no rocky area between Mt. Sobo and Mt. Karasu-dake that is suitable for *Hosta alata* habitats. Below, the population of Mt. Karasu-dake will be referred to as *H. alata* 1, and the population of Mt. Sobo will be referred to as *H. alata* 2. We also collected *H. kikutii* F. Maek. var. *kikutii*, *H. longipes* (Franch. & Sav.) Matsum. var. *caduca* N. Fujita, *H. pulchella*, and two undescribed species (labeled *H. sp. 1* and *H. sp. 2*) from eight localities on the main island of Kyushu, and an additional sample of *H. longipes* var. *caduca* from the Kochi Prefecture, Shikoku Island (Table 1). A total of 29 samples collected from August to September 2020 were included in the following analysis. In addition, we collected

Table 1. A list of samples used for phylogenetic analyses. The georeference data of the *H. alata* localities are not described to avoid facilitating collection.

Scientific name	Voucher ID	Locality	Latitude and Longitude
<i>H. alata</i>	JPN2280	Mt. Karasu-dake, Oita	Available on request
<i>H. alata</i>	JPN2281	Mt. Karasu-dake, Oita	Available on request
<i>H. alata</i>	JPN2282	Mt. Karasu-dake, Oita	Available on request
<i>H. alata</i>	JPN2283	Mt. Karasu-dake, Oita	Available on request
<i>H. alata</i>	JPN2350	Mt. Sobo, Oita	Available on request
<i>H. alata</i>	JPN2351	Mt. Sobo, Oita	Available on request
<i>H. alata</i>	JPN2372	Mt. Sobo, Oita	Available on request
<i>H. kikutii</i> var. <i>kikutii</i>	JPN1852	Kaeda Valley, Miyazaki	31.81001388, 131.3968194
<i>H. kikutii</i> var. <i>kikutii</i>	JPN1968	Mt. Osuzu, Miyazaki	32.28691111, 131.4649500
<i>H. longipes</i> var. <i>caduca</i>	JPN1248	Niyodogawa-cho, Kochi	33.47491388, 133.1060944
<i>H. longipes</i> var. <i>caduca</i>	JPN2374	Onagara, Oita	32.94940300, 131.7618470
<i>H. pulchella</i>	JPN2298	Mt. Shojidake, Miyazaki	32.81073888, 131.3482194
<i>H. pulchella</i>	JPN2306	Mt. Shojidake, Miyazaki	32.81073888, 131.3482194
<i>H. pulchella</i>	JPN2311	Mt. Shojidake, Miyazaki	32.81032222, 131.3494556
<i>H. pulchella</i>	JPN2312	Mt. Shojidake, Miyazaki	32.81032222, 131.3494556
<i>H. pulchella</i>	JPN2355	Mt. Sobo, Oita	32.83274444, 131.3520500
<i>H. pulchella</i>	JPN2356	Mt. Sobo, Miyazaki	32.82803500, 131.3467830
<i>H. pulchella</i>	JPN2360	Mt. Sobo, Miyazaki	32.82803500, 131.3467830
<i>H. pulchella</i>	JPN2364	Mt. Sobo, Miyazaki	32.82803500, 131.3467830
<i>H. pulchella</i>	JPN2365	Mt. Sobo, Miyazaki	32.82803500, 131.3467830
<i>H. pulchella</i>	JPN2368	Mt. Sobo, Oita	32.83269200, 131.3515610
<i>H. pulchella</i>	JPN2369	Mt. Sobo, Oita	32.83269200, 131.3515610
<i>H. pulchella</i>	JPN2370	Mt. Sobo, Oita	32.83269200, 131.3515610
<i>H. sp. 1</i>	JPN2012	Mt. Oninome, Miyazaki	32.70122500, 131.5138861
<i>H. sp. 1</i>	JPN2013	Mt. Oninome, Miyazaki	32.70122500, 131.5138861
<i>H. sp. 1</i>	JPN2208	Mt. Mukabaki, Miyazaki	32.62879900, 131.5790560
<i>H. sp. 1</i>	JPN2209	Mt. Mukabaki, Miyazaki	32.62879900, 131.5790560
<i>H. sp. 1</i>	JPN2210	Mt. Mukabaki, Miyazaki	32.62879900, 131.5790560
<i>H. sp. 2</i>	JPN2292	Mt. Sobo, Oita	32.82829166, 131.3904722

samples of *Hosta* widely from Shikoku and Honshu, examined phylogenetic relationships, and confirmed that other Japanese species are remotely related to *Hosta alata* (data not shown).

DNA isolation, sequencing, and construction of SNP-based phylogenetic trees

Total DNA was extracted from dried leaves using the CTAB method (Doyle and Doyle 1990). *De novo* SNP discovery was performed using MIG-seq. Based on methods reported by Suyama and Matsuki (2015), we prepared an MIG-seq library using a two-step PCR amplification process with minor modifications; the annealing temperature of the first PCR was altered from 48 °C to 38 °C. The second-round PCR products were purified in the size range of 300–800 bp and sequenced using the Illumina MiSeq platform (Illumina, San Diego, CA, USA) and the MiSeq Reagent Kit v3 (150 cycles, Illumina). The sequencing of the first 17 bases of reads 1 and 2 (SSR primer regions and anchors) was skipped using ‘DarkCycle’. Low-quality reads and extremely short reads containing adapter sequences were removed using Trimmomatic 0.39 (Bolger et al. 2014). The Stacks 2.41 pipeline software (Catchen et al. 2013; Rochette et al. 2019) was used to obtain individual genotypes with the following parameters: minimum depth of coverage required to create a stack (m) = 3, maximum distance between stacks (M) = 2, maximum mismatches between loci when building the catalog (n) = 2. Three different filtering criteria were considered for quality control of the SNP data. First, any SNP site where one of two alleles had less than three counts was filtered out because it was difficult to distinguish polymorphisms from sequencing errors when the minor allele count of SNPs is too low (Roesti et al. 2012). Second, loci containing SNPs with high heterozygosity ($H_o \geq 0.6$) were removed because excess heterozygosity might have resulted from artifactual loci built from several paralogous genomic regions. Third, a SNP was excluded if the number of samples shared by the SNP was below the reference value R; the minimum percentage of samples that retained a SNP. As the resolution of phylogenetic trees depends on R (Wagner et al. 2013), we used four SNP datasets in which the reference value R was changed in the following four steps: R = 0.1, 0.3, 0.5, and 0.8. As is described in Results, the basal topology of phylogenetic trees did vary with R values. The variability of topology with R values is probably derived from the limited sample sizes of *H. alata* 1, *H. alata* 2, and *H. sp.*1, ranging from 3 to 5. Under these low sample sizes, phylogenetic reconstructions using datasets with high R values tend to neglect the presence of SNPs unique to each lineage. Furthermore, phylogenetic reconstruction using datasets with low R values can contain noise with artifacts. The variability of the topology is expected to be reduced by using more samples for each lineage, but we could collect limited number of samples for *H. alata* 1, *H. alata* 2, and *H. sp.*1 because these plants were found on high vertical cliffs.

Phylogenetic trees based on SNPs was inferred using the maximum likelihood method implemented in RAxML 8.2.10 (Stamatakis 2014). We used a GTRCAT model and performed 1,000 replicates of parallelized tree search bootstrapping. Considering a possibility of reticulate relationship due to past hybridization, we also

reconstructed a split network using SplitsTree4 4.14 (Huson and Bryant 2006) by implementing neighbor-net algorithm with the uncorrelated P distance matrix calculated from the SNPs matrix. We also performed an analysis of population genetic structure using STRUCTURE 2.3.4 (Pritchard et al. 2000). This software assumes a population genetic model in which there are K populations, each of which has a unique set of allele frequencies at each locus, and the individuals in the sample are probabilistically assigned to populations. If a multi-locus genotype of an individual indicates a sign of mixture, it is assigned to more than one population. To estimate the log-likelihood for each model with a different number of populations ($K = 1-10$), we performed 20 independent runs with a burn-in of 100,000 steps and additional 100,000 steps with the admixture model. Optimal K values were determined by using the Delta K method of Evanno et al. (2005) in STRUCTURE HARVESTER (Earl and Vonholdt 2012).

Data resources

All raw MIG-seq data were deposited at the DDBJ Sequence Read Archive (DRA) with accession number DRA011465.

Results

A phylogenetic tree reconstructed using MIG-seq

A total of 17,666,364 raw reads ($609,185 \pm 16,586$ reads per sample) were obtained by performing MIG-seq. After quality control, 16,924,537 reads ($583,605 \pm 16,419$ reads per sample) were used for further analyses. After *de novo* SNP detection and filtering, the following four datasets with different R values were used: $R = 0.1$, 16,510 loci, 31,769 SNPs; $R = 0.3$, 8,163 loci, 18,296 SNPs; $R = 0.5$, 3,345 loci, 8,037 SNPs; and $R = 0.8$, 460 loci, 1,069 SNPs.

A phylogenetic tree reconstructed using MIG-seq by setting $R = 0.5$ (Fig. 1; SNPs shared among 15 samples of the 29 total were used) recovered *Hosta alata* as sister to *H. pulchella* (98% bs). The two known populations of *H. alata*, Karasu-dake (*H. alata* 1: JPN2281–2283) and Sobo (*H. alata* 2: JPN2350, JPN2351, JPN2372) were each recovered monophyletic (100 bs), and these form a well-supported clade (100 bs). Three samples from Mt. Mukabaki (JPN2208–2210) and two samples from Mt. Oninome (JPN2012, 2013) formed a clade supported by a 100% bootstrap value, designated as *H. sp. 1* (Fig. 1). The clade that included *H. alata*, *H. pulchella*, and *H. sp. 1* (100 bs) was sister to the remaining sampled species including *H. kikutii*, *H. longipes* var. *caduca*, and a sample from Mt. Sobo designated as *H. sp. 2* (100 bs).

The topology of the phylogenetic reconstructions using MIG-seq data varied with the setting of R, the minimum percentage of samples that shared a SNP (Fig. 2). When $R = 0.1$ (SNPs shared by three or more samples are used; Fig. 2A), or $R = 0.3$ (SNPs shared by nine or more samples are used; Fig. 2A), *Hosta alata* 1, *H. alata* 2, and

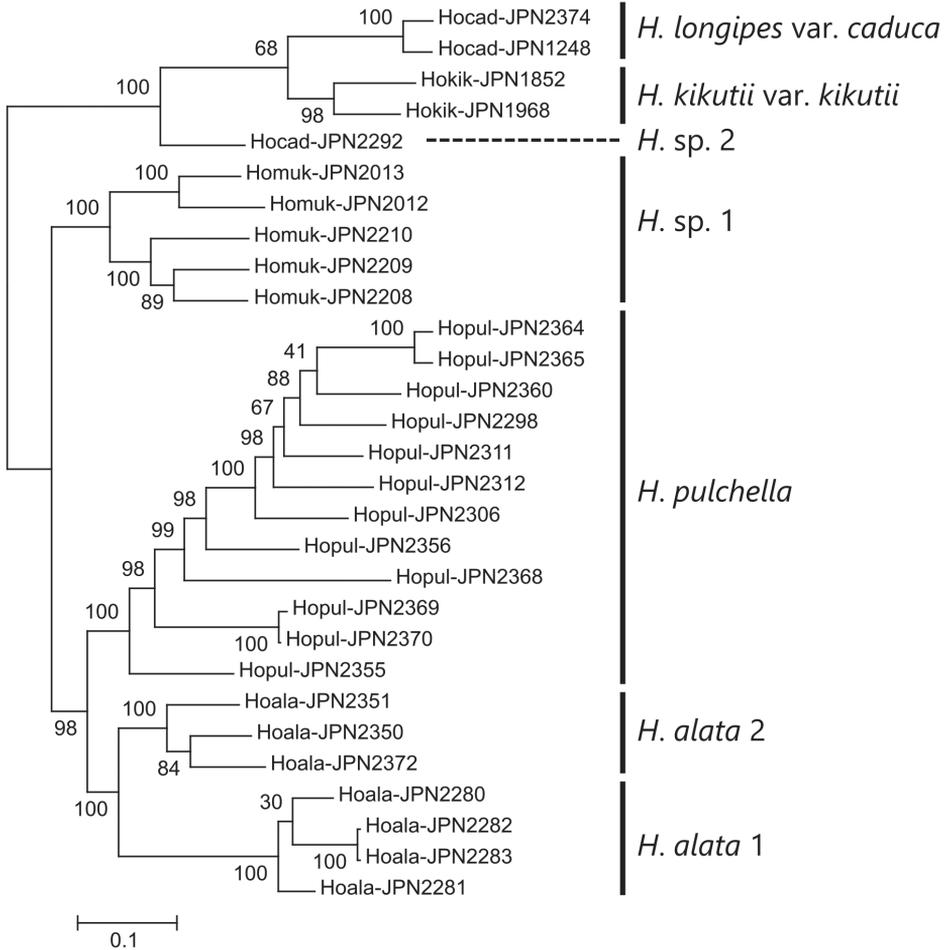


Figure 1. A molecular phylogeny of *Hosta alata* and its relatives reconstructed on the basis of MIG-seq data. Bootstrap values are shown on the internodes. The scale bar represents the average number of substitutions per SNP site.

H. pulchella were trichotomous, and the monophyly of the clade including these three was supported by a 100% bootstrap value; *H. sp. 1* was sister to this clade. When $R = 0.5$ (SNPs shared by 15 or more samples were used; Fig. 2B), the two *H. alata* populations were sister to *H. pulchella*. When $R = 0.8$ (SNPs shared by 24 or more samples are used; Fig. 2C), *H. alata 1* and *H. alata 2* were not monophyletic; *H. alata 1* was sister to *H. sp. 1* and *H. alata 2* was sister to *H. pulchella* (Fig. 2C).

A split network reconstructed using MIG-seq

A split network reconstructed using $R = 0.5$ (Fig. 3) showed that *Hosta pulchella*, *H. alata 1*, *H. alata 2*, and *H. sp. 1* formed four distinct clusters. *Hosta alata 2* was placed

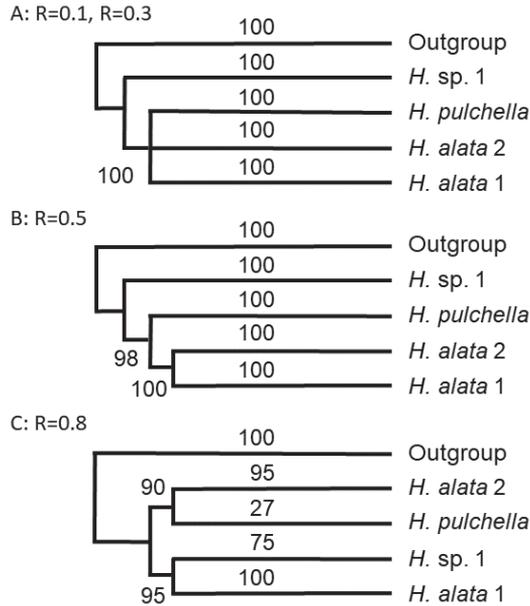


Figure 2. Three different topologies of *Hosta* phylogenetic trees reconstructed on the basis of MIG-seq conducted using different settings for the proportion of missing loci, **A** the topology when $R = 10$ or 30 **B** the topology when $R = 50$ **C** the topology when $R = 80$. Bootstrap values are shown on the internodes.

between *H. pulchella* and *H. alata 1*. Two samples of *H. longipes* var. *caduca* were clustered together, but nested within *H. kikutii* var. *kikutii*. *Hosta* sp. 2 was placed outside the cluster including *H. longipes* var. *caduca* and *H. kikutii* var. *kikutii*.

STRUCTURE analysis

In the STRUCTURE analysis, using $R = 0.5$, $K = 4$ or 5 was optimal: delta K increased from $K = 3$ to $K = 4$, took almost the same value at $K = 4$ and $K = 5$, and decreased from $K = 5$ to $K = 6$. When $K = 4$ (Fig. 4), *H. pulchella*, *H. alata 1*, *H. sp. 1*, and a group including *H. kikutii* var. *kikutii*, *H. longipes* var. *caduca* represented genetically unique populations, and *H. alata 2* showed a mixture of genetic elements derived from *H. pulchella* and *H. alata 1*. Genetic elements from *H. sp. 1* were found in three other genetically unique populations, albeit infrequently. When $K = 5$, *H. alata 2* and some individuals of *H. pulchella* represented the fifth genetically unique populations, and thus *H. pulchella* was shown to be genetically heterogeneous. *Hosta alata 2* had some genetic elements derived from *H. alata 1*.

Field observations

On Mt. Karasu-dake, a small population of *Hosta alata 1* is found on cliffs along the ridge line at 676 m elevation. On Mt. Sobo, *H. alata 2* grows along the ridge line at

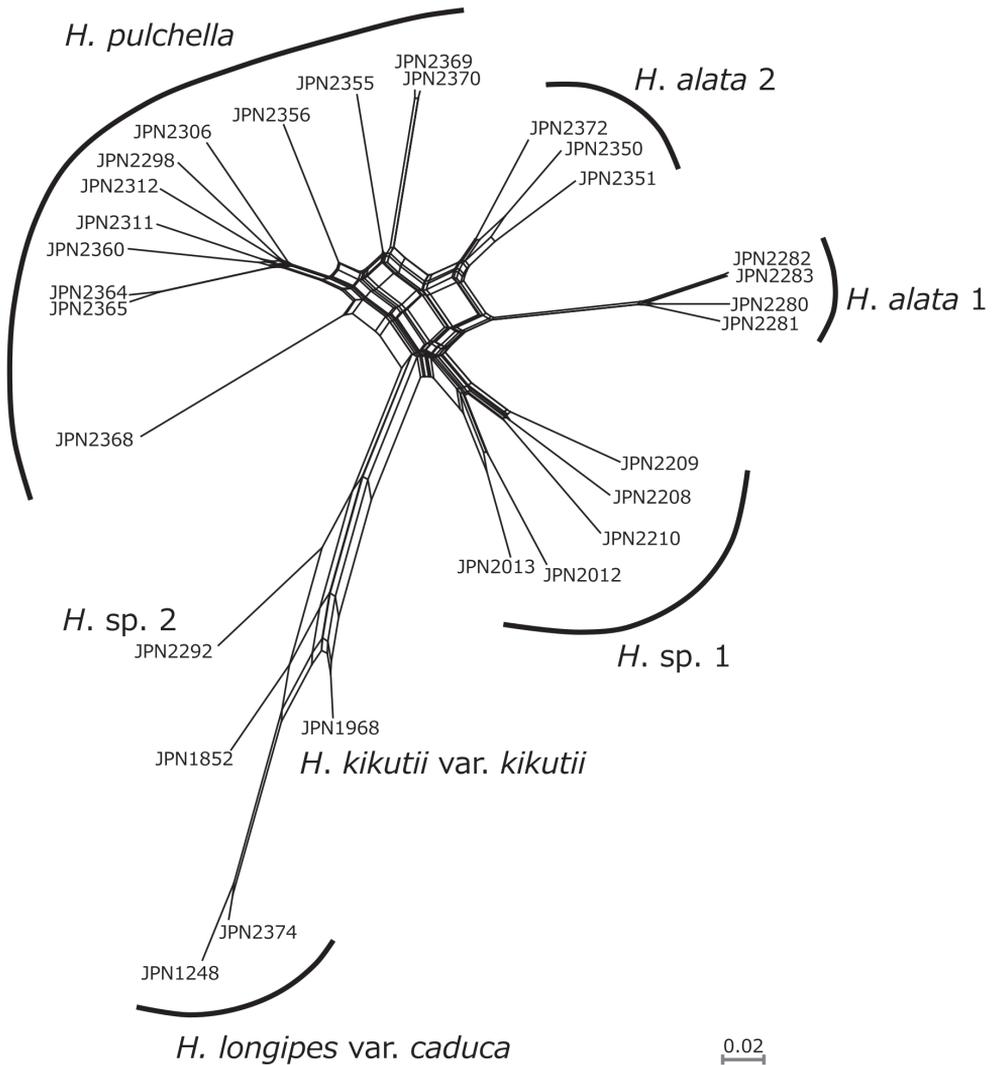


Figure 3. A split network of *Hosta alata* and its relatives reconstructed on the basis of MIG-seq data by setting $R = 0.5$.

1500 m elevation, where we also found a population of *H. pulchella*. While *H. alata* 2 grows on steep cliffs, *H. pulchella* grows in crevices of rocks along the mountain path. In the vicinity of the peak of Mt. Sobo at 1756 m elevation, we found only *H. pulchella* growing in rock crevices. We found several (fewer than 10) flowering *H. alata* 1 in Mt. Karasu-dake on September 24, 2020, but all *H. alata* 2 plants observed in Mt. Sobo on September 26, 2020, were fruiting (fewer than 10) or sterile (ca. 20). In contrast, we collected a few flowering *H. pulchella* specimens at the peak of Mt. Shojidake, located 2 km south of Mt. Sobo, on September 25, 2020; however, other plants observed in Mt. Shojidake were fruiting or sterile.

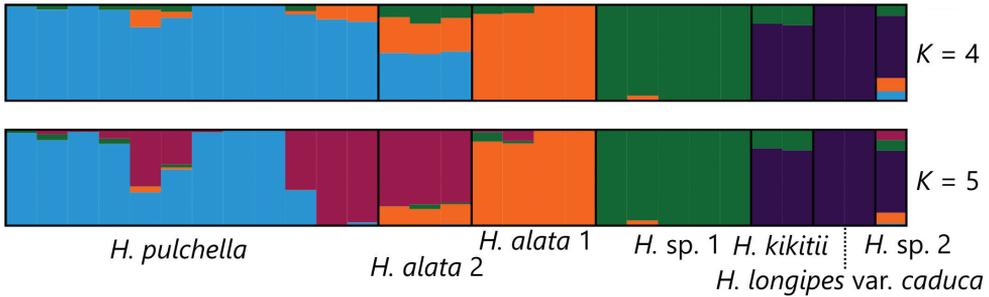


Figure 4. Population genetic structure of *Hosta alata* and its relatives at $K = 4$ and 5 inferred from MIG-seq data by setting $R = 0.5$.

According to the photographs, sketched illustrations, and description of *H. alata* 1 (Arakane 2001) and our own observations of *H. alata* 1 and *H. alata* 2, *Hosta alata* plants in Mt. Karasu-dake and Mt. Sobo were indistinguishable in both floral and vegetative traits. *Hosta alata* was similar to *H. pulchella*, as evidenced by the presence of dark purple veins inside perianth lobes (Fig. 6C); bracts in anthesis are vivid (not withering) and erect or diagonally spreading, and leaf blades are ovate or oblong-ovate with smooth veins on the lower surface. However, *H. alata* was distinguished from *H. pulchella* by the presence of more leaves (5–9 vs. 3–4), larger leaf blades (8.5–24.5 cm long vs. 2.7–8.0(–8.9) cm long), more lateral veins (5–9 pairs vs. 3–4 pairs), wider-winged petioles (0.4–1.4 cm wide vs. 0.2–0.4 cm wide), more flowers with 9–40 flowers per scape vs. 3–4 flowers, longer pedicels (1.1–2.3 cm long vs. 0.5–0.8 cm long), and fertile bracts which are purplish green in color (vs. pale green).

On Mt. Mukabaki and Mt. Oninome, plants of *Hosta* sp. 1 were found on high vertical cliffs. When we visited these localities late September, all plants we observed were sterile. These plants were similar to *H. alata* in the number of leaves, leaf size, the number of lateral veins, and width of petiole wings.

Discussion

The MIG-seq tree showed that *Hosta alata* was closely related to *H. pulchella* and *H. sp. 1*; the monophyly of a clade including these three species was strongly supported irrespective of R values (Fig. 2). The MIG-seq trees also showed that *H. alata* 1, *H. alata* 2, *H. pulchella*, and *H. sp. 1* were clearly differentiated irrespective of R values. The monophyly of *H. alata* 1 and *H. alata* 2 was supported by the MIG-seq tree with $R = 0.5$, but not supported by the MIG-seq tree with $R = 0.8$. Morphologically, the former result is supported: *H. alata* 1 and *H. alata* 2 are identical in key characters and clearly distinguished from *H. pulchella*, even though the two *H. alata* populations are geographically isolated from one another. *Hosta alata* and *H. pulchella* both grow approximately at 1500 m elevation on Mt. Sobo and prefer different habitats: *H. alata* with a larger plant size prefers steep, often vertical cliffs, but *H. pulchella* owing to its smaller size grows in rock

crevices along the mountain path. According to our unpublished observation, the difference in plant size is preserved even in cultivation. We did not observe any intermediate between *H. alata* 2 and *H. pulchella*. Based on this evidence, *H. alata* and *H. pulchella* are considered reproductively isolated species. The differences in flowering times between *H. alata* and *H. pulchella* may contribute to their reproductive isolation and their molecular divergence from one another. On Mt. Sobo, *H. alata* flowers from late August to late September, while *H. pulchella* flowers mostly in July (Arakane 2001). It was unusual that we collected a *H. pulchella* in flower in late September among fruiting individuals.

Split network (Fig. 3) also showed that *Hosta pulchella*, *H. alata* 1, *H. alata* 2, and *H. sp.* 1 were clearly differentiated. However, *Hosta alata* 2 was placed between *H. pulchella* and *H. alata* 1, suggesting that *H. alata* 2 might be of hybrid origin between *H. pulchella* and *H. alata* 1. The $K = 4$ result of STRUCTURE analysis (Fig. 4) also suggested that *H. alata* 2 has genetic elements from not only *H. alata* 1 but also *H. pulchella*. However, the $K = 5$ result of STRUCTURE analysis showed that *H. alata* 2 and some individuals of *H. pulchella* represented the fifth genetically unique population, suggesting that these individuals of *H. alata* 2 and *H. pulchella* shared genetic elements of old origin. These findings suggest that *H. alata* 2 was differentiated from *H. alata* 1 due to geographical isolation over a long geological time, hybridized with *H. pulchella* in the past, but retained its morphological traits that characterize *H. alata* today. Because *H. alata* 2 is morphologically distinct from *H. pulchella*, flowering from late August to late September when *H. pulchella* is fruiting, and *H. alata* 2 is separated from *H. pulchella* in the split network (Fig. 3), we taxonomically identify *H. alata* 2 as a population of *H. alata*. It is now widely known that a taxonomic species often has a history of past hybridization (Suarez-Gonzalez et al. 2018), and *H. alata* may be one example of such species. The split network (Fig. 3) also suggested that *H. longipes* var. *caduca* and *H. kikutii* var. *kikutii* may have a history of hybridization, because two species were nested despite their morphological distinction.

In the MIG-seq tree constructed in the present study, *Hosta sp.* 1 collected from Mt. Mukabaki and Mt. Oninome formed a distinct clade supported by a 100% bootstrap value. In the split network, *Hosta sp.* 1 formed a distinct cluster outside of *H. alata* and *H. pulchella*. These findings suggest that *Hosta sp.* 1 is another undescribed species. However, only sterile plants in this clade were collected. Further studies on flowering materials are warranted to describe this clade as a species.

It is likely that *H. sp.* 2 is another undescribed species. To better characterize *H. sp.* 2, however, further studies on two polymorphic species, *H. kikutii* and *H. longipes*, are needed. Notably, *Hosta kikutii* var. *kikutii*, with vivid bracts in anthesis, is shown to be sister to *H. longipes* var. *caduca* with withering bracts in anthesis. The condition of fertile bracts has been emphasized as a discriminating trait in the taxonomy of *Hosta* (Maekawa 1940; Fujita 1976; Tamura and Fujita 2013; Tamura 2015). Consequently, *Hosta longipes* is placed in Section *Picnolepis* (Maekawa 1940; Fujita 1976; Zonneveld and Van Iren 2001), whereas *H. kikutii* is placed in Section *Rhynchophorae* (Maekawa 1940; Zonneveld and Van Iren 2001) or Section *Helipteroides* (Fujita 1976). Further studies are needed to understand how the condition of fertile bracts varies between closely related species. By examining the phylogenetic relationships of more species using MIG-seq, significant developments are expected in the taxonomic revision of *Hosta* species.

Taxonomy

Hosta alata Hatus. ex Yahara, sp. nov.

urn:lsid:ipni.org:names:77219558-1

Figs 5, 6

Japanese name: Bungo-giboshi

Diagnosis. *Hosta alata* is distinguished from *H. pulchella* by the presence of more leaves (5–9 vs. 3–4), larger leaf blades (8.5–24.5 cm long vs. 2.7–8.0(–8.9) cm long), more lateral veins (5–9 pairs vs. 3–4 pairs), wider-winged petioles (0.4–1.4 cm wide vs. 0.2–0.4 cm wide), more flowers (9–40 flowers per scape vs. 3–4 flowers), longer pedicels (1.1–2.3 cm long vs. 0.5–0.8 cm long), and fertile bracts which are purplish green in color (vs. pale green).

Type. JAPAN. Oita Pref.: Ogata-cho, Mt. Karasu-dake (recorded as Karasu-yama), September 15, 1995, with flowers, *K. Nogami s.n.* (**holotype:** KAG 151816!).

Description. Herbs perennial, up to 48 cm in height, including scape. Plants green (not whitish-green). Leaves basal, spiral, long petiolate, 5–9 per ramet; blades ovate or oblong-ovate, 8.5–20.5 × 3.7–15.0 cm, thinly papery, glabrous on both surfaces, base cuneate to subcordate, apex acute to short acuminate, acumen to 1 cm long, margin entire, veins in 5–9 pairs, smooth on the lower surface; petioles 6.0–15.5 cm long, 0.4–1.4 cm wide, winged, wings 0.5–2.0 mm wide, glabrous, reddish maculate proximally. Scape 20–48 cm, terete. Raceme 9–40-flowered; sterile bracts at low to middle part of rachis 2, longer than 3 cm, apex not seen (broken and disappeared); one fertile bract subtending each flower, vivid (not withering) in anthesis, erect or diagonally, purplish green, oblong-lanceolate, boat-shaped, 0.8–2.4 × 0.2–0.6 cm, membranous, glabrous, apex acuminate. Flowers not fragrant, 4.2–7.4 cm long; pedicels 1.1–2.3 cm long, glabrous. Perianth light purple, funnel-form, 3.0–5.4 cm long, glabrous, 6-lobed; tube ca. 0.2 cm wide at base, abruptly dilated from apical 2/3, to 0.7–1.4 cm wide at throat, lobes narrowly triangular, 0.9–1.2 cm long, apex acute. Stamens 6, slightly shorter than perianth, not exerted; filaments white, free, 3.4–4.2 cm long, glabrous, anthers yellow, 2.5–3.5 mm long. Ovary oblong-ellipsoid, ca. 8 mm long, glabrous, style 3.7–4.5 cm long, upwardly curved at the distal part, subequal to 0.2–0.3 cm exerted from perianth, glabrous, stigma capitate. Capsule dark purple, dotted, cylindrical, 1.7–2.3 × 0.3–0.5 cm, 3-angled.

Phenology. Flowering from late August to late September, and fruiting in late September and probably to October.

Distribution and habitat. Oita Prefecture, Japan (endemic). This species grows on rock cliffs in the southern part of the Oita Prefecture on the main island of Kyushu.

Etymology. The specific epithet is derived from its winged petioles.

Conservation status. This species is listed in the Red Data Book Oita (Anonymous 2011) as Endangered (EN). The total number of fertile individuals in the two localities was estimated to range between 50 and 100. While the population of Mt. Sobo is located in the protected area of the Sobo Katamuki National (Kokutei) Park, the population occurring in Mt. Karasu-dake is not protected. It grows on steep



Figure 5. Holotype of *Hosta alata* Hatusima ex Yahara. (Nogami s.n. KAG151816, available from https://dbs.kaum.kagoshima-u.ac.jp/musedb/s_plant/picture/KAG151816/KAG151816.jpg).



Figure 6. Depiction of *Hosta alata* Hatusima ex Yahara in its natural habitat in Mt. Karasu-dake, Oita Pref., Japan. **A** leaves with winged petioles **B** flowering plant **C** front view of a flower. Scale bars: 2 cm (**A**); 10 cm (**B**); 1 cm (**C**). Photographs taken by K. Fuse on September 24, 2020.

rocky cliffs and the localities are not commonly known, and thus the populations appear stable. However, the formal description of this species may increase the collection pressure. Protection measures are currently being planned with administration.

Additional specimens examined. JAPAN. Oita Pref.: Ogata-cho, Mt. Karasu-dake, on cliff, 676 m elevation, September 24, 2020, with flowers, *T. Yahara* et al. *JPN2280* -2283(FU!); Ogata-cho, Ogouchi Forest Road, 780 m elevation [in the vicinity of the *JPN2280* - 2283 collection site at Mt. Karasu-dake], September 19, 2001, photographs taken by M. Arakane (KAG 151818!); Mt. Sobo, August 23, 2000, with flowers, *M. Arakane AR-43465* (KAG 151817!); Mt. Sobo, September 26, 2020, sterile, *T. Yahara* et al. *JPN2350, 2351, 2372* (FU!).

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Miyazaki Prefectures and the local offices of Forestry Agency. Additionally, *H. kikutii* specimens were collected from the protected areas of the Osuzu and Wanitsuka Prefectural Natural Parks with the permission granted by the Miyazaki Prefecture and the local offices of Forestry Agency. We thank the Ministry of Environment's Rare Species Conservation Promotion Office and Saki Funamoto of Kyushu Open University for their assistance in obtaining collection permits. We thank Editage (www.editage.com) for English-language editing.

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References

- Anonymous (2011) Red Data Book Oita 2011. <https://www.pref.oita.jp/10550/reddata2011/index.html>
- Arakane M (2001) *Hosta alata* Hatusima, sp. nov. Oita-no-Shokubutsu 11: 4–6. [Plants of Oita]
- Binh HT, Ngoc NV, Tagane S, Toyama H, Mase K, Mitsuyuki C, Suyama Y, Yahara T (2018) A taxonomic study of *Quercus langbianensis* complex based on morphology, and DNA barcodes of classic and next generation sequences. PhytoKeys 95: 37–70. <https://doi.org/10.3897/phytokeys.95.21126>
- Bolger AM, Lohse M, Usadel B (2014) Trimmomatic: A flexible trimmer for Illumina Sequence Data. Bioinformatics (Oxford, England) 30(15): 2114–2120. <https://doi.org/10.1093/bioinformatics/btu170>
- Catchen J, Hohenlohe PA, Bassham S, Amores A, Cresko WA (2013) Stacks: An analysis tool set for population genomics. Molecular Ecology 22(11): 3124–3140. <https://doi.org/10.1111/mec.12354>
- Chen X, Boufford DE (2000) *Hosta*. Flora of China 24: 204–205. <http://flora.huh.harvard.edu/china/PDF/PDF24/hosta.pdf>
- Doyle JJ, Doyle JL (1990) Isolation of plant DNA from fresh tissue. Focus (San Francisco, Calif.) 12: 13–15.
- Earl DA, Vonholdt BM (2012) STRUCTURE HARVESTER: A website and program for visualizing STRUCTURE output and implementing the Evanno method. Conservation Genetics Resources 4(2): 359–361. <https://doi.org/10.1007/s12686-011-9548-7>
- Evanno G, Regnaut S, Goudet J (2005) Detecting the number of clusters of individuals using the software STRUCTURE: A simulation study. Molecular Ecology 14(8): 2611–2620. <https://doi.org/10.1111/j.1365-294X.2005.02553.x>
- Fujita N (1976) The genus *Hosta* in Japan. Acta Phytotaxonomica et Geobotanica 27: 66–96. <https://doi.org/10.18942/bunruichiri.KJ00002992172>
- Huson DH, Bryant D (2006) Application of phylogenetic networks in evolutionary studies. Molecular Biology and Evolution 23(2): 254–267. <https://doi.org/10.1093/molbev/msj030>
- Jones Jr SB (1989) *Hosta yingeri* (Liliaceae/Funkiaceae): A new species from Korea. Annals of the Missouri Botanical Garden 76(2): 602–604. <https://doi.org/10.2307/2399504>

- Lee S, Kim K, Lee B, Lim C (2019) Complete chloroplast genomes of all six *Hosta* species occurring in Korea: Molecular structures, comparative, and phylogenetic analyses. *BMC Genomics* 20(1): e833. <https://doi.org/10.1186/s12864-019-6215-y>
- Maekawa F (1940) The genus *Hosta*. *Journal of the Faculty of Science, Imperial University of Tokyo, Section 3 Botany* 5: 317–425.
- Pritchard JK, Stephens M, Donnelly P (2000) Inference of population structure using multilocus genotype data. *Genetics* 155(2): 945–959. <https://doi.org/10.1093/genetics/155.2.945>
- Rochette NC, Rivera-Colón AG, Catchen JM (2019) Stacks 2: Analytical methods for paired-end sequencing improve RADseq-based population genomics. *Molecular Ecology* 28(21): 4737–4754. <https://doi.org/10.1111/mec.15253>
- Roesti M, Salzburger W, Berner D (2012) Uninformative polymorphisms bias genome scans for signatures of selection. *BMC Evolutionary Biology* 12(1): e94. <https://doi.org/10.1186/1471-2148-12-94>
- Schmid WG (1991) *The Genus Hosta – Giboshi Zoku*. Batsford/Timber Press, London and Portland.
- Stamatakis A (2014) RAxML version 8: A tool for phylogenetic analysis and post-analysis of large phylogenies. *Bioinformatics (Oxford, England)* 30(9): 1312–1313. <https://doi.org/10.1093/bioinformatics/btu033>
- Strijk JS, Binh HT, Ngoc NV, Pereira JT, Slik F, Sukri RS, Suyama Y, Tagane S, Wiering JJ, Yahara T, Hinsinger DD (2020) Museomics for reconstructing historical floristic exchanges: Divergence of stone oaks across Wallacea. *PLoS ONE* 15(5): e0232936. <https://doi.org/10.1371/journal.pone.0232936>
- Suarez-Gonzalez A, Lexer C, Cronk QCB (2018) Adaptive introgression: A plant perspective. *Biology Letters* 14(3): 20170688. <https://doi.org/10.1098/rsbl.2017.0688>
- Suyama Y, Matsuki Y (2015) MIG-seq: An effective PCR-based method for genome-wide single-nucleotide polymorphism genotyping using the next-generation sequencing platform. *Scientific Reports* 5(1): e16963. <https://doi.org/10.1038/srep16963>
- Tamura MN (2015) *Hosta*. In: Ohashi H, Kadota Y, Murata J, Yonekura K (Eds) *Wildflowers of Japan* 1, 250–253.
- Tamura MN, Fujita N (2013) *Hosta*. In: Iwatsuki K, Yamazaki T, Boufford DE, Ohba H (Eds) *Flora of Japan* IVb. Kodansha Scientific, Tokyo.
- Wagner CE, Keller I, Wittwer S, Selz OM, Mwaiko S, Greuter L, Sivasundar A, Seehausen O (2013) Genome-wide RAD sequence data provide unprecedented resolution of species boundaries and relationships in the Lake Victoria cichlid adaptive radiation. *Molecular Ecology* 22(3): 787–798. <https://doi.org/10.1111/mec.12023>
- Zhang M, Yahara T, Tagane S, Rueangruea S, Suddee S, Moritsuka E, Suyama Y (2020) *Cryptocarya kaengkrachanensis*, a new species of Lauraceae from Kaeng Krachan National Park, southwest Thailand. *PhytoKeys* 140: 139–157. <https://doi.org/10.3897/phytokeys.140.34574>
- Zonneveld BJM, Van Iren F (2001) Genome size and pollen viability as taxonomic criteria: Application to the genus *Hosta*. *Plant Biology* 3(2): 176–185. <https://doi.org/10.1055/s-2001-12900>

The genus *Deschampsia* and the epithet “*alpina*”

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Abstract

The epithet “*alpina*” has been recurrently used in the genus *Deschampsia* to name plants located in northern regions of Europe, Asia and North America, as a species (*Deschampsia alpina* (L.) Roem. & Schult.), but also in infraspecific categories (*Deschampsia cespitosa* subsp. *alpina* Tzvel. and *Deschampsia cespitosa* var. *alpina* Schur.). The morphological and molecular available evidence suggests the existence of a single species, *Deschampsia cespitosa* (L.) P. Beauv., in which individuals belonging to the same morphological gradient have received different names in different taxonomic categories throughout its wide distribution range. An evaluation of the available names indicates that all uses of the epithet “*alpina*” are illegitimate. A new combination is proposed at the infraspecific level as *Deschampsia cespitosa* subsp. *neoalpina* Chiapella, Xue & Greimler.

Keywords

Aira alpina, *Deschampsia*, *Deschampsia alpina*, *Deschampsia cespitosa* var. *alpina*, *Deschampsia cespitosa* subsp. *alpina*

Introduction

Deschampsia cespitosa (L.) P. Beauv. has a nearly cosmopolitan distribution, being more common in cold temperate regions of the Northern Hemisphere. This extended geographic distribution shows different morphological variants, which have been

considered in two alternate ways, either as infraspecific taxa of a widely distributed species (Tzvelev 1976; Clarke 1980; Chiapella 2000; Chiapella and Probatova 2003; Chiapella et al. 2011), or as separate, though related taxa. Authors using the latter approach (separate taxa) include Böcher et al. (1968), Scoggan (1978) and Porsild and Cody (1980). Barkworth (2007) used a mixed approach for North America north of Mexico, accepting three subspecies for *Deschampsia cespitosa* but keeping *D. alpina* at the species level.

Taxa delimitation and nomenclatural problems are common in *Deschampsia* of northern regions of North America, Europe and Asia. The present contribution aims at clarifying the status of the taxon appearing alternatively under the names *Deschampsia alpina* (L.) Roem. & Schult., *Deschampsia cespitosa* subsp. *alpina* Tzvel. and *Deschampsia cespitosa* var. *alpina* Schur.

Morphology

Morphological quantitative characters in *Deschampsia cespitosa* may vary greatly in short environmental gradients. Plants growing along a 40 m long gradient on tidal soils showed significant differences in plant height and leaf width (Seliskar 1985a, b). Such gradient-like variability at larger scales has been shown in studies on *Deschampsia cespitosa* in Central and Northern Europe (Chiapella 2000) and in North America (Chiapella et al. 2011) (Fig. 1). The environment affects key characters normally used in grass systematics (i.e., plant height, size of panicles, spikelets, glumes and lemmas, length of the awns, etc.).

An additional problem in *Deschampsia* is the development of the sprouting spikelet (glumes, lemmas, paleas), a consequence of the pseudovivipary typical in the taxon named “*alpina*”. These parts elongate beyond the habitual range of *D. cespitosa*, eventually becoming plantlets. Pseudovivipary is an asexual reproductive strategy commonly found in grasses, in which plantlets develop from spikelets and detach from the parental plant after development (Elmqvist and Cox 1996). In *Poa*, pseudovivipary may confer an advantage for growth and dispersal in nutrient-poor habitats (Pierce et al. 2003).

Cytogenetics

Aiken et al. (2007) provide a summary of available cytogenetical information for *Deschampsia alpina* (L.) Roem. & Schult. (Table 1). Most of the counts, however, were made in the decades of 1930, 1940 and 1950, with the most recent dates from 1980. Pronounced differences could be due to technical limitations, or to poor chromosome separation in counts of some material (Rothera and Davy 1986: 453). While the many counts cover most of the distribution area of *D. alpina*, their differences might also suggest a possible complex history, with hybridization and chromosome doubling (Levy and Feldman 2002) as probable driving forces of the changes.

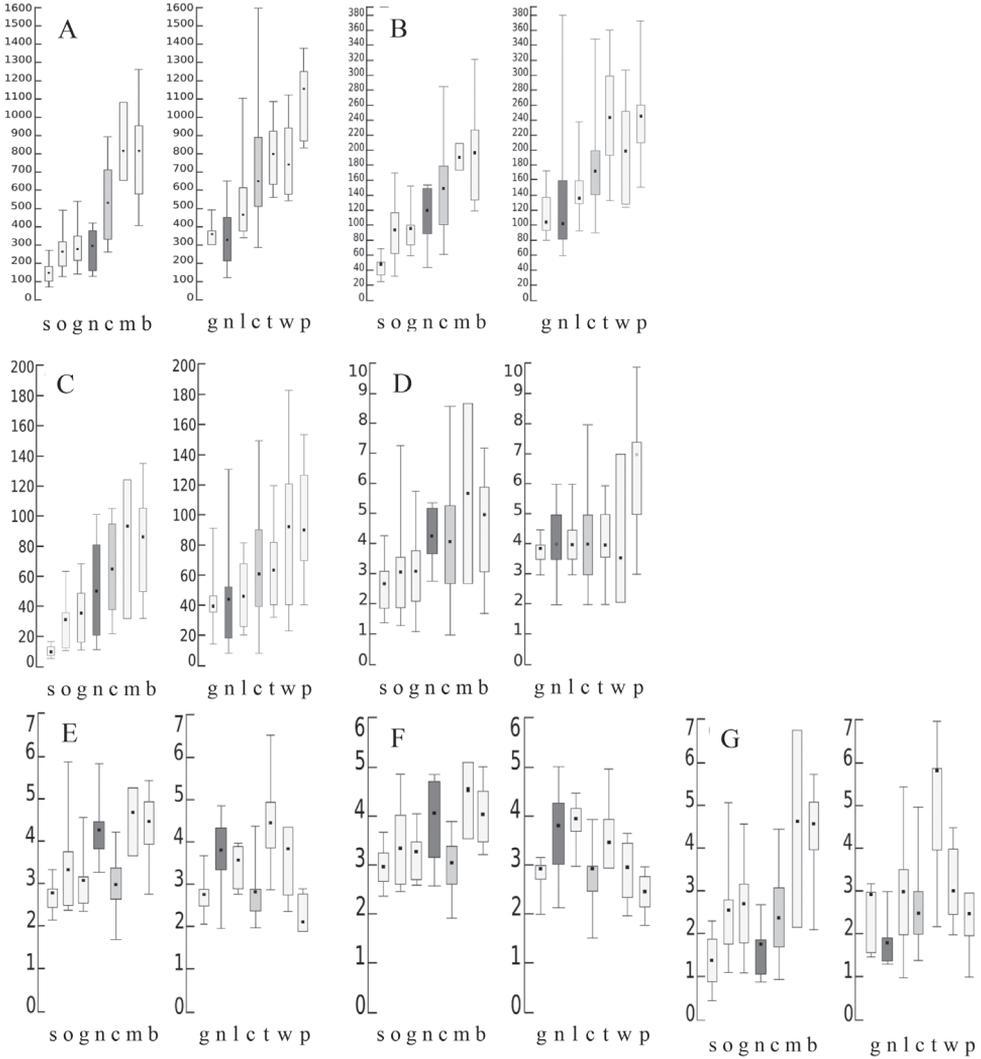


Figure 1. Comparison of selected morphological traits in *Deschampsia cespitosa* s.l. in North America (left panel) and North Central Europe (right panel): plant height **A** panicle length **B** panicle width **C** ligule length **D** lower glume length **E** lemma length **F** awn length **G** taxa codes: *Deschampsia cespitosa* subsp. *septentrionalis* (s); *D. cespitosa* subsp. *orientalis* (o); *D. cespitosa* subsp. *glauca* (g); *D. cespitosa* subsp. *nealpina* (n); *D. cespitosa* subsp. *cespitosa* (c); *D. cespitosa* ssp. *mackenzieana* (m); *D. cespitosa* ssp. *beringensis* (b); *D. cespitosa* ssp. *littoralis* (l); *D. cespitosa* subsp. *wibeliana* (w); *D. cespitosa* subsp. *parviflora* (p). Redrawn from Chiapella (2000) and Chiapella et al. (2011). All in mm.

The lack of recent cytogenetic studies prevents a comprehensive analysis of the taxon history. However, Aiken et al. (2007) suggest that *Deschampsia alpina* is either an autopolyploid derivative of *Deschampsia cespitosa* subsp. *cespitosa*, or an allopolyploid with one still unknown parent (Elven et al. 2003).

Table 1. Synopsis of cytogenetic information for *Deschampsia alpina* (L.) Roem. & Schult. (Source: Aiken et al. 2007).

Count	Distribution	Source
2n = 39, 41, 49.	Spitzbergen, Svalbard Archipelago	Flovik (1938, 1940)
2n = 56.	Northern Europe	Hagerup (1939)
2n = 49.	British Isles	Maude (1939)
2n = 26, 39, 48, 52	Northern Europe	Nygren (1949)
2n = 52.	Greenland	Böcher and Larsen (1950)
2n = 49, 56.	British Isles	Hubbard (1954)
2n = 35–38.	Arctic Russia	Sokolovskaya (1955)
2n = 39, 52.	Iceland	Löve and Löve (1956)
2n = 49, 49 + 2B.	Greenland	Jørgensen et al. (1958)
2n = 26, 38–39.	Arctic Russia	Sokolovskaya and Strelkova (1960)
2n = 39 + 3 – 4ff, 49.	Northern Norway	Engelskjøn and Knaben (1971)
2n = 50.	Bear Island, Svalbard Archipelago	Engelskjøn (1979)
2n = 29 49–52.	Europe, northern Africa	Albers (1980)

Taxonomic history

The combination *Deschampsia cespitosa* subsp. *alpina* (L.) Tzvel. has been deemed an illegitimate homonym (Aiken et al. 2007) because of the existence of an earlier *Deschampsia cespitosa* var. *alpina* Schur. Schur (1859) described this taxon for plants collected during a trip carried out in July–August 1853 to the Carpathian Mountains in Siebenbürgen (present day Romania). The description portrays a high mountain grass growing above the treeline, and was based on the basionym *Aira alpina* L. In the case of Schur’s combination, the Article 11.2 of the Code of Nomenclature (Turland et al. 2018), states that “a name has no priority outside the rank at which it is published” thus limiting the priority of the combination of Schur (1859) to the rank of variety. Tzvelev published his combination at the rank of subspecies. The earliest combination of the epithets “*caespitosa*” and “*alpina*” was made as *Aira caespitosa* subsp. *alpina* (L.) Hook. in 1870, however in another genus. Furthermore, Article 11.4 (Turland et al. 2018) rules that for infraspecific taxa, the correct name is the combination of the final epithet of the earliest legitimate name of the taxon at the same rank, with the correct name of the genus or species to which it is assigned. Since the correct genus to which this taxon should be assigned is *Deschampsia*, and on account of the reasons mentioned before, the correct category is infraspecific, therefore the combination *Deschampsia cespitosa* subsp. *alpina* (L.) Tzvelev would have been used.

However, Article 53.3 (Turland et al. 2018) rules specifies that “two infraspecific taxa of the same species at different ranks are homonyms if they are not based on the same type”. In 1869, Ducommun published a textbook on the Swiss flora, including three combinations in *Deschampsia cespitosa* (L.) P. Beauv.: α) *D. cespitosa* (L.) P. B. var. *genuina* G.; ß) *D. cespitosa* (L.) P. B. var. *pallida* K.; and γ) *D. cespitosa* (L.) P. B. var. *alpina* G. Explicitly the var. *alpina* was based on *Aira alpina* Roth non L., based on another type. Therefore, since both names, the one by Schur and the one by Gaudin are based on different types, they are homonyms.

Discussion

The debates on delimitation of taxa -at specific or infraspecific level- have been recurrent during the 1990's (Soreng 1991; Luckow 1995; McDade 1995). While now a more sophisticated approach using genomic data and the coalescent is available (Barrett and Freudenstein 2011; Fujita et al. 2012; Leaché et al. 2014), in most cases there is limited molecular information and a lack of basic data on morphology and geographic distribution. The most commonly used strategy has been to differentiate taxa by some character or a combination of characters (Nixon and Wheeler 1990). In cases dealing with infraspecific variation, the preferred approach is to combine morphological variation with geographic allopatry (McDade 1995), which refers to the seminal concept of Du Rietz (1930) – defining subspecies as subtle morphological variants more or less related to defined geographic regions.

The available information for *Deschampsia cespitosa* comprises a set of morphological data for Central Europe (Chiapella 2000) and morphological and molecular data for North America (Chiapella et al. 2011). The morphological data show a gradient-like variability, with recognizable taxa assigned to sections of the gradient (Fig. 1). The molecular information available from the combined *trnK-rps16* spacer and the ITS region yielded 39 haplotypes, two being more abundant and with no obvious relationships between them or to LGM events (Chiapella et al. 2011: 1375). This combined data set was used for maximum parsimony and Bayesian analyses with PAUP* version 4b10 (Swofford 2002) and MrBayes 3 (Ronquist and Huelsenbeck 2003) (for more details, see Chiapella et al. 2011: 1370), and resulted in a single taxon with strong support, *Deschampsia cespitosa*, but with several morphological characters showing a gradient- showing a gradient-like variation corresponding to known infraspecific taxa (Fig. 1).

Since molecular data supports the existence of a single entity, but the morphological data shows variation, the treatment as infraspecific entities seems proper. Consequently, and because all available combinations using the epithet “*alpina*” are illegitimate, a replacement name in reference to Article 41 (Turland et al. 2018) is proposed.

Nomenclature

***Deschampsia cespitosa* subsp. *nealpina* Chiapella, Xue & Greimler.**

≡ *Aira alpina* L. Sp. Pl. 65. 1753.

≡ *Deschampsia alpina* (L.) Roem. & Schult. Syst. Veg. 2: 686. 1817.

≡ *Aira alpina* Lilj., Utkast Sv. Fl. 49. 1792.

≡ *Aira alpina* var. *vivipara* Parn., Grasses Brit.: 242 t. 109. 1845.

≡ *Avena alpina* (L.) Trin., Fund. Agrost.: 157. 1820.

≡ *Aira caespitosa* subsp. *alpina* (L.) Hook. f. Student Fl. Brit. Isl. 3: 437. 1870.

≡ *Aira major* subsp. *alpina* (L.) Syme ex J.E. Sowerby, Engl. Bot. (ed. 3B) 11: 65. 1877.

- ≡ *Deschampsia cespitosa* (L.) P.Beauv. var. *alpina* Vasey in Beal, Grasses N. Amer. 2: 368. 1896.
- ≡ *Deschampsia cespitosa* subsp. *alpina* (L.) Tzvel., in Fed., Fl. Evrop. Chasti SSSR 1: 209. 1974.
- = *Aira alpina* Roth, Tent. Fl. Germ. 2(1): 98. 1789.
- = *Aira laevigata* Sm., Engl. Bot. 30: t. 2102. 1810.
- = *Deschampsia laevigata* (Sm.) Roem. & Schult., Syst. Veg. 2: 687. 1817.
- = *Deschampsia cespitosa* var. *alpina* Schur, Oesterr. Bot. Z. 9: 326. 1859.
- = *Deschampsia cespitosa* var. *alpina* Gaudin ex Ducommun, Taschenb. Schweiz. Bot. 861. 1869.
- = *Deschampsia cespitosa* var. *alpina* (Hoppe) Honda (J. Fac. Sci. Univ. Tokyo (1): 139. 1930.
- = *Aira caespitosa* var. *alpina* Hoppe, Flora: 166. 1817–1823.
- = *Deschampsia cespitosa* var. *alpina* (Hoppe) Honda, J. Fac. Sci. Univ. Tokyo, Sect. 3, Bot. a3(1): 139. 1930.
- = *Aira caespitosa* var. *alpina* Gaudin, Fl. Helv. 1: 323. 1828.
- = *Deschampsia cespitosa* var. *alpina* Gaudin ex Ducommun, Taschenb. Schweiz. Bot. 861. 1869.
- = *Aira caespitosa* var. *alpina* Heuff. Verhandlungen der Zoologisch-botanischen Gesellschaft in Wien 8: 228. 1858.
- = *Aira vivipara* Steud., Syn. Pl. Glumac. 1: 222. 1854.
- = *Aira alpina* var. *vivipara* (Steud.) Lange, Consp. Fl. Groenland. 3: 163. 1880.

Type. Sweden, Torne Lappmark, Mt. Njuolja, 25.07.1950, leg. N.D.Simpson 50133 (BM), neotype selected by Cope in Cafferty et al., Taxon 49: 293. 2000.

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References

- Aiken SG, Dallwitz MJ, Consaul LL, McJannet CL, Boles RL, Argus GW, Gillett JM, Scott PJ, Elven R, LeBlanc MC, Gillespie LJ, Brysting AK, Solstad H, Harris JG (2007) Flora of the Canadian Arctic Archipelago: Descriptions, Illustrations, Identification, and Information Retrieval. NRC Research Press, National Research Council of Canada, Ottawa. <http://nature.ca/aafflora/data> [accessed on 21 September 2020]

- Albers F (1980) Comparative Karyology of the grass sub-tribes Aristaveninae and Airinae (Poaceae – Avenae). *Plant Systematics and Evolution* 136(3–4): 137–167. <https://doi.org/10.1007/BF01004624>
- Barkworth ME (2007) *Deschampsia*. In: Barkworth ME, Capels KM, Long S, Anderton LK, Piep MB (Eds) *Flora of North America North of Mexico*, vol. 24. Oxford University Press, New York, USA, 624–633.
- Barrett CF, Freudenstein JV (2011) An integrative approach to delimiting species in a rare but widespread mycoheterotrophic orchid. *Molecular Ecology* 13(13): 2771–2786. <https://doi.org/10.1111/j.1365-294X.2011.05124.x>
- Böcher TW, Larsen K (1950) Chromosome numbers of some arctic or boreal flowering plants. *Meddelelser om Grønland, udgivne af Kommissionen for Ledelsen af de Geologiske og Geografiske Undersøgelser i Grønland*. Copenhagen 147: 1–32.
- Böcher TW, Holmen K, Jakobsen K (1968) *The flora of Greenland*. P. Haase and Son, Copenhagen, Denmark.
- Chiappella JO (2000) The *Deschampsia cespitosa* complex in central and northern Europe: A morphological analysis. *Botanical Journal of the Linnean Society* 134(4): 495–512. <https://doi.org/10.1111/j.1095-8339.2000.tb00547.x>
- Chiappella JO, Probatova NS (2003) The *Deschampsia cespitosa* complex (Poaceae: Aveneae) with special reference to Russia. *Botanical Journal of the Linnean Society* 142(2): 213–228. <https://doi.org/10.1046/j.1095-8339.2003.00167.x>
- Chiappella JO, DeBoer VL, Amico GC, Kuhl JC (2011) A morphological and molecular study in the *Deschampsia cespitosa* complex (Poaceae; Poae; Airinae) in northern North America. *American Journal of Botany* 98(8): 1366–1380. <https://doi.org/10.3732/ajb.1000495>
- Clarke GCS (1980) In: Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA (Eds) *Flora europaea* 5, Cambridge University Press, Cambridge, 225–227.
- Du Rietz EG (1930) The fundamental units of biological taxonomy. *Svensk Botanisk Tidskrift* 24: 333–426.
- Ducommun JC (1869) *Taschenbuch für den schweizerischen Botaniker*. Schwendemann, Solothurn. <https://doi.org/10.5962/bhl.title.9825>
- Elmqvist T, Cox PA (1996) The evolution of vivipary in flowering plants. *Oikos* 77(1): 3–9. <https://doi.org/10.2307/3545579>
- Elven R, Murray DF, Yurtsev BA (2003) Checklist of the Panarctic Flora (PAF) Vascular Plants. Draft version, National Centre of Biosystematics, Natural History Museums and Botanic Garden. University of Oslo.
- Engelskjøn T (1979) Chromosome numbers in vascular plants from Norway, including Svalbard. *Opera Botanica* 52: 1–38.
- Engelskjøn T, Knaben G (1971) Chromosome numbers of Scandinavian arctic-alpine plant species. III. *Acta Boreal. American Scientist* 28: 1–30.
- Flovik K (1938) Cytological studies in Arctic grasses. *Hereditas* 24(3): 265–376. <https://doi.org/10.1111/j.1601-5223.1938.tb02674.x>
- Flovik K (1940) Chromosome numbers and polyploidy within the flora of Spitzbergen. *Hereditas* 26: 1430–1440. <https://doi.org/10.1111/j.1601-5223.1940.tb03246.x>

- Fujita MK, Leaché AD, Burbrink FT, McGuire JA, Moritz C (2012) Coalescent-based species delimitation in an integrative taxonomy. *Trends in Ecology & Evolution* 27(9): 480–488. <https://doi.org/10.1016/j.tree.2012.04.012>
- Hagerup O (1939) Studies on the significance of polyploidy. III. *Deschampsia* and *Aira*. *Hereditas* 25(2): 185–193. <https://doi.org/10.1111/j.1601-5223.1939.tb02692.x>
- Hubbard CE (1954) Grasses. A Guide to Their Structure, Identification, Uses and Distribution in the British Isles. Hardmondsworth, Middlesex, Penguin books Ltd., 428 pp.
- Jørgensen CA, Sorensen TJ, Westergaard M (1958) The flowering plants of Greenland. A taxonomical and cytological survey. *Kongelige Danske videnskabernes selskabs skrifter* 9: 1–172.
- Leaché AD, Fujita MK, Minin VN, Bouckaert RR (2014) Species delimitation using genome-wide SNP data. *Systematic Biology* 63(4): 534–542. <https://doi.org/10.1093/sysbio/syu018>
- Levy AA, Feldman M (2002) The impact of polyploidy on grass genome evolution. *Plant Physiology* 130(4): 1587–1593. <https://doi.org/10.1104/pp.015727>
- Löve Á, Löve D (1956) Cytotaxonomical conspectus of the Icelandic flora. *Acta Horti Gothoburgensis* 20: 65–291.
- Luckow M (1995) Species concepts: Assumptions, methods, and applications. *Systematic Botany* 20(4): 589–605. <https://doi.org/10.2307/2419812>
- Maude PF (1939) The Merton catalogue. A list of the chromosome numbers of species of British flowering plants. *The New Phytologist* 38(1): 1–34. <https://doi.org/10.1111/j.1469-8137.1939.tb07082.x>
- McDade LA (1995) Species concepts and problems in practice: Insight from botanical monographs. *Systematic Botany* 20(4): 606–622. <https://doi.org/10.2307/2419813>
- Nixon KC, Wheeler QD (1990) An amplification of the phylogenetic species concept. *Cladistics* 6(3): 211–223. <https://doi.org/10.1111/j.1096-0031.1990.tb00541.x>
- Nygren A (1949) Studies on vivipary in the genus *Deschampsia*. *Hereditas* 35(1): 27–32. <https://doi.org/10.1111/j.1601-5223.1949.tb02859.x>
- Pierce S, Stirling CM, Baxter R (2003) Pseudoviviparous reproduction of *Poa alpina* var. *vivipara* L. (Poaceae) during long-term exposure to elevated atmospheric CO₂. *Annals of Botany* 91(6): 613–622. <https://doi.org/10.1093/aob/mcg067>
- Porsild AE, Cody WJ (1980) Vascular plants of continental Northwest Territories, Canada. National Museum of Canada, Ottawa, Ontario. <https://doi.org/10.5962/bhl.title.70336>
- Ronquist F, Huelsenbeck JP (2003) MrBayes 3: Bayesian phylogenetic inference under mixed models. *Bioinformatics (Oxford, England)* 19(12): 1572–1574. <https://doi.org/10.1093/bioinformatics/btg180>
- Rothera SL, Davy AJ (1986) Polyploidy and habitat differentiation in *Deschampsia cespitosa*. *The New Phytologist* 102(3): 449–467. <https://doi.org/10.1111/j.1469-8137.1986.tb00822.x>
- Schur F (1859) Beobachtungen in der Flora von Siebenbürgen. *Österreichische. Botanischeskii Zhurnal* 9: 323–333. <https://doi.org/10.1007/BF01962295>
- Scoggan HJ (1978) The flora of Canada. Publications in Botany 7(2). National Museum of Natural Sciences, Ottawa, Ontario. <https://doi.org/10.5962/bhl.title.122890>

- Seliskar DM (1985a) Effect of reciprocal transplanting between extremes of plant zones on morphometric plasticity of five plant species in an Oregon salt marsh. *Canadian Journal of Botany* 63(12): 2254–2262. <https://doi.org/10.1139/b85-320>
- Seliskar DM (1985b) Morphometric variations of five tidal marsh halophytes along environmental gradients. *American Journal of Botany* 72(9): 1340–1352. <https://doi.org/10.1002/j.1537-2197.1985.tb08391.x>
- Sokolovskaya AP (1955) The size of pollen grains and the number of chromosomes in some arctic cereal species. *Botanicheskii Zhurnal (Moscow & Leningrad)*. Bot. 40: 850–853. [In Russian]
- Sokolovskaya AP, Strelkova OS (1960) Geographical distribution of the polyploid species of plants in the Euroasiatic arctic. *Botanicheskii Zhurnal (Moscow & Leningrad)* 45: 370–381. [In Russian]
- Soreng RJ (1991) Systematics of the “Epiles” group of *Poa* (Poaceae). *Systematic Botany* 16(3): 507–528. <https://doi.org/10.2307/2419340>
- Swofford DL (2002) PAUP*: Phylogenetic analysis using parsimony (*and other methods), version 4.0b10. Sinauer, Sunderland.
- Turland NJ, Wiersema JH, Barrie FR, Greuter W, Hawksworth DL, Herendeen PS, Knapp S, Kusber W-H, Li D-Z, Marhold K, May TW, McNeill J, Monro AM, Prado J, Price MJ, Smith GF (2018) International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. *Regnum Vegetabile* 159. Glashütten: Koeltz Botanical Books. <https://doi.org/10.12705/Code.2018>
- Tzvelev NN (1976) Grasses of the Soviet Union. Nauka Publishing House, Leningrad.

Vaccinium motuoense (Ericaceae), a new species from Xizang, China

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Abstract

Vaccinium motuoense (Ericaceae), a new species from Motuo County, Xizang Autonomous Region, China is described and illustrated. This new species belongs to *Vaccinium* sect. *Calcicolus* and is morphologically most similar to *V. dunalianum*, but differs in having yellowish-brown tomentose young branches, petioles and inflorescence rachis, leaf blades with 2–3(–4) pairs of secondary veins, usually all basal and with fine veins impressed adaxially and urceolate to spherical corollas.

Keywords

Morphology, new species, *Vaccinium dunalianum*

Introduction

The genus *Vaccinium* L. (Ericaceae), with about 450–500 species distributed worldwide, is the largest genus of the blueberry tribe or Vaccinieae Rchb. (Fang 1991; Fang and Stevens 2005; Vander Kloet and Dickinson 2009). In China, 95 species of

Vaccinium are recorded, including the recently published *V. damingshanense* Y. H. Tong & N. H. Xia and *V. napoense* Y. H. Tong & N. H. Xia from Guangxi and *V. zhangzhouense* Y. H. Tong et al. from Fujian (Tong and Xia 2015; Tong et al. 2020, 2021). There are 15 species of *Vaccinium* recorded from Xizang Autonomous Region, most of which occur in the south to south-eastern part of that Province (Fang 1986).

During work on a revision of *Vaccinium* species from China, we observed that several specimens, identified as *V. dunalianum* var. *urophyllum* Rehder & E. H. Wilson from Motuo County, southeast Xizang, differ substantially from those from other places in China in the leaf blade with relatively long caudate apex and the yellowish-brown tomentose inflorescence rachis. Thus, we conducted two field trips to collect fresh flowering and fruiting material for further study. We found that, in addition to the difference in the indumentum on the inflorescence rachis noted by Fang (1991: 95), the population of *V. dunalianum* var. *urophyllum* from Motuo County could be further distinguished from other populations of that variety and, even, the entire species *V. dunalianum* Wight by the shape and venation of the leaf blade and the shape of the corolla. Thus, we concluded that the population of *V. dunalianum* var. *urophyllum* from Motuo represents a new species, described below.

Materials and methods

Fruiting and flowering material was collected from Motuo County, Xizang Autonomous Region, China during two field trips in January 2020 and May 2021. Descriptions were based on both living and dried collections, which were deposited at the Herbaria of the Institute of Botany, Chinese Academy of Sciences (PE), Kunming Institute of Botany, Chinese Academy of Sciences (KUN) and South China Botanical Garden, Chinese Academy of Sciences (IBSC). Measurements were performed with a ruler and small plant parts were observed and measured under a stereomicroscope (Mshot-MZ101).

Taxonomic treatment

Vaccinium motuoense Y.H. Tong & Y.J. Guo, sp. nov.

urn:lsid:ipni.org:names:77219644-1

Figures 1, 2

Type. CHINA. Xizang Autonomous Region: Motuo County, Km 80 on Zhamo Road, epiphytic on trees in evergreen broad-leaved forest, 29°40'59.9"N, 95°30'6.3"E, 2191 m a.s.l., 28 May 2021 (fl.), Z. Liu & W. L. Zhao TYH-2523 (holotype: IBSC, isotypes: IBSC, KUN).

Diagnosis. Similar to *V. dunalianum* Wight, especially *V. dunalianum* var. *urophyllum* Rehder & E. H. Wilson, in the hairy young branches, the shape, size and

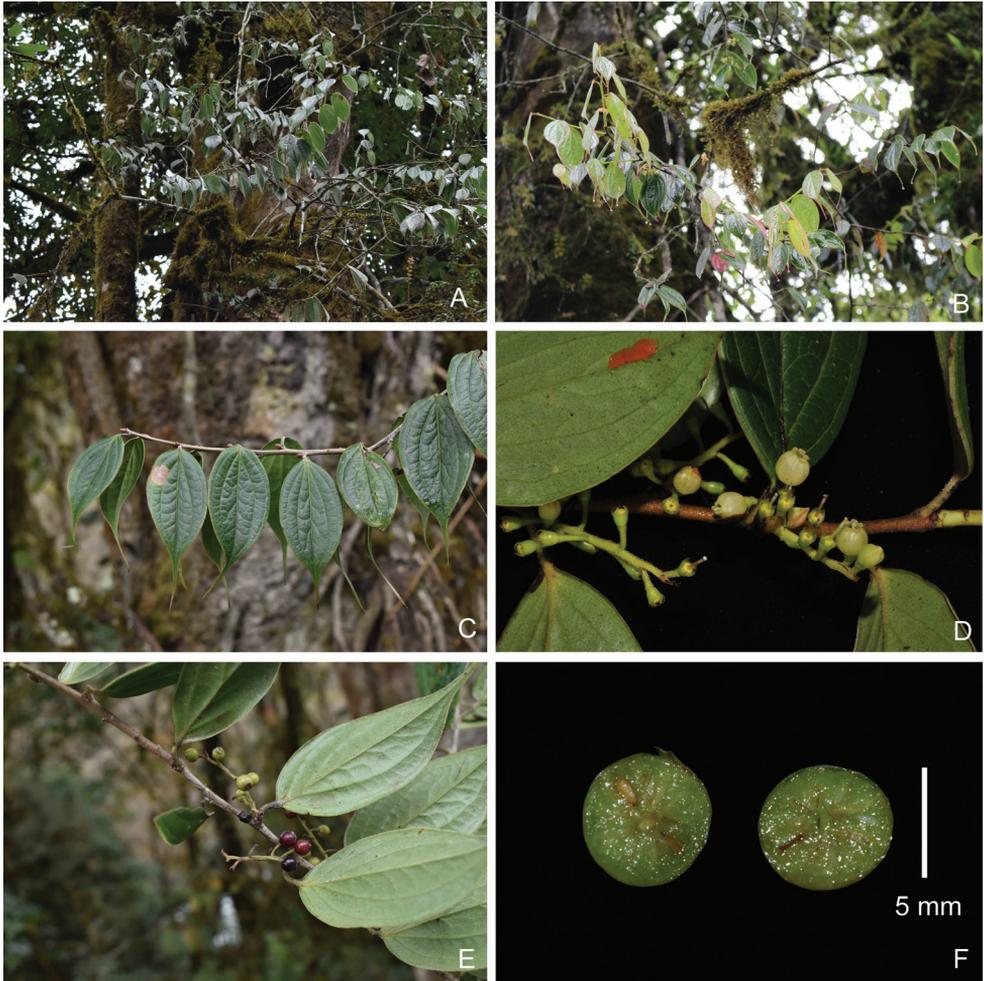


Figure 1. *Vaccinium motuoense* sp. nov. **A, B** habit **C** sterile branch with leaves **D** inflorescence **E** fruiting branch **F** fruits, cross section **A, C, E** and **F** taken by Y. H. Tong **B** by W. L. Zhao and **D** by J. Cai.

indumentum of leaf blade and the axillary racemose inflorescence, but distinguished by the yellowish-brown tomentose (vs. glabrous or brownish-white pubescent) young branches, petioles and inflorescence rachis, leaf blades with 2–3(–4) pairs (vs. 4–5) of secondary veins, usually all basal (vs. only lowermost 2–3 pairs basal), with veins impressed adaxially (vs. plane or slightly raised) and flowers with urceolate to spherical corollas (vs. broadly campanulate) (Table 1).

Description. Evergreen shrubs, epiphytic on tree trunks, sprawling or hanging, stem 0.5–3 m long, without swollen basal tuber or root swellings. Young branches brownish, slightly angled, without lenticels, yellowish-brown tomentose, glabrescent and becoming greyish-white when older. Perennating buds dimorphic (floral perennating buds are at least twice the size of vegetative perennating buds). Leaves alter-

Table 1. Morphological comparison of *Vaccinium motuoense* and *V. dunalianum*.

Characters	<i>V. motuoense</i> sp. nov.	<i>V. dunalianum</i>
Young branches	Yellowish-brown tomentose	Glabrous or brownish-white pubescent
Petiole	Yellowish-brown tomentose	Glabrous or brownish-white pubescent
Leaf blade shape	Ovate or ovate-elliptic	Elliptic, oblong, oblong-lanceolate or ovate
Secondary veins	2–3(–4) pairs, usually all basal, with fine veins impressed adaxially	4–5 pairs, only lowermost 2–3 pairs basal, with fine veins plane or slightly raised adaxially
Inflorescence rachis	Yellowish-brown tomentose	Glabrous
Corolla shape	Urceolate to spherical	Broadly campanulate
Filament	Puberulous and pubescent adaxially, slightly puberulous abaxially	Glabrous or puberulous both sides

nate; petiole flattened above, 0.8–1.2 cm long, 1.7–2.2 mm wide, yellowish-brown tomentose throughout, glabrescent; blade ovate or ovate-elliptic, 8.5–13.5 (including caudate apex) × 2.4–5.0 cm, leathery, abaxially with dense appressed black-glandular trichomes, brown-tomentose or -pubescent on veins that are near leaf base both sides, otherwise glabrous, base broadly cuneate to rounded, with one basal gland per side at the junction of leaf base and petiole, margin flat or slightly revolute when dry, entire, apex long caudate 2–4 cm long; veins impressed adaxially, more so when dry, raised abaxially, secondary veins 2–3(–4) per side, usually all basal, short cross-veins (tertiary veins) between the secondaries prominent, nearly transverse and paralleled. Inflorescence racemose, usually axillary on biennial branches, 7–16-flowered. Peduncle usually very short, inflorescence rachis pale green, 0.7–3 cm long, yellowish-brown tomentose, glabrescent when fruiting; bracts pale green, obovate, cucullate, 6–8 × 4–6 mm, abaxially yellowish-brown tomentose or pubescent, adaxially glabrous, margin ciliate, caducous; bracteoles 2, inserted at base of pedicel, pale green, linear, 5–6 × ca. 0.2 mm, ciliate, caducous. Pedicel pale green, 2.5–4.5 mm long, yellowish-brown tomentose or pubescent or nearly glabrous, articulate with the hypanthium. Hypanthium green, cupuliform, 1.5–2.0 × 1.2–1.5 mm, glabrous; calyx limb lobed nearly to base, lobes 5, green, triangular, ca. 1.5 × 1 mm, apex acuminate, margin ciliate, with denser and longer cilia at apex. Corolla white or virescent, sometimes tinged with red on angles when young, urceolate to spherical, slightly angled when young, 4.5–6 × ca. 4.5 mm, glabrous outside, pubescent inside, 5-lobed; lobes ovate-triangular, reflexed, ca. 1 × 1.2 mm. Stamens 10, 4–4.5 mm long; filaments flat, slightly S-shaped, 1.5–2.0 mm long, puberulous and pubescent adaxially, slightly puberulous abaxially; anthers 3.0–3.5 mm long, thecae 1.5–1.7 mm long, tubules narrower than the thecae, 1.5–1.8 mm long, each with an oblique pore 0.7–1.0 mm long, 0.2–0.3 mm in diam.; spurs 2, borne at abaxial base of tubules, 0.8–1 mm long, echinate. Disc yellowish, annular, glabrous; style cylindrical, slightly angled in sicco, 5.0–5.2 mm long, glabrous, stigma punctate; ovary pseudo-10-locular, each locule with 8–10 ovules. Fruiting pedicel 4–11 mm long, expanded at apex; berry green when young, turning dark red later and finally dark purple at maturity, globose, 4–6.5 mm in diam., glabrous, with persistent calyx lobes appressed at apex. Seeds ovoid, 1.2–1.5 × 0.8–1 mm, testa brownish, reticulate, soft.

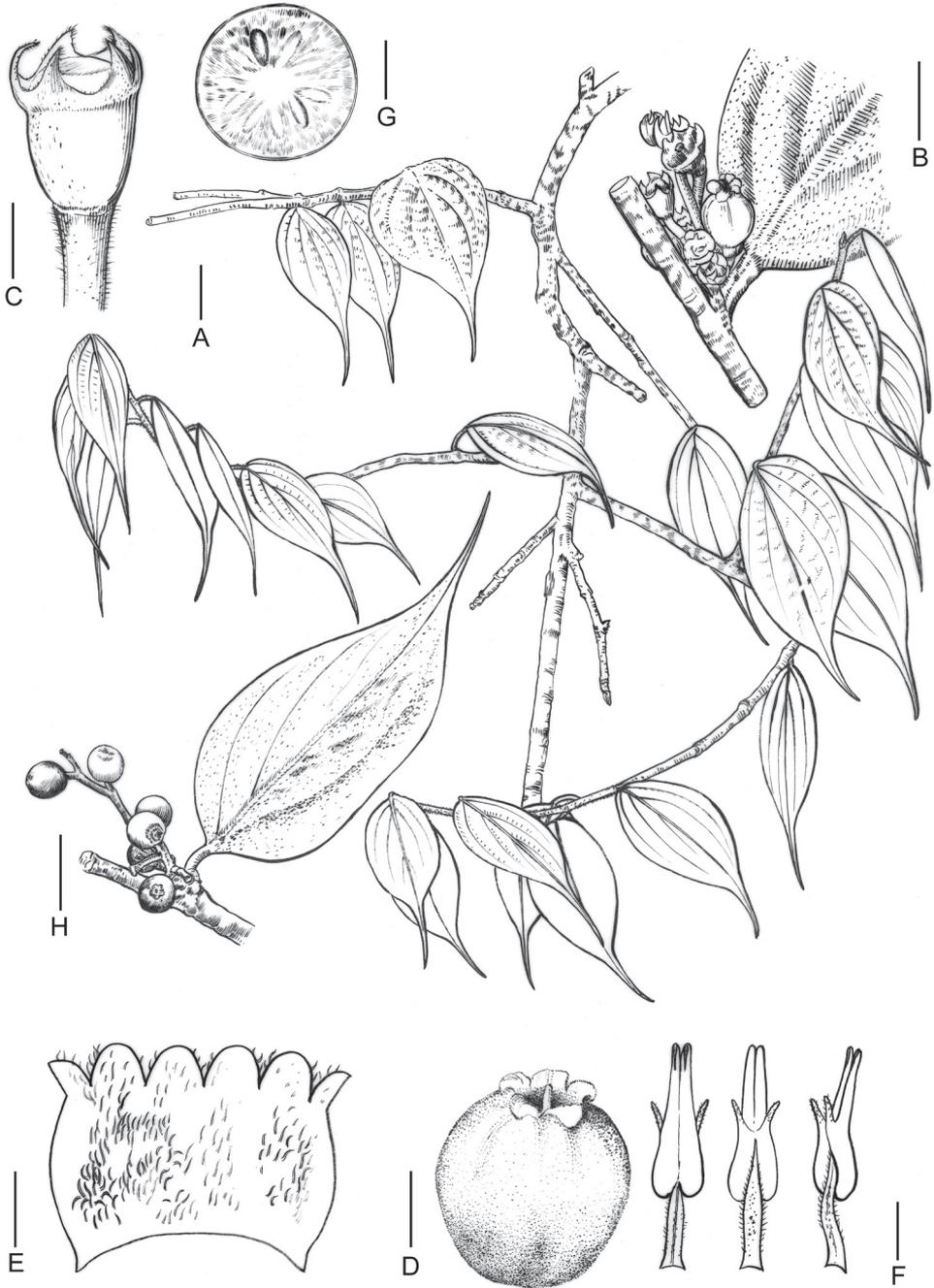


Figure 2. *Vaccinium motuoense* sp. nov. **A** sterile branches with leaves **B** inflorescence **C** calyx **D** corolla **E** opened corolla, showing pubescent internal surface **F** stamens, adaxial, abaxial and lateral view **G** transection of fruit **H** infructescence (Drawn by Ding-Han Cui). Scale bars: 2 cm (**A, B, H**); 5 mm (**C, G**); 2 mm (**D, E**); 1 mm (**F**).

Etymology. The species epithet is named after the type locality, Motuo County.

Vernacular name. 墨脱越橘 (Chinese pinyin: mò tuō yuè jú).

Distribution and habitat. This species is currently known only from Motuo County, Xizang, China. It grows on trees in evergreen broad-leaved forests at elevations of 1600–2300 m.

Conservation status. *Vaccinium motuoense* is common in the forests of Motuo County within an area over 3000 km² and the whole area is under the protection of Yarlung Zangbo Grand Canyon National Nature Reserve. The threat risk seems to be low because it is not economically valuable and the conservation condition of the Reserve is good. Thus, it is assigned a status of ‘Least Concern’ (LC), following the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Committee 2019).

Phenology. Flowering in April–May and fruiting in October–March.

Additional specimens examined (paratypes). CHINA. Xizang, Autonomous Region, Motuo County: 3.5 km away from Bolonggong to Km 52 on Zhamo Road, 31 May 2013 (fl.), *J. Cai, E. D. Liu & Y. J. Guo 13CS7683* (KUN); Km 80 on Zhamo Road, 5 January 2020 (fr.), *Y. H. Tong & B. M. Wang TYH-2381* (IBSC); *ibid.* 12 January 1983 (fr.), *B. S. Li & S. Z. Cheng 02486* (KUN); Beibeng Xiang, Buqiong Hu, 11 November 1992 (fr.), *H. Sun, Z. K. Zhou & H. Y. Yu ETM-1145* (KUN); Beibeng Xiang, Gelin Cun, 20 May 1983 (fl.), *B. S. Li, Z. C. Ni & S. Z. Cheng 03651* (KUN), 3 January 2020 (fr.); *ibid.* *Y. H. Tong & B. M. Wang TYH-2338* (IBSC); Beibeng Xiang, Xirang, Sangxingpeng, 26 April 1983 (fl.), *B. S. Li, Z. C. Ni & S. Z. Cheng 04317* (KUN); Beibeng Xiang, Xirang, Xideng Shan, 25 April 1983 (fl.), *B. S. Li, Z. C. Ni & S. Z. Cheng 04752* (KUN); *ibid.* 12 January 1983 (fr.), *B. S. Li, Z. C. Ni & S. Z. Cheng 02486* (KUN); Damu Xiang, 6 March 1993 (fr.), *H. Sun, Z. K. Zhou & H. Y. Yu ETM-4243* (KUN); Damu Xiang, Dachi Shan, 30 October 1982 (fr.), *B. S. Li & S. Z. Cheng 01600* (KUN, PE); Damu Xiang to Gedang Xiang, 13 March 1993 (fr.), *H. Sun, Z. K. Zhou & H. Y. Yu ETM-4562* (KUN); Gedang Xiang, 21 March 1993 (fr.), *H. Sun, Z. K. Zhou & H. Y. Yu ETM-4920* (KUN); without precise locality, without date, *H. Sun, Z. K. Zhou & H. Y. Yu ETM-2621* (KUN).

Discussion

According to Vander Kloet and Dickinson’s infrageneric classification of *Vaccinium*, *V. medongense* fits well with the circumscription of *V. sect. Calcicolus* Kloet that is characterised by an evergreen habit, dimorphic perennating buds (i.e. floral perennating buds at least twice the size of vegetative perennating buds), racemose inflorescences with large caducous bracts, pseudo-10-locular ovary, berry with 2–5 seeds per locule and soft seed testa (Vander Kloet and Dickinson 2005, 2009). In Xizang, besides *V. dunalianum*, there are two other species from the same section, viz. *V. gaultheriifolium* (Griff.) Hook. f. ex C. B. Clarke and *V. glaucoalbum* Hook. f. ex C. B. Clarke. However, these two species have glabrous and glaucous abaxial surface of leaf blades with serrate margins and acute or acuminate apices and, thus, are easily distinguishable from *V. motuoense*. This new species is common in its area of distribution, usually

growing together with other epiphytic plants on tree trunks covered with mosses, such as orchids, ferns and some other ericaceous species like *Agapetes praeclara* C. Marquand, *A. forrestii* W. E. Evans, *Vaccinium leucobotrys* (Nutt.) G. Nicholson, *V. retusum* Hook. f. ex C. B. Clarke and *V. kingdon-wardii* Sleumer.

Acknowledgements

We are grateful to Zhen Liu from Motuo Forestry Bureau and Xi-Xian Wang from China Railway 12th Bureau Group for their help during field trips. Our thanks also go to the curators of IBSC, KUN and PE for allowing us to examine their specimens and to Mr. Ding-Han Cui for preparing the line drawing. This study was funded by the National Natural Science Foundation of China (grant no. 31870180), Biological Resources Program, Chinese Academy of Sciences (KFJ-BRP-017-33) and the programme of Germplasm Bank of Wild Species, National Science & Technology Infrastructure and the Large-scale Scientific Facilities of the Chinese Academy of Sciences (2017-LSFGBOWS-02).

References

- Fang RC (1986) *Vaccinium*. In: Wu CY (Ed.) Flora Xizangica. Vol 3. Science Press, Beijing, 721–733.
- Fang RC (1991) *Vaccinium*. In: Wu CY (Ed.) Flora Reipublicae Popularis Sinicae. Vol 57(3). Science Press, Beijing, 75–164.
- Fang RC, Stevens PF (2005) *Vaccinium*. In: Wu ZY, Raven PH (Eds) Flora of China. Vol 14. Science Press, Beijing; Missouri Botanical Garden Press, St. Louis, 476–504.
- IUCN Standards and Petitions Committee (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. Prepared by the Standards and Petitions Committee. <http://www.iucnredlist.org/documents/RedListGuidelines.pdf>
- Tong YH, Xia NH (2015) *Vaccinium damingshanense* sp. nov. (Ericaceae) from Guangxi, China. Nordic Journal of Botany 33(1): 74–78. <https://doi.org/10.1111/njb.00581>
- Tong YH, Huang YS, Ye XH, Cai ZY, Xia NH (2020) *Vaccinium napoense*, a new species of *V.* sect. *Conchophyllum* (Ericaceae) from Guangxi, China. Nordic Journal of Botany 2020(12): e02773. <https://doi.org/10.1111/njb.02773>
- Tong YH, Zhu YY, Ye XH, Ye XE, Yang CZ, Xia NH (2021) *Vaccinium zhangzhouense*, a new species endemic to Fujian, China. Nordic Journal of Botany 39(7): 03091. <https://doi.org/10.1111/njb.03091>
- Vander Kloet SP, Dickinson TA (2005) RAPD typification: Phenetic analysis of *Vaccinium* inflorescences. Botanical Journal of the Linnean Society 148(4): 445–457. <https://doi.org/10.1111/j.1095-8339.2005.00429.x>
- Vander Kloet SP, Dickinson TA (2009) A subgeneric classification of the genus *Vaccinium* and the metamorphosis of *V.* section *Bracteata* Nakai: More terrestrial and less epiphytic in habit, more continental and less insular in distribution. Journal of Plant Research 122(3): 253–268. <https://doi.org/10.1007/s10265-008-0211-7>

Microlicia deflexa and *M. johnwurdackiana* (Melastomataceae), two new species from the Brazilian Cerrado

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Abstract

Microlicia deflexa **sp. nov.** and *M. johnwurdackiana* **sp. nov.** are described, illustrated and an updated identification key for the species of *Microlicia* from Clube Caça e Pesca Itororó de Uberlândia is provided. *Microlicia deflexa* occurs in Minas Gerais and Goiás States and is characterised by its linear-lanceolate and deflexed sepal on flower and immature fruit, long pedicel and indumentum of glandular trichomes, mixed with spherical, golden glands. *Microlicia johnwurdackiana* is endemic to Uberlândia and characterised by having indumentum of setose trichomes and spherical, golden glands, magenta petal with greenish abaxial surface at the apex and dimorphic stamens with bicolourous and tetrasporangiate anthers.

Abstract

Microlicia deflexa **sp. nov.** e *M. johnwurdackiana* **sp. nov.** são descritas, ilustradas e uma chave de identificação atualizada para as espécies de *Microlicia* do Clube Caça e Pesca Itororó de Uberlândia é fornecida. *Microlicia deflexa* ocorre nos estados de Minas Gerais e Goiás, e é caracterizada pela sépala linear-lanceolada e deflexa na flor e no fruto imaturo, pedicelo longo e indumento com tricomas glandulares misturados com glândulas esféricas, douradas. *Microlicia johnwurdackiana* é endêmica de Uberlândia, e caracterizada pelo indumento de tricomas setosos e glândulas esféricas, douradas, pétala magenta com a face abaxial esverdeada apenas no ápice e estames dimórficos com anteras bicolores e tetraesporangiatas.

Keywords

Endemism, Microlicieae, Minas Gerais, Goiás, taxonomy

Introduction

Microlicia D. Don is a predominantly Brazilian genus composed of ca. 240 species (Versiane et al. 2021), with most species occurring in the campo rupestre from Minas Gerais, Bahia and Goiás States (Romero 2003a, b; Romero et al. 2020) and about 49 species occurring in the cerrado phytophysiognomy. The species are generally characterised by solitary flowers or, in dichasia, reduced to one flower, with five to six occasionally nine petals, a superior or semi-inferior ovary with three to six locules and capsules dehiscent longitudinally from the apex to the base (basipetal) or from the base to the apex (acropetal) (see Versiane et al. 2021).

The Cerrado domain comprises approximately 23% of the central portion of Brazil and is represented by savannah and forest vegetation (Ribeiro and Walter 2008). Despite its rich and diverse flora (Klink and Machado 2005), the Cerrado has been threatened by economic development for several decades and has been classified as a biodiversity hotspot for more than 20 years (Myers et al. 2000).

The Triângulo Mineiro in western Minas Gerais with a heterogeneous landscape due to its different vegetation types, is included within the Cerrado domain (Novais 2011). Its central portion has an important fragment of vegetation inside a private club, the Clube Caça e Pesca Itororó de Uberlândia, in Uberlândia Municipality. This area has 127 hectares of well-preserved vegetation composed of cerrado, campo sujo, vereda, forest (Apolinário and Schiavini 2002) and a considerable area of campo úmido and campo limpo (Bacci et al. 2016). The inventory of the Melastomataceae from Clube Caça e Pesca Itororó de Uberlândia catalogued 28 species (Bacci et al. 2016); however, the authors were unable to fit some collections of *Microlicia* under any of the existing names in the genus. In this present study, we analysed these collections and confirm that two were undescribed species. Furthermore, from some of the collections from Serra dos Pireneus, Goiás State and Catas Altas, Minas Gerais, one was also recognised as a new species, increasing its geographic distribution. The two new species are described and morphologically compared with similar species. Information about their geographic distribution and conservation status and images of the morphological structures are provided. In addition, the identification key for the species of *Microlicia* in the Clube Caça e Pesca Itororó de Uberlândia is updated.

Methods

This study was based on analysis of *Microlicia* specimens deposited mainly at HUFU, with duplicates at BHCb, HRCb, NY, OUPR, RB, UFG and US Herbaria (acronyms according to Thiers 2021) and on field observations in the Clube Caça e Pesca Itororó de Uberlândia. The general morphological terminology followed Radford et al. (1986) and the indumentum followed Wurdack (1986) and Silva et al. (2018). Distribution data were plotted on a map using the application ArcMap ver. 10.5.1. in ArcGis Desktop (ESRI 2017). The area of occupancy (AOO) and extent of occurrence (EOO) were

calculated using GeoCAT georeferenced data from cited collections (Bachman et al. 2011). Recommended conservation assessments were based on the IUCN Red List Categories and Criteria (IUCN 2019). Images of vegetative and reproductive structures were obtained using a digital camera coupled to a Zeiss stereoscopic microscope and organised on Adobe Photoshop CS6.

Taxonomic treatment

Microlicia deflexa R.Romero & Valentim, sp. nov.

urn:lsid:ipni.org:names:77219658-1

Figs 1–2

Type. BRAZIL. Minas Gerais: Uberlândia, Clube Caça e Pesca Itororó de Uberlândia, 9 June 2011 (fl, fr), *A.F.A. Versiane et al.* 20 (holotype: HUFU!; isotypes: BHCB!, HRCB!, OUPR!, UFG!).

Diagnosis. *Microlicia deflexa* is recognised by the deflexed and linear-lanceolate sepals on flowers and immature fruits, long pedicels (3–5 mm long) and indumentum of glandular trichomes, glands sometimes caducous, mixed with spherical, golden glands covering branch, leaf, pedicel, hypanthium and sepal.

Description. Subshrub or shrub, 0.3–0.8 m tall, erect, multi-branched. Stem terete, glabrous, brownish. Branch fastigiate, younger branch quadrangular, green, densely covered with glandular trichomes 0.4–0.8 mm long and spherical, golden glands, older branch terete, brownish, leafless with age. Leaf ascending, not imbricate; petiole up to 0.6 mm long, leaf rarely sessile; blade 3–18.5 × 1.5–10.5 mm, leaf larger in the main branch, concolorous (when dry), green, sometimes with magenta or yellow-brownish spots on both surfaces, chartaceous, oblong to ovate-oblong, sometimes elliptic, rarely lanceolate, acute at the apex, with a terminal setose trichome 0.1–0.4 mm long, base rounded, margin slightly sinuous to serrate-dentate, glandular-ciliate, both surfaces with a dense indumentum of glandular trichomes 0.4–0.8 mm long, glands sometimes caducous, mixed with spherical, golden or sometimes vinaceous glands, 3–5-veined, veins conspicuously visible on both surfaces, impressed on the adaxial surface, thickened and prominent on abaxial surface. Flower 5-merous, solitary, terminal or lateral, perianth actinomorphic; pedicel 3–5 mm long; hypanthium 1.8–2.3 × 1–2 mm, green, cylindrical, with a dense indumentum of glandular trichomes 0.1–0.8 mm long, glands sometimes caducous, mixed with spherical, golden glands, calyx tube ca. 0.2 mm long, sepal 3–3.2 × 0.5–1.2 mm, longer than the length of the hypanthium, deflexed, green, sometimes magenta at the apex (when dry), linear-lanceolate, acute at the apex, with a terminal setose trichome 0.1–0.4 mm long, with glandular trichomes 0.1–0.3 mm long, glands sometimes caducous, mixed with spherical, golden glands; petal 6–7 × 3–4.5 mm, pinkish, oblong or obovate, acute at the apex, margin entire, glabrous; stamen 10, dimorphic, anther bicolorous, tetrasporangiate; larger (antese-palous) stamen with filament 2.5–3.7 mm long, lilac, pedoconnective 1.5–2.5 mm

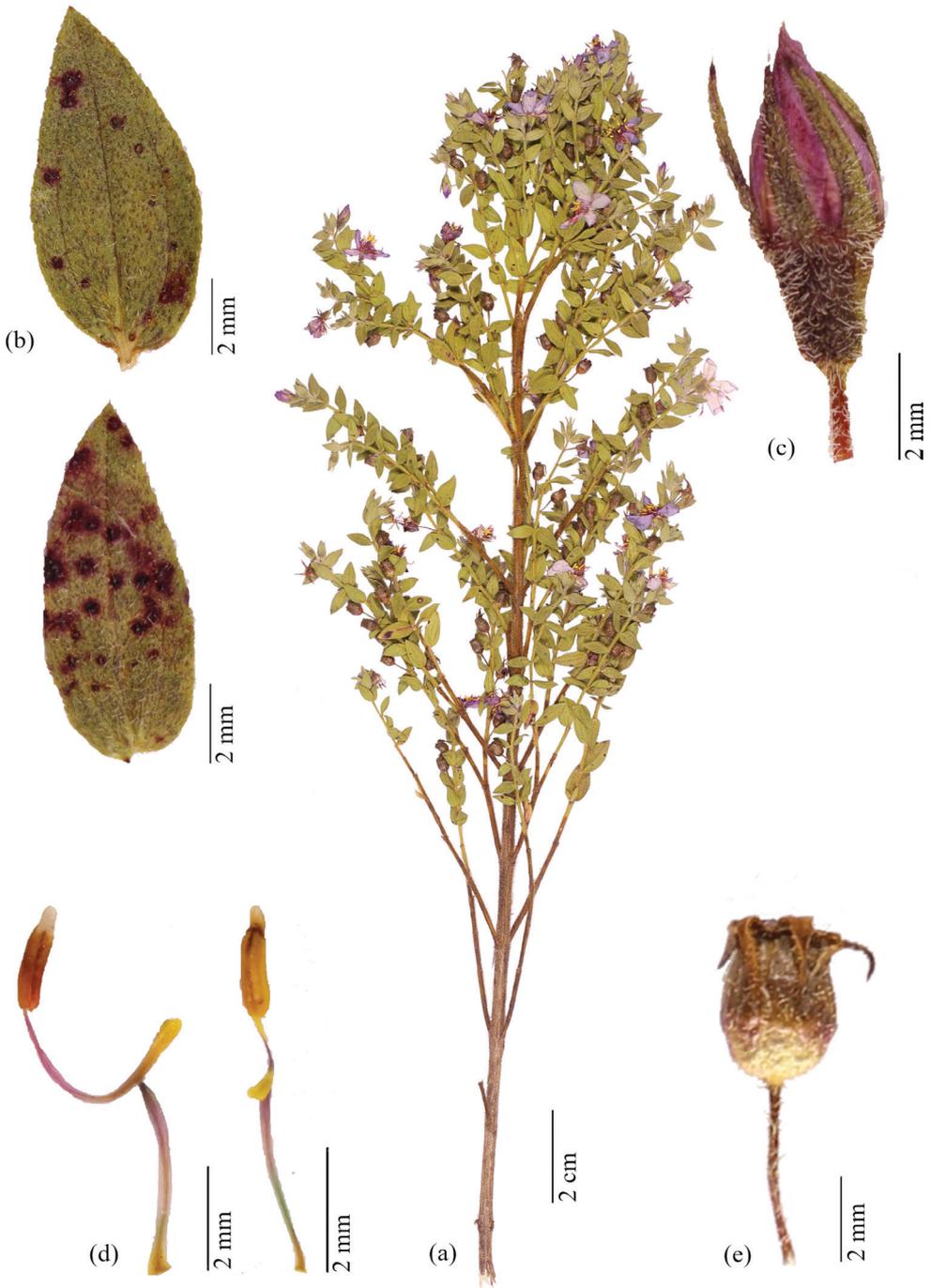


Figure 1. *Microlicia deflexa* R.Romero & Valentim **A** flowering branch **B** leaf abaxial surface (up) and adaxial surface (down) **C** floral bud **D** larger (antesealous) stamen (on the left) and smaller (an-terpetalous) stamen (on the right) **E** immature fruit enveloped by the hypanthium with deflexed sepals (**A, E** R. Romero 8690 **B–D** A.F.A. Versiane 20).



Figure 2. *Microlicia deflexa* R.Romero & Valentim **A** cerrado landscape at Uberlândia, Triângulo Mineiro, Brazil, the type locality of *M. deflexa* **B** habit **C** details of the deflexed sepals on the flower and immature fruits **D** flower bud **E** flower in frontal view **F** flower in lateral view **G** immature fruit. Photos: Rosana Romero.

long, lilac, ventral appendage 0.7–1.2 mm long, yellow, retuse or sometimes slightly bilobed at the apex, anther 1.8–2.2 mm long including beak, pinkish, sometimes with yellow spots, oblong, beak 0.2–0.4 mm long, white; smaller (antepetalous) stamen with filament 2.4–3.7 mm long, lilac, pedoconnective 0.7–1.2 mm long, lilac, ven-

tral appendage 0.2–0.4 mm long, yellow, retuse at the apex, anther ca. 1.5 mm long including beak, yellow, oblong, beak 0.2–0.4 mm long, yellow; ovary 3–5-locular, sub-globose to terete, superior, glabrous; style 3.5–6.5 mm long, terete, slightly curved, pinkish, glabrous; stigma punctiform. Capsule 2.7–4.2 × 1.3–2.7 mm, brownish, globose, dehiscent into 3–5 valves from the apex, hypanthium enveloping the entire capsule and peeling off top to bottom as the fruit mature, columella deciduous; seed 0.2–0.4 × 0.1–0.3 mm, pale brown, oblong, testa foveolate.

Distribution and habitat. *Microlicia deflexa* is found in Minas Gerais, in Uberlândia, occurring in campo sujo near vereda, at ca. 860 m elevation and in Catas Altas, in a shaded area of cerrado, at 1085 m elevation. It also occurs in Goiás, in Cocalzinho de Goiás, in campo sujo near vereda, at 1220 m elevation (Fig. 3).

Conservation status. *Microlicia deflexa* has a restricted area of occupancy (AOO = 12 km²) and should be preliminarily assessed as Endangered [(EN) B2ab (iii)], following the IUCN (2019) guidelines. Only the populations in Cata Altas are protected since it occurs inside the Reserva Patrimônio Natural Santuário do Caraça.

Phenology. Flowers have been collected in April and from July to September and fruits from July to October.

Etymology. The specific epithet “deflexa” refers to the sepal characteristically deflexed on flower and immature fruit i.e. turned abruptly downwards.

Discussion. *Microlicia deflexa* is morphologically similar to *M. serpyllifolia* D. Don, which occurs in Rio de Janeiro, Minas Gerais, Goiás, Bahia and Distrito Federal (Silva and Romero 2008, as *M. fulva*; Romero and Woodgyer 2015; Romero et al. 2020) in campo rupestre, campo limpo and cerrado. Both species have long pedicel and sepal, dimorphic stamen with bicolorous and tetrasporangiate anther. *Microlicia serpyllifolia* differs in having a very peculiar velutinous indumentum composed of thin, short and soft trichomes covering branch, leaf, pedicel, hypanthium and sepal mixed with spherical glands (vs. glandular indumentum mixed with spherical, golden glands in *M. deflexa*). The sepal in *M. serpyllifolia* is triangular and ascending (vs. linear-lanceolate and deflexed). *Microlicia deflexa* also bears some resemblance to *Microlicia helvola* (Spreng.) Triana, which occurs in Goiás, Mato Grosso do Sul, Mato Grosso and Minas Gerais States (Romero et al. 2020; Versiane et al. 2020) in campo limpo, campo sujo and the edges of vereda and swamp areas (Bacci et al. 2016; Versiane et al. 2016) and less frequently in cerrado rupestre (Machado and Romero 2020). *Microlicia deflexa* and *M. helvola* are subshrub or shrub with sessile leaf or with a short petiole, acute at the apex, rounded at the base and 3–5-veined. Furthermore, both species have pinkish petal and dimorphic stamens with bicolorous anthers. However, *M. helvola* differs in having an indumentum of setose trichomes mixed with spherical glands (vs. glandular trichomes mixed with spherical glands in *M. deflexa*), urceolate and 10-striate hypanthium (vs. cylindrical and not striate), sepal shorter than the hypanthium length (vs. sepal longer than the hypanthium length) and polysporangiate anther (vs. tetrasporangiate). *Microlicia deflexa* also resembles *M. phlogiformis* (DC.) Versiane & R. Romero, which also occurs in the Clube Caça e Pesca Itororó de Uberlândia, in campo úmido or inside the vereda on waterlogged soil (Bacci et al. 2016). The indumentum, the sepals and the

Table 1. Comparative features between *Microlicia deflexa* and relatives.

Characters/species	<i>M. deflexa</i>	<i>M. helvola</i>	<i>M. phlogiformis</i>	<i>M. serpyllifolia</i>
Petiole (mm)	Absent or up to 0.6	Absent or up to 0.5	Absent or 2–5	Absent or ca. 0.4
Pedicle (mm)	3–5	0.7–1	2–9	1.3–3
Leaf trichomes	Glandular trichomes, and spherical glands	Setose and spherical glands	Glandular trichomes	Setose and spherical glands
Hypanthium shape	Cylindrical	Urceolate	Urceolate	Campanulate
Sepal length (mm)	3–3.2	1–2	3.5–4	1.3–4
Sepal	Deflexed	Ascending	Ascending	Ascending
Anther sporangia	Tetrasporangiate	Polysporangiate	Tetrasporangiate	Tetrasporangiate
Distribution	Minas Gerais, Goiás	Goiás, Mato Grosso do Sul, Mato Grosso, Minas Gerais	Paraná, Espírito Santo, Minas Gerais, Rio de Janeiro, São Paulo, Goiás, Mato Grosso do Sul, Mato Grosso, Bahia, Distrito Federal	Rio de Janeiro, Minas Gerais, Goiás, Bahia, Distrito Federal

long pedicel of both species are similar; however, *M. phlogiformis* differs in having flowers in dichasia (vs. solitary) and ascending sepals (vs. deflexed). Table 1 includes additional features comparing *M. helvola*, *M. phlogiformis* and *M. serpyllifolia* to *M. deflexa*.

Additional specimens examined (paratypes). BRAZIL. Goiás: Cocalzinho de Goiás, estrada para plantação de eucalipto final da estrada, 26 April 2012 (fl), *J.N. Nakajima et al.* 5083 (BHCB!, HRCB!, HUFU!, NY!, RB!, UFG!, US!). Minas Gerais: Catas Altas, Reserva Patrimônio Natural Santuário do Caraça, trilha para a cascatinha, 18 October 2016 (fr), *M. Castro et al.* 180 (BHCB!, HUFU!); Uberlândia, Clube Caça e Pesca Itororó de Uberlândia, 21 March 2011, *A.F.A. Versiane et al.* 2 (HUFU!, SP!, UEC!); idem, 6 April 2011 (fl), *A.F.A. Versiane* 10 (HUFU!, NY!, OUPR!, RB!); idem, 12 July 2011 (fl, fr), *A.F.A. Versiane et al.* 29 (HUFU!, HRCB!); idem, 12 July 2011 (fl, fr), *A.F.A. Versiane et al.* 30 (HUFU!, K!, P!); idem, 12 July 2011 (fl, fr), *A.F.A. Versiane et al.* 32 (HUFU!); idem, 26 August 2015 (fl, fr), *R. Romero et al.* 8690 (HUFU!, OUPR!); idem, 9 September 2015 (fl, fr), *R. Romero et al.* 8693 and 8695 (HUFU!); idem, 4 February 2017 (fl), *A.P.S. Caetano* 52 (HUFU!); idem, 10 May 2018 (fl, fr), *R.V. Brito et al.* 37 (HUFU!).

***Microlicia johnwurdackiana* R.Romero & Valentim, sp. nov.**

urn:lsid:ipni.org:names:77219659-1

Figs 4–5

Type. BRAZIL. Minas Gerais: Uberlândia, 26 August 2015 (fl, fr), *R. Romero et al.* 8687 (holotype: HUFU!; isotypes: BHCB!, K!, OUPR!, P!, RB!, UEC!).

Diagnosis. *Microlicia johnwurdackiana* is recognised by its dense indumentum of setose trichomes and spherical, golden glands covering branch, leaf, pedicel, hypanthium and sepal, magenta petal with greenish apex on the abaxial surface and bicolorous and tetraesporangiate anther.

Description. Subshrub or shrub, 0.3–1 m tall, erect, multi-branched. Stem terete, brownish. Branch fastigiate, younger branch quadrangular, green, densely

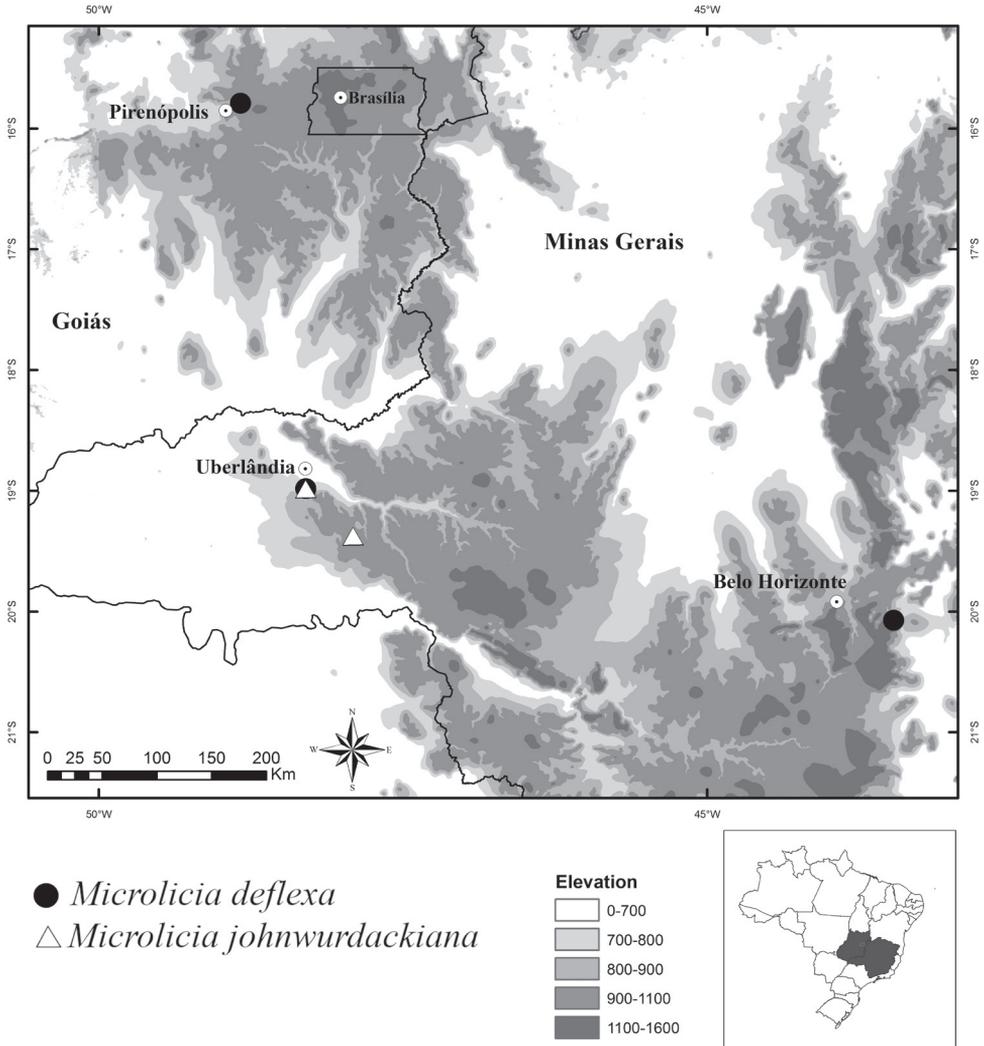


Figure 3. Geographical distribution of *Microlicia deflexa* and *Microlicia johnwurdackiana* in Minas Gerais and Goiás States, Brazil.

covered of setose, pale trichomes 0.2–0.3 mm long mixed with spherical, golden glands, older branch sub-quadrangular, brownish, leafless with age. Leaf ascending, not imbricate; petiole ca. 0.3 mm long, leaf rarely sessile; blade 3.5–9.5 × 1.7–7 mm, leaf with the same size in the main and lateral branches, concolorous (when dry), green-brownish, chartaceous, ovate, acute at the apex, base rounded, margin crenulate, setose-ciliate, both surfaces with a dense indumentum of setose, pale trichomes 0.2–0.3 mm long mixed with spherical, golden glands, 3-veined, rarely 5-veined. Flower 5-merous, solitary, terminal or lateral, perianth actinomorphic; pedicel 0.8–1.2 mm long; hypanthium 2.3–3 × ca. 1.5 mm, light green, cylindrical, with a dense indumentum of setose, pale trichomes 0.2–0.3 mm long mixed with spherical,

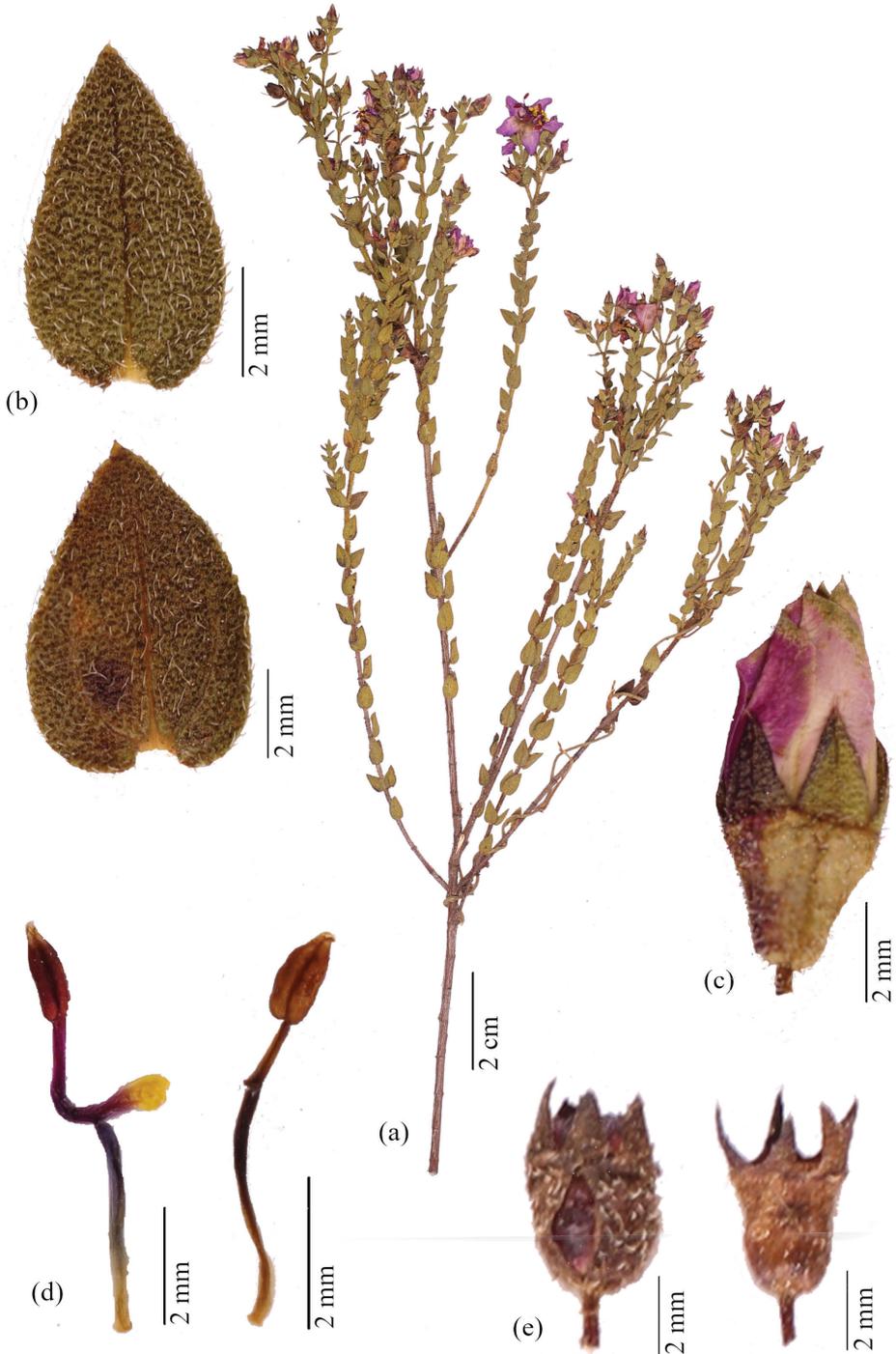


Figure 4. *Microlicia johnwurdackiana* R.Romero & Valentim **A** flowering branch **B** leaf abaxial surface (up) and adaxial surface (down) **C** floral bud **D** larger (antepetalous) stamen (on the left) and smaller (anthesepalous) stamen (on the right) **E** capsule in two stages: immature enveloped by the hypanthium (on the right) and mature with hypanthium peeling off (on the left) (**A, E** A.F.A. Versiane et al. 57 **B–D** M.L. Viana 4).



Figure 5. *Microlicia johnwurdackiana* R.Romero & Valentim **A** cerrado landscape at Uberlândia, Triângulo Mineiro, Brazil, the type locality of *M. johnwurdackiana* **B** habit **C** flowering branches **D** flower in lateral view **E** flower in front view, detail of a greenish apex in the petals in the flower bud **F** immature fruits. Photos: Rosana Romero.

golden glands; calyx tube ca. 0.3 mm long; sepal 1.5–2 × 1–1.5 mm, vinaceous, triangular, with a dense indumentum of setose, pale trichomes 0.2–0.3 mm long mixed with spherical, golden glands, acute at the apex, with a terminal setose trichome ca. 0.2 mm long; petal 4.5–8 × 3.5–5 mm, magenta, greenish at the apex on the abaxial surface, obovate, acute or asymmetrically acuminate at the apex, margin entire, with sparse, spherical, golden glands at the apex; stamen 10, dimorphic, anther bicolorous, tetrasporangiate; larger (antesepalous) stamen, with filament 2.5–3 mm long, vinaceous, pedoconnective 1.8–2.5 mm long, vinaceous, ventral appendage ca. 1 mm long, with proximal half magenta, distal half yellow, obtuse at the apex, anther 2–2.5 mm long including beak, vinaceous, ovate-oblong, beak 0.4–0.6 mm long, white; smaller (antepetalous) stamen with filament 2–3 mm long, vinaceous, pedoconnective ca. 0.8 mm long, yellow, ventral appendage ca. 0.1 mm long, yellow, retuse at the apex, anther 1.5–1.8 mm long including beak, yellow, ovate-oblong, beak 0.3–0.5 mm long, yellow; ovary 3-locular, ovate to ovate-elliptic, superior, glabrous; style 4–4.5 mm long, magenta, terete, slightly curved, glabrous; stigma punctiform. Capsule 4–4.5 × 2–2.5 mm brownish to reddish, globose, dehiscent into 3-valves from the apex, hypanthium and sepals enveloping the entire capsule and peeling off top to bottom as the fruit mature, columella deciduous; seed 0.3–0.5 × 0.2–0.3 mm, brownish or reddish, oblong, testa foveolate.

Distribution and habitat. *Microlicia johnwurdackiana* is endemic to Uberlândia, city of the Triângulo Mineiro, western Minas Gerais, Brazil. It occurs at Clube Caça e Pesca Itororó de Uberlândia in campo sujo near to vereda, on sandy soil, and in a private area in campo úmido with murundus (see Paulino et al. 2015) in the upper course of the Bacia do Rio Uberabinha, about 850 m elevation (Fig. 3).

Conservation status. *Microlicia johnwurdackiana* has a restricted area of occupancy (AOO = 12 km²) and, according to the IUCN Categories and Criteria (IUCN 2019), we recommend a conservation status of Critically Endangered [CR B1ab (iii) + 2ab (iii)]. According to the Brazilian Forest Code (Law 12.651/2012), the vereda in rural or urban areas are permanent preservation areas (APP). However, both localities, where *M. johnwurdackiana* occurs, are not protected by any conservation unit. Large populations occur at Clube Caça e Pesca Itororó de Uberlândia, a well-preserved vegetation fragment, located in the urban area of Uberlândia, recognised in 1992 as Reserva Particular de Patrimônio Natural (RPPN) (IBAMA 1992). However, the ordinance was revoked by the same Institute (IBAMA 2000) for lack of proper documentation, making this area vulnerable, except for the vereda and its surroundings, which is a permanent preservation area. Nevertheless, in recent years, this area has been heavily impacted by periodic fires, predatory collections, real estate speculation and the opening of trails for cyclists in the interior of the cerrado. The other area of occurrence is private property that has been seriously affected by the expansion of agriculture, invasion of exotic *Pinus* species, removal of refractory clay and frequent burning caused by farmers. As a result of so many threats, the civil society from Uberlândia has made an effort, through the non-governmental organisation Angá (Associação para a Gestão

Socioambiental do Triângulo Mineiro), for part of this area to become a permanent preservation area (P.K.B. Hemsing, pers. comm.).

Phenology. Flowers and fruits have been collected from March to May and from July to December.

Etymology. The specific epithet honours John Julius Wurdack (1921–1998), an American botanist who dedicated part of his life to studying the Melastomataceae family and described more than 900 species (see IPNI 2021). About 20 years ago, Wurdack examined the first collections of *Microlicia* made at Clube Caça e Pesca Itororó de Uberlândia (Romero *et al.* 535 at US) and indicated that it was likely a new species.

Discussion. *Microlicia johnwurdackiana* is similar to *M. hirticalyx* Romero & Woodgyer, which is endemic to the south of the Espinhaço Range, Minas Gerais State, occurring in campo rupestre (Romero and Woodgyer 2011). Both species have a dense indumentum of setose trichomes mixed with spherical, golden glands covering branch, leaf, hypanthium and sepal, 5-merous flower, solitary, terminal and lateral, dimorphic stamens with bicolorous and tetrasporangiate anthers. *Microlicia hirticalyx* differs in having oblong-campanulate hypanthium with patent trichomes 0.5–1.5 mm long (vs. cylindrical, ascending trichomes 0.2–0.3 mm long in *M. johnwurdackiana*), sepal 2–3.5 mm long (vs. 1.5–2 mm long) and petal apiculate at the apex (vs. acute or asymmetrically acuminate, not apiculate). *Microlicia johnwurdackiana* also bears some resemblance to *M. fasciculata* Martius ex Naudin and *M. polystemma* Naudin. *Microlicia fasciculata* occurs in São Paulo, Minas Gerais, Goiás, Bahia and Distrito Federal (Silva and Romero 2008; Romero *et al.* 2020) in campo rupestre, cerrado, campo limpo, campo sujo and campo úmido, while *M. polystemma* occurs in São Paulo, Minas Gerais, Goiás and Distrito Federal (Silva and Romero 2008; Romero and Woodgyer 2015; Bacci *et al.* 2016; Romero *et al.* 2020) in campo rupestre and campo úmido. Both species are similar to *M. johnwurdackiana* in having setose trichomes and spherical glands covering the branch, leaf, pedicel, hypanthium and sepal. However, *M. fasciculata* has a villous indumentum with white trichomes that give a glaucous tonality to the plant (vs. setose indumentum with pale trichomes in *M. johnwurdackiana*), campanulate hypanthium (vs. cylindrical), petal entirely pink (vs. magenta, greenish at the apex on the abaxial surface), rounded at the apex (vs. acute or asymmetrically acuminate), ciliate-glandular margin (vs. with sparse, spherical, golden glands only at the apex) and polysporangiate anther (vs. tetrasporangiate). *Microlicia polystemma* differs in having campanulate hypanthium (vs. cylindrical in *M. johnwurdackiana*), yellow stamens, sometimes with pink spots in the anther (vs. vinaceous anther in the antesealous whorl and yellow in the antepetalous one) and ovate-triangular sepal with a conspicuous setose trichome ca. 0.8 mm long at the apex (vs. triangular, trichome ca. 0.2 mm long). Table 2 includes additional features comparing *M. hirticalyx*, *M. fasciculata* and *M. polystemma* to *M. johnwurdackiana*.

Additional specimens examined (paratypes). BRAZIL. Minas Gerais: Uberlândia, Clube Caça e Pesca Itororó de Uberlândia, 22 October 1993 (fl, fr), R. Romero *et al.* 535 (HUFU!, US!); idem, 30 November 1993 (fl, fr), R. Romero & A.A. Arantes 553 (HUFU!); idem, 1 December 1993 (fl, fr), R. Romero & J.N. Nakajima 559 (HUFU!); idem, 22 March 1994 (fl, fr), R. Romero 780 (HUFU!, K!); idem, 17 May 1994 (fl),

Table 2. Comparative features between *Microlicia johnwurdackiana* and relatives.

Characters/species	<i>M. fasciculata</i>	<i>M. hirticalyx</i>	<i>M. johnwurdackiana</i>	<i>M. polystemma</i>
Hypanthium shape	Campanulate	Oblong-campanulate	Cylindrical	Campanulate
Sepal length (mm)	1.6–2.3	2–4	1.5–2	2.5–4.4
Sepal shape	Triangular	Narrowly triangular	Triangular	Ovate-triangular
Petal apex	Acute, asymmetrically acute, or rounded	Apiculate	Acute or asymmetrically acuminate	Rounded
Anther, numbers of sporangia	Polysporangiate	Tetrasporangiate	Tetrasporangiate	Tetrasporangiate
Anthers colours	Bicolorous, rarely concolorous	Bicolorous	Bicolorous	Concolorous
Distribution	São Paulo, Minas Gerais, Goiás, Bahia, Distrito Federal	Minas Gerais	Minas Gerais	São Paulo, Minas Gerais, Goiás, Distrito Federal

R. Romero et al. 1004 (HUFU!); idem, 24 May 1994 (fr), *R. Romero & A.A. Arantes 1013* (BHCBI, HUFU!); idem, 9 October 1998 (fl, fr), *G.M. Araújo s.n.* (HUFU 17845!); idem, 4 December 1998 (fl), *A.F. Amaral et al 1419* (HUFU!); idem, 5 March 1999, *A.A.A. Barbosa 1912* (HUFU!, SP!); idem, 29 November 2002 (fl), *A.A.A. Barbosa s.n.* (HUFU 31783!); idem, 14 April 2009 (fl, fr), *R. Romero et al. 8212* (HUFU!, UEC!); idem, 26 May 2011 (fl, fr), *A.F.A. Versiane & L.F. Bacci 17* (HUFU!, P!, US!); idem, 27 July 2011 (fl, fr), *A.F.A. Versiane & L.F. Bacci 34* (HUFU!, RB!); idem, 1 September 2011 (fl, fr), *A.F.A. Versiane et al. 39* (HUFU!, K!, P!, SP!, US!); idem, 1 November 2011 (fl, fr), *A.F.A. Versiane et al. 57* (HUFU!, SP!, UEC!, UFG!); idem, 22 August 2012 (fl, fr), *A.F.A. Versiane et al. 243* (HUFU!); idem, 26 October 2015, *R. Romero 8687* (HUFU!); idem, 6 November 2015 (fl, fr), *F.L. Contro et al. 169* (HUFU!); idem, 6 November 2015 (fl, fr), *J.N. Nakajima 5100* (HUFU!); idem, 9 May 2016 (fl, fr), *R. Romero 8825* (HUFU!, RB!); idem, 16 March 2017 (fl, fr), *P.K.B. Hemsing et al. 564* (HUFU!) and *571* (HUFU!); idem, 30 October 2017 (fl, fr), *J. Santiago et al. s.n.* (HUFU 75665!); idem, 30 October 2017 (fl, fr), *R.G. Clemente et al. s.n.* (HUFU 75682!); idem, 9 March 2018 (fr), *M.L. Viana 4* (HUFU!); idem, 7 May 2018 (fl, fr), *F. L. Jesus et al. s.n.* (HUFU 76820!); idem, 7 May 2018 (fl, fr), *T. R. Leal & V. R. Teixeira s.n.* (HUFU 76818!); idem, 10 May 2018 (fl, fr), *R.V. Brito et al. 42* (HUFU!); Bacia do Rio Uberabinha, 19°22'33"S, 47°54'44"W, 9 October 2014 (fl, fr), *P.K.B. Hemsing & J.C. Aguilar 328* (BHCBI, HUFU!, OUPR!).

Key to the species of *Microlicia* from Clube Caça e Pesca Itororó de Uberlândia, Minas Gerais State, Brazil

- 1 Flower 6-merous; capsule dehiscent from the base *Microlicia macrantha*
- Flower 5-merous; capsule dehiscent from the apex..... 2
- 2 Anther polysporangiate..... 3
- Anther tetrasporangiate..... 4
- 3 Leaf blade with glaucous, villous indumentum; hypanthium campanulate....
.....*Microlicia fasciculata*
- Leaf blade with greenish to yellowish, setose indumentum; hypanthium urceolate*Microlicia helvola*
- 4 Petal white to pinkish-white or cream to white with pink vein..... 5

- Petal pinkish or magenta..... **6**
- 5 Leaf discolorous (darker adaxial surface), revolute at the margin; petiole 6–10 mm long; flower with a short pedicel (1–2 mm long) *Microlicia parviflora*
- Leaf concolorous (green), flat at the margin; petiole 2–3 mm long; flower with a long pedicel (6–9 mm long) *Microlicia phlogiformis*
- 6 Main branch with leaf larger than in the lateral branches **7**
- Main and lateral branches with the same size leaf..... **8**
- 7 Leaf blade cordate; hypanthium campanulate; sepal positioned horizontally on flower and immature fruit..... *Microlicia cordata*
- Leaf blade oblong to ovate-oblong, sometimes elliptic, rare lanceolate; hyp-anthium cylindrical; sepal deflexed on flower and immature fruit *Microlicia deflexa*
- 8 Stamen with concolorous anther (yellow), sometimes with vinaceous spots; petal longer than 8.5 mm..... *Microlicia polystemma*
- Stamen with bicolorous anther (vinaceous and yellow); petal less than 8 mm **9**
- 9 Leafblade with dense indumentum of setose trichomes and spherical glands; hypanthium cylindrical; petal with greenish abaxial surface at the apex *Microlicia johnwurdackiana*
- Leafblade with sparse indumentum of spherical glands; hypanthium campanulate; petal entirely magenta..... *Microlicia trembleyiformis*

Bacci et al. (2016) catalogued seven species of *Microlicia* to Clube Caça e Pesca Itororó de Uberlândia: *M. cordata* (Spreng.) Cham., *M. fasciculata*, *M. helvola*, *M. polystemma*, *M. macrantha* Versiane & R.Romero (as *Lavoisiera grandiflora* A.St.-Hil. ex Naudin), *M. parviflora* (D.Don) Versiane & R.Romero (as *Trembleya parviflora* D.Don) and *M. phlogiformis* (DC.) Versiane & R.Romero (as *Trembleya phlogiformis* DC.) and we add here three more species: *M. deflexa*, *M. johnwurdackiana* and *M. trembleyiformis* Naudin.

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References

- Apolinário V, Schiavini I (2002) Levantamento Fitossociológico de espécies arbóreas de Cerrado (stricto sensu) em Uberlândia - Minas Gerais. *Boletim do Herbário Ezechias Paulo Heringer* 10: 57–75.
- Bacci LF, Versiane AFA, Oliveira ALF, Romero R (2016) Melastomataceae na RPPN do Clube Caça e Pesca Itororó, Uberlândia, MG, Brasil. *Hoehnea* 43(4): 541–556. <https://doi.org/10.1590/2236-8906-27/2016>
- Bachman S, Moat J, Hill AW, de la Torre J, Scott B (2011) Supporting red list threat assessments with GeoCAT: Geospatial conservation assessment tool. *ZooKeys* 150: 117–126. <https://doi.org/10.3897/zookeys.150.2109>
- ESRI (2017) ArcGIS Desktop. Release 10 V.5.1 Redlands, California, USA, Environmental Systems Research Institute.
- IBAMA (1992) Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis. Portaria Normativa nº 84/1992, de 7 de agosto de 1992. Reconhecimento oficial da Reserva Particular do Patrimônio Natural do Clube de Caça e Pesca Itororó.
- IBAMA (2000) Instituto Brasileiro do Meio Ambiente e dos Recursos Renováveis. Portaria Normativa nº 44/2000, de 23 de agosto de 2000. Revogação da Portaria Normativa nº 84/1992.
- IPNI (2021) International Plant Names Index. <http://www.ipni.org> [accessed June 2021]
- IUCN (2019) Guidelines for Using the IUCN Red List Categories and Criteria. Version 14. <https://www.iucnredlist.org/documents/RedListGuideLines.pdf> [accessed July 2021]
- Klink CA, Machado RB (2005) Conservation of the Brazilian Cerrado. *Conservation Biology* 19(3): 707–713. <https://doi.org/10.1111/j.1523-1739.2005.00702.x>
- Machado AIMR, Romero R (2020) Melastomataceae in the Parque Estadual da Serra Dourada, Goiás state, Brazil. *Phytotaxa* 450(1): 17–54. <https://doi.org/10.11646/phytotaxa.450.1.3>
- Myers N, Mittermeier RA, Mittermeier CG, da Fonseca GAB, Kent J (2000) Biodiversity hotspots for conservation priorities. *Nature* 403(6772): 853–858. <https://doi.org/10.1038/35002501>
- Novais GT (2011) Caracterização Climática da Mesorregião do Triângulo Mineiro/Alto Paranaíba e do Entorno da Serra da Canastra. Novais GT, Uberlândia, Minas Gerais, 189 pp.
- Paulino HB, Assis PCR, Vilela LAF, Curi N, Carbone AMA (2015) Campos de murundus: Gênese, paisagem, importância ambiental e impacto na agricultura nos atributos do solo. In: Nascimento CWA (Eds) *Tópicos em ciência do solo*. Sociedade Brasileira de Ciência do solo, 172–211.

- Radford AE, Dickison WC, Massey JR, Bell CR (1986) Fundamentals of plant systematics. Harper and Row, New York, 498 pp.
- Ribeiro JF, Walter BMT (2008) As principais fitofisionomias do bioma Cerrado. In: Sano SM, Almeida SP, Ribeiro JF (Eds) Cerrado: ecologia e flora. Brasília, 151–212.
- Romero R (2003a) Revisão taxonômica de *Microlicia* sect. Chaetostomoides (Melastomataceae). Brazilian Journal of Botany 26(4): 429–435. <https://doi.org/10.1590/S0100-84042003000400001>
- Romero R (2003b) A newly described species of *Microlicia* (Melastomataceae) from Minas Gerais, Brazil. Novon 13(1): 116–118. <https://doi.org/10.2307/3393575>
- Romero R, Woodgyer EM (2011) *Microlicia hirticalyx* (Melastomataceae): A new name for *Microlicia acuminata* Cogn. Kew Bulletin 66(1): 163–165. <https://doi.org/10.1007/s12225-011-9264-1>
- Romero R, Woodgyer EM (2015) *Microlicia*: Lista de Espécies da Flora do Brasil. Jardim Botânico do Rio de Janeiro. <http://floradobrasil.jbrj.gov.br/jabot/floradobrasil/FB9782> [accessed 10 June 2021]
- Romero R, Fontelas JC, Moreira KVC, Ferreira-Alves R, Oliveira LFA, Versiane AFA (2020) *Microlicia*. Flora do Brasil 2020. Jardim Botânico do Rio de Janeiro. <http://reflora.jbrj.gov.br/reflora/floradobrasil/FB9782> [accessed June 2021]
- Silva MAO, Romero R (2008) Melastomataceae das serras do município de Delfinópolis, Minas Gerais, Brasil. Rodriguésia 59(4): 609–647. <https://doi.org/10.1590/2175-7860200859401>
- Silva KR, Romero R, Simão DG (2018) Leaf characters of *Lavoisiera*, *Microlicia* and *Trembleya* (Microlicieae, Melastomataceae) and their implications for taxonomy. Feddes Repertorium 129(2): 123–136. <https://doi.org/10.1002/fedr.201700019>
- Thiers B (2021) [continuously updated] Index Herbariorum: a global directory of public herbaria and associated staff. New York Botanical Garden's Virtual Herbarium. <http://sweetgum.nybg.org/science/ih/> [accessed April 2021]
- Torres W (2018) Empresários querem investir R\$ 1,3 bi no Clube Caça e Pesca. Diário de Uberlândia, Uberlândia, May 2018. <https://diariodeuberlandia.com.br/noticia/16825/empresarios-querem-investir-r-1-3-bi-no-clubecaca-e-pesca> [accessed 23 December 2019]
- Versiane AFA, Santos ML, Romero R (2016) Melastomataceae na Serra dos Pirineus, Goiás, Brasil. Rodriguésia 67: 721–759. <https://doi.org/10.1590/2175-7860201667314>
- Versiane AFA, Silva DN, Romero R (2020) A new species of *Microlicia* (Melastomataceae) from Bolivia and Brazil, a new synonym, and an identification key for the genus in Mato Grosso, Brazil. Phytotaxa 455(1): 9–20. <https://doi.org/10.11646/phytotaxa.455.1.2>
- Versiane AFA, Romero R, Reginato M, Welker CAD, Michelangeli FA, Goldenberg R (2021) Phylogenetic analysis of Microlicieae (Melastomataceae), with emphasis on the re-circumscription of the large genus *Microlicia*. Botanical Journal of the Linnean Society 197(1): 35–60. <https://doi.org/10.1093/botlinnean/boab011>
- Wurdack JJ (1986) Atlas of hairs for Neotropical Melastomataceae. Smithsonian Contributions to Botany 63(63): 1–80. <https://doi.org/10.5479/si.0081024X.63>