Plant diversity in Southeast Asia

Edited by

Xiao-Hua Jin, Yu-Min Shui,
Yun-Hong Tan, Ming Kang

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EDITORIAL

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Taxonomic discoveries bridging the gap between our knowledge and biodiversity

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Southeast Asia includes four overlapping biodiversity hotspots: Indo-Burma, Philippines, Sundaland and Wallacea (Myers et al. 2000; Sodihi et al. 2004). Southeast Asia covers about 4.5 million km^2, which is approximately 3 % of earth's total land area. There is, however, approximately 20 to 25 % of Earth's higher plant species in this area (Myers et al. 2000). It is crucial to understand the biodiversity for conservation and sustainable development in the shadow of climate change and growth of economics and population.

Biological surveys and scientific research of biodiversity have a long history in Southeast Asia and several hypotheses for biogeography have been proposed (e.g. Che et al. 2010; Hou and Li 2017). However, the species richness of biodiversity is far underestimated. Taxonomy, including discoveries of new taxa, taxonomic revision and inventory, is the precondition of our conservation and sustainable development. Although frontiers of taxonomy and systematics biology, integrated taxonomy and genomics are main trends, the taxonomic work of checklist, flora and description of new taxa are far from sufficient in Southeast Asia. Many species will become extinct before we know that they even exist in Southeast Asia. Although it is a daunting task, it is extremely urgent to investigate, understand and conserve our biota.

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In order to understand and conserve the biodiversity in Southeast Asia, the Southeast Asia Biodiversity Research Institute (SEABRI) was established by the Chinese Academy of Sciences in 2014. It is an international scientific research and education organisation managed by the Xishuangbanna Tropical Botanical Garden (XTBG). With financial and personnel support from Chinese Academy of Sciences, SEABRI seeks to substantially improve our understanding and conservation of biodiversity in Southeast Asia by cooperation with all CAS institutes, international agencies and government of ASEAN countries.

This special issue of Phytokeys, entitled "Plant diversity in Southeast Asia" represents a new effort by SEABRI to promote awareness of the biodiversity and its conservation in the region. We are here firstly focusing on taxonomic discoveries to bridge the gap between our knowledge and diversity. Twelve articles in this issue mostly involve the description of new species from botanical surveys in the region. They include two new species of *Oreocharis* (Gesneriaceae) and a new species of *Didymocarpus* (Gesneriaceae) from Vietnam, a new species of *Aristolochia* (Aristolochiaceae), a new species of *Dendrobium* (Orchidaceae), a new species of *Gastrodia* (Orchidaceae), a new species of *Hedychium* (Zingiberaceae) and two new species of *Trivalvaria* (Annonaceae) from Northern Myanmar, a new species of *Primulina* (Gesneriaceae) from southwest China and seven species of *Begonia* (Begoniaceae) from Northern Vietnam and Southern China. The description of the little known species, *Begonia kingdon-wardii* (Begoniaceae) in Myanmar was also included. Results of molecular phylogenetics of tribe Neottieae (Orchidaceae) are also reported. Most studies are financially supported by the CAS (2015CASEABRI005, Y4ZK111B01).

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RESEARCH ARTICLE

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Two new species of *Trivalvaria* (Annonaceae) from northern Myanmar

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Abstract

Trivalvaria rubra and *Trivalvaria casseabriae*, two new species of Annonaceae from Putao, Kachin State, Myanmar, are here described and illustrated. They are morphologically similar to *T. costata* and *T. macrophylla*. The major differences between them are outlined and discussed. A diagnostic key to the species of *Trivalvaria* is provided.

Keywords

Kachin state, *Trivalvaria costata*, Annonaceae, field expedition, Myanmar

Introduction

Trivalvaria (Miq.) Miq. (Miquel, 1865) is a small genus with six species now recognised, which are mainly distributed in Indochina and Southeast Asia (Scheffer 1869, Das Debika 1968, Kessler 1993, van Heusden 1997, Li and Gilbert 2011, Chatrou et al. 2012). The genus belongs to the subfamily Annonoideae Raf. tribe Miliuseae Hook. f. & Thomson (Chatrou et al. 2012). The monophyly of *Trivalvaria* as well as its sister group relationship with *Marsypopetalum* Scheff., is confirmed with strong support; it

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was considered very close to *Marsypopetalum* and is characterised by morphological synapomorphies such as extra-axillary inflorescences, short pedicels (less than 1 cm long) and a single, basal ovule in each carpel and hence a solitary seed in each monocarp (Xue et al. 2011, Chaowasku et al. 2014). To date, there are currently two species *Trivalvaria dubia* (Kurz.) J. Sincl. and *T. macrophylla* Miq. recorded in Myanmar (Kress et al. 2003), the former now treated as a synonym of *T. costata* (Hook. f. & Thomson) I. M. Turner (Turner 2009).

Since 2014, repeated China-Myanmar joint field expeditions have been carried out to survey plant diversity in Northern Myanmar, specimens of *Trivalvaria* being found in Putao, Kachin state. Based on a detailed examination of the morphological and anatomical characters of the material and possible closely similar species (van Heusden 1997, Turner 2009, Gardner et al. 2015), it was concluded that the specimens collected in Myanmar belong to species new to science and these are hereby described and illustrated.

Material and methods

Measurements and morphological character assessments of the two possible new species *Trivalvaria rubra* and *Trivalvaria casseabriae* were examined based on dried specimens and fresh materials in field observations. They were compared with the morphologically similar species *T. costata*, *T. macrophylla* and *T. nervosa*, with affinities inferred using descriptions, type specimens and other herbarium specimens (van Heusden 1997, Turner 2009, Li and Gilbert 2011, Gardner et al. 2015). Protologues and images of type specimens were gathered from JSTOR Global Plants (http://plants.jstor.org). Conservation status evaluations of the new species were based on the International Union for Conservation of Nature guidelines (IUCN 2012).

Taxonomic treatment

Trivalvaria rubra **Y.H.Tan, S.S.Zhou & B.Yang, sp. nov.**
urn:lsid:ipni.org:names:60475911-2
Figure 1

Diagnosis. *Trivalvaria rubra* is similar to *Trivalvaria costata* in flower size and petal shape and size and also shares similarities with *T. macrophylla* in leaf shape, but can be distinguished by its pink flowers, androdioecious, petals spreading, outer petal lanceolate to narrowly oblong, 14–20 × 4–6 mm, inner petal 17–25 × 4–7 mm, oblong-ovate to ovate-triangular.

Type. MYANMAR. Kachin State, Putao District, on the way from Nanmti to Nahsihbo, 27°24'29"N, 97°39'59"E, 890 m a.s.l, 16 May 2017, *Myanmar Exped. 1801* (holotype, HITBC!; isotype, RAF!).

Description. Shrubs up to 1.2 m high. Young twigs densely to very sparsely pubescent, older twigs glabrous to pubescent. Leaves subcoriaceous, glabrous above, sparsely pubescent beneath, obovate to narrowly elliptic or oblong-lanceolate, 13.5–27.5 × 4.2–10.5 cm, base cuneate to obtuse, apex attenuate to acuminate or acute, sometimes retuse, midrib sunken above, prominent beneath, sparsely pubescent, lateral veins 9–11 pairs, faintly distinct above, prominent beneath, smaller veins faintly prominent beneath. Petiole 5–10 mm long, 2–3 mm thick, pubescent to glabrous. Flowers pink, androdioecious 2.6–2.8 cm in diam., extra-axillary or ramiflorous, solitary or sometimes in pairs, Bracts 2–4 (Fig. 1.G1), triangular to ovate, 3–6 × 2.5–5 mm, pubescent outside. Pedicel 2–3 mm long, pubescent. Sepals 3 per flower (Fig. 1.G2), free or sometimes shortly connate, triangular to triangular-ovate, 6–9 × 3–6 mm, pubescent to densely pubescent outside, glabrous inside, base rounded, apex acute to acuminate. Petals 6 per flower in two whorls, sub-equal, imbricate, spreading, outer petals (Fig. 1.G3) lanceolate, or oblong-ovate to ovate-triangular, 14–20 × 4–7 mm, pubescent to sparsely pubescent outside, glabrous inside, base rounded to obtuse, apex acute to acuminate; inner petals (Fig. 1.G4) lanceolate or narrowly oblong, 17–25 × 4–6 mm, sparsely pubescent outside, glabrous inside, base rounded to obtuse, apex acute to acuminate. Stamens numerous, ca. 2 mm long, apex shield-like, sometimes tongue-shaped in outer whorl, glabrous; torus triangular conical. Carpels several or many, 15–25 per flower, ovary densely hairy, stigma more or less subglobose, pubescent. Fruiting pedicel 3–4 mm long. Monocarps green, pink to red, ca. 5–10 per fruit, ellipsoid or oblong, 15–18 × 7–10 mm, sparsely pubescent, stipe 2–5 mm, pericarp thin. Seed one per monocarp.

Phenology. Flowering in May to June and fruiting occurs from June to December.

Etymology. The species epithet refers to its pink flower.

Distribution and habitat. *Trivalvaria rubra* is hitherto known from the type locality of Putao, Kachin state in Northern Myanmar, it is a small shrub that grows in the understory in tropical dipterocarpa forests, the dominant tree species are *Shorea assamica*, *Dysoxylum mollissimum*, *Aglaia elaeagnoidea*, *Garcinia* spp., *Goniothalamus peduncularis*, *Antidesma* spp., shrub species are *Hymenandra wallichii*, *Ardisia* sp., *Zingiber* sp., at an elevation of ca. 600–900 m a.s.l.

Conservation status. *Trivalvaria rubra* was collected on the way from Namti to Nahsihbo, Putao, Northern Myanmar, this area being difficult to travel due to its rugged terrain. At least three populations and ca. 60 individuals per population have been discovered. Currently, the locality is not legally protected and, although young individuals were recorded in field, the fragmented habitat and continuous logging severely threaten its survival. At present, it is suggested that it be considered as 'Vulnerable' (VU) on the basis of current IUCN Red List Categories and Criteria (IUCN 2012).

Specimen examined (paratypes). MYANMAR. Kachin State, Putao District, near Nahsihbo village, 27°24'36"N, 97°36'26"E, 970 m a.s.l, 11 Dec. 2017, *Myanmar Exped. 3373* (HITBC!); Putao District, near Namti village, 27°24'43"N, 97°39'56"E, 820 m a.s.l, 15 Dec. 2017, *Myanmar Exped. 3698* (HITBC!).

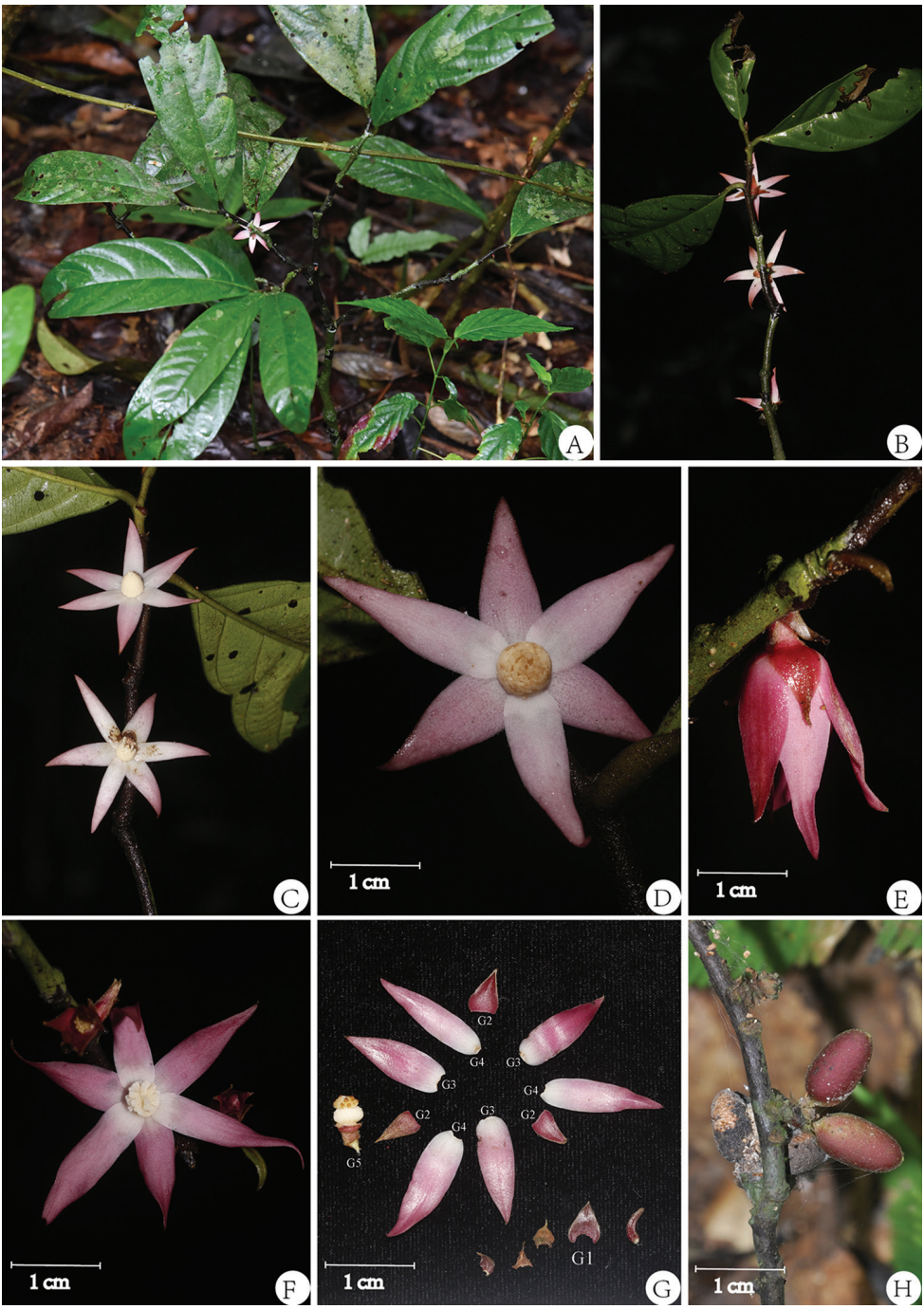

Figure 1. *Trivalvaria rubra* Y.H.Tan, S.S.Zhou & B.Yang, sp. nov. **A** Habitat **B** Branch with flowers (adaxial view) **C** Branch with flowers (abaxial view) **D** Male flower (abaxial view) **E** Flower bud (side view) **F** Female flower (abaxial view) **G** Flower (G1 Bracts; G2 Sepals; G3 Outer petals; G4 Inner petals; G5 Androphore) **H** Fruit. Photographed by Y.H. Tan, H.B. Ding and B. Yang.

Trivalvaria casseabriae **Y.H.Tan, S.S.Zhou & B.Yang, sp. nov.**
urn:lsid:ipni.org:names:60475912-2
Figure 2

Diagnosis. *Trivalvaria casseabriae* is similar to *Trivalvaria argentea* in leaf shape, but can be distinguished by its larger flower size and outer petals equal to inner petals, petals 6–10 × 3–5 mm (vs. 2 × 3 mm), 2–2.5 times as long as wide and elliptic to ovate-elliptic.

Type. MYANMAR. Kachin State, Putao District, Wasadam to Upper Shankhaung, 27°26'42"N, 97°14'27"E, 850m a.s.l, 21 May 2017, *Myanmar Exped. 2379* (holotype, HITBC!; isotype, RAF!).

Description. Shrubs up to 1.5 m high. Young twigs pubescent, older twigs glabrous to sparsely pubescent. Leaves subcoriaceous, glabrous above, sparsely pubescent beneath, lanceolate to oblong, 12.5–24.5 × 2.5–5.5 cm, base cuneate to obtuse, apex acuminate to caudate, midrib immersed above, prominent beneath, sparsely pubescent, lateral veins 5–7 pairs, immersed and faintly distinct above, prominent beneath, smaller veins faintly prominent beneath. Petiole 3–8 mm long, 1–3 mm in diameter, pubescent. Flowers white, androdioecious, 14–20 mm in diam., solitary or in pairs between leaf axils (extra-axillary), rarely ramiflorous. Bracts 1–2, triangular to ovate-triangular, 2–3 × 1–2 mm, pubescent to densely pubescent outside. Pedicel 2–3 mm long, pubescent. Sepals 3 per flower, free or sometimes shortly connate, ovate to broadly ovate, 2–3.5 × 2–3 mm, pubescent outside, puberulous inside and apex acute to obtuse, base rounded. Petals 6 per flower in two whorls, imbricate, spreading, subequal, outer petals (Fig. 2.F1) elliptic to ovate-elliptic, 6–10 × 4–5 mm, sparsely pubescent outside, puberulous inside, base rounded to obtuse, apex acute to obtuse; inner petals (Fig. 2.F2) elliptic to ovate-elliptic, 6–10 × 3–5 mm, sparsely pubescent outside, puberulous inside, base rounded to obtuse, apex acute. Stamens numerous stamens, ca. 2 mm long, apex shield-like, sometimes tongue-shaped in outer whorl, glabrous; torus triangular conical. Carpels 6–10 per flower, with globose stigma, pubescent. Monocarps and seeds not seen.

Phenology. Flowering at May to July.

Etymology. The specific epithet is derived from the abbreviation of Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences (CAS-SEABRI); noun in apposition. The name is dedicated to its three-part mission, viz., (a) Serve China's "the Silk Road Economic Belt and the 21st Century Maritime Silk Road" initiative; (b) Integrate efforts by CAS and international institutes to organise professional research groups and train researchers in Southeast Asian countries; and (c) Provide support to all domestic and international partners.

Distribution and habitat. *Trivalvaria casseabriae* is only known from the type locality of Putao, Kachin state in Northern Myanmar, where it grows in the understory of tropical montane broadleaf forests, the dominant tree species being *Altingia excels*, *Dysoxylum* spp., *Garcinia* spp., *Elaeocarpus* spp., at an elevation of ca. 700–900 m.

Conservation status. Although *Trivalvaria casseabriae* was collected on the way from Wasadam to Upper Shanhkaung, Putao District, Northern Myanmar, only one

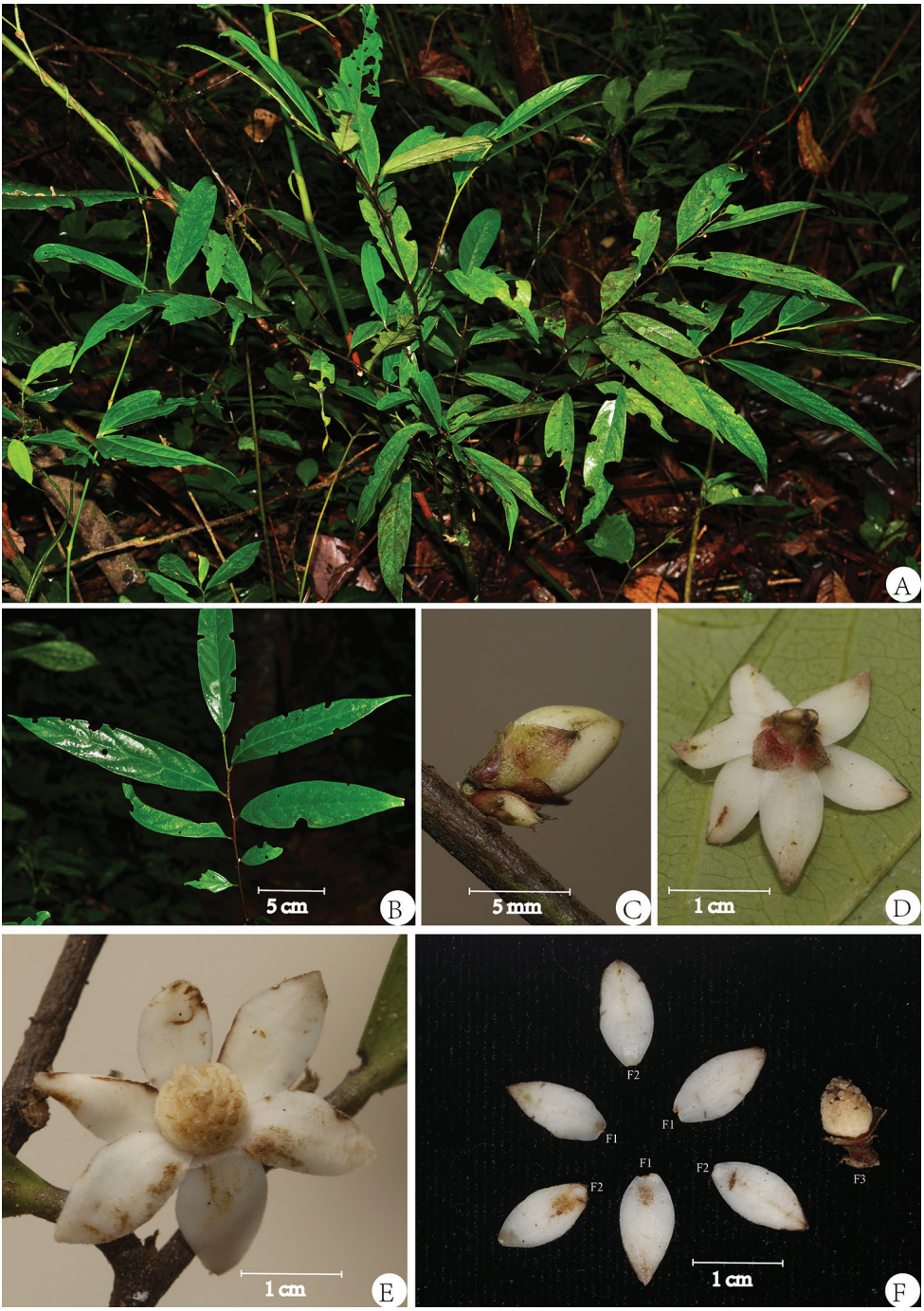

Figure 2. *Trivalvaria casseabriae* Y.H.Tan, S.S.Zhou & B.Yang, sp. nov. **A** Habitat **B** Branch **C** Flower buds (side view) **D** Flower (adaxial view) **E** Flower (abaxial view) **F** Flower (F1 Outer petals; F2 Inner petals; F3 Androphore). Photographed by Y.H. Tan, H.B. Ding and B. Yang.

population and less than 50 individuals, has been discovered. Potential populations and more individuals may be found in future field surveys. Currently, the locality is not legally protected and, although young individuals were recorded in field, the fragmented habitat and continuous logging severely threaten its survival. At present, it is suggested that it be considered as 'Vulnerable' (VU) on the basis of current IUCN Red List Categories and Criteria (IUCN, 2012).

Specimen examined (paratypes). MYANMAR. Kachin State, Putao District, on the way from Wasadam to Upper Shankhaung, 27°26'39"N, 97°14'23"E, 800 m a.s.l, 21 May 2017, *Myanmar Exped. 2389* (HITBC!), Putao District, Upper Shanhkaung, 27°26'30"N, 97°14'26"E, 680 m a.s.l, 28 April 2016, *Myanmar Exped. 201614* (HITBC!).

Key to the species of the genus *Trivalvaria*

1 Flowers minute, less than 10 mm in diam.; inner petals ca. 2–4 mm long **2**
– Flowers conspicuous, more than 10 mm in diam.; inner petals more than 5 mm long **3**
2 Leaf blade obovate to oblong; petals glabrous inside; monocarps ellipsoid-oblong, 14–20 × 7–10 mm ....***T. argentea***
– Leaf blade lanceolate; petals puberulous inside; monocarps subglobose, 9–10 mm in diam. .... ***T. kanjilalii***
3 Petals pubescent or puberulous inside **4**
– Petals glabrous inside **5**
4 Tree to 15 m, elliptic-oblong to oblong-lanceolate, 2.8–3.5 times as long as wide .... ***T. nervosa***
– Shrub up to 1.5 m, leaf blade lanceolate to oblong, 4.5–5 times as long as wide ....***T. casseabriae***
5 Petals densely hairy outside, inner petals of mature flowers connivent, less than 1.5 times as long as wide ....***T. macrophylla***
– Petals pubescent or hairy outside, inner petals of mature flowers spreading, 2–4 times as long as wide **5**
6 Flowers pink .... ***T. rubra***
– Flowers white **6**
7 Monocarps subglobose; inner petals oblanceolate, tip triangular to ligulate, ca. 2 times as long as wide; leaf blade less than 2.5 times as long as wide ....***T. carnosa***
– Monocarps elliptic-oblong; inner petals oblanceolate, elliptic to narrowly oblong, 3–4 times as long as wide; leaf blade 3 times as long as wide ....***T. costata***

Discussion

Also as a genus, *Trivalvaria* was revised and mentioned by several experts (Heusden 1997, Gardner et al. 2015), but it is still poorly understood due to the very limited

Table 1. Morphological comparison of key characters and distribution in *Trivalvaria rubra*, *T. casseabriae* and the similary taxa. Morphological characters of *T. costata*, *T. macrophylla*, *T. nervosa*, *T. argentea* following Heusden (1997) and Gardner et al. (2015), *T. kanjilalii* following Das (1968), *T. carnosa* following Scheffer (1869) , Teijsmann (1863) & our field observation in Xishuangbanna Tropical Botanical Garden (XTBG).

Character	*Trivalvaria rubra*	*T. casseabriae*	*T. costata*	*T. macrophylla*	*T. nervosa*	*T. argentea*	*T. kanjilalii*	*T. carnosa*
Habitat	shrub up to 1.2 m	shrub up to 1.5 m	shrub to 3 m	tree or shrub up to 12 m	tree to 15 m	shrub	shrub 2–3 m	shrub to1m
Leaf blade	obovate to narrowly elliptic or oblong-lanceolate, 13.5–27.5 × 4.2–10.5 cm	lanceolate to oblong, 12.5–24.5 × 2.5–5.5 cm	narrowly elliptic to obovate or oblong-lanceolate, 12–20 × 4–7 cm	elliptic-oblong to oblanceolate 9(–16)–(22–)30 × 3–10 cm	elliptic-oblong to oblong-lanceolate, 17–37 × 5–13 cm	obovate to oblong, 9–20 × 2.5–7 cm	lanceolate 12–15 × 3–4 cm	ovate-oblong, 15–17 × 6.5–7 cm
Flowers	pink, polygamous (male and bisexual), 26–28 mm in diam.	white, male and bisexual, 14–20 mm in diam.	white, male and bisexual, ca.12–24 mm in diam.	white to pale brownish creamy, bisexual, ca. 12 mm in diam.	white, polygamous (male and bisexual), ca. 14–26 mm in diam.	minute, ca. 6–8 mm in diam.	bisexual, ca. 5–6 mm in diam.	white, bisexual, 14–20 mm in diam.
Sepals	triangular to triangular-ovate, 6–9 × 3–6 mm	ovate to broadly ovate, 2–3.5 × 2–3 mm	triangular to broadly ovate, 2–3.5 × 1.5–4 mm	broadly ovate or triangular, 3–4 × (4–)5–6 mm	broadly ovate, 1.5–3 × 2–3.5 mm	broadly triangular-ovate, 1.5 × 2 mm	broadly ovate, 3–4 × 4 mm	broadly ovate, 2–3 × 2 mm
Petals	glabrous inside	puberulous inside	glabrous or downy inside	glabrous inside	pubescent inside	glabrous inside	puberulous inside	glabrous inside
Outer petals	lanceolate, or oblong-ovate to ovate-triangular, 14–20 × 4–7 mm	elliptic to ovate-elliptic, 6–10 × 4–5 mm	oblong-lanceolate, elliptic-oblong, 4–8(–12) × (1–)2–4 mm	broadly ovate or or triangular, 4–8 × 4–7 mm	obovate to elliptic-oblong, (6–)8–15 × 3.5–10 mm	ca. 2 mm long	ovate, 2.5–3 × 2.5 mm	broadly ovate, 5–6 × 4–5 mm
Inner petals	spreading, lanceolate or narrowly oblong, 17–25 × 4–6 mm	spreading, elliptic to ovate-elliptic, 6–10 × 3–5 mm	spreading, oblanceolate, elliptic to narrowly oblong, 4–12 × 1–4 mm	connivent, broadly ovate to broadly elliptic, or broadly triangular-ovate, 5–13 × 4–10 mm	spreading, obovate to elliptic-oblong, (5–)7–17 × 3–9 mm	ca. 2 mm long	tip incurved, more or less rhomboid, 3–4 × 2.5–3 mm	oblanceolate, tip triangular, 10–12 × 5–6 mm
Monocarps stipe	2–5 mm	unknown	1–6 mm	2–6 mm	9–(25–)30 mm	3–6 mm	5–6 mm	5–6 mm
Monocarps	ellipsoid or oblong, 15–18 × 7–10 mm	unknown	elliptic-oblong, 12–24 × 6–10 mm	ovoid to ellipsoid or oblong, 14–20 × 7–10 mm	oblong, 20–25 × 13–15 mm	ellipsoid-oblong, 14–20 × 7–10 mm	subglobose, 9–10 mm in diam.	subglobose, 10–12 × 8–10 mm
Distribution	Myanmar	Myanmar	Southeast Asia, China (Hainan)	S. Thailand, Malaya, Sumatra, Java, Borneo	S. Thailand and Malaysia	NE India, Bangladesh	E India	Java

collections and poorly known taxonomic information. For this study, the authors have tried to combine the original description and field observations to present a brief approved taxonomic characters (Table 1).

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RESEARCH ARTICLE

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Aristolochia sinoburmanica (Aristolochiaceae), a new species from north Myanmar

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Abstract

Aristolochia sinoburmanica Y.H.Tan & B.Yang, a new species of Aristolochiaceae from Putao, Kachin State, Myanmar, is described and illustrated. According to morphology (strongly curved perianth, 3-lobed limb, as well as 3-lobed gynostemium, anthers 6, adnate in 3 pairs to the base of gynostemium, opposite to the lobes), the species belongs to *Aristolochia* subgenus *Siphisia*. It is morphologically similar to *A. faviogonzalezii*, *A. hainanensis*, *A. tonkinensis*, *A. saccata* and *A. xuanlienensis*. The major differences between them are outlined and discussed. A detailed description, along with line drawings, photographs, habitat, distribution and conservation status, as well as a comparison to morphologically similar species, are also provided.

Keywords

Kachin state, *Aristolochia*, Aristolochiaceae, field expedition, Myanmar

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Introduction

Aristolochia L., with about 550 recognised species (González 2012), is a predominantly tropical and subtropical genus that extends to the Mediterranean and temperate zones worldwide and has highest species richness in the New World (Wanke et al. 2006). The genus is also rich in Asia, particularly in eastern and southern Asia, with more than 70 species (Ma 1989; Do et al. 2015a). There are currently 61 species recorded in China (Zhu et al. 2016, 2017), 22 species in Vietnam (Do and Nghiem 2017) and 12 species in Myanmar (Kress et al. 2003). Recent phylogenetic studies of the genus based on morphological and molecular data suggested the subdivision of *Aristolochia* into three subgenera, i.e. subgenus *Aristolochia*, subgenus *Siphisia* and subgenus *Pararistolochia* (Wanke et al. 2006). The distribution and key morphological characters of the subgenus *Siphisia* have been described and discussed by González et al. (2014) and Do et al. (2015a, 2015b).

During a field expedition to Putao, Kachin state, north Myanmar, an unknown species of *Aristolochia* was collected. After careful studies of the genus, particularly the floral characteristics of those species in the adjacent regions, as well as comparison between this unknown species and its related species, it is confirmed as a new species of *Aristolochia* which has strongly curved perianth, 3-lobed limb, as well as 3-lobed gynostemium and should be assigned to the subgenus *Siphisia*. The new species presented here was also collected by a famous Chinese botanist, Professor K. M. Feng in 1959 (KUN, No. 0163232) from northwest Yunnan, China. The specimen consists of four leaves, being complemented by good field notes and was identified as *Aristolochia hainanensis*. In this paper, this new *Aristolochia* species is described and illustrated.

Material and methods

Measurements and morphological character assessments of the possible new species *Aristolochia sinoburmanica* were made from both dried specimens and field observations of living plants which allowed comparison of morphological characters and colouration of the perianth (utricle, tube and limb) as well as morphology of the inside of the trap flowers, including the gynostemium, which are often impossible to observe in dried specimens. The description of the new species follows the terminology used by Hwang et al. (2003) and Do et al. (2015a). This new species was compared with the morphologically similar species *A. hainanensis* Merrill, *A. saccata* Wallich and also the recently published new species *A. xuanlienensis* (Huong et al. 2014), *A. faviogonzalezii* T. V. Do, S. Wanke & C. Neinhuis and *A. tonkinensis* T.V. Do & S. Wanke from Vietnam (Do et al.2015a), according to the descriptions from type specimens and dried herbarium specimens and also literature descriptions (Hwang1988, Hwang et al. 2003, Huong et al. 2014, Ma 1989, Do et al. 2015a, 2015b). Protologues and images of type specimens and dried herbarium specimens were gathered from JSTOR Global Plants (http://plants.jstor.org) and the KUN website (http://db.kun.ac.cn/).

Data resources

The data underpinning the analyses reported in this paper are deposited in the Dryad Data Repository at https://doi.org/10.5061/dryad.2501p.

Taxonomy

***Aristolochia sinoburmanica* Y.H.Tan & B.Yang, sp. nov.**
urn:lsid:ipni.org:names:60475913-2
Figures 1, 2

Diagnosis. *Aristolochia sinoburmanica* is morphologically similar to *A. hainanensis* Merrill, *A. saccata* Wallich, *A. xuanlienensis* (Huong et al. 2014), *A. faviogonzalezii* T. V. Do, S. Wanke & C. Neinhuis and *A. tonkinensis* T.V. Do & S. Wanke from Vietnam (Do et al. 2015a), but is distinguishable from these species by the following diagnostic characters: leaf blade ovate or ovate-lanceolate to narrowly ovate, subcoriaceous, base rounded to slightly cordate; cyme solitary on old woody stems and young branches, each cyme with 1–2 flowers; perianth claret (deep purple red), outside densely brown hirsute with parallel dark purple veins, 6.5–7.5 cm high; tube horseshoe-shaped, 8.3–8.5 cm, uniformly claret (deep purple red), with visible dark purple veins, limb trumpet-shaped, 4.2–4.8 cm high, 4–4.4 cm wide, 3-lobed, lobes subequal; throat deep purple red, glabrous. The summary and main characters comparison is presented in Table 1.

Type. MYANMAR. Kachin State: Putao, near Shinshanku, on the roadside slope of a mountain range bordering the zone of Hkakaborazi National Park, perennial lianas under tropical mountain broadleaf forest, 27°38'48.65"N, 97°54'01.61"E, 900 m a.s.l., 11 May 2017, *Myanmar Exped. 1532* (holotype HITBC!).

Description. Perennial woody liana, 8–12 m high. Stem terete, circular in cross section, ca. 1 cm in diam., young branches green, sparsely pubescent, becoming glabrescent, bark deeply irregularly longitudinally fissured when mature, internodes 7–15 cm long. Petiole 3.5–6.0 cm long, twisted, pubescent. Leaf blade ovate or ovate-lanceolate to narrowly ovate, subcoriaceous, 15–31.5 × 5.8–12.5 cm, base rounded to slightly cordate, apex acuminate, margin entire, both surfaces densely villous when young, then the adaxial surface dark-green and glabrous, the abaxial surface densely villous; basal veins five, palmate, secondary veins four to six pairs, pinnate; tertiary veins coarsely reticulate, slightly sunken adaxially, prominent abaxially. Inflorescence cymose on old woody stems and young branches, solitary or two cymes, each cyme with one or two flowers, clearly separated from each other. Inflorescence axis 2–6 mm long, tomentose. Bracteole clasping the axis, ovate-triangular, 2–4.5 × 1.5–2 mm, subsessile, both surfaces densely brown villous. Pedicel 1.3–1.6 cm long, pendulous, densely brown villous. Ovary oblong, 1.5–1.7 × 0.3–0.4 cm, densely brown villous. Perianth horseshoe-shaped (in lateral view), 6.5–7.5 cm high, claret (deep purple red),

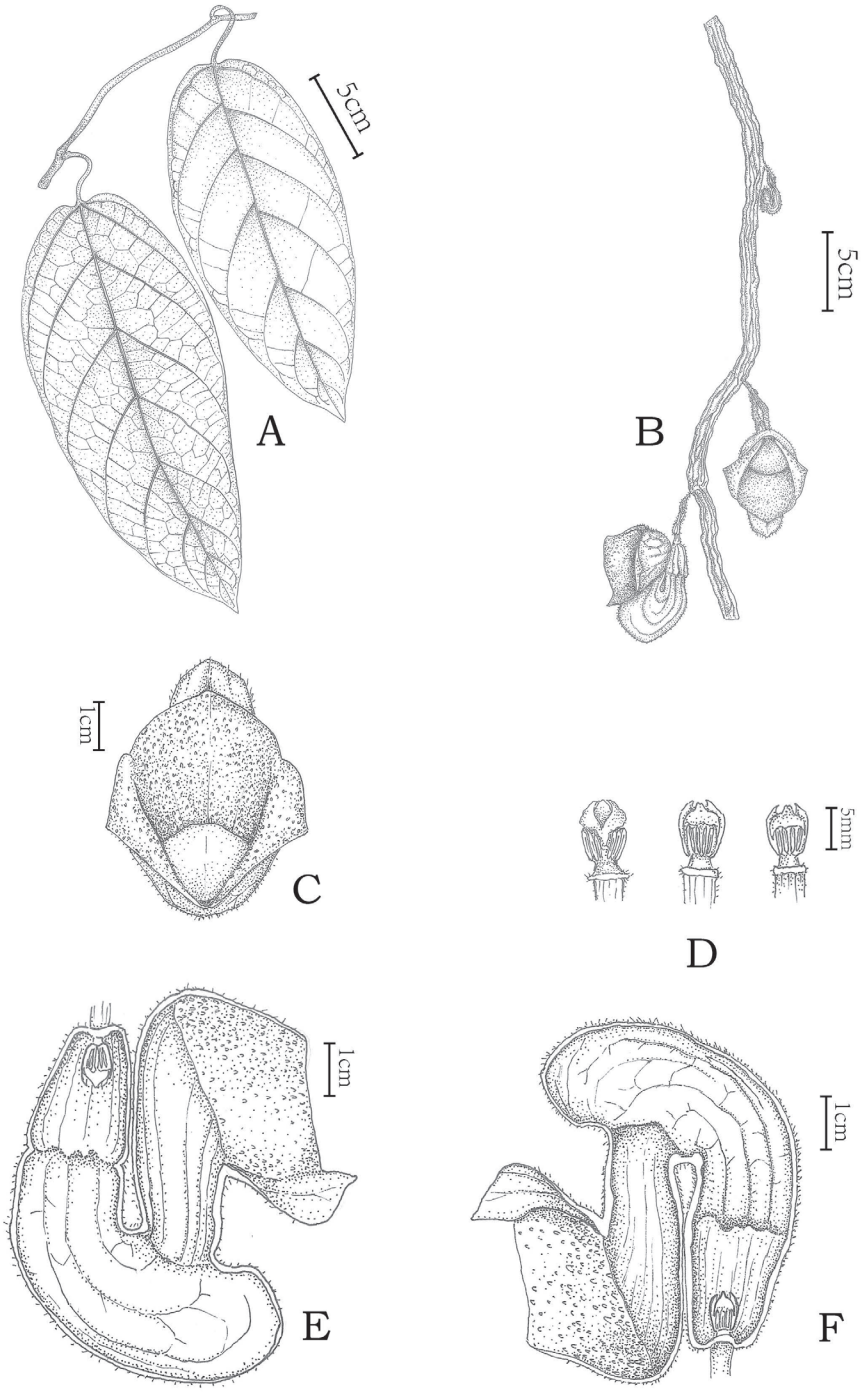

Figure 1. *Aristolochia sinoburmanica* Y.H.Tan & B.Yang, sp. nov. **A** Habitat **B** Flowering branch **C** Flower (front view) **D** Anthers and gynostemium **E** Opened flower (showing the inside structure) **F** Opened flower (showing the inside structure). Illustration by Zhengmeng Yang.

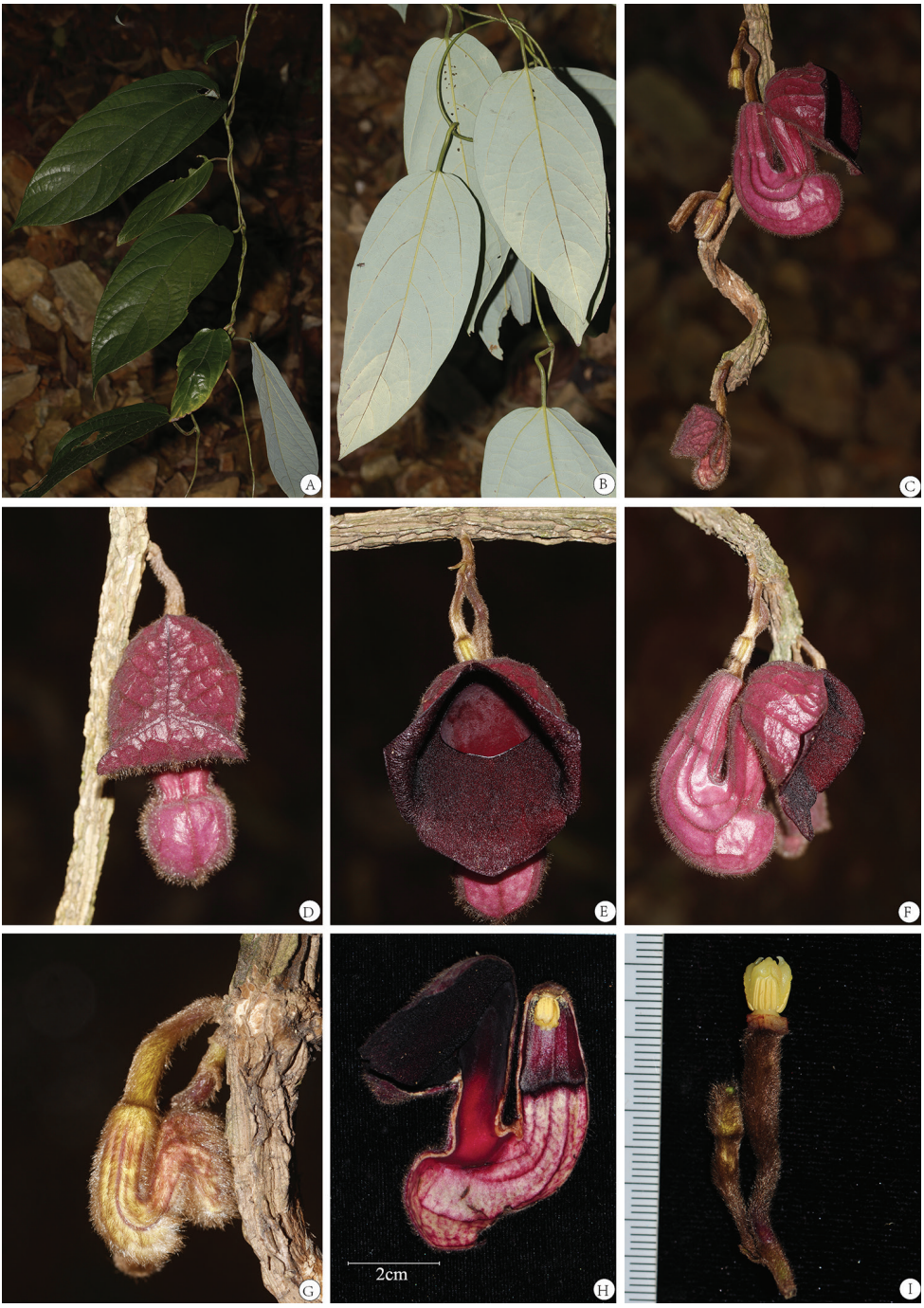

Figure 2. *Aristolochia sinoburmanica* Y.H.Tan & B.Yang, sp. nov. **A** young branch and adaxial leaf **B** young branch and abaxial leaf **C** cymes on old woody stems **D** front view of preanthesis flower **E** front view of open flower **F** lateral view of open flower **G** lateral view of young flower **H** longitudinal section of flower **I** gynostemium, ovary and pedicel. (Photographed by Y. H. Tan, H. B. Ding & B. Yang).

Table 1. Morphological comparison of key characters and distribution in *A. sinoburmanica* and its similar taxa.

Character	*A. sinoburmanica*	*A. faviogonzalezii*	*A. hainanensis*	*A. tonkinensis*	*A. saccata*	*A. xuanlienensis*
Leaf blade	ovate or ovate-lanceolate to narrowly ovate	broadly ovate to cordate	ovate to ovate-lanceolate	ovate to broadly-ovate	ovate-oblong to ovate-lanceolate	ovate or lanceolate-ovate to narrowly ovate
Leaf base	rounded to slightly cordate	slightly to deeply cordate	cuneate to rounded	rounded to truncate	cordate	rounded
Inflorescence	cyme solitary on old woody stems and young branches, each cyme with1–2 flowers	cluster of 6–8(-10) cymes at each node on old woody stem, each cyme with 3–4 flowers	cyme in axils of leafy shoots or on old woody stems, with 3–6 flowers	cyme solitary on old woody stems and young branches with 3–4 flowers	cluster of 2–3 cymes at each node on old woody stems, each cyme with 3–5 flowers	cyme usually in axils of leafy shoots or on old woody stems, 3–4(-5) flowers
Perianth	claret (deep purple red), outside densely brown hirsute with parallel dark purple veins, 6.5–7.5 cm high	yellowish-white with parallel dark purple veins or dots, 3.5–5 cm high	yellowish with obscure purplish veins	outside white, densely villous with parallel purple veins, 3.2–3.5 cm high	white with purple reticulate veins	white with light purple veins outside and dark purple spots, 4.5–4.8 cm high
Limb	discoid-rotund or trumpet-shaped , 4.2–4.8 cm high, 4–4.4 cm wide, 3-lobed, lobes subequal, dark purple, densely covered with dark purple warts	trumpet-shaped, nearly rectangular, 2.4–2.6 cm high, 1.8–2 cm wide, 3-lobed, lobes unequal, dark purple, warty on inner surface	obliquely trumpet-shaped, nearly circular, 2.2–2.5 cm wide, 3-lobed, lobes unequal, purple, densely dark purple warts	trumpet-shaped, nearly rectangular, 1.2–1.3 cm high, 0.9–1.0 cm wide, 3-lobed, lobes unequal, dark purple, densely covered with dark purple bristles	obliquely trumpet-shaped, nearly circular, 1.8–2 cm wide, 3-lobed, lobes unequal, upper 2 distinctly recurved, deltoid, lower one broadly deltoid, covered with purple warts	trumpet-shaped, ca. 2.5 cm wide, 3-lobed , lobes subequal , fused with margins of all lobes strongly revolute, densely covered with purple papillate
Throat	deep purple red, glabrous	upper half white with dark purple dots and lower half pinkish without visible dots	yellow, without visible dots	white, without visible dots	yellow, without visible dots	white, densely covered with purple dots
Distribution	China, Myanmar	Vietnam	China, Vietnam	Vietnam	China, Bhutan, NE India, Myanmar, Nepal	Southern Vietnam

outside densely brown hirsute with parallel dark purple veins, inside glabrous to white villous. Utricle distinct from the tube, bell-shaped, 2.3–2.5 cm high, 1.2–1.3 cm in diam. at base, 1.6–1.8 cm in diam. at apex, inside vinaceous (purplish red) with densely white trichomes. Tube horseshoe-shaped, 8.3–8.5 cm, uniformly claret (deep purple red), with visible dark purple veins, lower tube strongly inflated, saccate, 2.5–2.7 cm high, 1.8–2.0 cm in diam. and upper tube obliquely shortened funnel-shaped, parallel to the utricle, inner surface stramineous dyed with purple red patches, 3–3.5 cm high, narrower at base, 1–1.1 cm in diam. and broader at apex, 1.3–1.4 cm in diam. Limb discoid-rotund or trumpet-shaped, 4.2–4.8 cm high, 4–4.4 cm wide, with three subequal lobes, valvate preanthesis, lobes broadly ovate-triangular, each 3.3–3.8 cm wide, 1.8–2.2 cm high, margins of all lobes revolute during anthesis, warty on inner surface of lobes dark purple. Throat deep purple red, glabrous, without dots. Annulus present. Gynostemium with trilobed stigma on top, 7–7.5 × 5.5–6.5 mm in diam., anthers 6 in 3 pairs, oblong, 4.3–4.5 × 1.2–1.4 mm, yellow. Fruit and seeds were not seen.

Phenology. Flowering specimens have been collected in May but it is possible that flowering begins in April and fruiting may be from July to August.

Etymology. The species epithet refers to the type locality in Myanmar and adjacent regions of China. It also shows that the two countries are friendly neighbours, their friendship being retained over a long period and also expresses our appreciation for the whole-hearted cooperation amongst members of the China-Myanmar joint expedition.

Distribution and habitat. *Aristolochia sinoburmanica* is hitherto known from the type locality of Putao, Kachin state in north Myanmar and adjacent regions of Gongshan County, northwest Yunnan, southwest China, where, according to one sheet of the specimen deposited in KUN, it is a perennial liana which grows under the montane broadleaf forests, at an elevation of ca. 900–1400 m.

Preliminary conservation status. In Nov. 2014, the China-Myanmar joint expedition conducted the first field investigation of plant diversity along the same route in north Myanmar, within the area which included the type locality of this new species. The path through the mountains could only be accessed by foot, but in the most recent expedition in May 2017, with the development of road construction, most of the trees and habitats have been destroyed. *A. sinoburmanica* is known from a single population on the roadside. In fact, during the present study, only two healthy individuals were located growing about 20m apart from each other. Therefore, the new species is assigned a preliminary status of vulnerable (VU) according to the IUCN Red List Categories (IUCN 2012). However, since very few details exist about its natural distribution, a detailed investigation of the same habitats may identify more populations and individuals of this new species. The lack of sufficient data currently does not allow a final risk evaluation and the species might be regarded as data deficient (DD). Further field surveys in northern Myanmar are needed to gain more information on its distribution.

Additional specimens examined. China. Yunnan: Gongshan, east of Dulong River, 27°41'51.81"N, 98°19'11.22"E, 1400 m a.s.l., 12 Nov. 1959, *G.M. Feng. 24217* (KUN, No. 0163232).

Key to the species of *Aristolochia sinoburmanica* and closely related species

1 Perianth claret (deep purple red), outside densely brown hirsute with parallel dark purple veins ..... ***A. sinoburmanica***
– Perianth yellowish, yellowish-white or white with purple to dark purple veins or dots **2**
2 Leaf base slightly to deeply cordate **3**
– Leaf base round, cuneate to rounded or rounded to truncate **4**
3 Leaf blade broadly ovate to cordate ..... ***A. faviogonzalezii***
– Leaf blade ovate-oblong to ovate-lanceolate ..... ***A. saccata***
4 Throat yellow ..... ***A. hainanensis***
– Throat white **5**
5 Limb 3-lobed, lobes unequal, throat without visible dots ..... ***A. tonkinensis***
– Limb 3-lobed, lobes subequal, throat densely covered with purple dots ..... ***A. xuanlienensis***

Discussion

Aristolochia sinoburmanica is morphologically similar to *A. faviogonzalezii*, *A. hainanensis*, *A. tonkinensis*, *A. saccata* and *A. xuanlienensis*. However, the new species differs from the aforementioned species in several important vegetative and reproductive characters (summarised in Table 1). *A. sinoburmanica*, with a horseshoe-shaped perianth of 3 lobes which are valvate in preanthesis, annulated perianth throat and gynostemium with trilobed stigma on top, each lobe consisting of one pair of stamens, belongs to the *Aristolochia* subgenus *Siphisia* (Wanke et al. 2006, Do et al. 2015a).This new discovery, along with several new species recently described from Vietnam (Huong et al. 2014, Do et al. 2014, 2015a, 2015b), Guangxi and Hainan Island, China (Xu et al. 2011, Huang et al. 2013, Wu et al. 2013) and Peninsular Malaysia (Yao 2012), provide evidence that the genus *Aristolochia* and, in particular, *Aristolochia* subgenus *Siphisia* is very diverse in South-East Asia. Currently there are only 12 *Aristolochia* species recorded in Myanmar (Kress et al. 2003), indicating that the species diversity of *Aristolochia* in Myanmar is still open to discovery. It is predicted that more new species will be discovered when more field investigations are conducted in this region.

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RESEARCH ARTICLE

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Gastrodia kachinensis (Orchidaceae), a new species from Myanmar

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Abstract

Gastrodia kachinensis, a new species of Orchidaceae, is described and illustrated from Putao, Kachin State, Myanmar. It is morphologically similar to *G. gracilis*, presumably its nearest relative, but can be easily distinguished from the latter by having perianth tube with punctate outer surface, verrucose outer surface of sepal lobe, orbicular petals, ovate-elliptic lip with truncate apex and auriculate-clawed base, glabrous lip apex with a pair of twin protuberance-like lamellae and column with a pair of blade-like lateral wings and acute stelidia at apex. Identification key and colour photographs are provided. A preliminary risk-of-extinction assessment, according to the IUCN Red List Categories and Criteria, is given for the new species.

Keywords

Gastrodieae, Kachin, key, montane forest, taxonomy

Introduction

Gastrodia R. Brown (1810: 330) (Orchidaceae, Epidendroideae, Gastrodieae) is composed of approximately 90 species, widespread from northeast India through the eastern Himalayas and southern China to Japan and eastern Siberia, southwards to Malaysia and Australia, eastwards to the Pacific Islands as far as Samoa and westwards to Madagascar, Mascarene Islands and tropical Africa (Pridgeon et al. 2005, Chen et al. 2009, Cribb et al. 2010, The Plant List 2013, Chase et al. 2015, Huang et al. 2015, Hsu et

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al. 2016). It is characterised by a fleshy tuber or coralloid underground stem, absence of leaves, union of sepals and petals and two mealy pollinia with/without caudicles (Dressler 1993, Seidenfaden and Wood 1995, Leou 2000, Chung and Hsu 2006). Although there is no record of *Gastrodia* in the checklist of Myanmar (Kress et al. 2003), two species of *Gastrodia* were newly recorded in Myanmar recently (Kurzweil and Lwin 2014, Jin and Kyaw 2017). During fieldwork in Putao, Kachin State, Northern Myanmar, in May 2017, a new species of *Gastrodia* was discovered and is described below.

Material and methods

All measurements of the new species here described, i.e. *Gastrodia kachinensis*, were taken from dried herbarium specimens and field notes. In the description, length and width are represented as length × width. About five living plants and four dried specimens of the new species were examined. In addition, all specimens of *Gastrodia* kept in the Herbarium of Myanmar Forest Department, KUN and PE were examined. Morphological characters of the new species, *Gastrodia gracilis* Blume and other related species, were based on dried herbarium specimens deposited at the Chinese National Herbarium (PE) and on the high resolution photographs of live plants provided by Tian-Chuan Hsu and Xiao-Hua Jin.

Taxonomic treatment

Gastrodia kachinensis **X.H.Jin & L.A.Ye**
urn:lsid:ipni.org:names:77175482-1
Figures 1–3

Diagnosis. *Gastrodia kachinensis* is similar to *G. gracilis*, but it can be easily distinguished from the latter by having perianth tube with punctate outer surface, verrucose outer surface of sepal lobe, orbicular petals, ovate-elliptic lip with truncate apex and auriculate-clawed base, glabrous lip with a pair of twin protuberance-like lamellae only at apex and column with a pair of blade-like lateral wings and acute stelidia at apex.

Type. MYANMAR. Kachin State: Putao Township, Hponkanrazi Wildlife Sanctuary, subtropical, evergreen, broad-leaved forest, 1400 m in elevation, 19 May 2017, Xiaohua Jin et al., *PT -6897* (Putao expedition team 6897) (Holotype, PE!).

Description. Terrestrial, fully mycoheterotrophic, leafless herb. Rhizome tuberous, vertical, subterete, 10–14 cm long, ca. 1 cm thick, greyish brown, covered with membranous scales. Stem erect and slender, ca. 30–40 cm long, 0.6 cm thick, distantly noded and sheathed. Raceme laxly 8–10-flowered, peduncle 10–30 cm long, ca. 0.5 cm in diameter, floral bracts minute, erect, lanceolate-ovate, dark brown, acute apex, 6 × 1.5 mm. Pedicel and ovary ca. 1 cm long, pedicel slightly curved, ovary ca. 2.5 mm in diameter. Flowers urceolate, resupinate, bending downwards,

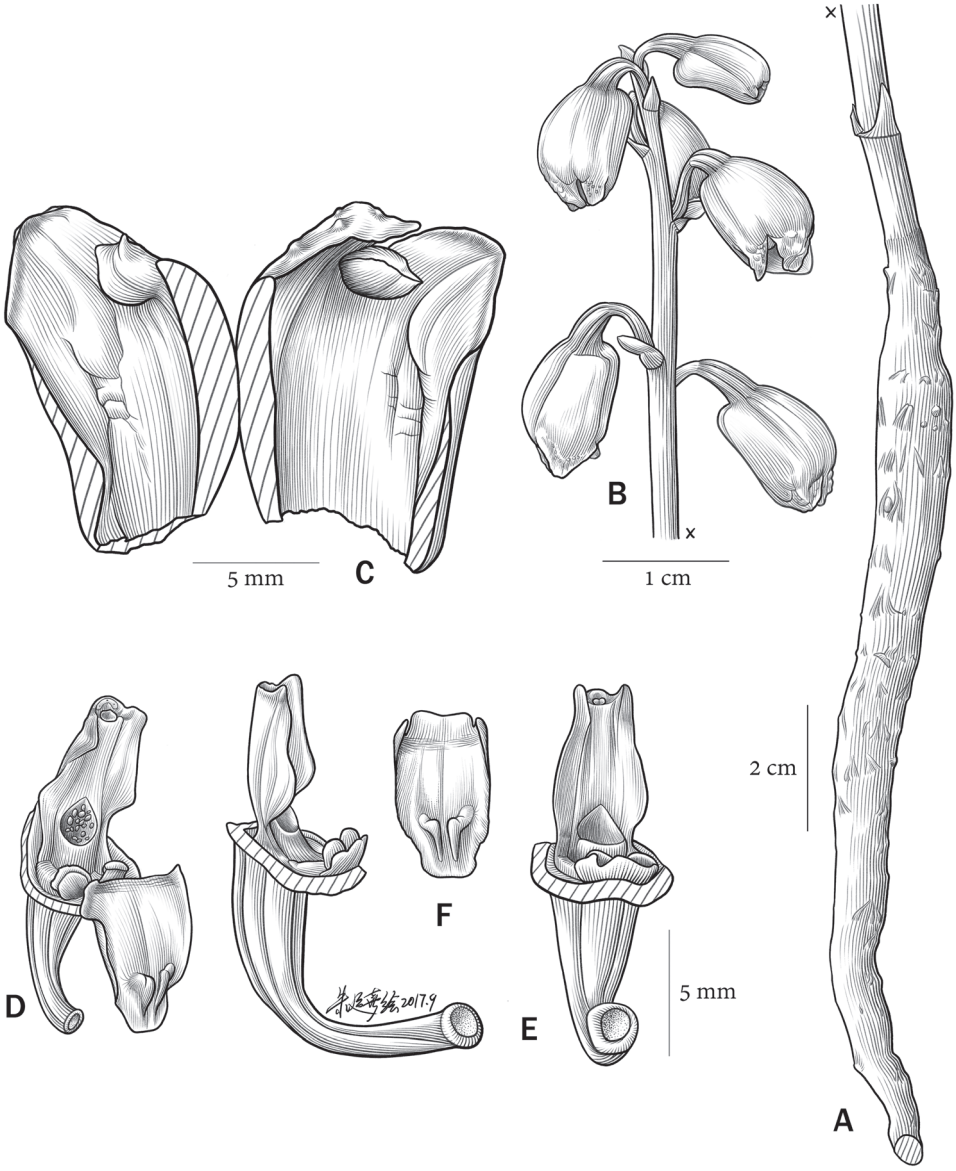

Figure 1. *Gastrodia kachinensis* X.H.Jin & L.A.Ye. **A** Rhizome **B** Inflorescence **C** Longitudinal section of sepal tube, showing two petals **D** Front view of column and lip, showing the stigma area with sectile pollinia **E** Lateral view of column and hypochile, showing a pair of sub-globose calli at lip hypochile **F** Lip epichile, showing a pair of twin protuberance-like lamellae at its apex. Illustration by Yunxi Zhu.

dark yellowish brown, ca. 1.3 cm long, 0.8 cm in diameter; sepals connate, forming a tube, tubular part ca. 1 cm long, outer surface punctate, trilobed at apex, sepal lobes ovate, 0.3 × 0.3 cm, outer surfaces verrucose; petals attached to sepal tube, orbicular, 0.2 × 0.2 cm; lip adnate to column foot, orange-yellow towards apex and pale greenish

Figure 2. Habit of *Gastrodia kachinensis*. Photographed by X.H. Jin.

white along each lateral margin, ovate-elliptic, 0.7 × 0.4 cm, margin entire, apex truncate, base auriculate-clawed, two light yellow sub-globose calli at claw, adaxial surface of lip glabrous, with a pair of twin protuberance-like lamellae only at apex, lamellae ca. 1 mm tall; column straight, as long as lip, ca. 0.6 cm long excluding column foot, with a pair of blade-like lateral wings towards apex, stelidia acute at apex; column foot distinct; stigma distinct, near base of column, rounded, ca. 1.5 mm in diameter.

Etymology. The new species is named after Kachin State, the northernmost state of Myanmar in which it was discovered in a vast area of primitive montane forest.

Distribution and habitat. *Gastrodia kachinensis* is a terrestrial mycoheterotrophic species that grows in broad-leaved, evergreen forest at 1400 m in elevation. *Gastrodia kachinensis* is only known from the type locality.

Conservation status. Endangered (EN). *Gastrodia kachinensis* was collected in the lowland forest of Hponkanrazi Wildlife Sanctuary, Putao, Northern Myanmar. Until now, only one population, consisting of ca. 10 individuals, has been discovered in the reserve (2704 km^2). As the lowland forest is under direct threat from slash-and-burn agriculture, the species is here assigned a status of Endangered (EN) according to the guidelines for using the IUCN Red List Categories and Criteria (IUCN Standards and Petitions Subcommittee 2017).

Figure 3. *Gastrodia kachinensis* X.H.Jin & L.A.Ye. **A** Inflorescence **B** Longitudinal section of sepal tube, showing two petals **C** Front view of column and lip, showing the stigma area with sectile pollinia **D** Sepal tube, lip, lateral view of column and the base of lip, showing a pair of sub-globose calli at lip hypochile **E** Rhizome. Photographed by X.H. Jin.

Key to *Gastrodia kachinensis* and *G. gracilis*

1 Perianth tube outer surface punctate; sepal lobes outer surface verrucose; petals orbicular; lip ovate-elliptic, margin entire, apex truncate, base auriculate-clawed, adaxial surface glabrous, with a pair of twin protuberance-like lamellae only at apex; column with a pair of blade-like lateral wings, stelidia acute at apex ..... ***Gastrodia kachinensis***

– Perianth tube outer surface smooth; sepal lobes outer surface smooth; petals ovate; lip ovate-triangular, margin undulate, apex obtuse, base truncate-clawed, adaxial surface tomentose, with a pair of longitudinal lamellae which are distinctly crested only at apex; column with a pair of semilunar lateral wings, stelidia acuminate at apex..... ***Gastrodia gracilis***

Discussion

Gastrodia kachinensis and *G. gracilis* are very similar in their vegetative as well as floral morphology. However, *Gastrodia kachinensis* can be easily distinguished from *Gastrodia gracilis* by having perianth tube with punctate outer surface, verrucose outer surface of sepal lobe, orbicular petals, ovate-elliptic lip which is orange-yellow towards apex

Table 1. Morphological comparison of diagnostic features of *Gastrodia kachinensis* and its related species (Meng et al. 2007, Chen et al. 2009, Huang et al. 2015).

Character	*G. kachinensis*	*G. gracilis*	*G. longitubularis*	*G. huapingensis*
Flower position	bending downwards	nodding	horizontal or slightly bending	pointing slightly downwards
Flower colour	dark yellowish brown	dull brownish	grey-brownish	greyish brown
Perianth tube	punctate, urceolate, outer surface of sepal lobe verrucose, petals orbicular	glabrous, ventricose, outer surface of sepal lobe glabrous, petals ovate	glabrous, slender, outer surface of sepal lobe glabrous, petals ovate or sub-rotundate	glabrous, bell-shaped, outer surface of sepal lobe glabrous, petals ovate
Labellum	orange-yellow towards apex and pale greenish white along each lateral margin, ovate-elliptic, apex truncate, base auriculate-clawed, adaxial surface of lip glabrous, with a pair of twin protuberance-like lamellae only at apex	red or orange-red, ovate-triangluar, apex obtuse, base truncate-clawed, adaxial surface of lip tomentose, with a pair of longitudinal lamellae which are distinctly crested only at apex	red or orange-red, ovate or cordate, apex cuspidate, base rounded-clawed, adaxial surface of lip longitudinally 3-5-grooved, with a pair of longitudinal lamellae near apex	pale yellowish brown, ovate, apex truncate, base obtuse-clawed, adaxial surface of lip with 5 longitudinally ridges, of which central two are much longer and more prominent
Column	As long as lip, with a pair of blade-like lateral wings and acute stelidia at apex	As long as lip, with a pair of semilunar lateral wings and acuminate stelidia at apex	Longer than lip, laterally winged from middle to apex, stelidia acute-triangular at apex	Dimorphic column; extended in some flowers, whereas incurved in some flowers

and pale greenish white along each lateral margin and is composed of entire margin, truncate apex, auriculate-clawed base and glabrous adaxial surface with a pair of twin protuberance-like lamellae only at apex and column with a pair of blade-like lateral wings and acute stelidia at apex (Table 1). *Gastrodia kachinensis* grow at 1400 m in elevation and *G. gracilis* at ca. 600–1500 m in elevation (Chen et al. 2009). In addition, *Gastrodia longitubularis* Q.W. Meng, X.Q. Song & Y.B. Luo and *G. huapingensis* X.Y. Huang, A.Q. Hu & Yan Liu might also be the allied species of *Gastrodia kachinensis* (Meng et al. 2007, Huang et al. 2015), but *G. kachinensis* can be easily distinguished from the former two species (Table 1).

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RESEARCH ARTICLE

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Dendrobium naungmungense (Orchidaceae, Dendrobieae), a new species from Kachin State, Myanmar

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Abstract

Dendrobium naungmungense, a new species from Naungmung, Kachin State, North Myanmar, is described and illustrated. It is morphologically similar to *D. ciliatilabellum* and *D. vexabile,* but the epichile is oblong with three long-ciliate laminae and the column wing has significant denticulation. A preliminary risk-of-extinction assessment shows that the new species should be regarded as Critically Endangered (CR) according to the IUCN Red List Categories and Criteria.

Keywords

Taxonomy, risk-of-extinction assessment, Khakaborazi National Park

Introduction

The orchid flora of Myanmar is highly diverse but poorly known, as a result of the past political isolation and instability of the country. The remoteness of many orchid-rich areas and the difficulties of investigation in rugged terrain have also played a role

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(Ormerod and Kumar 2003; Kurzweil and Lwin 2014). According to recent estimates, about 800 orchid species are distributed in Myanmar (Kurzweil and Lwin 2014), but this is probably an underestimate. Many new distribution records and new species have been published in the last few years (Ormerod 2002, 2012; Ormerod and Kumar 2008; Ormerod and Wood 2010; Nyunt 2006; Kurzweil and Lwin 2012a, b; Tanaka et al. 2011; Tan et al. 2015; Liu et al. 2017; Aung et al. 2017; Yang et al. 2017).

Dendrobium Swartz (1799: 82) (Orchidaceae: Epidendroideae; Dendrobieae) is one of the largest genera of Orchidaceae, with approximately 800–1500 species, which are mainly distributed in diverse habitats in South, East and South-east Asia and Australasia, including the Philippines, Borneo, Australia, New Guinea and New Zealand (Cribb and Govaerts 2005; Wood 2006; Zhu et al. 2009). Around 129 species of *Dendrobium* have been recorded from Myanmar (Kurzweil and Lwin 2014; Govaerts et al. 2017). During fieldwork in Khakaborazi National Park, Kachin State, Northern Myanmar since 2015, one new species of *Dendrobium* has been discovered, which is described below. The new species belongs to *Dendrobium* section *Dendrobium* Lindl. (Lindley 1844).

Materials and method

Morphological observations of the new species were carried out based on living plants (five individuals) and dried herbarium specimens (three specimens kept in the herbaria of HITBC and YAF). Measurements were made using a vernier caliper and the descriptive terminology follows Stearn (1983). Both herbarium and fresh specimens of *Dendrobium vexibile* (Liu et al. 2015) were examined under a stereo dissecting microscope. The conservation status of the new species was evaluated based on the guidelines of the International Union for Conservation of Nature (IUCN 2017).

Taxonomic treatment

Dendrobium naungmungense **Q.Liu & X.H.Jin, sp. nov.**
urn:lsid:ipni.org:names:77175481-1
Figs 1, 2

Diagnosis. *Dendrobium naungmungense* is similar to *D. vexabile* and *D. ciliatilabellum*, but can be distinguished by the oblong epichile with three long-ciliate laminae and the margin crisped with hairs and the margin of column wing with significant denticulation.

Type. MYANMAR. Kachin State. Putao County, Naungmung Town, tropical forest, 500–600 m a.s.l., epiphytic on the trunk of riparian trees, 8 Apr 2017, Qiang Liu, *430* (Holotype, HITBC!).

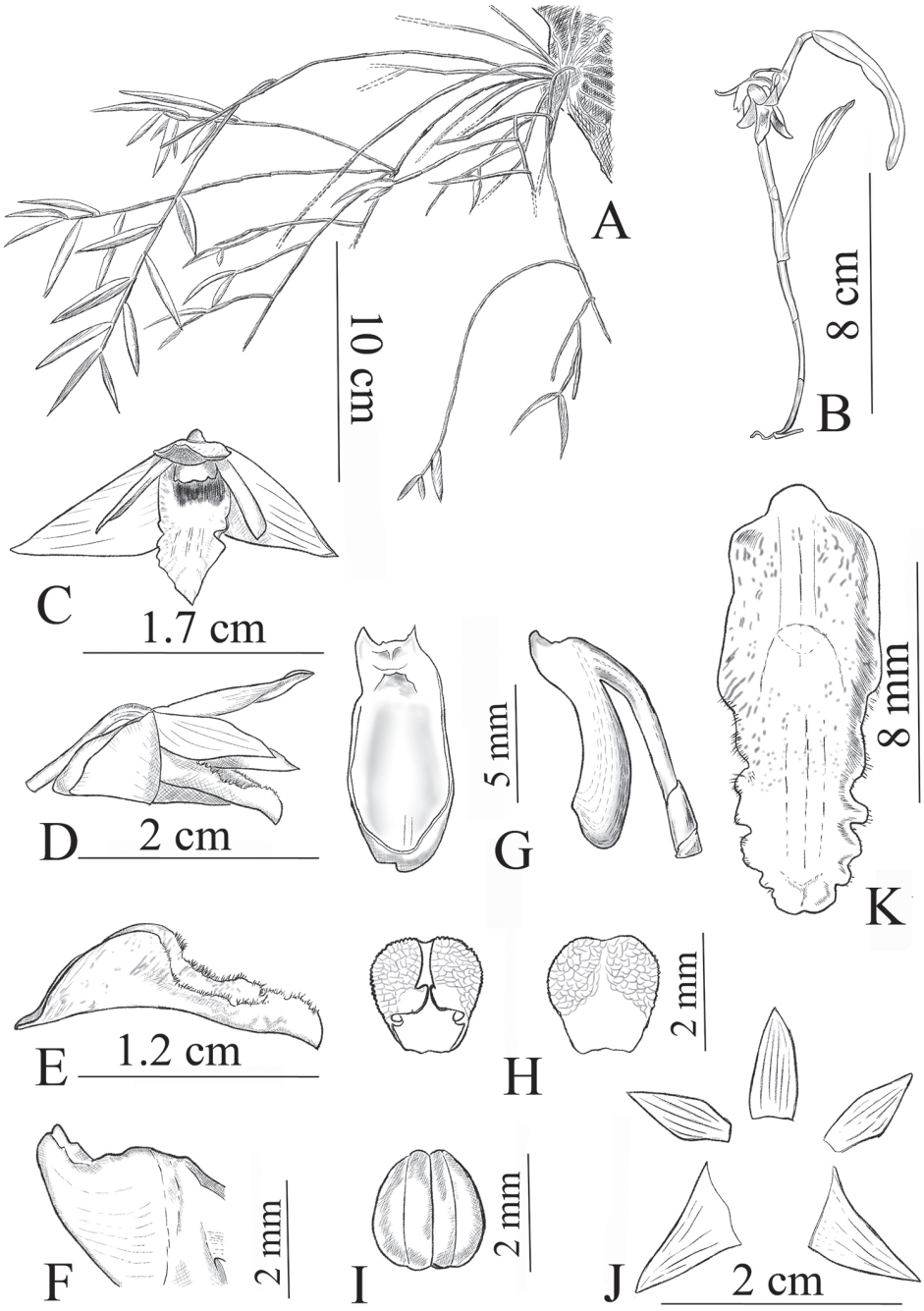

Figure 1. *Dendrobium naungmungense*. **A** Habitat **B** Plant **C** Flower **D** Lateral view of flower **E** Lateral view of labellum **F** Column wing **G** Front and lateral view of column **H** Abaxial and adaxial anther cap **I** Pollinarium **J** Sepals and petals **K** Front view of labellum. All from the type collection (Qiang Liu, *430*) and drawn by Bo Pan.

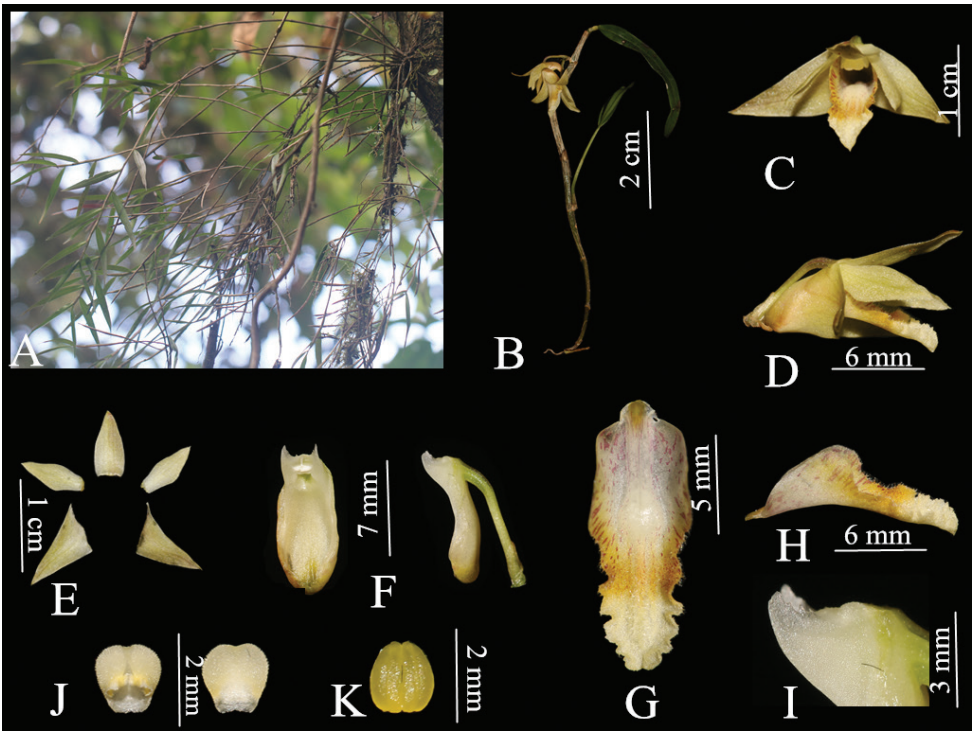

Figure 2. *Dendrobium naungmungense*. **A** Habitat **B** Plant **C** Flower **D** Lateral view of flower **E** Sepals and petals **F** Column **G** Front view of labellum **H** Lateral view of labellum **J** Abaxial and adaxial anther cap **K** Pollinarium **I** Column wing (Photographed by Q. Liu).

Description. Plant epiphytic, pendent, 30–50 cm long. Stems slender, branching from nodes, internodes covered by sheaths, yellowish, 1.4–2.8 cm long. Leaves anguste-ovate, acute to acuminate, entire, sessile, distichous, 3.0–4.2 × 4.0–5.5 mm. Inflorescence leaf-opposed, 1–2 flowered; peduncle short, sheathed at base, 0.7–0.9 cm long; sheaths membranous, overlapping, 2.5–3.0 mm long; floral bracts broadly lanceolate, three veined membranous, 3.0–4.5 × 2.0–2.5 mm. Flower fragrant, ca. 1.5 cm diameter when open, yellowish green, lip with sparsely purple stripe and spots. Dorsal sepals elliptic, 5-veined, 11.2–12.3 × 6.0–6.5 mm, acuminate; lateral sepals triangular, 5-veined, 12.0–13.5 × 8.0–8.5 mm, apex acuminate; mentum broad, ca. 3 mm. Petals lanceolate, 3-veined, 10.5–11.0 × 4.0–4.5 mm, acuminate. Lip 3-lobed with a short claw, obovate (when spread), 14.5–15.0 × 7.5–8.0 mm, lateral lobes elliptic, 6.0–6.5 × 2.6–3.1 mm, margin with hairs; mid-lobe oblong, 7.5–8.0 × 3.5–3.8 mm, margin crisped with hairs. A broad median band on the hypochile; disc with an ovoid cushion, three long-ciliate laminae extending from base to near apex of epichile. Column ca. 9.0 mm, stelidia falcate with significant denticulation. Operculum subglobose, with densely white crystalline papillate.

Etymology. The new species is named after Naungmung, Kachin State, North of Myanmar, where it was discovered in a vast area of tropical rainforest.

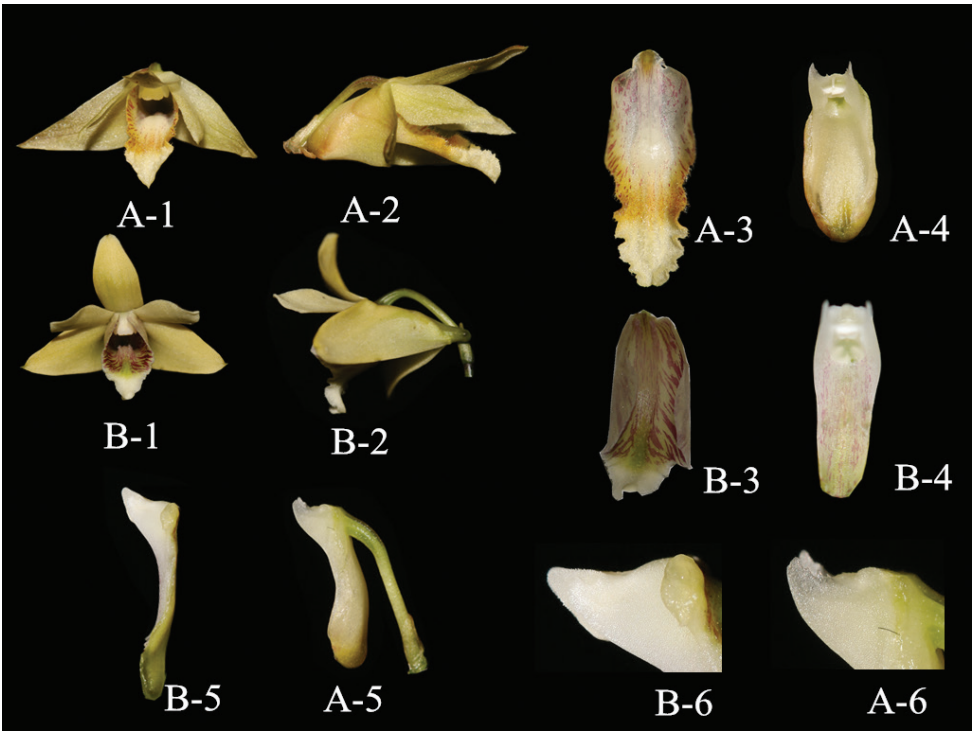

Figure 3. A *Dendrobium naungmungense* (**A–1** Front view of flower **A–2** Lateral view of flower **A–3** Labellum **A–4** Front view of column **A–5** Lateral view of column **A–6** Column wing) **B** *Dendrobium vexabile* (**B–1** Front view of flower **B–2** Lateral view of flower **B–3** Labellum **B–4** Front view of column **B–5** Lateral view of column **B–6** Column wing) (Photographed by Q. Liu)

Distribution and habitat. *Dendrobium naungmungense* is only known from the type locality. It is epiphytic on the trunk of riparian trees in tropical rainforest, which is dominated by *Dipterocarpus obtusifolius* Teijsm. ex Miq. (Dipterocarpaceae).

Additional specimens examined (Paratype). MYANMAR. Kachin State. Putao County, Naungmung Town, tropical forest, 500–600 m a.s.l., epiphyte on the trunk of riparian trees, 11 Jun 2017, Hong Jiang & Qiang Liu, *17017* (YAF!) and 8 Apr 2017, Qiang Liu, *430* (HITBC!).

Conservation status. *Dendrobium naungmungense* was collected in Naungmung Town, Kachin State, Northern Myanmar. Until now, only one population, consisting of ca. 20 mature individuals, has been discovered in 3 years of continuous field investigations (2015–2017). In addition, population growth and human activities have led to serious habitat destruction and deforestation in this region. It is also illegally collected by local people due to the highly ornamental and medicinal values. Hence, according to IUCN Red List Categories and Criteria (IUCN Standards and Petitions Subcommittee 2017), *D. naungmungense* should be regarded as Critically Endangered (CR B1ab (iii, v) + 2ab (iii, v); D), which is the category for species facing the highest risk of extinction in the wild. It meets the IUCN criteria in having an extent of

occurrence < 100 km^2, an area of occupancy < 10 km^2, is known from a single location and with a continuing decline inferred from the number of mature individuals, a continuing decline in the quality of habitats and a population size of less than 50 mature individuals.

Key to *D. naungmungense*, *D. vexabile* and *D. ciliatilabellum*

1 Mentum (1 × 3 mm), epichile (7.5–8.0 mm) longer than hypochile (6.0–6.5 mm), oblong epichile with three ciliate laminae and margin crisped with dense hairs, column wing with significant denticulation ..... ***D. naungmungense***

– Mentum (2 × 1 mm), epichile (3.5–4 mm) significantly shorter than hypochile (9–10 mm), ovate epichile without ciliate laminae and margin crisped without hairs, column wing without denticulation **2**

2 Mid-lobe (2 × 2 mm), disc of lip with densely long-ciliate lamina and undeflexed epichile..... ***D. ciliatilabellum***

– Mid-lobe (4 × 5 mm), disc of lip with sparsely ciliate lamina and de-flexed epichile ..... ***D. vexabile***

Discussion

Morphologically, *D. naungmungense*is is similar to *D. vexabile* and *D. ciliatilabellum*, which are characterised by branched stems, short inflorescences with 1 or 2 flowers, lip 3-lobed with a narrow claw and flowers yellowish green, except the lip with purple streaks or spots. However, the new species differs from *D. vexabile* and *D. ciliatilabellum* by having a wide mentum, small hypochile, oblong epichile with 3 ciliate laminae and margin crisped with dense hairs and column wing with significant denticulation. Meanwhile, *D. ciliatilabellum* differs from *D. vexabile* by having a small mid-lobe, disc of lip with densely long-ciliate laminae and un-reflexed epichile (large mid-lobe, disc of lip with sparsely ciliate lamina and reflexed epichile in *D. vexabile*) (Seidenfaden 1985, Rao and Haridasan 2005; Liu and Gao 2016).

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RESEARCH ARTICLE

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Molecular systematics and the evolution of mycoheterotrophy of tribe Neottieae (Orchidaceae, Epidendroideae)

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Abstract

Neottieae comprise about 150–200 species and are distributed mainly in temperate and subtropical zones of the northern hemisphere. Mycoheterotrophy is common in Neottieae. Based on three DNA markers and a broad sampling of Neottieae, these results indicate that Neottieae is strongly supported as monophyletic and *Palmorchis* is sister to the remaining genera of Neottieae. *Holopogon* and *Neottia* s.s. are deeply nested within *Listera*. The habit of leafless mycotrophy has independently evolved at least three times in Neottieae, one in *Cephalanthera*, another in *Neottia* s.l. and the third in the clade formed by *Limodorum* and *Aphyllorchis*.

Keywords

Generic delimitation, Molecular phylogenetics, Mycoheterotrophy, Neottia, peloric form

Introduction

Neottieae Lindl. is a small tribe in Orchidaceae, comprising about 150–200 species and distributed mainly in temperate and subtropical zones of the northern hemisphere with a few species extending into tropical alpine regions (Chen et al. 2009; Dressler 1981; Jin 2014; Jin and Pang 2016; Pridgeon et al. 2005). Most phylogenetic reconstructions

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indicate that Neottieae is monophyletic and one of the basal groups of the subfamily Epidendroideae (Chase et al. 2015; Feng et al. 2016; Freudenstein and Chase 2015; Freudenstein et al. 2004; Gorniak et al. 2010; van den Berg et al. 2005; Xiang et al. 2012). Recent literature indicates that the habits of mixotrophy and of mycoheterotrophy are common in Neottieae (Gebauer and Meyer 2003; Girlanda et al. 2006; Jacquemyn et al. 2015; Julou et al. 2005; Liebel et al. 2010; Tesitelova et al. 2015; Yagame et al. 2016). Pridgeon et al. (2005) stated that one of the remarkable evolutionary trends in Neottieae is the repeated transition from photosynthetic autotrophy to obligate mycoheterotrophy. Some mixotrophic orchids, such as *Cephalanthera damasonium*, *Epipactis* spp. and *Limodorum abortivum*, obtain carbon from their mycorrhizal fungi and through photosynthesis (Girlanda et al. 2006; Julou et al. 2005; Liebel et al. 2010), while some species, such as *Aphyllorchis caudata* and *Cephalanthera exigua*, are fully mycoheterotrophic. Julou et al. (2005) proposed the evolution of mycoheterotrophy in Neottieae in three successive transitions: first a 'mycorrhizal shift' to ectomycorrhizas fungi allowing mixotrophic nutrition; second a transition to high specificity; and third a transition to fully heterotrophic nutrition.

The aims of the present study are 1) to analyse phylogenetic interrelationships within Neottieae using evidence from molecular data (chloroplast *mat*K, *rbcL* and nuclear ITS) and 2) to understand the evolutionary pattern of the mycoheterotrophic habit in Neottieae.

Material and methods

Taxon sampling

Sixty-eight species were included in this study, representing eight genera of Neottieae: *Aphyllorchis*, *Cephalanthera*, *Epipactis*, *Holopogon, Limodorum*, *Listera*, *Neottia* and *Palmorchis.* Outgroups include three species from tribe Orchideae: *Ophrys insectifera*, *Ophrys apifera* and *Serapias cordigera.* Chloroplast DNA (specifically *rbcL* and *matK*) and nuclear ITS were analysed. Voucher information and GenBank accession numbers are shown in Supplementary material 1. New sequences are in Supplementary material 4–6.

DNA extraction, amplification and sequencing

Total genomic DNA was isolated from silica-gel-dried materials using a Plant Genomic DNA Kit (Beijing Biomed Co., LTD, Beijing, China). For this study, three markers (the coding plastid gene *matK*, *rbcL*) and the nuclear ribosomal DNA internal transcribed spacers (ITS) were used. The PCR and sequencing primers for *matK*, *rbcL* and ITS are listed in Supplementary material 2. The selected DNA regions

were amplified by using a standard polymerase chain reaction (PCR). The sequencing reactions were performed by using the ABI Prism Bigdye Terminator Cycle Sequencing Kit (Applied Biosystems, ABI).

Phylogenetic analysis

Sequences were aligned using the default parameters in ClustalX v1.83 (Thompson et al. 1997) and manually adjusted with BioEdit v5.0.9 (Hall 1999). Alignments are listed in Supplementary material 4–6. Phylogenetic analyses of the combined dataset were carried out using parsimony (PAUP* v4.0b10) (Swofford 2003) and Bayesian Inference (BI; MrBayes v3.2.0) (Ronquist and Huelsenbeck 2003). Parsimony heuristic searches were performed with 1000 random sequence addition replicates, tree-bisection-reconnection (TBR) branch swapping, MulTrees in effect and steepest descent off, saving all minimum length trees (MULPARS on). Internal branch support under maximum parsimony (MP) was estimated by using 1000 bootstrap (BS) replicates; the starting trees were obtained by random addition with ten replicates for each replication, TBR branch swapping and MULPARS in effect.

For BI analyses, the data were partitioned a priori on the basis of gene identity and, for coding regions, codon position. Based on Bayes factors, the partitioning strategy (*rbcL*, *matK*) was identified as optimal for these data and was applied in all subsequent Bayesian analyses. Initial analyses providing data for comparison of the different partition strategies were run for 3000000 generations and analyses applying the final best-fit model were run for 5000000 generations. Runs were started from a random tree sampled every 1000 generations of the MCMC chain, with default priors and the option prset/ratepr set as variable. Each parameter estimation, obtained from the results of two runs, was checked in Tracer v1.5 (http://tree.bio.ed.ac.uk/software/tracer) to ascertain whether they had obtained a proper effective sample size and to verify that the stationary state had been reached. Trees from the first 10% of generations were discarded as burn-in. The remaining trees were combined to build a 50% majority-rule consensus tree. Bayesian Inference was run on CIPRES (Miller et al. 2010).

Results

Sequences characteristics

In this study, 159 new sequences were obtained (60 ITS, 48 *matK*, 51 *rbcL*). In the overall matrix, the combined dataset of three markers comprised 3817 aligned nucleotides: 730 bp from ITS and 3087 bp from chloroplast regions; 24% of the combined alignment sites were parsimony-informative. The alignments of each matrix and their properties are summarised in Supplementary material 3–6.

Phylogenetic analyses

As the partition homogeneity test for plastid DNA + ITS shows there were no strongly supported incongruent results in the datasets ($P = 0.17$), the datasets for simultaneous analyses were therefore combined.

Phylogenetic relationships based on the ITS data had a better resolution than the two combined plastid DNA data (results not shown here). Based on the combined ITS and plastid DNA data, these findings are consistent in the overall topology of the trees produced with maximum parsimony (MP) and Bayesian Inference (BI) methods, except for a few of the collapsed nodes. Bootstrap values (BS) were often lower than the Posterior Probability (PP) from the Bayesian analysis. The BI topology from the combined dataset was chosen as the primary tree for discussion of phylogenetic relationships (Figure 1; the MP strict consensus tree is not shown).

The results indicated that the tribe Neottieae can be subdivided into five clades:

Clade I consists of sampled species of *Epipactis* and all the species can be subdivided into 2 subclades: subclade I includes 17 species (PP = 88, BP = 57); subclade II includes *Epipactis veratrifolia* and *Epipactis flava* (PP = 100, BP = 83).

Clade II consists of sampled species of *Aphyllorchis* and *Limodorum* with strong support (PP = 100, BP = 99). *Aphyllorchis* is moderately supported as monophyletic (PP = 100, BP = 81) and is subdivided into two groups, a temperate group and a tropical group.

Clade III includes sampled species of *Holopogon, Listera, Neottia* with strong support (PP = 100, BP = 99). All sampled mycoheterotrophic species of *Holopogon* and *Neottia* form a monophyletic subclade nested within *Listera* with strong support (PP = 100, BP = 100) and sister to an autotrophic and alpine group. *Neottia alternifolia* is sister to *N. morrisonicola* with strong support (PP = 100, BP = 99).

Clade IV includes sampled species of *Cephalanthera* with moderate support (PP = 100, BP = 75) and forms a polytomy with three groups: an Eastern Asian autotrophic group with 4–5 species (pp = 1.00, BP = 65), a holomycotrophic group with 2 species (pp = 1.00, BP = 84) and a Central Asian Group with 2 species.

Clade V includes sampled species of *Palmorchis* (PP = 100, BP = 100) and is sister to the other four clades.

Discussion

Phylogenetic interrelationships within Neottieae

There are some discussions about the phylogenetic relationships in Neottieae and its alliance (Feng et al. 2016; Pridgeon et al. 2005; Xiang et al. 2012), most of these interrelations being supported by the authors' results. However, many new relationships within Neottieae were discovered.

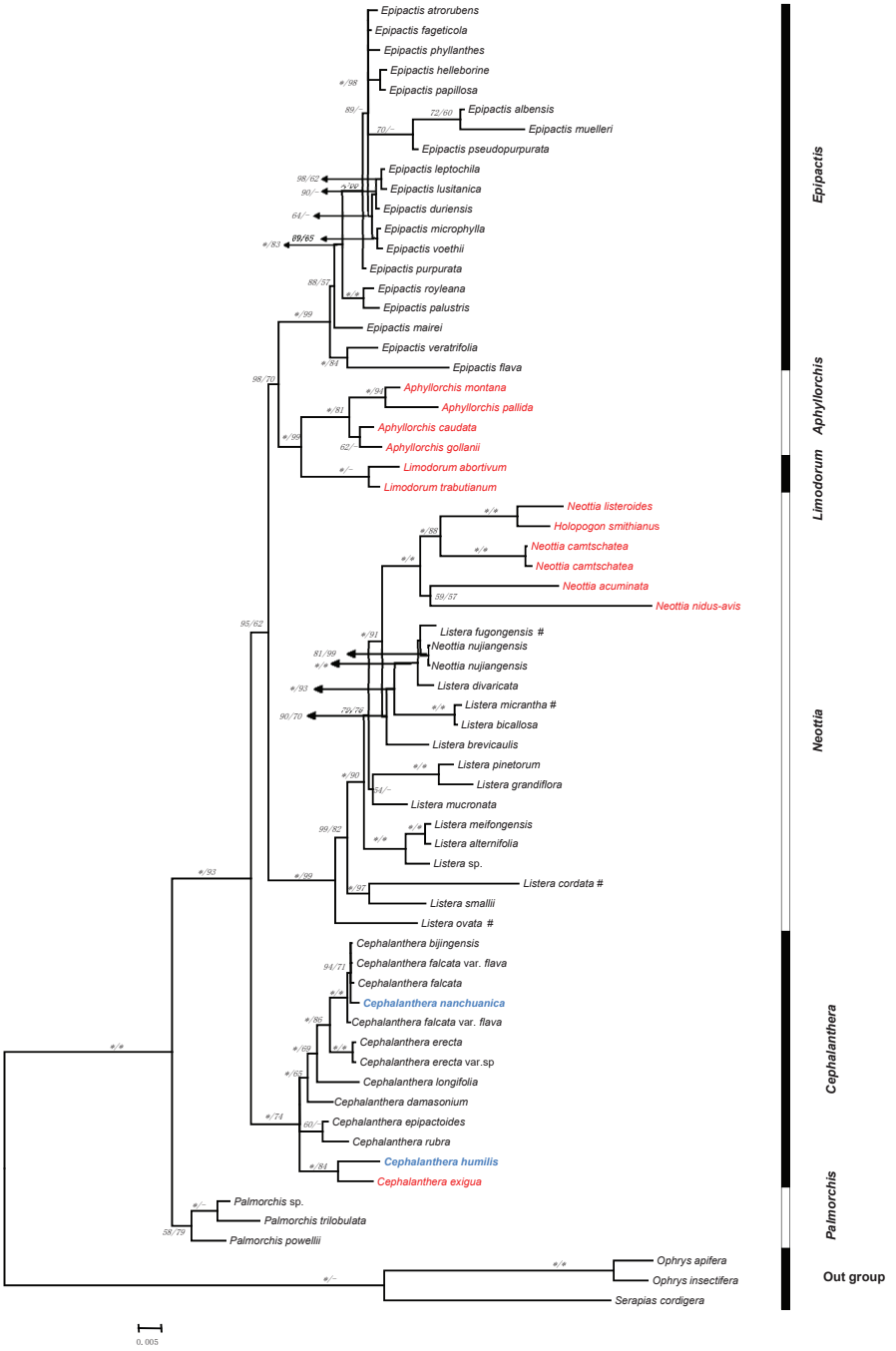

Figure 1. Phylogram obtained from Bayesian Inference analysis of combined nrDNA ITS, matK and rbcL data. Numbers at nodes are Bayesian posterior probabilities and bootstrap percentages (≥ 50%), respectively. "–" indicates that the node was not supported in MP analysis, asterisk (*) represent 100% support and red colour denotes species that are mycotrophic herbs.

Epipactis: Although *Epipactis* is a small to middle size genus with 15–75 species, there is much debate about species delimitation in this genus (Squirrell et al. 2002). Although these results indicate that *Epipactis* is strongly supported as monophyletic and is sister to clade II formed by *Aphyllorchis* and *Limodorum*, the infrageneric system needs to be re-evaluated. Two species of sect. *Arthrochilium*, *Epipactis veratrifolia* and *E. flava*, form a well resolved clade that is sister to the remaining *Epipactis* species. Sect. *Epipactis* is deeply nested within sect. *Arthrochilum* and is supported as a monophyletic clade (PP = 1.00, BS = 95). Despite its morphological homogeneity, sect. *Arthrochilum* is paraphyletic as sect. *Epipactis* is deeply embedded within it.

Aphyllorchis* and *Limodorum: The sister relationship between *Aphyllorchis* and *Limodorum* is supported by the shared holomycotrophic habit and several morphological characters, such as the long and slender column and two powdery pollinia with viscidium (Pridgeon et al. 2005). However, these two genera can be distinguished easily by the lip morphology and by their distribution pattern. *Limodorum* has an entire labellum with a spur and is restricted to central and southern Europe, southwest Asia and north Africa, whereas *Aphyllorchis* has a more or less lobed labellum without spur and is restricted to the area ranging from the eastern part of Asia to Australia. The four sampled species of *Aphyllorchis* are subdivided into two groups; one is of two species (*A. pallida, A. montana*) restricted to montane forest in tropical Asia, while the other is distributed mainly in subtropical regions.

***Neottia* s.l.**: *Neottia s.l.* is monophyletic with strong support (PP = 1.00, BS = 99). Several widespread temperate species, *Neottia ovata, N. cordata* + *Neottia smallii*, are resolved as the successive basal groups in *Neottia*, while the mycotrophic and alpine taxa are nested deeply within *Neottia* (Figure 1). Four sampled mycotrophic taxa form a clade with strong support (PP = 1.00, BP = 88), sister to the alpine group (including *Neottia brevicaulis*). The relationship between *Neottia alternifolia*, *N. morrisonicola* and *Neottia* sp. (Jin 11279) is supported by morphological characters, such as two more or less alternate leaves in the middle of the stem, apex of lip shallowly notched or emarginate and column short. *Neottia bicallosa* is sister to *N. micrantha* (PP = 1.00, BS = 100) supported by morphological characters, such as two prostrate leaves, three-lobed lip and mid-lobe dentate, column short. *Neottia camtschatea* is sister to the group formed by *N. listeroides* + *Holopogon* with strong support (PP = 1.00, BS = 88).

Cephalanthera: *Cephalanthera* is moderately supported as monophyletic and resolved as sister to Clade I + Clade II + Clade III with weak support. Peloric forms are common in *Cephalanthera*, such as *C. humilis, C. nanchuanica, C. falcate* var. *flava* and *C. erecta* var. *lanceolata*. The results indicated that such peloric forms have independently evolved at least three times in *Cephalanthera* (Figure 1).

Palmorchis: There is some debate about the phylogenetic treatment of *Palmorchis*. Dressler (1993) treated *Palmorchis* as a distinct tribe, Palmorchideae, while Chase et al. (2003) placed it in Neottieae and was followed by later authors. Recent results of molecular evidence indicated that *Palmorchis* is sister to the remaining genera of Neottieae (Cameron et al. 1999; Freudenstein et al. 2004; Xiang et al. 2012) and the authors' results agree well with these results. Morphologically, *Palmorchis* is isolated in Neottieae by having reed-like

stems, petiolate and plicate leaves, column more or less adnate to lip, four granular or subceraceous pollinia without caudicles or stipes (Dressler 1993). *Palmorchis* is restricted to Central and South America, where no other members of Neottieae s.s. occurs.

Evolution of mixotrophic and mycoheterotrophic habit

Leafless mixotrophic/mycoheterotrophic orchids of Neottieae can be subdivided into two kinds. One is obligate mycoheterotrophic, such as *Cephalanthera exigua* and *Neottia nidus-avis,* characterised by achlorophyllous plants, fleshy roots without root hairs. The other is mixotrophic, such as *Limodorum abortinum*, characterised by leafless but more or less green plants, roots elongate, more or less hairy. The results indicate that the habit of leafless mixotrophic/mycoheterotrophic orchids has independently evolved at least three times in Neottieae, in Clade II (*Cephalanthera*), Clade III (*Neottia* s.l.) and Clade V (*Limodorum* + *Aphyllorchis*) respectively.

Julou et al. (2005) suggested the evolution of a three-step transition to mycoheterotrophy via mixotrophy. The results indicated an interesting evolution pattern of mixotrophic/mycoheterotrophic orchids, which may have evolved independently within each clade. Two mycoheterotrophic species (*C. humilis*, *C. exigua*) and two mixotrophic ones (*C. damasonium, C. longifolia*) are nested within *Cephalanthera*. In Clade V, the mixotrophic genus *Limodorum* is sister to the mycoheterotrophic genus *Aphyllorchis*. Recent results indicate that mixotrophy has been confirmed in *Platanthera minor* (Yagame et al. 2012) and that specificity of mycoheterotrophic orchis-fungus association is low (Roy et al. 2009). It seems that mycoheterotrophy and mixotrophy could evolve from autotrophic ancestors independently. However, this hypothesis needs to be further tested.

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Supplementary material 1

Table 1
Authors: Ting Zhou, Xiao-Hua Jin
Data type: Word document.
Explanation note: List of taxa, vouchers and GenBank accession numbers downloaded from NCBI. Newly sampled sequences are in Supplementary material 4–6.
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Supplementary material 2

Table 2
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Explanation note: A list of primers used for PCR and sequences in this study.
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Supplementary material 4

Alignment of ITS
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Supplementary material 5

Alignment of matK
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Supplementary material 6

Alignment of rbcL
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Data type: Fasta file.
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RESEARCH ARTICLE

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Hedychium putaoense (Zingiberaceae), a new species from Putao, Kachin State, Northern Myanmar

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Abstract

Hedychium putaoense Y.H. Tan & H.B. Ding, a new species of Zingiberaceae from Putao, Kachin state, Northern Myanmar, is described and illustrated. It is similar to *H. densiflorum* Wall. and *H. longipedunculatum* A.R.K. Sastry & D.M. Verma, but differs by its very small bract (4–6 × 2.5–3 mm vs. 18–19 × 5–5.5 mm and ca. 11 × 7 mm, respectively), semicircle and dark red bracteole, orange flower and broadly falcate to lanceolate lateral staminodes.

Keywords

Hedychium, Myanmar, Taxonomy, Morphology, Zingiberaceae

Introduction

The pantropical Zingiberaceae is the largest family in the monophyletic order Zingiberales with 53 genera and more than 1377 species (Kress et al. 2002; Pederson 2004; Kong et al. 2010). *Hedychium* Koenig, commonly called the "ginger lily" or "butterfly lily", produces one of the most beautiful and fragrant flowers in the family Zingiberaceae (Sanoj et al. 2010). The genus was established by Koenig in 1783, based on the species *H. coronarium* Koenig. There is currently little consensus on the number of species, with recent estimates varying from about 50 (Wu and Larsen 2000) to 80 (Sirirugsa and Larsen 1995) and these

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are mainly distributed throughout most of tropical Asia (Sirirugsa and Larsen 1995; Wood et al. 2000). The genus has its highest species diversity in the tropical and subtropical Himalayan region (Sanoj et al. 2010). *Hedychium* is characterised by flowers with very long (rarely short) filaments, dorsifixed anther and usually fragrant flowers (Hu and Liu 2010a). Members of the genus can be easily recognised by their showy, many-flowered terminal spikes, some of which have been cultivated worldwide (Picheansoonthon and Wongsuwan 2011).

Several new species of *Hedychium* have been described in the last few decades (Williams et al. 2003; Wongsuwan 2008; Picheansoonthon and Wongsuwan 2009, 2011; Sanoj et al. 2010; Hu and Liu 2010a, 2010b; Sanoj and Sabu 2011; Thomas et al. 2015; Odyuo and Roy 2017). So far, 15 species of *Hedychium* have been recorded in Myanmar: *H. bordelonianum* W.J. Kress & K.J. Williams, *H. coccineum* Buch.-Ham. ex Sm., *H. coronarium* Koenig, *H. elatum* R. Br., *H. ellipticum* Buch.-Ham., *H. flavum* Roxb., *H. forrestii* Diels, *H. gomezianum* Wall., *H. gracile* Roxb., *H. marginatum* C.B. Clarke, *H. spicatum* Sm., *H. stenopetalum* Lodd., *H. thyrsiforme* Sm., *H. venustum* Wight, and *H. villosum* Wall. (Kress et al. 2003).

From April to May in 2017, a team from the Xishuangbanna Tropical Botanical Garden (XTBG) in collaboration with the Forest Research Institute of Myanmar, conducted field work in Northern Myanmar to survey plant diversity. During field work, some interesting specimens of *Hedychium* were found in Putao, Kachin state. Based on a detailed examination of the morphological characteristics of the collected material and those of the closely related similar species, the authors have arrived at the conclusion that the specimens of *Hedychium* collected in Myanmar belong to a species new to science, which are described and illustrated herein.

Material and methods

Measurements and morphological character assessments of the new species *Hedychium putaoense* have been examined based on fresh materials and dried specimens. It has been compared with the morphologically similar species *H. densiflorum*, *H. longipedunculatum*, with affinities inferred using descriptions, type specimens and other herbarium specimens (Wallich 1832; Sastry and Verma 1968; Wu and Larsen 2000; Moaakum and Dey 2013). Protologues and images of type specimens were gathered from JSTOR Global Plants (http://plants.jstor.org).

Taxonomic treatment

Hedychium putaoense **Y.H.Tan & H.B.Ding, sp. nov.**
urn:lsid:ipni.org:names:77175483-1
Figure 1

Diagnosis. *Hedychium putaoense* Y.H. Tan & H.B. Ding is morphologically similar to *H. densiflorum* Wall. and *H. longipedunculatum* A.R.K. Sastry & D.M. Verma, but

it can be easily distinguished by its very small bract (4–6 × 2.5–3 mm vs. 18–19 × 5–5.5 mm and ca. 11 × 7 mm, respectively) and bracteole (2–2.5 × 3–3.5 mm vs. ca. 9 × 2 mm and ca. 6 × 4 mm, respectively), orange flower and broadly falcate to lanceolate lateral staminodes.

Type. MYANMAR. Kachin State: Putao District, the top of the mountain from Masabu village to Namti village. Epiphytic herbs in tropical montane forests, 97°17'42"E, 27°25'29"N. 1700 m a.s.l., 13 May 2017, flowering, *Myanmar Exped. M1724* (holotype: HITBC!; isotypes: HITBC!)

Description. Epiphytic, sometimes terrestrial, perennial rhizomatous herbs, light greyish-green externally. Leafy shoot 20–50 cm high, slanting with erect inflorescence. Leaves 4, spreading, sessile, upper petioled; petiole 2–10 mm long; ligule ca. 8–19 mm long, apex obtuse, glabrous, membranous, translucent, reddish brown when fresh, yellowish brown when dry, closely appressed to the stem; lamina 13–23 × 3–7 cm, lanceolate, dark green above, pale green below, or sometimes light purple-tinged below, glabrous; margin undulate, membranous, non-ciliate; apex narrowly caudate, twisted, base attenuate. Inflorescences 7–10 cm long, cylindrical, dense, erect, rachis glabrescent. Bracts 4–6 × 2.5–3.0 mm, ovate, purplish-red, glabrous, convolute, margin ciliate, membranous, tip acute, cincinnus 1-flowered. Bracteoles 2.0–2.5 × 3.0–3.5 mm, semicircular, dark red, glabrous, membranous, acute at tip, margin ciliate. Flower 2.8–3.9 cm long, small, orange, nearly entire inflorescence open at a time, ascending. Calyx 1.2–1.4 cm long, 2.0–2.5 mm wide at mouth, tubular, pale light red, densely villous, tufted hairs at tip, membranous, upper half inflated, lower part closely appressed to corolla tube, unilaterally split up to ca. 5 mm depth. Corolla tube 10–13 mm long, creamy yellow, glabrous, tube intensely curved towards tip about 90° to 180°. Corolla lobes 10–16 × 1–2 mm linear-lanceolate, red, membranous, glabrous. Lateral staminodes 11–13 × 3–4 mm, broadly falcate to lanceolate, clawed towards base, orange, spreading on flower, obtuse at tip, intensely reflexed back. Labellum 12–14 × 4–7 mm, widely obovate, orange, spreading on flower, base cuneate, sinus ca. 2–3 mm deep, lobes oblong, obtuse at tip. Stamen 1.4–1.7 cm long. Filament 1.1–1.2 cm long, ca. 2 mm wide at base, orange, creamy yellow towards base, intensely curved towards tip about 180°. Anthers ca. 5 × 2 mm, oblong, orange, split opens from top to bottom, attached with the filament at ca. 1 mm above from base, thecae parallel with the filament; connective red, glabrous, non-crested. Ovary ca. 2.5 mm diameter, sub-globose, densely villous. Style filiform, creamy white, glabrous, dark red-tinged towards stigma. Stigma ca. 0.5 mm wide, dark red, cup-shaped, mouth margin ciliate, ca. 1 mm exserted from the anther. Epigynous glands 2, ca. 1 mm long, oblong, orange. Fruit unknown.

Phenology. Flowering from May to July.

Distribution and habitat. This new species is known to grow at the top of the mountain from Masabu village to Namti village, Putao District, Kachin State, where it grows epiphytically on the trees of tropical montane forests at an elevation of ca. 1400–1800 m.

Etymology. The species is named after the type locality, Putao county, in Kachin State, Myanmar.

Affinities. *Hedychium putaoense* Y.H. Tan & H.B. Ding shares certain characteristics with *H. densiflorum* (Wallich 1832) and *H. longipedunculatum* (Sastry and Verma

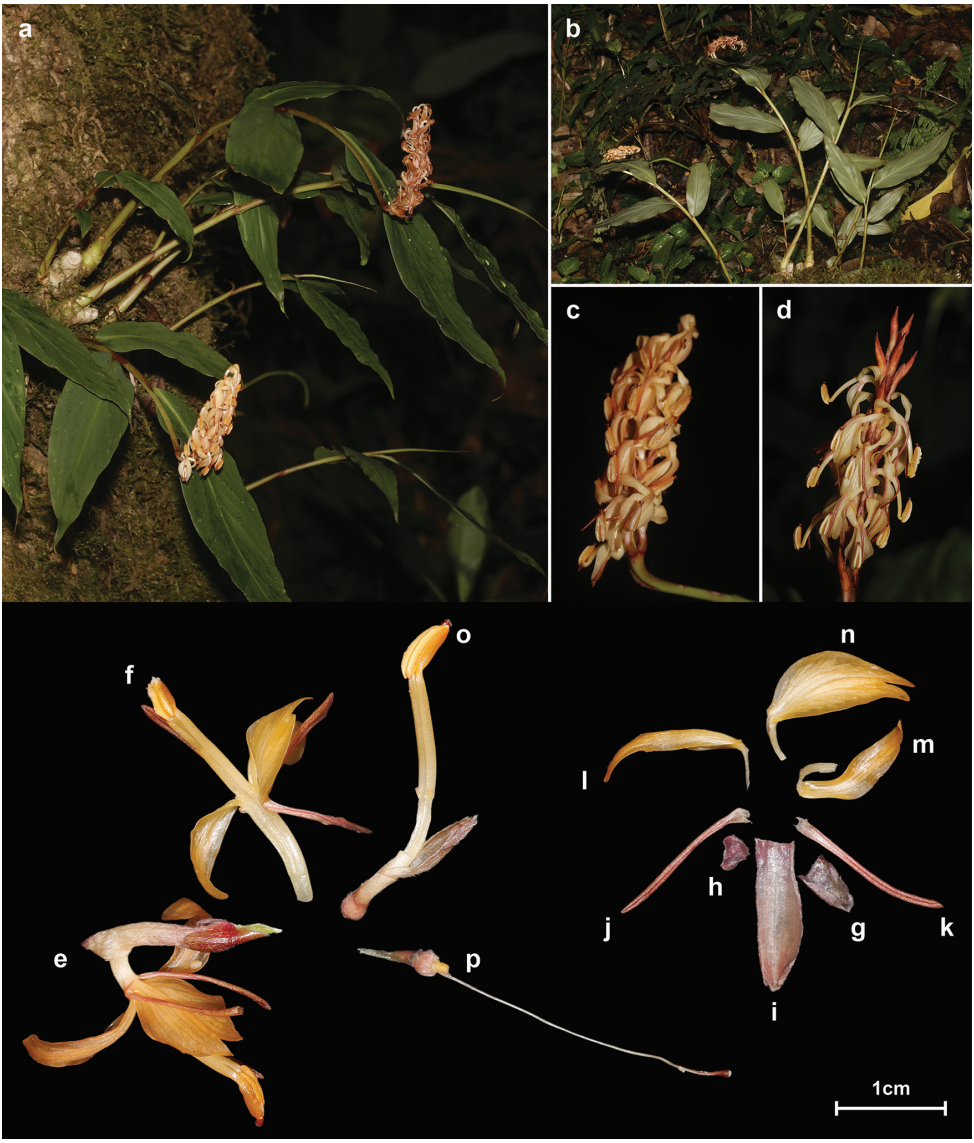

Figure 1. *Hedychium putaoense* Y.H. Tan & H.B. Ding. **a–b** Habit **c–d** Inflorescence **e–f** Front and lateral view of flower **g** Bract **h** Bracteole **i** Calyx **j–k** Corolla lobe **l–m** Lateral staminodes **n** Labellum **o** Corolla tube with anther and calyx **p** Ovary with pistil and glands. Photographed by Y.H. Tan & H.B. Ding.

1968), e.g. non-imbricating bracts, cincinnus 1-flowered, small and dense flower, oblong anther and sub-globose ovary. After comparison with specimens and descriptions in literature, it was found that *H. putaoense* can be clearly differentiated from the latter two species, even on the basis of their vegetative characters: e.g. the proportion of the bract to the calyx; *H. putaoense* has very small bracts that are shorter than the calyx (4–6 vs. 12–14 mm), whereas, the bracts of *H. densiflorum* are longer than the calyx (18–19 vs. 13–14 mm) and the bracts of *H. longipedunculatum* are equal in length

Table 1. Comparison of key morphological characters of *Hedychium putaoense*, *H. densiflorum*, and *H. longipedunculatum.*

Attributes	*H. putaoense*	*H. densiflorum*	*H. longipedunculatum*
Ligule	8-19 mm long apex obtuse	10–11 mm long apex obtuse	15–20 mm long notched at tip
Lamina	13–23 × 3–7 cm lanceolate	28–31 × 4.5–5.8 cm elliptic	15–23 × 6–10 cm broadly elliptic
Inflorescence	7–10 cm long rachis glabrescent	11–17 cm long rachis glabrescent	9–20 cm long rachis hairy
Bract	4–6 × 2.5–3 mm ovate, purplish red	18–19 × 5–5.5 mm elliptic, pale green	ca. 11 × 7 mm triangular, pinkish-red
Bracteole	2.0–2.5 × 3–3.5 mm semicircle, dark red	8–10 × ca. 2 mm tubular, pale green	ca. 6 × 4 mm ovate, red
Flower	2.8–3.9 cm long, orange	2.8–3 cm long, orange-red	3–3.3 cm long, creamy yellow
Calyx	12–14 mm long, pale light red	13–14 mm long, white	ca. 11 mm long, pale yellow
Corolla tube	10–13 mm long creamy yellow curved towards tip about 90° to 180°	18–19 mm long white, orange-red towards tip bent to one side towards tip	ca. 11 mm long creamy yellow with pale red erect
Corolla lobes	10–16 × 1–2 mm linear-lanceolate, red	12–13 × ca. 3 mm elliptic, yellow	ca. 16 × 3 mm linear-lanceolate, creamy yellow
Labellum	12–14 × 4–7 mm, widely obovate, orange, sinus 2–3 mm deep	9–10 × ca. 8 mm, widely obovate, orange-red, sinus 3.5–4 mm deep	ca. 15 × 6 mm, spatulate, creamy yellow, sinus ca. 1 mm deep
Lateral staminodes	11–13 × 3–4 mm broadly falcate to lanceolate, orange	8–8.5 × 5 mm elliptic, orange-red	17 × 7 mm spatulate, creamy-yellow
Stamen	1.4–1.7cm long	1.4–1.5 cm long	ca. 2.2 cm long
Filament	11–12 mm long, orange intensely curved towards tip about 180°	8–8.5 mm long, orange-red straight	ca. 15 mm long, yellow erect
Anther	ca. 5 × 2 mm, orange	ca. 6.5 × 2.5 mm, orange-red	ca. 7 mm long, bright-yellow
Connective	red	orange-red	bright-yellow
Ovary	ca. 2.5 mm diameter densely villous	ca. 2 mm diameter glabrous	ca. 3 mm diameter densely villous
Stigma	ca. 0.5 mm wide, dark red	ca. 1 mm wide, yellow	ca. 1 mm wide, green
Style	filiform, creamy white dark red tinged towards stigma	filiform, white yellow tinged towards stigma	filiform, white green tinged towards stigma

with that of the calyx (ca. 11 vs. 11 mm). *H. putaoense,* furthermore, differs in having semicircular and dark red bracteole, corolla tube curved towards the tip by about 90° to 180°, orange lateral staminodes and labellum, filament intensely curved towards the tip by about 180°, densely villous ovary and dark red stigma. *H. densiflorum* has tubular and pale green bracteole, corolla tube slightly bent to one side towards the tip, orange-red lateral staminodes and labellum, straight filament, glabrous ovary and yellow stigma. *H. longipedunculatum* from India has notched ligule, hairy rachis, triangular bract, ovate bracteole, creamy yellow flower, erect corolla tube, straight filament and green stigma. A detailed comparison of the morphological differences amongst these taxa is given in Table 1 and the evidence from morphological analysis supports the recognition of *H. putaoense* as a distinct species.

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RESEARCH ARTICLE

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Rediscovery and amended descriptions of *Begonia kingdon-wardii* (Begoniaceae) from North Myanmar

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Abstract

Begonia kingdon-wardii Tebbitt was rediscovered in 2014 from Myanmar after 67 years based on its last collection in 1937. Its previously unknown female flower and inaccurate morphology of leaf and ovary have been additionally described. This species belongs to *Begonia* sect. *Sphenanthera* (Hassk.) Warb. due to its dioecious habit, 3-locular ovary, berry fruits and thick placenta segments. Morphologically, it is similar to *Begonia gulinqingensis* S. H. Huang & Y. M. Shui in the leaf shape, placentation and fruit shape, but different in its dioecious plants, pliciform leaves, two-petalled female flowers and berry fruits. The rediscovery of this amazing living species will attract significant interest for scientific research and horticultural application.

Keywords

Begonia, *Begonia kingdon-wardii*, *Begonia* sect. *Sphenanthera*, Myanmar, Rediscovery

Introduction

Begonia L. includes more than 1800 species which are widely distributed in tropical and subtropical areas (Ku et al. 2007; Hughes et al. 2015). During a recent botanic survey on plant diversity of Hkakaborazi National Park in North Myanmar in 2014, a dioecious species was collected of *Begonia* with 3-loculed berry fruits and was un-

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known by the comparison with the report of the floristic report in this region (Khin and Aung 2002). According to the treatment of sections in *Begonia* (Doorenbos et al. 1999; Shui et al. 2002), this species should belong to *Begonia* sect. *Sphenanthera* (Hassk.) Warb. Based on further comparison with all the previously published species in *Begonia* sect. *Sphenanthera* (Smith et al. 1986; Ku et al.1997; Pham1999; Huang and Shui 2006; Hughes 2008; Averyanov and Nguyen 2012), its two-petalled female flower and the serpentinous adaxial leaf surface are distinct and unique in this section.

Begonia kingdon-wardii was first reported in 2007 based on the holotype specimen collected from Northern Myanmar in 1926 (Fig. 1) and a paratype specimen collected near its type locality in 1937. Thereafter, no more specimens of this species had been found until 2014 subsequent to examination of the main herbaria worldwide which possessed rich collections from the regions, such as E, K, NY and so on (Hughes et al. 2015). Therefore, the species was rediscovered 67 years later in the field after the last specimens had been collected in 1937 (Tebbitt 2007). In the protologue, there were no detailed descriptions of petals on the female flower and a wrong description with 4-locular ovary, which is actually 3-locular ovary according to the authors' observation in the field.

Begonia kingdon-wardii was named after Frank Kingdon-Ward, a famous plant hunter in the earlier period of the 20th century. For the purpose of collecting seeds of beautiful hardy plants and of dried specimens for English gardens, he carried out many expeditions in N Myanmar, NE India (Assam) and SW China (SE Tibet and NW Yunnan) from 1911 (Lyte 1989, Tebbitt 2007). Furthermore, he wrote and published 25 books, such as "On the Road to Tibet" (1910), "In Furthest Burma" (1921), "Riddle of the Tsangpo Gorges" (1926), "Plant Hunting on the Edge of the World" (1930), "Burma's Icy Mountains" (1949) etc. Up to now, more than 100 species have been named after him, such as *Aralia kingdon-wardii* J. Wen, Lowry & Esser, *Cinnamomum kingdon-wardii* Kosterm., *Daphne kingdon-wardii* Halda., *Euphrasia kingdon-wardii* Pugsley, *Lilium wardii* Stapf ex W. W. Sm., *Impatiens kingdon-wardii* Nob. Tanaka & T. Sugaw., *Ixora kingdon-wardii* Bremek., *Mussaenda kingdon-wardii* Joyaweera, *Rhododendron wardii* W. W. Sm., and *Vaccinium kingdon-wardii* Sleumer.

Begonia kingdon-wardii **Tebbitt in Kew Bulletin 62: 143, 2007**
Figs 1A, 2

Type. Myanmar, Kachin Mts E of Fort Hertz, 27°20'N, 97°30'E, alt. 900 m, Aug. 1926, Kingdon-Ward 7341 (holotype, K000037101!; isotype, K000037102!).

Handwriting annotation from the holotype specimens (Fig. 1B): "Begonia ass. B. Balansaeanae Gagnep. almost aff.?. Flowers white. Leaves very dark green above, glossy, with a metallic lustre, purple nervation, margin crenated. On shady banks and rocks in the jungle. Whole plant glabrous. The contrast between the white flowers and the dark shining leaves amongst which they nestle is very striking".

Revised description. Plants terrestrial, perennial; stems rhizomatous, 3–10 cm long, 0.2–0.4 cm diam., with fibrous roots on node and 0.5–0.8 cm long internode.

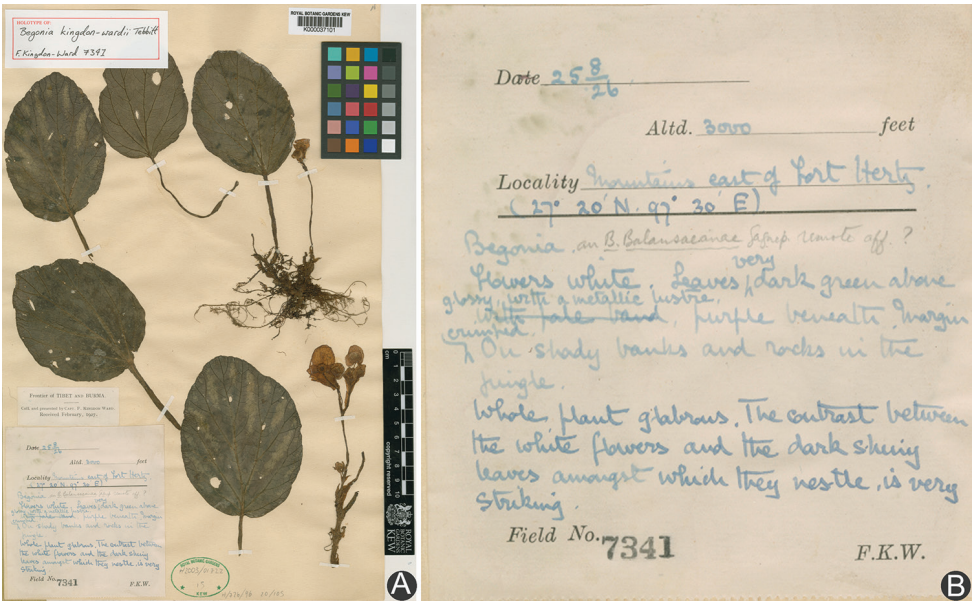

Figure 1. Holotype of *Begonia kingdon-wardii* Tebbitt (**A**) and the annotation on the holotype specimens (**B**).

Stipules caducous, lanceolate, 1.1–1.3 × 0.4–0.5 cm, margin entire, apex acuminate. Leaf alternate, pliciform, rotund, 10–16 cm diam., margin entire, symmetric on base, usually 4–7-palmatifid venation; adaxially glabrous and serpentinous, green lines and 3–5 spots along each main nerve, abaxially red and pubescent along the main nerves. Petiole 10–18 cm long, densely pubescent. Inflorescences axillary, cymose, dichasial, with separate male and female individuals; peduncles 3–5 cm long; bracts greenish, ovate, 8–9 × 3–4 mm, persistent during flowering. Bracteoles similar to and slightly smaller than bracts; petals white, glabrous on both sides. Male flower: petals 4; outer 2, ovate, 1.2–1.4 × 0.6–0.7 cm, inner 2, elliptic, 0.5–0.6 × 0.2–0.3 cm; androecium actinomorphic, 0.5–0.6 cm diam., filaments free below, anthers oblong, almost equal to the filaments, dehiscent with laterally and obliquely longitudinal slits, connective slightly extended and truncate on the top. Female flower: petals 2, broadly elliptic, 0.9–1× 1.1–1.3 cm; ovary wingless, obtusely 3-hooked, 3-locular, placentation axial, placenta segments thick, 2 per locule, ovules present on both sides of placental branches; styles 3, forked twice, caducous in fruit, stigmas spiralled into a band. Fruit triangular berry-like, pendulous, with an in distinct beak. Flowering Oct. to Nov., Fruiting from the first of Nov. to Oct. of the next year.

Distribution. Only seen in Kachin State, Myanmar.

Additional examined specimens. Upper Burma (=Myanmar): Kachin Hills, 30 November, 1912, collect. Capt. & M. Joppin 4378 (K!); Myanmar, Kachin, Putao, on shaded banks and rocks, 27°20'N, 97°30'E, alt. 900 m, Dec. 10 1937, Kingdon-Ward 13569 (BM!); Myanmar, Kachin State, Putao, Wasadam village, alt. 860 m,

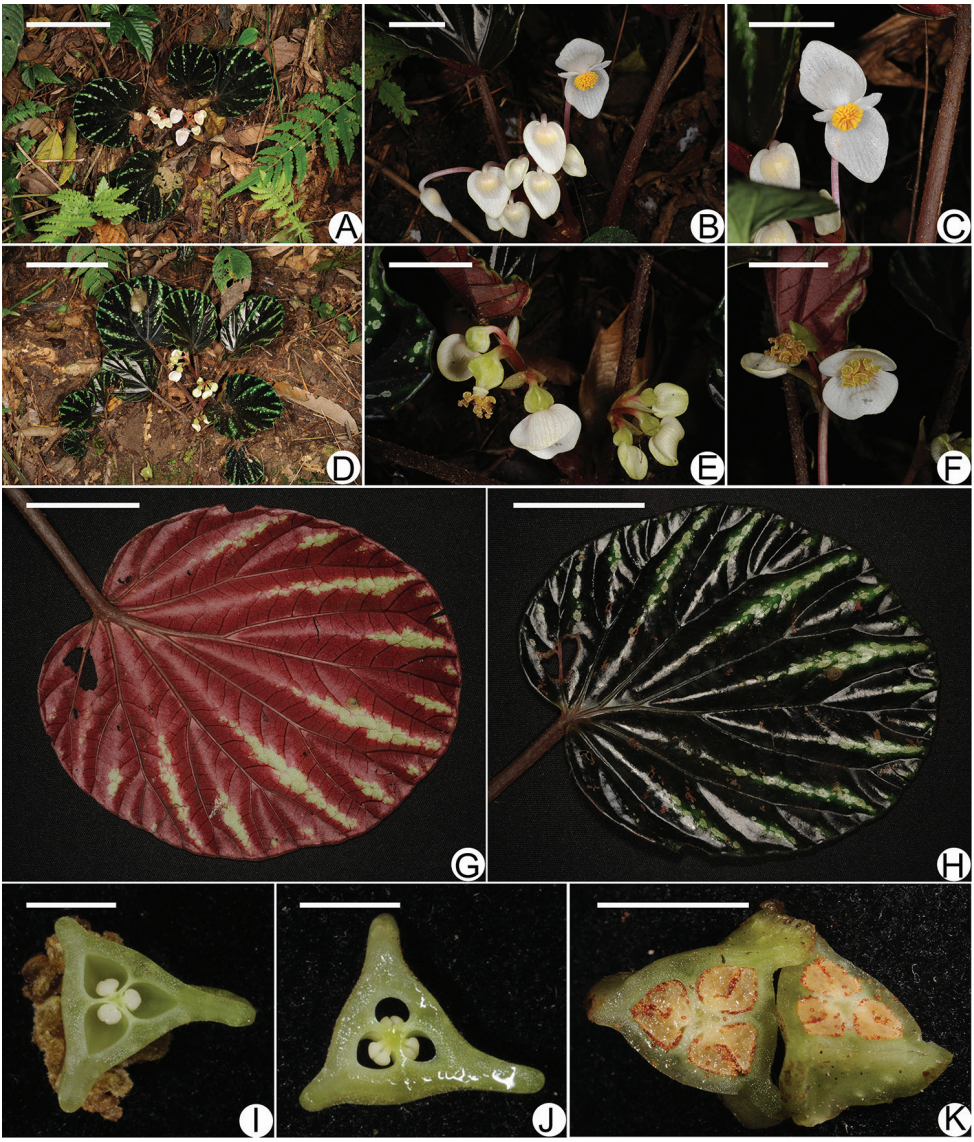

Figure 2. The images of *Begonia kingdon-wardii* Tebbitt (Putao Exped. 311 in PE and KUN) **A** Male plant **B** Male inflorescences **C** Face view of male flower **D** Female plant **E** Female inflorescences **F** Face view of female flower **G** Leaf blade adaxially **H** Leaf blade abaxially **I** Middle section of ovary in flower showing two placenta segments per locule **J** Inferior section of ovary in flower **K** Middle section of mature berry-like fruit showing thick placenta segments. Scale bars: **A, D** 10 cm **B, E** 1 cm **C, F** 1 cm **G, H** 4 cm **I, J, K** 1 cm. All photographed by Yu-Min Shui.

27°30'09"N, 97°11'45"E, near the stream in the Musa forests, occasional, Oct. 15, 2014, Putao Exped. 311 (KUN!, PE!); Myanmar, Kachin State, Putao, Wasadam village, alt. 900 m, 27°30'06"N, 97°11'44"E, along the moist slope in the *Musa* forests, occasional, Oct. 25, 2014, Putao Exped. 1230 (PE!).

Discussion. In *Begonia* sect. *Sphenanthera*, *Begonia kingdon-wardii* is unique in the pliciform leaf and female flower with two tepals (Doorenbos et al. 1999; Shui et al. 2002). It is obviously different from *Begonia burkillii* Dunn in *B.* sect. *Sphenanthera* and *B. rockii* Irmsch. in *B.* sect. *Platycentrum* in the locules of ovary and leaf shape. Morphologically, this species is also similar to *B. gulinqingensis* S. H. Huang & Y. M. Shui (*Begonia* sect. *Diploclinium*) in the leaf shape, placentation and fruit shape, but different in its dioecious plant, pliciform leaf, female flower with two sepals and berry fruit. It is also similar to *B. leprosa* (*Begonia* sect. *Leprosae*) in the leaf shape, especially the texture of the leaf blade and *B. zhengyiana* Y. M. Shui (*Begonia* sect. *Coelocentrum*) in shape of the leaf blade and fruit.

The rediscovery of its living plants provides researchers an opportunity to explore its taxonomic description and horticultural value in North Myanmar. This species with very rare individuals is distributed in a restricted area in Northern Myanmar and grows in the very shady and dark places under the forests. Its flowers are near the ground under the leaves, so that this habit influences the pollination and fruit setting. Another important and interesting habit may be that the fruits need over one year to become mature as some species [*B. handelii* Irmsch. and *B. silletensis* (A. DC.) C. B. Clarke] in *Begonia* sect. *Sphenanthera*. Besides, the pliciform leaf of the living plant is difficult to be observed on the holotype (Figs 1, 2). Now, the rediscovery not only reveals the need to undertake more surveys in North Myanmar, but also fills the gap about the deficient data of the species indicated by Tebbitt (2007) and so can bring an amazing plant to mankind for research and horticultural use (Fig. 2).

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RESEARCH ARTICLE

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Seven new species of *Begonia* (Begoniaceae) in Northern Vietnam and Southern China

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Abstract

Since 2016, KIB (Kunming Institute of Botany) and CPC (Centre for Plant Conservation of Vietnam) have conducted several surveys in the transboundary karst regions in Northern Vietnam and Southern China and seven new species in the genus *Begonia* Linn. (Begoniaceae) are firstly described. Amongst them, two species, *Begonia albopunctata* Y.M. Shui, W.H. Chen & H.Q. Nguyen and *B. erectocarpa* H.Q. Nguyen, Y.M. Shui & W.H. Chen, respectively belong to section *Sphenanthera* with berry fruits and section *Leprosae* with clavate berry fruits; four species, *B. gulongshanensis* Y.M. Shui & W. H. Chen, *B. minissima* H.Q. Nguyen, Y.M. Shui & W.H. Chen, *B. mollissima* Y.M. Shui, H.Q. Nguyen & W.H. Chen, *B. rhytidophylla* Y.M. Shui & W.H. Chen, belong to section *Coelocentrum* with parietal placentation; one species, *Begonia bambusetorum* H.Q. Nguyen, Y.M. Shui & W.H. Chen, belongs to section *Diploclinium* with 3-loculed ovary and capsules. The diagnostic characters of these species are described and illustrated in the text and photographs.

Keywords

Begonia, *Begonia* sect. *Coelocentrum*, *Begonia* sect. *Diploclinium*, *Begonia* sect. *Leprosae*, *Begonia* sect. *Sphenanthera,* China, new species, Vietnam

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Introduction

The Tonkin region is one of the biodiversity hotspots worldwide (Takhtajan 1986; Myers et al. 2000) that include Northern Vietnam and Southern China (Fig. 1). This region is characterised by the massive area of the limestone landform and the lowland less than 1200 m elevation (Fang et al. 1994; Averyanov et al. 2003). The floristic region mainly covers the northernmost region from the North-west to North-east in Vietnam (Takhtajan 1986; Averyanov et al. 2003) that borders with the South-western Guangxi and South-eastern Yunnan in China (Wu and Wu 1998). In the last ten years, a large number of new species in different families have been discovered in the region, such as Begoniaceae, Gesneriaceae, Magnoliaceae etc. (Averyanov and Nguyen 2012; Chen et al. 2017; etc.).

Since 2016, for nearly three months, transboundary surveys have been conducted in Northwestern and Northeastern Vietnam (Bac Kan, Cao Bang, Lao Cai, Phu Tho, Tuyen Quang) and Southern China (Southwestern Guangxi and Southeastern Yunnan). After review of the type specimens and taxonomic publications within the regions (Gagnepain 1921; Irmscher 1939; Ho 1991; Nguyen 2004; Shui and Chen 2005; Truong et al. 2005; Nguyen and Tebbit 2006; Kiew 2007; Nguyen et al. 2010; Peng et al. 2014, 2015a,b; Hughes et al. 2015), seven new species of *Begonia* have been confirmed, and their sectional positions designated here (Doorenbos et al. 1998; Shui et al. 2002). Due to the taxonomic complexity of the genus (Thomas et al. 2011; Chung et al. 2014), the DNA samples of the above new species have also been collected and some possible different opinions will be issued about their systematic position in the broad context in the future.

Taxonomy

Begonia albopunctata **Y.M.Shui, W.H.Chen & H.Q.Nguyen, sp. nov.**
urn:lsid:ipni.org:names:77175484-1
Fig. 2

Begonia sect. *Sphenanthera* (Hassk) Warb.

Remarks. The new species is similar to *B. hahiepiana* H.Q. Nguyen & Tebbitt in broadly ovate asymmetric leaves with slightly truncate or round apex and the corned berry fruit, but different from it in the broadly ovate or rotund leaves (vs. ovate), almost flat adaxial surface of leaves (vs. puckered), glabrous outer surface of petals (vs. with red trichomes), 4-loculed and glabrous berry fruit covered by dense white spots (vs. 3-loculed and pubescent fruit covered by the lax white spots).

Type. VIETNAM. Phu Tho Province, Xuan Son county, Xuan Son National Park, 21°07'05"N, 104°57'09"E, 478 m a.s.l., 8 April 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen, H.T. Nguyen, N.Q. Chuong CK 0916* (holotype, KUN!; isotype,

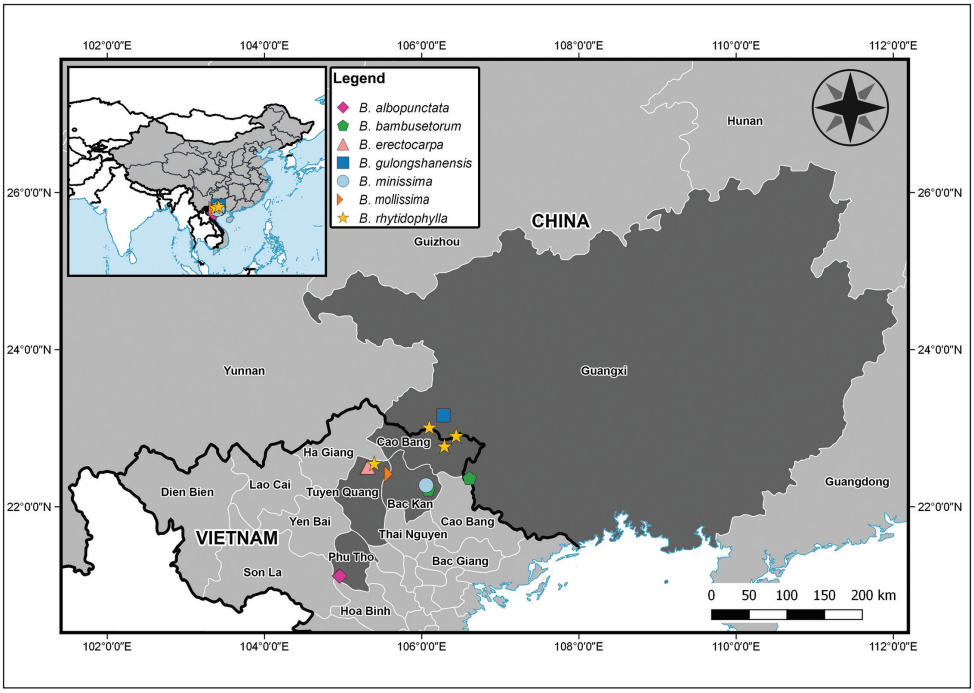

Figure 1. The geographical distribution of the seven new species of *Begonia* (Begoniaceae) from North Vietnam and South China under QGIS version 2.14.19.

CPC!=Herbarium of the Centre for Plant Conservation, Vietnam Union of Science and Technology Associations, Hanoi).

Herb, rhizomatous. Rhizome: 4–6 cm long, 0.5–1 cm in diam. Stipule pale brown to reddish, triangular, glabrous, 0.7–1 cm × 0.2–0.4 cm, margin entire, apex acuminate. Leaves: petiole terete, 7.5–11 cm long, 1–2 mm in diam., densely covered by red lanes; blade greenish, asymmetric, broadly ovate or rotund, 8–14 × 6.5–9 cm; base cordate; apex subacute to obtuse; margin denticulate, short ciliate; adaxially greenish, almost flat, slightly glabrous and extremely sparely strigillose between secondary veins; abaxially red, veins densely red pubescent; venation palmate, 5–6 primary veins, secondary veins brunching dichotomous, tertiary veins reticulate. Inflorescence: dichasial cyme, peduncle erect, 6–9 cm long, red or brownish villous; bracts caducous, triangular to lanceolate, reddish, 5–7 × 2–3 mm, apex acuminate, margin entire. Staminate flower: pedicels 0.5–1.5 cm long; tepals 4, white, adaxially subglabrous, abaxially glabrous; outer tepals 2, broadly ovate, 0.7–1.5 × 0.6–1.2 cm; inner tepals 2, white, oblanceolate to oblong, 0.8–1.6 × 0.2–0.5 cm, base cuneate to rounded, apex acute to obtuse, margin entire; androecium actinomorphic, stamens numerous; filaments fused at base; anthers yellow, obovate, 1–1.2 mm long, apex convex, shorter than filaments, with longitudinal slits. Pistillate flower: pedicel 0.4–0.7 cm long; tepals 5, white; outer tepals 3, broadly ovate, 0.8–1.2 × 0.4–0.6 cm, apex obtuse to rounded, margin entire; inner tepals 2, ovate, 0.5–0.7 × 0.4–0.6 cm, apex obtuse to rounded,

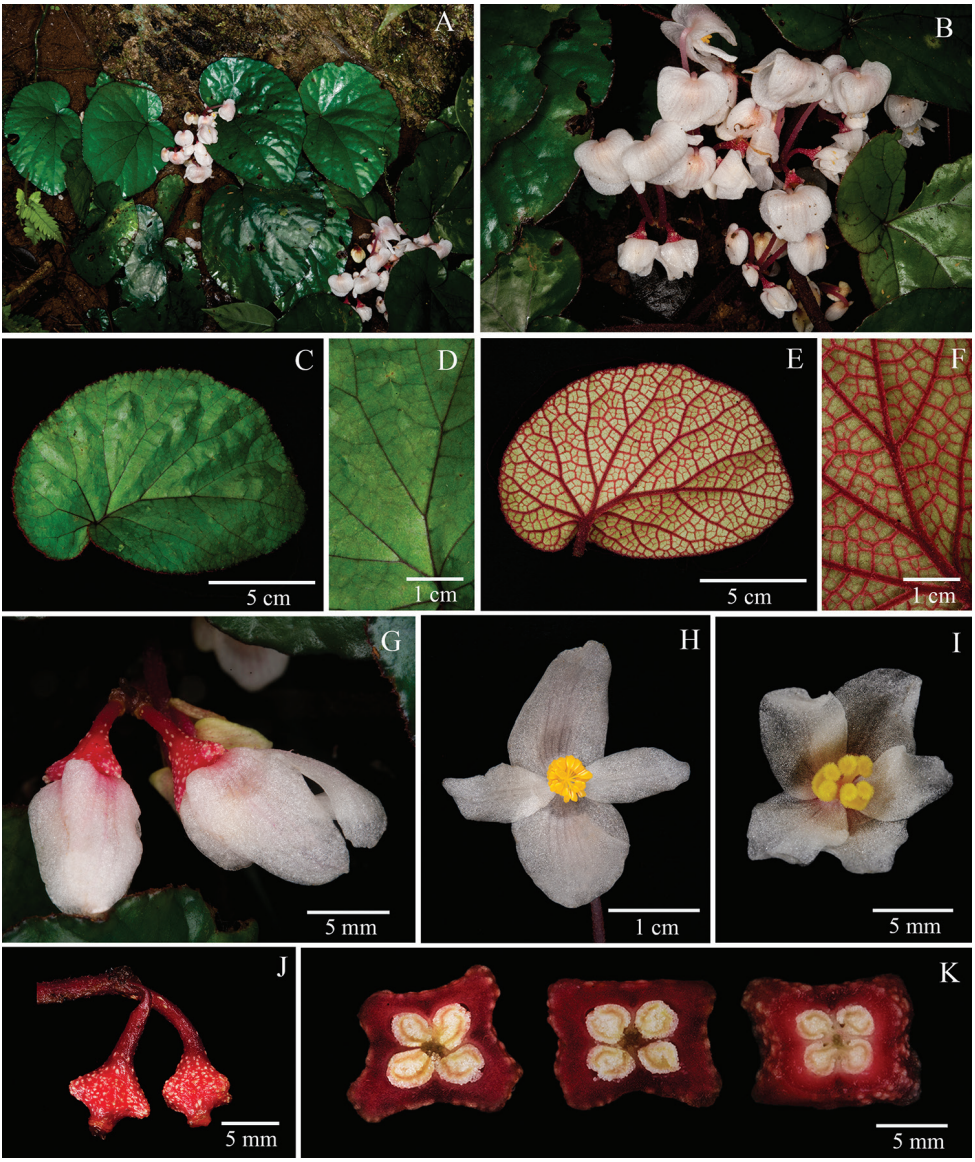

Figure 2. *Begonia albopunctata* Y.M. Shui, W.H. Chen & H.Q. Nguyen **A** Habitat **B** Inflorescence **C** View of adaxial leaf **D** Close-up of adaxial leaf **E** View of abaxial leaf **F** Close-up of abaxial leaf **G** Pistillate flower, side view **H** Staminate flower, face view **I** Pistillate flower, face view **J** Fruits **K** Serial cross sections of ovary. (**A–J** photographs by Y.M. Shui; **K** by S. Radbouchoom).

margin entire; styles 3, free; stigmas bifid with twisted bands; ovary reddish, 0.2–0.3 cm long, 0.2–0.4 cm in diam., with white papillose and 4 thickened corns; placentation axile, 4-loculed, placentae 2 each locule. Fruit berrylike, white papillose, wingless and with 4 thickened rib-like horns.

Phenology. Flowering in April–May, fruiting in April–June.

Etymology. The epithet refers to the white spots on the fruit surface.

Habitat. The species only grows in deep ground amongst rocks in limestone forests.

Distribution. The species occurs exclusively in Phu Tho Province, Xuan Son country, Xuan Son National Park of Vietnam.

Additional examined specimens. VIETNAM. Phu Tho Province, Xuan Son county, Xuan Son National Park, 21°07'01"N, 104°57'29"E, 438 m a.s.l., 8 April, 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen, H. T. Nguyen, N. Q. Chuong CK 0918* (KUN, CPC).

Note. Currently six species from section *Sphenanthera* are recognised as occurring in Vietnam: *Begonia acetosella* Craib, *B. balansana* Gagnep., *B. handelii* Irmscher, *B. longifolia* Blume, *B. ceratocarpa* S.H. Huang & Y.M. Shui and *B. hahiepiana* H.Q. Nguyen & Tebbitt. Although this new species grows together with *B. hahiepiana*, it is easily distinguished by the glabrous and 4-loculed berry fruit, which has been discussed in the above diagnostic description. Within the Vietnamese species of the section, the stemless habit, the narrow inflorescence and the small horned appendage of the berry fruit indicate that the new species is also similar to *Begonia ceratocarpa* and *B. balansana*. The detailed comparison reveals that it is more similar to *B. ceratocarpa* with 3–4-loculed fruits than *B. balansana* with 6–7-loculed fruit. It is different from *B. ceratocarpa* in the broadly ovate or rotund leaves (*vs.* ovate), the unlobed leaf blade (*vs.* slightly lobed), round leaf top (*vs.* acuminate leaf top), petioles with red pubes (*vs.* with brown 1anes), 5 female tepals (*vs.* 3), densely white-spotted surface of berry fruit (*vs.* sparely spotted), truncate fruit top without a beak (*vs.* an acute fruit top with a beak).

***Begonia bambusetorum* H.Q.Nguyen, Y.M.Shui & W.H.Chen, sp. nov.**
urn:lsid:ipni.org:names:77175485-1
Fig. 3

Begonia sect. *Diploclinium* A. DC.

Remarks. The new species is similar to *Begonia sinovietnamica* C. Y. Wu in their habit and distribution (Fig. 1; Fig. 2), but different from the latter species in expanding villous hairs on petiole and peduncles (vs. pubescent), 2 petals of the male flowers (vs. 4 petals), 2 petals of the female flowers (vs. 5 rarely 4 petals).

Type. VIETNAM. Bac Kan Province, Nari county, An Tinh committee, 22°12'39"N, 106°05'02"E, 285 m a.s.l., in the forests of Bamboo around streams, flowers pinkish, 23 April 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen, H.T. Nguyen, N.Q. Chuong CK 1296* (holotype, KUN!; isotype, CPC!)

Herb, rhizomatous. Rhizome: densely villous, 9–19 cm long, 0.5–1 cm in diam. Stipule reddish, triangular, 0.8–1.5 × 0.4–0.7 cm, densely villous outside, glabrous inside, margin entire and ciliate. Leaves: petiole terete, greenish to reddish, villous, 14–19 cm long, 1.5–3 mm in diam.; blade greenish, asymmetric, ovate to widely ovate, 11–17 × 8.5–11.5 cm, slightly rugose; base cordate, apex caudate, margin serrulate

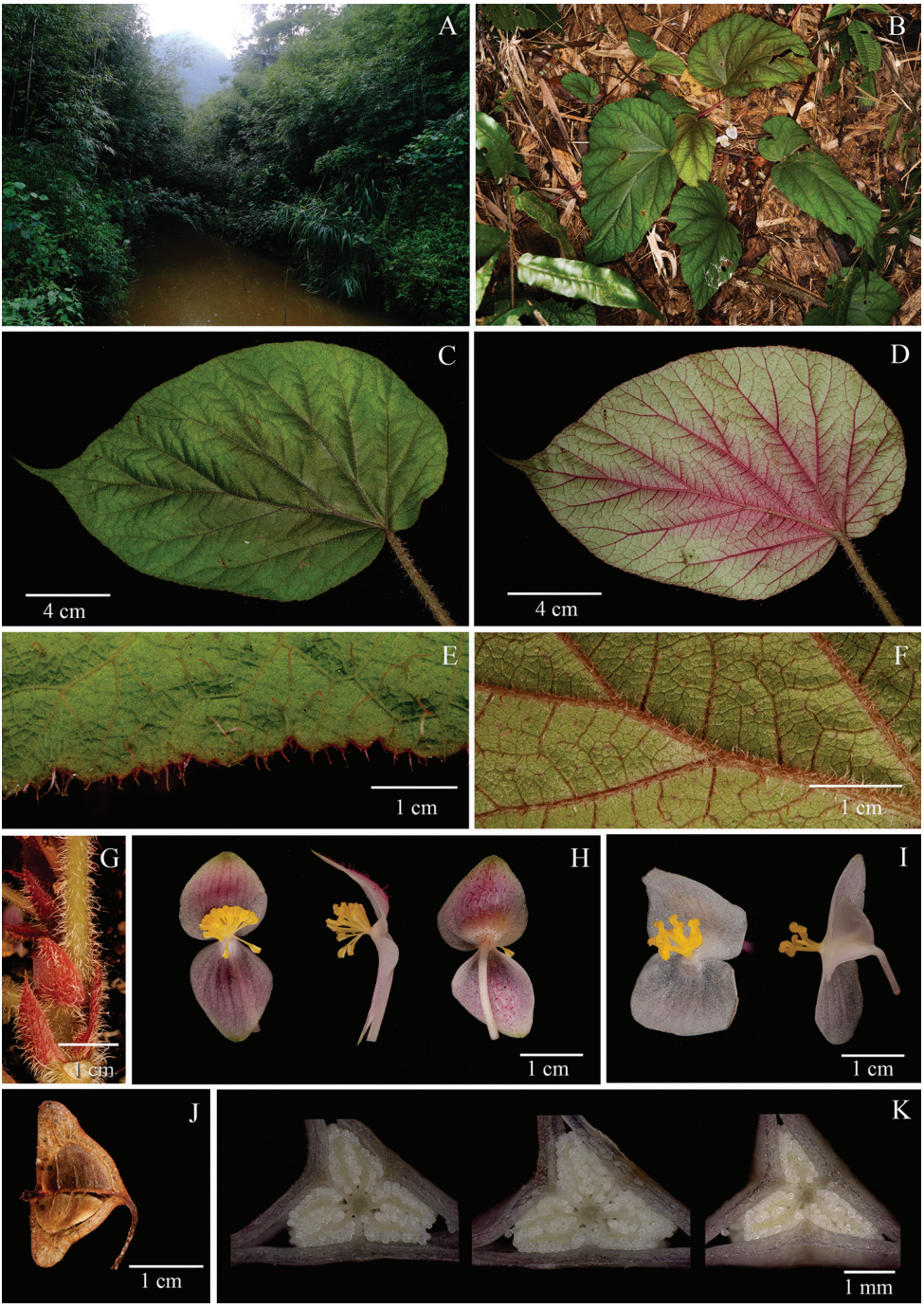

Figure 3. *Begonia bambusetorum* H.Q. Nguyen, Y.M. Shui & W.H. Chen **A** Habitat **B** Plant **C** View of adaxial leaf **D** View of abaxial leaf **E** Close-up of adaxial leaf **F** Close up of abaxial leaf **G** Stipule and petiole **H** Staminate flower, face view, side view and dorsal view **I** Pistillate flower, face view and side view **J** Fruits **K** Serial cross sections of ovary. (**A–D** photographs by Y.M. Shui; **E–K** by S. Radbouchoom).

and long ciliate; adaxially greenish, sparsely brevi-setose, abaxially greenish, sparely villous and densely strigose on veins; venation palmate, 6–8 primary veins, secondary veins brunching dichotomous, tertiary veins slightly reticulate, veins prominent on both sides. Inflorescence: dichasial cyme, peduncle erect, 4–10 cm long, villous; bracts caducous, triangulate to lanceolate, reddish, 5–7 × 2–3 mm, adaxially red villous, apex acuminate, margin serrate and ciliate, abaxially glabrous. Staminate flower: pedice 1–1.5 cm long; tepals 2, white to pink, adaxially red villous, abaxially glabrous; tepals 2, widely ovate, 1.5–2 × 0.7–1 cm, apex obtuse to rounded, margin entire; androecium actinomorphic, stamens numerous, filaments almost free, 1–2 mm long, anthers yellow, obovate, 1–1.2 mm long, apex convex, shorter than filaments, with two lateral longitudinal slits. Pistillate flower: pedicel 1–1.5 cm long; tepals 2, white to pink, adaxially red villous, abaxially glabrous; outer tepals 2, widely ovate, 1–1.5 × 0.7–1.2 cm, apex obtuse to rounded, margin entire; styles 3, free, stigmas bifid with twisted bands; ovary white, sparely red villous; placentation axile with 2-segments per locule. Capsule nodding, 0.35–0.5 cm long, 0.27–0.31 cm in diam. (wings excluded), with 3 subequal wings; abaxial wing 0.6–1 × 0.3–0.7 cm; lateral wings 0.4–0.7 × 0.5–0.7 cm.

Phenology. Flowering in May–June, fruiting in June–August.

Etymology. The epithet refers to the habitat of the new species: the bamboo forests along streams.

Habitat. The new species just grows in bamboo forests along watersides.

Distribution. The species occurs both in Nari county of Bac Kan Province in Vietnam and in Longzhou county of Guangxi, China.

Additional specimens examined. CHINA. Guangxi Zhuang Autonomous Region, Longzhou Xian, Chunxiu community, 22°21’22”N, 106°36’34”E, alt. 460 m a.s.l., November, 2016, cultivated in Horticulture Nursery of Beijing Florascape Company, in flowers, 1 October, 2017, *Y. M. Shui and S. W. Guo* BE-004 (KUN).

Note. The new species seems to be a member of the first group with rhizome and without erect stem in *Begonia* sect. *Diploclinium* A. DC. (Doorenbos et al. 1998). Within the group, it is more similar to *Begonia sinovietnamica* in the locality and habit than the other, but different in the hairs of plants and morphology of the flowers. Additionally, its reticulate nerves on the upper surface of leaves are more obvious than those in *B. sinovietnamica,* which can easily be examined in living plants instead of in dry specimens.

Begonia erectocarpa **H.Q.Nguyen, Y.M.Shui & W.H.Chen, sp. nov.**
urn:lsid:ipni.org:names:77175486-1
Fig. 4

Begonia sect. *Leprosae* Y. M. Shui

Remarks. The new species is similar to *Begonia longicarpa* K.Y. Guan et D. K. Tian in the clavate berry fruit, but differs from it in its hispid petiole (vs. pubescent), five female petals (vs. three) and short segments of placentation per locule (vs. long segments).

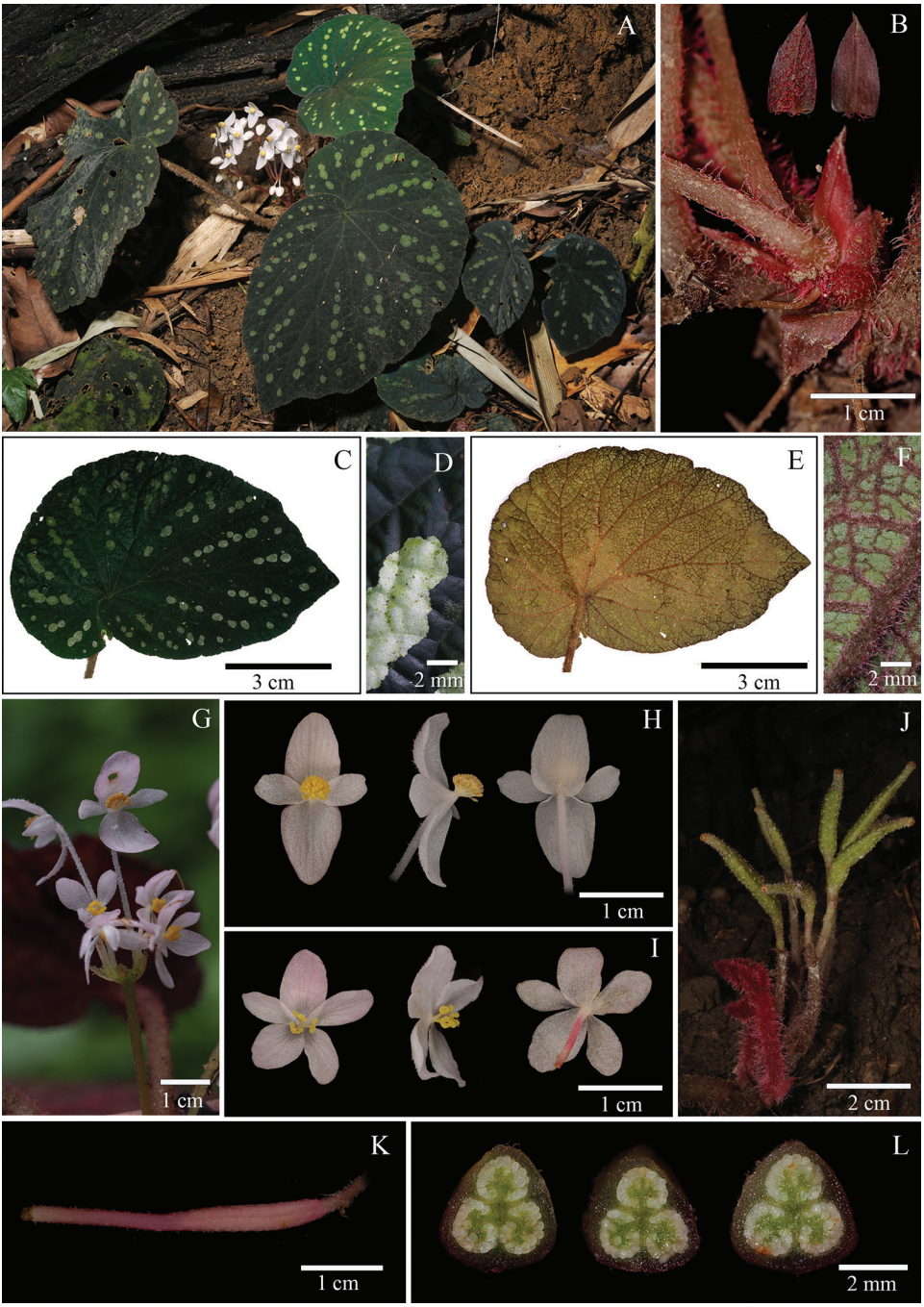

Figure 4. *Begonia erectocarpa* H.Q. Nguyen, Y.M. Shui & W.H. Chen **A** Habitat **B** Stipule, dorsal view and face view **C** View of adaxial leaf **D** Close-up of adaxial leaf **E** View of abaxial leaf **F** Close-up of abaxial leaf **G** Inflorescence **H** Staminate flower, face view, side view and dorsal view **I** Pistillate flower, face view, side view and dorsal view **J** Fruits **K** Young fruit **L** Serial cross sections of ovary. (**A, C, E, H, I, J, K** photographs by S.W. Guo; **B, D, F, G** and **L** by H.Q. Nguyen).

Type. VIETNAM. Tuyen Quang province, Lam Binh district, Thuong Lam community, in the secondary tropical evergreen lowland rainforest and broad-leaved forests on the slopes and ridge of crystalline limestone hills with highly eroded earth, grow on ground soil, male and female flowers white, fruit berry, green or pink, 22°30'05"N, 105°18'11"E, 484 m a.s.l., 11 October 2017, *H.Q. Nguyen,H.T. Nguyen, K. S. Nguyen, N.Q. Chuong CPC 8463* (holotype, KUN!; isotype, CPC!).

Herb, rhizomatous. Rhizome: 3–5 cm long, 1.0–1.7 cm in diam. Stipule triangular, 0.8–1×0.2–0.4 cm, pale brown to reddish, margin entire, apex acuminate, adaxially glabrous, abaxially red hirsute. Leaves all basal, alternate; petiole terete, 9–15 cm long, 2–5 mm in diam., densely reddish hirsute; blade dark green or brown, asymmetric, broadly ovate, 7–14× 3.5–9.0 cm, base cordate, oblique, apex subacute to obtuse, margin denticulate, short ciliate, adaxially dark green, almost glabrous, usually with white spots, abaxially dark red, densely red lanate on veins; venation palmate, 6–7 primary veins, secondary veins brunching dichotomous, tertiary veins obviously reticulate, densely velutinous on veins. Inflorescence dischasial cyme, axillary, peduncle 3–5 cm, erect, red to brownish villous; bracts pale greenish, triangular to lanceolate, 1–1.5× 2–3 mm, margin dentate and ciliate, apex acuminate. Staminate flower: pedicel 2.2–3.5 cm, glabrous above the middle, villous below the middle; tepals 4, white-pinkish, glabrous; outer tepals 2, ovate, 1.2–1.5× 0.6–1 cm, apex acute, base cuneate, margin entire; inner tepals 2, oblanceolate to oblong, white-pinkish, 0.8–1.6× 0.2–0.4 cm, base cuneate, apex acute, margin entire; stamens numerous, filaments free, anthers yellow, obovate, 1–1.2 mm long, apex rounded, shorter than filament, with longitudinal slits. Pistillate flower: pedicel 8–1.6 cm long, hirsute; tepals 5, white to pinkish, glabrous; outer tepals 3, ovate, 0.8–1.0× 0.3–0.5 cm, apex obtuse to rounded, margin entire; inner tepals 2, ovate, 0.6–1.0× 0.2–0.4 cm, apex obtuse to rounded, margin entire; styles 3, free, stigmas bilobed, with twisted band; ovary green or pinkish, 1.5–2.0 cm long, 0.3–0.5 cm in diam., cylindric, wingless, puberulent; placentation axile, 3-locular, placentae partly branching 2–4 each locule. Fruit berrylike, wingless.

Phenology. Flowering in October–December, fruiting in November–January next year.

Etymology. The epithet refers to the upward fruit when nearly mature (Fig. 4-J). The erect case of fruit when nearly mature is unusual in the genus *Begonia*. The exceptional species is in some species in *Begonia* sect. *Trachelocarpus* (C. Müller) A. DC., such as *Begonia lanceolata* Vellozo in Brazil (Doorenbos et al. 1998; Tebbitt 2005).

Habitat. The species just grows on soil within the secondary tropical evergreen lowland rainforest and broad-leaved forests on the slopes and ridge of crystalline limestone with highly eroded earth at an elevation 400–700 m above sea level.

Distribution. The species occurs exclusively in Tuyen Quang Province in Vietnam.

Additional examined specimens. VIETNAM. Tuyen Quang province, Lam Binh district, Thuong Lam community, 22°30'17"N, 105°18'48"E, 420 m a.s.l., 13 October 2017, in flower, *H.Q. Nguyen et al. CPC 8449* (KUN!; CPC!). The same locality, 22°30'06"N, 105°19'29"E, 255 m a.s.l., 29 November 2017, flower pinkish, *Y.M. Shui, W.H. Chen, S.W. Guo, H.Q. Nguyen,H.T. Nguyen, K. S. Nguyen, N.Q. Chuong CK1505* (KUN!; CPC!). The same place, 420 m a.s.l., 30 November 2017, in fruit,

Y.M. Shui, W.H. Chen, S.W. Guo, Q.H. Nguyen, T.H. Nguyen, S.K. Nguyen CK1513 (KUN!; CPC!).

Note. The new species should be a member of *Begonia* sect. *Leprosae* Y.M. Shui according to its clavate berry fruit (Shui et al. 2002). In the section, it is more similar to *B. longicarpa* and *B. leprosa* Hance than the other species. It is similar to *B. longicarpa* in the habitat of ground soil and different mainly in the petal number (5 *vs.* 3), the hairs of petiole (hispid *vs.* pubescent) and the morphology of the segments of placentation per locule (irregular placenta segments vs. 2 regular placenta segments per locule). It is also similar to *B. leprosa* in the morphology of the fruit and hairs on the petiole, but differs mainly in the habitat (ground soil *vs.* limestone surface), the abaxial surface of leaves (obviously reticulate nerves *vs.* obscurely reticulate nerves) and the petal number of the female (5 *vs.* 4) and the morphology of placentation at the upper part of ovary (axile *vs.* parieta). As to the white spots on the adaxial leaf surface, it is somewhat similar to *Begonia gulinqingensis* S.H.Huang & Y.M.Shui in *B.* sect. *Diploclinium*, but different in the fruit (berry *vs.* capsule) (Fig. 4-J; Shui and Chen 2017).

***Begonia gulongshanensis* Y.M.Shui & W.H.Chen, sp. nov.**
urn:lsid:ipni.org:names:77175487-1
Fig. 5

Begonia sect. *Coelocentrum* Irmsch.

Remarks. The new species is similar to *Begonia daxinensis* T. C. Ku, but different from it in its ovate leaves (vs. broadly ovate in *B. daxinensis*), slightly oblique leaf base (vs. extremely oblique), glandulose-villous on peduncles, pedicels, adaxial surface of exterior tepals and fruits (vs. glabrous, sparely eglandulose-pubescent), filaments connected to a half (vs. only at base), the smaller petals of male flowers (0.7–1.2 × 0.7–0.9 cm vs. 1.2–1.9 × 1–1.6 cm), the smaller petals of the female flowers (0.9 × 1.0 vs. 1–1.5 × 1–1.2 cm).

Type. CHINA. Guangxi Zhuang Autonomous Region, Jingxi county, Gulongshan, 23°19'44"N, 106°16'46"E, 286 m a.s.l., in the deep valley, growing on the moist surface of steep cliffs, flower pinkish, 18 February 2016, *Y.M. Shui et al. B2016-048* (holotype, KUN!).

Herb, rhizomatous. Rhizome: 0.3–0.5 cm in diam. Stipule triangular, 0.2–0.4 × 0.6–0.8 cm, apex acute, adaxially subglabrous, abaxially hispid. Leaves all basal, alternate; petiole 5–9 cm long, glandular-hispid; blade greenish, asymmetric, ovate or ovate-lanceolate, 12–18 × 5–9 cm, base cordate, auricular, oblique or slightly oblique, apex caudate, margin serrulate; adaxially greenish, tubercular-setose, with white semi-circle in the middle and with dark red patches along the main nerves; abaxially greenish, glandular-pubescent along veinlets, sparsely villous and densely strigose on main veins; venation palmate, ca. 7 primary veins, secondary veins branching di-

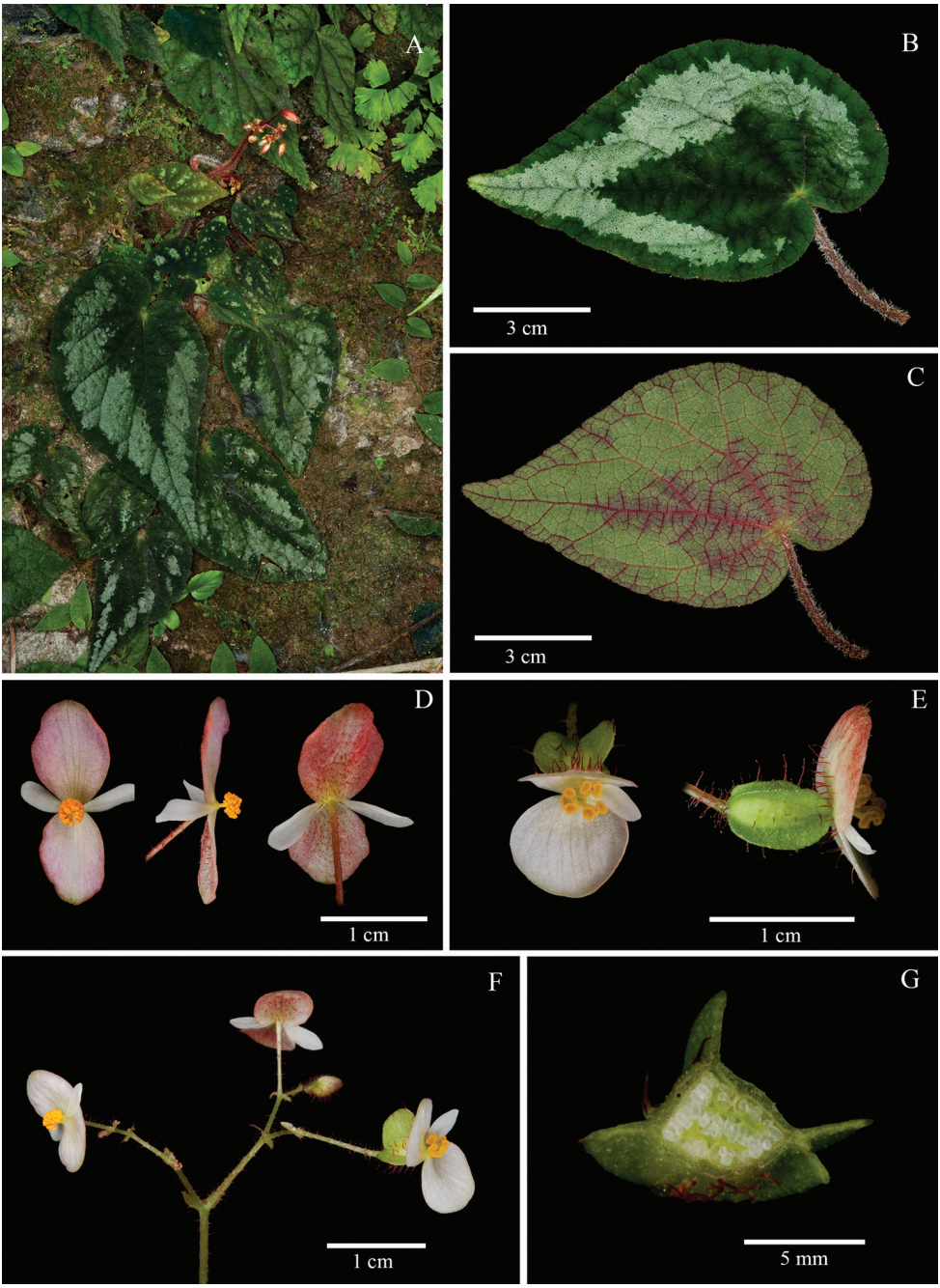

Figure 5. *Begonia gulongshanensis* Y.M. Shui & W.H. Chen **A** Habitat **B** View of adaxial leaf **C** View of abaxial leaf **D** Staminate flower, face view, side view and dorsal view **E** Pistillate flower, face view and side view **F** Inflorescence **K** Cross section of ovary in the middle part. (All photographs by Y.M. Shui).

chotomous, tertiary veins slightly reticulate, veins prominent adaxially. Inflorescence dichasial cyme, axillary, peduncle 5–9 cm, glandular-villous; bracts caducous, oblong-lanceolate, ca. 5 × 1 mm, apex acuminate, adaxially glabrous, abaxially long setulose. Staminate flower: pedicel 1.1–1.8 cm long, glandular-villous; tepals 4, pinkish to pink; outer tepals 2, widely ovate, 0.7–1.2 × 0.7–0.9 cm, apex rotund, margin entire, adaxially glabrous, abaxially glandular-villous; inner tepals 2, narrowly oblong or obovate, 0.6–1.0 × 0.2–0.25 cm, apex acute; androecium actinomorphic; stamens numerous, filaments connected to a half, ca. 1 mm long; anthers yellow, obovate, ca. 0.5 mm long, apex emarginate. Pistillate flower: pedicel ca. 1.1 cm long, glandular-villous; tepals 3, pinkish or pink; outer tepals 2, widely ovate, ca. 0.9 × 1.0 cm, apex rotund, margin entire, adaxially glabrous, abaxially glandular-villous; inner tepal 1, oblong, 5–6 × 2–3 mm, base cuneate, apex acute, margin entire; styles 3, fused at base; stigmas spiralled, papillose; ovary green, elliptic, 0.8–0.9 cm long, glandular-villous; placentation parietal, 2-segmented per carpel. Capsule nodding, 3-winged unequally; major wing ca. 3.5 mm long, lateral wings ca. 2.1 mm long.

Phenology. Flowering in February–May, fruiting in May–June.

Etymology. The epithet refers to the locality of the type specimens.

Habitat. The species only grows on the moist surface of shady cliffs at the entrance to shallow caves in a deep valley.

Distribution. The species occurs exclusively in Jingxi county of Guangxi in China.

Note. In *Begonia* sect. *Coelocentrum*, the new species is similar to the population of *B. daxinensis* with a white area on the leaves, but differs mainly in its long glandular hairs (Wu and Ku 1997; Ku et al. 2004). In the latter species, the petals are covered abaxially by brown pubescence and are much larger than those of the new species. As to the lanceolate and colourful leaves, the new species is similar to *Begonia locii* C.-I Peng, C. W. Lin & H. Q. Nguyen, but different in the absence of glandular hairs of flowers (Peng et al. 2015a). Furthermore, as to the glandular pubes, the new species is also similar to *B. filiformis* Irmsch., but differs in the subglabrous adaxial surface and laxly pubescent abaxial surface of leaves (*vs.* densely pubescent adaxial and abaxial surface of leaves in the latter).

Begonia minissima **H.Q.Nguyen, Y.M.Shui & W.H.Chen, sp. nov.**

urn:lsid:ipni.org:names:77175488-1
Fig. 6

Begonia sect. *Coelocentrum* Irmsch.

Remarks. The new species is similar to *Begonia rugosula* Aver. in the small leaves and climbing habit, but different from it in the round leaf top (vs. acute leaf top), flat surface on the adaxial surface of the leaves (vs. uneven surface in *B. rugosula*), ovate interior petals (vs. narrowly obovate or narrowly obovate), 2-branching stigma (vs. slightly spherical).

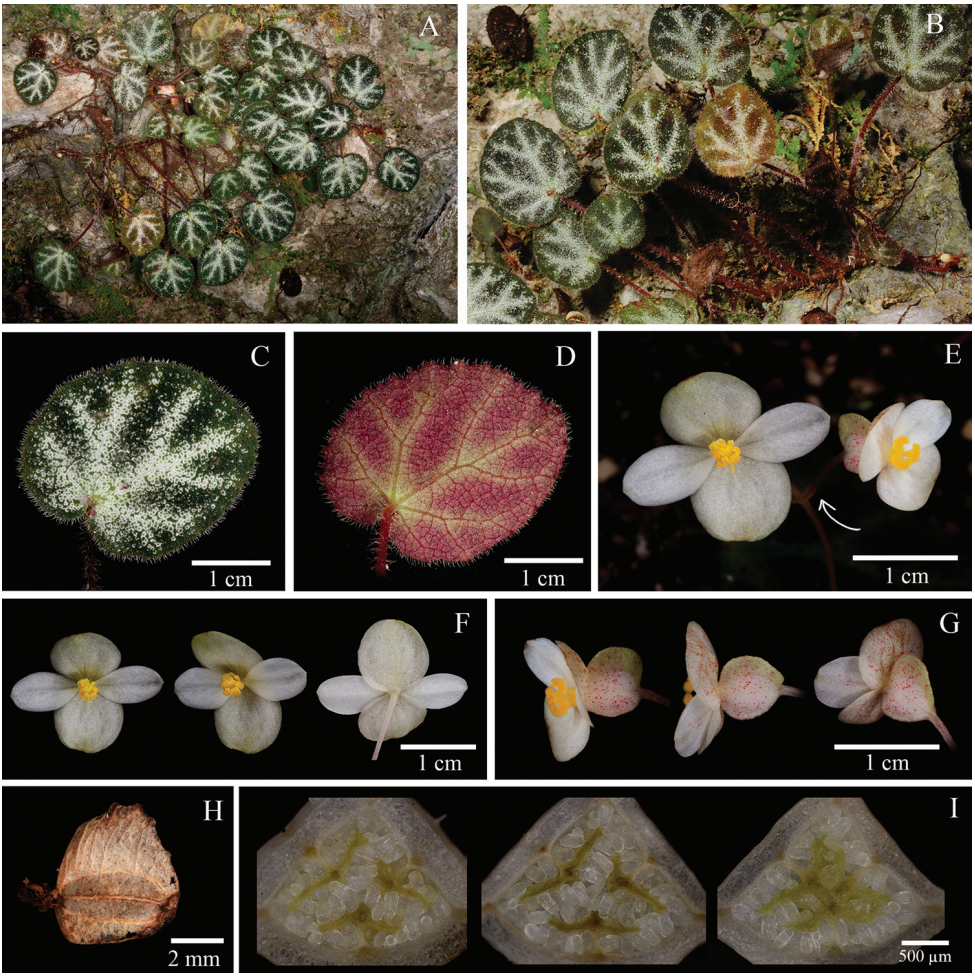

Figure 6. *Begonia minissima* H.Q. Nguyen, Y.M. Shui & W.H. Chen **A** Habitat **B** Plant with rhizome **C** View of adaxial leaf **D** View of abaxial leaf **E** Inflorescence **F** Staminate flower, face view, side view and dorsal view **G** Pistillate flower, side views and dorsal view **H** Capsule **I** Serial cross sections of ovary. (**A–D** photographs by Y.M. Shui; **E–I** by S. Radbouchoom).

Type. VIETNAM. Bac Kan Province, Nari county, Kim Hy National reserve, 22°16'22"N, 106°03'23"E, 504 m a.s.l., 18 April 2016, in flowers, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen, H.T. Nguyen, N.Q. Chuong CK1210* (holotype, KUN!; isotype, CPC!).

Small herb, rhizomatous. Rhizome: slender, 2.5–7 mm long, 1.5–2 mm in diam. Stipule reddish, triangular, subglabrous, 1–1.8 × 8–1.2 mm wide. Leaves: petiole reddish, erect, villous, 1.5–3.5 cm long, 0.5–1 mm in diam.; blade asymmetric, widely ovate or rotund, 2.2–2.6 × 1.6–1.8 cm, base cordate, apex obtuse to acute, margin slightly serrulate, ciliate; adaxially dark green with white line or stripes along veins, strigose; abaxially slightly greenish striated and short strigose along primary and sec-

ondary veins; venation palmate, 4–5 primary veins, 2 or 3 secondary veins brunching dichotomous, tertiary veins reticulate. Inflorescence: dichasial cyme; peduncle 2–3.5 cm long, glabrous; bracts caducous, greenish, triangular, glabrous, apex acute, margin entire. Staminate flower: pedicel ca. 1 cm long; tepals 4, widely ovate, white inside, pinkish outside, both sides glabrous; outer tepals 2, broadly ovate, glabrous, base cuneate, apex obtuse or rounded, margin entire; inner tepals 2, ovate, base cuneate, apex acute to obtuse, margin entire; androecium actinomorphic, stamens numerous, filaments longer than anthers, fused at base; anthers yellow, obovoid, apex emarginate, with longitudinal slits. Pistillate flower: pedicel ca. 1 cm long; tepals 3, white, both sides glabrous; outer tepals 2, broadly ovate, ca. 5 × 6 mm, abaxially slightly pinkish with red spots, base rounded, apex obtuse or rounded, margin entire; inner tepal 1, elliptic to oblong, ca. 6 × 4 mm, base cuneate to rounded, apex obtuse, margin entire; styles 3, free, stigmas bifid with twisted bands; ovary slightly pinkish with red minute spots, ca. 5 mm long, ca. 3 mm in diam. (wings excluded), glabrous, 1-loculed; placentation parietal, 2-branched each placenta; Capsule nodding, trigonous-ellipsoid, subequally 3-winged; abaxial wing lunate, ca. 5 ×3 mm, slightly larger than lateral wings; lateral wings narrowly lunate, ca. 5 × 2 mm. Seeds ca. 0.15 mm long, oblong.

Phenology. Flowering in April–May, fruiting in May–June.

Etymology. The epithet refers to the small size of leaves.

Habitat. The species just grows in limestone crevices of cliffs.

Distribution. The species occurs exclusively in Nari county of Bac Kan Province in Vietnam.

Note. In *Begonia* sect. *Coelocentrum*, the new species is one of the smallest species in morphology. Its closest species with limited morphology is *Begonia regosula* Aver. also from Bac Kan Province (Averyanov and Nguyen 2012). In the new species, however, the wider interior petals and the obvious bifid stigma can separate it from *B. regosula* (Fig. 6).

Begonia mollissima **Y.M.Shui, H.Q.Nguyen & W.H.Chen, sp. nov.**

urn:lsid:ipni.org:names:77175489-1
Fig. 7

Begonia sect. *Coelocentrum* Irmsch.

Remarks. The new species is similar to *Begonia guangxiensis* T.C. Ku in the dense white villous hairs on the whole plants, differs from the latter in the shorter hairs of plants (2.1–2.4 mm vs. 3.4–4.0 mm), its one obtuse leaf lobe (vs. 3–4 acute leaf lobes in B. guangxiensis), subequal three wings of the fruit (vs. unequal three wings), narrowly semi-lunar major wings (vs. broadly square major wings).

Type. VIETNAM. Bac Kan Province, Cho Ra county, Ba Be National Park, 22°24'56"N, 105°37'48"E, 235 m a.s.l., 18 April 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen,H.T. Nguyen, N.Q. Chuong CK1183* (holotype, KUN!; isotype, CPC!).

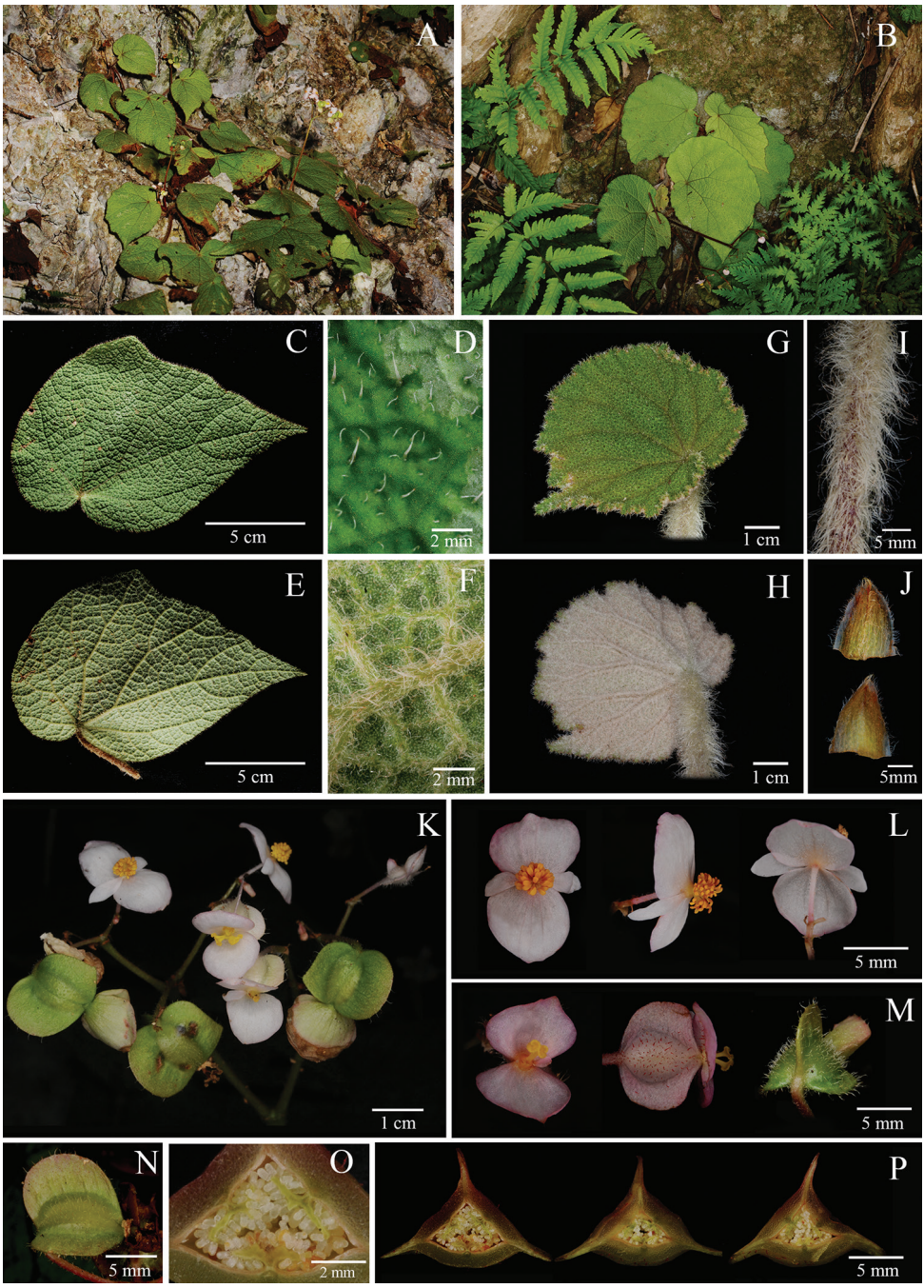

Figure 7. *Begonia mollissima* Y.M. Shui, H.Q. Nguyen & W.H. Chen **A** Habitat **B** Plant **C** View of adaxial leaf **D** Close-up of adaxial leaf **E** View of abaxial leaf **F** Close-up of abaxial leaf **G** Young leaf adaxially **H** Young leaf adaxially **I** Petiole **J** Stipule, adaxial view and abaxial view **K** Inflorescence **L** Staminate flower, face view, side view and dorsal view **M** Pistillate flower, face view, side view and dorsal view **N** Fruit, side view **O** Close-up of ovary cross section **P** Serial cross sections of ovary. (All photographs by Y.M. Shui).

Herb, rhizomatous. Rhizome, densely white villous, 2–3 cm long, 0.7–1 cm in diam. Stipule green, 1.5–2 × 1–1.5 cm, widely ovate, apex acute to obtuse, margin ciliate. Leaves: petiole erect, densely white villous, 6–13 cm long, 1–3 mm in diam.; blade green, asymmetric, widely ovate, 8.5–18 × 7–12 cm, rugose, usually with one obtuse lobe; base cordate, apex acuminate or acute, margin slightly denticulate, ciliate; adaxially green, densely tubercular-based setose, abaxially pale green, reddish when young, densely villous on veins; venation palmate, 5–6 primary veins, 2 or 3 secondary veins brunching dichotomous, tertiary veins reticulate. Inflorescence: dichasial cyme, peduncle 12–15 cm long, villous; bracts not seen. Staminate flower: pedicels 0.5–1 cm long; tepals 4; outer tepals 2, broadly ovate, 7–11 × 6–8 mm, apex rounded to acute, margin entire sometimes serrate and ciliate; inner tepals 2, oblanceolate, 5–7 × 1.8–2 mm, apex obtuse to acute, margin entire; androecium actinomorphic, stamens numerous; filaments longer than anthers, slightly fused at base; anthers yellow, 1–1.2 mm long, shorter than filaments, with two longitudinal slits. Pistillate flower: pedicel 1.2–2 cm long; tepals 2, white or pinkish, widely obovate to orbicular, 0.5–1 × 0.5–1 cm, apex acute, margin entire; styles 2–3, free; stigmas bilobed with twisted bands; ovary green or pinkish, trigonous ellipsoid, 1–1.5 cm long, 0.5–1 cm in diam. (wings excluded), white or red villous, 1-loculed; placentation parietal, placentae 3, 2-branched. Capsule pale green to pink, trigonous-ellipsoid, 1–1.5 cm long, 0.5–1 cm in diam. (wings excluded), villous, brownish when dried, 3-winged unequally; abaxial wing lunate, 0.9–1.2 × 0.3–0.7 mm; lateral wings lunate, 0.9–1.2× 0.2–0.5 cm. Seeds oblong, ca. 0.2 mm long.

Phenology. Flowering in March–May, fruiting in April–June.

Etymology. The epithet refers to the dense villous trichomes of the new species.

Habitat. The species only grows on cliffs in limestone forests.

Distribution. The species occurs exclusively in Ba Be National Park (Cho Ra county) of Bac Kan Province in Vietnam.

Note. In *Begonia* sect. *Coelocentrum*, the new species is similar as *Begonia guangxiensis* in the dense hairy habit, mainly differing in the dense tubercular-based pubes on the abaxial surface of leaves (*vs.* villous trichomes in the latter species) and subequal wings (*vs.* unequal) (Wu and Ku 1997; Shui and Chen 2017). It is also similar as *B. calciphila* C.-I Peng in the shape and trichomes of leaves, but differs in 0.5–1.2 cm long stout internodes (*vs.* 1.5–4.5 cm long slender inter-nodes) and hairy flowers and fruits (*vs.* glabrous in the latter species) (Peng et al. 2015b). In Bac Kan Province, Vietnam, there are four new species already described, viz. *B. regosula* Aver., *B. babeana* Aver. & H.Q. Nguyen (Averyanov and Nguyen 2012) and two more new species described in this paper.

Begonia rhytidophylla **Y.M.Shui & W.H.Chen, sp. nov.**
urn:lsid:ipni.org:names:77175490-1
Fig. 8

Begonia sect. *Coelocentrum* Irmsch.

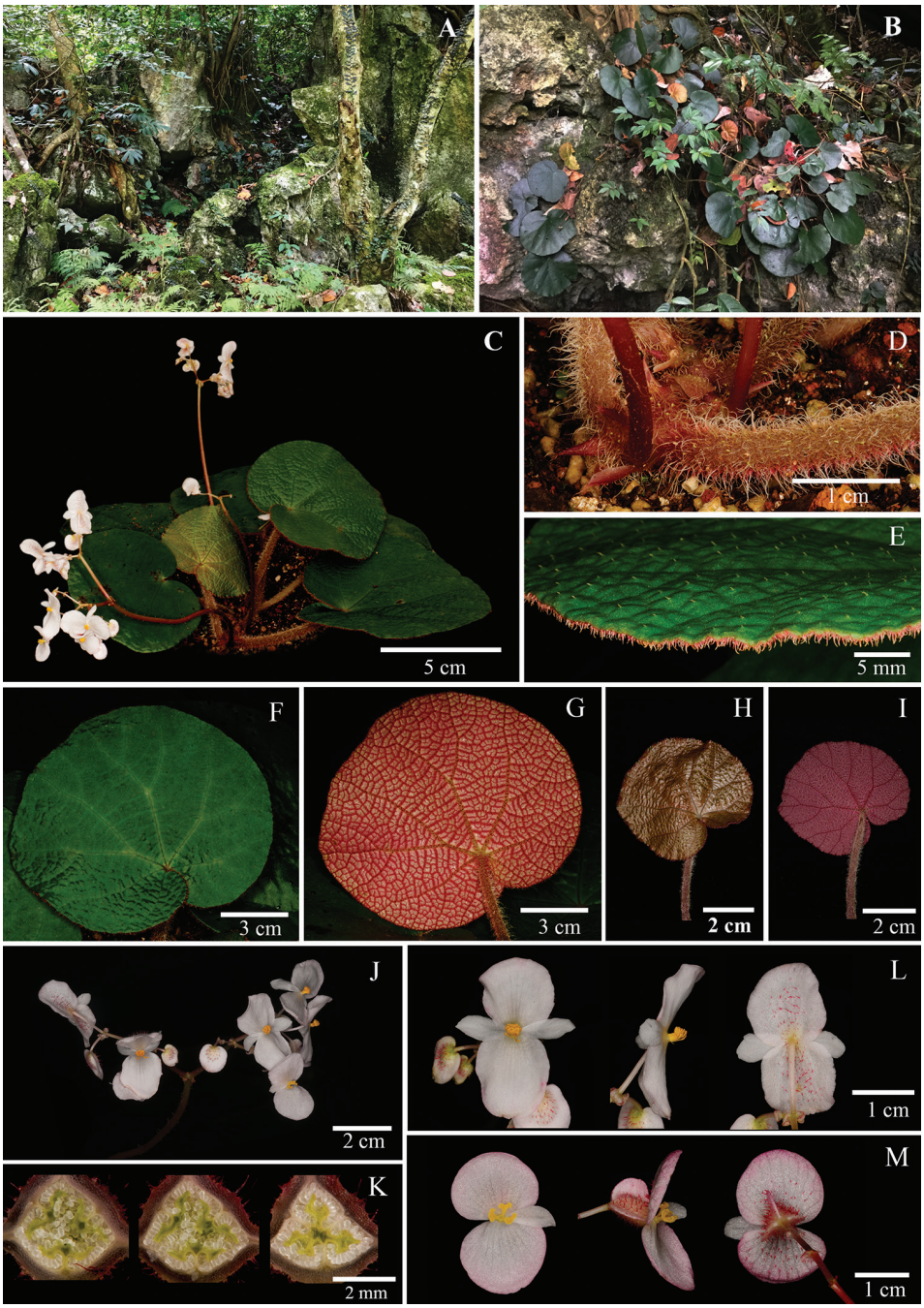

Figure 8. *Begonia rhytidophylla* Y.M. Shui & W.H. Chen **A** and **B** Habitat **C** Plant **D** Stipule and petiole **E** Close-up of adaxial leaf **F** View of adaxial leaf **G** View of abaxial leaf **H** Young leaf adaxially **I** Young leaf abaxially **J** Inflorescence **K** Serial cross sections of ovary **L** Staminate flower, face view, side view and dorsal view **M** Pistillate flower, face view, side view and dorsal view. (**A, B,** photographs by Y.M. Shui; **C–M** by S. Radbouchoom).

Remarks. The new species is similar to *Begonia crystinilla* Y.M. Shui & W. H. Chen in the thick texture and shape of leaves, but differs in the flat adaxial surface of leaves with sparse setae (vs. the uneven with dense setae), pubescent abaxial surface of leaves (vs. lane), triangulate major wing of fruit (vs. semi-lunar).

Type. CHINA. Guangxi Zhuang Autonomous Region, Jingxi county, Banliang community, 22°53'44"N, 106°26'22"E, 260 m a.s.l., at the roadside in bushes on the shady slope in the limestone hills, in fruits, 13 May 2017, *Y. M. Shui et al. B2017-300* (holotype, KUN).

Herb, rhizomatous. Rhizome: stout, 7–10 cm long, 1–1.5 cm in diam. Stipule reddish, triangular, adaxially glabrous, abaxially villous, 1–1.5 × 0.5–0.7 cm. Leaves: petiole terete, dark red or brown, densely reddish expanding villous or strigose, 5–20 cm long, 0.5–0.7 cm in diam.; blade asymmetric, widely suborbicular to reniform, 7.5–14 × 6–11 cm; base cordate, apex subacute to obtuse; margin long ciliate; adaxially greenish, extremely sparsely short setulose; abaxially dark reddish, velutinous, densely strigose on reticulate veins; venation palmate, 5–6 primary veins, secondary veins brunching dichotomous, tertiary veins netted and obviously reticulate. Inflorescence: dichasial cyme, peduncle 13–16 cm long, villous; bracts caducous, broadly ovate to orbicular, margin serrate-ciliate, apex obtuse to rounded. Staminate flower: pedicel 0.6–1.0 cm long; tepals 3–4, white to pink, adaxially glabrous, abaxially hirsute-villous; outer tepals 2, broadly ovate, 1.2–1.5 × 1–1.3 cm, abaxially white to pale pink, glabrous to sparsely red setulose, base cuneate to rounded, apex obtuse to rounded, margin entire; inner tepals 2, white to pale pink, oblanceolate, 1–1.5 × 0.2–0.5 cm, base cuneate to rounded, apex acute to obtuse, margin entire; androecium actinomorphic, stamens numerous; filaments longer than anthers, slightly fused at base; anthers yellow, obovate, 0.5–1 mm long, apex truncate, shorter than filaments, with longitudinal slits. Pistillate flower: pedicel 1.5–2 cm long; tepals 3, pinkish or white; outer tepals 2, widely obovate to orbicular, 1.5–1.7 × 1.2–1.5 cm, base cuneate to rounded, apex rounded, margin entire; inner tepal 1, elliptic to oblanceolate, 1–1.3 × 0.2–0.4 cm, base cuneate to rounded, apex acute, margin entire; styles 3, fused at base; stigmas spirally twisted; ovary pinkish, trigonous ellipsoid, 0.6–1.2 cm long, 0.4–0.7 cm in diam. (wings excluded), red villous, 1-loculed; placentation parietal upper and axile at base. Capsule pinkish when fresh, brownish when dried, trigonous-ellipsoid, 1–1.5 mm long, 0.5–0.7 mm in diam. (wings excluded), 3-winged unequally; abaxial wing lunate, 0.6–1 ×0.3–0.6 cm; lateral wings narrowly lunate, 0.6–1 × 0.2–0.4 cm; Seeds oblong, ca. 0.2 mm long.

Phenology. Flowering in August–November, fruiting in December–March next year.

Etymology. The epithet refers to the reticulate pattern of nerves on the abaxial surface of leaves.

Habitat. The species only grows on rocks at the entrance to caves or on the shady slope in limestone forests.

Distribution. The species distributes to the border region between China and Vietnam, e.g. Jingxi county of Guangxi in China and Cao Bang and Tuyen Quang Province in Vietnam.

Additional examined specimens. CHINA. Guangxi Zhuang Autonomous Region, Jingxi county, Renzhuang community, 13 May 2017, *Y. M. Shui et al. B2017-301* (KUN!). VIETNAM. Cao Bang Province, Tra Linh county, Quoc Toan committee, 22°45'56"N, 106°17'32"E, 11 April 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen,H.T. Nguyen, N.Q. Chuong CK0953* (KUN!, CPC!); the same locality, Thang Moons mountain, 12 Apr 2016, *Y.M. Shui, W.H. Chen, C. Liu, H.Q. Nguyen,H.T. Nguyen, N.Q. Chuong CK1005*(KUN!, CPC!). Tuyen Quang province, Na Hang district, Sinh Long, 22°32'36"N, 105°23'42"E, 300 m a.s.l., 28 November 2017, flower pinkish, *Y.M. Shui, W.H. Chen, S.W. Guo, H.Q. Nguyen,H.T. Nguyen, N.Q. Chuong, K.S. Nguyen CK1453* (KUN! CPC!).

Note. In *Begonia* sect. *Coelocentrum* Irmsch., the new species is unique in the dense reticulate nerves on the abaxial surface of leaves (Shui et al. 2002; Averyanov and Nguyen 2012). As to the morphology of leaves (thick texture, the even abaxial surface and broadly ovate lamina) and flowers (glabrous pink flowers and glandular hairs outside petals), the new species is similar to *B. crystallina, B. lanternaria* Irmsch. and *B. longgangensis* C.-I Peng & Yan Liu (Shui and Chen 2017). However, the latter three species are obviously different from the new species in their slightly pubescent abaxial surface of leaves. In Cao Bang Province, Vietnam, there already are the other three new species described recently (Peng et al. 2015a), viz. *B. caobangensis* C.-I Peng & C. W. Lin, *B. circularis* C.-I Peng & C. W. Lin and *B. melanobullata* C.-I Peng & C. W. Lin. The new proposed species is different from the above three species. During the survey in North Vietnam, *B. caobangensis* has been firstly discovered in the field in Tuyen Quang Province instead of Caobang Province. *B. circularis* seems to be similar as *B. lanternaria* Irmsch. but slightly different in the morphology of leaves and variable wings of fruit, while *B. melanobullata* is also similar to *B. nahangensis* Aver. & H.Q.Nguyen in Vietnam instead of *B. ferox* C.-I Peng & Yan Liu in China, but still slightly different with black hairs on the abaxial surface of leaves.

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RESEARCH ARTICLE

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Didymocarpus puhoatensis (Gesneriaceae), a new species from Vietnam

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Abstract

Didymocarpus puhoatensis, a new species from Vietnam is described and illustrated with photographs. The new species is morphologically similar to *D. brevicalyx* and *D. epithemoides*, but can be easily distinguished by a combination of characters. So far, five species have been recorded in the genus *Didymocarpus* from Vietnam.

Keywords

Didymocarpus, Gesneriaceae, plant taxonomy, Vietnam

Introduction

The delimitation of the genus *Didymocarpus* Wallich (1819: 378) has varied considerably over time (Burtt 1998, Weber et al. 2000, 2011, Möller et al. 2011, Möller and Clark 2013, Li et al. 2015). Now approximately 70 species range from northwest India, eastwards through Nepal, Bhutan, northeast India, Burma (Myanmar), to southern China, Vietnam, Laos, Cambodia, Thailand, the Malay Peninsula and northwards to Sumatra (Weber and Burtt 1998, Weber et al. 2000, Möller et al. 2016). Only three species of this genus were found in Vietnam before 2012, then *D. kerrii* and *D. purpureobracteatus* were respectively reported as new record species for the flora of Vietnam (Phuong et al. 2012,

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2014). *Didymocarpus bonii* [= *Calcareoboea bonii*], is now a synonym of *Petrocodon bonii* (Weber et al. 2011). So now there are four species of *Didymocarpus* recorded in Vietnam: *D. kerrii*, *D. pulcher*, *D. poilanei* and *D. purpureobracteatus*.

During a floristic expedition to northern Vietnam in 2015, the authors observed a population of an interesting Gesneriaceae in Pu Hoat Nature Reserve, Nghe An province, Vietnam. It was confirmed that it is member of the genus *Didymocarpus* based on its disc-like stigma (Wang et al. 1998). Over the past two years, the living plants were monitored in the field and an ecological survey was carried out by the co-author in Vietnam and in the nursery of Gesneriads Conservation Centre of China (GCCC) in China.

After thorough comparisons of diagnostic morphological and anatomical features of similar taxa from China, Vietnam, Thailand and adjacent regions (Kiew 1990, Hilliard and Burtt 1995, Wang et al. 1998, Burtt 1998, 1999, Weber et al. 2000, Hilliard 2001, Nangngam and Maxwell 2013, Nangngam and Middleton 2014, Phuong et al. 2014), it is concluded that, as its morphological characters do not fit any known species, it is a new species to science and accordingly described herein. Its morphological characters are compared with the closely related species: *D. brevicalyx* Nangngam & D.J. Middleton (2014: 35) and *D. epithemoides* B.L. Burtt (2001: 92). Therefore, there are five species of the *Didymocarpus* recorded in Vietnam.

Material and methods

Measurements and morphological character assessments of the putative new species were performed and described using specimens' work by the current authors, living material observed in the field and also those cultivated at the Gesneriad Conservation Centre of China. All available specimens of Southeast Asian *Didymocarpus* kept in the following herbaria were examined: E, GH, HN, IBK, K, KUN, MO, PE, PH, US and VNMN. The images of type specimens were also obtained from Tropicos (http://www.tropicos.org), JSTOR Global Plants (http://plants.jstor.org) and the International Plant Names Index (http://www.ipni.org). All morphological characters were studied under dissecting microscopes and are described using the terminology presented by Wang et al. (1990, 1998).

Taxonomic treatment

Didymocarpus puhoatensis **X.Hong & F.Wen, sp. nov.**
urn:lsid:ipni.org:names:77175491-1
Figures 1, 2

Diagnosis. Although it is morphologically similar to *D. brevicalyx*, it differs by stem densely pubescent, orbicular purple bracts, apices of calyx lobes obtuse, filaments glabrous, staminodes 2; and also similar to *D. epithemoides*, but differs from the latter in having purple calyx, funnel-form corolla, 4–5 cm long, glabrous, dark purple-blackish, ovary glandular puberulent.

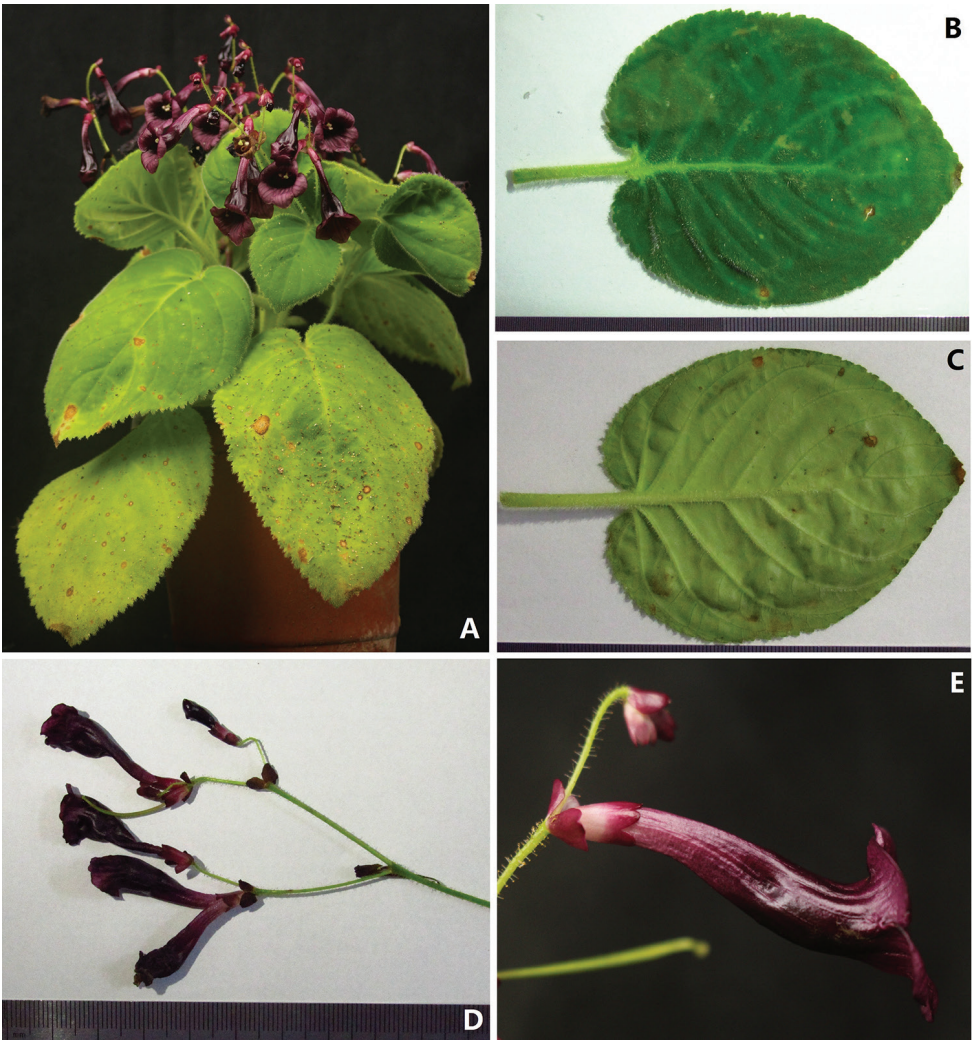

Figure 1. *Didymocarpus puhoatensis* X.Hong & F.Wen **A** Habitat **B** Adaxial surface view of leaf blade **C** Adaxial surface view of leaf blade **D** Cyme with flowers, showing the bracts **E** Lateral view of corolla, showing the calyx consisting of a tube.

Type. VIETNAM. Nghệ An Province: Quế Phong, Thông Thụ, Pu Hoat Nature Reserve (Khu Bảo tồn thiên nhiên Pù Hoạt), 19°52'30.5"N, 104°56'15.1"E, alt. 390 m, 18 July 2014, flowering, *Truong Van Do et al. VNM-CN439* (holotype: IBK; isotype: VNM).

Description. Deciduous, perennial, lithophytic herb, 10–30 cm tall. *Stems* erect, single, sparsely puberulent to glabrescent, the upper, leaf-bearing part and young stems densely covered with whitish multicellular eglandular hairs. *Dry season* plants unknown. *Rainy season* leaves opposite, anisophyllous; petioles terete, 0.5–2.5 cm long, densely covered with multicellular eglandular hairs as on the stems; blades asymmetrically ovate, 6–10 cm long, 5–8 cm wide, apex bluntly acute, base slightly oblique, obtuse-

Figure 2. Flower of *Didymocarpus puhoatensis* X.Hong & F.Wen **A–B** Frontal view of corolla, showing the disc-like stigma **C** Top view of corolla **D** Upward view of corolla **E** Opened corolla, showing stamens and staminodes **F** Pistils without corolla.

cuneate, margin finely serrate or finely doubly serrate, papery, upper surface densely covered with whitish multicellular eglandular hairs, green, lower surface sparsely covered with hairs as on upper surface, pale green, venation pinnate, secondary veins 4–8 on each side of midrib, mostly opposite sometime alternate, obscure above, prominent beneath, covered with whitish multicellular eglandular hairs. *Inflorescences* terminal or from the upper leaf axils, cymose, ca. 12 cm long, 4–10 (–30) flowered; peduncles slender, 6–10 cm long, light green, sparsely covered with multicellular glandular hairs; pedicels 1–1.5 cm long, pale green, with indumentum as on the peduncle. *Bracts* paired, orbicular, ca. 5 mm long and wide, green to pale purple, glabrous. *Calyx* consisting of a tube and shallowly 5-lobed margin, symmetrical, campanulate, 6 mm long, glabrous, somewhat tawny to pinkish purple, tube ca. 5 mm long, 3 mm in diameter;

lobes triangular, ca. 1 mm long, ca. 2 mm wide, apices obtuse. *Corolla* funnelform, 4–5 cm long, glabrous outside, blackish purple, becoming light purple at base; tube ca. 3.5 cm long, base narrow, ca. 2 mm wide, dilated and slightly ventricose towards the throat; widest at throat, diameter ca. 9 mm; corolla bi-lipped, lobes suborbicular; lower lip 3-lobed, ca. 8 mm long, 6 mm wide, more or less equal; upper lip 2-lobed, ca. 4 mm long and wide. Fertile stamens adnate to corolla ca. 1.5 cm from base; anther locules, ca. 2.5 mm long, ca. 1.5 mm wide, densely covered with brownish multicellular eglandular hairs; filaments slender, ca. 1 cm long, white, glabrous; staminodes 3, reduced to thin filaments, lateral ones 3 mm long, the other one 1 mm long, glabrous, adnate to corolla ca. 1 cm from base. *Disc* cylindrical, ca. 2 mm long, margin irregular. *Pistil* ca. 2–3 cm long; ovary narrowly linear, ca. 2 cm long, sparsely glandular puberulent, base reddish, with purple tinge towards stigma and apex green; stigma 1, peltate, concave, papillose, cream. *Capsules* unknown.

Phenology. It flowers and fruits from June to September.

Etymology. The specific epithet is derived from the type locality, Pu Hoat Nature Reserve, Nghệ An Province, Vietnam.

Distribution and habitat. This new taxon is an endemic species from Pu Hoat Nature Reserve of Vietnam. The species grows on limestone rocks in tropical monsoon forest with sufficient seasonal run-off water, at an elevation of 390 m a.s.l. It distributes much lower in altitude and the habitat is much hotter and more humid than other species with stems of the genus.

Preliminary conservation assessment. As population information of *Didymocarpus puhoatensis* is still unclear, it is not appropriate to make an assessment of the extinction risk faced by this new taxon. Thus, the category of Data Deficient (DD) should be appropriate, according to IUCN (2016) criteria. Fortunately, the known habitat of the species is protected as part of a nature reserve. Besides prolonged droughts and illegal logging in the area, there are other potential risks to the persistence of this new species.

Key to the species of *Didymocarpus* in the Vietnam

1 Ovary smooth **2**
– Ovary hair **4**
2 Corolla outer hair; leaf blade ovate or elliptic, ca. 4–10 × 2–6 cm ..... ***D. pulcher***
– Corolla outer smooth; leaf blade near round or broadly elliptic, ca. 1–4 × 1–4 cm ..... ***D. kerrii***
4 Base of leaf often axisymmetric; bract lanceolata, ca. 2–3 mm long; sepal tube ca. 3 mm long, sepal lobed ca. 1–1.5 mm long ..... ***D. poilanei***
– Base of leaf often oblique; bract elliptic ovate or orbicular, ca. 3–8 mm long; sepal tube ca. 8–9 mm long, sepal lobed ca. 2–3 mm long **5**
5 Peduncle 4–10 cm, glabrous; bracts connate at base; calyx 1–1.2 cm; corolla 3–4 cm, purple to pinkish purple ..... ***D. purpureobracteatus***
– peduncles 6–10 cm, glandular hairs; bracts separate; calyx 6 mm; corolla 4–5 cm, blackish purple ..... ***D. puhoatensis***

Discussion

It is morphologically similar to *D. brevicalyx* and *D. epithemoides* in having the calyx consisting of a tube, similar shape and colour of corolla, both morphological affinities being distributed in Thailand. However, *D. puhoatensis* can be clearly differentiated from both by several characters. The major differences between the species are outlined in Table 1.

Table 1. Diagnostic characters for *Didymocarpus puhoatensis* sp. nov. and its relatives.

Character	*Didymocarpus puhoatensis*	*D. brevicalyx*	*D. epithemoides*
Indumentum of Stem	densely pubescent	densely glandular pubescent	densely pubescent
Bracts	orbicular c. 5 mm long and wide	triangular c. 2 mm long and 1.5 mm wide	orbicular, 5 mm long and wide
Calyx	lobes apices obtuse, purple	lobes apices acute, reddish	lobes apices rounded, violet
Corolla	funnelform, 4–5 cm long, glabrous, dark purple-blackish	funnelform, 4.5 cm long, glabrous, dark purple-blackish	salverform, 3–3.5 cm long, glandular pubescent outside, dark violet
filaments	glabrous	gland-tipped hairs on the upper part	glabrous
Indumentum of ovary	sparsely glandular puberulent	densely glandular pubescent	glabrous

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RESEARCH ARTICLE

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Two new species of *Oreocharis* (Gesneriaceae) from Fan Si Pan, the highest mountain in Vietnam

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Abstract

Two new species of *Oreocharis* Benth. from Fan Si Pan, the highest mountain in Vietnam (Sa Pa) are described and illustrated. *Oreocharis grandiflora* W.H.Chen, Q.H.Nguyen & Y.M.Shui, is similar to *O. flavida* Merr. from Hainan province, China, but differs mainly by its larger and infundibuliform corolla, stamens adnate to the base of the corolla tube and stamens coherent in two pairs. The second, *Oreocharis longituba* W.H.Chen, Q.H.Nguyen & Y.M.Shui, is similar to *O. hirsuta* Barnett, endemic to northern Thailand, but mainly differs in its pubescence, coherent stamens and glabrous filaments.

Keywords

Biogeographical affinis, Sino-Himalayan forest subkingdom, Southeastern Asia, *Oreocharis* with yellow or orange flowers

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Introduction

Fan Si Pan is a species-rich diversity hotspot in Indochina, the flora of which is still incompletely known. Fan Si Pan (in Vietnamese: Phan Xi Păng), the highest mountain in Vietnam (3143 m elevation), is situated in the northwest of the country and its orogeny is linked to the Himalayan Mountain chain (Nguyen and Harder 1996; Tapponnier et al. 1990, 2001). It also has the highest recorded levels of biodiversity in Indo-China and is part of one of the 25 world's biodiversity hotspots (Takhtajan 1986; Myers et al. 2000). With more than 100 years of collecting and research in Fan Si Pan, a rich flora of 1659 species in 723 genera and 228 families has been recorded (Nguyen and Nguyen 1998). According to the floristic subdivision of Eastern Asia, Fan Si Pan is floristically related to the Sino-Himalayan forest subkingdom (= Sino-Himalaya Floristic Region in the past) (Nguyen and Harder 1996, Wu and Wu 1996). Even after a century of research, Fan Si Pan still yields new species. Over the last few decades several new species have been described, such as *Abies fansipanensis* Xiang et al. and *Manglietia crassifolia* Vu et al., adding to our understanding of its floristic affinities (Xiang et al. 1997; Vu and Xia 2010; Vu et al. 2011).

The genus *Oreocharis* Benth. now includes over 90 species after its recent re-circumscription (Möller et al. 2011). Since then, several new taxa have been described from China and the genus now includes over 106 species (Möller et al. 2016). The genus is distributed predominantly in China, with few species in Thailand, Myanmar, Bhutan, NE India, Japan and Vietnam (Möller et al. 2011; Möller and Clark 2013; Möller et al. 2014, 2016). Most *Oreocharis* species occur in relatively restricted and geographically isolated localities with very few widely distributed, such as *O. aurea* Dunn, occurring from South Yunnan in China (type locality) to North Vietnam (Pellegrin 1930; Wang et al. 1990, 1998; Li 1991; Ho 2000). No new species of *Oreocharis* were described from Vietnam from 1908 until recently when three new species were discovered (Do et al. 2017; Chen et al. 2017).

During a joint Sino-Vietnamese botanical survey in Fan Si Pan in November 2012, two of the authors (QHN and YMS) collected several specimens of Gesneriaceae. These included two collections of fruiting specimens. From the vegetative habit and fruit characters, they were identified as belonging to *Oreocharis*. In September 2013, cultivated plants of the two collections produced flowers unlike any of the described species in the genus (Figs 1 and 2). After consulting the relevant literature from China and Vietnam (Barnett 1961; Ho 2000; Wang et al. 1990, 1998; Li and Wang 2004; Chen et al. 2017; Do et al. 2017), it was confirmed that the two species were new to science. On examination of other recent and historic unidentified collections from Vietnam, a number of other specimens of one of the species were also found. Here, they are described and illustrated via photography and drawings.

Taxonomy

Oreocharis grandiflora **W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov.**
urn:lsid:ipni.org:names:77175492-1
Figs 1A–F, 3

Diagnosis. This new species is similar to *O. flavida* in the orange colour of the corolla, but differs from the latter by its much larger corolla (3.3–3.6 cm long vs. 1.5–1.7 cm), the shape of the corolla tube (infundibuliform vs. campanulate) and the reniform anthers which are coherent in two pairs (vs. horseshoe-shaped and not coherent). The two species further differ by the narrowly oblong or elliptic leaf blades in the new taxon (vs. ovate-elliptic to broadly ovate), cuneate leaf base (vs. cordate to rounded), the glandular villous indumentum on the outer surface of the calyx lobes (vs. eglandular villous).

Type. VIETNAM. Lao Cai, Sa Pa distr., Ta Phin cave, in secondary forests, on cliffs nearby waterfalls, 22°20'43.66"N, 103°46'30.48"E, 2017 m elevation, 30 October 2012, type specimen from a plant cultivated in an experimental greenhouse at Kunming Botanic Garden, 7 September 2013, *Y.M. Shui* et al. *B2013-550* (holotype, KUN!; isotype: Herbarium of the Centre for Plant Conservation, Vietnam Union of Science and Technology Associations, Hanoi!).

Perennial herbs. Leaves in basal rosette. Petiole 2.2–2.6 cm long, with dense white glandular hairs; leaf blade coriaceous, narrowly oblong or elliptic, 4–6 × 1.8–3.5 cm, adaxially and abaxially covered by white glandular hairs, more densely on veins, base narrowly cuneate, apex acute, margin crenate; lateral veins 4–5 on each side of the midrib, adaxially depressed, abaxially prominent. Inflorescences axillary, 1–4-flowered. Peduncles 6–12 cm long, with white glandular hairs; bracts 2, lanceolate, 5.6–6 × 1.1–1.2 mm, abaxially covered by white glandular hairs. Pedicel 1.5–1.8 cm long. Calyx 5-lobed from base, lobes equal, linear-lanceolate, 7–8 × 1.1–1.2 mm, entire, adaxially glabrous, abaxially with white glandular hairs. Corolla deep orange, slightly bilabiate, 3.3–3.6 cm long, inside pubescent, outside with white glandular short hairs; tube infundibuliform, 2–2.2 cm long, 2.7–3 mm in diam. at base and 8–9 mm in diam. at throat; adaxial lip 2-lobed, lobes suborbicular, 8.5–9 × 11–12 mm, apex obtuse; abaxial lip 3-lobed, lobes suborbicular, slightly equal, 13–14 × 8–9 mm, apex more or less rounded. Stamens 4, anthers coherent in two pairs, filaments adnate to base of corolla tube, adaxial stamens 2–2.2 cm long, abaxial stamens 2.6–2.8 cm long; filaments with white glandular hairs; anthers reniform, basifixed; staminode 1, adnate to base of corolla tube, 5–6 mm long. Pistil 3.1–3.5 cm long when mature; ovary cylindrical, 2–2.2 cm long, glabrous; style 1–1.3 cm long, with white glandular hairs; stigma 1, flattened with central depression. Disc ringlike, yellowish, 2–3 mm high. Capsule straight, cylindrical, 2.1–2.5 cm long.

Distribution, habitat and phenology. This new species is endemic to Sa Pa, northern Vietnam and grows densely on cliffs by waterfalls along deep valleys in evergreen broad-leaved forests, at an elevation of around 1800–2010 m. Flowering from August to October and fruiting from September to October.

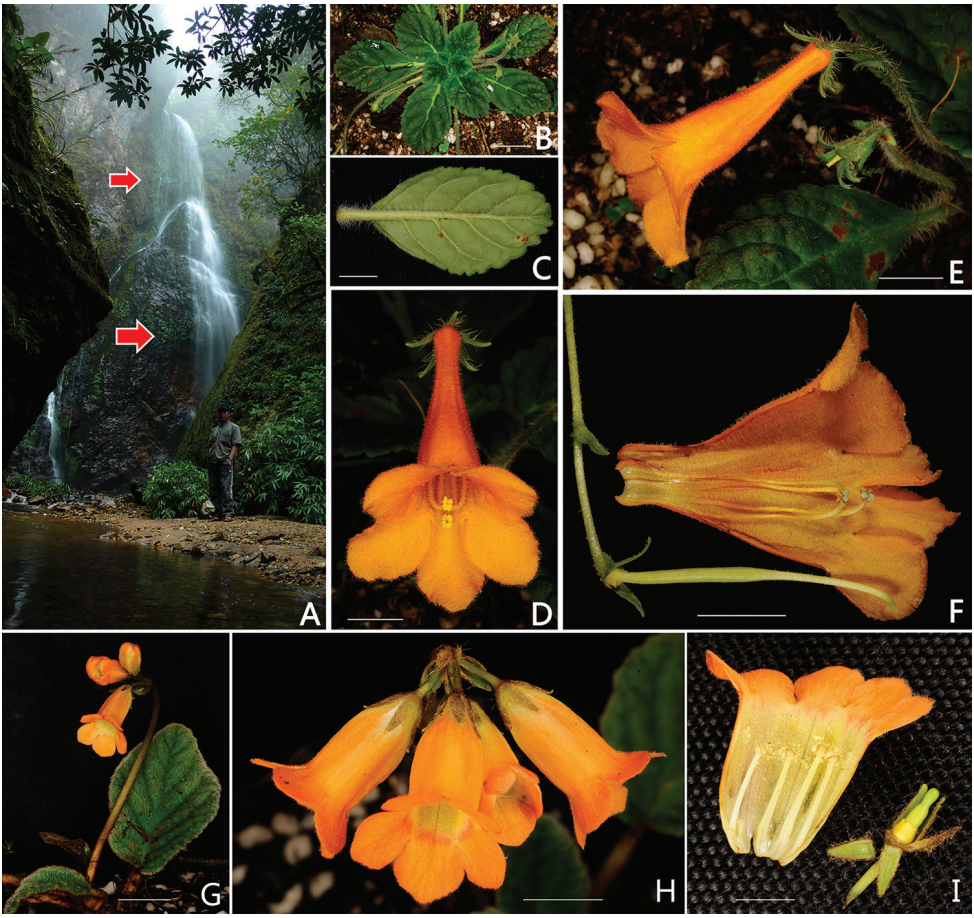

Figure 1. *Oreocharis grandiflora* W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov. (**A–F**) and *O. flavida* Merr. (**G–I**) **A** Habitat (red arrows indicate position of plants in the field) **B** Mature plant **C** Abaxial leaf surface **D** Front view of flower **E** Lateral view of flower **F** Opened corolla, pistil, disc and calyx **G** Plant **H** Inflorescence and open flowers **I** Dissected flower, showing corolla with free anthers, pistil, disc and calyx. Scale bars: **A, C–F** = 1 cm; **B,G** = 2 cm; **H, I** = 5 mm. All photographs by Yu-Min Shui.

Etymology. The species epithet refers to the large size of the flowers. Based on the authors' observation and other relevant publications (Wang et al. 1990, 1998), the new species has one of the largest flowers in *Oreocharis*.

Conservation status. This new species appears to be restricted to a very moist habitat in Sa Pa, Lao Cai Province, northern Vietnam. It grows on several steep cliffs at 1800–2100 m elevation by waterfalls with flowing water throughout the year (Fig. 1A). It flowers during the rainy season (September to October), during which the locality is inaccessible. This is likely the reason why it had not previously been discovered. It is naturally protected by its inaccessible habitat on the cliffs. According to our observations in the field, the two known populations harbour about 100 mature individuals in each. In fact, there are many waterfalls at this altitudinal range and, thus, the real number of populations and individuals may

Table 1. Morphological comparison between *Oreocharis grandiflora* sp. nov. and *O. flavida* Merr.

Character	*O. grandiflora* sp. nov.	*O. flavida*
Petiole	2.2–2.6 cm long, white long glandular hairs	13–16 cm long, densely pale brown villous or woolly
Leaf blade	narrowly oblong or elliptic, 4–6 × 1.8–3.5 cm, adaxially and abaxially glandular, densely glandular on veins	ovate-elliptic to broadly ovate, 4–10 × 2–7.2 cm, adaxially densely pubescent, abaxially densely brown woolly, more densely along veins
Leaf base	cuneate	cordate to rounded
Peduncle	densely glandular	densely pale brown woolly
Calyx	outside glandular	outside eglandular villous
Corolla	3.3–3.6 cm long, outside white glandular	1.5–1.7 cm long, outside sparsely pubescent
Corolla tube	infundibuliform	campanulate
Corolla lips	adaxial lobes 8.5–9 × 11–12 mm, apex obtuse; abaxial lip 3-lobed, lobes 13–14 ×8–9 mm	all lobes slightly equal, 3–6 × 3–5 mm.
Stamens	4, anthers coherent in two pairs; anthers reniform	4, anthers not coherent; anthers horseshoe-shaped
stigma	1	2
disc	2–3 mm tall	1 mm tall

be higher. Nevertheless, its unusually humid habitat might be affected by climate change-induced droughts. Overall however, the species has been classified as "Data Deficient" [DD] following IUCN Red List Categories and Criteria (IUCN 2012).

Additional specimens examined. VIETNAM. Lao Cai, Sa Pa distr., Ta Phin cave, in secondary forests, 22°20'43.66"N, 103°46'30.48"E, 2017 m elevation, 30 October 2012, in fruit, *Q.H.Nguyen, T.H.Nguyen, Y. M. Shui, Y. K. Sima, S. X. Yang, Z. Zhou, J. Liu CK687* (KUN!, Herbarium of the Centre for Plant Conservation, Vietnam Union of Science and Technology Associations, Hanoi!).

Notes. This new species resembles *Oreocharis flavida*, but differs in the characters in Table 1 (see also Fig. 1). Additionally, the corolla size range is larger than any other species in the former delimitation of *Oreocharis*. In size and shape, the corolla of the new species resembles that of *Oreocharis ronganensis* (K.Y. Pan) Mich. Möller & A. Weber (formerly *Ancylostemon ronganensis* K.Y. Pan), but in the latter the corolla is pink, not deep orange. This is a rare colour in *Oreocharis s.l.*, since only about six of the >106 species have a corolla of such an intensely deep orange colour.

Oreocharis longituba W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov.

urn:lsid:ipni.org:names:77175493-1
Figs 2A–H, 4

Diagnosis. This new species is similar to *O. hirsuta* Barnett from Thailand, but differs from it in its pubescent petioles (vs. hirsute), (sub)orbicular leaves (vs. narrowly ovate or lanceolate), rounded leaf apex (vs. acute to short acuminate), crenate leaf margin (vs. bi-serrate), narrowly infundibuliform corolla tube (vs. tubular), anthers coherent in pairs (vs. free) and glabrous filaments (vs. hirsute).

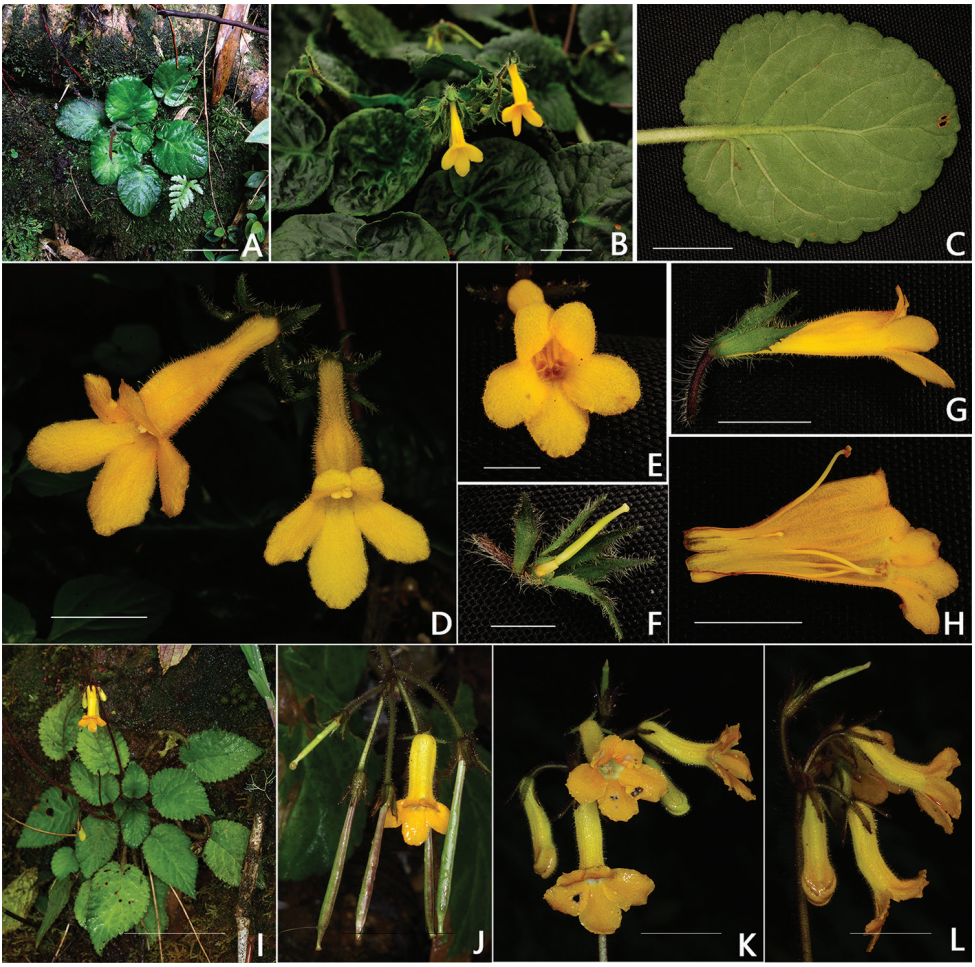

Figure 2. *Oreocharis longituba* W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov. (**A–H**) and its most similar species, *Oreocharis hirsuta* Barnett (**I–L**) **A** Habitat **B** Mature plant **C** Abaxial leaf surface **D, E** Front view of flower **F** Pistil with immature stigma, disc and calyx **G** Lateral view of flower **H** Opened corolla **I** Mature plant **J** Flower and fruits **K** Front view of flowers **L** Side view of flowers. Scale bars: **A, I** =5 cm, **D–H** = 1 cm; **J, K, L**= 2 cm. **A–H** photographs by Yu-Min Shui, **I–L** by Preecha Karaket of *Middleton et al. 4550*.

Type. VIETNAM. Lao Cai, Sa Pa distr., Ta Phin cave, in secondary forests, 22°20'54.48"N, 103°46'12.98"E, 1879 m elevation, 30 October 2012, type specimens from plants cultivated in an experimental greenhouse at Kunming Botanic Garden, 7 September, 2013, *Y.M. Shui* et al. *B2013-551* (holotype, KUN!; isotype, Herbarium of the Centre for Plant Conservation, Vietnam Union of Science and Technology Associations, Hanoi!).

Perennial herb. Leaves in basal rosette. Petiole 4–7 cm long, densely long pubescent; leaf blade (sub)orbicular, 3–9 × 2.4–8.9 cm, adaxially sparsely hirsute, abaxially

pubescent, more densely so on venation, base cordate, apex rounded, margin crenate; lateral veins 5–6 pairs, adaxially depressed, abaxially prominent. Inflorescences axillary, 1–2-flowered. Peduncles 8–11 cm long, densely white villous; bracts 2, linear-lanceolate, 5–22 × 0.7–1.2 mm, adaxially subglabrous, abaxially pubescent; pedicel 1.8–2 cm, pubescent. Calyx 5-parted almost from base, segments linear-lanceolate, 8–15 × 1–4 mm, margin dentate, adaxially glabrous, abaxially white hispid. Corolla yellow, bilabiate, 3–3.5 cm long, inside pubescent, outside white glandular; tube narrowly infundibuliform, 2–2.5 cm long, 3–3.5 mm in diam. at base and 6–7 mm in diam. at throat; adaxial lip 6.5–7 mm long, 2-lobed, lobes suborbicular, 3.3–3.5 × 3.5–3.8 mm, apex obtuse; abaxial lip 3-lobed, lobes sub-oblong, almost equal, 8–10 × 6–8 mm, apex obtuse. Stamens 4, anthers coherent in two pairs, adaxial stamens 5–7 mm long, adnate to corolla tube 1.2–1.5 mm from base, abaxial stamens 7.5–8 mm long, adnate to corolla tube 1–1.2 mm from base; filaments glabrous; anthers round, basifixed, dehiscing longitudinally; staminode 1, 2.5–3 mm long, adnate to corolla tube 6–7 mm from base. Pistil 1.7–2.1 cm long when mature; ovary cylindrical, 1.2–1.4 cm long, glabrous, 2-locular; style 5–7 mm long, white pubescent; stigma 1, flattened with a central depression. Disc cylindrical, yellowish, 2.8–3 mm high, margin shallowly dentate. Capsule straight, cylindrical, 3–5 cm long. Seeds oblong, 1.1–1.2 mm long.

Distribution, habitat and phenology. This new species is also endemic to Sa Pa, northern Vietnam and grows widely scattered on wet ground along road sides or along streams in evergreen broad-leaved forests, at an elevation of 1700–1890 m. Flowering from August to September and fruiting from September to October.

Etymology. The species epithet refers to the unusually long length of the corolla tube in *Oreocharis*.

Conservation status. Endangered EN B2ab (iii), following IUCN (2012) guidelines. This is based on an EOO of < 35 km^2, being known from fewer than five populations and with disturbed locality.

Additional specimens examined. VIETNAM. Lao Cai, Sa Pa distr., Kuoang Village, 22°28'43.66"N, 103°47'41.5"E, 1700 m elevation, growing on humus soil in wet and shady places, 11 September 2005, *X. P. Vu, D. H. Duong, V. D. Nguyen, Q. B. Nguyen, T.D.Nguyen, R. de Kok, G. Bramley, G. Challen, M. Vorontsova HNK 58* (K!); Sa Pa, Ta Phin cave, in secondary forests, 22°20'54.48"N, 103°46'12.98"E, 1879 m elevation, 30 October 2012, in fruit, *Q. H. Nguyen, T.H. Nguyen, Y. M. Shui, Y. K. Sima, S. X. Yang, Z. Zhou, J. Liu CK670* (KUN!, Herbarium of the Centre for Plant Conservation, Vietnam Union of Science and Technology Associations, Hanoi!); Sapa distr., the path to Fanxipan from Ton Station, 22°20'01"E, 103°46'47.8"E, 2000 m elevation, 10 August 2007, in fruit, *N. V. Du, P. Wharton & B. Wynn-Jones 10* (K!); Tonkin, route de Chapa à la garderie du Col de Lo Qui Ho, 1800 m elevation, September 1929, in flower, *P. A. Pételot 5177* (P: P03934211!; P04079324!; P03511246!); Col de Lo Qui Ho, elev. 2000 m, August 1933, in flower, *P. A. Pételot 7247* (P: P03934227); Col de Lo Qui Ho, elev. 1900, 16 August 1926, in flower, *Poilane 12965* (P: P04079331).

Notes. A previous collection of this species, *X.P. Vu* et al. *HNK 58*, K!, had been identified as *Oreocharis hirsuta*, a species from Thailand that demarcates the southern-

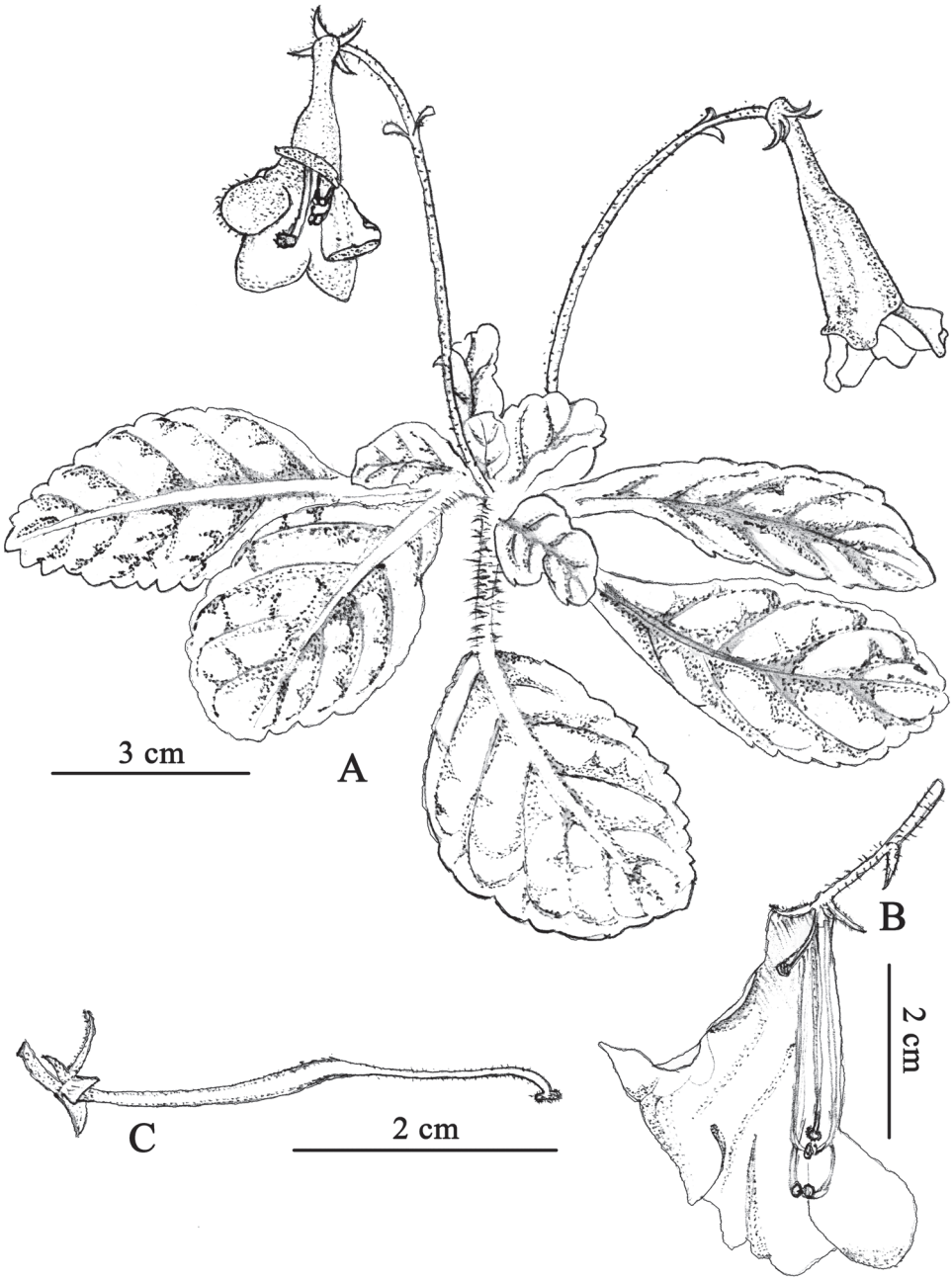

Figure 3. *Oreocharis grandiflora* W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov. (all drawings based on the holotype *Y.M. Shui* et al. *B2013-550* in KUN, drawn by Y.F. Shui) **A** Habit **B** Opened corolla showing corolla lobes and two pairs of stamens **C** pistil at stigma receptivity and calyx.

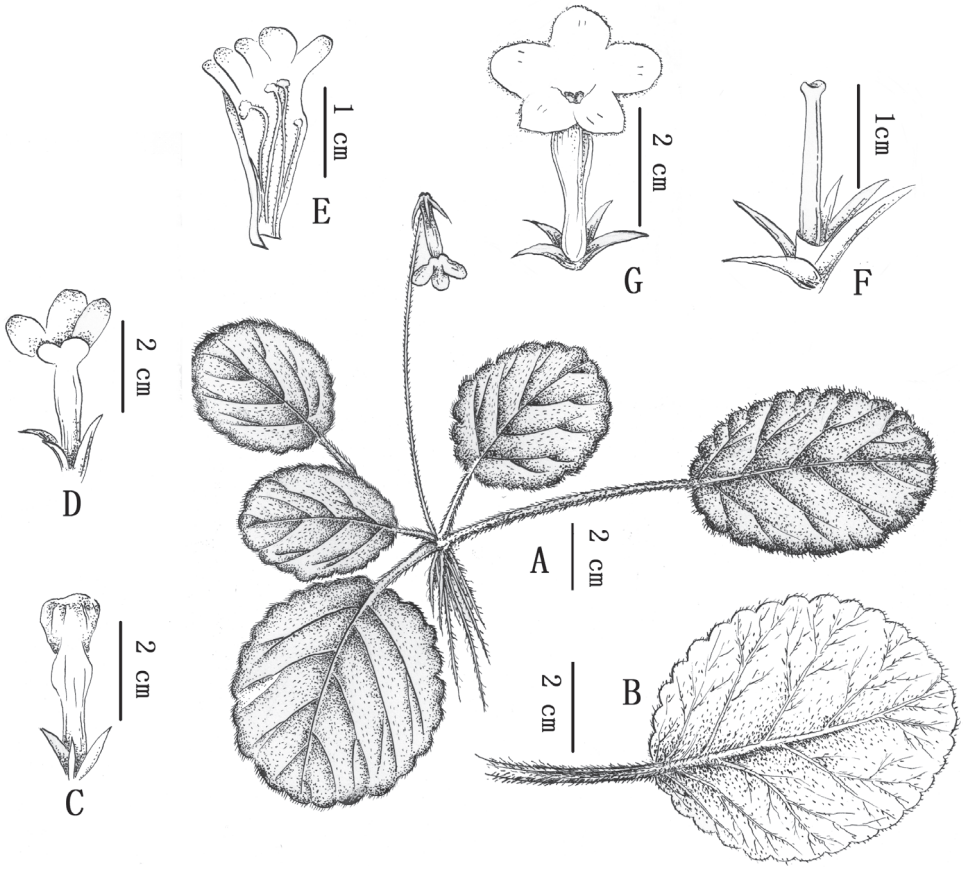

Figure 4. *Oreocharis longituba* W.H.Chen, Q.H.Nguyen & Y.M.Shui, sp. nov. (all drawings based on the holotype *Y.M. Shui* et al. *B2013-551* in KUN, drawn by J.X. Liu). **A** Habit **B** Abaxial leaf surface **C** Opening flower from below showing the inflated part near the distal end of the corolla tube **D** Open flower from above **E** Opened corolla showing two pairs of stamens **F** Pistil (immature at male stage), disc and calyx **G** Front view of flower.

most distribution of the genus (Barnett 1961; Möller et al. 2011). When comparing the specimens studied here with type material and recent collections of *O. hirsuta* in the herbaria of the Royal Botanic Gardens, Kew (K) and the Royal Botanic Garden Edinburgh (E), it was found that they can be morphologically differentiated (Table 2; Figs 2I–L). Earlier collections by Pételot and Poilane in Vietnam and deposited in the Muséum National d'Histoire Naturelle in Paris (P), remained unnamed until now. These collections were made near Chapa at Lo Qui Ho, a station on the slopes near the summit of Fan Si Pan).

With its long corolla tube up to 2.5 cm, *O. longituba* has the longest tube amongst the yellow flowered species with infundibuliform corollas in *Oreocharis*. It is also the only species with coherent anthers amongst species in the previous, narrower concept

Table 2. Morphological comparison between *Oreocharis longituba* sp. nov. and *O. hirsuta* Barnett.

Character	*O. longituba* sp. nov.	*O. hirsuta*
Petiole	pubescent	hirsute
Leaf blade	(sub)orbicular, margin crenate	narrowly ovate or lanceolate, margin bi-serrate
Peduncle	densely white villous	hirsute
Calyx	0.8–1.5 cm long, abaxially hispid	3.4–7.5 mm long, abaxially hirsute
Corolla	3–3.5 cm long, inside pubescent	1.9–2.5 cm long, inside glabrous
Corolla tube	2–2.5 cm long, 3–3.5 mm in diam. at base and 6–7 mm in diam. at throat	1.5–1.9 cm long, 4–5 mm in diam. from base to top
Corolla lip	lobes unequal	lobes more or less equal
Stamens	4, anthers coherent in two pairs; filaments glabrous; anthers round	4, anthers not coherent, glabrous; filaments hirsute; anthers oval
Ovary	1.2–1.4 cm long	5–5.5 mm long
Disc	2.8–3 mm tall	1–2 mm tall

of *Oreocharis*. In the current wider delimitation of *Oreocharis*, the corolla tube is more similar in shape, though not in size, to those species previously placed in *Ancylostemon* Craib and *Paraisometrum* Wang (Wang et al. 1990, 1998; Weitzman et al. 1997; Chen et al. 2014).

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RESEARCH ARTICLE

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Primulina malipoensis (Gesneriaceae), a new species from Sino-Vietnamese border area

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Abstract

Primulina malipoensis, a new species from limestone areas around the Sino-Vietnamese border, is described and illustrated. This new species is morphologically similar to *P. maguanensis* and *P. lungzhouensis*, but obviously differs from the latter two species by its pale greenish-yellow flowers (vs. purple, with different colour patterns). The phylogenetic affinity, illustration and photographs of this new species are provided in this paper.

Keywords

Limestone flora, New taxon, Sino-Vietnamese border area, Taxonomy

Introduction

The recently redefined *Primulina* Hance has become a species-rich genus within the subfamily Didymocarpoideae of Gesneriaceae (Wang et al. 2011, Weber et al. 2011, 2013) and its species diversity is still growing due to numerous new species being constantly discovered (e.g. Pan et al. 2013, Guo et al. 2015, Lai and Wen 2015). This group shows high levels of endemism and ecological (edaphic) specialisation (Hao et al. 2015). The majority of its species occur in karst areas of southern and south-

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western China and northern Vietnam, with narrow, island distributions, often limited to a single cave or karst limestone hill system (Wang et al. 1998, Li and Wang 2004, Wei et al. 2010). Local-scale mosaics of soil type are ubiquitous features in the karst landscapes and thus, soil nutrient availability may influence diversification and speciation of *Primulina* via local adaptation to specific edaphic microhabitats (Hao et al. 2015). However, in the *P. eburnea* complex, geographical isolation has been shown to be a major driver of its diversification and speciation in *Primulina* (Gao et al. 2015, Wang et al. 2017).

During field explorations in 2013, one of the authors (JC) found an unknown species of *Primulina* near the Sino-Vietnamese border at Malipo County, southeastern Yunnan, China. Several living individuals from the population found in the field were brought to the South China Botanical Garden (SCBG) and cultivated there. These plants showed leaf blade characteristics very common in *Primulina*. However, when flowering, they displayed uncommon yellow flowers. Flower colour has been used as an important character for the description of new *Primulina* species (Pan et al. 2016, Yang et al. 2017). Therefore, these plants soon caught the authors' attention. Checking of specimens and literature studies were undertaken immediately. When specimens were checked in KUN (by its online service), an interesting specimen was found (numbered *KUN 1275938*), which possesses a similar leaf to these plants and had been collected from nearly the same locality as the findings. This specimen was identified as *Chirita eburnea* (a synonym to *P. eburnea*). However, this specimen was represented by only a piece of leaf and without flowers, thus, its identification is doubtful. To further reveal the true taxonomic identity of both of these plants and the specimen, other field works were carried out by one of the authors (FW) in 2017. Fortunately, he found this species at the recoded site of the specimen (*KUN 1275938*) and also found other populations at a nearby location in Vietnam. At the same time, additional investigations, i.e. phylogenetic analysis and morphological comparison, were undertaken. Based on these results, all of these plants from the three populations are considered as the same new species, which is described and illustrated here.

Methods

Morphological observations were carried out using living cultivated plants (ten individuals) as well as dried specimens. All morphological characters were measured using dissecting microscopes and descriptions were made following the terminology presented by Wang et al. (1998). Literature studies included all relevant monographs (Wang et al. 1998, Li and Wang 2004, Wei et al. 2010) and recently published literature (Xu et al. 2008, 2012, Li and Möller 2009, Pan et al. 2013, 2016, Li et al. 2014, Lai and Wen 2015, Guo et al. 2015). Checking of specimens was undertaken at IBSC and IBK and with the help of web databases (Chinese Virtual Herbarium: http://www.cvh.ac.cn/; Herbarium, Kunming Institute of Botany, CAS: http://www.kun.ac.cn/; Global Plants: http://plants.jstor.org/). A map of the species' geographical distribution was prepared

based on field records. The molecular phylogenetic analyses of the species were included in a broader study in which the most comprehensive species-level phylogeny of *Primulina* was reconstructed based on 20 plastid and nuclear regions (Kong et al. 2017).

Taxonomy

Primulina malipoensis **L.H. Yang & M. Kang, sp. nov.**
urn:lsid:ipni.org:names:77175494-1
Figures 1, 2

Diagnosis. *Primulina malipoensis* mainly differs from *P. maguanensis* and *P. lungzhouensis* by its pale greenish-yellow flowers (vs. purple, with different colour patterns). This new species can further be distinguished from *P. maguanensis* by its greenish bracts (vs. white) and from *P. lungzhouensis* by its entire bracts margin (vs. denticulate).

Type. CHINA. Guangdong Province, Guangzhou City, voucher from a cultivated plant at South China Botanical Garden, 29 July 2016 (flowering), *Li-Hua Yang*, *YLH369* (holotype: IBSC!), introduced from Yunnan province, Malipo county, Xiajinchang town, growing on moist limestone rocks, Alt. 1500 m, 23°10'N, 104°49'E, 31 August 2013, *Jun-lin Chen*.

Description. *Perennial herbs*. *Rhizomatous* stem subterete, 20–60 mm long, 5–15 mm in diameter. *Leaves* 8–12, basal or clustered at apex of stem, opposite decussate. *Petiole* flattened, 20–40 mm long, 8–10 mm wide, pubescent. *Leaf blade* slightly fleshy when fresh, thickly chartaceous when dried, ovate to broadly elliptic, 7–12 × 7–10 cm, adaxially densely pubescent, abaxially glabrescent and only puberulent along veins, apex subacute to obtuse, base cuneate, margin inconspicuously serrate; *lateral veins* 4 on each side, abaxially conspicuous. *Cymes* 3–5, axillary, 2–4 branched, 8–16-flowered; *peduncles* 15–27 cm long, ca. 2 mm in diameter, densely pubescent; *bracts* 2, sometimes with bracteoles (narrowly ovate, 8–12 × 4–7 mm), green, opposite, ovate, 16–25 × 8–13 mm, margin entire, apex acute, outside densely pubescent, inside sparsely pubescent. *Pedicel* 10–14 mm long, ca. 1 mm in diameter, densely glandular pubescent and puberulent. *Calyx* 5-parted to near base, lobes narrowly lanceolate, white, 7–9 × ca. 2 mm, outside densely glandular pubescent and puberulent, inside sparsely pubescent, margin entire. *Corolla* pale greenish-yellow, 24–32 mm long, outside glandular-pubescent and puberulent, inside glabrous; *tube* infundibuliform, 21–25 mm long, ca. 8 mm in diameter at mouth, ca. 5 mm in diameter at base; *limb* distinctly 2-lipped, adaxial lip 2-parted, lobes broadly ovate, 7–9 × 6–7 mm, apex rounded, abaxial lip 3-lobed, lobes oblong, 11–13 × 5–7 mm, apex rounded. *Stamens* 2, adnate to 10–13 mm above the corolla tube base; *filaments* linear, 9–11 mm long, pale greenish-yellow, geniculate near middle, sparely pubescent; *anthers* fused by the entire adaxial surfaces, ca. 2 mm long, abaxially densely covered with glandular hairs. *Staminodes* 3, lateral ones 6–7 mm long, adnate to 10–12 mm above the corolla tube base, middle one ca. 1.5 mm long, adnate to 6–8 mm above the corolla tube base. *Disc* annular,

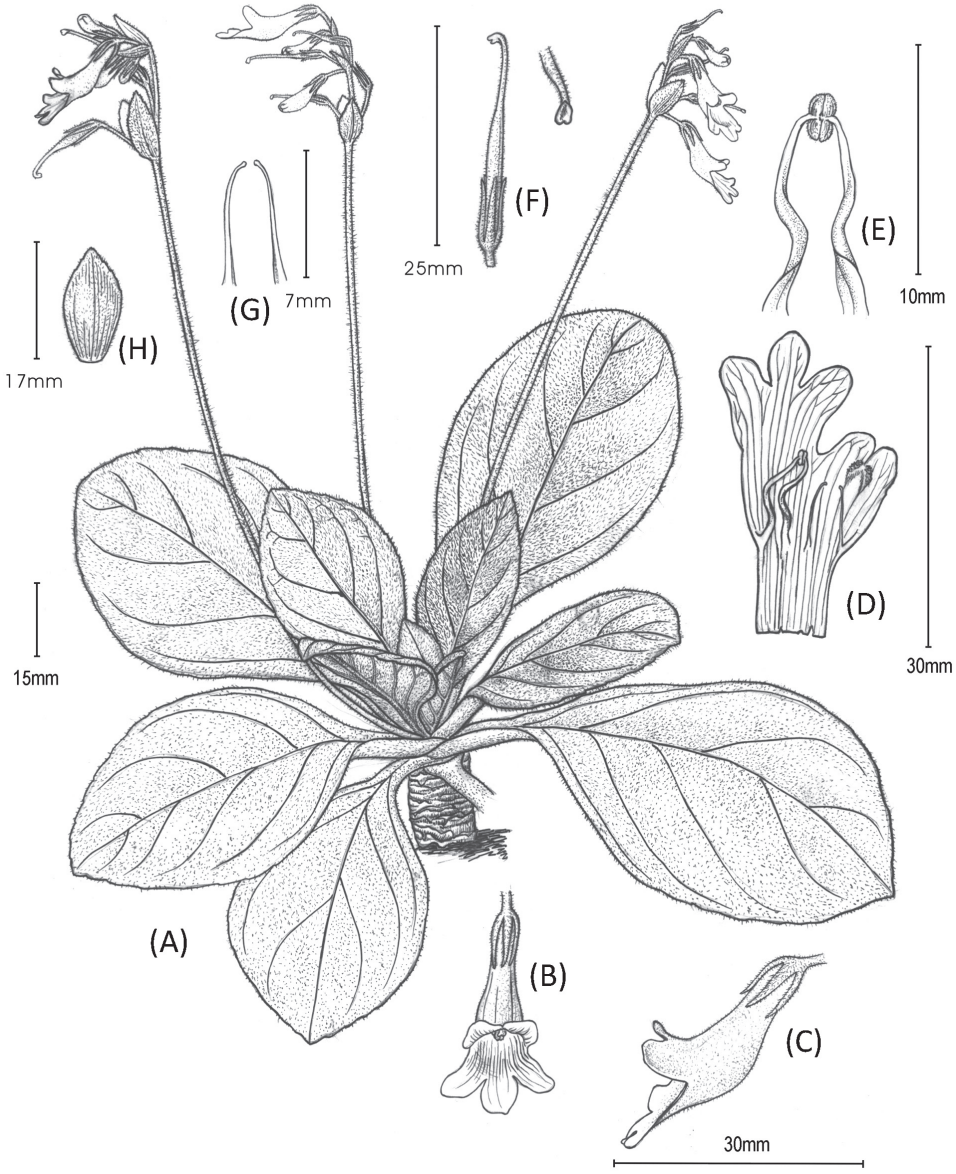

Figure 1. *Primulina malipoensis*. **A** habit **B** flower in front view **C** flower in side view **D** opened corolla, showing stamens and staminodes **E** fertile stamens **F** pistil and stigma **G** staminodes **H** bract. Drawn by Yun-Xiao Liu based on a cultivated individual collected from type locality.

ca. 1.5 mm in height. *Pistil* 22–26 mm long; *ovary* cylindrical, 15–18 mm long, ca. 1.5 mm in diameter, densely glandular pubescent and puberulent; *style* ca. 7 mm long, densely glandular-pubescent and puberulent; *stigma* 1, its upper lobe lacking, lower lobe obtrapeziform, shallowly 2-lobed at apex, ca. 2 mm long, ca. 1.5 mm wide. *Capsule* linear, ca. 30 mm long, densely pubescent.

Distribution and habitat. *Primulina malipoensis* is a narrowly endemic species restricted to a small area at both sides of the Sino-Vietnamese border (Xiajinchang Town, Malipo County, Yunnan Province, China. Khau La Village, Quyet Tien Community, Quan Ba District, Ha Qiang province, Vietnam.) (Figure 4). It grows on moist and shady limestone rocks, at ca. 1000–1500 m altitude.

Conservation status. Based on the field investigations, *Primulina malipoensis* is currently only known from three sites around the Sino-Vietnamese boundary. Each population possesses no more than 150 mature individuals. However, the type population, which grew close to a road, had disappeared in 2017 and thus, the primary reason why it disappeared is probably due to its destruction by human activities. Based on currently available information, *P. malipoensis* should be considered as Endangered (EN): B1b(iii,v)c(iv)+2b(iii,v)c(iv); C2b, following the IUCN Categories and Criteria (IUCN 2016).

Phenology. This new species was observed flowering from June to July and fruiting from August to September.

Etymology. The specific epithet is derived from the place, Malipo County in Yunnan province, China, where the new species was first found.

Note. *Primulina malipoensis* (Figures 1 and 2) can be morphologically connected to *P. maguanensis* (Z. Yu Li, H. Jiang & H. Xu) Mich. Möller & A. Weber (Figure 3A–B) and *P. lungzhouensis* (W.T. Wang) Mich. Möller & A. Weber (Figure 3D–E) by its ovate or broadly elliptic leaf blade, with inconspicuously (or conspicuously) serrate margin, obvious bracts, white calyx lobes and infundibuliform corolla tube. However, it can easily be distinguished from the latter two species by the characters summarised in the diagnosis.

The authors' molecular phylogenetic analyses illustrate that *P. malipoensis*, *P. lungzhouensis*, *P. beiliuensis* B. Pan & S.X. Huang (Pan et al. 2013) and *P. beiliuensis* B. Pan & S.X. Huang var. *fimbribracteata*. F. Wen & B.D. Lai (Lai and Wen 2015) form a monophyletic clade (Kong et al. 2017). However, their morphology and geographical distribution allow the assumption that *P. maguanensis* and *P. maculata* W.B. Xu & J. Guo (Guo et al. 2015) are also closely related to this group. Both *P. maguanensis* and *P. maculata* were compared to *P. eburnea* in the original protologue (Xu et al. 2008, Guo et al. 2015). Nevertheless, based on the observation of living plants, *P. maguanensis* seems most similar to *P. lungzhouensis* and *P. malipoensis*; *P. maculata* (Figure 3I–J) seems most similar to *P. beiliuensis* var. *beiliuensis* (Figure 3G–H) and *P. beiliuensis* var. *fimbribracteata* (Figure 3C–F). Further, the geographical distribution of *P. maguanensis* is adjacent to *P. lungzhouensis* and *P. malipoensis* (Figure 4) and the geographical distribution of *P. maculata* is adjacent to *P. beiliuensis* (Figure 4). Moreover, the results of the phylogenetical analysis in Guo et al. (2015) show that *P. maculata* is more closely related to *P. lungzhouensis* than *P. eburnea*. All of the above five species occur in nearly the same latitude zone of karst limestone areas from Southern China (from S-Yunnan to S-Guangdong), but with a disjunctive distribution (Figure 4). Therefore, these species perhaps represents a complex of longitudinal speciation, which may be caused by geographical isolation. Further studies are needed to confirm the

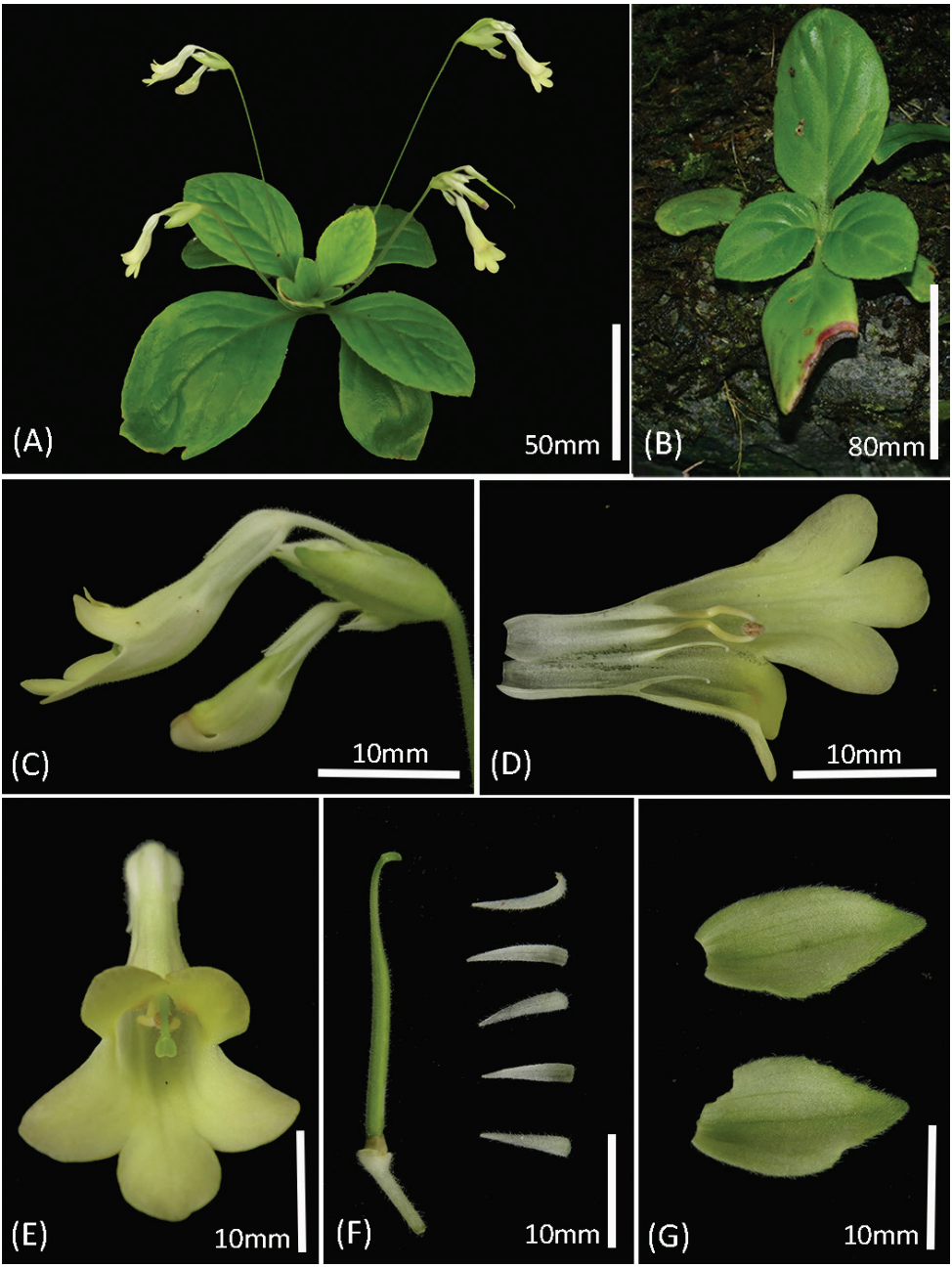

Figure 2. *Primulina malipoensis*. **A** flowering plant cultivated in South China Botanical Garden **B** plant in natural habitat **C** flower in side view **D** opened corolla, showing stamens and staminodes **E** flower in front view **F** pistil and calyx **G** bracts. Photographs by Li-Hua Yang.

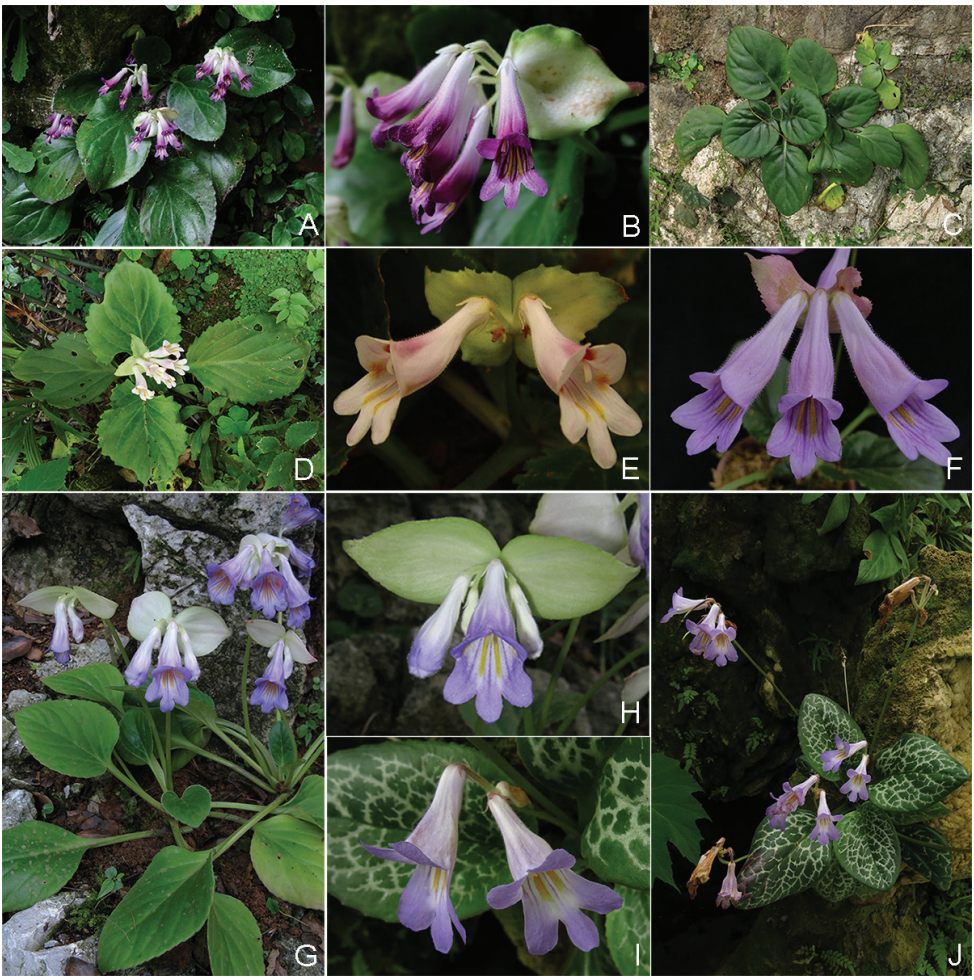

Figure 3. *Primulina maguanensis* (**A, B**), *P. lungzhouensis* (**D, E**), *P. beiliuensis* var. *fimbribracteata* (**C, F**), *P. beiliuensis* var. *beiliuensis* (**G, H**) and *P. maculata* (**I, J**). (**A, C, D, G, J**) habit, (**B, E, F, H, I**) flower. Photographs by Fang Wen (**A–H**) and Li-Hua Yang (**I, J**).

phylogenetic relationship of this species complex and to determine its evolutionary mechanism of speciation.

Primulina malipoensis could also be related to other species by its yellow flowers. However, the phylogenetic results illustrate that *P. malipoensis* has a distant relationship with all yellow flowering species, such as *P. lutea* (Yan Liu & Y. G. Wei) Mich. Möller & A. Weber, *P. alutacea* F. Wen, B. Pan & B.M. Wang (Pan & al. 2016), *P. pteropoda* (W.T. Wang) Yan Liu, *P. leprosa* (Yan Liu & W.B. Xu) W.B. Xu & K.F. Chung and *P. jiangyongensis* X.L. Yu & Ming Li (Li et al. 2014) (cf. Kong et al. 2017). These yellow flowering species are distributed across different clades (Kong et al. 2017), which means that yellow flowers have independently evolved in different species. This result

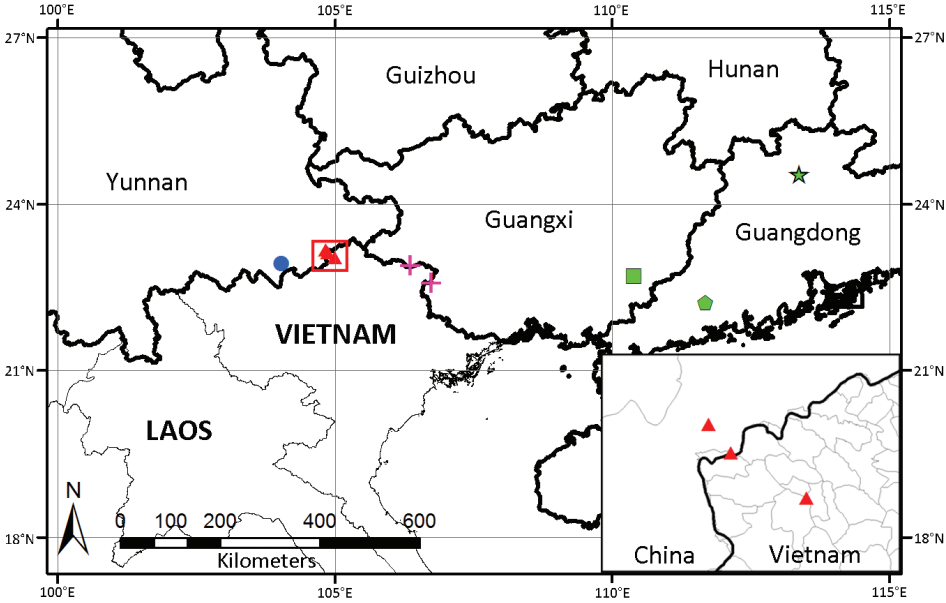

Figure 4. Geographical distribution of *Primulina malipoensis* (triangle), *P. lungzhouensis* (cross), *P. maguanensis* (dot), *P. maculata* (pentagon), *P. beiliuensis* var. *beiliuensis* (square) and *P. beiliuensis* var. *fimbribracteata* (star).

also suggests that flower colour can be used as an important character to differentiate species in *Primulina*.

Other specimen examined. CHINA. Yunnan Province, Malipo county, Xiajinchang town, Aotang, 23°07'45.41"N, 104°51'29.25"E, Alt. 1400 m, growing on moist limestone rocks near a road, 8 January 2010, *Southeast Yunnan investigation team of DNA barcoding*, *GBOWS189* (KUN!). CHINA. Guangdong Province, Guangzhou City, voucher from a cultivated plant at South China Botanical Garden, 12 June 2016 (flowering), *Li-Hua Yang*, *YLH350* (IBSC!), introduced from same locality and by the same people as the type. VIETNAM. Ha Qiang province, Quan Ba District, Quyet Tien Community, Khau La Village, Alt. 1100 m, growing on moist limestone rocks, 17 October 2017, *Fang Wen et al. VMN-CN 874* (IBK!, VMN!).

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RESEARCH ARTICLE

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Premna grandipaniculata (Lamiaceae, Premnoideae), a remarkable new species from north Myanmar

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Abstract

A remarkable new *Premna* species from Myanmar, *P. grandipaniculata* Y.H.Tan & Bo Li (Lamiaceae), is here described and illustrated. It differs from all known congeneric taxa by having huge complicated panicles which have tertiary branches formed by spike-like thyrses. In *Premna*, such a spike-like thyrse is found in *P. bracteata* and *P. interrupta*, but those species can be easily distinguished from *P. grandipaniculata* by their habit, indumentum, leaf size and inflorescence structure.

Keywords

Morphology, paniculiform inflorescence, *Premna*, spike-like thyrses

Introduction

Myanmar is an important component of the Indo-Burma biodiversity hot-spot (Conservation International, available at: http://www.biodiversityhotspots.org/xp/Hotspots/indo_burma/) and its northern region emerges in the Himalaya Centre, one of the globally richest plant diversity centres (Rafiqpoor et al. 2005, Brooks et al. 2006). However, for nearly half a century, there has been a great shortage of critical floristic surveys in northern Myanmar. A recent surge of field explorations in this region coordinated by

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the Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences, has resulted in the discovery and description of new species (e.g. Aung et al. 2017, Liu et al. 2017, Tan et al. 2017, Yang et al. 2017a, b, c). During fieldwork in 2016 and 2017, the first author encountered and collected an unusual *Premna* L. plant, a huge woody climber bearing large, complicated paniculiform inflorescences and large, suborbicular, glabrous leaves. The terminal branches of the inflorescence are spike-like thyrses formed by sessile cymes laxly arranged on the axis. After checking and comparing the plant with all known congeneric taxa, it was found that such an inflorescence is similar to that of *P. bracteata* Wall. ex C.B. Clarke and *P. interrupta* Wall. ex Schauer, but the plant differs significantly from those two species in many aspects (Figure 1, Table 1). Thus, it was confirmed that it represents a remarkable undescribed new species and it is presented here.

Methods

Both herbarium specimens and living branches of the putative new species and of *P. bracteata* and *P. interrupta* were observed under a stereo dissecting microscope (StereoZoom Leica S8 APO, Leica Microsystems 2017) and measured using a ruler and a micrometer. High resolution images of the type specimens of *P. bracteata* (held at M and K, acronyms according to Thiers 2017) and of *P. interrupta* (held at BM, E, K, and P) were consulted on JSTOR Global Plants (http://about.jstor.org/, accessed 15 August 2017). Type specimens held at K, (barcode no. K001114139 for *P. bracteata*, K000884639, K000884640 and K001114151 for *P. interrupta*) were examined in the Herbarium. The conservation status of the new species was evaluated based on the guidelines of the International Union for Conservation of Nature (IUCN 2012).

Taxonomy

Premna grandipaniculata **Y.H.Tan & Bo Li, sp. nov.**
urn:lsid:ipni.org:names:77175495-1
Figures 1A–C, 2

Diagnosis. This species is distinguishable by its huge complicated paniculiform inflorescences. *Premna grandipaniculata* shares the same primary inflorescence structure with *P. bracteata* and *P. interrupta*, but is distinct from the latter two in its spike-like thyrses forming a panicle with tertiary branches (vs. with secondary branches in *P. bracteata*, while without branches in *P. interrupta*) and in having nearly glabrous branchlets, petioles, leaves and inflorescences (vs. densely pubescent throughout in the latter two species) (Table 1).

Type. MYANMAR. Kachin State, Putao District, ca. 2–3 miles from Wasandum village, 27°29'00.29"N, 97°12'01.48"E, Alt. 1050 m, 29 April 2016, *Y.H. Tan & S.S. Zhou 20160031* (holotype: HITBC!; isotypes: HITBC!,RAF!, JXAU!).

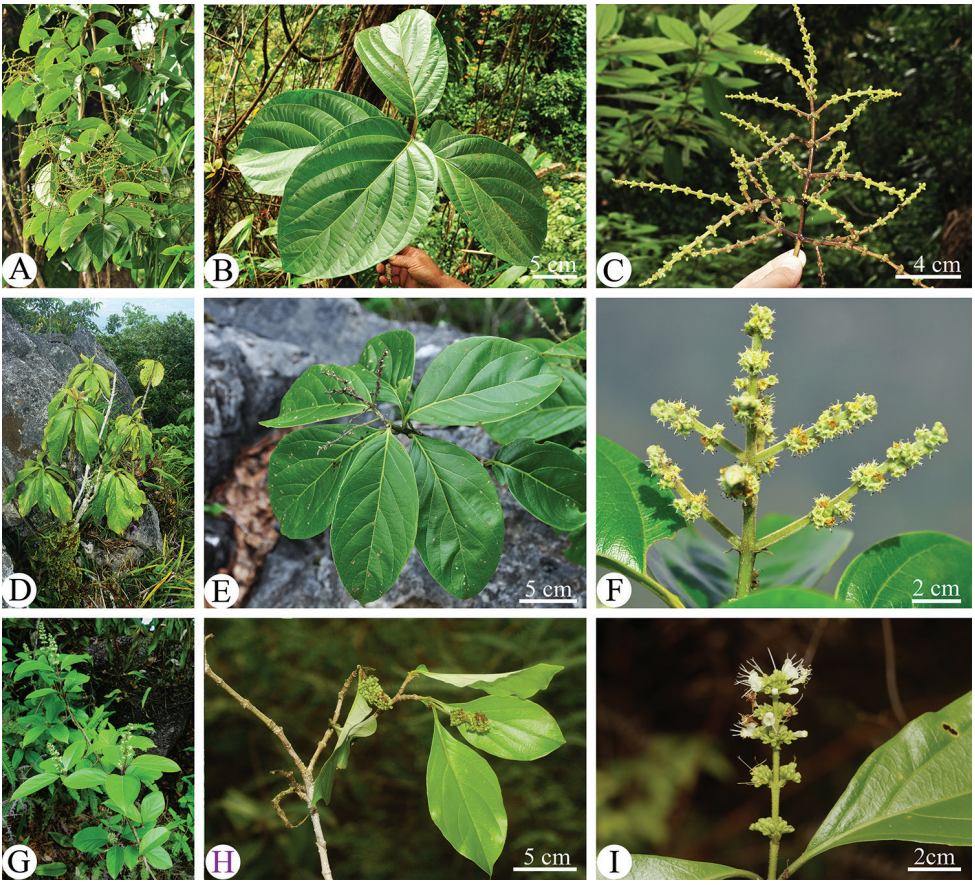

Figure 1. Morphological comparisons amongst *Premna grandipaniculata* (**A–C**), *P. bracteata* (**D–F**) and *P. interrupta* (**G–I**). **A, D, G** habit **B, E, H** branchlets with leaves **C, F, I** inflorescences.

Description. *Woody* climbers. *Branches* grey, terete, robust, nutant, without an interpetiolar ridge. *Branchlets* purplish brown, with densely small white elliptic lenticel stomentose, without bracts at the base. *Leaves* simple, opposite-decussate, glabrous, broadly ovate to suborbicular, leathery, 14–23 × 10.5–17.5 cm, apex acute, base subrounded, rounded to slightly cordate, margin entire; veins 4–7 pairs, abaxially raised and adaxially slightly compressed, secondary veins curved and jointed near margin; petiole 2.4–3.5 cm long, purplish dark green, slightly inflated, purplish furrowed on upper part. *Inflorescences* terminal, a large complicated panicle with tertiary branches, 18–30 cm long, 12–20 cm wide, peduncle nearly glabrous, terminal branches spike-like thyrses, 10–20 cm long, formed by sessile cymes laxly arranged on axis; bracts ovate, 3.0–10 mm long, easily deciduous; bracteoles subulate, tiny. *Calyx* campanulate, 2.0–2.5 mm long, outside minutely brownish pubescent, 2-lipped; lips entire, or upper lip emarginate and ciliate, apex subrounded. *Corolla* green to greenish white, subglabrous, outside glandular, inside densely white villose

Table 1. Morphological comparisons amongst *Premna grandipaniculata*, *P. bracteata* and *P. interrupta*.

Taxonomic traits	*P. grandipaniculata*	*P. bracteata*	*P. interrupta*
Habitat	large climbers	small trees	erect to climbing shrubs
Indumentum	nearly glabrous throughout	branchlets, petioles, leaf veins and inflorescences densely pubescent	branchlets, petioles, leaf veins and inflorescences densely pubescent
Leaves (length × width)	14–23 × 10.5–17.5 cm, leathery, broadly ovate to subrounded, base subrounded, rounded to slightly cordate, apex acute	6.5–17 × 5.5–10 cm, subleathery, oblong to ovate, base broadly cuneate to subrounded, apex abruptly acuminate or rarely obtuse	6.0–12 × 4.0–7.5 cm, papery to subleathery, rhomboid-elliptic, ovate-oblong to obovate, base acuminate, cuneate to broadly cuneate, apex acuminate, acute or rarely obtuse
Inflorescence	a large complicated panicle with 4–6 pairs of secondary branches and 2–3 pairs of tertiary branches, terminal branches are spike-like thyrses with sessile cymes	a panicle with 2–4 pairs secondary branches, each is a spike-like thyrse with sessile cymes	a single spike-like thyrse formed by sessile cymes

around throat, 4-lobed; lobes broadly obovate, apex subrounded. *Stamens* 4, equal, exserted; anther purple. *Ovary* oblong, 1.0–1.5 mm long, glabrous, glandular; style white, slender, 3.5–4.5 mm long. *Fruits* drupaceous, narrowly obovate, 4.0–5.0 × 2.5–3.5 mm, yellowish brown.

Phenology. Flowering was observed from early March to April and fruiting from late May to late June.

Distribution. The species is currently known only from the type locality of Putao, Kachin State, northern Myanmar, grows in tropical montane forests, at an elevation 700–1200 m a.s.l.

Etymology. The specific epithet "*grandipaniculata*" indicates that the species bear large complicated paniculiform inflorescences.

Preliminary conservation status. This species is only known from a single locality in Myanmar and as the habitat, in which it is found, is threatened by deforestation (author's personal observation), it is categorised as critically endangered under criteria B and D following IUCN Red List Categories (IUCN 2012).

Note. The most noticeable trait of the new species is its huge complicated paniculiform inflorescence. After examination, it was found to be formed by tertiary branches of spike-like thyrses. Such a spike-like thyrse is a rare type of inflorescence in *Premna*, currently found in only two species, *P. bracteata* and *P. interrupta*. In *P. interrupta*, sessile cymes form a single spike-like thyrse without branches, while in *P. bracteata* the lower parts of inflorescence bear 2–4 pairs of secondary branches. Besides its inflorescence structure, *P. grandipaniculata* also differs from *P. bracteata* and *P. interrupta* in having larger leaves (Figure 3), nearly glabrous branchlets, petioles and inflorescences (Table 1).

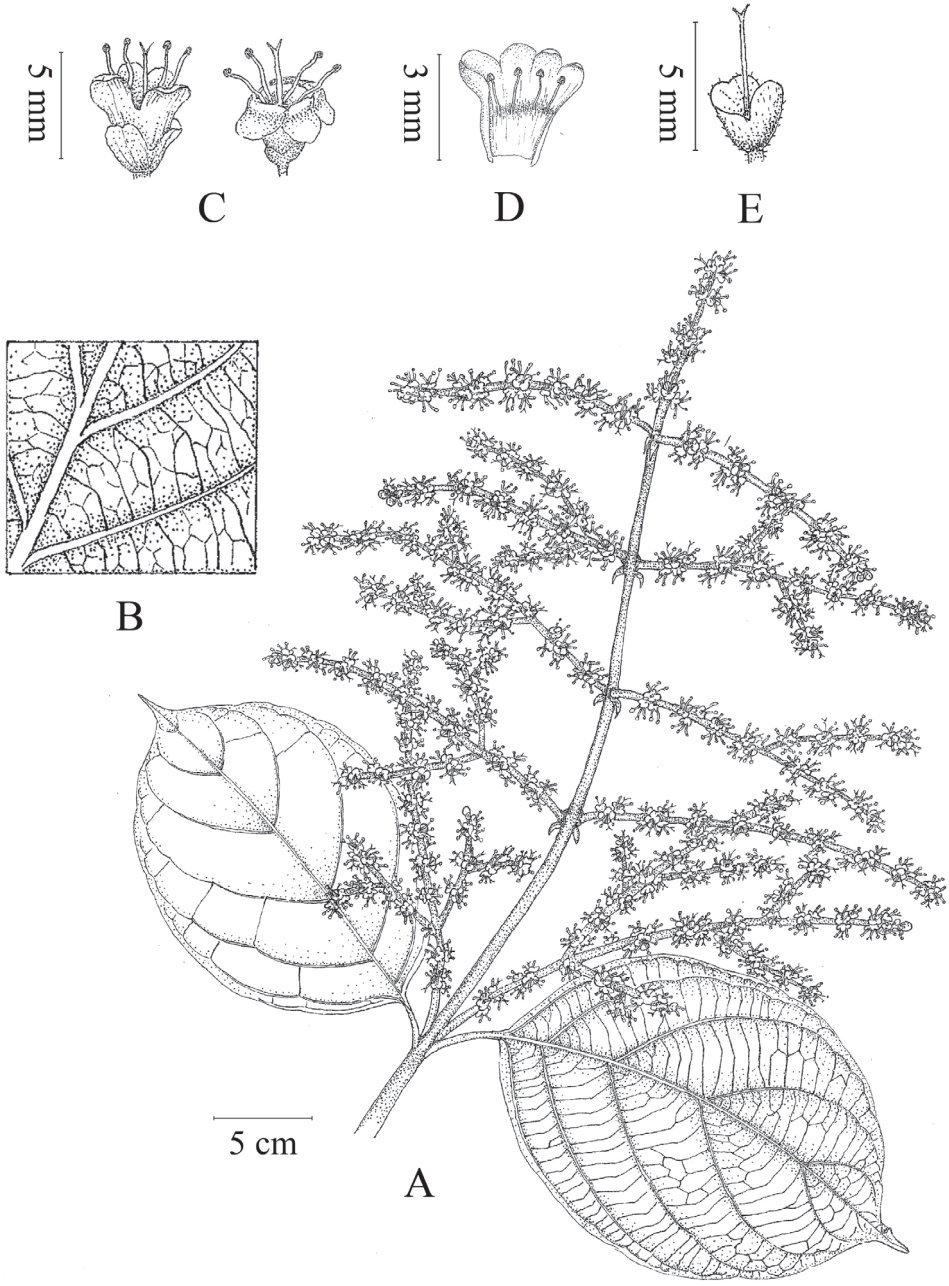

Figure 2. Line drawing of *Premna grandipaniculata* Y. H. Tan & Bo Li, sp. nov. **A** a branchlet with leaves and inflorescence **B** abaxial surface of leaf blade **C** flowers **D.** dissected corolla and stamens in a bud **E** calyx and style.

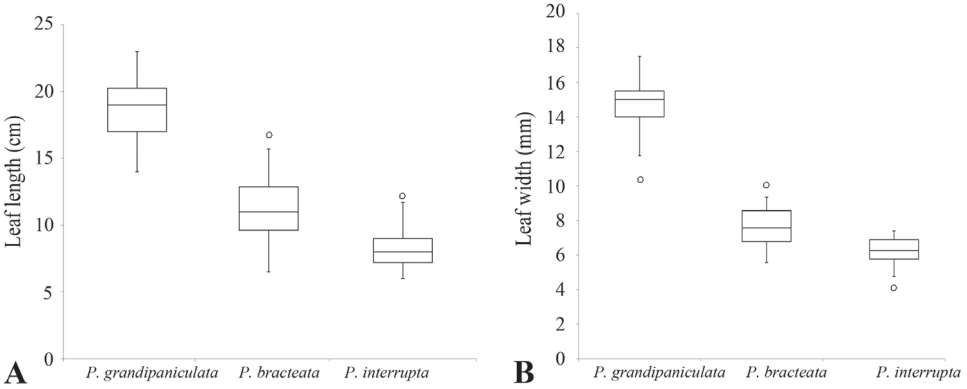

Figure 3. Box plots of two quantitative characters, leaf length (**A**) and leaf width (**B**), of *Premna grandipaniculata*, *P. bracteata* and *P. interrupta*. The boxes (rectangle region) represent the interquartile range and the whiskers (vertical line) represent the range excluding the outliers (circles). The three upper, middle and lower lines on the boxes represent the 75%, 50% and 25% of the variables, respectively. The upper and lower ends of the whiskers represent the maximum and minimum values of the variables, respectively. The circles represent the single value, where the variable value exceeds 1.5 times the difference between the 75% and 25%.

Geographically, *P. bracteata* is mainly recorded from the southern and eastern slopes of the Himalayas with several collections from Bangladesh, Bhutan, Myanmar, north eastern India and southeast Tibet of China and has also been collected from a rare and isolated population in Xishuangbanna, south Yunnan of China (Chen and Gilbert 1994, Govaerts et al. 2008, unpublished data). *Premna interrupta* frequently occurs from southwest China (Guangxi, Guizhou, Sichuan, Xizang and Yunnan provinces) to southern and south east Asia (Bangladesh, Bhutan, Cambodia, Laos, Myanmar, north eastern India, Nepal, Peninsular Malaysia, Thailand and Vietnam) (Chen and Gilbert 1994, Govaerts et al. 2008). In Myanmar, *P. bracteata* is recorded from Chin, Mandalay and Sagaing, while *P. interrupta* from Kachin, Rakhine and Sagaing (Kress et al. 2003). In Kachin States, the distribution of *P. interrupta* overlaps that of *P. grandipaniculata* and their habitat and habit are also similar, but *P. grandipaniculata* significantly differs from *P. interrupta* in morphology as mentioned above.

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